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Sunshine Coast Sand Sourcing Study

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Background technical report - not Council policy

Executive Summary

With specific reference to beach nourishment of Sunshine Coast Beaches, four (4) potential sand sources have been considered and assessed with regard to environmental constraints, sediment quality, the quantity of material available and the likely sand extraction and delivery method. The key sand sources are referred to as:

- Port of Brisbane Pty Ltd (PBPL) Commercial Sand
- The Offshore Area
- Northern Pumicestone Passage
- Lower Maroochy River

In the short to medium term it is possible that the erosion threat to the northern Pumicestone Passage mainland shoreline can be managed with material from within the passage. Considering the existing environmental constraints an estimated volume of 700,000m^3 is assumed available. It's proposed that this sand source could also provide a small volume of material to Kings Beach. Additional material from this sand source could become available through changes to the Moreton Bay Marine Park Conservation Zone. A review of the zoning plan is expected to commence in 2017, at which time Council may wish to make a submission to allow access to sand that is currently restricted.

It's expected that undesirable erosion at Maroochydore Beach can be mitigated using material from the lower Maroochy River in the short term. Under the existing permits, Council has a remaining allocation of 150,000m^3 until late 2016. Monitoring of the dredge footprint between 2013 and 2015 suggests this sand source is replenished at an estimated rate of 50,000m^3/year following a dredging campaign. It is therefore assumed that Council could expect lower Maroochy River sand source to sustainably provide up to 100,000m^3 every two years (subject to ongoing approval and monitoring beyond 2016). This limited sand source may not have the capacity to mitigate the risks to land based assets in the medium to long term or provide sufficient material to recover from an extreme erosion event (or sequence of events).

Due to the larger dredge plant required to access the PBPL and any potential Offshore Area sand sources, these options are expected to be considerably more expensive than accessing material within shallow and sheltered environments. In comparison to recycling material within the existing sand budget (e.g. relocating material from an estuary to the adjacent beach), the PBPL and Offshore Area sand sources may provide the most benefit long term since they have the potential to add a significant volume to the Sunshine Coast littoral system.

Placement of nourishment material via bottom dumping from a Trailer Suction Hopper Dredge is expected to be a cost-effective means to supplement the Sunshine Coast sand budget. This method also offers the advantage of causing minimal disruption to beach users. It is recommended that a trial is undertaken at Maroochydore Beach using PBPL Commercial Sand to help to determine whether this nourishment method is a suitable at this location. If this method proves unsuccessful, future beach nourishment activities using this sand source and/or material from an Offshore Area would need to consider more operationally challenging and expensive delivery options.

Contents

Executive Summary i
1 Introduction 1
1.1 Potential Sand Source Locations 3
2 Potential Sand Sources 5
2.1 Port of Brisbane Pty Ltd Commercial Sand 5
2.1.1 Study Area Description and Previous Work 5
2.1.2 Environmental Constraints 5
2.1.3 Sediment Quality and Suitability for Beach Nourishment 6
2.1.4 Estimated Quantity of Sediment Suitable for Beach Nourishment 6
2.1.5 Operational Considerations 7
2.1.6 Costs 7
2.2 Offshore Area Surveyed in 2015 8
2.2.1 Study Area Description and Previous Work 8
2.2.2 Environmental Constraints 13
2.2.3 Sediment Quality and Suitability for Beach Nourishment 13
2.2.4 Estimated Quantity of Sediment Suitable for Beach Nourishment 13
2.2.5 Operational Considerations 18
2.2.6 Costs 19
2.3 Northern Pumicestone Passage 21
2.3.1 Study Area Description and Previous Work 21
2.3.1.1 Golden Beach and Bribie Island Breakthrough Strategy (2015 – ongoing) 22
2.3.2 Environmental Constraints 23
2.3.3 Sediment Quality and Suitability for Beach Nourishment 26
2.3.4 Estimated Quantity of Sediment Suitable for Beach Nourishment 26
2.3.4.1 Moreton Bay Park Zone Review 27
2.3.5 Operational Considerations 29
2.3.6 Costs 30
2.4 Lower Maroochy River 31
2.4.1 Study Area Description and Previous Work 31
2.4.1.1 Maroochydore Beach Renourishment Project (2013 – ongoing) 31
2.4.2 Environmental Constraints 32
2.4.3 Sediment Quality and Suitability for Beach Nourishment 37
2.4.4 Estimated Quantity of Sediment Suitable for Beach Nourishment 38
2.4.5 Operational Considerations 41

2.4.6 Costs 41
3 Approval Strategy and Legislative Framework 42
3.1 General Approval Strategy 42
3.1.1 Planning and Tenure Considerations 42
3.1.2 Environmental Considerations 43
3.1.3 Heritage Considerations 44
3.1.4 Socio-economic Considerations 44
3.1.5 Timing and Approval Pathway 44
3.2 Additional Considerations for Establishing a New Offshore Sand Extraction Site 45
3.2.1 Planning and Tenure Considerations 45
3.2.2 Environmental Considerations 46
3.2.3 Heritage Considerations 46
3.2.4 Socio-economic Considerations 47
3.2.5 Timing and Approval Pathway 47
4 Additional Minor Sand Sources 49
4.1 Currimundi Lake Entrance 49
4.2 Mooloolaba Harbour Entrance 51
4.2.1 Recent Assessment of Capital Works Options to Mitigate Shoaling 52
5 Sunshine Coast Sand Sources Summary 55
5.1 Viable Sand Sources and Priority Areas 55
5.2 Recommended Further Work 59
5.2.1 Long Term Cost Considerations 59
5.2.2 Nearshore Nourishment Trial 59
6 References 62
Appendix A Nourishment of Sunshine Coast Beaches using Offshore Placement Techniques A-1
Appendix B Mooloolah Sand Survey Report (Acoustic Imaging, 2015) B-1
Appendix C Pumicestone Passage Sediment Investigation Report (Cardno Bowler, 2011a) C-1
Appendix D Maroochy River Sediment Investigation Report (Cardno Bowler, 2011b) D-1
Appendix E Maroochy River Sediment Investigation Report (Cardno Bowler, 2015) E-1

List of Figures

Figure 1-1 Map of Priority Areas for Beach Nourishment (highlighted in red) Identified in the SEMP 2
Figure 1-2 Sand Sourcing Study Key Locations of Interest 4
Figure 2-1 Offshore Survey Area and Previous Sampling Locations 10
Figure 2-2 Seismic Profile and Sediment Cores East of Warana: Holocene (HS-s), Transgressional Nearshore (TX-n) and Pleistocene (P-u) Deposits (from Jones, 1992); Line 4 in Figure 2-1. 11
Figure 2-3 Seismic Profile and Sediment Cores East of Point Cartwright: Holocene (HS-s), Transgressional Nearshore (TX-n), Transgressional Estuarine (TX-e) and Pleistocene (P-u) Deposits (from Jones, 1992); Line 3 in Figure 2-1. 12
Figure 2-4 Unconsolidated Sediment Layer Thickness 15
Figure 2-5 Interpolated Unconsolidated Sediment Layer Thickness 16
Figure 2-6 Proposed Offshore Sand Source 17
Figure 2-7 Rainbowing at Woorim Beach (top panel, BMT WBM, 2014) and Pumping Sand Onshore (bottom panel, SANDAG, 2015) 19
Figure 2-8 Sediment Transport and Bed Types at the Northern Entrance to Pumicestone Passage (Jones, 1992) 21
Figure 2-9 Northern Pumicestone Passage Morphology 21/07/2010 to 09/04/2015 (NearMap, 2015) 24
Figure 2-10 Environmental Constraints within Northern Pumicestone Passage 25
Figure 2-11 Permitted and Proposed Dredge Areas within Northern Pumicestone Passage 28
Figure 2-12 400mm Cutter Suction Dredge (Photo Courtesy of Hall Contracting) 29
Figure 2-13 Before (left) and After (right) Maroochydore Beach Renourishment Project Stage One (photos courtesy of Birdon Pty Ltd) 32
Figure 2-14 Maroochy River Mouth Morphology 21/07/2010 to 03/07/2012 (NearMap, 2015) 33
Figure 2-15 Maroochy River Mouth Morphology 15/08/2012 to 16/06/2013 (NearMap, 2015) 34
Figure 2-16 Maroochy River Mouth Morphology 11/08/2013 to 09/04/2015 (NearMap, 2015) 35
Figure 2-17 Environmental Constraints within the Lower Maroochy River 36
Figure 2-18 Infilling of the Permitted Dredge Footprint between October 2013 and June 2015 39
Figure 2-19 Dredge Areas within the Lower Maroochy River 40
Figure 2-20 Cutter Suction Dredge and Pipeline Sand Delivery to Maroochydore Beach 41
Figure 4-1 Currimundi Lake Entrance (NearMap, 2011) 49
Figure 4-2 Berm Building at Currimundi Lake Entrance (Sunshine Coast Daily, 2015) 50

Figure 4-3 Conceptual Model of Sand Bypassing at the Mooloolaba Harbour Entrance (modified from: Department of Harbours and Marine, 1987) 52
Figure 4-4 Mooloolaba Harbour Shoaling Assessment Results: Existing (top) and Modified (bottom) Entrance Configurations (Barnes et al., 2015) 53
Figure 5-1 Maroochydore Beach Nearshore Placement Trial Target Area 61

List of Tables

Table 5-1 Sunshine Coast Sand Sources Summary 57
Table 5-2 Key Stages of Proposed Sand Sourcing 58

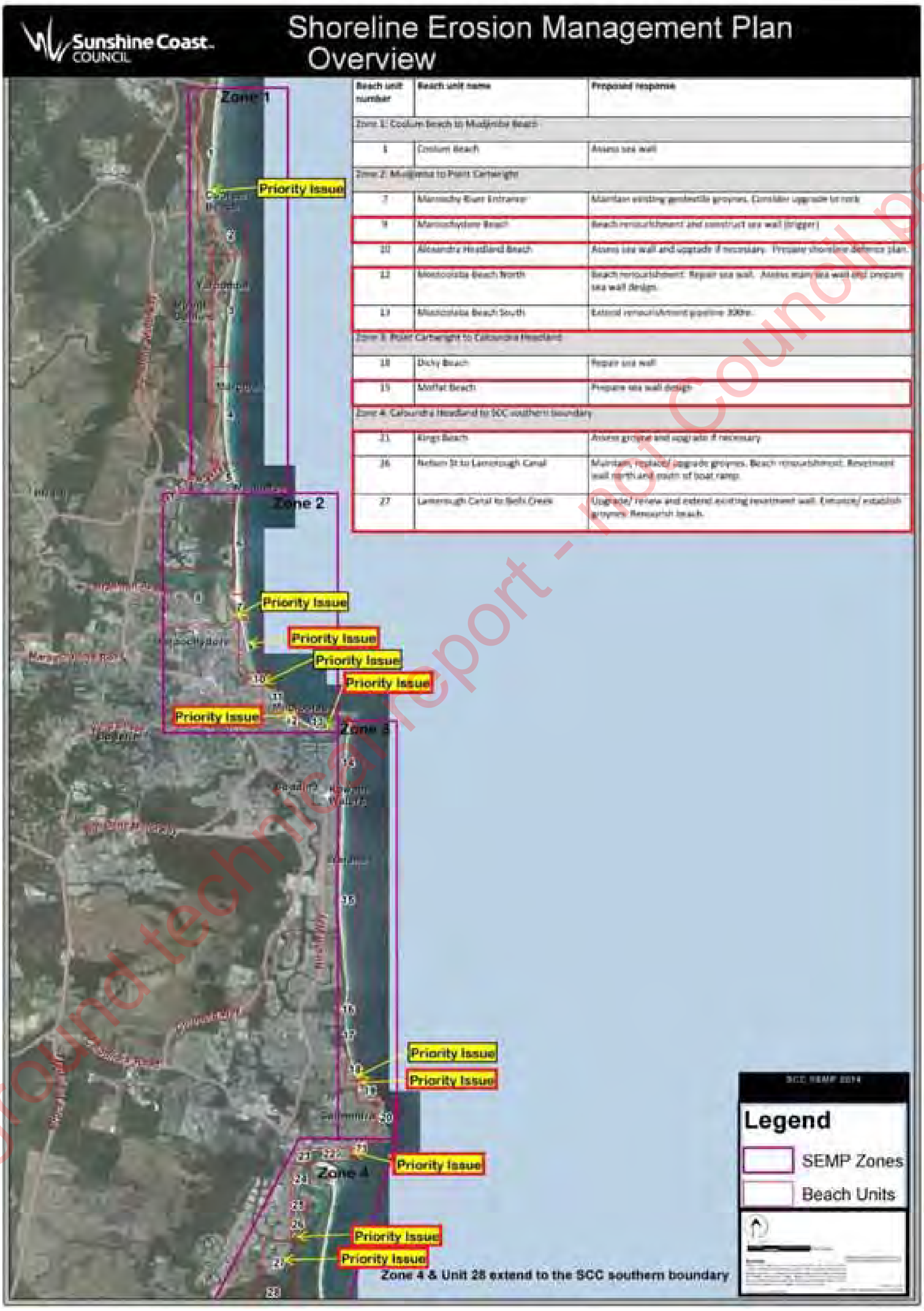
1 Introduction

The Sunshine Coast Council strategy and planning framework includes the Coastal Policy and Shoreline Erosion Management Plan (SCC, 2014) which have been developed to assist in preserving and/or enhancing identified coastal values and assets. The Shoreline Erosion Management Plan (SEMP) is a 10 year action plan that describes the key coastal processes along the Sunshine Coast, identifies current shoreline erosion threats to Council controlled assets, and outlines preferred management options to address priority erosion threats.

While Council responsibility only extends to Council controlled land and assets, it is considered appropriate to advocate potential impacts to social and economic values associated with State Controlled land, and to promote appropriate impact mitigation options. In many cases, beach nourishment is the preferred shoreline management option to mitigate risk, maintain beach amenity and delay the need for hard erosion control structures. Specifically, the SEMP identifies beach nourishment (if viable) as the preferred shoreline erosion management option for the following priority areas:

- Maroochydore Beach
- Mooloolaba Beach North
- Mooloolaba Beach South
- Moffat Beach (minor nourishment works)
- Kings Beach (minor nourishment works)
- Nelson Street to Lamerough Canal
- Lamerough Canal to Bells Creek

These priority areas for beach nourishment are highlighted in red in Figure 1-1. Nourishment throughout the study area is currently restricted due to the limited availability of known sand reserves in the nearby marine areas and legislative and environmental constraints applicable to possible sand sourcing locations.



Shoreline Erosion Management Plan Overview

Beach unit number	Beach unit name	Proposed response
Zone 1: Coolum Beach to Mudjimba Beach		
1	Coolum Beach	Assess sea wall
Zone 2: Mudjimba to Point Cartwright		
7	Maroochy River Entrance	Maintain existing geotextile groynes. Consider upgrade to rock
9	Maroochydore Beach	Beach renourishment and construct sea wall (trigger)
10	Alexandra Headland Beach	Assess sea wall and upgrade if necessary. Prepare shoreline defence plan.
12	Mooloolaba Beach North	Beach renourishment. Repair sea wall. Assess main sea wall and prepare sea wall design.
13	Mooloolaba Beach South	Extend renourishment pipeline 300m.
Zone 3: Point Cartwright to Caloundra Headland		
18	Dicky Beach	Repair sea wall
19	Moffat Beach	Prepare sea wall design
Zone 4: Caloundra Headland to SCC southern boundary		
21	Kings Beach	Assess groyne and upgrade if necessary
26	Nelson St to Lamerough Canal	Maintain, replace/ upgrade groynes. Beach renourishment. Revetment wall north and south of boat ramp.
27	Lamerough Canal to Bells Creek	Upgrade/ renew and extend existing revetment wall. Entrance/ establish groynes. Renourish beach.

Figure 1-1 Map of Priority Areas for Beach Nourishment (highlighted in red) Identified in the SEMP

1.1 Potential Sand Source Locations

In this study four (4) potential sand sources are considered and assessed with regard to environmental constraints, sediment quality, the quantity of material available and the likely sand extraction and delivery method. The key sand sources of interest are shown in Figure 1-2 and described in the following report sections:

- Section 2.1 – Port of Brisbane Pty Ltd (PBPL) Commercial Sand
    - North of Northwest Channel
    - Spitfire Re-alignment Channel
- Section 2.2 – The offshore area surveyed as part of the present study
- Section 2.3 – Northern Pumicestone Passage
- Section 2.4 – Lower Maroochy River

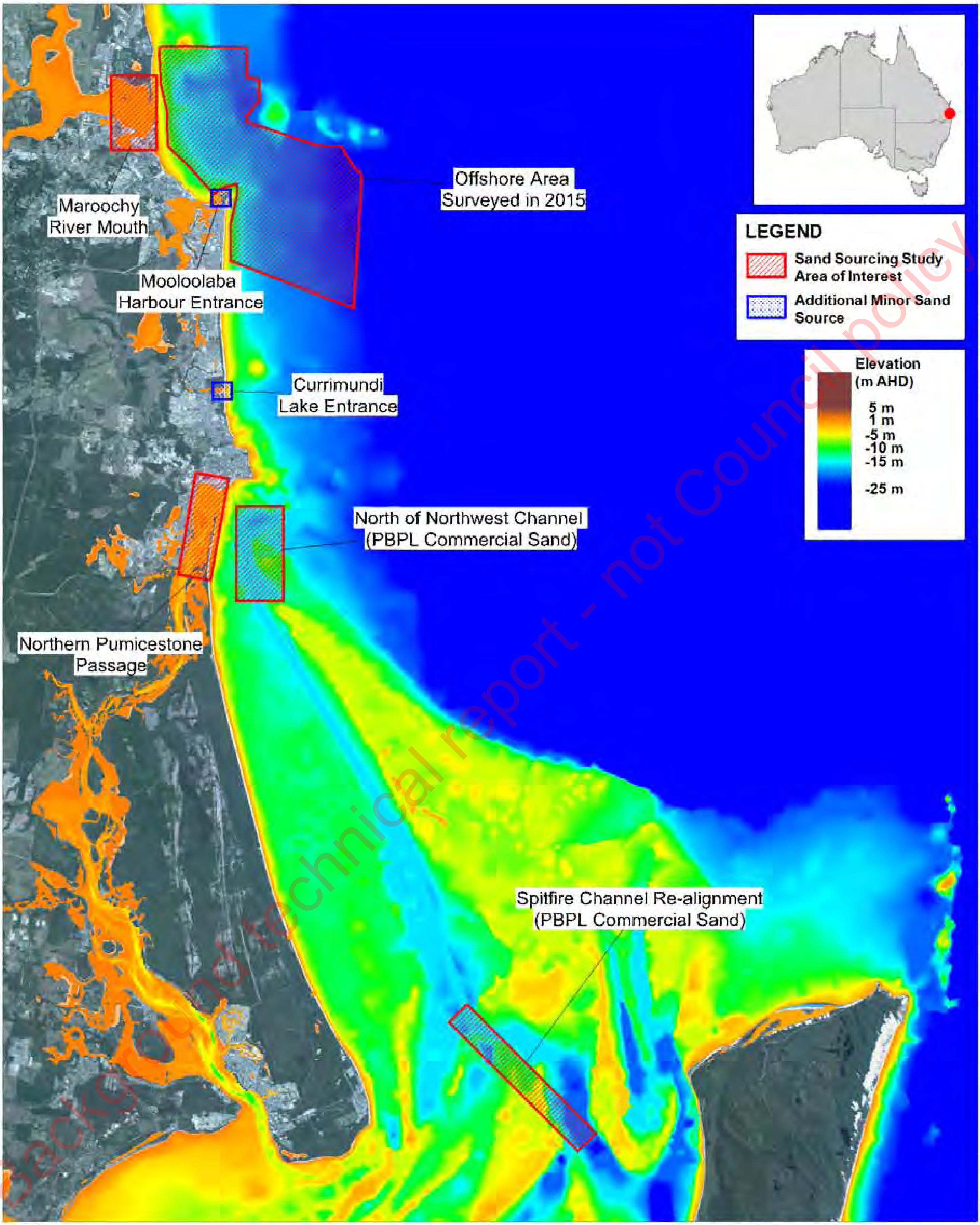
In addition to the above, Figure 1-2 also indicates the relatively minor sand sources at the Currimundi Lake and Mooloolaba Harbour entrances. These sand sources are discussed in Section 4.

Terrestrial sources of nourishment sand have not received a detailed assessment in this study. While some land-based sites and/or commercial sand mining operations with suitable material may exist, their production capacity is expected to be limited. Challenges typically associated with land-based sand sources include:

- Social impacts associated with the transport of material via truck (e.g. undesirable noise, road closures and spillage);
- Access to the desired placement location is often constrained, particularly in developed areas;
- Difficulty matching grain size, colour, composition and texture of the material with the native beach sand; and
- Long haul distances from source location to placement area which increases the cost per unit volume of material.

It is noted that the under the Gold Coast Planning Scheme, any sand suitable for beach nourishment that is excavated from a development site within the coastal zone must be deposited back to the beach (with delivery costs incurred by the developer). A similar amendment to the Sunshine Coast Planning Scheme may occasionally provide small volumes of sand at little or no cost to Council.

The Moffat Beach and Kings Beach priority areas identified in the SEMP that would benefit from minor beach nourishment works may consider land-based delivery options; however, stockpiling of marine sand at a location where it can be accessed and transported to site is likely to be the more favourable option. This is discussed further in Section 5.



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Sand Sourcing Study Key Locations of Interest

Figure:
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2 Potential Sand Sources

2.1 Port of Brisbane Pty Ltd Commercial Sand

2.1.1 Study Area Description and Previous Work

Port of Brisbane Pty Ltd (PBPL) is permitted to extract sand from designated locations within Moreton Bay. This material is typically used for reclamation as part of development of the Future Port Expansion area.

A teleconference attended by Sunshine Coast Council, PBPL and BMT WBM was held on Monday 25 March 2013. The objective of the teleconference was to initiate discussion regarding the potential for beach nourishment of Maroochydore Beach using PBPL dredge material. Key items discussed included:

- Type of dredging equipment capable of delivering beach nourishment sand to Maroochydore Beach;
- The volume and quality of sand available for beach nourishment purposes; and
- Cost estimate for sand delivery to Maroochydore Beach.

A technical memorandum summarising the discussion with PBPL is included in Appendix A. As part of the present study BMT WBM has continued discussion with PBPL regarding their commercial sand sources. PBPL has confirmed that the advice provided in 2013 remains valid in 2015. Information relevant to the present study is summarised below.

2.1.2 Environmental Constraints

The sandbanks of northern Moreton Bay and offshore of Bribie Island provide a variety of environmental values, recognised under a number of wetland/marine park designations. Part of this area is recognised under the Moreton Bay Ramsar wetland and Moreton Bay nationally important wetland, and is protected under Moreton Bay Marine Park designation. The values represented and protected by these designations include seagrass meadows, which providing foraging habitat for dugongs, marine turtles and fish, and sandy substrate benthic habitat for invertebrates and infauna. In addition, migratory marine megafauna, such as dugongs, marine turtles, dolphins and whales, are also known to utilise these areas and are protected under state, federal and international regimes.

While these constraints will apply to ongoing works in these areas environmental values may not always be present. Seagrass is known to recolonise navigation channels in Moreton Bay and other values will occur within the vicinity of dredging areas but existing controls within the dredging framework are generally expected to be sufficient to appropriate manage potential impacts to constraints these areas.

It is noted that Council would not be required to gain environmental approval to access PBPL sand, however, would require the relevant permits for placement activities.

2.1.3 Sediment Quality and Suitability for Beach Nourishment

PBPL has identified two dredge areas with material expected to be consistent with the natural sand found on most Sunshine Coast beaches. These areas are indicated in Figure 1-1 and referred to as:

(1) North of Northwest Channel

(2) Spitfire Re-alignment Channel

Sediment quality from these areas is typically clean white sand with a mean grain size diameter of approximately 0.25 to 0.30mm. Particle size distribution (PSD) analysis suggests this sand is consistent with the material found on Sunshine Coast beaches. PSD analysis results from the Spitfire Re-alignment Channel area (provided by PBPL) and is included in Appendix A.

PBPL undertakes limited dredging in these areas (less than 60,000m^3/year) with material typically used for port reclamation purposes. PBPL indicated that sand dredging and delivery to Sunshine Coast beaches would need to be a specific contract (i.e. not part of other PBPL maintenance or capital dredge programs) with the placement activities requiring a separate approval.

2.1.4 Estimated Quantity of Sediment Suitable for Beach Nourishment

In 2000, the Moreton Bay Sand Extraction Study (MBSES) was initiated to examine the feasibility of using Bay sand to supply raw materials for several major infrastructure and development projects in the Australia Tradecoast area and for the construction sector. Based on the MBSES, the State Government decided on a 20 year approach for management of sand resources in northern Moreton Bay, in order to supplement diminishing land based sources of sand.

From a total available sand resource in Moreton Bay of approximately 3,770 million m^3, the State Government made a decision in 2005 that over the next 20 years it would support:

- Extraction of up to 40 million m^3 (less than 1.1% of the total sand resource) of sand for development of Australia Trade Coast projects including the expansion of Brisbane Airport, Trade Coast Central site and the Port of Brisbane.
- Extraction of up to 20 million m^3 (less than 0.6% of the total sand resource) of sand for use within the construction sector.
- Restricting approved sand extraction to specified locations at Spitfire and Western Banks (within and adjacent to the Spitfire Channel Re-alignment area) and at Middle Banks within Northern Moreton Bay.

Beach nourishment sand volumes required by SCC in the short to medium term could potentially be sourced from the PBPL or construction sector allocation. Since 2005, the majority of construction industry sand dredging has occurred at the Spitfire Re-alignment Channel area. Permits for this area were issued for an initial period of two years after the MBSES and have been extended annually. The permits allow the construction industry to take up to 1 million m^3 of material from the Bay annually, although it is understood that the industry has not needed to fully utilise this allocation in meeting the current demand[1]. SCC annual requirements for beach nourishment sand are not expected to exceed the existing permitted volume; however, the existing sand extraction permits are due to expire in 2025.

2.1.5 Operational Considerations

PBPL identified the small Trailer Suction Hopper Dredge (TSHD) "*Brisbane"* as suitable equipment for delivering beach nourishment material to Maroochydore Beach (which was subject to a case study in 2013 described in Appendix A).

TSHD Brisbane has a 6.5m draft. The most cost effective sand delivery method from a TSHD is via bottom dumping. PBPL indicated an additional under keel clearance of approximately 1m is required for bottom dumping via *TSHD Brisbane*. Using this method of delivery, sand could be placed close to the -8mLAT (equivalent to -9mAHD) depth contour. The -8mLAT (-9mAHD) contour is located approximately 350m offshore from Maroochydore Beach. Placing material in the nearshore zone of Gold Coast beaches has been undertaken since the mid-1980s and has been proven to be an efficient method of beach nourishment (e.g. Boak et al., 2001). This and other placement methods are discussed further in Section 2.2.5 and Section 5.2.2.

PBPL estimate approximately 2,000m^3 of sand could be delivered to Maroochydore Beach per trip using *TSHD Brisbane* and bottom dumping delivery method and that four trips per 24 hour day could be completed. *TSHD Brisbane* is typically available for South East Queensland work between the months of December and April.

2.1.6 Costs

PBPL have provided the following cost estimates to deliver sand to Maroochydore Beach via *TSHD Brisbane* using a bottom dumping placement method:

- Sand from North of Northwest Channel approximately \$11/m^3
- Sand from Spitfire Re-alignment Channel approximately \$15/m^3.

