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Land and Property Management Authority

Report for Tweed River Entrance Sand Bypassing Project

Options Feasibility - Summary Report

September 2011

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Introduction

The Tweed River Entrance Sand Bypassing Project (TRESBP) is a joint scheme between the NSW and Queensland Governments to establish and maintain a navigable entrance to the Tweed River and to restore and maintain natural sand supply to the southern Gold Coast beaches in perpetuity.

The Governments engaged GHD to undertake a feasibility study of three specific options for enhancing operations of the Tweed River Entrance Sand Bypassing System (TRESBS). BMT-WBM was engaged separately to investigate the feasibility of a fourth option involving back-passing of sand along Letitia Spit.

This Report provides a summary of the key findings of these feasibility studies with respect to the feasibility of the four options.

Background

The Tweed River Entrance Sand Bypassing Company operates the TRESBS for the Governments at the mouth of the Tweed River and across the NSW/QLD border. The TRESBS comprises two sand delivery methods:

(1) Pumping by jet pumps mounted on a jetty south of the Tweed River entrance and through a network of buried pipelines to four separate discharge outlets north of the Tweed River entrance; and

(2) Dredging of the Tweed River entrance area by floating dredge and deposition in designated offshore areas north of the Tweed River entrance.

As intended in the original Project design, large volumes of sand were delivered by the TRESBS in the initial years of operation to clear the Tweed entrance bar, and to restore the badly eroded southern Gold Coast beaches. However due to prolonged calm weather conditions, the natural northwards movement of sand through the southern Gold Coast beaches has been slower than predicted. This combination of events produced a large accretion of sand in Coolangatta Bay which resulted in very wide beaches; reduced exposure of Kirra Reef; and the development of a long continuous surfing bank from Snapper Rocks to Coolangatta known as the 'Superbank'. In addition, the extraction of large volumes of sand has resulted in a significant landward realignment of the shoreline along Letitia Spit.

Although recent studies have shown that the excess sand volumes are dispersing from Coolangatta Bay, community concern led to a campaign for changes to the TRESBS operations. In response, the Governments implemented several strategies for reducing sand supply into the Bay in order to accelerate the dispersal of the sand build up at Kirra/Central Kirra beaches. The Governments also agreed to investigate the feasibility of other operational options to provide longer-term enhancements for achieving a project objective of delivering sand at a rate that is consistent with the highly variable natural supply rate.

Study Objectives

GHD was engaged to undertake a feasibility study of the following three operational options for enhancing the TRESBS:

1. **North Kirra Outlet**: Extension of the existing sand pumping and delivery capability to a new outlet located at North Kirra;

2. **Additional Dredge Placement Areas**: Development of additional nearshore placement areas along the southern Gold Coast beaches for deposition of dredged sand; and
3. **Kingscliff Sand Delivery**: Consideration of the Tweed River entrance as a one-off source of sand for proposed beach nourishment works proposed by Tweed Shire Council at Kingscliff.

In addition, BMT-WBM was engaged to undertake an additional study into the feasibility of a fourth option, **Sand Back-passing**, involving the development of a dredging and/or pumping regime which would allow the interception of sand at, or before, the Tweed River Entrance and return delivery to Letitia Spit.

Methodology

Following a review of all relevant data, previous studies and the governing legislation, a benchmark condition was defined for each beach within the Project area based on the current coastal condition and expected future trends. A combination of conceptual and numerical models of sand movement was used to provide the basis for evaluating beach responses to each operational feasibility option.

In consultation with the project partners LPMA, DERM, GCCC, and TSC, and representatives of the Tweed River Entrance Sand Bypassing Company Pty Ltd, the following tasks were undertaken in the feasibility assessment of the four options:

- Assessment of the natural viability, effectiveness and cost/benefit in terms of
  - Whether they result in a timely and effective response to the current issue of the build up of sand at Kirra and Central Kirra beaches, and
  - Whether they result in improved longer term operation of the system given the natural variability in sand transport conditions along the project area that impact on operations and project objectives;
- Identification of potential adverse impacts, risks/uncertainties and mitigation/management measures; and,
- Recommendation of an environmental planning path to navigate through approvals and permits.

Feasibility Assessment

Over recent years, the jetty operations have been progressively modified to capture and pump sand quantities consistent with natural supply. Dredge placements in outer nearshore reserve placement areas have been trialled and were successful in reducing the sand drift into Coolangatta Bay to promote dispersal of the sand build up at Kirra. Survey results indicate that sand build up from the initial years of operations is dispersing naturally and sand volumes in Coolangatta Bay are approaching pre-pumping conditions under the current sand delivery strategies. However, there is still significant sand build up in the Central/North Kirra Beach areas.

It is noted that the project's EIS (Hyder et al, 1997) stated that substantial variability of beach widths and surfing conditions will always be an inherent natural feature of these beaches. The EIS advised that sand delivery programs should not be reactive in response to short term variations in the beach systems but rather planned in the context of the longer term operation of the system to best match natural sand supply to the southern Gold Coast beaches.

The following options for alternative sand placement provisions have been investigated to assess their feasibility and potential for addressing issues associated with the sand build up at Kirra/Central Kirra Beaches and potential enhancement of longer term operations to achieve project objectives.

Option 1 – North Kirra Outlet

The construction of an additional outlet at North Kirra physically offers potential for reducing sand drift volumes passing through Kirra by reducing the sand supply to Coolangatta Bay. This approach could assist the dispersal of the sand build up at Kirra/Central Kirra and lead to improved beach amenity, surfing conditions, and reef health at Kirra. However, the implementation of this option is likely to take in the order of two to three years, by which time the need for an additional northern outlet is likely to have diminished given the current trending in sand dispersal from Kirra.

It is important to note that depending on the selected placement method, location, timing, and volume of sand pumping, a North Kirra outlet could potentially cause a local realignment of the beach south (east) to Kirra by contributing to sand build up. This could potentially leading to detrimental effects on beach width, surf quality and Kirra Reef.

The construction of infrastructure and the operation of a northern outlet would impact severely on both the visual values of Kirra to Bilinga and the usability of the beach in the immediate vicinity of the outlet. In addition, regular use of a North Kirra outlet could also starve the beaches from Rainbow Bay to Kirra through the delivery of sand to these beaches at rates less than the natural supply. Consequently, a northern outlet would have limited benefit in promoting project objectives in the longer term, because routine use would not maintain the natural sand supply to all the southern Gold Coast beaches.

Given the significantly high costs associated with this option, the uncertainty of beach responses and the implementation timeframe of several years, it is difficult to recommend this option as a feasible short-term solution, especially in light of the present sand reduction trend due to natural dispersion in Coolangatta Bay.

Option 2 – Additional Dredged Placement Areas

Option 2A - Bilinga to Tugun Nearshore Areas

While the approval of additional dredge placement areas would improve the flexibility of the sand delivery system, the placement of dredged material in these areas would only be appropriate during periods of excess sand supply to the southern Gold Coast beaches. It is unlikely that this option could be implemented on a routine long term basis as would impact on the beach amenity from Rainbow Bay to North Kirra because of the less than natural sand delivery that would be available to these beaches. Consequently, routine long term use of these areas would not promote the objectives of the project legislation that aim to ensure sustainable and ‘natural’ beach amenity by requiring full natural sand supply to all southern Gold Coast beaches.

Given that the southern Gold Coast beaches are currently adjusting to the ‘natural’ volumes of sand being targeted by project operations, the need for these placement areas is likely to have decreased during the lead time required to secure approvals and project agreements and to realise an impact on the sand drift passing through Kirra. Nevertheless, the relatively low cost involved in establishing these additional placement areas can be justified in terms of providing additional operational flexibility for the project. However, the relatively high operational costs involved in transporting sand by dredge to these additional placement areas should be compared against the limited benefit these additional areas would provide in addressing the current issues at Kirra and in promoting project objectives in the longer term.

Option 2B - Project Area Extended 'Deep Water' Placement Areas

The placement of dredged sand in deeper water would delay the onshore movement of the placed sand which would provide some ability to gradually incorporate dredged sand into the alongshore sand drift, ie spreading over time to better match natural sand supply conditions.

Although no dredging has been necessary in the last two years, an extension of deep water dredged sand placement areas would provide the TRESBS with additional placement flexibility at generally low cost, and would be more consistent with the project objective of delivering sand consistent with natural supply rates. If carefully managed in conjunction with the other project operations, further consideration of this option is justified.

Option 3 – Kingscliff Sand Delivery

Whilst it would be physically feasible for sand to be taken from the vicinity of the Tweed River Entrance to Kingscliff Beach for use in the proposed beach works, these operations would provide limited direct benefit to the TRESBP. This is due to the requirement to use a large hopper dredge for operational efficiency and costing reasons since each load of sand must be transported a large distance to South Kingscliff. Use of a dredge of this size means the shallower parts of the entrance bar that are usually dredged, may not be accessible and sand could have to be drawn from further offshore.

Depending on the capabilities of the dredge selected, separate entrance maintenance dredging by smaller dredging plant may also be required in order to maintain the required navigable depth within the entrance channel to the Tweed River.

Delivery of sand from the Tweed River Entrance to Kingscliff Beach appears physically and environmentally feasible with the key feasibility issue likely to be the high cost of sand transport and placement on the upper beach, which may be prohibitive and should be considered at the initiation of any further planning.

Option 4 – Sand Back-Passing

The investigations carried out by BMT-WBM concluded that it is feasible and practical to undertake back-passing of sand to Letitia Beach either by nearshore placement of sand dredged from the river entrance or by pumping via a pipeline from the existing bypassing plant to a discharge outlet location along the beach.

Back passing offers potential for reducing sand drift volumes passing through Kirra/Central Kirra by reducing the sand supply to Coolangatta Bay. It is likely that this option may take up to one year to implement but has the significant advantages of comparatively low overall cost and lead time to implement and achieve benefits, compared to a North Kirra outlet or Bilinga/Tugun nearshore dredge placement option.

It is considered highly probable that, provided the back-passing rate is sufficient, pumping from the jetty system through a land-based pipeline would widen the beach berm and would effectively lead over time to accretion of the shoreline both updrift and downdrift of the discharge location.

