STOCKTON BEACH SAND NOURISHMENT SCOPING STUDY

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Introduction

Stockton Beach is located in the Newcastle local government area and forms part of the southern end of the embayed section of Stockton Bight (Figure 1). The sandy beach extends from the northern breakwater at the entrance to the Hunter River approximately 32km to Anna Bay in the north.

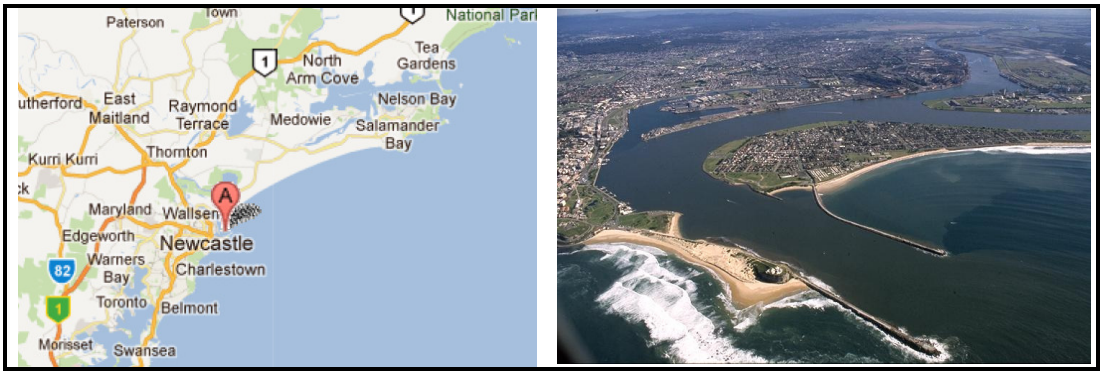

Figure 1. Locality Map (left, source: Google) Aerial View (right, source: OEH)

The beach has experienced episodes of erosion over many years and the City of Newcastle (Council) has undertaken a series of investigations and studies to address this issue. In 2000 Council issued the *Newcastle Coastline Hazard Definition Study* (WBM, 1998). This was followed in 2003 with the *Newcastle Coastline Management Plan* (NCMP; Umwelt, 2003). The NCMP stated that erosion at Stockton Beach was worsening progressively and, as such, additional investigations were required. Accordingly, the *Stockton Beach Coastal Processes Study* (DHI, 2006) and the draft *Stockton Beach Coastal Zone Management Study* (DHI, 2009) were undertaken.

In these studies the long term average sediment transport processes at Stockton Beach were identified and a range of potential options for long term management of Stockton Beach were assessed. Beach nourishment was identified as a necessary aspect to all management options. The capital beach nourishment requirements identified ranged from 410,000 m^3 to 515,000 m^3, with ongoing maintenance of up to 30,000 m^3 required per year.

WorleyParsons was engaged by Council to prepare a Sand Scoping and Funding Feasibility Study (WP, 2011) on the suitability of a range of potential sources (terrestrial, estuarine and offshore) for beach nourishment at Stockton Beach. The key objectives of the study were:

- identify potential sources of sand for beach nourishment
- identify potential methods for extraction and placement of sand
- provide a cost estimate for each beach nourishment option
- recommend the preferred option for beach nourishment
- identify potential funding opportunities for beach nourishment activities

Scope of Work

The scope of work included:

- A desktop literature review to identify relevant information including:
    - information on aquatic habitats, biota and fisheries in the study region
    - procedures and protocols for sand extraction for beach nourishment with particular emphasis on the implications for terrestrial / aquatic flora and fauna and species of special interest
    - impacts of sand extraction on the local environment
    - impacts of beach nourishment on coastal processes
    - social and economic issues associated with sand extraction and beach nourishment
    - identifying data gaps
- Identifying and investigating possible sand sources including the quality and quantity of sand and its suitability for capital and ongoing maintenance volumes for beach nourishment
- Describing methods of extraction, transport and placement
- Investigating funding feasibility
- Recommending and costing a preferred option
- Consultation with stakeholders

The study comprised a synthesis of available data on terrestrial and estuarine sand sources and original investigation work comprising coring, sampling and testing offshore sand sources. A comparative assessment was made of the potential sand sources giving consideration to the availability of the source, approvals required to access the source, the compatibility of the source with the native sand and the cost.

Existing Environment at Stockton Beach

Sediment Transport Processes

The sediment transport processes of Newcastle Bight and Stockton Beach were documented in MHL (1977), WBM (1998), Umwelt (2002) and DHI (2006). From these studies a conceptual model of sediment transport was developed (Figure 2).

The sediment transport model indicated that the beach profile was deepening at the central and northern parts of the suburb, sand was accumulating at the tip of the northern breakwater, sand was accumulating on the lobe off the southern breakwater and that there was a net sediment loss from the Stockton area of around 30,000 m^3/a.