The delivery of 200,000m^3 of nourishment material to the nearshore zone of Sunshine Coast Beaches would therefore cost between \$2.2 to \$3.0 million dollars in 2015.

A trial of nearshore placement via bottom dumping using PBPL Commercial Sand is proposed and discussed further in Section 5.2.2. The key objective the trial would be to determine whether future beach nourishment activities could adopt the bottom dumping delivery method or need consider more operationally challenging and expensive delivery options.

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[1] The proposed volume of 1.1 million m^3 from the Spitfire Channel Re-alignment area for the Sunshine Coast Airport Expansion Project is in addition to the existing construction industry allocation.

2.2 Offshore Area Surveyed in 2015

2.2.1 Study Area Description and Previous Work

Beach nourishment using material sourced from offshore is a potential option for Sunshine Coast beaches. Offshore sand reserves have provided approximately 6.4 million m^3 of sand for Gold Coast beaches since the mid-1980s (e.g. Jackson et al., 2013). In order to minimise disruption to the nearshore sediment budget, these operations have sourced material from beyond the 20m depth contour which is the estimated limit of the “active profile” for Gold Coast beaches. The active profile concept in the context of Sunshine Coast beaches is discussed further Section 2.2.4 and in Appendix A.

As part of the present study an offshore survey was undertaken by PBPL and Acoustic Imaging Pty Ltd to better understand the Sunshine Coast offshore sand source. The survey area is shown in Figure 2-1 together with sediment sampling locations previously reported by Jones (1992). The PBPL and Acoustic Imaging survey report is provided in Appendix B and interpretation of this and the relevant previous work is presented and discussed below.

Numerous investigations of onshore geology and offshore sand resources throughout south-east Queensland were commissioned by the state government between the late 1970s and early 1990s (e.g. Stephens, 1982; Jones, 1992). This collection of works provides the baseline understanding of the regional coastal setting.

Jones (1992) described the offshore area between Woorim and Point Cartwright using data obtained by the following methods:

- Offshore transect lines extending up to 10km offshore surveyed by echo sounder to record the seabed level;
- Seismic reflection profiles obtained along a selection of the transect lines to define substrate stratigraphy;
- Surface sediment samples collected along the lines analysed for grain size and composition; and
- Sediment cores up to 4m long collected from the seabed.

A map summarising the data reported by Jones (1992) relevant to the present study is provided in Figure 2-1, which also shows the area subject to additional survey work in 2015. Key observations reported by Jones (1992) are summarised below.

To the south of Warana an underlying rock surface exerts a major influence on the seafloor profile, particularly on the inner shelf (beyond 1800m offshore) where rock platforms and pinnacles are common. Unconsolidated sediments mostly of post-glacial marine Transgressional (approximately between 19,000 and 6,000 years old) and Pleistocene age (approximately 120,000 years old) overlie the rock surface. The sediment layer thickness is typically less than 7m.

Offshore from Warana the sediment layer thickness increases up to approximately 22m. This sediment layer is also dominated by older deposits, with thin surface Holocene (modern sediments up to 6,000 years old) deposits typically less than 1.7m. These surficial sediments are quartz sands with grain sizes between 0.18 and 0.23 mm. The transect line results at Warana (Line 4 in Figure 2-1) are illustrated in Figure 2-2[2].

The rock which forms the Point Cartwright headland and dominates the nearshore zone continues seaward beneath a cover of unconsolidated sediments. This rock eventually rises to re-intersect the seafloor about 4km offshore (see the Inner and Outer Gneerings in Figure 2-1). To the east of Point Cartwright, the unconsolidated deposits overlying the rock increase to approximately 16m and are dominated by sediments of Transgressional and Pleistocene age. Sediment core data suggest the Holocene deposits are typically less than 2m in thickness with median grain size close to 0.25 mm while the deeper Transgressional and Pleistocene age deposits are slightly coarser.

The transect line results east of Point Cartwright (Line 3 in Figure 2-1) are illustrated in Figure 2-3. The results show only a thin layer of sand in the nearshore zone. This restricted distribution of sand suggests northwards transport around Point Cartwright occurs at a low rate. Recent assessments estimate the average net northerly transport is close to 10,000 m^3/year (e.g. BMT WBM, 2013a); however, significantly higher rates are known to occur episodically (e.g. Voisey et al. 2012; Barnes et al. 2015).

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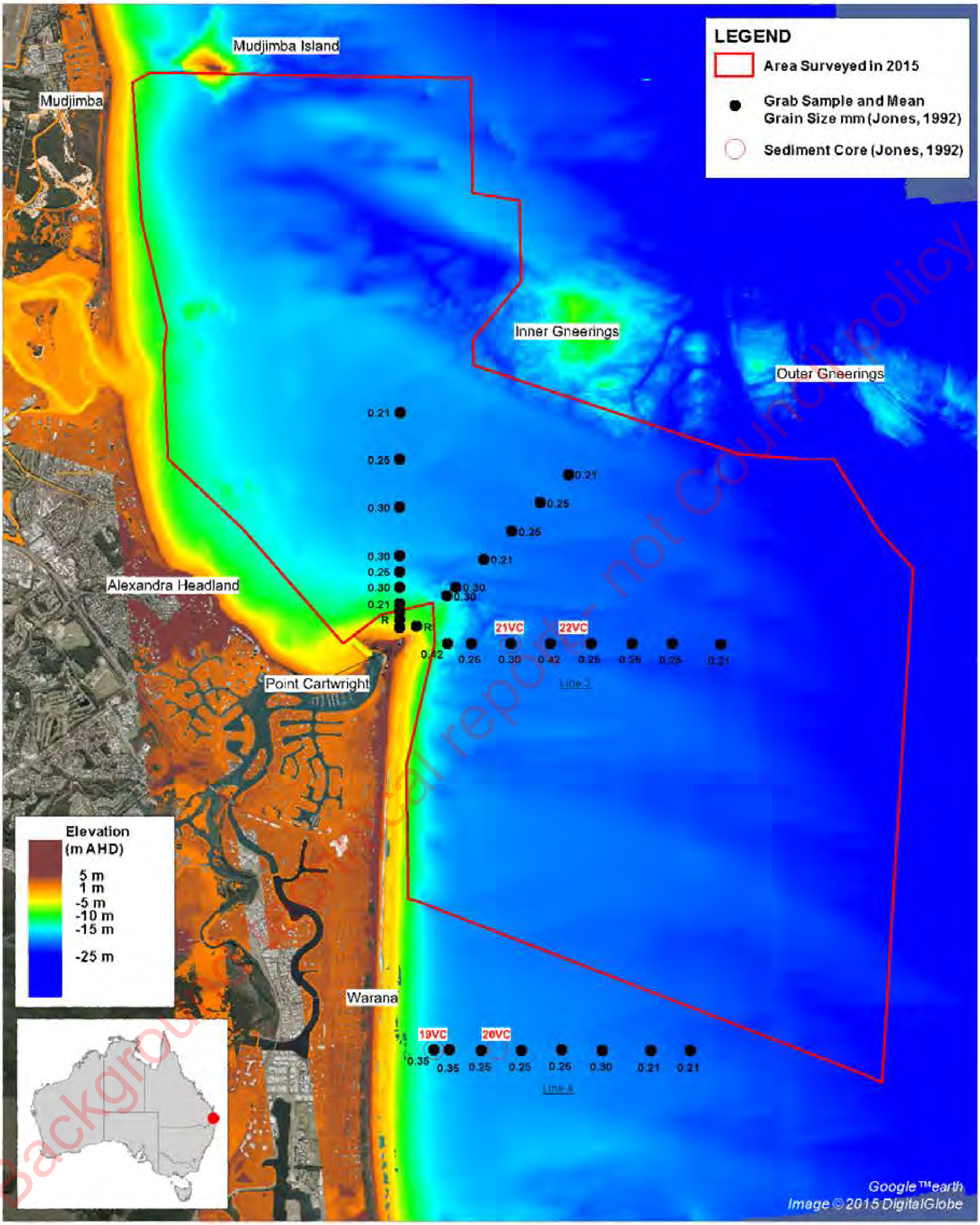
[2] Sediment sizes shown in Figure 2-2 and Figure 2-3 are in phi scale. The conversion between phi scale and grain size diameter (mm) is given by: grain size diameter (mm) = 0.5^{phi}



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Offshore Survey Area and Previous Sampling Locations

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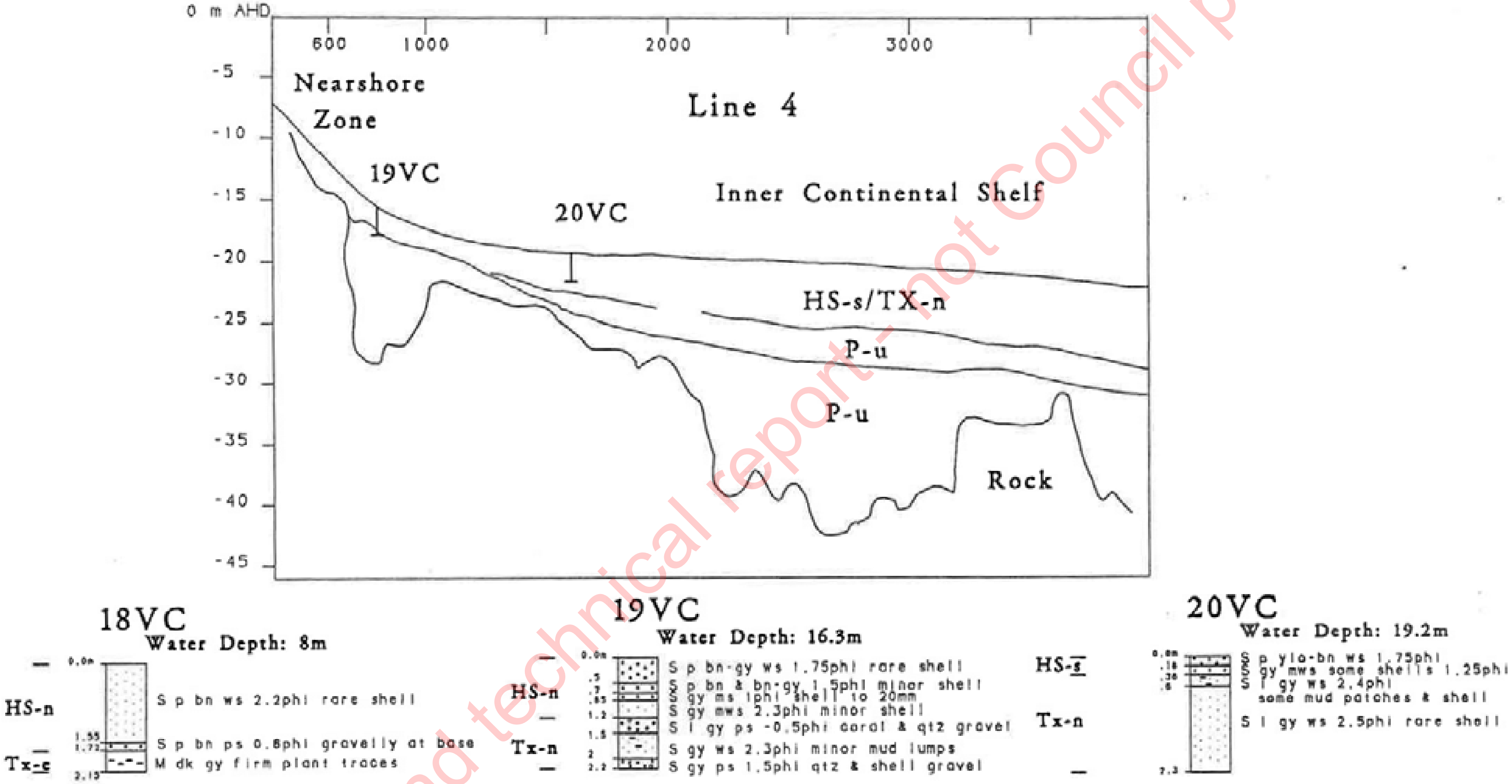

Figure 2-2 Seismic Profile and Sediment Cores East of Warana: Holocene (HS-s), Transgressional Nearshore (TX-n) and Pleistocene (P-u) Deposits (from Jones, 1992); Line 4 in Figure 2-1.

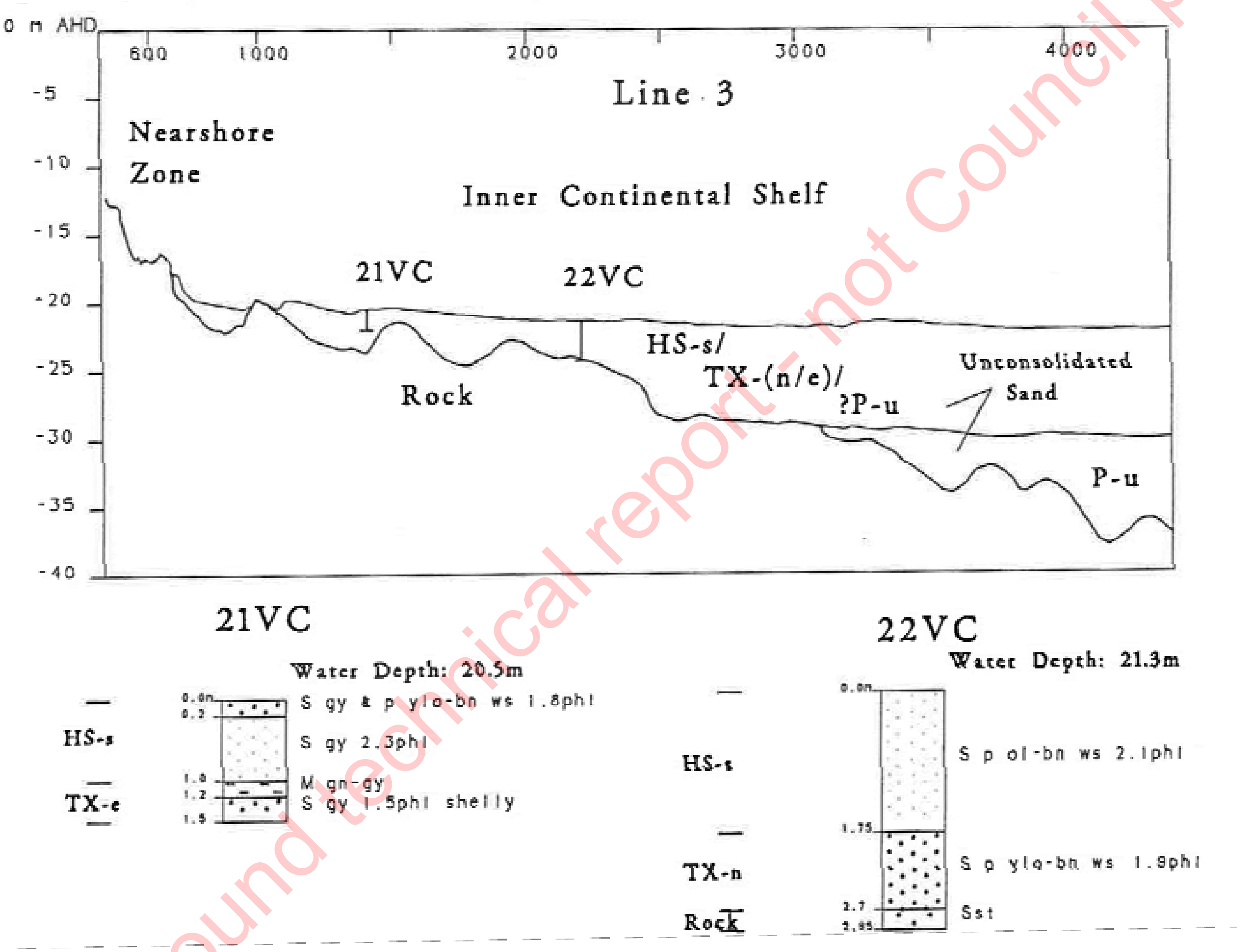

Figure 2-3 Seismic Profile and Sediment Cores East of Point Cartwright: Holocene (HS-s), Transgressional Nearshore (TX-n), Transgressional Estuarine (TX-e) and Pleistocene (P-u) Deposits (from Jones, 1992); Line 3 in Figure 2-1.

2.2.2 Environmental Constraints

The main environmental constraints associated with offshore waters are the benthic fauna and infauna within the actual dredge footprint and any migratory/transient marine megafauna that may pass through the area. The offshore waters may provide suitable habitat for spanner crabs (*Ranina ranina*), a commercially important fishery value, as these crabs typically inhabit depths of 10-100m on sandy-smooth substrata.

Marine megafauna that may transit the area include migratory whales (e.g. southern right whale, humpback whale, Bryde’s whale), dugongs, dolphins (e.g. dusky dolphin, Irrawaddy dolphin, Indo-Pacific humpback dolphin) and marine turtles (e.g. loggerhead turtle, green turtle). Given that seagrass is unknown/unlikely to occur in this area, it is unlikely that any foraging by dugongs or turtles occurs.

Shipwrecks may also occur in this area though this is not considered highly likely and does not pose a significant constraint outside of the footprint of the wreck.

In contrast to accessing PBPL commercial sand, Council would be required to gain environmental approval for both the extraction and placement of material from any new offshore deposits.

2.2.3 Sediment Quality and Suitability for Beach Nourishment

As discussed in Section 2.2.1, southeast of Point Cartwright the sediment cover overlying rock is up to 22m thick. This previous finding was qualitatively confirmed through the sub-bottom profiling undertaken as part of the present study which detected minimum sand thicknesses of 9m throughout the majority of this area (refer Section 2.2.4). The layer of surficial Holocene sediments, which would be preferred for beach nourishment, is less than 1.7m thick. In terms of grain size, the more extensive underlying sediment deposits that accumulated during the post-glacial marine transgression and Pleistocene periods are slightly larger but still expected to be suitable for beach nourishment of Sunshine Coast beaches. It is noted that these deposits may have higher shell content and may be more variable in colour than the surficial Holocene sediment.

To the north and northeast of Point Cartwright and offshore from Maroochydore the inner shelf is mildly sloping with a sand cover. Surface grabs show Holocene sediments that are of suitable quality for beach nourishment in terms of grain size and colour (see Figure 2-1). In comparison to the areas south of Point Cartwright, the thickness of sediment cover over rock is significantly reduced and typically less than 3m. The northern area is considered a less favourable sand source for reasons discussed further in Section 2.2.4.

2.2.4 Estimated Quantity of Sediment Suitable for Beach Nourishment

As part of the present study PBPL and Acoustic Imaging Pty Ltd were commissioned to acquire and interpret a sub-bottom profiler (SBP) dataset within the Sunshine Coast offshore area. The survey extent is shown in Figure 2-1 and focused on areas less than 25m depth between Warana and Mudjimba. Aspects of the survey relevant for quantifying the volume of sand theoretically available for beach nourishment are described below. A full description of the survey method and results is provided in Appendix B.

The SBP instrument is an acoustic system that measures the sediment layers below the seabed surface. The SBP sends an acoustic signal down through the water column with some of the energy penetrating the seabed. The energy is reflected when it encounters boundaries between sediment layers that have different acoustic impedance (which is related to the density of the material). The SBP uses the reflected energy to create a profile of the marine sediments.

For the Sunshine Coast SBP survey, an identified “basement” reflector was interpreted to represent the rocky surface. Often the basement reflector was located at the seabed surface (i.e. reef areas) or just below a layer of unconsolidated shelf sediment (presumably sand) less than 3m in thickness. However, across most of the survey area to the east and southeast of Point Cartwright the basement reflector was not visible. This suggests unconsolidated sand deposits in excess of 8-9m thickness (the approximate penetration of the SBP).

Figure 2-4 shows the SBP survey lines and individual data points binned into “unconsolidated sediment layer” thicknesses. This presentation of the SBP data shows a distinct difference between the areas to the north and east to southeast of Point Cartwright. Key observations include:

- The area north of Point Cartwright is characterised by a relatively thin layer of sand over rock, typically 0-3m thickness;
- A relatively small area between the Inner Gneerings and Mudjimba where the unconsolidated sediment layer thickness is greater that 4m;
- Significant rocky outcrops around Point Cartwright and northwest of the Inner Gneerings; and
- East and southeast of Point Cartwright is characterised unconsolidated sediment layers in excess of 4m.

An interpolated presentation of the SBP dataset is shown in Figure 2-5.

Material removed from within the active littoral zone may lead to an undesirable shortage of sand supply to down drift beaches. Consequently, any offshore sand extraction would need to occur in depths beyond the active littoral zone. Previous offshore sand extraction for nourishment of Gold Coast beaches has occurred in locations beyond the 20m depth contour. Considering the milder wave climate experienced at Sunshine Coast beaches the offshore limit of the active littoral zone is likely to be in shallower waters (e.g. for Maroochydore Beach the seaward limit of the littoral zone has been previously estimated to be close to the 12m depth contour, see Section 1.3.4 in Appendix A). Nevertheless, for the purpose of quantifying the Sunshine Coast offshore sand resource a minimum sand extraction depth of 20m has been assumed[3].

Figure 2-6 shows the proposed area for offshore sand extraction based on interpretation of the SBP dataset and a desire to target material in depths beyond the active littoral zone. As discussed above, this area to the east and south east of Point Cartwright is generally characterised by unconsolidated sediment layers in excess of 4m. By assuming a dredge depth to 4m this potential resource represents a total sand volume of 96 million m^3.

There are significant operational and legislative considerations associated with accessing a new offshore sand resource. These are discussed further below and in Section 3.2.

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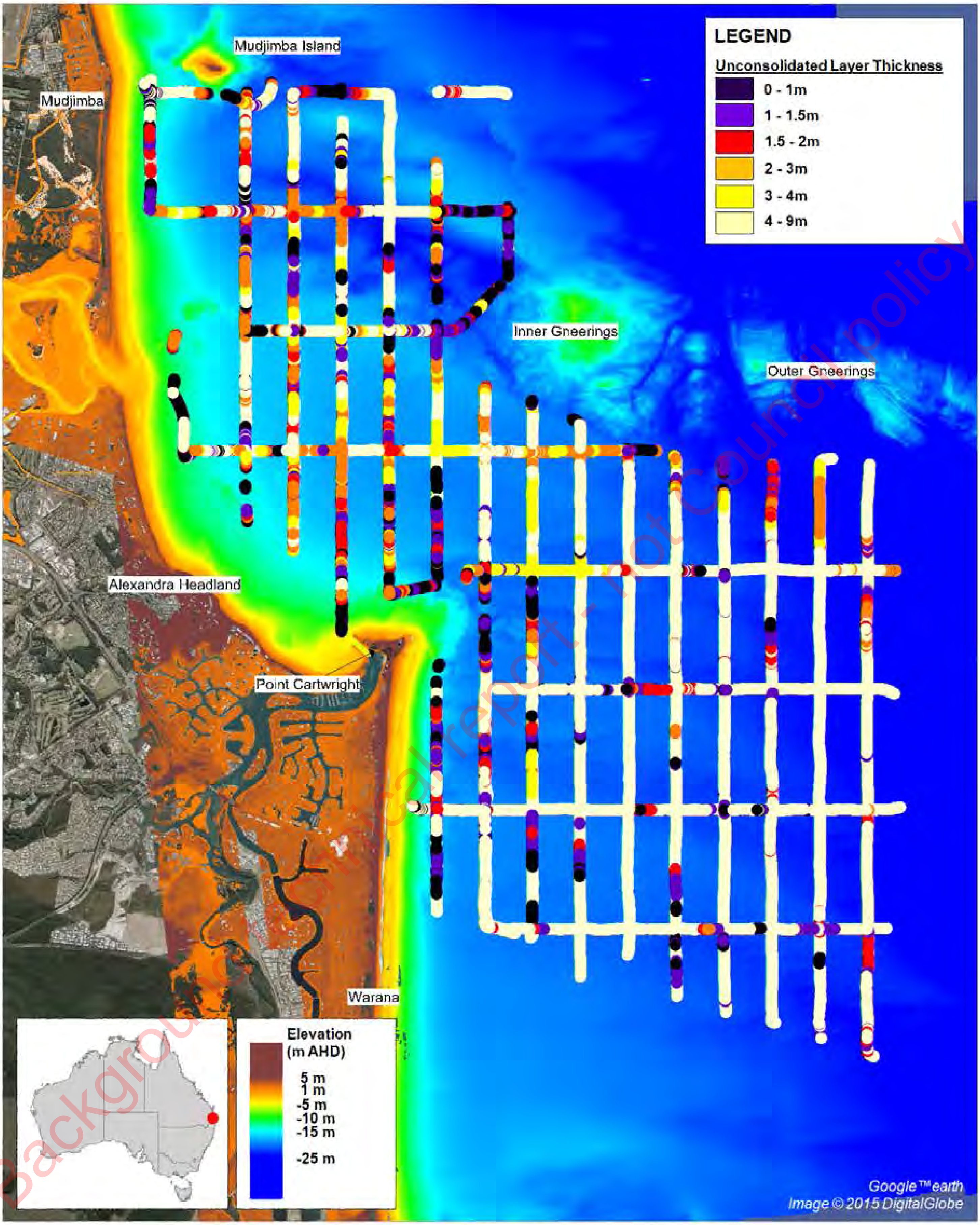
[3] Accessing material from shallower depths would be the more efficient and therefore cost effective option. The offshore limit of the littoral zone would be refined as part of the feasibility study to support the development of a new offshore sand extraction area.