The option to place the sand via a bottom-dump dredge represents another effective back-passing option. No onshore infrastructure would be required and greater flexibility would be available in the location of the sand placement along Letitia Spit. However building of the upper beach and dune would take a significant time and, as a standalone process, would not provide immediate benefits in terms of shoreline maintenance.

A combination of the two processes could be undertaken, giving flexibility in where the back-passed sand may be sourced and placed – ie from the jetty system to a fixed discharge point or from the entrance dredging to the preferred placement location at any time.

Back passing provides improved flexibility for operations to respond to the highly variable sand supply conditions along Letitia Spit and the difference in the sand drift rates along the southern Gold Coast beaches that may occur over the short term or persist from time to time. Back passing offers cost effective longer term benefits in promoting project objectives through its major advantage of improved control of sand quantities being delivered to Queensland beaches and hence greater flexibility for system management to better match the natural sand drift patterns along the southern Gold Coast beaches.

Conclusions

The establishment of new project operations needs to be considered in terms of their location and frequency of use. Long-term use of the options outlined within this report would impact on the southern Gold Coast beaches by altering the current rates of sand delivery. Numerous related issues must also be given consideration in order to achieve balanced economic, social and environmental outcomes.

Specifically, a North Kirra outlet would have a direct detrimental impact on the local beach amenity where the sand delivery outlet infrastructure is located. The use of a north Kirra outlet on a routine basis could also seriously starve the southern-most Gold Coast beaches of their requirements for restored sand supply. Consequently, routine use of this option would not provide a long-term enhancement to the system operations in terms of achieving project objectives that seek to restore and continue a natural sand supply to all the southern Gold Coast beaches. Surf quality at Kirra may be improved by the use of a North Kirra outlet. However, this would be subject to careful planning and placement of sand, as sand pumping to this location may also cause a local realignment of the beach south (east) to Kirra, to the detriment of Kirra surfing and Kirra Reef in the future. Given the significantly high costs and implementation timeframe of several years, this option would not be considered a cost-effective solution to the existing sand build up at Central Kirra when compared to other options, especially in light of the sand reduction that is continuing to occur.

The establishment of additional dredge sand placement areas for project operations also needs to be considered in light of their location and frequency of use. Long-term use of Bilinga to Tugun nearshore placement areas would impact on the coastline from Rainbow Bay to Kirra. Similar to the case of a North Kirra outlet, this section of coastline would be denied natural supply of sand. Availability of these placement areas would only be beneficial in terms of promoting project objectives during a period of excess sand supply. However, dredge placement would be more expensive and would not provide any additional benefit compared to the use of optional deep water reserves within the project area.

Addition of deeper nearshore placement reserves seaward of the existing project placement areas would provide worthwhile increases in operational flexibility at relatively low cost and are recommended for consideration.

Supplying sand to Kingscliff Beach from the vicinity of the Tweed River Entrance provides no direct benefit to the TRESBP during periods of average sand supply rates. The requirement for the use of a large dredge means the shallower parts of the entrance bar that are usually dredged, may not be accessible and sand could have to be drawn from further offshore.

Delivery of sand from the Tweed River Entrance to Kingscliff Beach appears physically and environmentally feasible with the key feasibility issue likely to be cost, which may be prohibitive and should be considered at the initiation of any further planning.

The investigations completed by BMT-WBM concluded that back passing of sand to Letitia Spit Beach is a feasible and practical means to enhance the management of the volume of sand that is delivered to the southern Gold Coast beaches, to cater for the highly variable natural rate of sand supply along Letitia Spit on a short and long term basis.

The back passing strategy could be initially targeted at reducing the quantity of sand build up at Central Kirra by reducing delivery under high natural transport conditions, while maintaining acceptable conditions at Snapper Rocks through to Coolangatta Beach. Given the short lead time expected for implementation of backpasssing, when compared to the various options, back passing is considered to be an effective option for promoting more rapid dispersal of the sand build up at Central Kirra to improve beach conditions and surf quality at Kirra.

Back passing also provides a mechanism to restore and maintain the Letitia Spit shoreline in the longer term with improved operational capability to promote beach rebuilding at Letitia as required.

The back passing option is a feasible and practical means to provide a timely and effective response to the current sand build up at Central Kirra and inproved operational capabilities to promote the longer term project objectives of managing sand delivery to match natural sand transport conditions along the project area.

Subject to the feasibility constraints, risks and recommendations for further investigations outlined within this report, the four options generally appear to be physically and environmentally feasible. The key feasibility issues are the time required for implementation to respond to the current issue of sand build up at Central Kirra, potential longer term operational benefits that promote project objectives and relative cost / benefit ratio of implementing these strategies, which may be prohibitive. These issues and constraints should be considered at the initiation of any further planning.

With this in mind, development of deeper nearshore placement reserves and back-passing capabilities, which would provide worthwhile increases in operational flexibility at relatively low cost during periods of high natural sand supply rates are recommended for further consideration.

1. Introduction

The NSW and QLD Governments have instigated feasibility studies of four options for modifying system operations to better respond to the highly variable natural sand supply rates by the provision of more flexible sand delivery strategies.

The four options are as follows:

1. **North Kirra Outlet**: Extension of the existing sand pumping capability to a new sand delivery outlet located at North Kirra;
2. **Additional Dredge Placement Areas**: Development of additional nearshore placement areas along the southern Gold Coast beaches for deposition of dredged sand;
3. **Kingscliff Sand Delivery**: Consideration of the Tweed River entrance as a one-off source of sand for proposed beach nourishment works at Kingscliff; and,
4. **Sand Back-passing**: Development of a dredging and/or pumping regime which would allow the interception of sand at, or before, the Tweed River Entrance and return delivery to Letitia Spit.

Options 1, 2, and 3 have been investigated by GHD, while the feasibility of Option 4 was examined by BMT-WBM.

The primary objective of these studies was to investigate the feasibility of modifying the existing sand bypass system to provide more flexible sand delivery capabilities such that the system is better able to respond to the highly variable natural sand supply rates. More specifically, the feasibility studies were required to undertake the following:

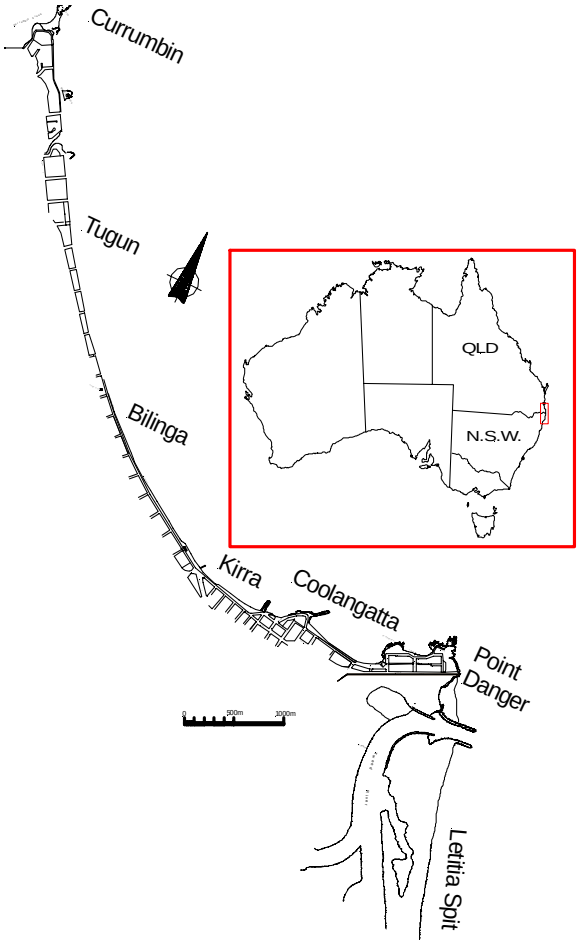
- to review whether the options are consistent with the TRESBP legislation and the extent to which they may promote the achievement of project objectives; and
- to assess the viability, effectiveness and cost/benefit of options in terms of the following:
    - o whether they result in a timely and effective response to the current issue of the build up of sand at Kirra and Central Kirra beaches; and
    - o whether they result in improved longer term operation of the system given the natural variabilities in sand transport conditions along the project area that impact on operations and project objectives.

In order to develop a practical summary of the information contained within the feasibility study reports, GHD has been engaged by LPMA on behalf of the TRESBP to prepare a concise summary report covering the key findings of the studies completed by GHD and WBM-BMT.

2. Background

The Tweed River entrance is located on the NSW / QLD border approximately 900 km north of Sydney and 105 km south of Brisbane. Whilst the primary study area extends from Letitia Spit north to Kirra Beach as shown on Figure 1 (LPMA, 2010), consideration has also been given to the areas of Bilinga, Tugun and Kingscliff.

Figure 1 Map of Study Area



This area contains approximately 6 km of coastline which is used for numerous recreational pursuits such as surfing, swimming, kayaking and boating.

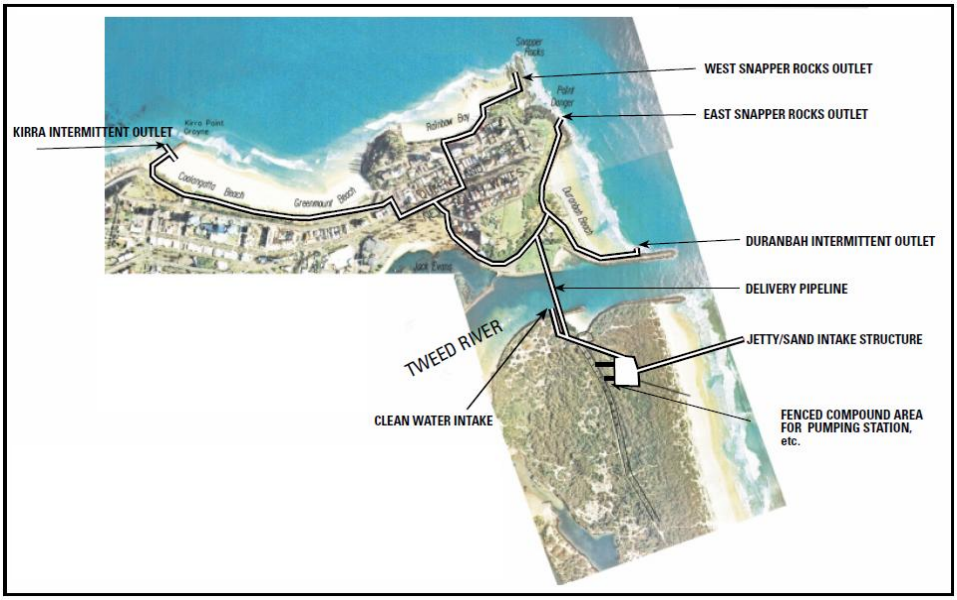
The Tweed River Entrance Sand Bypassing Project (TRESBP) is a joint scheme of the NSW and Queensland Governments to establish and maintain a navigable entrance to the Tweed River and to restore and maintain coastal sand supply along the southern Gold Coast beaches.