Native Beach Sand Grading

Samples of the native sands were collected from across the beach profile from the dune, beach berm, swash zone and nearshore zone along three transects. Samples were found to comprise medium to coarse sand with an average sand content of 97%. Dune and beach berm samples comprised 99 to 100% sand. The fines content (i.e. less than 75 µm) of swash zone and nearshore sands, typically, was less than 4%. Gravel was observed in samples from the swash zone and nearshore zone along a transect in the vicinity of the former Stockton STP with the nearshore zone sample comprising 23% gravel.

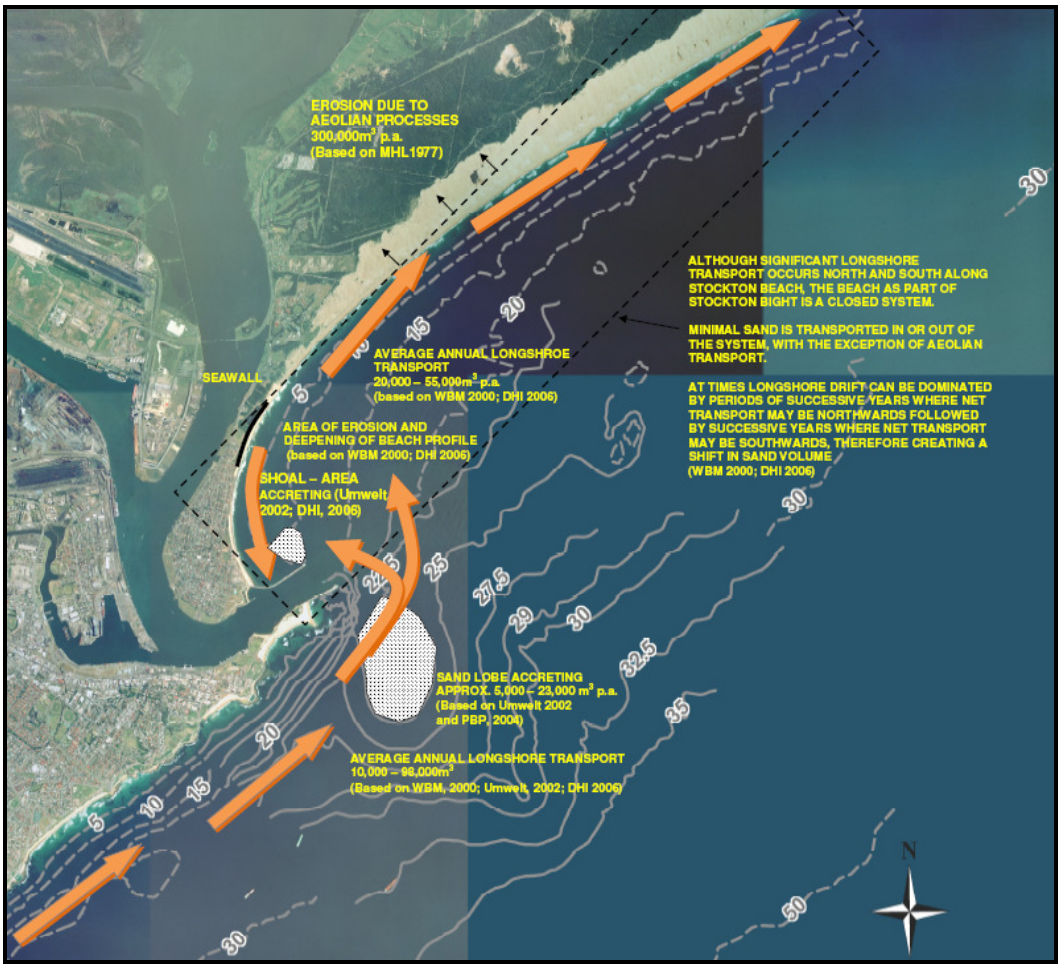

Figure 2. Conceptual model of sediment transport at Stockton Beach.

The average grain size was 0.6 mm. Removal of the gravelly sample in the nearshore zone resulted in an average grain size of 0.37 mm. Generally, the sand samples were found to be well to very well sorted. Samples comprised a maximum of 11% shell with an average shell content of 6%.

Potential Sources for Nourishment Sand

Terrestrial Sources

Existing Sand Quarries

Existing sand quarries currently operate out of Salt Ash and Anna Bay at the northern end of Stockton Bight. They have approved supplies of dune sand in excess of their existing customer demand. Available particle size distribution results from the suppliers are plotted in Figure 3. The D_{50} grain sizes are around 0.3 mm. However, there is one product that has a D_{50} grain size of around 0.4 mm.