Title:

Unconsolidated Sediment Layer Thickness and Bathymetry

Figure: **2-4**

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0 1.5 3 km

Approx. Scale

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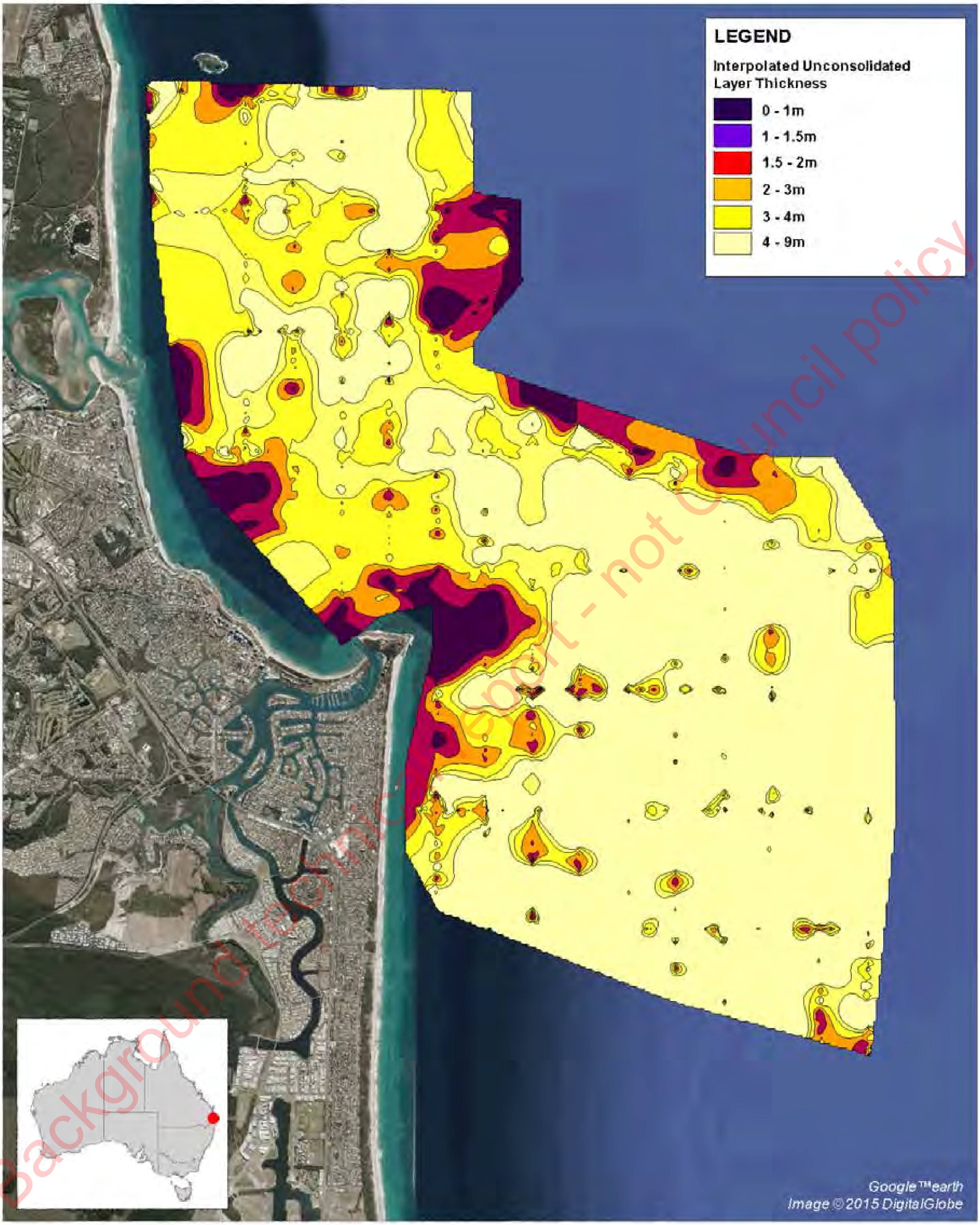

Title:

Interpolated Unconsolidated Sediment Layer Thickness

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Approx. Scale

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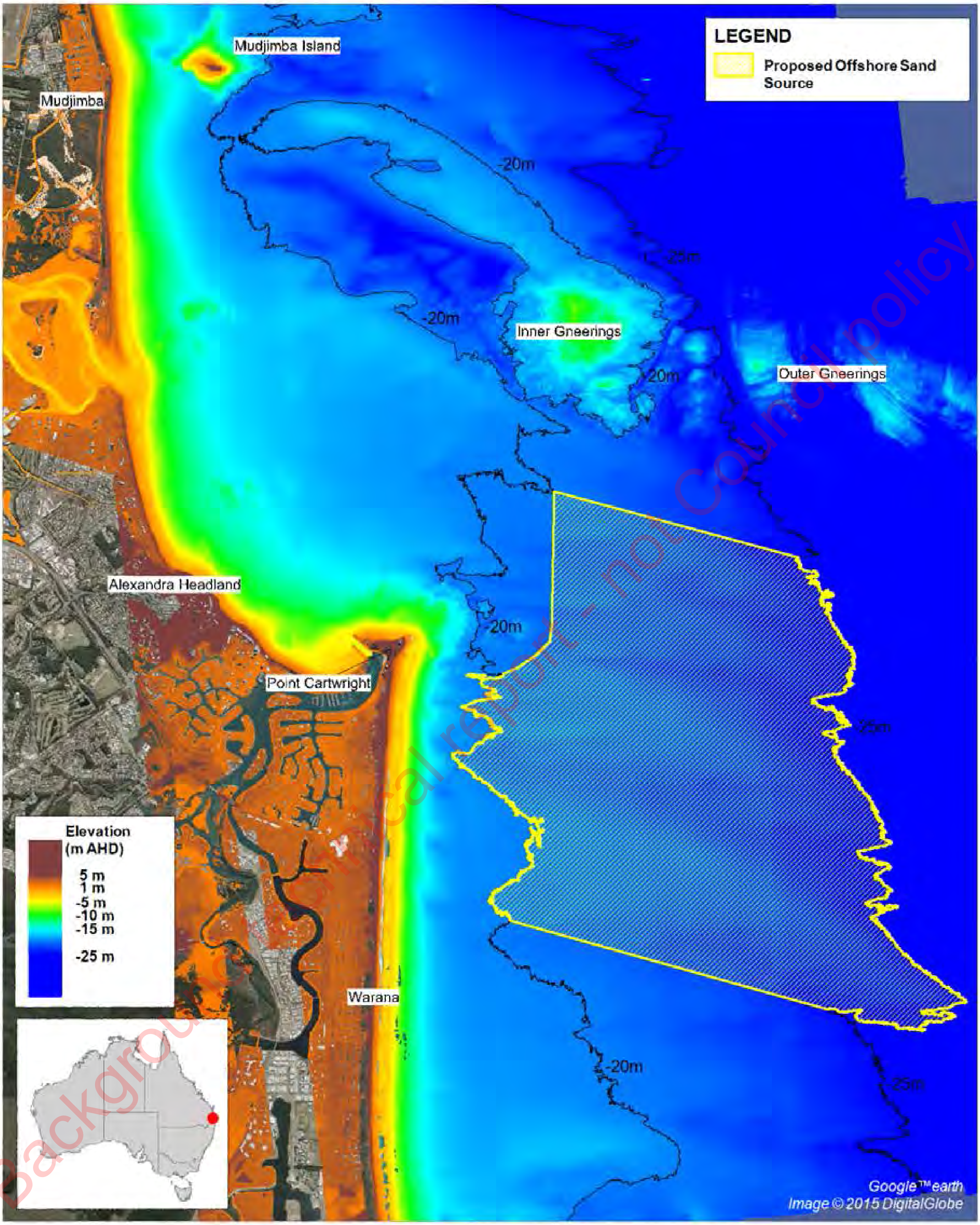

Title:

Proposed Offshore Sand Source

Figure: **2-6**

Rev: **A**

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0 1.5 3 km

Approx. Scale

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Filepath : I:\B21192_CMJ_SCC_Sandsourcing\DRG\COA_004_150715_Proposed_Offshore_Sand_Sources.wor

2.2.5 Operational Considerations

Accessing an offshore sand source would require a relatively large TSHD dredge capable of operating in depths beyond 20m and in seas with significant wave heights up to approximately 2.0m. Generally there are three options for placement of nourishment material dredged by a TSHD[4]:

(1) Bottom dumped within the active littoral zone (nearshore nourishment)

(2) "Rainbowing" into the surf zone (profile nourishment)

(3) Pumped ashore via a mooring and pipeline (onshore nourishment).

Bottom dumping places the material furthest offshore and in deeper water but still within the active littoral zone, which has been previously estimated to be landward of the 12m contour at Maroochydore Beach (see Section 1.3.4 in Appendix A). This method aims to build an offshore berm (or sand bar) that slowly migrates onshore due to the prevailing coastal processes.

"Rainbowing" or "over-the-bow" places material into the surf zone where the natural coastal processes will redistribute the placed material toward the equilibrium profile (refer to top panel in Figure 2-7).

Onshore pumping will generally place the material on the upper beach where conventional land based earthmoving equipment can be used to re-profile the material (refer to bottom panel in Figure 2-7).

It should be considered that in comparison to profile or onshore nourishment, the benefits of nearshore nourishment may not be immediately recognised by the community. However, in the medium term (up to a few years) the difference between the placement methods may be indistinguishable in terms of the achieved beach profile (and ultimate resilience to storm erosion) as the prevailing coastal processes redistribute the placed sand toward a new equilibrium.

Experience at the Gold Coast suggests a berm constructed shoreward of the 9m depth contour moves onshore over a period of about 18 months (Jackson et al., 2013). It should be noted that this observation is strongly related to the local wave climate and coastal processes and is not necessarily representative of Sunshine Coast locations. A previous assessment for Maroochydore Beach suggests accretionary conditions (expected to promote the onshore movement of sand) typically occur between June and December (see Section 1.3.3 in Appendix A).

The perceived benefit of nearshore nourishment is expected to be realised sooner if material is placed in shallower depths. As discussed in Section 2.1.5 of this report, PBPL indicated that *TSHD Brisbane* sand could place sand near the 8m depth contour using the bottom dump method. It is noted that a Gold Coast based shallow draft TSHD has been successfully used to dredge offshore sand deposits and bottom dump close to the 6m depth contour at Palm Beach (Jackson et al., 2013). A local trial of this placement method would be recommended prior to it being adopted in as part of a long term beach nourishment strategy. This is discussed further in Section 5.2.2.

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[4] Individual dredge plants may not have the necessary equipment to undertake all placement options

Figure 2-7 Rainbowing at Woorim Beach (top panel, BMT WBM, 2014) and Pumping Sand Onshore (bottom panel, SANDAG, 2015)

2.2.6 Costs

The overall cost for beach nourishment using offshore material is primarily related to the placement method. The simplest and most cost effective method is to place the material in the nearshore zone via bottom dumping. This method is also likely to keep environmental impacts to a minimum and typically avoids beach closures so that social and economic values associated with the beach are not significantly disrupted (AECOM, 2010).

Evaluations of previous tenders that have considered the three placement options at the Gold Coast suggest (e.g. Jackson and Tomlinson, 1990):

- Profile nourishment via rainbowing is approximately 200% more expensive than nearshore nourishment via bottom dumping; and
- Onshore nourishment via a mooring and pipeline is approximately 260% more expensive than nearshore nourishment via bottom dumping.

Considering these percentage increases, the cost estimate to deliver 200,000 m^3 of sand to open coast Sunshine Coast Beaches in 2015 is:

- $2.2 to $3.0 million dollars for nearshore nourishment via bottom dumping (following the PBPL estimate presented in Section 2.1.6)
- $6.6 to $9.0 million dollars for profile nourishment via rainbowing
- $7.9 to $10.8 million dollars for onshore nourishment via mooring and pipeline.

These estimates assume a suitable dredge plant is available on the Australian east coast. The mobilisation costs for a TSHD capable of undertaking offshore dredging are significant and likely to vary depending on the location of the desired plant. It is noted that individual dredge plants and operators may not have the necessary equipment and/or experience to undertake all placement options.

In comparison to the other sand sources considered in this report, accessing new offshore deposit is likely to require additional environmental assessment and subsequently incur greater planning costs. These are discussed further in Section 3.2.

2.3 Northern Pumicestone Passage

2.3.1 Study Area Description and Previous Work

There has been a continual supply of marine sand to Bribie Island throughout the Holocene period via the regional longshore sediment transport pathway that operates along the south eastern Queensland coast (Jones, 1992). This prevailing net-northerly sand transport has led to the formation of Stradbroke, Moreton and Bribie Islands which act as barriers to the prevailing ocean swells and associated sediment transport within Moreton Bay and Pumicestone Passage.

Caloundra Head represents a littoral drift divide, with sediment being transported to the north and south of the rocky headland. The dominant longshore transport is to the south which supplies sediment to the northern Pumicestone Passage entrance. Current and wave processes at the entrance control the position of the Caloundra Bar. The northern section of Pumicestone Passage is characteristic of a bar-built estuary with relatively shallow depths inside the mouth. Figure 2-8 provides a conceptual diagram of the dominant sediment transport mechanisms and bed types throughout the study area.

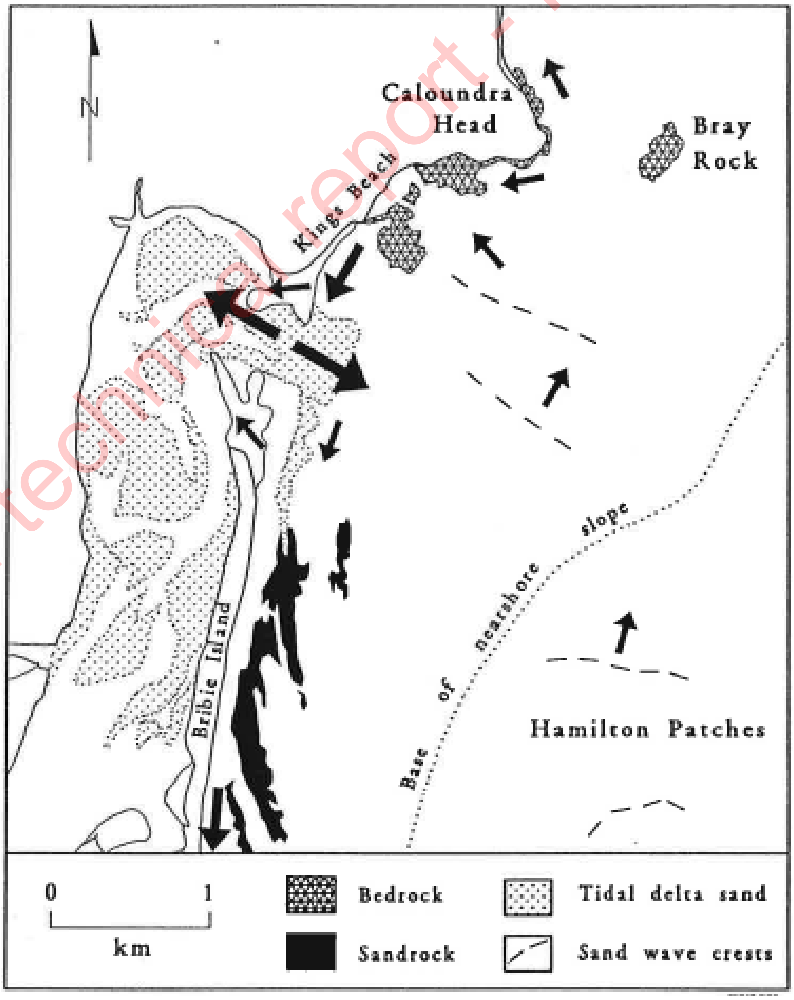


Figure 2-8 Sediment Transport and Bed Types at the Northern Entrance to Pumicestone Passage (Jones, 1992)

Sand that enters the northern entrance is re-worked by tidal and wave processes within the passage to form intertidal banks. Aerial photograph shows these banks extending south beyond the entrance to Lamerough Canal. Under normal conditions, the position of the Caloundra Bar and the intertidal bank morphology remain relatively stable. During storm conditions changes at the entrance may be observed as the position and morphology of the Caloundra Bar rapidly changes. This causes a subsequent change to the tidal efficiency at the entrance and sediment transport patterns and intertidal bank morphology will also adjust toward a new equilibrium.

Prior to urbanisation, the width of the northern Pumicestone Passage beaches was strongly dependant on the position of the ebb and flood channels (Riedel and Byrne, 1979). Today, the beaches are managed using a combination of shoreline erosion management options (refer BMT WBM, 2015).

The sequence of aerial photos in Figure 2-9 suggests a relatively stable physical system within the northern reach of Pumicestone Passage. The key threat to stability of the area is associated with the expected breakthrough of the Bribie Island spit. This may cause a change to the tidal regime within the northern Pumicestone Passage. Reduced tidal attenuation within the passage and therefore greater tidal amplitude will lead to an increased risk of coastal inundation associated with storm tide events. This threat is significantly greater for land assets on low-lying land south of the Caloundra Power Boat Club.

2.3.1.1 Golden Beach and Bribie Island Breakthrough Strategy (2015 – ongoing)

To address the perceived threat to assets and values, a strategy to implement the management options promoted in the Sunshine Coast Shoreline Erosion Management Plan (SCC, 2014) has been developed (BMT WBM, 2015). This strategy is underpinned by the monitoring of shoreline erosion and water levels within Pumicestone Passage. The following triggers for enhanced management action have been established:

(1) Material required for beach nourishment exceeds the existing permitted volume of 10,000m^3/year;

(2) An unstainable volume of sand is required for ongoing beach nourishment; and/or

(3) An observed increase to the mean high water springs level and/or mean sea level greater than 0.2m relative to 2014 levels.

Before any triggers are realised minor and existing permitted works, including the Golden Beach Nourishment program which allows the dredging and placement of up to 10,000m^3 of sand per year, are to continue under the strategy. This material is accessed from the permitted dredge area shown in Figure 2-10.

Realisation of the first trigger is intended to prompt an expansion of the dredging and nourishment program to provide material for the Nelson Street to Bells Creek Shoreline (up to 40,000m^3 of sand). Council has recently applied for environmental permits to access this one off volume from within the existing permitted dredge area.

Realisation of the second and/or third trigger indicates that shoreline values and inundation risk are not being maintained via beach nourishment and that the detailed design and construction of a revetment seawall along the Nelson Street to Bells Creek Shoreline is to commence. This structure is primarily intended to mitigate coastal inundation risk associated with an undesirable change to the tidal regime with Pumicestone Passage.

This strategy has been formally supported by DEHP in a letter from Director-General Jonathan Black dated 9th June 2015. This letter acknowledges the support of DEHP for coastal protection works at Golden Beach in response to a likely breakthrough of Bribie Island.

2.3.2 Environmental Constraints

The Directory of Important Wetlands Australia (DIWA) entry for the Pumicestone Passage nationally important wetland (QLD136) describes the area as follows:

> *Several creek systems drain into Pumicestone Passage at the northern extent of Moreton Bay. The direct access of these creeks to the sea is blocked by the barrier island, Bribie Island. This gives rise to a narrow, shallow passage which has limited water exchange with the ocean. The build up of silt carried down through these creeks has formed vast tidal flats, providing feeding areas for waders. Seagrass meadows occur throughout the site. The adjacent national park on Bribie Island is fringed by mangroves backed by melaleuca swamps*.

As noted in this entry, the northern Pumicestone Passage provides a number of significant environmental values which constrain the extraction of sand. Specifically, these include:

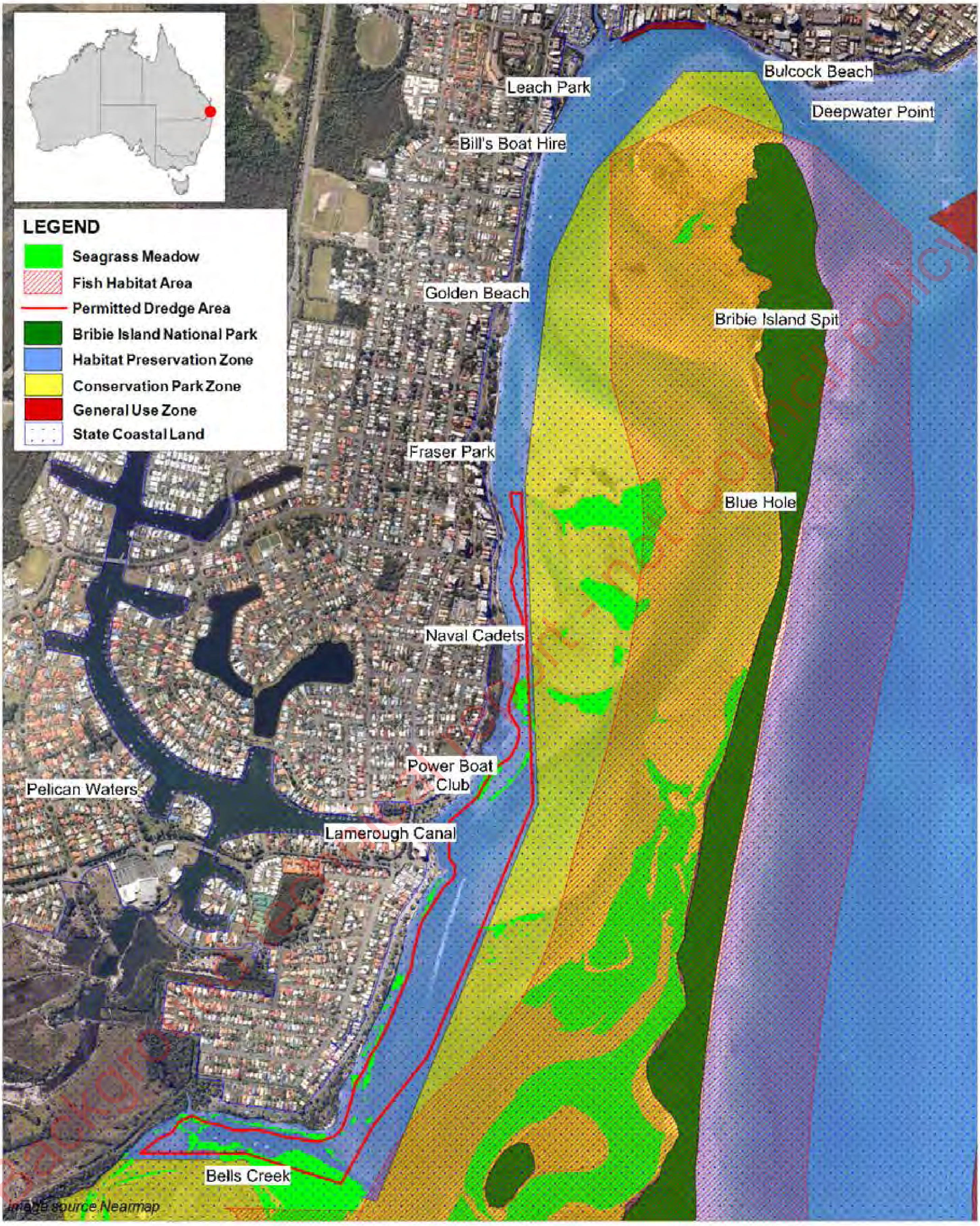
- Intertidal habitat suitable for resident and migratory shorebirds, protected under state and federal legislation as well as international conventions;
- Seagrass meadows and other habitat values that support fishery values (including recreational and commercial fisheries) and marine megafauna (e.g. loggerhead turtles, green turtles, dugongs) which are protected under state and federal legislation; and
- High environmental values waters.

In addition to these values, the northern Pumicestone Passage is part of the Moreton Bay Marine Park, the Moreton Bay Ramsar Wetland of International Importance, and the Pumicestone Channel Fish Habitat Area (FHA). Some of the intertidal wetlands in these areas are also included in the Bribie Island National Park.

These values and protected areas typically constrain dredging to existing navigational areas that are free from seagrass. In addition, sand access is constrained to activities that would limit impacts to water values, intertidal nesting areas and resident fauna (e.g. seasonal limitations to avoid impacts to shorebirds, operational limitations to avoid generation of turbidity).

The environmental constraints relevant to the northern Pumicestone Passage sand source are shown in Figure 2-10. The existing permitted dredge area and a proposed extended dredge area are discussed further in Section 2.3.4.

Figure 2-9 Northern Pumicestone Passage Morphology 21/07/2010 to 09/04/2015 (NearMap, 2015)



Title:

Environmental Constraints within Northern Pumicestone Passage

Figure:
2-10

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0 375 750m
Approx. Scale

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2.3.3 Sediment Quality and Suitability for Beach Nourishment

Sediments within northern Pumicestone Passage are generally expected to be suitable for nourishment of the adjacent mainland beaches. Council holds existing permits that allow the dredging and placement of sand throughout this area. The notional “approved” maintenance dredge area, subject to permit conditions, is shown in Figure 2-11.

Sediment sampling and analysis previously completed by Cardno Bowler Pty Ltd in 2011 identified that subsurface strata throughout the maintenance dredge area were dominated by fine to medium grained sands with varying but generally very low levels of silt. The sediment investigation report including borehole logs 2-3m below the seabed and laboratory analysis results is provided in Appendix C. Findings relevant to the present project included:

- Sediments tested were generally consistent and dominated by sands with low levels of silt.
- The southern section of the maintenance dredge area (toward Bells Creek) showed more variable soil profiles with some darker material close to the surface. The more northern sample locations were generally more uniform and paler in colour.
- The presence of Acid Sulfate Soils (ASS) was detected however in the majority of samples the levels of acidity were very low. In all but three of the samples the material intrinsic acid neutralising capacity exceeds the potential of the material to generate acidity.

The additional characterisation of sediments within the existing permitted dredge area may be required prior to any future renourishment campaigns.

2.3.4 Estimated Quantity of Sediment Suitable for Beach Nourishment

The available sand resource with Northern Pumicestone Passage is primarily limited by the environmental constraints discussed in Section 2.3.2 and mapped in Figure 2-10. Nevertheless, this sand source is expected have sufficient material for the nourishment of mainland shorelines in the short to medium term.

An extended dredge area is proposed in Figure 2-11. This area has similar characteristics to the existing permitted area (also shown in Figure 2-11), namely:

- Navigation channel for recreational boating
- Outside of the Marine Park Zones
- Maintains a buffer from FHA of at least 100m.

Considering both the existing and proposed dredge areas and an average dredge depth of 2m the following estimates have been derived:

- Existing permitted dredge area: 325,000m^3
- Proposed extended dredge area: 374,000m^3.

These estimates assume the following:

- A dredge depth of 2m. This assumption is based on previous borehole logs 2-3m below the seabed showing a dominance of fine to medium grained sands within the existing permitted area (refer Appendix C).
- An exclusion of the southern section of the permitted area due to the more variable sediment profiles and the presence of seagrass habitat.

Key conditions regarding seagrass attached to the existing permits for dredging within Pumicestone Passage are listed in Section 2.3.5.

2.3.4.1 Moreton Bay Park Zone Review

The original Moreton Bay Marine Park was implemented in 1997. It was reviewed in 2007/08 and the current zoning plan came into effect on 1 March 2009. A review of the zoning plan for Moreton Bay is required under the *Statutory Instruments Act 1992*, which requires subordinate legislation to be reviewed every 10 years.

The process for the forthcoming zoning plan review is expected to commence in 2017. During this process user groups will have an opportunity to propose changes to the zoning plan. In the context of the sand sourcing study, the Moreton Bay Conservation Park Zone (refer Figure 2-10) currently restricts access to a significant reserve of sand within northern Pumicestone Passage. Council may wish to make a submission to the review to provide to allow access to this sand for the purpose of nourishing the mainland shoreline. For example, additional material could become available through either:

- Revocation of the of the Conservation Park Zone or changes to its landward extent; or
- Changes to the permitting conditions that currently restrict the extraction of sand from within the Conservation Park Zone.

Title:

Permitted and Proposed Dredge Areas within Northern Pumicestone Passage

Figure:
2-11

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2.3.5 Operational Considerations

It is assumed that a small, shallow draft cutter suction dredge (CSD) similar to that shown in Figure 2-12 could access the target dredge areas with Northern Pumicestone Passage. A CSD works most effectively in loose unconsolidated material which is pumped directly by pipeline to a disposal area. Such operations are an efficient means of delivering sand to a target renourishment location. The maximum distance of pumping depends on the dredge capacity. For the type of dredger that would have sufficient manoeuvrability to operate effectively in Pumicestone Passage a maximum pumping distance of approximately 1 km may apply. If required, delivery of sand beyond this distance would be achieved using booster pumps along the pipeline route. A pipeline would need to be permanently in place over the dredging period, as it cannot be easily dismantled and installed each day. Council had recent experience with this type of dredging and placement method through the Maroochydore Beach Renourishment Project (discussed further Section 2.4.1.1).

Figure 2-12 400mm Cutter Suction Dredge (Photo Courtesy of Hall Contracting)

It is noted that the placement of 40,000m^3 of material between Bells Creek and Lamerough Canal proposed as of the Golden Beach and Bribie Island Breakthrough Strategy is intended to be an expansion of the existing permitted dredging activities for a single year only. In subsequent years, the permitted allocation of up to 10,000m^3/year is expected to provide sufficient material for nourishment throughout the wider Golden Beach study area.