The Tweed River Entrance Sand Bypassing Company operates a sand bypassing jetty facility comprised of a 450 m long permanent fixed jetty structure that is sited around 250 m south of the Tweed River entrance and extends offshore to the -5.0m Indian Spring Low Water (ISLW) contour. The jetty supports ten jet pumps installed in series that are buried beneath the seabed. When operational the jet pumps create cones in the sand that intersect each other to form a trench at right angles to the beach alignment

which captures the sand moved by waves and currents along the more active portion of the beach profile.

The sand is pumped hydraulically to a sump located at the onshore end of the structure from where it is again pumped via a slurry pump into a 400 mm diameter discharge pipeline. The discharge pipeline crosses under the Tweed River and directs sand slurry to outlets located at Duranbah beach, Snapper Rocks (East and West) and Kirra Point, as shown in Figure 2 (DERM, 2010). Once discharged the sand is reworked northwards by natural coastal processes across and along the beach profile.

Figure 2 Discharge Pipeline Layout (DERM 2010)



The pumping operation is supplemented by dredging on an as-required basis. In particular, a small trailer suction hopper dredger (TSHD) is periodically required to remove sand that has deposited within the entrance channel to the Tweed River. This material is removed from the entrance channel and placed within the subaqueous portion (inner or outer area) of the beach profile, generally off Point Danger.

As intended in the original Project design, large volumes of sand were delivered by the TRESBS in the initial years of operation (2001 – 2006) to develop a sand trap at the jetty; reduce the Tweed entrance bar; and restore the depleted southern Gold Coast beaches. However due to prolonged calm weather conditions, the natural northwards movement of sand through the southern Gold Coast beaches has been slower than predicted. This combination of events produced a large accretion of sand in Coolangatta Bay which resulted in very wide beaches; partial coverage of Kirra Reef; and the development of a long continuous surfing bank from Snapper Rocks to Coolangatta known as the 'Superbank'. In addition, the extraction of large volumes of sand has resulted in a significant landward realignment of the shoreline along Letitia Spit.

Although recent studies have shown that the excess sand volumes are dispersing from Coolangatta Bay, community concern has led to a campaign for changes to the TRESBS operations. In response, the Governments have implemented several strategies for reducing sand supply into the Bay in order to accelerate the dispersal of the sand build up at Kirra/Central Kirra beaches. The Governments have also agreed to investigate the feasibility of other operational options, to provide longer-term enhancements for achieving a project objective of delivering sand at a rate that is consistent with the natural supply.

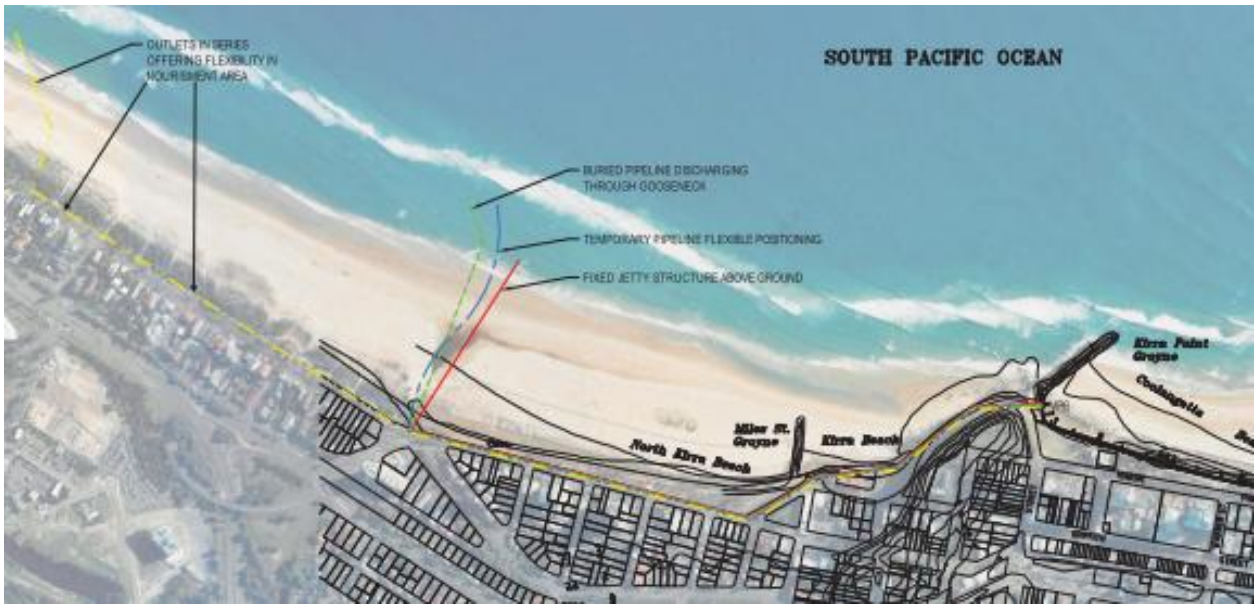
3. Options for Consideration

A number of sand placement scenarios have been considered for each of the four options specified by TRESBP. These placement scenarios have been selected in consultation with key stakeholders and developed through workshops with senior personnel experienced in coastal management, and dredging and beach nourishment operations. Full details of the proposed sand placement options are provided in the Feasibility Reports (GHD 2011, BMT-WBM 2010). A brief summary of each Option is provided below in Sections 3.1 to 3.4.

3.1 Option 1 - North Kirra Outlet

Option 1 comprises the extension of the existing system to a supplementary sand delivery outlet located at Coolangatta Creek to nourish Kirra Central and further north as indicated in Figure 3 below. Based on booster station requirements, consideration has been given to additional pumping distances of 1200 m and 2400 m from the existing outlet at Kirra Point groyne. The outlet types considered include Fixed Jetty Structure, Buried Pipeline, Temporary Flexible Pipeline and Multiple Temporary Outlets. The quantity of material pumped will be dependant on beach conditions at the time of operation.

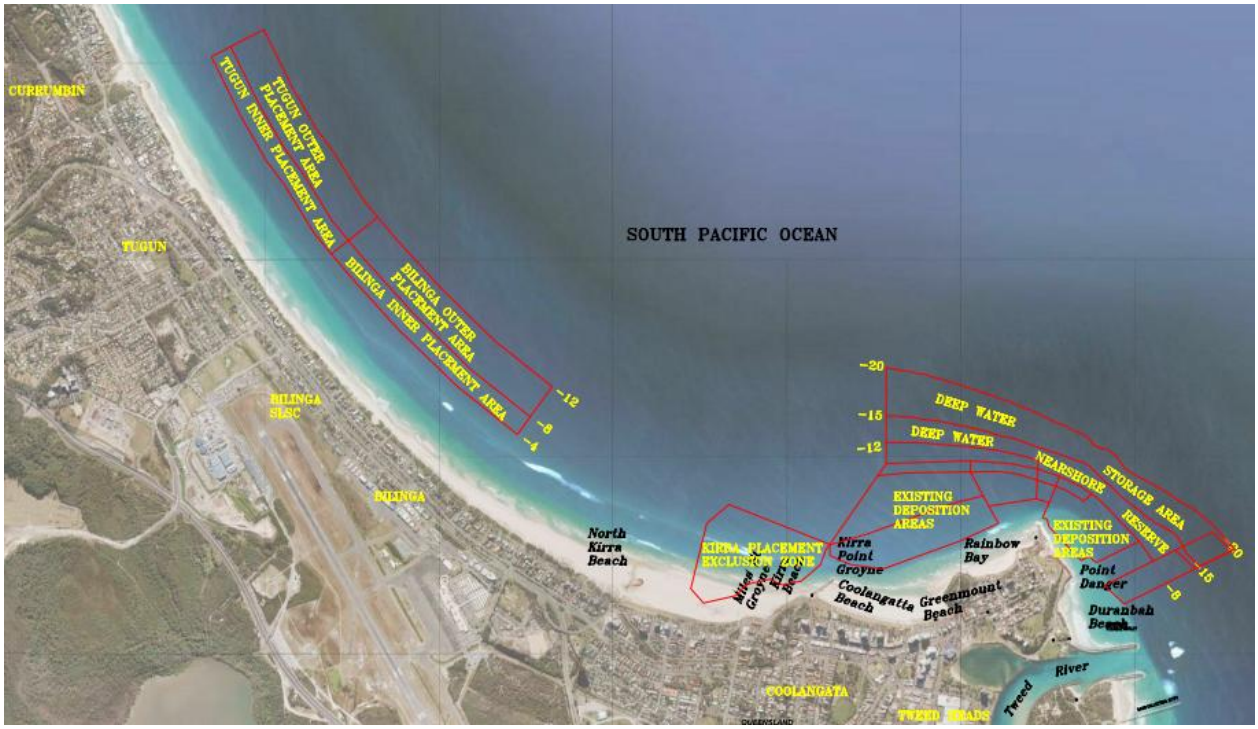
Figure 3 North Kirra Outlet



3.2 Option 2 - Additional Dredged Placement Areas

Option 2 entails the development of additional nearshore placement areas along the southern Gold Coast beaches for deposition of the sand dredged from the entrance to the Tweed River as indicated in Figure 4 below. The placement areas investigated consist of nearshore areas seaward of Bilinga and Tugun in water depths of around 7 – 12 metres and deeper storage reserves seaward of the existing dredge deposition boxes from Point Danger to Coolangatta Beach out to the – 20 m AHD contour. The sand placement scenarios associated with Option 2 have been developed based on the dredging and disposal of an average of 200,000 m^3 per dredging campaign.