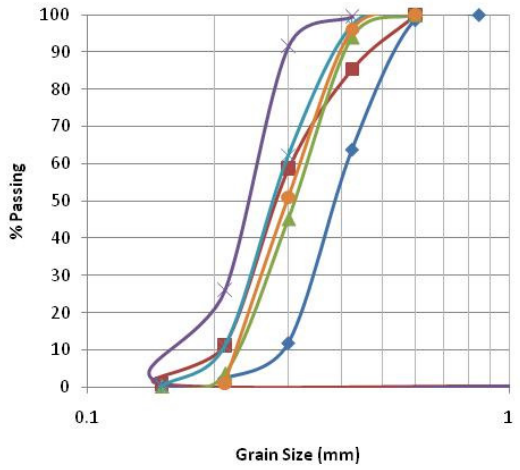

Figure 3. Grain size distributions from Salt Ash and Anna Bay

Beach Scraping

Another terrestrial source of sand that may be considered for nourishment of the beach at Stockton is sand from the beach face itself, further to the north along Stockton Bight (Figure 4). The grain size would be perfectly suited for nourishment, the transport distance short and relocation of this sand would cause little disturbance to communities or the back beach environment.

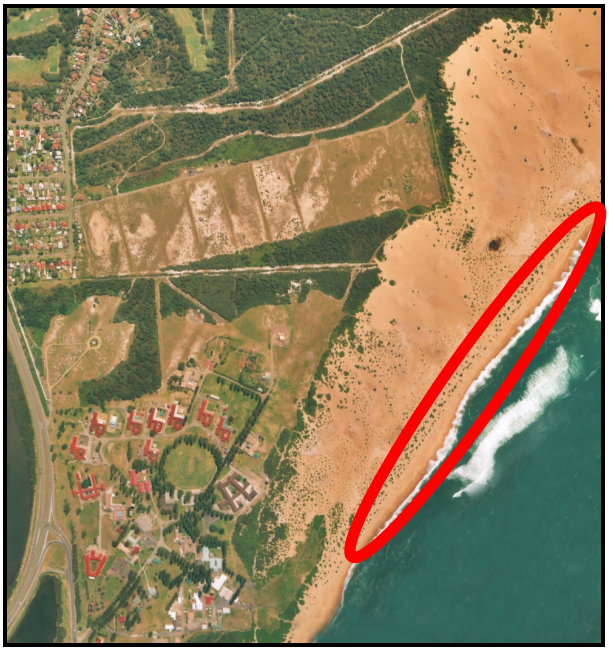

Figure 4. Possible sand nourishment source - beach face from Stockton Bight

Estuary Sources

Reworked marine sand from the inner and outer sand barriers of the Stockton embayment extend 10 km upstream in the Hunter River. As such, material extracted from within Newcastle Harbour, either as part of ongoing maintenance dredging

activities or port development, is likely to represent a potential source of marine sand suitable for beach nourishment. Sand grading curves from several sites to be dredged within Newcastle Port are presented in Figure 5.

Currently, Newcastle Port Corporation (NPC) is planning to seek approval for the dredging of ten (10) additional berths within Newcastle Harbour, which they will lease to proponents who, ultimately, will dredge the berths to their design depth and construct any associated wharf infrastructure required for operations at each berth. As such, the timing of berth development and potential availability of any excess sand from dredging activities is difficult to determine until NPC is granted development approval for the dredging works and receives interest from potential proponents.

NPC advised that it would instruct proponents to reuse any surplus sand to nourish Stockton Beach. However, the onshore filling requirements of any foreshore development undertaken by proponents would take precedence in each case.

Council may be able to use plant and equipment mobilised to Newcastle Harbour for undertaking beach nourishment activities (extracting material from other sources) if Council is able to negotiate a cost-sharing arrangement for mobilisation/demobilisation costs with proponents. However, the capabilities of port dredgers may be limited to <20 m water depths.

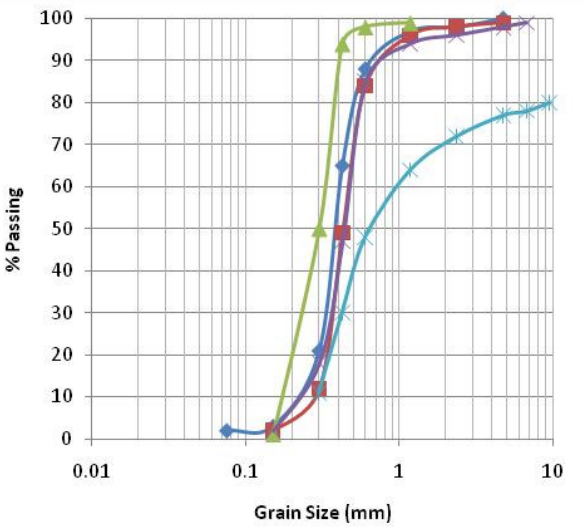

Figure 5. Grain size distributions from various potential port dredging sites

Offshore Sources

Offshore Sand Lobe and Inner Shelf Sand Sheet

Four seabed cores were taken within the 10 km radius study area; two from a sand lobe off Nobbys Head and two from the inner shelf sand sheet (Figure 6).

Samples taken from the cores were found to comprise yellow to light grey well sorted medium to coarse sand with shell and fine gravel. The average distribution comprised 93% sand, 6% gravel and less than 1% fines. The average grain size was 0.59 mm (median 0.45 mm).