It's also expected to be operationally feasible for minor renourishment of Kings Beach using a CSD and pipeline from Northern Pumicestone Passage (approximately 1km north of the northern entrance). Alternatively, material could be temporarily stockpiled at Bulcock Beach (Deepwater Point) and transported via truck to Kings Beach. The SEMP (SCC, 2014) identifies this location as a priority area for minor nourishment and this work could be coordinated with the planned restoration of the Kings Beach groyne.

It is expected that Pumicestone Passage dredging would be undertaken during the winter months due to calmer conditions (i.e. to avoid summer storms) and in consideration of shorebird roosting and foraging and seagrass growing seasons (typically occurring in summer). Depending upon the nature of the dredge used a dredge rate of approximately 200m^3/h (~10,000m^3/week) and operating six days per week between 7am and 5pm is expected to be feasible within Pumicestone Passage.

Some of the relevant conditions attached to the existing permits for dredging within Pumicestone Passage are as follows:

- Maintain a buffer of 50m from seagrass and100m from Pumicestone Channel FHA;
- No disturbance of marine plants;
- No visible plume beyond 50m of dredging and placement activities;
- Dredging material to be free of silt and contaminants (to be determined through sediment sampling);
- No visible petroleum products;
- Maintaining pH between 8-8.3 in dry weather and 6.5-8.3 during wet weather;
- Treatment of any ASS exposed during operations;
- Dredging not to exceed 30 days in a calendar year;
- Seagrass survey to be undertaken prior to any dredging in a calendar year to confirm presence and extent of seagrass patches; and
- Submission and implementation of a seagrass monitoring plan.

As a minimum, any ongoing and/or expanded dredging operations would be expected to meet these conditions.

2.3.6 Costs

The cost estimate to dredge and deliver sand to mainland shorelines within Northern Pumicestone Passage via a small CSD is approximately \$11/m^3. The cost per cubic metre estimate is greater than similar works in the lower Maroochy River (refer Section 2.4.6) due to the relatively small volume of sand likely to be targeted Pumicestone Passage (Denis Shaw, pers. comm. 2015).

The extraction and delivery of 40,000m^3 of nourishment material proposed under the Golden Beach and Bribie Island Breakthrough Strategy would therefore cost approximately \$0.45 million dollars in 2015.

2.4 Lower Maroochy River

2.4.1 Study Area Description and Previous Work

The lower estuary of the Maroochy River is a complex system of channels, intertidal shoals, islands and coastal bars. The entrance is dominated by a large spit which extends southwards from the north shore. Within the estuary Goat and Channel Islands (presently connected) divide the river into two main channels.

The river entrance is an important controlling factor on the tidal regime in the estuary. The shoals and sand bars at the entrance generally restrict the propagation of the tide from the ocean into the estuary with corresponding reduction in the tidal range when the entrance area is relatively small. Natural river entrances on sandy coastlines have been shown to exhibit a dynamic equilibrium wherein there is a relationship between the tidal prism and the cross-sectional area of the entrance (e.g. O'Brien, 1969). The present river entrance is considered to be in such dynamic equilibrium.

As part of the process of the Maroochy River entrance relocating to the south of Pincushion Island in 1999 (e.g. Andrews and Witt, 1999), a large quantity of sand, which was the beach and dune system connecting to Pincushion Island, moved into the entrance. This caused substantial shoaling in the lower part of the estuary. This sand has largely remained within the estuary and is reworked by the prevailing coastal and estuarine processes. Under major riverine flood conditions much of this material would be scoured and naturally distributed back to the sea with the flood flow discharge. Such river conditions have not been experienced in the lower Maroochy River since 1992, an event that caused the river mouth bed level to scour and deepen by up to 4m (e.g. BMT WBM, 2008).

At the Maroochy River entrance there is a strong relationship between coastal and estuarine processes. Coastal sediment transport plays a significant role in the development of coastal spits and the migration of the entrance channels. It is also an important factor in the overall dynamic behaviour of the lower river by suppling sand which is transported into the estuary under the influence of the prevailing tide and south-easterly wind and wave conditions. The coastal sand typically forms as a spit connected to the Cotton Tree Holiday Park shoreline before a breakthrough of the spit occurs and the sand enters the lower estuary. The aerial imagery presented in Figure 2-14 to Figure 2-16 shows the ongoing cycle of spit formation, subsequent breakthrough into the entrance and spit reformation between 2010 and 2015.

2.4.1.1 Maroochydore Beach Renourishment Project (2013 – ongoing)

Stage one of the Maroochydore Renourishment Project was completed in 2013 and involved relocation approximately 125,000 m^3 of sand from a permitted area within the lower Maroochy River to Maroochydore Beach. The sand was relocated via a Cutter Suction Dredge (CSD) and pipeline. The dredge can be seen working within the permitted area in aerial image dated 11/08/2013 in Figure 2-16. Stage one before and after photos are shown in Figure 2-13.

Figure 2-13 Before (left) and After (right) Maroochydore Beach Renourishment Project Stage One (photos courtesy of Birdon Pty Ltd)

A subsequent campaign involving the relocation of 75,000m^3 of sand was recently completed in 2015. Under the regulatory approvals associated with this project Council is permitted to relocate up to 350,000m^3 of sand over a four year period (dated from November 2012), subject to the availability of sand within the designated dredge footprint within the lower Maroochy River. Considering the sand volumes extracted during the 2013 and 2015 campaigns, Council has a remaining allocation of 150,000m^3 until late 2016 under the existing permits. The monitored infilling of the designated dredge area by natural coastal processes is considered in Section 2.4.4.

2.4.2 Environmental Constraints

The majority of the lower Maroochy River is part of the Maroochy River FHA based on the fisheries values provided within the river. While there is no known seagrass through this area, fish passage is known to occur to the north and south of Channel and Goat Islands. In addition, the sand banks of the estuary provide roosting and feeding habitat for resident and migratory shorebirds. These include species protected under state and federal legislation and international conventions. Turtle nesting has also be known to occur on the coastline near the estuary mouth albeit extremely rare. Turtle foraging may also occur within the mouth.

The north shore or the Maroochy River, including intertidal areas and parts of Goat and Channel Islands, is part of the Maroochy River Conservation Park.

These values constrain sand access to areas outside the FHA and within the marked navigation channel. In addition, extraction activities would be operationally and temporally constrained to avoid impacts to migratory shorebirds and marine turtles.

The environmental constraints relevant to the lower Maroochy River sand source are shown in Figure 2-17. The existing permitted and proposed extended dredge areas discussed further in the following sections are also indicated.

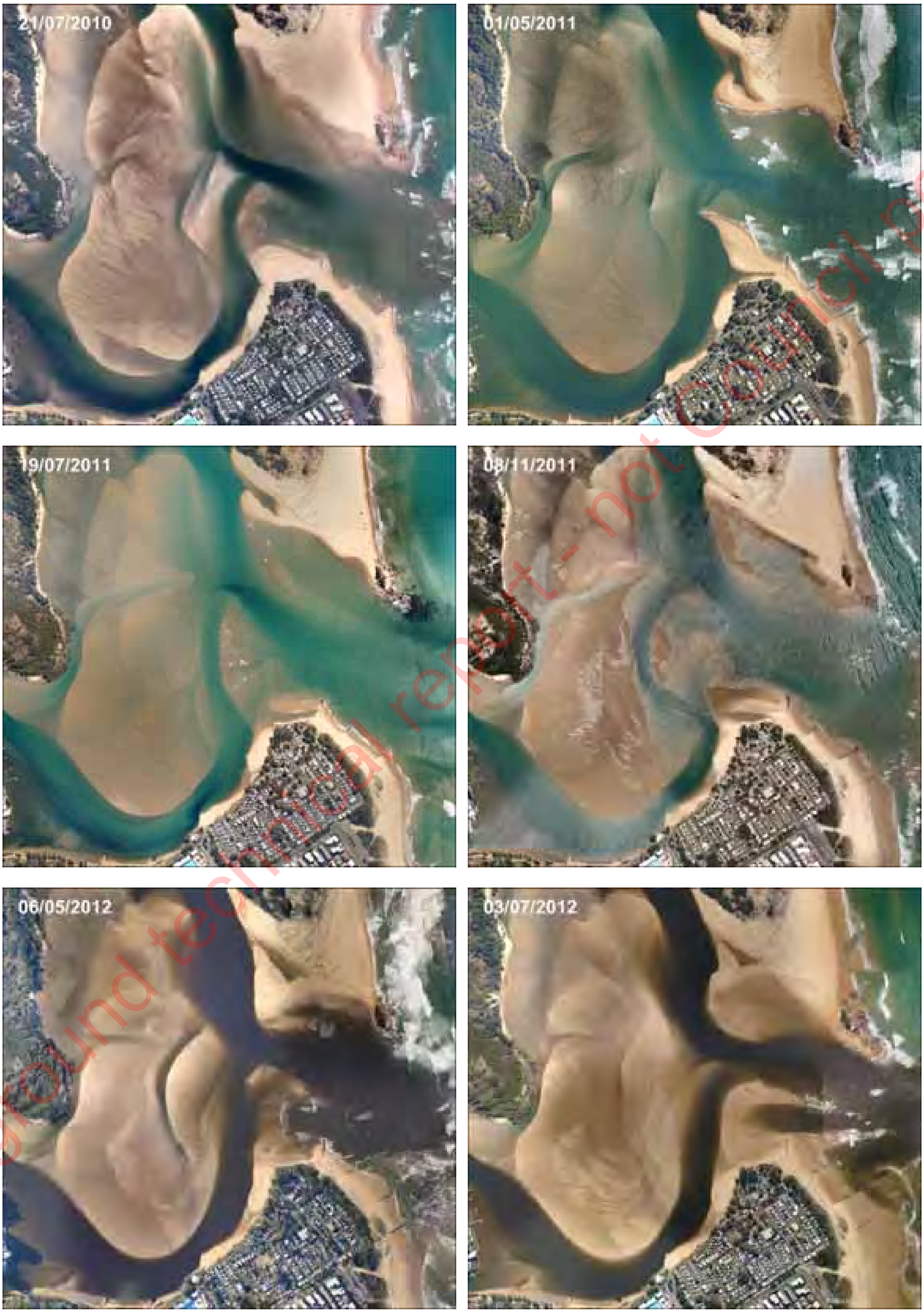

Figure 2-14 Maroochy River Mouth Morphology 21/07/2010 to 03/07/2012 (NearMap, 2015)

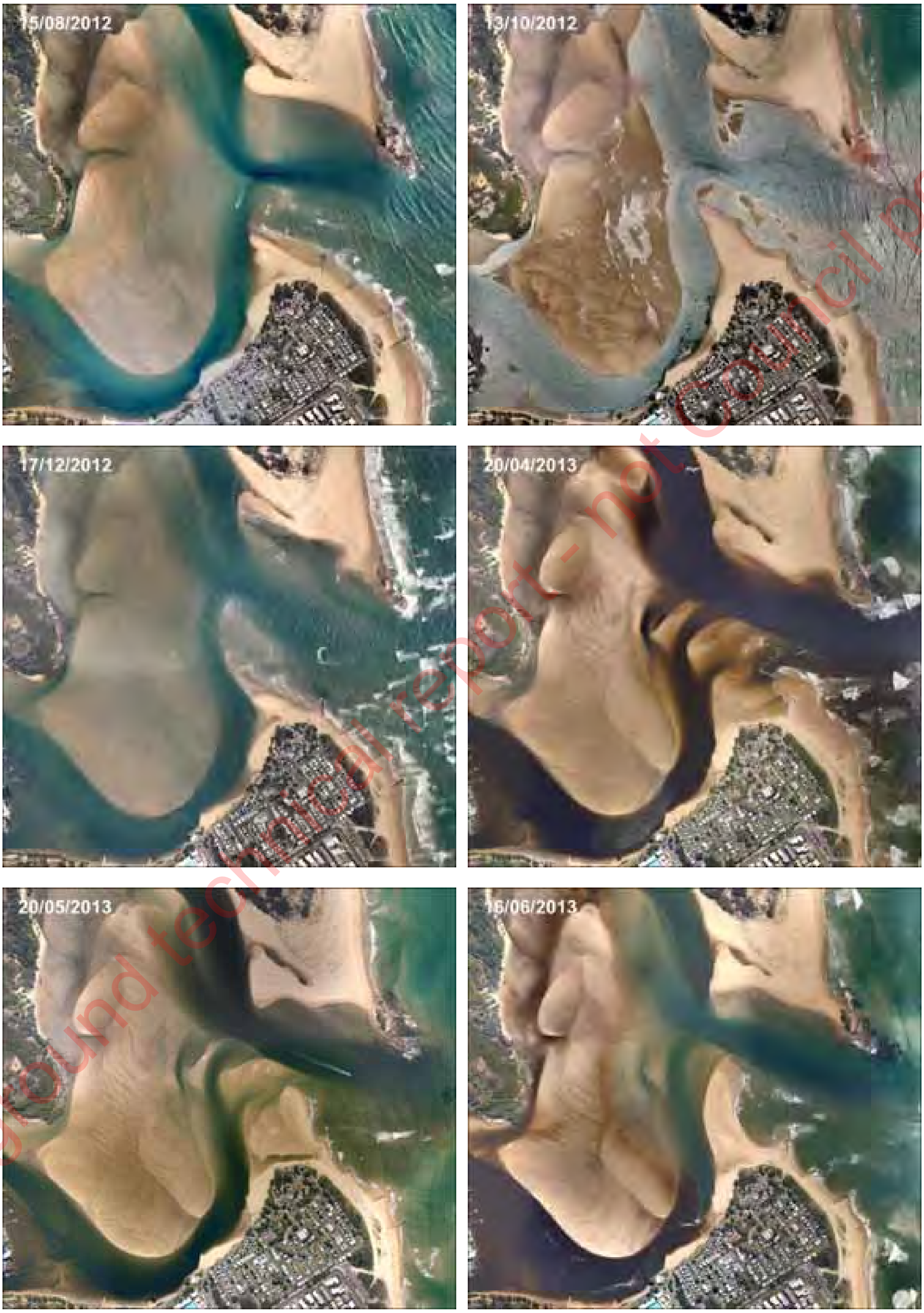

Figure 2-15 Maroochy River Mouth Morphology 15/08/2012 to 16/06/2013 (NearMap, 2015)

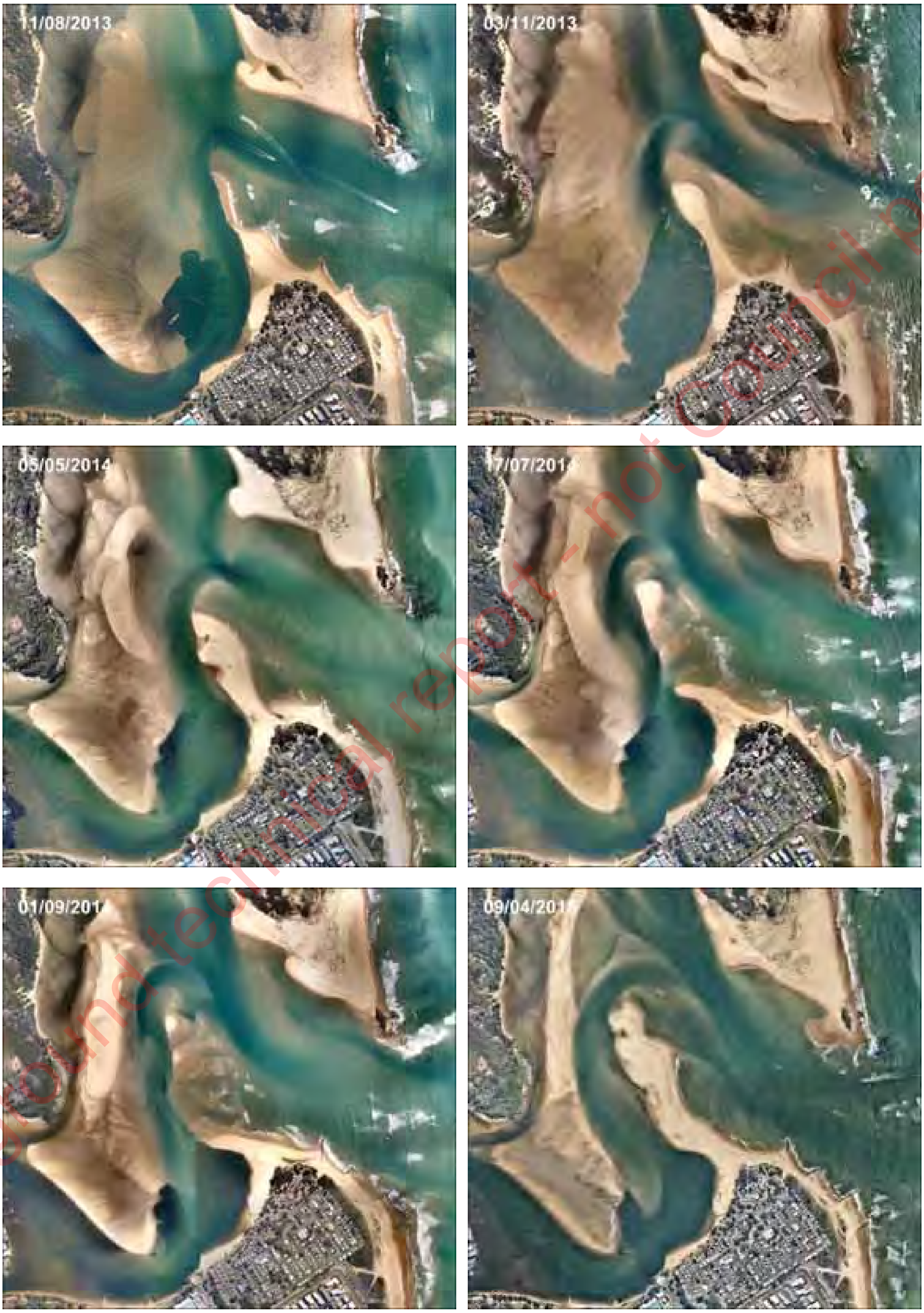

Figure 2-16 Maroochy River Mouth Morphology 11/08/2013 to 09/04/2015 (NearMap, 2015)

Title:

Environmental Constraints within the Lower Maroochy River

Figure: 2-17

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N

0 250 500

Approx. Scale

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2.4.3 Sediment Quality and Suitability for Beach Nourishment

As part of a suite of feasibility studies completed to support the Maroochydore Beach Renourishment Project approval application (BMT WBM, 2012), a Maroochy River mouth sediment investigation was undertaken by Cardno Bowler Pty Ltd in 2011. The investigation targeted potential areas to extract sand for the purpose beach nourishment. Samples were laboratory analysed for PSD and ASS. The sediment investigation report including borehole logs and laboratory analysis results is provided in Appendix D. Findings relevant to the present project included:

- The target depth for sediment boreholes was 3m below the existing sediment surface level however some boreholes were terminated slightly above this depth due to the presence of stiff clays. It is therefore assumed that any sand extraction operation for the purpose of beach nourishment would not exceed a dredge depth of 3m.
- PSD analysis identified a dominance of non-cohesive sand material and a high proportion of particles with a diameter between 0.150-0.425mm. This range in grain size is consistent with the material found on Maroochydore Beach where the median sand grain size diameter (D_{50}) is approximately D_{50} = 0.2mm.
- The presence of ASS was detected however the in the majority of samples the levels of acidity were very low and in all cases the material intrinsic acid neutralising capacity exceeds the potential of the material to generate acidity. As such no further treatment of the materials tested would be required.
- While the dominant particle size is consistent with that typically sort for beach nourishment purposes, the material quality present at the upstream sample locations (Areas 1, 2 and 3 in Cardno Bowler, 2011b) would not be suitable for nourishment of Maroochydore Beach. This was based on the variable makeup of the material including colour and silt content.

The outcomes of the Cardno Bowler (2011b) investigation helped to guide the selection of the target area for beach nourishment sand within the lower Maroochy River. This area is shown in Figure 2-17 and Council received permits to extract material from this designated footprint in 2012.

In preparation for Stage 2 of the Maroochydore Beach Renourishment Project, additional sediment sampling and analysis was undertaken during 2015 within and adjacent to the designated footprint. The sediment investigation report including borehole logs and laboratory analysis results is provided in Appendix E. This investigation helped to confirm the availability of suitable material within the designated area prior to the 2015 dredging and renourishment campaign. In addition, the areas adjacent to the designated area were also show to contain suitable beach nourishment material. The ongoing availability of sand within the lower Maroochy River is considered further in Section 2.4.4.

2.4.4 Estimated Quantity of Sediment Suitable for Beach Nourishment

Similar to northern Pumicestone Passage, the available sand resource within the lower Maroochy River is primarily limited by the environmental constraints. In the short term (up to 5 years) it is anticipated that this sand source can provide enough material to offset undesirable erosion at Maroochydore Beach. However, this limited sand source may not have the capacity to mitigate the risks to land based assets in the medium to long term or provide sufficient material to recover from an extreme erosion event (or sequence of events).

Prior to the 2015 dredging campaign the existing permitted area was surveyed and estimated to contain approximately 75,000m^3 of sand suitable for renourishment purposes (Definium, pers. comm. 2015). This estimate considered a depth to 3m below AHD and excluded the southwest corner of the permitted area where a more variable sediment profile was identified during dredging in 2013. Most of this available volume can be attributed to material that has infilled the area since the previous dredging and renourishment campaign. Figure 2-18 provides a comparison of hydrographic surveys obtained at the completion of the 2013 dredging and prior to the commencement of dredging in 2015[5]. This comparison suggests a fill volume of 73,327m^3 (indicated under General Notes) between October 2013 and June 2015 which corresponds to an infilling rate of approximately 50,000m^3/year. Based on this finding and the existing dredging and renourishment practices, Council could expect lower Maroochy River sand source to sustainably provide up to 100,000m^3 every two years. It is noted that this estimate is based on limited data and that amount a material available for a given renourishment campaign would require confirmation via hydrographic survey and sediment sampling.

An extended dredge area is proposed in Figure 2-19. Similar to the existing permitted area (and associated permit conditions) the extended area maintains a 50m buffer from the FHA boundary shown Figure 2-17. Assuming a dredge depth of 3m, this area could provide an additional 105,000m^3 of renourishment material for Maroochydore Beach.

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[5] This comparison includes the amended dredge footprint area (i.e. the small triangle area to the north of the permitted area shown in Figure 2-18). This additional area was approved for dredging in 2013 and again in 2015.

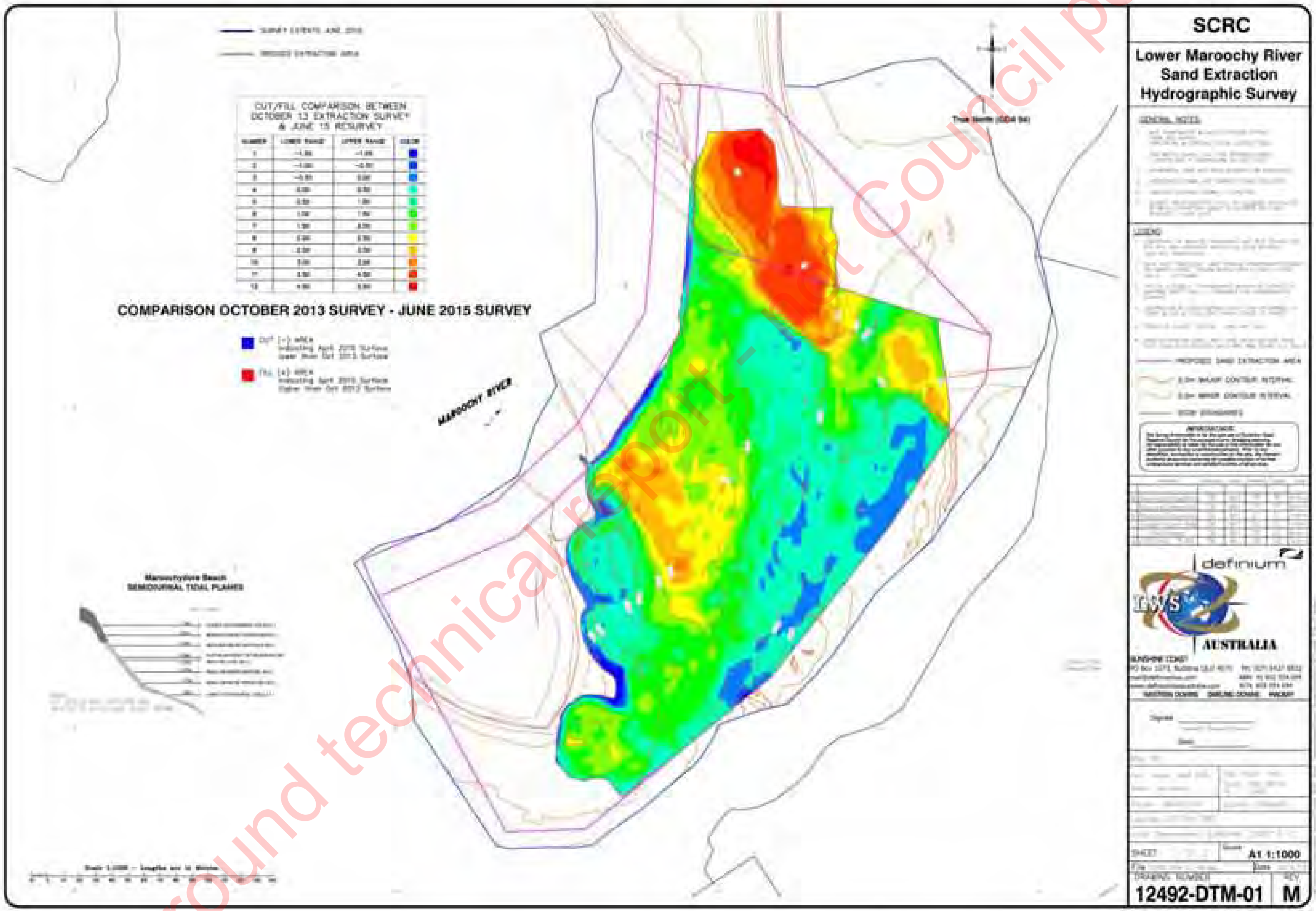

Figure 2-18 Infilling of the Permitted Dredge Footprint between October 2013 and June 2015

Title:
Dredge Areas within the Lower Maroochy River

Figure:
2-19

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A

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0 200 400m
Approx. Scale

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www.bmtwbm.com.au

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2.4.5 Operational Considerations

Consistent with recent dredging campaigns in the lower Maroochy River, any ongoing access to this sand resource is likely to be via a CSD and pipeline with profiling of the material using standard earthworks equipment as shown in Figure 2-12. Other general considerations relevant to this renourishment methodology have been previously discussed in Section 2.3.5.

Figure 2-20 Cutter Suction Dredge and Pipeline Sand Delivery to Maroochydore Beach

The primary operational constraint associated with the existing permits to access material from the lower Maroochy River is:

- Nourishment activities can only take place between May and September on the basis of potential impacts to migratory birds and turtle nesting.

2.4.6 Costs

Based on the 2013 and 2015 renourishment campaigns, the cost deliver sand to Maroochydore Beach from the lower Maroochy River via a small CSD is approximately \$8/m^3 in 2015 (including beach profiling). This cost estimate is based on the relocation of at least 70,000m^3 and that access to the semi-permanent pipeline that was installed as part of stage one of the Maroochydore Renourishment Project is available.