Figure 4 Additional Dredged Placement Areas



3.3 Option 3 - Kingscliff Sand Delivery

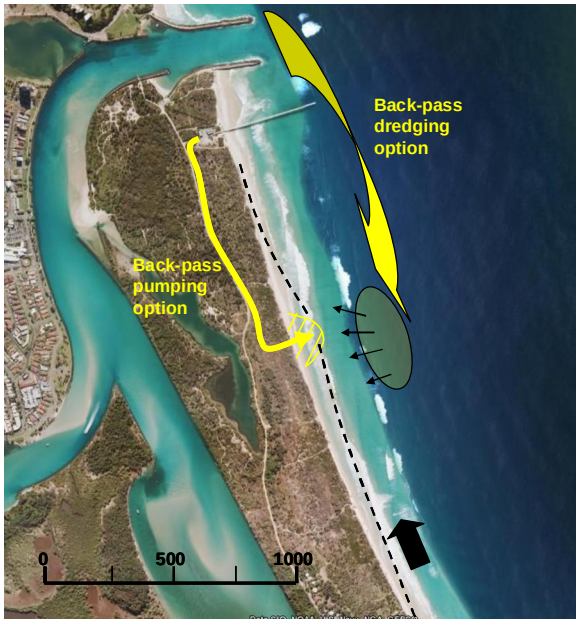
Option 3 involves consideration of the Tweed River entrance as a one-off source of sand for beach nourishment works proposed by Tweed Shire Council at Kingscliff as indicated in Figure 5 below. In each of the three sand placement scenarios, sandy material would be dredged from the Tweed River entrance by a TSHD and transported approximately 10 km south to Kingscliff. The sand placement scenarios associated with Option 3 have been developed based on the dredging and disposal of a required nourishment volume of approximately 200,000 m^3. The placement methods investigated include: - bottom dumping; rainbowing; and, pumping material onshore.

Figure 5 Kingscliff Sand Delivery

3.4 Option 4 - Sand Back-Passing

Option 4 involves the development of a dredging and/or pumping regime to allow extraction of sand at, or before, the Tweed River Entrance and delivery of the sand back into the longshore sand transport system along Letitia Spit south of the jetty as indicated in Figure 6 below. Two options have been investigated, the first of which involves pumping directly from the jetty system onto Letitia Spit south of the jetty and into the littoral zone of longshore transport. The second requires redirecting some of the sand extracted from the Tweed River Entrance by existing entrance dredging operations and transporting it 1.3 km south to a nearshore deposition area outside the surfzone from which it would migrate shoreward into the longshore transport zone.

Figure 6 Sand Back-Passing (Source: BMT WBM "Tweed River Entrance Sand Bypassing Sand Back Passing Feasibility Assessment Sept 2010)



4. Coastline Response to TRESBP

Since the commencement of full-scale sand bypassing operations in May 2001, numerous investigations and regular beach surveys have been undertaken to determine the responses of southern Gold Coast beaches.

Along with the survey data collected by the TRESBP, the results of previous investigations have been reviewed and the beach responses since commencement of TRESBP operations summarised below.

4.1 Early years of TRESBP Operations 2000 - 2005

Due to the depleted condition of the southern Gold Coast beaches at the time of commencement of bypass operations in 2001, sand was initially pumped to Duranbah Beach, Snapper Rocks and Kirra Point during the first three years of bypassing operations. An average rate of approximately 700,000 m^3/year of sand was pumped from 2001 to 2003, significantly in excess of the natural long term average transport rate, estimated to be approximately 550,000 m^3/year (BMT-WBM, 2010). This initial oversupply of sand was required to replenish the eroded southern Gold Coast beaches, which had not received a full natural sand supply since the extension of the Tweed River entrance breakwaters in the early 1960s (Dyson, 2001). The significant increase in sand supply led to the rapid growth of beach widths from Snapper Rocks to Kirra (Castelle, 2009). Sand reserves within the nearshore area also dramatically increased during this period on account of the Tweed River entrance dredging operations. Material that had accumulated in the river entrance prior to commencement of the sand bypass operations was removed to establish a clear navigation channel and transported to nearshore reserves along the southern Gold Coast beaches at a rate of almost 300,000 m^3/year (TRESBP, 2010).

Sand delivery rates remained high during 2004 and 2005. An average of approximately 610,000 m^3/year was pumped via the bypass system, and on average an additional 180,000m^3/year was dredged from the Tweed River entrance (TRESBP, 2010).

The refraction of the prevailing south-east wave energy around Point Danger into Rainbow Bay provided for reasonably consistent northward sediment transport from the Snapper Rocks TRESBP outlets in the form of episodic sand slugs (Hyder et al., 1997). Transported sand then accumulated within the less active shadow zone of the southern Gold Coast beaches, requiring significant wave energy from the north-east to be transported northwards to Bilinga and Tugun.

The delivery of large quantities of sand during the early years of bypass operations, combined with a period of unusually calm north-easterly wave conditions, contributed to the accumulation of excess sand volumes on southern Gold Coast beaches. Volume analysis of beach profiles (Strauss et al., 2009) tracked the slow northerly progress of the accumulating sand which initially peaked at Rainbow Bay in September 2002, shortly after commencement of sand bypassing operations. Beach volumes then peaked at Coolangatta in March 2004 and at Kirra in July 2006 as the sand mass dispersed northward.

Excess sand quantities were of particular concern at Kirra, where the offshore reef was significantly impacted by increased sand levels, raising ecological issues and limiting the recreation potential of the reef for SCUBA diving and fishing (Castelle et al., 2006, Lazarow, 2007). In addition, the once world class surf break to the west of Kirra Point groyne suffered as the previously well aligned sandbanks were buried by excess sand and as a result became poorly aligned to the predominant swells (Lazarow, 2007).

4.2 Recent Beach Responses 2006 - 2010

Following the reduction of sand pumping rates in 2006 to more closely match the natural rate of net littoral drift and the placement of dredged material in deeper offshore areas at Duranbah, the initial sand supply has dispersed northwards under the influence of the predominant wave, wind and current conditions, leading to a gradual decrease in sand volumes and beach widths from Snapper Rocks to Kirra (Castelle et al., 2009).

Recent surveys have revealed that significant quantities of sand have now dispersed from the upper beach profile and the nearshore zone and beach bar in the area between Kirra Point Groyne and the Miles St Groyne. In addition to the natural loss of sand to northward transport, a further reduction of around 20 m in beach width was achieved as a result of beach scraping works undertaken by GCCC on behalf of DERM (QLD) in July 2009 (TRESBP 2010). The overall reduction in beach width has been in excess of 100 m over the last two years.

During the early years of bypass operations, the areas down-drift from North Kirra experienced little change as a result of sand pumping operations. Recently however, the initial sand supply has been transported beyond Kirra and is spreading out along the stretch of beach between North Kirra Surf Club and the Bilinga Surf Club (TRESBP 2010).

The area from Snapper Rocks to Coolangatta Beach has also seen a significant decrease in beach widths and volume since the reduction of sand pumping rates in 2006 and placement of dredged sand in deeper nearshore areas in 2008. The majority of this material was lost from the Rainbow Bay / Coolangatta area, where both beaches have experienced significant shoreline retreat in recent years. Partly as a result of the reduced sand supply, Snapper Rocks experienced severe erosion during a severe storm in May 2009. Concerns were raised as to whether surfing conditions would improve in time for the Association of Surfing Professionals (ASP) world championship tour event scheduled for February 2010. Although surfing conditions improved prior to the contest, the erosion event served as a reminder of the highly variable nature of the study area.

Shoreline retreat at Duranbah Beach has been less than that predicted in the Stage 2 EIS/IAS (Hyder et al., 1997). However, the Beach has shown an increased potential for erosion since the already restricted natural sand supply around the training walls was interrupted by the commencement of sand bypassing operations in conjunction with regular dredging of the Tweed River entrance shoals. Initial pumping operations led to the accumulation of shallow mounds within the nearshore area along the northern side of the northern entrance training wall. In recent years the sand placed on Duranbah Beach has been reworked using land based plant and equipment to more evenly distribute the sand supply along the length of the beach.

As was predicted in the Stage 2 EIS/IAS (Hyder et al., 1997), the shoreline along Letitia Spit has undergone significant realignment since the bypass operations commenced removal of downdrift sand which had accumulated at the southern training wall of the Tweed River entrance. The most extensive recession has been recorded in the area immediately surrounding the TRESBP jetty where the shoreline has receded by around 120 m since pumping began in 2001 (BMT-WBM, 2010). Although shoreline recession was predicted, the high rate of sand removal during the early years of the project combined with a number of storms led to rapid recession of the shoreline and loss of vegetation as the beach system retreated part way between pre-pumping conditions and conditions observed prior to the extension of the Tweed River entrance training walls. Following the reduction of pumping rates in 2006, Letitia Spit has begun to stabilise and a revised shoreline has begun to rebuild in the area up to one kilometre south of the TRESBP jetty.

5. Benchmark Coastline Conditions

Following a review of recent investigations and survey data, the current benchmark coastal conditions of each of the southern Gold Coast beaches have been summarised and described in Sections 5.1 to 5.5.

For the purposes of assessing the relative benefits of each option, the coastal conditions of each of the southern Gold Coast beaches has been benchmarked against the current coastal conditions with respect to a range of physical, social and environmental criterion.