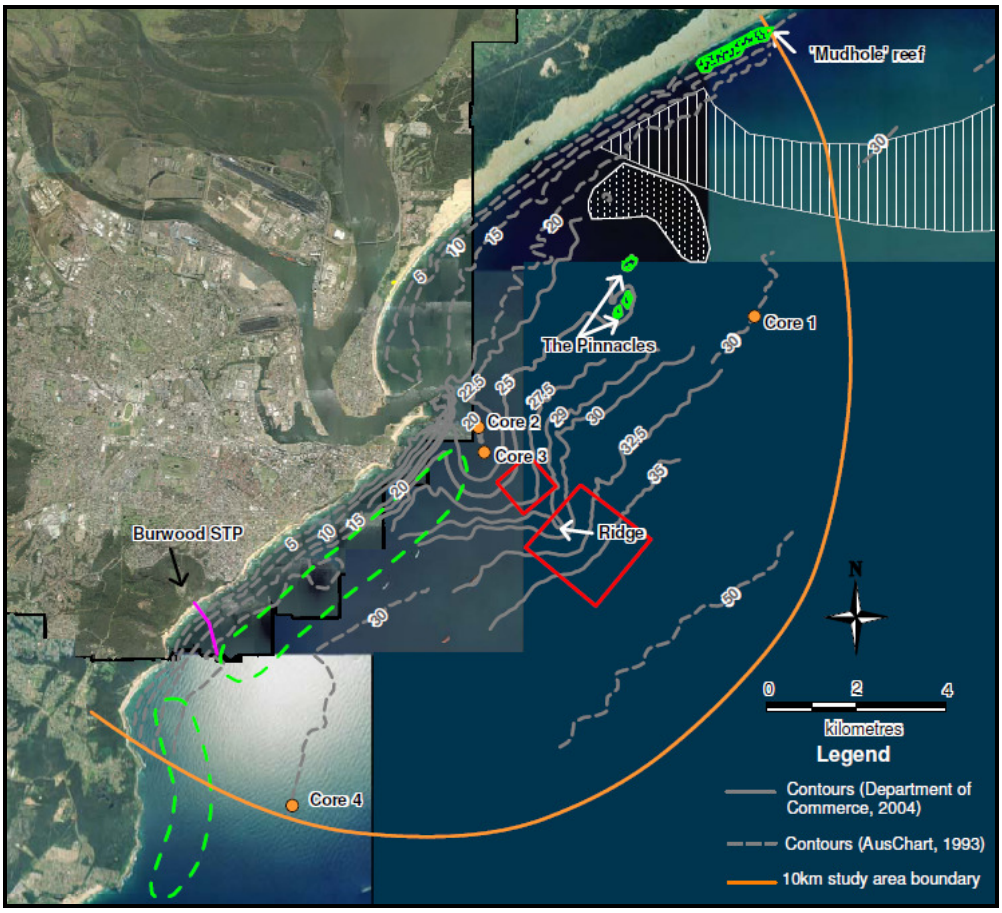

Figure 6 Study area and offshore core sampling sites

Gravel was observed in surface sands from all cores and at a depth below 3.6 m in Core 1. Cores 2 and 3 from the sand lobe offshore of Nobbys Head were inter-bedded with several thin layers (<10 cm) of fine gravel and/or with dark grey mud containing limited amounts of organic matter.

Sand Bypassing of Nobbys Head

Sand bypassing of Nobbys Head was not considered to be feasible for the following reasons:

- the pipe work required to transport sand would need to cross the main shipping channel into Newcastle Harbour, which would require complex infrastructure to implement this scheme without disrupting ongoing shipping activities
- there would be a high risk of damage to and failure of such a pipeline with maintenance dredging activities undertaken in the channel by the Port authority
- there would not be enough sand at Nobbys Head to supply the capital nourishment requirement of some 515,000 m^3; the modest sand reserves at Nobbys Head would satisfy only maintenance nourishment requirements

Grain Size Compatibility Assessment

Grain size grading of the 'native' and 'borrow' material is necessary for assessing the feasibility of a beach nourishment project. This provides an opportunity to evaluate likely performance of borrow material when placed in nourishment (native) areas (i.e. will it stay or be washed away?).

The James (1975) model of beach fill behaviour, described in the Shore Protection Manual (CERC, 1984), was adopted for assessing the physical suitability of the various sources of borrow material. The model assumes that the textural properties of the native material (mean grain size and sorting) are the direct response of sand sorting by natural processes (waves) and that these same processes will redistribute borrow material to a similar textural pattern as native material. For instance, fine sands which may be within the borrow material and not the native material, may not be stable in the beach environment and may be moved offshore and lost from the active system.

The application of the beach fill model involves calculation of two factors, an overfill factor R_A and a renourishment factor R_J, where:

R_A	=	the estimated number of cubic metres of fill (nourishment) material required to produce 1 cubic meter of beach material when the beach is in a condition compatible with the native material. It is used to estimate the initial quantities of nourishment required;
R_J	=	the ratio of the rate which borrow material will erode to the rate at which the native beach material is eroding. It is used to estimate how often renourishment may be required.