3 Approval Strategy and Legislative Framework

3.1 General Approval Strategy

As discussed in Section 2, the primary sand extraction opportunities available at the Sunshine Coast are those related to nearshore/estuarine sand sources already exploited by SCC. These consist of the Pumicestone Passage and Lower Maroochy River, as well as sand available from dredging operations undertaken by PBPL. Section 3.2 discusses the approval implications of extraction from a new offshore site.

Due to historical approved dredging and placement activities in Pumicestone Passage and the Maroochy River, there is an existing approvals and management framework that would form the basis of an overarching approvals strategy.

The use of sand from PBPL provides access to an existing quantity of material without the need for a specific extraction permit but would still need to consider approvals for placement sites and methods.

In this context, approvals may be required for both onshore placement (i.e. placement on beaches from a cutter suction dredge or similar operating in Sunshine Coast sandbanks) and nearshore subtidal placement (i.e. in 8m depth from the PBPL dredge due to operational depth constraints).

The considerations making up an approvals strategy for these options are discussed below.

3.1.1 Planning and Tenure Considerations

It is assumed that all dredging in the Pumicestone Passage and Lower Maroochy River would allow for the placement of material onshore due to the dredging plant typically used in these areas (i.e. cutter suction dredge).

In this context, the following approvals would likely be required for these options:

- Quarry material allocation under the *Coastal Protection and Management Act 1995* for the purposes of removing material from below high water mark (i.e. placement above high water);
- An environmental authority under the *Environmental Protection Act 1994* for ERA 16 (dredging);
- Development permit under the *Sustainable Planning Act 2009* pursuant to the *Coastal Protection and Management Act 1995* for the purpose of conducting tidal works, including prescribed tidal works (i.e. works in local government tidal waters), and pursuant to the *Fisheries Act 1995* for the purposes of conducting work impacting on marine plants (e.g. seagrass);
- Referral and prospective approval under the *Environment Protection and Biodiversity Conservation Act 1999* to address potential impacts on migratory shorebirds (both sites), threatened megafauna and Ramsar wetlands (Pumicestone Passage only); and
- Permit to undertake works in relevant zones of the Moreton Bay Marine Park under the *Marine Park Act 2004* (Pumicestone Passage only).

Use of material accessed by PBPL does not require an additional extraction permit on the part of SCC (assuming the required volume of sand can be sourced from PBPLs maintenance activities and/or current allocation of sand as part of the Spitfire Channel Realignment Area). However, the establishment of one or more new placement areas for this material will require:

- Tidal works development permit under the *Sustainable Planning act 2009* and *Coastal Protection and Management Act 1995*; and
- Any permits related to impacts on environmental constraints that existing in the placement area, i.e. marine plants, fish habitat, marine park zones and/or matters of national environmental significance.

It should be noted that any subtidal placement (e.g. below high water mark) will not require a separate allocation of quarry material on the basis that the material is not being 'removed' from the system.

3.1.2 Environmental Considerations

As discussed in Sections 2.3 and 2.4, existing sand sourcing areas used by the Sunshine Coast Council occur in areas with high environmental values and conservation significance.

The Pumicestone Passage in particular is recognised as an internationally important wetland/estuary in relation to local seagrass beds and intertidal habitat and providing habitat for migratory and threatened species. They key environmental values in this area related to dredging are seagrass beds and associated fish habitat, and migratory shorebird roosting areas. In addition, marine megafauna (e.g. turtles, dugongs) are known or likely to occur throughout the area and are protected under both Federal and State legislation.

The values of the Lower Maroochy River also include fish habitat areas and intertidal habitat for migratory shorebirds, though this area is not noted as having seagrass and is not protected under marine park or Ramsar listings. Potential placement areas at the Sunshine Coast, potentially along the open coast, provide habitat opportunities for migrating marine megafauna and shorebird roosting.

Sediment in both estuaries is typically known to be clean sand though pockets of silty and potential acid-forming sediment have also been identified as part of previous dredging exercises. Sediment beyond current active dredging areas has not been tested and could contain higher quantities of fines impacting on water quality during both dredging and placement although risk of contamination is considered to be low.

Current sand supplies in both areas are expected to be of a volume adequate for sand sourcing activities without an adverse impact to coastal processes. However, studies have indicated that a breakthrough of the Bribie Island spit is likely to occur within the current planning horizon and the impact of a breakthrough on sand supply would need to be considered as part of a long term approvals strategy.

Based on these constraints, significant expansion of dredging and placement operations will likely be problematic with a need to demonstrate a clear and present need for addressing erosion 'hot spots' and through the evaluation of other feasible alternatives to expanding dredging operations.

3.1.3 Heritage Considerations

There have been no significant studies into heritage values in the Pumicestone Passage and Lower Maroochy Estuary though previous dredging exercises are yet to have uncovered any items of heritage value. Moving beyond these pre-existing areas for dredging and/or placement may lead to discovery of heritage items, however. As native title notification is expected to be required for approval applications in these areas, any significant risk of heritage impacts may trigger the need for a Cultural Heritage Management Plan or similar arrangement with local Aboriginal Parties. Historic heritage values would also need to be investigated as part of selection of new sites or the expansion of existing sites.

3.1.4 Socio-economic Considerations

Both the Pumicestone Passage and Maroochy River are used for navigation and recreational purposes. These areas also support significant fisheries values and are located within close proximity of holiday/recreation infrastructure (e.g. Tripcony and Cotton Tree caravan parks). Other socio-economic values are also known to occur across the Sunshine Coast beaches, including areas that could be affected by dredging and placement operations. Therefore socio-economic considerations in conducting dredging and placement include:

- Navigational use of dredging areas by recreational and commercial boat users, especially in Pumicestone Passage where dredging currently occurs only in the navigation channel;
- Recreational and commercial fisheries operating in the Pumicestone Passage and Lower Maroochy River as well as in nearshore areas across the coastline; and
- Amenity and recreational use values of local beaches, especially in the context of caravan parks, recreation reserves, boardwalks and foreshores, and patrolled swimming beaches.

3.1.5 Timing and Approval Pathway

Depending upon the extraction and approval approaches adopted for the sand sourcing options, timing for approval may vary between 6 months (if existing permits can be amended) and 18 months (where an EIS or strategic sand sourcing approval is required). At present, there are a number of approval pathways which would need to be refined upon further investigation of a sand sourcing project in these areas:

- Expansion of existing extraction approvals already present in Pumicestone Passage and Maroochy River – this would be feasible where sand sourcing needs can be met without a significant increase in extraction volumes or locations. This could be handled mostly through renewal or amendment of existing permits and would be expected to take up to 6 months at a maximum without significant commissioning of new environmental studies. The overall scope of the approval, therefore, would need to be determined and discussed with regulators to ensure the volumes required could be permitted for the planning horizon intended by SCC.
- Obtaining approval for existing and new placement sites (using sand from the Passage, Maroochy River or PBPL material) – this would require new environmental assessment studies to support a permit application for placement sites and would be expected to be able to be completed within 6-9 months. This process would be fairly straightforward and anticipated to

cost in the order of $20,000-$40,000 depending upon the number, extent and sensitivity of proposed placement locations.

- Extraction of material from existing sites that represents a significant change from existing operations - particularly if significantly larger volumes of sand are required to meet SCC nourishment needs. This process would almost certainly require additional environmental assessments and new State approvals, including, potentially the need for an EIS prior to lodgement of applications. Depending upon the nature of the constraints and impacts in the proposed extraction areas, this approval pathway could take on the order of 12-18 months.

As discussed with Council officers, all of these approval pathways could benefit from a greater 'systems approach' to sand extraction and nourishment across the LGA under an integrated approach. This strategy could allow extraction and placement in the long-term to be managed under a single permit with different zones of environmental management and planning based on known environmental constraints and risks. However, such an approach will likely take considerable up-front investment to determine sand and nourishment requirements and subsequent negotiation with agencies which will, in turn impact on timing.

3.2 Additional Considerations for Establishing a New Offshore Sand Extraction Site

As outlined in Section 2.2, the Sunshine Coast offshore sand area option provides a long term, semi-permanent source of suitable sand for beach nourishment in relative close proximity to required nourishment areas.

However, compared to other options, there are no secondary benefits from extraction (such as improved maritime navigation from the shipping channel options), nor is the area subject to active coastal processes where some level of accretion and sand replenishment would be likely over time (as it the case at the estuary mouths). Impacts in this context would be more permanent to the offshore area but noting the general absence of sensitive ecological receptors that are present in the alternative nearshore environments.

The following sections described the issues that would need to be considered and resolved in assessing the feasibility of establishing a long term sand extraction area in offshore waters of the Sunshine Coast.

3.2.1 Planning and Tenure Considerations

Assuming all extraction and subsequent placement occurs below the high water mark, the extraction and placement is outside the jurisdiction of the local government planning scheme. Likewise, the area is not located within a State or Federal marine park. Given this, the major planning consents required would be:

- An allocation to access the resource in the form of a lease under the *Land Act 1994*, a permit to occupy under the *Land Act 1994* or a right to use and occupy associated with an approval for tidal works pursuant to the *Coastal Protection and Management Act 1995;*

- Approval under the *Environment Protection and Biodiversity Act 1999* pursuant to potential impacts to migratory marine species and the Commonwealth Marine Area;[6]
- Approval under the *Sustainable Planning Act 2009* pursuant to the *Coastal Protection and Management Act 1995* for tidal works (sand extraction works area) and material placement in a coastal management district; and
- An environmental authority for ERA 16 under the *Environmental Protection Act 1994*.

3.2.2 Environmental Considerations

As outlined previously, the main environmental constraints associated with offshore extraction are:

- Loss of benthic macrofauna and infauna within the actual sand extraction footprint
- Potential interactions (vessel strike, noise, etc.) with migratory/transient marine megafauna that may pass through the area.

In particular, the offshore waters may provide suitable habitat for spanner crabs (*Ranina ranina*), a commercially important fishery value, as these crabs typically inhabit depths of 10-100m on sandy-smooth substrata.

More detailed survey of the seabed would also be required in the proposed works areas to exclude and provide a buffer to any hard substrate or biogenic rubble found on the seabed in the proposed extraction area which may act as a fish and crustacean aggregation point.

Marine megafauna that may transit the area include migratory whales (e.g. southern right whale, humpback whale, Bryde's whale), dugongs, large sharks, dolphins (e.g. dusky dolphin, Irrawaddy dolphin, Indo-Pacific humpback dolphin) and marine turtles (e.g. loggerhead turtle, green turtle). However, given that seagrass is unknown/unlikely to occur in this area, it is unlikely that any foraging by dugongs or turtles occurs. Further study would also be warranted to ensure the area is not used by any of these pelagic species for breeding, calving or other important life cycle periods.

Marine sediments from the area have been assessed from a geotechnical perspective as suitable for nourishment noting some basic sediment chemistry and porewater testing would be warranted to ensure all the material is high quality, clean Holocene sand deposits.

Impacts to coastal processes and water quality would be negligible in the offshore area but may require some further consideration in the context of impacts to offshore islands and reefs and in the near shore areas during placement activities. This would likely take the form of some predictive modelling and then monitoring of dredge plumes on any identified sensitive receptors.

3.2.3 Heritage Considerations

The potential for indigenous cultural heritage objects or artefacts in the offshore area are extremely low, particularly if all sand that is targeted is from Holocene-aged deposits (e.g. avoiding Pleistocene aged strata that may have been exposed during Aboriginal occupation of the landscape prior to the most recent sea level rise during the Holocene marine transgression).

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[6] A referral under the Act would be required to determine if the activity was a controlled action requiring approval, a controlled action that does not require approval if undertaken in a particular manner or not a controlled action under the EPBC Act. The proposed extraction area is likely landward of the Commonwealth Marine Area but would be adjacent.

As there would not be registered Aboriginal Parties identified for the offshore area, native title notification would need to be undertaken as part of tenure and permit decisions, potentially leading to the development of a Cultural Heritage Management Plan for the works with nominated parties.

Shipwrecks may also occur in this area though this is not considered highly likely and does not pose a significant constraint outside of the footprint of the wreck. Given the large area of investigation, if any historic items of heritage value are discovered, operations could be moved to elsewhere in the approved footprint to avoid impacts.

3.2.4 Socio-economic Considerations

The offshore area would have a limited number of direct uses and users but noting the importance of investigating:

- Current use and any potential impacts to commercial fishing interests;
- Current use and any potential impacts to recreational fishing or boating interests including charters and similar operations;
- Current use and any adverse impacts from sand extraction on shipping and marine navigation; and
- Visual and other amenity impacts on nearby residents (depending on the distance between residential areas and frequency of offshore extraction).

3.2.5 Timing and Approval Pathway

The need for an EIS (under either the EPBC Act or State legislation such as the *Environmental Protection Act 1994)* will have a major effect on both the timing and cost of approvals and associated investigations regarding the offshore option.

If an EIS is not required, it is likely that the full range of approvals including tenure could be achieved in a 12 month period (or less) from lodgement. If an EIS is required, then it is likely that the approval timeframe would be on the order of 18-24 months (noting the need for issuance of a formal Terms of Reference for the study, bilateral agreement with the Commonwealth and public exhibition requirements).

In this context, the following approval pathway is recommended if this option is pursued:

(1) Prepare an Initial Advice Statement (IAS) or similar Review of Environmental Factors (REF) based on current knowledge and information about the area;

(2) Lodge the IAS/REF and hold initial meetings with relevant State and Commonwealth agencies to discuss the most likely approval pathway, the need for an EIS, and to confirm key issues and critical information gaps;

(3) Undertake targeted studies to fill critical information gaps; and

(4) Lodge development applications and Referral under the EPBC Act (assumes no EIS is required).

Preparation of an IAS/REF (Step 1 of the above) would be on the order of $50,000; noting the need for further investment depending on the extent of additional studies required and final approval pathway stipulated by the Government.

4 Additional Minor Sand Sources

The following additional sand sources are discussed in this Chapter:

- Currimundi Lake Entrance; and
- Mooloolaba Harbour Entrance

Permitted sand relocation works are currently undertaken on a semi-regular basis at both locations. These activities, and the potential to provide material to mitigate shoreline recession at adjacent open coast beaches, are discussed below.

4.1 Currimundi Lake Entrance

Currimundi Lake is a coastal lagoon which is intermittently open to tidal inundation from the ocean (e.g. Wilkes, 1995). When the entrance is open the tidal prism is relatively small and sand transported by tidal and wave driven currents deposits at the sheltered areas inside the entrance. Sand can accumulate rapidly at the entrance causing the lake to close. Once closed, the prevailing coastal processes will continue to push sand further into the lake forming a “sand plug”. The entrance will only reopen naturally with flood discharge after rain.

The Currimundi Lake system has been significantly modified and extended by canal estate development. The lake has also been connected to the artificial Lake Kawana. The system is now subjected to pressures associated with urbanisation and since the 1960’s the natural entrance processes have been intervened in an effort to achieve water quality and other environmental objectives. This is the management strategy currently adopted by Council with occasional works carried out as required to maintain the berm and a small channel and entrance to the north as shown in Figure 4-1.

Figure 4-1 Currimundi Lake Entrance (NearMap, 2011)

Council’s existing commitment to berm and entrance management avoids undesired physical and environmental outcomes that would be associated with the entrance remaining closed for an extended period.

Engineering of the entrance with structures such as training walls would have the objective of creating an ‘always open’ and well flushed system. This outcome would help manage water quality within the lake; however, it would also significantly alter the coastal processes and most likely lead to shoreline erosion at Wurtulla Beach. Ongoing maintenance dredging of the entrance would also be required. Management of the Currimundi Lake entrance should attempt to minimise the interruption to the natural sediment transport processes and therefore hard engineering of the entrance is not currently considered a viable option (e.g. BMT WBM, 2013b).

Management options for the entrance have been previously reported by Wilkes (1995), WBM Oceanics (2000) and more recently by Tomlinson et al. (2010) in their holistic study of the lake system. It is generally accepted that water quality and other environmental issues within the lake are influenced by the flushing potential at the entrance.

The recommendations regarding management of Currimundi Lake entrance reported by Tomlinson et al. (2010) are consistent with Council’s current management strategy and include:

- Artificial opening and closing of the entrance in an effort to achieve environmental objectives and manage the upstream flood risk; and
- Maintenance of a berm at height that minimises overtopping (a height approximately equivalent to the Mean High Water Spring level of 0.7mAHD) to stabilise the entrance and limit channel migration (see Figure 4-2).

Figure 4-2 Berm Building at Currimundi Lake Entrance (Sunshine Coast Daily, 2015)

Due to concerns regarding floodwater conveyance within the lake, significant dredging of the entrance was undertaken between December 2003 and April 2005. This exercise removed approximately 184,000m^3 of sand, effectively clearing the sand pug that had formed. It is estimated that 88,000m^3 of this material was used within the Lake Kawana development site (Tomlinson et al., 2010) with the remaining 96,000m^3 placed to the north of the entrance.

Due to the moderate erosion problems along the beaches to the south of the entrance, future sand plug removal or other necessary dredging activities should consider recycling some of the material to the south at either Moffat Beach (north of Tooway Creek) or South Currimundi Beach using conventional land based excavators and trucks. This would help relieve shoreline erosion pressure at these beaches. Material placed on beaches to the south would be expected to slowly migrate back toward the entrance under the prevailing coastal processes. Infilling rates at the entrance are not currently known; however, a net longshore sediment transport rate of 3,700 m^3/year has been previously estimated at South Currimundi Beach (BMT WBM, 2013). It is therefore assumed that the annual relocation of approximately 3,700 m^3 to adjacent updrift (southern) locations would be sustainable.

4.2 Mooloolaba Harbour Entrance

Training of the Mooloolah River occurred in 1968/69 and since this time the harbour entrance has experienced episodic shoaling with notable events in the early 1970s, 1985 to 1987, 1996, 2003/2004, 2008 and 2011/12. The Department of Transport and Main Roads (TMR) manage the harbour entrance with the primary objective of maintaining a safe navigation channel.

The sequence of coastal processes understood to cause a significant Mooloolah Entrance shoaling event were originally described by the Queensland Department of Harbours and Marine (1987) who suggested sand bypassing mechanisms at Point Cartwright contributed to the “stockpiling” of sand deposits that can then move toward the entrance under certain wave conditions. This conceptual model is illustrated in Figure 4-3 and was generally supported in a subsequent investigation by WBM Oceanics (2004).

Figure 4-3 Conceptual Model of Sand Bypassing at the Mooloolaba Harbour Entrance (modified from: Department of Harbours and Marine, 1987)

Due to the relatively infrequent nature of the shoaling events, TMR follows a reactive strategy to maintain the design depth of the entrance channel. The approach uses a shoaling prediction tool (WBM Oceanics 2004 and 2005) with monitoring of seabed changes via hydrographic surveys as an early warning system so that dredge equipment can be mobilised to mechanically move sand from the entrance. Historically, the dredged sand has been placed to the west of the entrance where it would eventually move onto Mooloolaba Beach under the prevailing coastal processes. More recently, the dredge material has been pumped directly to the beach via a buried pipeline. This system is estimated to deliver an annual average of 10,000m^3 of sand to Mooloolaba Bay beaches (e.g. BMT WBM, 2013a). However, it should be noted that this is merely an acceleration of natural processes and does not constitute beach nourishment (i.e. sand being added to the system).

4.2.1 Recent Assessment of Capital Works Options to Mitigate Shoaling

Local geological constraints and wave conditions mean that the sand must enter the navigational channel before it can be intercepted effectively by a dredge. This weakness of the management strategy was recently exposed (in terms of operation and cost) during a particularly persistent shoaling event that started during April 2011 and continued into early 2013.

A sand shifter trial operated by Slurry Systems Pty Ltd was commissioned by TMR during 2012 to investigate an alternative method to artificially bypass sand across the entrance. The sand shifter system was installed at Point Cartwright adjacent to the eastern breakwater where sand accumulation was anticipated. The system was designed to transfer accumulated sand via a pipeline from the eastern breakwater to the shoreline at Mooloolaba Bay (mimicking the "natural" entrance bypassing mechanisms). The trial showed that the system was not able to work efficiently due to the shallow thickness of sand across the rock shelf and inadequate sand trapping capacity of the present entrance configuration.

The weakness of the existing entrance shoaling management strategy and the failure of an alternative sand bypassing method with the present entrance configuration prompted an investigation of alternative capital works options for the Mooloolah Harbour entrance (BMT WBM, 2014; Barnes et al., 2015). This assessment considered the observed shoaling during 2011/12 and used a calibrated numerical modelling tool to demonstrate that an extension of the eastern breakwater would effectively mitigate shoaling of the harbour entrance. The model results for the existing and conceptual eastern breakwater extension scenarios are shown in Figure 4-4. The modified entrance configuration is shown to successfully intercept the design shoal event and maintain a safe navigable channel.

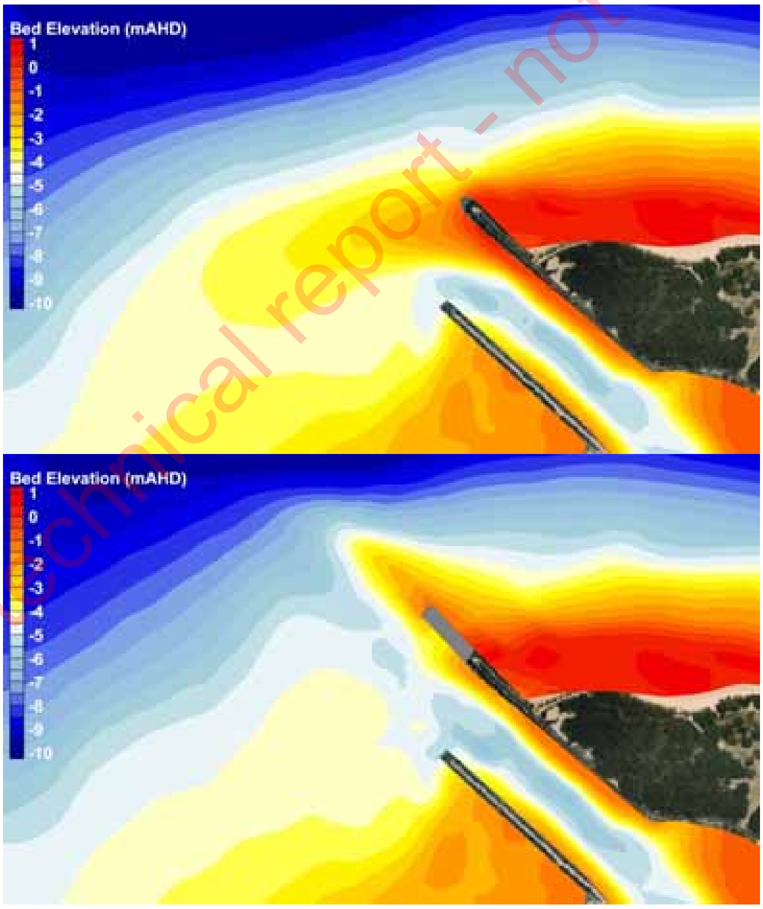

Figure 4-4 Mooloolaba Harbour Shoaling Assessment Results: Existing (top) and Modified (bottom) Entrance Configurations (Barnes et al., 2015)

An undesirable impact associated with an eastern breakwater extension is the interruption to the sediment transport pathway to Mooloolaba Bay, which unmitigated is likely to cause undesirable shoreline recession and threaten Council-controlled assets at Mooloolaba spit. In order to consider the potential changes in sand transport rates to Mooloolaba Bay, BMT WBM (2014) also considered the volume of sand passing the western breakwater (to an offshore depth of -10mAHD) during the 2011/12 assessment period using the numerical modelling tools. The results for the existing scenario suggest that approximately 100,000m^3 of material bypassed the entrance which is an order of magnitude greater than the annual average mechanically bypassed via a dredge and pipeline. These shoaling events therefore represent a significant contribution to the local sand budget. The 60m eastern breakwater extension shown in Figure 4-4 is estimated to cause a ~70% reduction in natural sand bypassing of the entrance.

There are no current plans to reconfigure the Mooloolaba Harbour entrance; however, if an eastern breakwater extension is adopted there will be an ongoing need to mechanically bypass intercepted sand to Mooloolaba Bay in perpetuity. The ultimate sand bypassing strategy would need to be developed following trial and may include a combination of options (e.g. dredging, sand shifter and/or pumping). For this reason, BMT WBM (2014) recommends that adequate state funding is available to enable the effective development of the most efficient shoaling management strategy.

5 Sunshine Coast Sand Sources Summary

5.1 Viable Sand Sources and Priority Areas

This report provides a summary of significant sand sources that may service the ongoing nourishment needs of Sunshine Coast Beaches. In accordance with the Sunshine Coast Council strategy and planning framework, which includes the Coastal Policy and SEMP, such works would be intended to assist in preserving and/or enhancing identified coastal values and assets.

With reference to locations identified in the SEMP where beach nourishment is the preferred shoreline erosion management option, the following sand sources are considered operationally viable:

- Maroochydore Beach: PBPL, Offshore and Lower Maroochy River
- Mooloolaba Beach North: PBPL and Offshore Sand
- Mooloolaba Beach South: PBPL and Offshore Sand
- Moffat Beach (minor nourishment works): Currimundi Lake
- Kings Beach (minor nourishment works): Northern Pumicestone Passage
- Nelson Street to Lamerough Canal: Northern Pumicestone Passage
- Lamerough Canal to Bells Creek: Northern Pumicestone Passage.

Since 2013, undesirable erosion at Maroochydore Beach has been mitigated using material from the lower Maroochy River. Under the existing permits, Council has a remaining allocation of 150,000m^3 until late 2016. Monitoring of the dredge footprint between 2013 and 2015 suggests this sand source is replenished at an estimated rate of 50,000m^3/year following a dredging campaign. It is therefore assumed that Council could expect lower Maroochy River sand source to sustainably provide up to 100,000m^3 every two years (subject to ongoing approval and monitoring beyond 2016). It is recognised that this limited sand may not have the capacity to mitigate the risks to land based assets in the medium to long term or provide sufficient material to recover from an extreme erosion event (or sequence of events).

Additional volume could be added to the Maroochydore and Mooloolaba Beach sand budget using the PBPL and/or Offshore Sand sources. Due to the larger dredge plant required to access these sand sources, these options are expected to be considerably more expensive than accessing material within shallow and sheltered environments. In comparison to recycling material within the existing sand budget (e.g. relocating material from an estuary to the adjacent beach), the PBPL and Offshore Sand sources may provide the most benefit long term since they have the potential to add a significant volume to the Sunshine Coast sand budget.

In the short to medium term it is possible that the erosion threat to the northern Pumicestone Passage mainland shoreline can be managed with material from within the passage. This sand source could also potentially provide a small amount of material to Kings Beach (in conjunction with a proposed restoration of the Kings Beach groyne). There is significant uncertainty associated with the timing and location of a Bribie Island breakthough and the possible increased threat to land based assets within northern Pumicestone Passage. The Golden Beach and Bribie Island Breakthrough Strategy, which includes an expanded beach nourishment program, is intended to help address this risk through a coordinated monitoring and trigger based management approach.

The primary sand source options considered in this report do not directly address the minor nourishment at Moffat Beach identified in the SEMP (in conjunction with an upgrade to the existing seawall adjacent to 45 Beerwah Pde). Access to this location by dredge equipment is not likely to be operationally feasible. It is proposed that the relatively small volume of sand required for this location could be accessed from Currimundi Lake (as part of routine opening and closing of the entrance to manage environmental and flood risk) and be delivered to Moffat Beach via truck.