5.1 Letitia Spit

As noted in Section 4.2, the erosion of Letitia Spit since commencement of bypass operations in 2001 was expected as the beach adjusted to the removal of a portion of the sand which had accumulated on the southern side of the Tweed River entrance training walls for the development of a sand trap at the jetty. The reduction of sand pumping volumes in recent years has seen the shoreline position along Letitia Spit begin to stabilise and rebuild. Recent surveys show that the general shoreline alignment has begun to stabilise approximately 90 m landward of the 2000 pre-TRESBP position in the vicinity of the pumping jetty. Sand volumes in the area have recovered by more than 30% of the initial losses observed since 2000 (LPMA 2010). However, the majority of the rebuilding has occurred in the nearshore zone.

5.2 Duranbah Beach

Due to the exposed nature of Duranbah Beach, particularly since the removal of Tweed River entrance sand shoals, the condition of the beach remains highly variable and heavily influenced by swell conditions. Similarly, surfing and swimming conditions at Duranbah Beach are heavily influenced by the wave climate and as a result vary from day to day. At the time of writing this report, sand was being pumped onto Duranbah Beach to replenish the beachfront which had been severely eroded by storms in May 2009 and again in early 2010. During a site visit in May 2010, the northern portion of the Duranbah Beach carpark and footpath was closed due to undermining of the roadway as a result of the storms in May 2009 and early 2010.

Duranbah Beach remains characterised by periods of erosion during inclement swell conditions followed by accretion on account of sand placed via the TRESBP system. As a result of restricted sand supply from the south and the cycle of erosion and controlled accretion, the current condition of Duranbah Beach is heavily influenced by TRESBP operations.

5.3 Rainbow Bay

The reduced sand quantities delivered by the TRESBP system in recent years have led to a significant reduction in sand volumes and beach widths within Rainbow Bay, particularly since 2009. Following the May 2009 storm event, sand volumes and beach widths returned to conditions not seen since the commencement of bypass operations in 2001. The May 2009 storm event also demonstrated that Rainbow Bay is presently vulnerable to erosion during storm conditions. TRESBP surveys of the beach profile following the storm event revealed that between February and May 2009 approximately 70,000 m^3 of sand was lost from the Snapper Rocks area, resulting in adverse surfing conditions. In order to restore the eroded beach profile, sand was pumped via the eastern and western TRESBP outlets at

Snapper Rocks in late 2009. This depleted beach condition has been viewed favourably by the local swimming community due to the separation of swimming areas from surfing areas.

Despite localised efforts to return sand to Snapper Rocks, the current volume of sand within Rainbow Bay remains at low levels similar to those recorded prior to commencement of bypass operations in 2001.

5.4 Greenmount / Coolangatta Beach

Efforts to reduce excess sand quantities within Coolangatta Bay have been successful in recent years with significant reductions recorded in beach volume and shoreline width. To date, much of the sand loss has been from the nearshore zone in water depths of 2 – 10 metres, however the upper beach profile is now also adjusting (TRESBP, 2010). Significant shoreline retreat in excess of 100m has occurred along the eastern section of Greenmount Beach to reduce beach width over the last two years to a width that is more consistent with pre-pumping conditions. Surfing conditions remain reasonable at Greenmount, however ride lengths have been reduced due to the erosion of the sandbank linking the surfing breaks at Greenmount and Rainbow Bay known as the Superbank. Swimming conditions have improved with the reduction of beach widths and separation of surfing and swimming areas. Following storms in May 2009 and early 2010, current conditions within Coolangatta Bay have almost returned to those experienced prior to commencement of sand bypass operations in 2001.

5.5 Kirra Beach

Recent efforts to reduce excessive sand quantities at Kirra have also begun to show significant progress, particularly in the area between Kirra Point groyne and the Miles Street groyne. Following the May 2009 storm event, sections of rocky foreshore were uncovered that had not been seen since the commencement of sand bypassing operations in 2001. A survey conducted in October 2009 showed that sand volumes have continued to decrease as sand progresses northwards. This reduction in sand volumes has seen a progressive uncovering of Kirra Reef, which is expected to continue as sand continues to disperse. The dispersal of sand has also seen improvements to surfing conditions associated with the deepening of nearshore areas to the west of Kirra groyne.

Similarly, TRESBP surveys in late 2009 revealed that Central Kirra has lost significant quantities of material, primarily from the nearshore zone. Results of the October 2009 survey reveal significant seaward cross-shore transport has been occurring as the beach profile adjusts to the recent sand loss from within the nearshore zone.

North Kirra Beach remains significantly wider than could be expected naturally due to the movement of the initial sand supply through Kirra. Recent surveys have shown that North Kirra has also begun to erode, however the reductions in volume and beach width are far less than the changes experienced between Kirra Point and the Miles Street groyne. The beach width at North Kirra is expected to continue to decrease as the initial sand mass continues to disperse northwards along the stretch of beach between North Kirra Surf Club and the Tugun Surf Club. The dispersal of this sand will greatly benefit the down-drift areas to the north of Kirra, which have remained in a depleted condition since the extension of the Tweed River entrance training walls in the early 1960s.

6. Predicted Impacts on Benchmark Conditions

It should be noted that the beach responses described in Sections 6.1 to 6.4 are based on the assumption that the TRESBP system will continue to receive and deliver sand at a rate close to the long-term net littoral drift, which has been estimated to be approximately 550,000 m^3/year. In reality, the conditions of the southern Gold Coast beaches will be heavily influenced by the highly variable natural sediment transport rate within the study area, which has been estimated to vary between 350,000 m^3/year and 750,000 m^3/year since 2000 (LPMA 2010). In addition, the episodic nature of sediment transport northwards around Point Danger contributes to the short term variations in southern Gold Coast beach conditions. Consequently the beach responses described below should be viewed as long-term trends expected to occur over the next 10 years. During this time there are likely be significant variations in beach conditions due to the highly variable nature of sand transport conditions within the study area.

Provided below is a summary of the predicted impacts relating to each of the four proposed options. Further details and discussion of these impacts are provided in the Feasibility Reports (GHD 2011, BMT-WBM 2010).

6.1 Option 1 – North Kirra Outlet

The construction of an additional outlet at North Kirra offers potential for decreasing sand accumulation at Kirra by reducing the sand supply to Coolangatta Bay. This could be expected to accelerate the dispersal of the sand build up at Kirra/Central Kirra and potentially promote improved beach amenity, surfing conditions, and reef health at Kirra. However, the implementation of this option is likely to take in the order of two to three years, by which time the impact of an additional northern outlet on the sand build up at Central Kirra is likely to have diminished given the current trending in sand dispersal from Kirra/Central Kirra Beach.

An additional outlet would result in the beaches of Bilinga and Tugun receiving increased sand volumes, leading to a rapid response in the nearshore beach profile and shoreline as the placed material is reworked northward via the affects of the prevailing wind, waves and currents.

However, it is important to note that depending on the selected placement method, location, timing and volume of sand pumping, the addition of sand through a North Kirra outlet could potentially slow the current sand dispersal process because it is sited in the area where the existing sand build up is most pronounced, and hence could delay the transition to 'normal' beach widths in the Central Kirra area. In addition, a new outlet may also cause a local realignment of the beach south (east) to Kirra, to the detriment of Kirra surf quality and Kirra Reef.

Routine use of a North Kirra outlet would reduce the available sand supply into Coolangatta Bay over the long term. This reduction in sand supply could potentially lead to the following impacts within Coolangatta Bay:

- narrow beaches and reduced surfing shoals that have been depleted of their sand supply;
- increased susceptibility to storm erosion; and
- reduced general amenity.

6.2 Option 2 – Additional Dredged Sand Placement Areas

6.2.1 Option 2A - Bilinga to Tugun Nearshore Areas

It is expected that the beach response will be more gradual than that associated with pumping of material directly into the active beach zone via pipelines. While the impacts to nearshore areas in the immediate vicinity of the deposition areas would be almost immediate, changes in the beach profile and shoreline would occur gradually as the placed material is reworked onshore under the influence of the predominant wave, wind and current conditions.

Given the greater exposure of Bilinga and Tugun to the predominant south east swells and resulting high rate of sediment transport (Delft, 1992), it is expected that the placed material will disperse from the placement areas more rapidly than previous nourishment campaigns at Kirra and Greenmount. The lack of obstructions to sediment transport along this stretch of beach (such as groynes and headlands) is expected to result in an even spreading of placed material along this stretch of coast, leading to a uniform seaward movement of the current shoreline position. It is important to note that these responses will be heavily influenced by the position of the current sand build up at the time of placement operations.

The removal of material from the Tweed River Entrance and placement adjacent to the stretch of beach from Bilinga to Tugun, would reduce the quantity of sediment transported through the beach systems from Duranbah to North Kirra. Beach responses to this approach would vary depending on the current condition of each beach.

Duranbah and Rainbow Bay (particularly Snapper Rocks) are currently in a depleted condition and at the time of GHD's Feasibility Report, were undergoing nourishment via the TRESBP system. The removal of material from the Tweed River Entrance and downdrift sand placement at Bilinga and Tugun would further reduce the littoral supply of sediment to Duranbah Beach and Rainbow Bay. As a result these beaches would continue to erode and require ongoing nourishment via the TRESBP system.

Beaches such as Coolangatta and Kirra, which have experienced a surplus of sand, would experience shoreline recession and decreases in beach volume as the littoral sand supply is reduced. The reduction of sand volumes in the offshore areas adjacent to Kirra/Central Kirra could be expected to result in increased exposure of Kirra Reef and provide significant benefits to reef health. However, the sand build up is likely to have substantially dispersed at Kirra during the lead time required to secure approvals and project agreements and realise an impact on the sand drift passing through Kirra. The provision of Bilinga to Tugun nearshore areas for future dredge placement would promote dispersal of possible sand build up further to the north over coming years, particularly at North Kirra.

6.2.2 Option 2B - Project Area Extended 'Deep Water' Placement Areas

The method of placing dredged sand in deeper water depths of 10m to 20m depth has been utilised in a previous dredging campaign off Duranbah Beach. The purpose of such placement is to delay the onshore movement of the placed sand if deemed operationally advantageous to do so. This approach provides the ability to gradually incorporate dredged sand into the alongshore sand drift, ie spreading over time to better match natural sand supply conditions.