The values of R_A and R_J are determined graphically based on the knowledge of the mean grain size and sorting characteristics of the native and borrow materials. Figure 7 shows isolines of the overfill factor R_A and renourishment factor R_J, where:

$M\phi$	=	the mean diameter of the grain size distribution in phi units (see below)
$\sigma\phi$	=	the standard deviation of the grain size distribution in phi units (a measure of sorting)
-b	=	subscript b refers to borrow material
-n	=	subscript n refers to native material

The phi unit scale is an alternative measure to millimetres for the size of sand grains thus:

$$\text{phi units } (\phi) = -\log_2 (\text{diameter in millimetres})$$

According to Figure 7, the poorest performing borrow material would be material that is finer and better sorted than the native material (high values of R_A and R_J). The beach fill models are simplistic descriptions of complex beach processes. Therefore, they must be used only as a general indication of possible nourishment behaviour. In all cases judgement and experience is required in the application of the results.

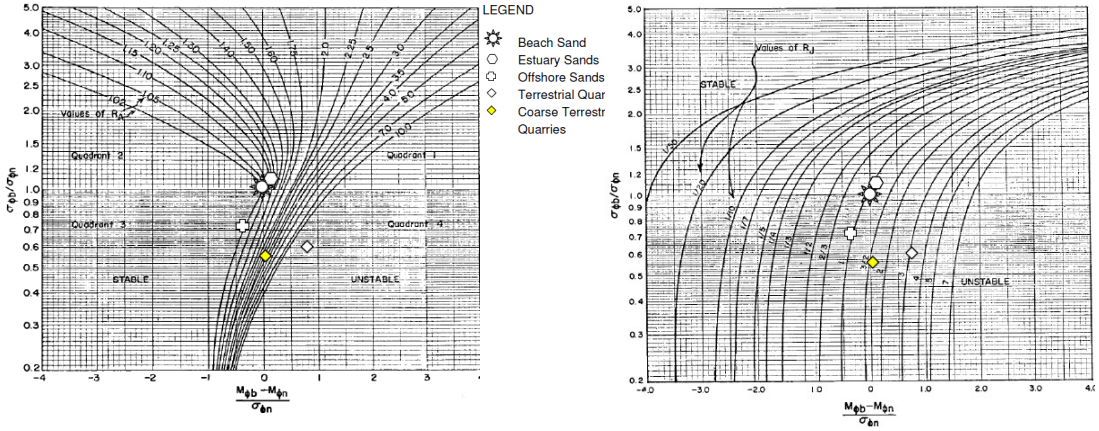

Figure 7. (Left) Isolines of the adjusted overfill factor, R_A, for values of phi mean difference and phi sorting ratio and (Right) isolines of the renourishment factor, R_J, for values of phi mean difference and phi sorting ratio, Δ=1 (source: CERC, 1984) annotated with R_A and R_J factors for the various borrow materials

Based on the data as shown in Figure 7, the terrestrial sand quarry sources would be unsuitable for the nourishment of Stockton Beach. The reason for this is that the sands, generally, are too fine and too well sorted, which would result in the nourishment being unstable. Even the coarser terrestrial sample was unsuitable, requiring some 2 to 3 times the amount (1.0M m^3 to 1.5M m^3) of sand to nourish the requisite volume (0.5M m^3).

The estuary sands (port dredging spoils) would be ideally suited for nourishment due to their grain size compatibility. Similarly, sand won from the beach itself would be ideal for nourishment from a grain size perspective.

The offshore sands would also be suitable from a grain size perspective because they are slightly coarser and slightly less well sorted than the native material.

Operations

Beach Scraping

Beach scraping typically has been applied as a coastal management activity to accelerate beach recovery following storm erosion by redistributing material deposited in the lower portion of the beach profile (above the low tide mark) to reconstruct the beach berm and dune system. These works are undertaken by dozers or excavators that are able to push or lift material over relatively short distances over the width of the exposed beach profile.

However, the distance between the extraction and placement location to move material from northern deposits to the southern end of Stockton Beach is significant and would be around 3.5 km. As such, shifting material with traditional earthworks equipment used in beach scraping would not be feasible across this distance. The most efficient tool to undertake this work would be a Wheel Tractor Scraper, such as those offered by Caterpillar (Figure 8). Wheel Tractor Scrapers are self-loading machines that are able to scrape beach sand into an onboard storage hopper (17 m^3 to 26 m^3 capacity), transport loaded material to the placement location and spread the material over the beach.

Figure 8. Wheel Tractor Scraper spreading material (Caterpillar, 2011)

A fleet of Wheel Tractor Scrapers would be required to undertake beach nourishment works at Stockton Beach within a reasonable timeframe. The optimum number of tractors that would be used would depend upon the bucket size and travel distance. For a round trip of 7 km, a tractor would take 10 minutes, being six trips each hour. With four 17.5 m^3 tractors operating, the delivery would be around 420 m^3 per hour. At this rate, the project could be completed within 6 months.