Table 5-1 summarises the key findings of this study and provides the per cubic metre cost estimates to deliver sand to priority areas. Table 5-2 provides a proposed staged management strategy that considers and combines:

- Stage 1 (current): Existing permitted and planned activities (within a five year planning horizon). It is recommended that these semi-regular maintenance activities are grouped into a strategic or 'systems-based' approval framework[7]. During this period a trial of nearshore placement beach nourishment at Maroochydore is also recommended (considered further in Section 5.2.2).
- Stage 2 (up to year 2025): Existing permitted activities are to continue and be supplemented with PBPL Commercial Sand (existing PBPL sand extraction permits due to expire in 2025). During this phase planning to establish a local offshore sand extraction site is recommended.
- Stage 3 (beyond 2025): Existing permitted activities are to continue and be supplemented with material from the local Offshore Sand extraction site.

The cost estimates provided in Table 5-2 represent operational costs over a five year period unless otherwise indicated. The introduction of PBPL Commercial Sand and/or material from a local Offshore Sand extraction site will add significant volumes to the littoral system and are expected to reduce the required frequency of the other existing permitted maintenance activities which is reflected in the Stage 2 and 3 estimates.

The cost estimates for PBPL Commercial Sand assumes a nearshore placement (via bottom dumping) delivery method at a rate of $15 per cubic metre. The extraction and delivery of sand from a new Offshore Sand extraction site also assumes nearshore placement, but at a reduced rate of $11 per cubic metre due to the shorter distance between the target and placement areas. These estimates assume a suitable dredge plant is available on the Australian east coast. The costs could increase significantly if an alternative delivery method was necessary (refer Table 5-1 and Section 2.2.6). Additional costs would also be incurred if rehandling the material from stockpile areas via a smaller dredge was required.

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[7] Council is presently investigating opportunities to combine a number of existing permits into a single approval framework.

Table 5-1 Sunshine Coast Sand Sources Summary

Sand Source	Environmental Constraints / Approvals	Sand Quality	Sand Quantity	Operational Considerations	Target Beaches	Operational Cost Estimate per m^3 of Sand
Port of Brisbane Pty Ltd Commercial Sand	No significant constraints Existing permits for sand extraction Approval required for nearshore placement	Clean sand with mean grain size 0.25 to 0.30mm	Sunshine Coast annual requirements expected to be within permitted volume	TSHD Brisbane typically available for southeast Queensland work between December and April Nearshore nourishment via bottom dumping close to the 8m depth contour	The nearshore area of open coast beaches (not including Kings or Moffat Beach)	$11 - $15/m^3
Sunshine Coast Offshore	No existing permits for sand extraction Approval required for nearshore, profile and/or onshore placement	Surficial layer within 2m of seabed surface clean sand (Holecene) with mean grain size 0.18 to 0.23mm Older deposits >2m below seabed more variable in colour with mean grain size 0.20 to 0.35mm	Sand volume of +100,000,000m^3 theoretically available Sunshine Coast medium to long term requirements not expected to exceed available volume	TSHD capable of working in depths >20m with significant wave height up to 2m Nearshore nourishment via bottom dumping simplest and most cost effective placement option Profile nourishment via Rainbowing more difficult and costly placement option Onshore nourishment via mooring and pipeline most expensive placement options	Open coast beaches (access dependent on TSHD size and placement method)	$11 - $15/m^3 (nearshore nourishment) $33 - $45/m^3 (profile nourishment) $40 - $54/m^3 (onshore nourishment)
Northern Pumicestone Passage	Adjacent Fish Habitat Area and Conservation Zone Seagrass Habitat Existing permits for extraction and placement up to 10,000m^3/year Council presently seeking permit for additional 40,000m^3	Generally clean white sand with mean grain size 0.15 to 0.43mm Some areas with high silt content previously identified	Sand volume 700,000m^3 theoretically available Extraction and placement up to 10,000m^3/year expected to be sustainable in medium to long term (subject to monitored infilling rate)	Small CSD and pipeline Maintain 50m buffer from known seagrass habitat (location confirmed via pre-dredge survey) Maintain 100m buffer from Fish Habitat Area and Conservation Zone Dredging not to exceed 30 days in a calendar year	Mainland shorelines within Pumicestone Passage Potential to pump via CSD and pipeline to Kings Beach	$11/m^3
Lower Maroochy River	Adjacent Fish Habitat Area Existing permits for extraction; remaining allocation of 150,000m^3 until late 2016	Generally clean white sand with mean grain size 0.18 to 0.23mm Some areas with high silt content previously identified	Sand volume of 200,000m^3 theoretically available Extraction and placement up to 100,000m^3 every 2 years expected to be sustainable in the medium to long term (subject to monitored infilling rate)	Small CSD and pipeline Maintain 50m buffer from Fish Habitat Area Dredging to occur between months May to September	Maroochydore Beach	$8/m^3

Table 5-2 Key Stages of Proposed Sand Sourcing

Stage 1 Sand Sources (5 year planning period)	**Existing Permitted and Planned Activities**	**5 year Planning Period Operational Cost Estimate**
Northern Pumicestone Passage	Extraction of permitted 10,000m^3/year. Material used to nourish mainland shorelines within Passage. Minor nourishment at Kings Beach also proposed.	$500,000
Northern Pumicestone Passage	Application for an additional allocation of 40,000m^3 currently being sought.	$440,000*
Lower Maroochy River	Remaining permitted allocation of 150,000m^3 until late 2016. Proposed extension of permits to allow up to 100,000m^3 every two years. Material used to nourish Maroochydore Beach upper profile.	$2,000,000
Currimundi Lake Entrance	Proposed use of entrance sand for minor nourishment works at Moffat Beach and/or South Currimundi Beach. Not currently permitted.	Routine maintenance budget
Mooloolaba Harbour Entrance	Average of 10,000m^3/year relocated from entrance to Mooloolaba Bay beaches (acceleration of natural processes, not beach nourishment). Permitted works undertaken by TMR.	Routine maintenance budget
PBPL Commercial Sand trial	Trial bottom dumping (nearshore placement) of 20,000m^3 PBPL Commercial Sand at Maroochydore Beach. Monitor placed sand over 12 month period.	$400,000*
Stage 2 Sand Sources (up to year 2025)	**Existing Permitted Activities Continue and Supplemented with PBPL Commercial Sand**	
PBPL Commercial Sand (existing sand extraction permits due to expire in 2025)	Supplement sand budget with PBPL commercial sand. Assume nearshore placement of 200,000m^3 at Maroochydore once every 5 years.	$3,000,000
Existing Permitted Activities	Northern Pumicestone Passage works to continue as described in Stage 1. PBPL Commercial Sand works expected to halve the required frequency of Maroochy River sand extraction.	$1,500,000
Sunshine Coast Offshore	Undertake geotechnical investigation and seek approval for establishing a long term offshore sand extraction area.	$500,000*
Stage 3 Sand Sources (beyond year 2025)	**Existing Permitted Activities Continue but no Longer Provide Required Volume (PBPL Commercial Sand permits expired)**	
Sunshine Coast Offshore	Supplement sand budget with Sunshine Coast Offshore material once every 5 years.	$2,200,000
Existing Permitted Activities	Extraction of 10,000m^3/year currently permitted. Material used to nourish mainland shorelines within Passage.	$1,500,000

*Cost incurred in a single year only

5.2 Recommended Further Work

5.2.1 Long Term Cost Considerations

The estimates provided in Table 5-2 suggest that the average operational cost over five years to support beach nourishment activities may reach up to $5.0M (based on estimates in 2015). Over time, long term costs may reduce through the establishment of an Offshore Sand extraction site located closer to target beach locations, particularly if cost-effective nearshore placement methods are demonstrated to be successful.

Coastal councils are often forced to make investment decisions relating to beach management without sufficient data to conduct cost-benefit evaluation of management options, particularly when social and recreational values are key considerations. Based on surveys of beach users, Anning et al. (2013) estimated that the annual recreational value Sunshine Coast beaches was $197M for residents and the annual value of tourist expenditure related to beaches was $270M. Survey results also suggested that tourists were likely to avoid beaches and regions impacted by undesirable erosion.

The information provided in this report provides a basis to extend a cost-benefit analysis of beach nourishment within the wider context of short to medium term shoreline management objectives, climate change adaptation planning and the significance of sandy beaches to the local economy. This type of analysis should be incorporated into future studies to support climate change adaptation and resilience planning.

5.2.2 Nearshore Nourishment Trial

As discussed in the main body of this report and in Appendix A, nearshore nourishment via bottom dumping from a TSHD is expected to be a cost-effective means to supplement the Sunshine Coast sand budget. This method also offers the advantage of causing minimal disruption to beach users. The method involves constructing an offshore berm (or sand bar) within the active littoral zone and relies on the prevailing coastal processes to move the material in a net landward direction during low energy conditions.

A key constraint associated with placing material within the active littoral zone is the required working draft of the dredging equipment. For example, the PBPL operated *TSHD Brisbane* is limited to placing material near the 8m depth contour. Smaller dredging equipment such as the *TSHD Port Frederick* (operated by McQuade Marine Pty Ltd) has previously placed material close to the 6m depth contour Gold Coast locations.

It is proposed that a trial of the nearshore placement method via the *TSHD Brisbane* is undertaken at Maroochydore Beach where the offshore limit of the active littoral zone is estimated to be at the 12m depth contour (refer Appendix A). An indicative target area is shown in Figure 5-1 and assumes the placement of 20,000m^3 of PBPL Commercial Sand close to the 8m contour. Considerations regarding the trial and associated costs include:

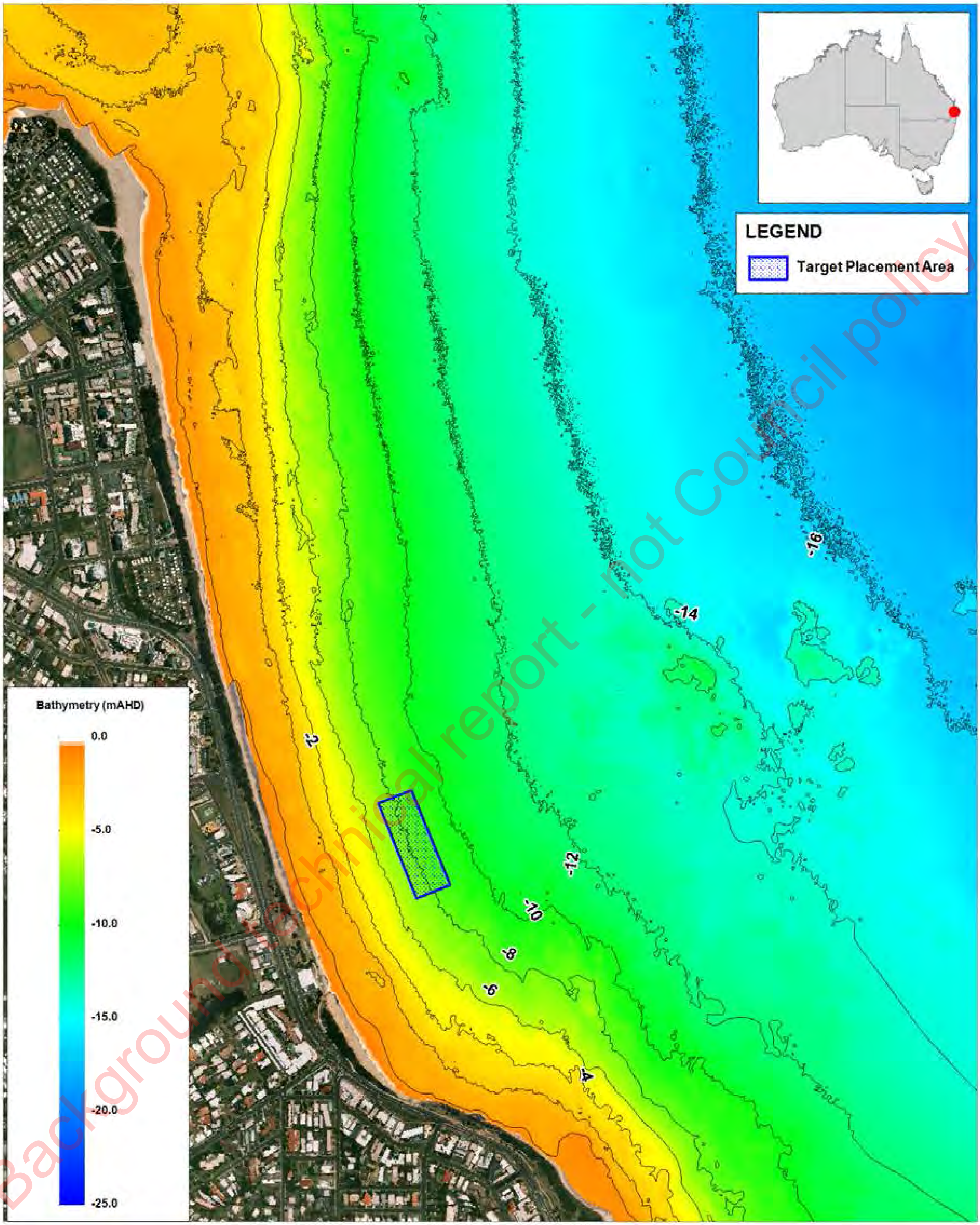
- Timing: *TSHD Brisbane* is typically available for South East Queensland work between the months of December and April. With this in mind, April is the preferred month for the nearshore placement works in order to minimise exposure to high energy seas and shoreline erosion typically associated with the summer months.

- Approvals: The use of PBPL Commercial Sand does not require an additional sand extraction permit. However, the establishment a new placement area for trial will require:
    - Tidal works development permit under the *Sustainable Planning act 2009* and *Coastal Protection and Management Act 1995*.
- Placement costs: PBPL Commercial Sand can be delivered to Maroochydore Beach at an estimated cost of \$11 - \$15/m^3. Based on the delivery of 20,000m^3, the nearshore placement costs are therefore between \$220,000 and \$300,000 in 2015.
- Monitoring costs: An offshore survey of the target placement area would be required prior to placement, after placement and at 2-3 monthly intervals for a period of 12-18 months. The surveys would provide the necessary information to determine whether the nearshore nourishment methodology provides benefit to Maroochydore Beach. The trail would need to make an allowance of up to \$100,000 for monitoring of the placed material.

The outcomes of the trial will help to determine whether nearshore placement via the *TSHD Brisbane* at Sunshine Coast beaches is a suitable beach nourishment method. If this method proves unsuccessful, future beach nourishment activities using to PBPL Commercial Sand and/or Offshore Sand extraction sites would need to consider:

- Rehandling of the placed material by a smaller dredge (such as the *TSHD Port Frederick*) and redepositing in shallower water; or
- Other placement methods such as “Rainbowing” into the surf zone (profile nourishment) or pumping ashore via a mooring and pipeline (onshore nourishment).

As discussed in Section 2.2.5, these alternative placement methods add considerable cost and duration to a beach nourishment program.



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Maroochydore Beach Nearshore Placement Trial Target Area

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Appendix A Nourishment of Sunshine Coast Beaches using Offshore Placement Techniques

External Memorandum

From:	Matthew Barnes	To:	Sunshine Coast Council
Date:	22 November 2013	CC:	
Subject:	Nourishment of Sunshine Coast Beaches Using Offshore Placement Techniques		

1 Nourishment of Sunshine Coast Beaches using Offshore Placement Techniques

This memorandum provides preliminary advice regarding the feasibility of using offshore sand placement techniques as part of a shoreline erosion management strategy for Sunshine Coast beaches. The assessment considers discussions with Port of Brisbane Pty Ltd (PBPL) and uses Maroochydore Beach as a case study to explore the potential for the onshore migration of sand placed offshore.

1.1 Introduction

1.1.1 The Beach System

The beach system is considered the active part of the offshore profile which in many SE Queensland locations extends to water depths beyond 20m. The beach system is continuously reworked by waves and currents, evolving in its position, alignment and profile shape between controlling features such as natural headlands or man-made structures. Shoreline change is commonly considered in terms of:

- Short term, cyclic behaviour associated with storm erosion and subsequent gradual accretion; and
- Longer term progressive change associated with natural and/or anthropogenic factors.

There is a depth dependence on the capacity of waves to transport sand sufficiently to modify the beach profile. Within the littoral zone, high cross shore sand transport rates and gradients may result in rapid adjustment of the profile shape and shoreline position. In deeper water outside the littoral zone, both the rates and gradients in sand transport are reduced such that bed level changes are less significant and occur more gradually.

It has been identified (Roy & Stephens 1980a, 1980b; Chapman et al 1982; Roy 2001; Patterson, 2013) that many NSW and SE Queensland coastal profiles exhibit a characteristic shape to a depth of about 15-20m, with an average slope of about 1° (1:55), that has evolved in dynamic equilibrium between the wave climate and the coastal sediment. However, below that depth range is a wide diversity of profile shapes. Commonly a transition in the profile shape occurs at about 15-20m water depth from the relatively active and well defined shoreface to the inner continental shelf, where the profile has lower average gradient and its contemporary evolution is slow. These zones are shown in Figure 1-1 using typical beach profiles from Northern NSW and SE Queensland (Gold Coast) locations.

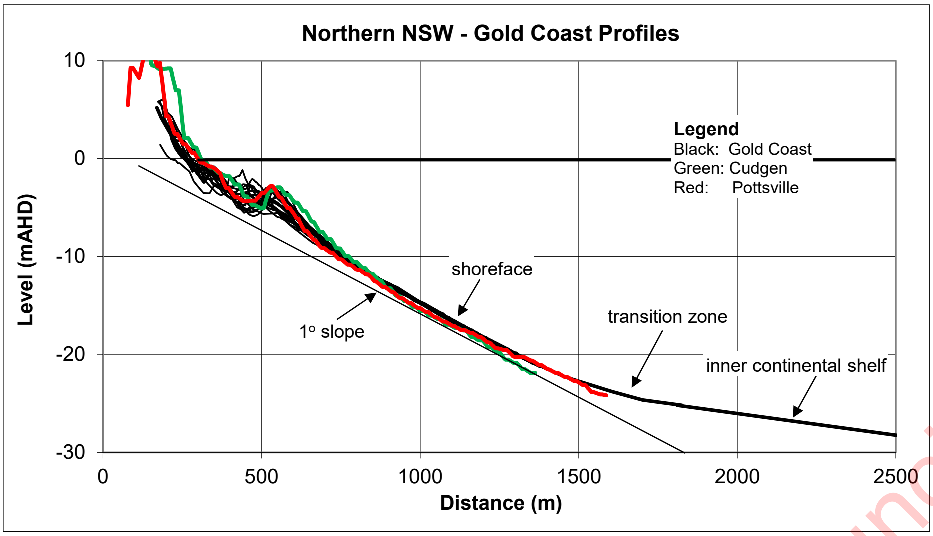


Figure 1-1 Typical Northern NSW and SE Queensland Profiles: Shoreface and Transition to Inner Shelf (from Patterson, 2013)

Variation with depth of the nature and timescale of profile evolution affects how the beach profile evolves in response to changing conditions within the littoral zone. Hallermeier (1977) suggests a depth value for the seaward limit of the littoral zone:

$$h_L = 2.28H_s - 68.5\left(\frac{H_s^2}{gT^2}\right) \qquad \text{Equation 1}$$

where H_s is the significant wave height exceeded for 12 hours per year (0.14% of the time) and T is associated wave period, giving an approximate depth of 9-10m along northern NSW and SE Queensland. For more intense storm wave conditions over a longer decadal to century statistical timeframe, this depth corresponds to about 13-14m (e.g. Patterson, 2013). The offshore limit of the littoral zone at Maroochydore Beach is considered further in Section 1.3.4.

1.1.2 Beach Nourishment

Beach nourishment is a common management strategy used to increase a shoreline's resilience to subsequent erosion events. One method involves the direct placement and distribution of sand on the beach. The other is the placement of sand offshore to create a "nearshore berm", a submerged, high-relief mound constructed parallel to shore. McLellan and Kraus (1991) divided constructed nearshore berms into two categories:

1. Active Berms

If a berm is placed in sufficiently shallow water (within the littoral zone) and with sufficiently high-relief, the larger erosive waves will break on its seaward slope and crest. Broken waves of reduced height then reform, propagate toward the shoreline and break again with less energy. This energy-reducing mechanism provides indirect benefit by reducing the capacity of storm waves to transport sand offshore. During prevailing, mild wave conditions, sand from the berm will migrate onshore and supplement the beach profile. Consequently, active berms should be constructed using sand that is similar to the natural sand within the beach system.

2. Stable Berms

A stable berm is intended to be a relatively permanent constructed feature of the seabed that attenuates wave energy during storm conditions. Material from a stable berm is not intended to move onshore and therefore may be constructed using wide range of grain sizes.

Preliminary assessment of key factors to be considered when determining the potential for successful berm design and construction presented in this document include:

- Quantity and quality of material to be dredged and placed offshore;
- Availability of suitable equipment;
- Local wave conditions; and
- Economics of berm construction.

1.2 Port of Brisbane Sand Sources

A teleconference attended by Sunshine Coast Council, PBPL and BMT WBM was held on Monday 25 March 2013 (meeting minutes provided in Appendix A). The objective of the teleconference was to initiate discussion regarding the potential for beach nourishment of Maroochydore Beach using PBPL dredge material. Key items discussed included:

- Type of dredging equipment capable of delivering beach nourishment sand to Maroochydore Beach;
- The volume and quality of sand available for beach nourishment purposes; and
- Cost estimate for sand delivery to Maroochydore Beach.

These items and other relevant issues are considered further below.

1.2.1 Sediment Quality

PBPL identified two dredge areas with material expected to be consistent with the natural sand at Maroochydore Beach. These areas are indicated on the Approaches to Moreton Bay (AUS235) chart in Figure 1-2 and referred to as:

(1) North of Northwest Channel (near Caloundra); and

(2) Spitfire Re-alignment Channel.

Sediment quality from these areas is typically clean white sand with a mean grain size diameter of approximately 300µm. Particle size distribution (PSD) analysis suggests this sand is consistent with the material found at Maroochydore Beach. PSD analysis results from the Spitfire Re-alignment Channel area (provided by PBPL) and from Maroochy River Entrance are provided in Appendix B. The Maroochy River Entrance samples were collected and analysed by Cardno Bowler (2011) as part of the approval application for beach nourishment (via direct placement) of Maroochydore Beach using marine sand extracted from the Maroochy River Entrance (BMT WBM, 2012).

PBPL undertakes limited dredging in these areas (less than 60,000m^3/year) with material typically used for port reclamation purposes. PBPL indicated that sand dredging and delivery to Maroochydore Beach would need to be a specific contract (i.e. not part of other PBPL maintenance or capital dredge programs).

1.2.2 Operational Considerations

PBPL identified the small Trailer Suction Hopper Dredge (TSHD) "*The Brisbane*" (refer Appendix C) as suitable equipment for delivering beach nourishment material to Maroochydore Beach.

The Brisbane has a 6.5m draft. The most cost effective sand delivery method from a TSHD is via bottom dumping. PBPL indicated an additional under keel clearance of approximately 1m is required for bottom dumping via *The Brisbane*. Using this method of delivery, sand could be placed close the -8mLAT (equivalent to -9mAHD) depth contour. Maroochydore Beach depth contours based on a 2011 bathymetric survey are shown in Figure 1-3. The -8mLAT (-9mAHD) contour is located approximately 350m offshore from Maroochydore Beach.

PBPL estimate approximately 2000m^3 of sand could be delivered to Maroochydore Beach per trip using *The Brisbane* and bottom dumping delivery method and that four trips per 24 hour day could be completed. *The Brisbane* is typically available for SE Queensland work between the months of December and April.

Other more operationally complicated methods to deliver material closer to shore and/or via a larger dredge vessel (with additional water depth restrictions) are available. These methods of delivery potentially offer the advantage of sand placement closer to shore. The main disadvantage is they require additional temporary infrastructure and/or equipment and are therefore more expensive in comparison to bottom dumping. Such methods include:

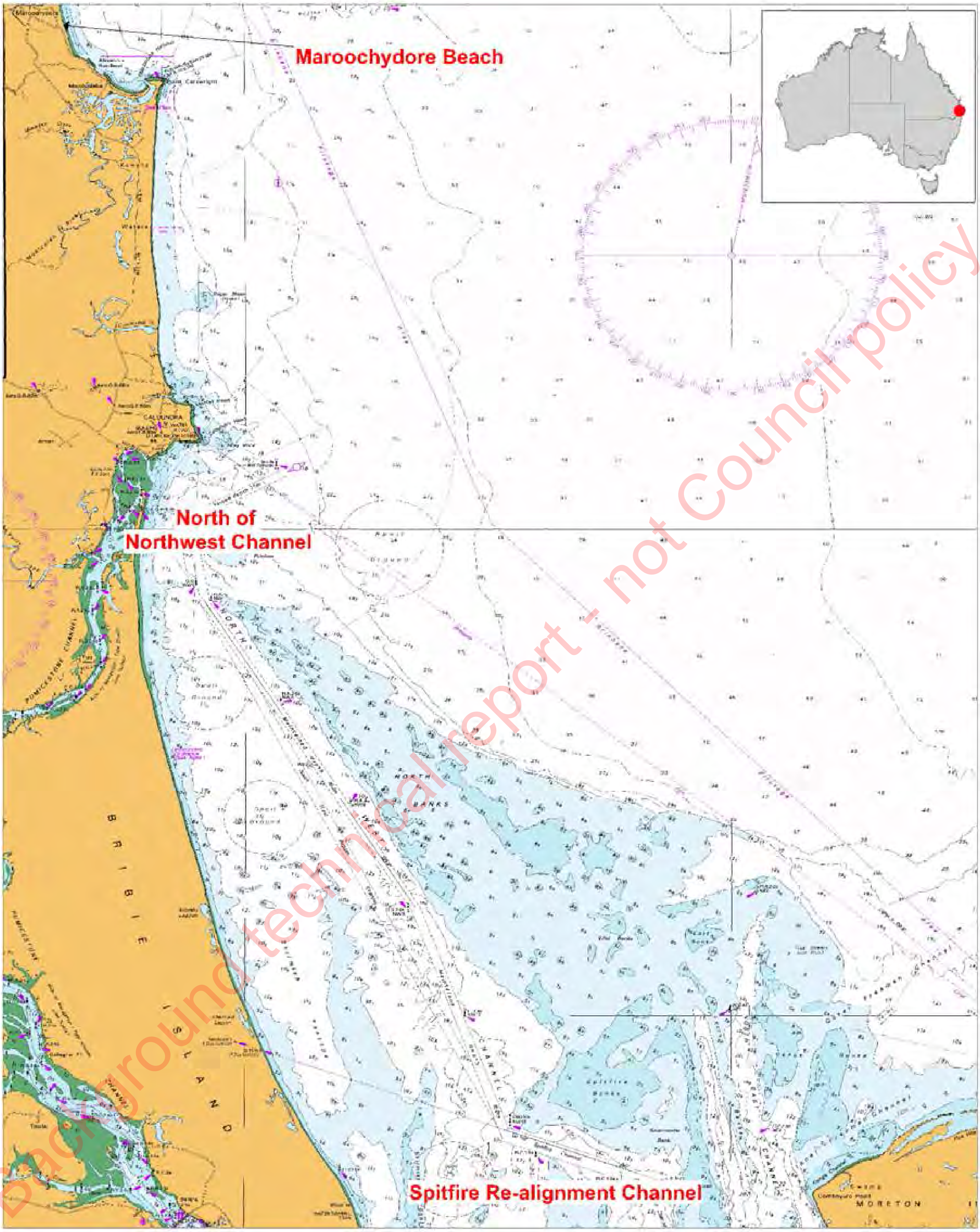
- Via pipeline from a dredge moored offshore; and
- Placement offshore by a large dredge and re-dredged by a smaller equipment and placed nearshore.