Sand that is placed in deeper water can be considered to remain within the "active sediment system" and will over time move onshore. Such sand is primarily mobilised by large swell events and will otherwise remain undisturbed as an outer nearshore sand reserve.

In general terms, the placement of dredged material in deeper nearshore areas, would see beaches such as Kirra/Central Kirra, which have experienced a surplus of sand, experience shoreline recession and decreases in beach volume as the littoral sand supply is reduced, allowing dispersal of the existing sand build up, particularly at Central Kirra and North Kirra. The reduction of sand volumes from offshore areas adjacent to Kirra/Central Kirra could be expected to result in increased exposure of Kirra Reef and provide significant benefits to reef health.

It is also important to note that reduced rates of littoral sand supply to Duranbah Beach, Rainbow Bay and Coolangatta Beach would need to be managed to avoid erosion of these beaches.

Beach responses would also be driven by changes in wave propagation due to the localised areas of reduced depth within the placement areas. This could potentially create a lens effect, which would lead to superposition of wave sets and focusing of wave energy onto areas of the southern gold coast beaches. Depending on the water depth in which the material is deposited, and the time required for the placed sand to dissipate, longer term impacts associated with variations in wave energy could include localised areas of erosion and accretion along the southern gold coast beaches. The specific areas of erosion and accretion would be primarily driven by the quantity of material deposited within each placement area and the method of placement.

It is important to note that there is a substantial outer nearshore area in water depths of -12 to -20m AHD seawards of the existing placement areas to spread the dredged sand as a relatively thin layer (up to approximately 0.3m thick). It is unlikely that placement in this manner would have a significant impact on wave propagation in these water depths if spread uniformly and implemented on an infrequent basis.

6.3 Option 3 – Kingscliff Sand Delivery

While the beach response at Kingscliff will vary depending on the method of placement, the response of the southern Gold Coast beaches to each of the three scenarios associated with Option 3 will essentially be the same.

Feasible methods of placing sand at Kingscliff Beach are likely to involve a large floating dredge (for operational efficiency and costing reasons) with more than three times the sand holding capacity of the dredge used routinely in Tweed River entrance dredging campaigns. Depending on the capabilities of the available dredging equipment at the time of construction, separate entrance maintenance dredging by smaller dredging plant may also be required in order to dredge some of the shallower parts of the entrance bar which may not be accessible by a larger dredge. Assuming this is the case, it would be necessary to source sand from the deeper parts of the Tweed entrance, which would be likely to have only an indirect influence on the natural sand drift to Queensland and on southern Gold Coast beaches.

Sand would be gradually reworked into the deeper parts of the entrance area that had been dredged. It is expected that it would take a significant number of years for the rebuilding of the dredged area during which time the natural bypassing of sand across the entrance would be reduced somewhat. Duranbah would likely experience gradual minor sand loss from nearshore shoals requiring some additional sand delivery to compensate. However, this additional delivery is likely to be available from within the existing project provisions for delivery of sand to Duranbah. The impact on the natural bypassing of sand across the border into Queensland would likely be minor but would need to be managed to maintain natural supply conditions to southern Gold Coast beaches over the longer term.

If however a larger hopper dredge was able to access and dredge the shallower parts of the Tweed entrance, the impacts on the southern Gold Coast beaches would be more pronounced. Specifically,

beaches that are currently in a depleted condition, such as Duranbah and Rainbow Bay (Snapper Rocks) would experience further sand loss from nearshore shoals, thereby reducing the storm buffer of these beaches and making them more vulnerable to erosion. On the other hand, beaches that have retained excess sand volumes in recent years, such as Kirra and Coolangatta, would be expected to decrease in width and volume in response to reduced sand feed from nearshore areas to the south as the existing sand surplus dissipates under the effect of prevailing winds, waves and currents.

The response of the proposed beach nourishment location at Kingscliff is expected to be increased beach width, seaward migration of the current shoreline position and the development of a flatter, more linear beach slope as the beach profile adjusts to the nourishment campaign. While the long-term beach response will be relatively similar for each sand placement scenario associated with Option 3, the short-term beach response will be heavily influenced by the method of placement.

6.4 Option 4 – Sand Back-passing

The investigations carried out by BMT-WBM revealed that the effects of back-passing operations on the Letitia Beach shoreline could be expected to be similar to those associated with a beach nourishment exercise since the discharge location represents an input to the local sand budget. Consequently, the beach could be expected to widen both updrift and downdrift of the discharge location.

Specifically, the Back-Passing Feasibility Report prepared by BMT-WBM predicted the following impacts:

- "The option to back-pass via pumping from the jetty system through a land-based pipeline would have immediate effect in widening the beach berm while having somewhat delayed effect in widening the nearshore profile at depth and in building the upper beach and dune. The back-passed sand would extend initially along a modest length of beach, subject to wave conditions, and thus would provide a 'groyne' effect in trapping the updrift supply and widening the beach there." (BMT-WBM, 2010)
- "The option to place the sand via a bottom-dump dredger would result in a mound of sand at the outer profile in depths of around 6-8m, spread over a wider area than for the pipeline pumping. The sand would both migrate shoreward and alter local wave propagation and lead to a more 'diffused' widening of the beach over time. As such, it represents an effective back-passing option. The key difference from the pipeline option is that its effects on the visible beach are less direct and building of the upper beach and dune would take a significant time." (BMT-WBM, 2010)

Whilst the impacts on the beaches from Snapper Rocks to Kirra would depend on the rate of sand backpassed to Letitia Spit, it is anticipated that back passing would generally provide enhanced flexibility in controlling rates of littoral sand supply such that quantity of sand build up at Central Kirra could be reduced while maintaining acceptable conditions at Snapper Rocks through to Coolangatta Beach.

It is envisaged that back passing would have little impact on beach conditions at Duranbah since the current approach to management of beach widths at Duranbah could be undertaken in conjunction with backapssing operations.

7. Feasibility Terms

As requested by TRESBP, the feasibility of each of the four options has been considered with respect to the following key assessment criteria:

- Kirra Reef Impacts;
- Kirra Surf Quality;
- Kirra Beach Width;
- Operations Improvement;
- Consistency with TRESBP Legislation;
- Necessary Approvals;
- Approvals Timing;
- Timing for Installation;
- Timeframe for Benefit to Materialise;
- Cost (Investigation, Design, Construct);
- Cost (Operational);
- Impacts on Benchmark Conditions; and,
- Adverse Impacts or Risks.

8. Assessment of Feasibility Terms

In recent years, the jetty operations have been progressively modified to capture and pump sand quantities consistent with natural supply. Dredge placements in outer nearshore reserve placement areas have been trialled and were successful in reducing the sand drift into Coolangatta Bay to promote dispersal of the sand build up at Kirra. Survey results indicate that sand build up from the initial years of operations is dispersing naturally and sand volumes in Coolangatta Bay are approaching pre-pumping conditions under the current sand delivery strategies. However, there is still a significant build up of sand in the Central/North Kirra Beach areas.

It is noted that the project's EIS (Hyder et al, 1997) stated that substantial variability of beach widths and surfing conditions will always be an inherent natural feature of these beaches. The EIS advised that sand delivery programs should not be reactive in response to short term variations in the beach systems but rather planned in the context of the longer term operation of the system to best match natural sand supply to the southern Gold Coast beaches.

Summaries of the assessments of each Option against the relevant feasibility terms have been provided below in Sections 8.1 to 8.4 and further summarised within Table 2. Comprehensive assessments of each of the four options are provided in the Feasibility Reports (GHD 2011, BMT-WBM 2010).

8.1 Option 1 – North Kirra Outlet

The construction of an additional outlet at North Kirra physically offers potential for reducing sand drift volumes passing through Kirra by reducing the sand supply to Coolangatta Bay. This could assist in the dispersal of the sand build up at Kirra/Central Kirra and promote improved beach amenity, surfing conditions, and reef health at Kirra. A North Kirra outlet could also provide an operational enhancement that provides some flexibility to better respond to potential sand build up in the future.

However, when undertaking a cost / benefit analysis of a North Kirra outlet, it is important to acknowledge the 'once only' nature of the prolonged and now dispersing sand build up that was due to the additional sand supply to Coolangatta Bay delivered during the initial years of operation of the TRESBP to restore the badly eroded beaches.

While a reduction in sand volume passing Kirra may appear attractive in light of the impacts of sand build up at Kirra/Central Kirra, the implementation of this option is likely to take in the order of two to three years, by which time the need for an additional northern outlet is likely to have diminished given the current trending in sand dispersal from Kirra. Furthermore, the addition of sand through a North Kirra outlet could potentially slow the current sand dispersal process because it is sited in the area where the existing sand build up is most pronounced and hence could delay the transition to 'normal' beach widths in the Central Kirra area.

Depending on the selected placement method, location, timing and volume of sand pumping to a new North Kirra outlet may also cause a local realignment of the beach south (east) to Kirra, to the detriment of Kirra surfing and Kirra Reef in the future.

Routine use of a North Kirra outlet would reduce the available sand supply into Coolangatta Bay over the long term. However, the project's legislation requires volumes of sand to be delivered to these beaches at "…a rate consistent with the natural littoral drift rates…".

Therefore, an ongoing program of delivering sand at rates less than natural supply will contribute to:

1. narrow beaches and reduced surfing shoals that have been depleted of their sand supply,
2. increased storm erosion hazard, and
3. reduced general amenity.

As a result, a North Kirra outlet does not promote the objectives of the TRESBP for the beaches from Rainbow Bay to Kirra.

The beach pipeline infrastructure necessary to make sand placements would impact severely on both the visual values of Kirra to Bilinga and the usability of the beach in the vicinity of the outlet. As a result local community opposition could be expected to this option.

The approvals required to implement an additional outlet at North Kirra would be the most onerous of the four options due to the requirement for onshore approvals through land of high social value in addition to the approvals required for disposal of dredge material in tidal water as required for the remaining options.