Dredging

Generally, sand is extracted and transferred from a seabed borrow area to a nourishment area by a cutter-suction dredger or a trailing suction hopper dredger.

The operation of a trailing suction hopper dredger is illustrated schematically in Figure 9. The dredger is an ocean-going vessel and navigates like any other ship. The vessel 'sails' back and forth over the borrow area and trails one or two arms on which are mounted dragheads that loosen the sand and deliver it to the suction pipe, which then loads the sand and water mixture (slurry) into the hopper of the vessel. In this mode the vessel traverses the sand borrow area at a speed of 1 to 2 knots.

To deliver the sand to the beach, the trailing suction hopper dredger must either moor to a buoy and pump the material through a pipeline arrangement (Figure 10), or use a 'rainbowing' technique to spray the material over the bow (Figure 11), or bottom dump the material directly in place on the seabed through the use of doors in the bottom of the hull.

Due to the relatively high cost of the equipment involved in dredging and placement of nourishment material, the operation takes place seven days a week, 24 hours per day. This includes the activities on the beach when material is being pumped ashore.

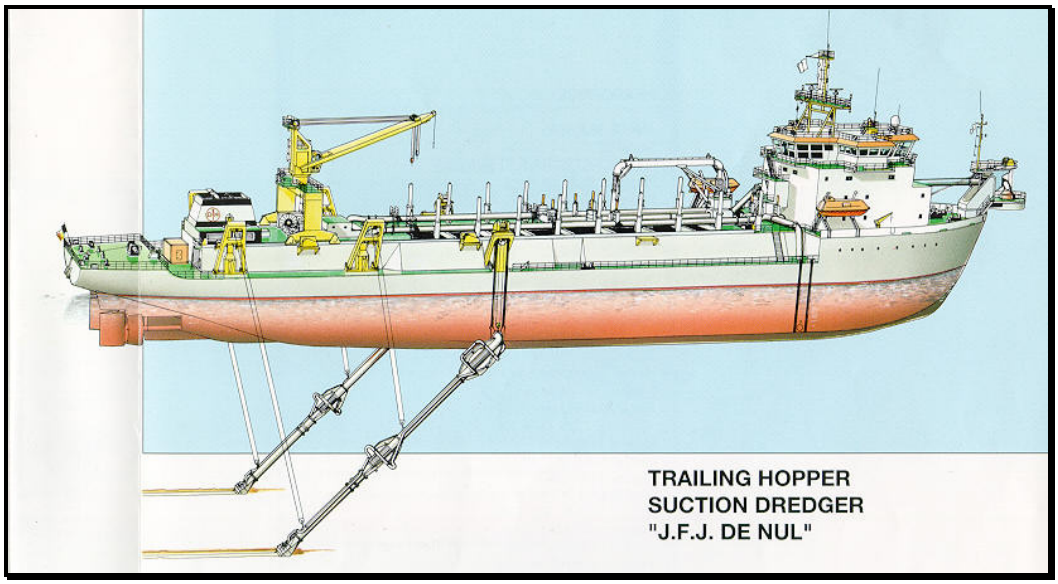

Figure 9. Artist Impression – trailing suction hopper dredger at work (Courtesy Jan de Nul Group)