It is noted that the perceived “benefit” of placing material closer to shore may be quickly lost as the prevailing coastal processes redistribute the placed sand to a new equilibrium. Over timescales of months and years, the difference between placing material in 8m or 10m depth is likely to be indistinguishable.

1.2.3 Costs

PBPL (Peter Nella, pers comm. 16/03/2013) provided the following cost estimates to deliver sand to Maroochydore Beach via *The Brisbane* using a bottom dumping placement method:

- Sand from North of Northwest Channel approximately \$11/m^3.
- Sand from Spitfire Re-alignment Channel approximately \$15/m^3.



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PBPL Dredge Areas with Material Suitable for Beach Nourishment

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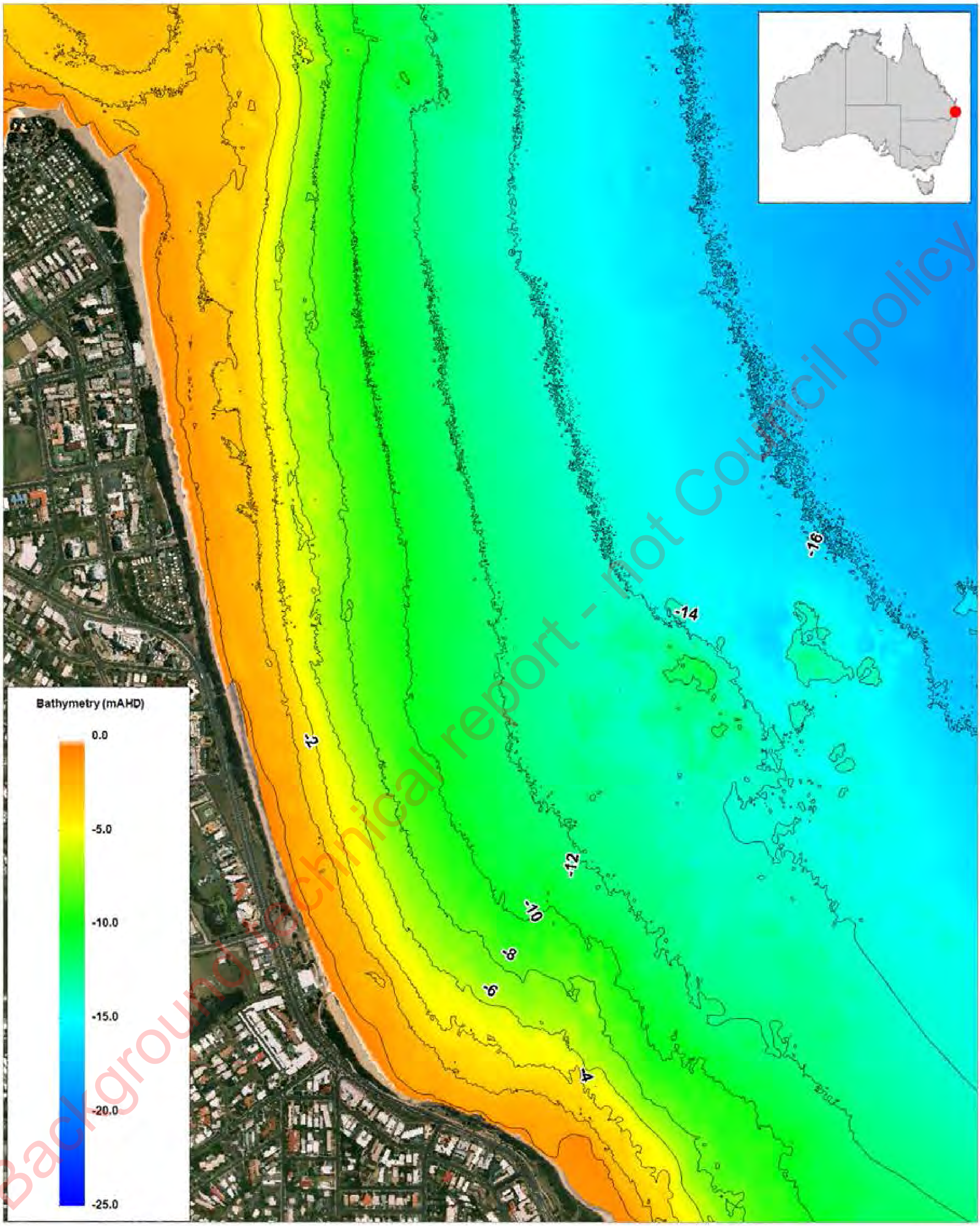

Title:

Maroochydore Beach Offshore Bathymetry

Figure: **1-3**

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BMT WBM
www.bmtwbm.com.au

Filepath : I:\B20258.I.mpb_Maroochydore_POB_nourishment\DRG\COA_001_131127_Maroochydore_bathy.WOR

1.3 Coastal Processes Assessments

Extensive studies on design considerations for nearshore dredge material placement or “berm construction” were conducted in the late-1980s to min-1990s. The majority of work was funded by the Dredging Research Program, a seven-year program of the U.S. Army Corps of Engineers. Since this time, a number of successful projects have been executed along U.S. coastlines. McLellan and Kraus (1991) suggested several criteria to be considered when designing nearshore berm construction programs, including:

- Timing of placement;
- Depth and length of berm;
- Location of placement; and
- Sediment grain size.

These criteria are considered in the following sections using Maroochydore Beach as a case study.

1.3.1 Maroochydore Beach Profile

Typical Northern NSW and SE Queensland beach profiles were presented in Section 1.1.1. It was shown that the transition in the profile shape occurs at about 15-20m and considering the wave climate, 9-10m depth was identified as the approximate offshore limit of the littoral zone (noting that this limit may extend to approximately 14m depth under design storm conditions).

From south to north, open coast Sunshine Coast beaches tend toward the “typical” profiles presented in Section 1.1.1. The transition from the shoreface to the inner continental shelf occurs at a shallower depth for the southern beaches, which is likely to be associated with the geological evolution of the region (e.g. Jones, 1992). Figure 1-4 presents offshore profiles for three Sunshine Coast beaches and shows the profile transition zone variation between locations. At Maroochydore Beach, the transition zone appears to occur close to 10m below AHD while further north at Marcoola and Peregian Beaches the transition occurs 15-20m below AHD.

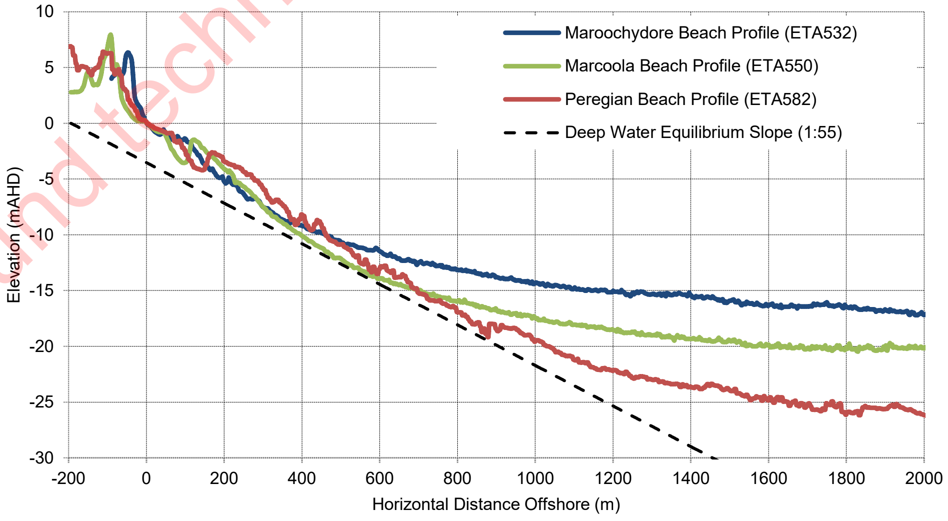

Figure 1-4 Sunshine Coast Beach Profiles Compared with Deep Water Equilibrium Slope

Figure 1-4 suggests a milder wave climate and narrower littoral zone exists at Maroochydore Beach in comparison to Marcoola and Peregian Beaches. This implies that the offshore limit of the active sand transport zone is reduced at Maroochydore Beach. This is explored further in Section 1.3.4.1.

1.3.2 Maroochydore Beach Wave Conditions

An existing Sunshine Coast wave modelling system (BMT WBM, 2013a) was used to hindcast approximately 12.5 years of offshore wave conditions at Maroochydore Beach. The long term average wave rose and wave height and direction recurrence statistics at a depth of 10m are presented in Figure 1-5 and Table 1-1. Use of the wave hindcast dataset to assess beach response and nourishment material placement depth is described in Section 1.3.3 and Section 1.3.4.

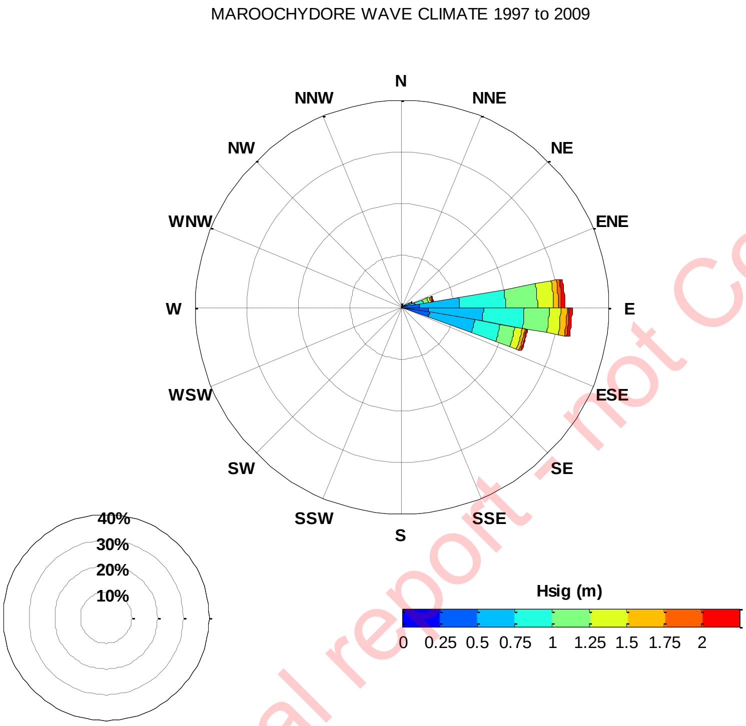

Figure 1-5 Maroochydore Beach 10m Depth Contour Long Term Average Wave Rose

Table 1-1 Maroochydore Beach 10m Depth Contour Wave Height and Direction Recurrence Frequency (% of time)

Hsig Bin (m)	Directional Bin (deg)												
	0	10	20	30	40	50	60	70	80	90	100	110	Total
0 - 0.25	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.1	0.0	1.1
0.25 - 0.50	0.2	0.2	0.1	0.0	0.0	0.0	0.5	0.8	3.2	4.7	5.3	0.0	15.1
0.50 - 0.75	0.2	0.2	0.1	0.1	0.2	0.2	1.0	1.6	7.8	10.7	8.8	0.1	30.8
0.75 - 1.00	0.0	0.1	0.1	0.0	0.0	0.1	0.4	1.6	8.9	7.9	5.0	0.1	24.3
1.00 - 1.25	0.0	0.0		0.0	0.0	0.1	0.0	1.0	6.2	4.8	2.9	0.0	15.2
1.25 - 1.50	0.0			0.0	0.0	0.0	0.0	0.5	3.1	2.2	1.4		7.4
1.50 - 1.75	0.0				0.0	0.0	0.0	0.2	1.0	1.2	0.5		3.0
1.75 - 2.00							0.0	0.2	0.6	0.4	0.3		1.6
>2.00							0.0	0.1	0.6	0.6	0.2		1.6
Total	0.6	0.6	0.3	0.2	0.3	0.5	2.1	6.2	31.5	32.9	24.7	0.2	100.0

1.3.3 Maroochydore Beach Response to Wave Conditions

Understanding the beach response to the local wave climate is important aspect of any shoreline erosion management strategy. For offshore placement of beach nourishment material, a key aspect of the design is establishing if and when the wave conditions are likely to promote onshore sand transport and ultimately beach accretion.

Larson and Kraus (1989) developed a cross-shore sand transport criterion that incorporates wave steepness and sand fall velocity. Subsequent work by Kraus (1990) further verified the criterion to a number of datasets and proposed the following simple approximation:

$$\frac{H_o}{wT} < 3.2 \qquad \text{accretion}$$

$$\frac{H_o}{wT} > 3.2 \qquad \text{erosion}$$

where H_o is the offshore wave height, w is the sand grain fall velocity in still water and T is the wave period.

Using the 12.5 year wave hindcast data for Maroochydore Beach, the cross-shore sand transport criterion was explored using the average daily wave condition (wave height and period) and an estimated fall velocity for 300µm sand grains of 0.039m/s (e.g. McLellan and Kraus, 1991). The results of this assessment have been summarised into the number of estimated “accretion” or “erosion” days per month between late-1996 and mid-2009 and are presented in Table 1-2.

Table 1-2 Maroochydore Beach Cross-Shore Sand Transport Condition Estimates

Month	Accretion days	Erosion days	Dominant Condition
Jan	116	287	erosion
Feb	103	264	erosion
Mar	105	298	erosion
Apr	134	256	erosion
May	188	215	erosion
Jun	219	171	accretion
Jul	188	185	accretion
Aug	247	125	accretion
Sep	223	137	accretion
Oct	232	140	accretion
Nov	197	173	accretion
Dec	214	185	accretion

The cross-shore sand transport assessment results presented in Table 1-2 generally follow the typical beach response observed throughout SE Queensland, that is beach erosion during the summer and autumn (December to May) and beach recovery during winter and spring (June to November). Following Larson and Kraus (1989), erosion is caused by periods of high steepness waves such as those generated by tropical cyclones, extra tropical storms or east coast low pressure systems. Ideally, the timing of sand placement for offshore berm construction would avoid periods of high erosion potential. For Maroochydore Beach, Table 1-3 suggests accretionary conditions typically occur between June and December. With this in mind, material placed offshore during early winter will be most likely to move onshore and benefit the beach.

1.3.4 Sand Placement Location

1.3.4.1 Depth of Closure

A berm intended to migrate onshore must be constructed within the active sand transport zone, optimally placed as close to shore as possible. The seaward limit of the littoral zone is commonly referred to as the "depth of closure" (DOC) and is a function extreme wave conditions and sediment size and composition. This limit can be identified using repetitive profile survey data from a given study area or following analytic methods (e.g. Hallermeier, 1977).

In a previous coastal processes study completed for Sunshine Coast Council (BMT WBM, 2013a), the DOC was estimated at a number of locations and used for long term (up to 100 years) coastal erosion risk assessments. For that purpose, the outer limit of the DOC was simply based on twice the 100 year Annual Recurrence Interval (ARI) wave height. This approach yields a "design storm" DOC estimate and at Maroochydore Beach this corresponded to 12.6m.

In this assessment, the method to estimate the outer limit of the littoral zone proposed by Hallermeir (1977) has been used and considers the 12.5 year wave hindcast dataset for Maroochydore Beach. The relationship proposed by Hallermeier (1977) was previously presented in Equation 1 and requires estimates of the significant wave height exceeded for 12 hours per year (0.14% of the time) and the associated wave period. Based on the 12.5 year wave hindcast dataset the 0.14% time exceedance wave conditions are:

- H_s = 3m; and
- T = 10s.

Substituting these values into Equation 1 suggests the outer limit of the littoral zone at Maroochydore Beach for the hindcast period was 6.2m, which is approximately half the depth obtained by BMT WBM (2013a) using more intense storm wave conditions over a longer statistical timeframe. This result suggests that nourishment material placed close to the 6m depth contour would be available to littoral zone processes. Material placed in deeper areas (up to approximately 12m depth) would still be expected to migrate onshore, albeit at a slower rate.

1.3.4.2 Wave Induced Near Bed Currents

Hands and Allison (1991) correlated active and stable constructed berms at a number of beaches with the near-bed, wave-induced current magnitude. Using this measure, Hands and Allison (1991) concluded that if 75th percentile wave induced current magnitude far exceeds 0.4m/s, or the 95th percentile far exceeds 0.7m/s, then constructed berms would be active.

The near-bed, wave-induced current magnitudes, u_w, were estimated using the 12.5 year wave hindcast dataset and shallow water wave approximations:

$$u_w = \pi \frac{H}{T} + \sinh \frac{2\pi d}{L} \qquad \text{Equation 2}$$

where d is the water depth and L is the wave length which in shallow water is approximated by $L = T\ \overline{gd}$. Analysis of the estimated wave-induced currents yields the statistics provided in Table 1-4 and suggest that the near-bed current magnitude at Maroochydore Beach is sufficient to promote active berm conditions.

Table 1-4 Maroochydore Beach Wave Induced Current Magnitude Percentiles

Percentile	Wave-Induced Current Magnitude at 10m depth (m/s)
95th	0.77
75th	0.55

1.4 Conclusions

The potential for beach nourishment of Sunshine Coast beaches, with a focus on Maroochydore Beach as case study, has been considered. By combining the information gained through discussions with PBPL and the coastal processes assessments presented in this memorandum the following is noted:

- PBPL identified two dredge areas with material expected to be consistent with the natural sand at Maroochydore Beach:
  - North of Northwest Channel (near Caloundra).
  - Spitfire Re-alignment Channel.
- Bottom dumping is the most cost effective and preferred method of material placement via the PBPL dredger *The Brisbane*.
- Cost estimates to deliver PBPL material to Maroochydore Beach via *The Brisbane* using a bottom dumping placement method range between \$11/m^3 to 15/m^3 (depending on the dredge location). The delivery of 100,000m^3 of nourishment material would therefore cost between \$1.1 to \$1.5 million dollars in 2013.
- *The Brisbane* is typically available for SE Queensland work between the months of December and April. With this in mind, placement of nourishment material would ideally occur in April to avoid erosive conditions during the summer months and maximise the potential for the placed sand to migrate landward during winter and spring.
- The offshore limit of the littoral zone at Maroochydore Beach is expected to lie between 6m and 10m depth, depending on wave conditions and only extending further offshore during design storm events. *The Brisbane* is restricted to placement of nourishment material close to the -8mLAT contour (equivalent to -9mAHD) which is expected to be the outer limit of the littoral zone at Maroochydore Beach.
- The assessment of near-bed, wave-induced current magnitude at a depth of 10m suggests the conditions at Maroochydore Beach are sufficient to promote an active constructed berm.

The benefits of placing nourishment material offshore include wave attenuation and the addition of sand to the beach system, which may be reworked by the prevailing processes and lead to beach accretion. It should be considered that in comparison to the direct placement of sand on the beach, the benefits of offshore placement may not be immediately recognised by the community. However, in the medium term (up to a few years) the difference between direct and offshore placement methods may be indistinguishable in terms of the achieved beach profile as the prevailing coastal processes redistribute the placed sand toward a new equilibrium.

Beach nourishment via the offshore placement of PBPL material has the potential to add a significant volume of sand to the beach system. This differs to recycling sand already in the system, such as relocating sand from the Maroochy River mouth to Maroochydore Beach. Offshore placement at Maroochydore Beach would complement the existing sand relocation strategy and would be expected to reduce the required frequency of Maroochy River sand relocation works.

The cost to deliver sand for beach nourishment via offshore placement could be significantly reduced if a viable source of material was identified in areas immediately offshore from Sunshine Coast beaches. A general recommendation by BMT WBM (2013b) and reiterated here is for an extensive investigation to identify potential offshore sand deposits.

2 References

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Appendix A – PBPL Meeting Minutes

Memorandum

From: Matthew Barnes

To: Peter Nella, Chris Allan, Mick Smith, Denis Shaw

Date: 26 March 2013

CC: Dean Patterson, Alex Byasse

Subject: Teleconference Meeting Minutes
Monday 25 March 2013, 3.30pm

R.E.: Beach Nourishment of Maroochydore Beach Using PBPL Dredge Material

Attendees:

Peter Nella (PBPL), Chris Allan (SCC), Mick Smith (SCC), Denis Shaw (SCC), Dean Patterson (BMT WBM), Matt Barnes (BMT WBM), Alex Byasse (BMT WBM)

Item 1: Details on the type of dredging equipment capable of delivering beach nourishment material to Maroochydore Beach

- Small Trailer Suction Hopper Dredge (TSHD) "*The Brisbane*". http://www.vuykrotterdam.com/uploads/FinalPDF/TSHD_Brisbane_newbuilding.PDF
- *The Brisbane* draft approximately 6.5m.
- Likely delivery method via bottom dump close to the -8mLAT contour. Over the bow (or "rainbowing") delivery method potentially possible only in very calm conditions.
- Deliver approximately 2000m^3 of nourishment material per trip (4 trips per 24 hour day)
- Delivery of beach nourishment material via a larger dredger complicated by greater draft requirements. Mooring and pipeline delivery option difficult and expensive.
- Some concerns about accuracy of bathymetric LiDAR data in nearshore region between Alexandra Headland and Maroochy River Entrance.

Actions:

BMT WBM to check bathymetric LiDAR data against other available data sources and provide PBPL with chart showing -8mLAT contour.

Item 2: Estimate of annual volume of material available for beach nourishment purposes

- Existing dredge areas with material likely to suitable for Maroochydore Beach:
    - North of Northwest Channel (near Caloundra)
    - Spitfire Re-alignment Channel
- PBPL undertakes limited dredging (<60,000m^3) per year in these areas. Any material from these areas is typically used for PBPL reclamation purposes.
- Likely that dredging and delivery to Maroochydore Beach would need to be a specific contract (i.e. not part of other PBPL maintenance or capital dredge program).
- Sand quality typically clean white sand with approximately 300µm diameter

Actions:

PBPL to provide sand Particle Size Distribution (PSD) analysis results to BMT WBM. Sand quality to be compared Maroochydore Beach sand (including nearshore zone).

Item 3: Cost estimate for beach nourishment material delivery to Maroochydore Beach

- Preliminary estimates for sand delivered to Maroochydore Beach discussed in meeting:
    - Sand from Northwest Channel approximately $13/m^3
    - Sand from Spitfire Re-alignment Channel approximately $18/m^3

Actions:

Peter Nella to provide more accurate cost estimates to BMT WBM. In follow up email to BMT WBM (26/03/2013) Peter Nella provided the following revised estimates:

- Sand from Northwest Channel approximately $11/m^3
- Sand from Spitfire Re-alignment Channel approximately $15/m^3

Item 4: Likely seasonal window PBPL services can be provided to Sunshine Coast Council

- Typically, *The Brisbane* is in SE Queensland and available between December and April.
- Due to existing commitments in 2013/14 not available until Feb 2014.

Appendix B – Particle Size Distribution

Particle Size Distribution (PSD) analysis results for:

(1) Spitfire Re-alignment Channel (provided by PBPL)

(2) Maroochy River Entrance (Cardno Bowler, 2011)

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

53B Fairlawn Street, Nathan, QLD, 4111
Ph: (07) 3274 4411 Fax: (07) 3274 4977

test results

client : *PORT OF BRISBANE CORPORATION*
job no : *GEOTNATH17509AQ*
principal :
laboratory : *BRISBANE*
project : *WICK DRAIN TRIALS*
report date : *24 November, 2006*
location : *PADDOCK S3A and TERMINAL 11*
test report no. : *E06-283*

test procedure : *AS1289 3.6.1*
test date : *23/11/06*

	PARTICLE SIZE DISTRIBUTION			
	CB062932	CB062933	CB062934	CB062935
	P453	*P425*	*P480*	*P502*
	Percent Passing			
4.75mm	*100*	*100*	*100*	*100*
2.36mm	*99.2*	*99.6*	*99.6*	*99.7*
1.18mm	*98.8*	*99.4*	*99.1*	*99.5*
0.600mm	*97.7*	*98.7*	*97.6*	*98.4*
0.425mm	*93.8*	*95.5*	*92.5*	*94.0*
0.300mm	*67.1*	*54.7*	*62.6*	*69.8*
0.150mm	*2.0*	*2.1*	*3.6*	*3.3*
0.075mm	*1.3*	*1.4*	*1.8*	*1.5*

remarks :

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Approved Signatory:
CHRIS PARK

Date : *24/11/06*

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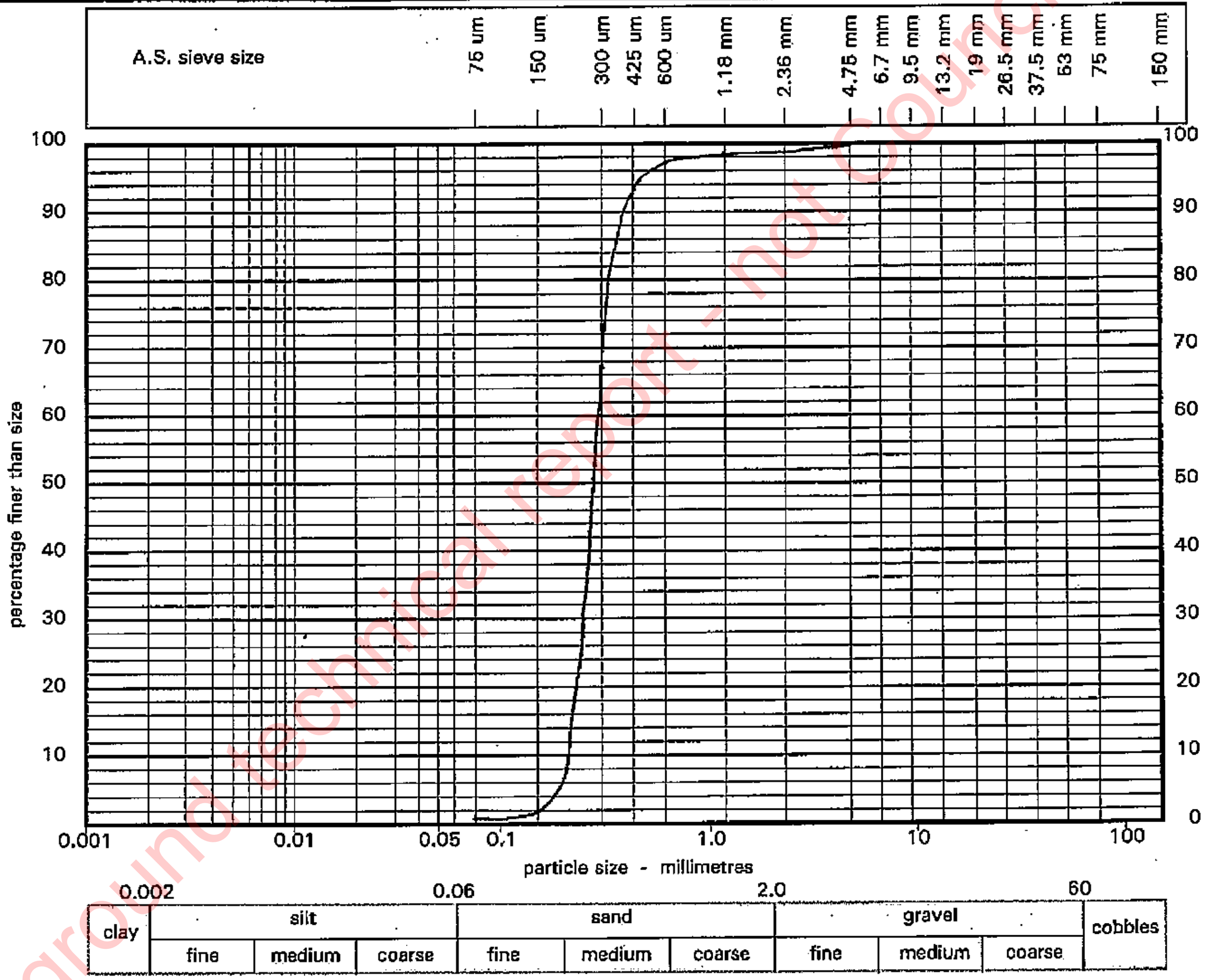
particle size distribution

client : *PORT OF BRISBANE CORPORATION*
job no : *GEOTNATH17509AQ*
principal :
laboratory : *BRISBANE*
project : *WICK DRAIN TRAILS*
report date : *November 24, 2006*
location : *PADDOCK S3A*
test report no. : *E06-283*

test procedure : *AS1289 3.6.1*
depth :
sample no : *CB062932*
sample identification: *P453*