In summary, a North Kirra outlet would be likely to have a direct detrimental impact on the local beach amenity where sand is placed. The use of a North Kirra outlet on a routine basis could also deprive other southern Gold Coast beaches of their requirements for restored sand supply, contrary to the principles that this feasibility study seeks to improve and protect. A North Kirra outlet has one identifiable benefit ie, the ability to directly nourish the beach at North Kirra, Bilinga and Tugun following storm erosion, should that need arise in the longer term. However, this should be evaluated against the beach rebuilding that would occur as part of the natural beach cycle under a restored sand supply which is the objective of the TRESBS operations. Given the significantly high costs associated with this option and the implementation timeframe of several years, it is difficult to recommend this option as a feasible short-term solution, especially in light of the present sand reduction trend due to natural dispersion in Coolangatta Bay.

8.2 Option 2 – Additional Dredged Sand Placement Areas

8.2.1 Option 2A - Bilinga to Tugun Nearshore Areas

The placement of dredged material from the Tweed River entrance in newly defined nearshore sand placement areas in the Bilinga to Tugun area would result in a reduced volume of sand moving through the beaches of Rainbow Bay to Kirra.

Reduction of sand drift into Coolangatta Bay may result in improved beach amenity, surfing conditions and reef health at Kirra. However, it would take some years for the depleted supply condition to impact on the sand build up at Kirra, during which time, the less than natural supply would deplete the beaches and surfing banks from Rainbow Bay to Coolangatta.

While the approval of additional dredge placement areas would improve the flexibility of the sand delivery system, the placement of dredged material in these areas would only be appropriate during periods of excess sand supply to the southern Gold Coast beaches. It is unlikely to be implemented on a routine basis as it does not promote the objectives of the project that aim at ensuring sustainable and ‘natural’ beach amenity by requiring full natural sand supply to all southern Gold Coast beaches.

Whilst the required approvals costs and timeframes must be considered in association with the development of additional dredged sand placement areas, no major impediments are envisaged with respect to approvals.

The southern Gold Coast beaches continue to adjust to the 'natural' volumes of sand being targeted by project operations. The sand build up is likely to have substantially dispersed at Kirra during the lead time required to secure approvals and project agreements and realise an impact on the sand drift passing through Kirra. Consequently the cost required to achieve this option should be compared against the limited benefit these additional areas would provide in addressing the current issues at Kirra and in promoting project objectives in the longer term.

8.2.2 Option 2B - Project Area Extended 'Deep Water' Placement Areas

The method of placing dredged sand in deeper water of 10m to 20m depth has been successfully utilised in a previous dredging campaign off Duranbah Beach. The purpose of such placement is to delay the onshore movement of the placed sand if deemed operationally advantageous to do so. It has the benefit in combination with existing nearshore placement areas of providing some ability to gradually incorporate dredged sand into the alongshore sand drift, ie spreading over time to better match natural sand supply conditions. As the TRESBP operation reaches its intended operational objectives of delivering 'natural' sand quantities to longer term aligned beaches, the use of new deep water placements of dredged sand seawards of the existing placement areas would likely be less frequent.

Sand that is placed in deeper water can be considered to remain within the "active sediment system" and will over time move onshore. Such sand is primarily mobilised in higher swell conditions and will otherwise remain undisturbed as an outer nearshore sand reserve.

Although no dredging has been necessary in the last two years, an extension of deep water sand placement areas would provide the TRESBS with additional placement flexibility at generally low cost, and would be more consistent with the project objective of delivering sand consistent with natural supply conditions if managed carefully, in contrast to the other options. Consequently further consideration is justified.

8.3 Option 3 – Kingscliff Sand Delivery

The Kingscliff sand delivery option is proposed as a 'once only' opportunity to potentially reduce sand inflow into Coolangatta Bay – through avoidance of sand placement in project areas, while assisting Tweed Shire Council with its foreshore works at Kingscliff Beach.

Feasible methods of placing sand at Kingscliff Beach are likely to involve a large floating dredge with more than three times the sand holding capacity of the dredge used routinely in Tweed River entrance dredging campaigns.

The requirement for a large dredge to achieve sand placement onto Kingscliff Beach means that such a dredge may not be able to dredge sand from the shallower waters of the Tweed entrance bar. Sand that is not captured by the jetty will build up in the entrance and impact on navigation conditions in waters shallower than about 5m in depth at lowest tide. Because of the limitations arising from the greater draft requirement and greater safety distance requirement (from mobile shallow shoals and rock training walls), required by the larger vessel, it is likely that sand can only be dredged from further offshore for this option.

Such a dredging campaign would not avoid the need for separate entrance maintenance dredging by smaller plant and associated Gold Coast nourishment and will not offer a direct benefit to the TRESBP operation or southern Gold Coast beaches as anticipated. Nevertheless it is physically feasible for sand to be taken from deeper water near the Tweed River entrance to Kingscliff Beach to assist the proposed beach works.

The sourcing of sand from the Tweed entrance for Kingscliff nourishment work is likely to have an indirect influence on the natural sand drift to Queensland and is therefore likely to require the support of the Queensland Government. Concurrence should be sought early in the planning process for such a dredging operation,

Indicative costs for sand delivery to the upper beach at Kingscliff Beach are relatively high (up to the order of $25/m3), given that sand would have to be pumped ashore from the dredge. These costs should be assessed early in the planning for further consideration of this option as cost effectiveness will be a key factor in determining the feasibility of sourcing sand from the entrance.

8.4 Option 4 – Sand Back-Passing

The BMT-WBM Report concluded that it would be generally feasible to develop sand back-passing operations along Letitia Spit either using the existing TRESBP extraction jetty and installing a new discharge pipeline or through nearshore placement of sand dredged from the Tweed River entrance. Back passing would provide additional flexibility to TRESBP operations with respect to management of sand delivery volumes to the southern Gold Coast beaches. A summary of the key points in regards to the feasibility of back-passing has been provided below.

Back-passing through an onshore discharge pipeline would be likely to provide an immediate response in the shoreline adjacent to the discharge point, and with time, is expected to lead to accretion of Letitia Spit to the north and south of discharge operations. However, this approach would provide limited flexibility with respect to the discharge location as pipelines would be confined to existing easements and pumping capabilities restricted to approximately 1300 m.

Utilisation of the existing river entrance dredging operations for back-passing would provide increased flexibility in that sand could be deposited at any point along Letitia Spit. In addition, no onshore infrastructure would be required, thereby minimising establishment costs and impacts on terrestrial habitat and beach amenity. However it is important to note that disposal activities using a bottom-dump dredger would be restricted to water depths of around 6 – 8 m, meaning that a significant length of time would be required to realise changes in the upper beach profile.

Ideally, a combination of the two approaches would be undertaken in order to provide both flexibility in discharge locations and adequate nourishment within the upper portion of the beach profile.

Back passing provides a mechanism for controlling sand volume delivery to Queensland and operational flexibility to reduce the volume of sand moving through the beaches to Central Kirra by maintaining an appropriate level of sand delivery to the beaches from Rainbow Bay to Kirra and reducing sand delivery to Queensland during high natural supply conditions to promote dispersal of sand from Central Kirra. Given the relative shorter lead time for implementation of this option, back passing would provide a benefit through an enhanced operational capability to respond to the current sand build up at Central Kirra.

The natural sand supply conditions along Letitia Spit are highly variable and the capture and delivery of this sand by jetty pumping or dredge is not always consistent with the transport conditions along the southern Gold Coast beaches. Back passing provides a means of catering for the natural variability of sand supply and any imbalance or irregularity in sand drift along the southern Gold Coast beaches by

controlling the quantities of sand delivered to Queensland. The increased flexibility in sand delivery offers long term operational benefits in terms of promoting the project objectives of matching delivery to natural sand supply conditions along the southern Gold Coast beaches.

Although additional investigations are required, preliminary indications suggest that no major impediments would be encountered with respect to approvals and legislation.

The primary risk identified by BMT-WBM is that the back-passing operations are not effective in increasing beach widths and providing additional flexibility to TRESBP operations. While there are uncertainties in the modelling of the back passing operations, BMT-WBM's investigations have indicated that this is not a significant feasibility risk but nevertheless recommend that the implementation of this option be approached on a trial basis. Also identified is the risk that back-passing trials may not be conducted for a sufficient length of time to enable informed decisions to be made regarding performance.

The cost assessment undertaken by BMT-WBM revealed that the incremental back-passing cost over 15 years would be approximately $2.5 – 3.0 million. The report noted that when considered in the context of alternative operations, the cost implications associated with back-passing are relatively minor compared to the potential benefits.

9. Summary of Costs

Estimates of the probable costs associated with the development, construction, operation and maintenance of the four options specified by TRESBP have been prepared by GHD and BMT-WBM.

In order to provide comparable estimates of the likely costs required to implement each option, a simplified costing summary table has been provided in Table 1. Project costs have been summarised as establishment and operational costs.

Further details and discussion of the cost implications of each of the proposed sand placement options are provided in the Feasibility Reports (GHD 2011, BMT-WBM 2010).

The preliminary estimates of probable cost presented in the Feasibility Reports have been developed for the purposes of comparing options and may be used for evaluation of options. They are not to be used for any other purpose. The scope and quality of the works has not been fully defined and therefore the estimates are not warranted by GHD. These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. In the case of Option 4, costs have been estimated by BMT-WBM and summarised by GHD. A more detailed functional design is recommended to provide more accurate costs estimates prior to the implementation of these options.