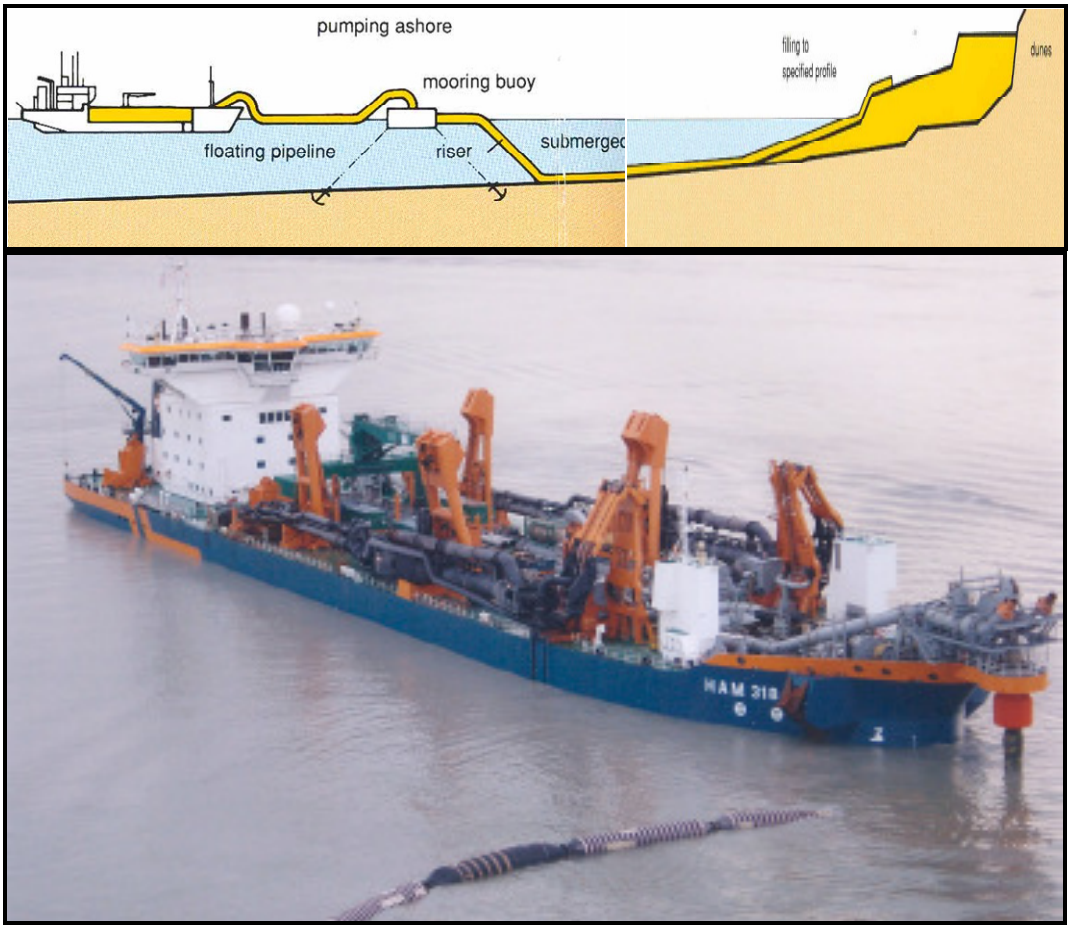

Figure 10. (Top) Pumping sand from the hopper through floating and submerged pipelines. Also shown is the Single Point Mooring (SPM). (Bottom) Trailing Suction Hopper Dredger pumping to shore (Courtesy Van Oord Australia)

Figure 11. Trailing suction hopper dredger pumping at least 50 m from the bow

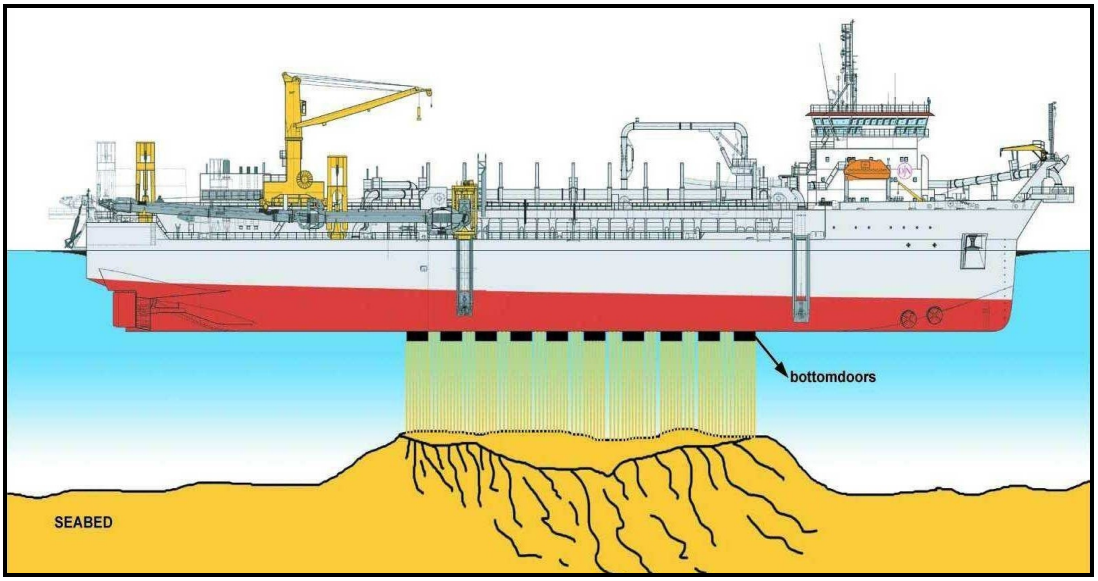

Figure 12. Schematic view of trailing hopper suction dredger bottom dumping (Courtesy Jan de Nul)

Approvals

The extraction of marine aggregate for purposes of beach nourishment from NSW statutory waters requires satisfaction of one principal Commonwealth Act and two principal NSW Acts:

- *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Offshore Minerals Act 1999* (OM Act)
- *Environmental Planning and Assessment Act 1979* (EP&A Act).

There are other Commonwealth and NSW Acts and regulations that must be addressed in order to gain approval, such as *Protection of the Environment Operations Act 1997*, *Threatened Species Conservation Act 1995*, *Fisheries Management Act 1994*, *Telecommunications and Other Legislation Amendment (Protection of Submarine Cables and Other Measures) Act 2005*.