Table 1 Cost Summary

Option Description	Establishment Costs	Additional Operational Costs
Option 1 - Additional North Kirra Outlet		
Scenario 1A-1C – 1200m Pumping Distance	$4.6M to $6.00M	$0.50 / m^3 ($150,000.00 pa)*
Scenario 1D – 2400m Pumping Distance	$7.6M	$1.00 / m^3 ($250,000.00 pa)*
Option 2 - Additional Dredge Placement Areas		
Scenario 2A – Bilinga & Tugun Placement	$100,000.00	$1.05M to $1.5M per campaign
Scenario 2B – Deep Water Placement	$100,000.00	Minimal Increase (<$100,000.00/campaign)
Option 3 – Sand Delivery to Kingscliff		
Scenario 3A – Bottom Dumping	$100,000.00	$2,500,000.00 per campaign
Scenario 3B - Rainbowing	$100,000.00	$3,200,000.00 per campaign
Scenario 3C – Pumping Ashore	$100,000.00	$5,100,000.00 per campaign
Option 4 – Sand Back-Passing		
Scenario 4A	$1,000,000.00	$125,000.00 ($2.85M over 15 years)
Scenario 4B	$1,000,000.00	$110,000.00 ($2.63M over 15 years)

* Based on data from similar bypass projects such as the Nerang Bypass System

10. Feasibility Summary

Table 2 has been prepared by GHD in consultation with TRESBP in order to present the key findings of the Feasibility Studies completed by GHD and WBM-BMT as summarised within Sections 8.1 to 8.4.

Table 2 Feasibility Summary

TWEED RIVER ENTRANCE SAND BYPASSING PROJECT - OPTIONS FEASIBILITY ASSESSMENT – FEBRUARY 2011

Assessment Key:	Unfavourable	Neutral/Caution	Favourable

		OPTIONS				
ASSESSMENT CRITERIA		NORTH KIRRA OUTLET	EXTENDED DREDGE PLACEMENT AREAS: Bilinga – Tugun Nearshore Area	EXTENDED DREDGE PLACEMENT AREAS: Project Area - Deep Water Extension	KINGSCLIFF BEACH SAND DELIVERY	BACK PASSING SAND TO SOUTH OF THE JETTY
1	Impact on: Kirra Reef Kirra Surf Quality Kirra Beach Width	**MINIMAL DIRECT BENEFIT** **Unlikely a North Kirra Outlet can be installed and have an impact before sand build-up has effectively dispersed from Kirra. Discharge pipework would have significant impact on Central/North Kirra beach amenity. Potential to cause detrimental re-alignment of Kirra Beach, and delay dispersal of sand build-up from Kirra.**	**MINIMAL DIRECT BENEFIT** **Provides improved longer term control in matching natural sand movements, however it is unlikely any benefit can be achieved prior to natural dispersion of sand build up from Kirra.**	**LONGER TERM BENEFIT** **Addition of deep-water placement opportunities provides improved longer term control in matching natural sand movements and in beach nearshore profiling.**	**NO DIRECT BENEFIT** **Requires large dredge restricted to dredging deeper parts of entrance. This would not avoid the need to dredge from shallower waters to maintain an entrance navigation channel. Sand taken from outer entrance bar in 'once only' operation has no significant direct impact at Kirra Beach, or southern Gold Coast beaches.**	**BENEFIT** **Back passing expected to improve sand delivery volume management and 'natural' sand supply to southern Gold Coast beaches.**
	Kingscliff Beach	**N/A**	**N/A**	**N/A**	**High cost of direct sand placement to upper Kingscliff Beach is a major feasibility issue. Operation is physically possible and would achieve the desired extent of beach nourishment at Kingscliff.**	**N/A**
2	Impact on Existing Benchmark Conditions	**Letitia Beach: Nil Impact** **Duranbah Beach: Nil Impact** **Provides unnatural depleted sand supply to Rainbow Bay, Coolangatta & Kirra beaches. Causes beach retreat and reduced storm resilience.**	**Letitia Beach: Nil Impact** **Duranbah Beach: Nil Impact** **Provides unnatural depleted sand supply to Rainbow Bay, Coolangatta & Kirra beaches. Causes beach retreat and reduced storm resilience.**	**Letitia Beach: Nil Impact** **Duranbah Beach: Nil Impact** **Rainbow Bay to Kirra: Improved nearshore profiling and 'natural' sand supply.**	**Nil**	**Letitia Beach: Improved capability for beach rebuilding, as required.** **Duranbah Beach: Nil Impact** **Rainbow Bay to North Kirra: Improved beach profile. Enhanced capability for delivering 'natural' sand supply to these beaches.**
3	Long Term Improvement to Operations	**MINIMAL BENEFITS** **Impacts as above plus increased energy usage.**	**MINIMAL BENEFITS** **Impacts as above plus increase in energy usage**	**YES** **Improved volume control and beach profiling.**	**MINIMAL BENEFITS** **Insignificant impact on TRESBP operations.**	**YES** **Significant operational enhancement in meeting project objectives.**
4	Consistent with Project Objectives	**NO** **Does not restore natural sand supply to Coolangatta Bay.**	**NO** **Does not restore natural sand supply to Coolangatta Bay.**	**YES**	**Has minor indirect impact on the natural sand flow to Queensland and Tweed River entrance navigability.**	**YES**
5	Time for Approvals	**2 Years ***	**1 Year***	**1 Year***	**1 Year**	**6 Months***
6	Time for Installation	**3 Years ***	**Possibly 2-3 years depending on need for dredging***	**Possibly 2-3 years depending on need for dredging***	**1 Year***	**6 Months***
7	Time until Benefit	**At least 4 years for impact at Kirra* Excess sand likely to have dispersed**	**No immediate impact at Kirra Excess sand likely to have dispersed**	**No immediate impact at Kirra though flexibility improved immediately**	**Immediate at Kingcliff**	**Immediate at start of operation**
8	Additional Set-up Cost	**$4.6M to $7.6M**	**$100,000**	**$100,000**	**$100,000**	**$1M**
9	Additional Operations Cost	**$125,000 to $250,000 pa**	**$1.05M to $1.5M per dredge campaign**	**$100,000 per Dredge campaign**	**$2.5M to $5.1M (nil TRESBP)**	**$110,000 to $125,000 pa**
10	Adverse Impacts or Risks	**Rainbow Bay-Coolangatta beaches, Kirra Beach environment. Plus additional energy usage.**	**Rainbow Bay-Coolangatta beaches, Kirra Beach environment. Plus additional energy usage.**	**Slightly increased energy usage. Requires careful management to achieve benefits**	**Nil**	**Slightly increased energy usage.**

**** Months/Years following decision to proceed.***

11. Conclusion

The establishment of new project operations needs to be considered in terms of their location and frequency of use. Long-term use of the options outlined within this report would impact on the southern Gold Coast beaches by altering the current rates of sand delivery. However, numerous related issues must also be considered in order to achieve balanced economic, social and environmental outcomes.

Specifically, a North Kirra outlet would have a direct detrimental impact on the local beach amenity where the sand delivery outlet infrastructure is located. The use of a north Kirra outlet on a routine basis could also seriously starve the southern-most Gold Coast beaches of their requirements for restored sand supply. Consequently, routine use of this option would not provide a long-term enhancement to the system operations in terms of achieving project objectives that seek to restore and continue a natural sand supply to all the southern Gold Coast beaches. Surf quality at Kirra may be improved by the use of a North Kirra outlet. However, this would be subject to careful planning and placement of sand, as sand pumping to this location may also cause a local realignment of the beach south (east) to Kirra, to the detriment of Kirra surfing and Kirra Reef in the future. Given the significantly high costs and implementation timeframe of several years, this option would not be considered a cost-effective solution to the existing sand build up at Central Kirra when compared to other options, especially in light of the sand reduction that is continuing to occur.

The establishment of additional dredge sand placement areas for project operations also needs to be considered in light of their location and frequency of use. Long-term use of Bilinga to Tugun nearshore placement areas would impact on the coastline from Rainbow Bay to Kirra. Similar to the case of a North Kirra outlet, this section of coastline would be denied natural supply of sand. Availability of these placement areas would only be beneficial in terms of promoting project objectives during a period of excess sand supply. However, dredge placement would be more expensive and would not provide any additional benefit compared to the use of optional deep water reserves within the project area.

Addition of deeper nearshore placement reserves seaward of the existing project placement areas would provide worthwhile increases in operational flexibility at relatively low cost and are recommended for consideration.

Supplying sand to Kingscliff Beach from the vicinity of the Tweed River Entrance provides no direct benefit to the TRESBP during periods of average sand supply rates. The requirement for the use of a large dredge means the shallower parts of the entrance bar that are usually dredged, may not be accessible and sand could have to be drawn from further offshore. The benefits will therefore depend largely on the capabilities of the dredging equipment available at the time of construction. Delivery of sand from the Tweed River Entrance to Kingscliff Beach appears physically and environmentally feasible with the key feasibility issue likely to be cost, which may be prohibitive and should be considered at the initiation of any further planning.

The investigations completed by BMT-WBM concluded that back passing of sand to Letitia Spit Beach is a feasible and practical means to enhance the management of the volume of sand that is delivered to the southern Gold Coast beaches, to cater for the highly variable natural rate of sand supply along Letitia Spit on a short and long term basis.

The back passing strategy could be initially targeted at reducing the quantity of sand build up at Central Kirra by reducing delivery under high natural transport conditions, while maintaining acceptable conditions at Snapper Rocks through to Coolangatta Beach. Given the short lead time expected for implementation of backpasssing, when compared to the various options, back passing is considered to be an effective option for promoting more rapid dispersal of the sand build up at Central Kirra to improve beach conditions and surf quality at Kirra.

Back passing also provides a mechanism to restore and maintain the Letitia Spit shoreline in the longer term with improved operational capability to promote beach rebuilding at Letitia as required.

The back passing option is a feasible and practical means to provide a timely and effective response to the current sand build up at Central Kirra and inproved operational capabilities to promote the longer term project objectives of managing sand delivery to match natural sand transport conditions along the project area.

Subject to the feasibility constraints, risks and recommendations for further investigations outlined within this report, the four options generally appear to be physically and environmentally feasible. The key feasibility issues are the time required for implementation to respond to the current issue of sand build up at Central Kirra, potential longer term operational benefits that promote project objectives and relative cost / benefit ratio of implementing these strategies, which may be prohibitive. These issues and constraints should be considered at the initiation of any further planning.

With this in mind, development of deeper nearshore placement reserves and back-passing capabilities, which would provide worthwhile increases in operational flexibility at relatively low cost during periods of high natural sand supply rates are recommended for further consideration.

12. References

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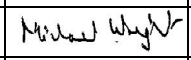
3	C. Dengate	P. O'Keeffe		M. Wright		09/2011