Sand, or marine aggregate, is recognised to be a mineral under Section 22 of the OM Act. To recover marine aggregate from the seabed within the 3 Nm limit from the baseline, an enterprise is required to hold a mining licence under Part 2.4 of the OM

Act. Since the OM Act has been gazetted (31 March 2000), no regulations have been gazetted or promulgated that will allow any enterprise to apply for a mining licence off the NSW coast. This situation reflects the current NSW Government draft policy statement 'opposing sand mining off the NSW coastline', both within and beyond the 3 Nm limit.

While there is a prohibition on offshore minerals extraction due to the effect of the OM Act, a report prepared by Patterson Britton & Partners for Byron Bay Shire Council (PBP 2006) titled "Scoping Study on the Feasibility to Access the Cape Byron Sand Lobe for Sand Extraction for Beach Nourishment" includes a discussion regarding the current government policy with respect to offshore sand extraction. The report states that a letter was written by the NSW Premier to The Northern Beaches Branch of the Surfrider Foundation Incorporated dated 6 March 2001, specifically in relation to Collaroy/Narrabeen Beach, which stated:

> As you are aware, the Government does not support offshore commercial sandmining, and the areas off the coast are currently protected by reserves under the Mining Act, which do not permit exploration or mining activity. Your proposal of dredging for beach nourishment, however, is a different matter, and bears further investigation. (PBP 2006).

An officer of the Department of Primary Industries (Mineral Resources) has confirmed recently that the understanding of the Government's policy position, being opposed to offshore commercial sand 'mining' remains.

Notwithstanding any potential environmental impacts and the need to undertake a comprehensive impact assessment, it is likely that any approval process for offshore mining would be complex and would involve a wide range of stakeholders. To avoid unreasonable delays or assessment requirements, it would be vital to seek government support at the outset of such a project. In particular, it would be critical to seek support from the Minister for Planning and the Minister for Mineral Resources as key 'approval' authorities, as well as the Minister for Environment and Climate Change with respect to determining environmental assessment requirements.

For beach scraping, the work could be considered by Council under State Environmental Planning Policy (Infrastructure) 2007 as a foreshore management activity. It is considered to be a Part 5 matter with Council the proponent and approval authority. Given the scale of the proposed works, an Environmental Impact Statement would be required.

Approval for dredging the estuary sources would be obtained by the port operators and approval for placement at Stockton would be a matter for Council.

Comparison of Options

The options considered are compared in Table 1 for the initial nourishment campaign.

The existing sand quarries were ruled out on cost and sand size compatibility.

The offshore sources were ruled out on cost and that approval to extract is unlikely to be obtainable in the near future.

The estuary sources, being dredging spoils from the development of Newcastle Port, were most favourable because the sands are suitable and the cost of acquisition would be minimal. However, the supply cannot be guaranteed as it is dependent upon the

availability of a sand surplus from onshore filling associated with port development and may not be made available for many years.

Beach scraping as a nourishment source was considered to be the most likely option to be achievable in the short term.

Table 1. Comparison of various nourishment sources

Source	Availability	Approval	Suitability	Cost	Comment
Terrestrial Sand Quarries	✗	✓	✗	$20 M to $40 M	The existing quarries have advised that they cannot supply the quantities required. The existing sources generally are too fine with material very well sorted. Commercial rates for the supply of quarried sands make these sources cost prohibitive.
Beach Scraping	✓	✓	✓	$5.2 M	Approvals to be obtained. Not a show stopper - done elsewhere.
Estuary Sources	?	✓	✓	$0.0	Sand availability reliant on activities of port developers and may not be available when needed. Cost of extraction, transportation and delivery borne by Port user.
Sand bypassing from Nobbys	✗	✗	✓		Littoral drift bypassing of Nobbys Head could not supply the capital quantities required. New offshore sand extraction is illegal in NSW.
Offshore Lobe	✓	✗	✗?	$6.3 M	Offshore sand extraction is currently illegal in NSW. Some of the fines materials on the lobe had elevated concentrations of hydrocarbons. Dredging in 20 m depth off beaches is problematic.
Offshore sand Sheet	✓	✗	✓	$8.4 M	Offshore sand extraction is currently illegal in NSW. Dredging in water depths of around 40 m requires an international dredger with high establishment costs. Port dredger is too small.

Legend: ✓ criterion acceptable; ✗ potential show stopper; ? more information is required

Conclusions

A scoping study for the sand nourishment of Stockton Beach has completed and has concluded the following:

- The most favourable option for the nourishment of Stockton Beach was found to be the acquisition of dredging spoils from the development of Newcastle Port. This was because the grain size distributions of the sand samples tested were ideally suitable and the cost of their acquisition could be minimal, being borne in the main by the various proponents of port developments. However, the supply cannot be guaranteed, it may not be available for many years and may come only intermittently.

- Beach scraping from Stockton Bight to win sand nourishment for Stockton Beach is the most likely option to be achievable in the short term.

- The existing terrestrial sand quarries were not favoured on the basis of cost and sand size suitability.

- The offshore sources were ruled out on the basis of cost and that approval to extract is unlikely to be obtainable in the near future.

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