Atterberg Limit :

liquid limit	%	-
plastic limit	%	-
plasticity index	%	-
linear shrinkage	%	-
natural moisture	%	-

Sample History

natural state ☐
air dried ☐
oven dried ☐
other ☐

Preparation Method

dry sieving ☐
wet sieving ☐

Linear Shrinkage

Mould size mm
crumbling ☐
curling ☐

classification :

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Approved Signatory:
Chris Park
Date : *24/11/06*

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particle size distribution

client :	*PORT OF BRISBANE CORPORATION*	job no :	*GEOTNATH17509AQ*
principal :		laboratory :	*BRISBANE*
project :	*WICK DRAIN TRAILS*	report date :	*November 24, 2006*
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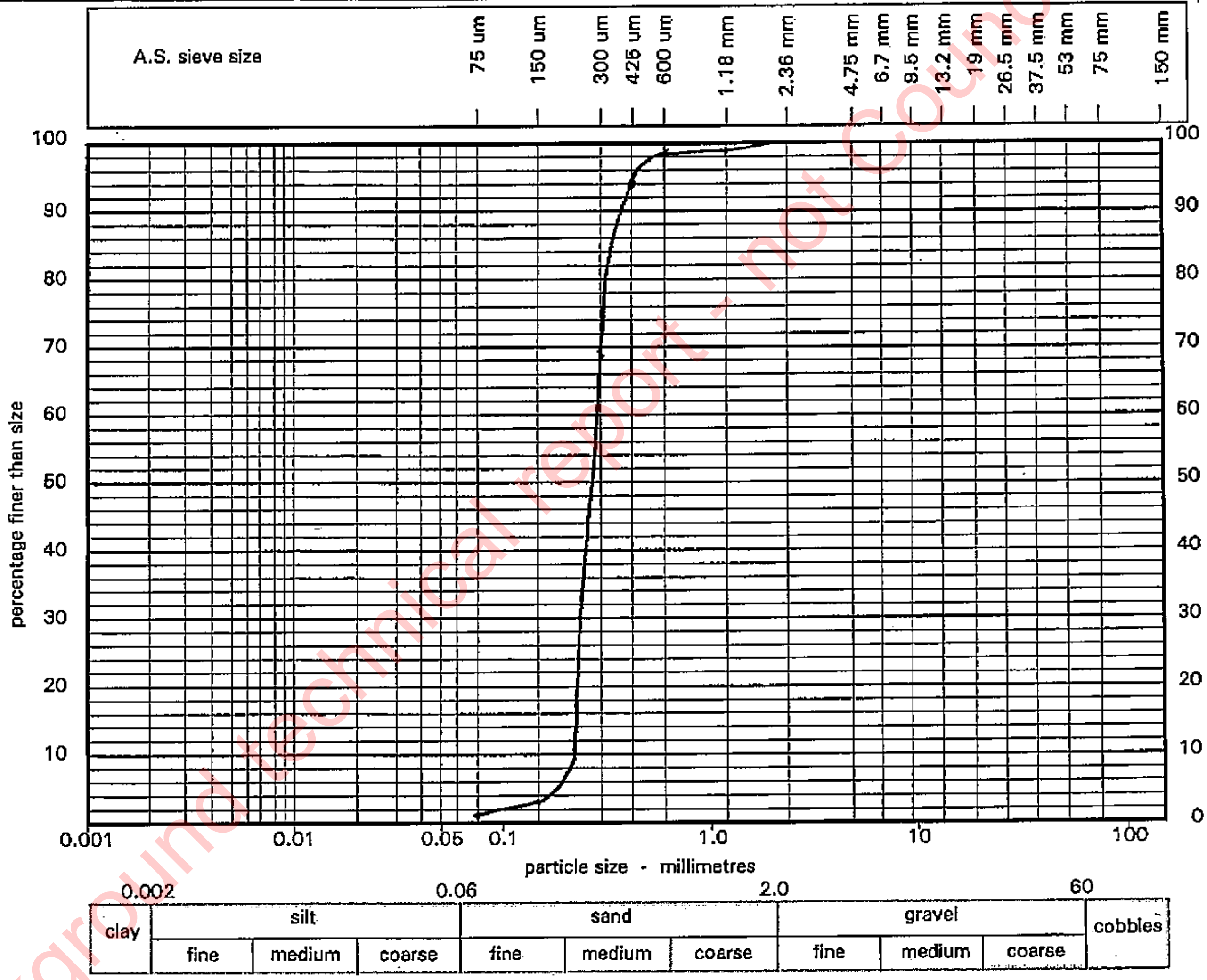
test procedure : *AS1289 3.6.1*

depth :

sample no : *CB062935*

sample identification: *P502*



classification :

Atterberg Limit :

liquid limit	%	-
plastic limit	%	-
plasticity index	%	-
linear shrinkage	%	-
natural moisture	%	-

Sample History

- natural state ☐
- air dried ☐
- oven dried ☐
- other ☐

Preparation Method

- dry sieving ☐
- wet sieving ☐

Linear Shrinkage

Mould size mm

- crumbing ☐
- curling ☐

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particle size distribution

client : *PORT OF BRISBANE CORPORATION*
principal :
project : *WICK DRAIN TRAILS*
location : *TERMINAL 11*

job no : *GEOTNATH17509AQ*
laboratory : *BRISBANE*
report date : *November 24, 2006*
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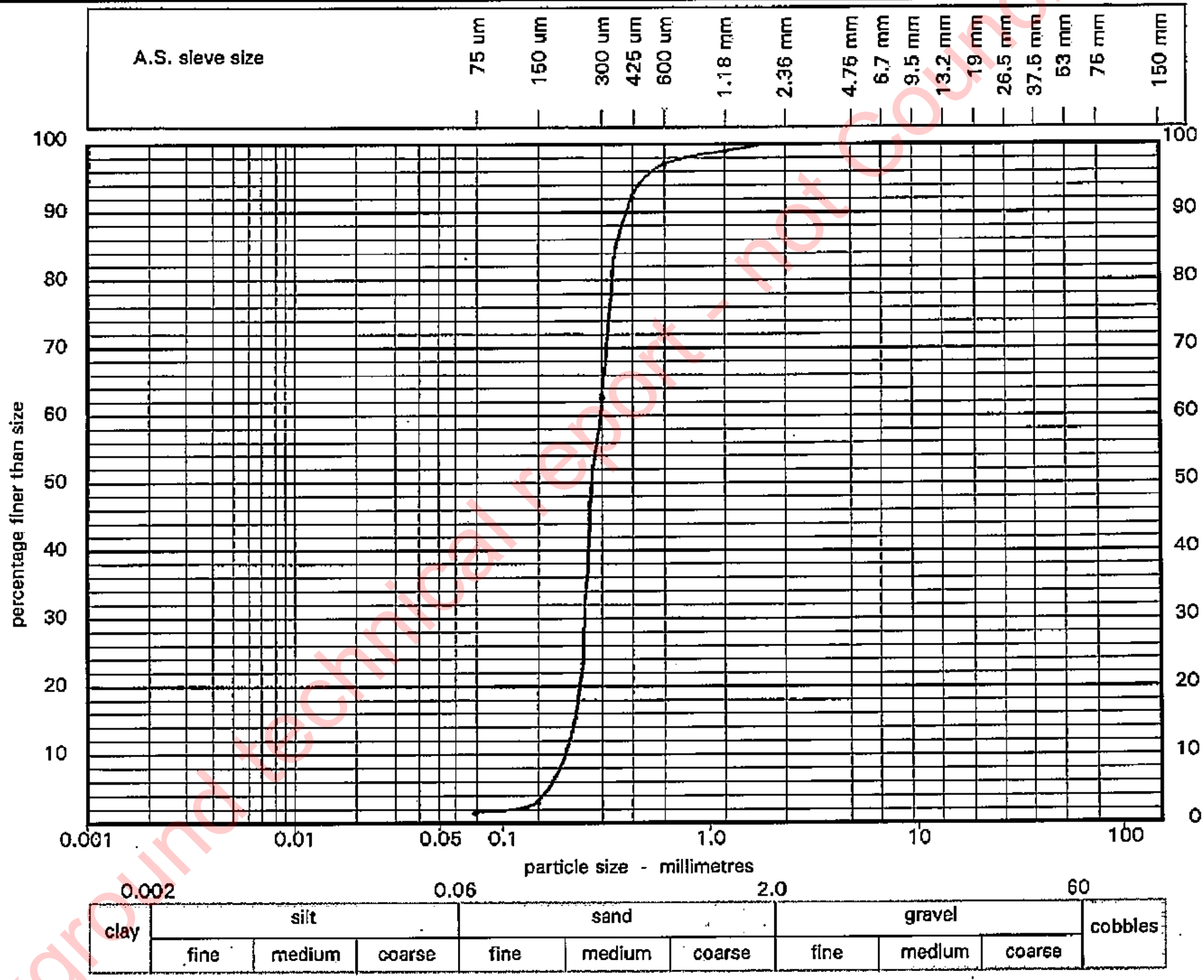

Atterberg Limit :

liquid limit	%	-
plastic limit	%	-
plasticity index	%	-
linear shrinkage	%	-
natural moisture	%	-

Sample History

natural state ☐
air dried ☐
oven dried ☐
other ☐

Preparation Method

dry sieving ☐
wet sieving ☐

Linear Shrinkage

Mould size mm
crumbing ☐
curling ☐

classification :

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particle size distribution

client : *PORT OF BRISBANE CORPORATION*
principal :
project : *WICK DRAIN TRAILS*
location : *PADDOCK S3A*

job no : *GEOTNATH17509AQ*
laboratory : *BRISBANE*
report date : *November 24, 2006*
test report no. : *E06-283*

test procedure : *AS1289 3.6.1*
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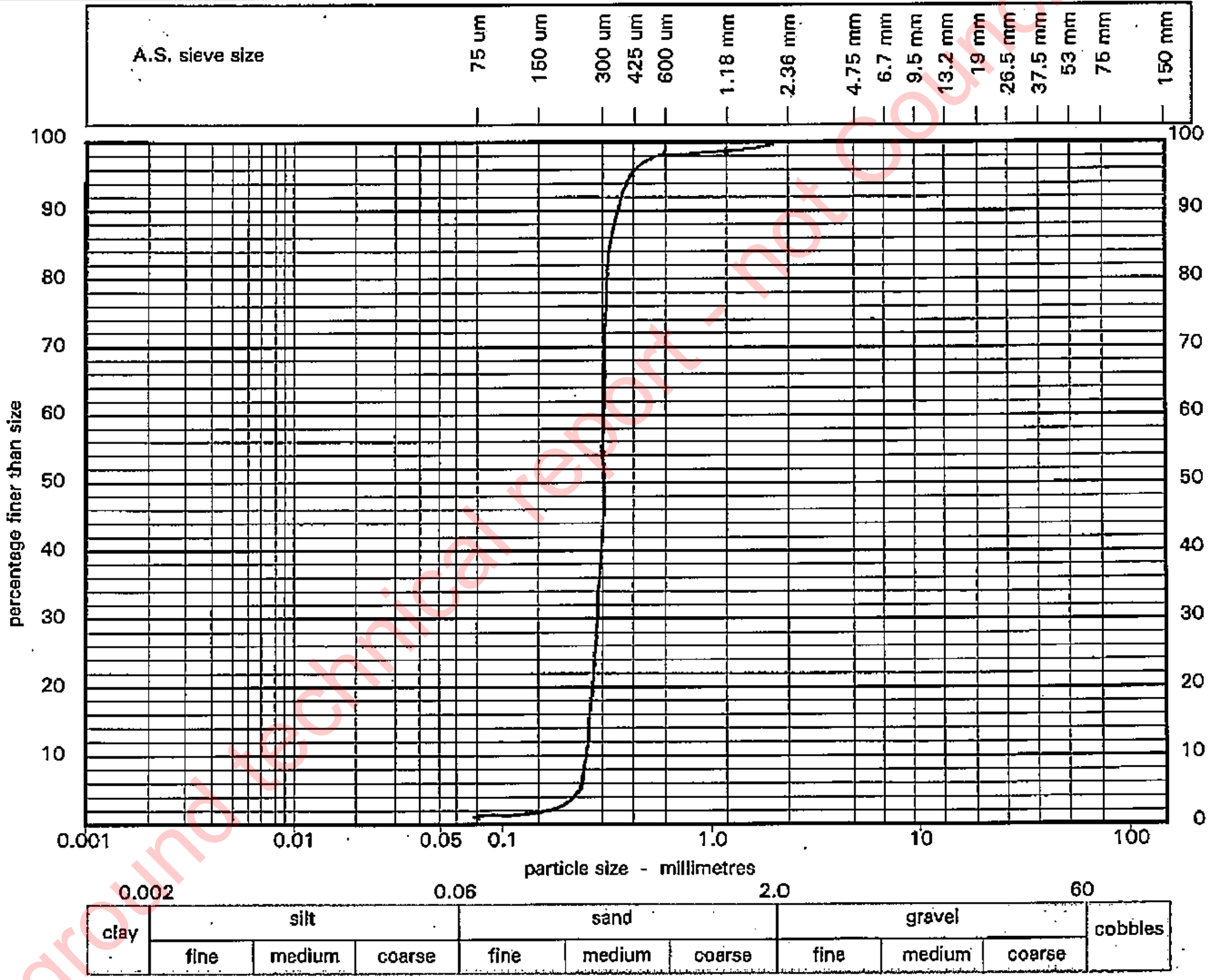
sample identification: *P425*
depth :



Atterberg Limit :

liquid limit	%	-
plastic limit	%	-
plasticity index	%	-
linear shrinkage	%	-
natural moisture	%	-

Sample History

natural state ☐
air dried ☐
oven dried ☐
other ☐

Preparation Method

dry sieving ☐
wet sieving ☐

Linear Shrinkage

Mould size mm
crumbing ☐
curling ☐

classification :

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Cardno Bowler Offices:
Brisbane, Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Sunshine Coast, Gold Coast,
Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

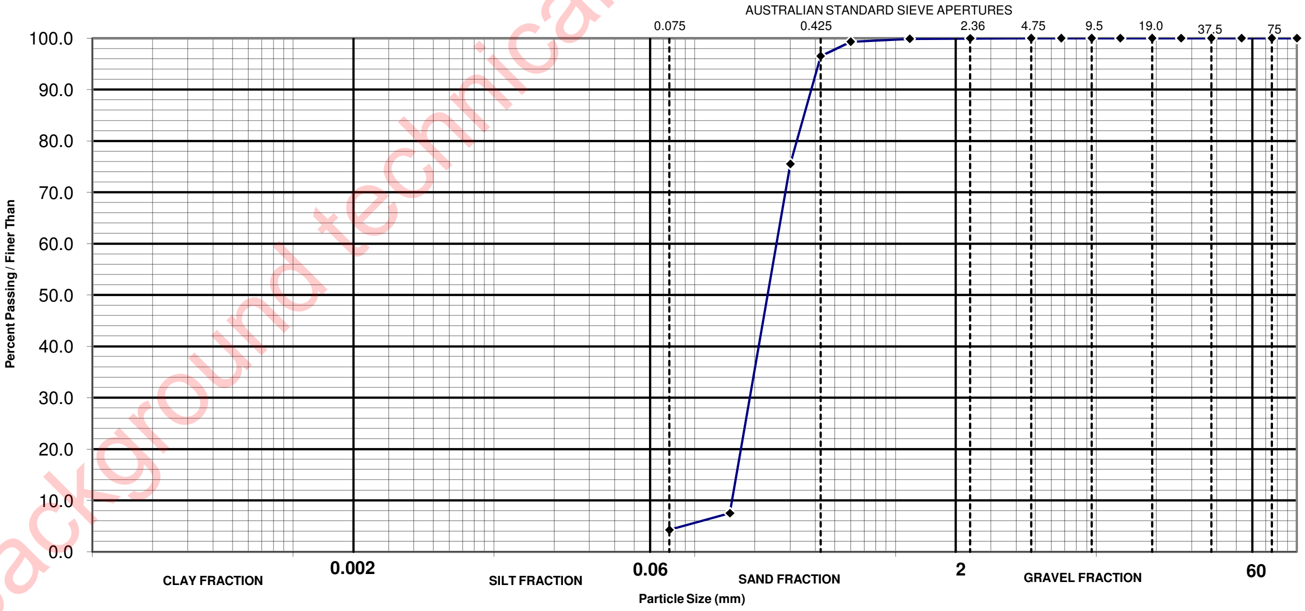
Sample Number: **3747/S/12841**
Sample Identification: **BH17: 2.0-2.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12841Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	96		
37.5		0.300	76		
26.5		0.150	8		
19.0		0.075	4		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Form Number

REP HYD-2

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Shaping the Future

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Cardno Bowler Offices:
Brisbane, Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Sunshine Coast, Gold Coast, Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

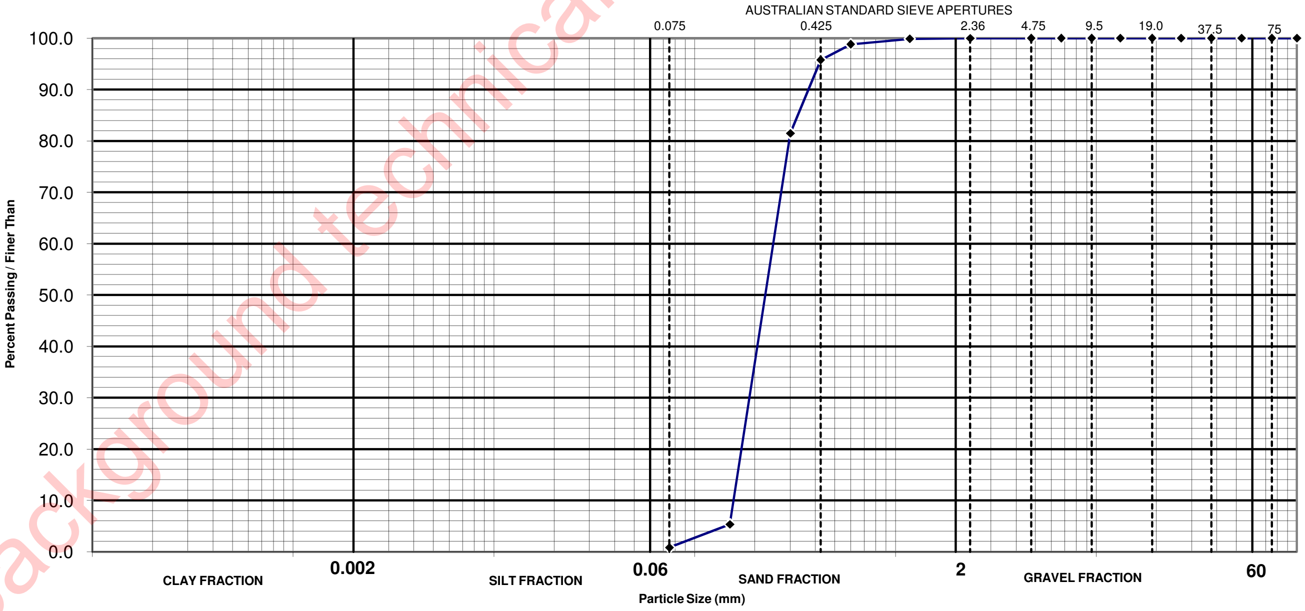
Sample Number: **3747/S/12843**
Sample Identification: **BH18: 0.0-0.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12843Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **mechanical**
Hydrometer Type: **grams/Litre**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	96		
37.5		0.300	81		
26.5		0.150	5		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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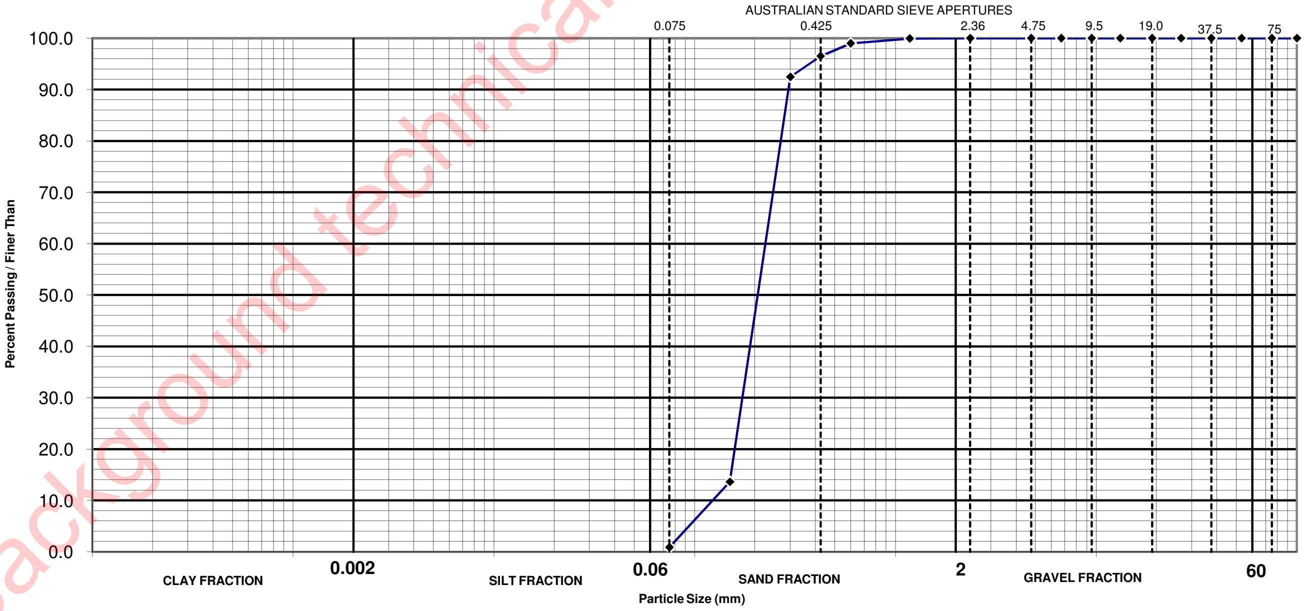
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12857Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12857**		
Sample Identification:	**BH19: 1.0-1.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	97		
37.5		0.300	92		
26.5		0.150	14		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

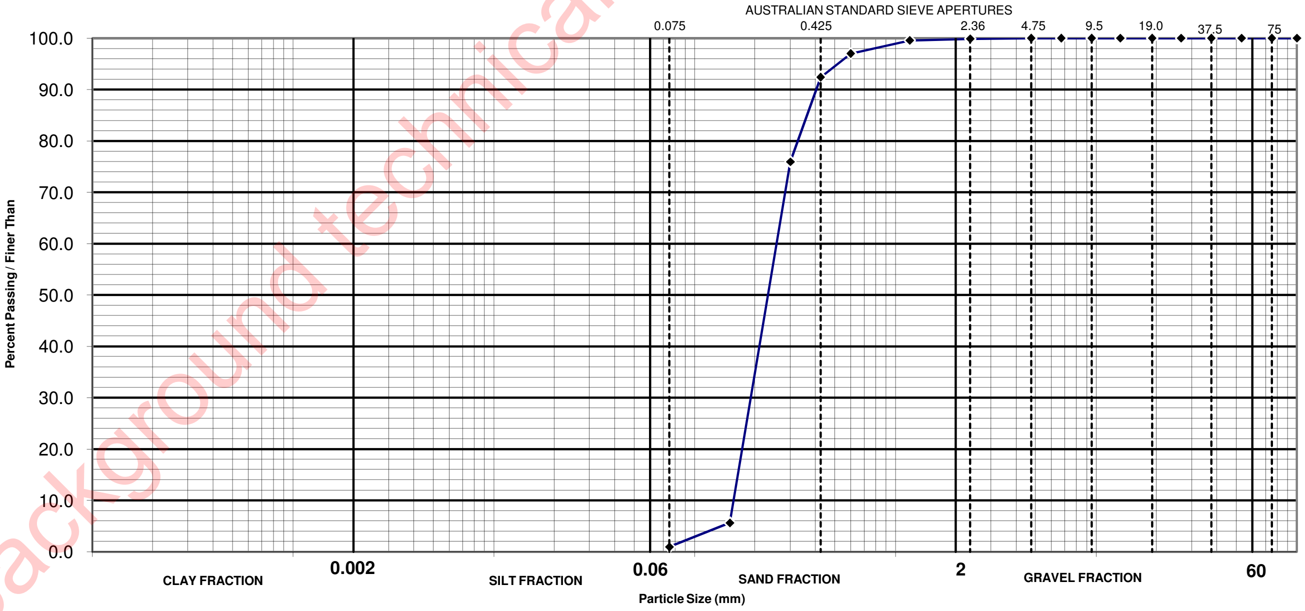
Sample Number: **3747/S/12866**
Sample Identification: **BH20: 2.5-3.0**
Date Sampled: **9/11/2011**

Report Number: **3747/S/12866Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	97		
53		0.425	92		
37.5		0.300	76		
26.5		0.150	6		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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NATA Accreditation No: 3747

SIGNATORY: Paul Mayes

Form Number

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Appendix C –*The Brisbane* Trailing Suction Hopper Dredger

Trailing Suction Hopper Dredger BRISBANE

Principal dimensions

Length overall	84,00	m
Length between perpendiculars	79.90	m
Breadth moulded	16.00	m
Depth moulded	7.00	m
Draught at summer load line	5.50	m
Draught at reduced freeboard	6.25	m

Capacity

Deadweight at summer load line	3 808	ton
Deadweight at reduced freeboard	4 747	ton
Hopper capacity	2 900	m³
Maximum speed	13.0	kn

Dredging equipment

Two trailing suction pipes, diameter	700	mm
Dredging depth	25.00	m
Two Warman dredge pumps, electrically driven	2x 750	kW
Two jet water pumps, capacity;	940	m³/h @ 8 bar
Five conical bottom valves, diameter each	3 000	mm

Fitted with:
* Self-emptying system
* Bow discharge

Machinery

Two Caterpillar main diesel engines for propeller drive and alternator drive, type 3606 DITA	2x 1 800	kW
One auxiliary diesel generator set, make Caterpillar, type 3508 DITA	1x 900	kW
One emergency generator set, make Caterpillar, type 3306 DIT	1x 114	kW
Two controllable pitch propellers	2 300	mm
One bow thruster	1x 310	kW
Two shaft generators	2x 1 875	kVA

Vuyk Engineering Rotterdam B.V.
Naval architects, Marine engineers, Consultants

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Fax +31 (0)10 458 72 45
Email vuyk@vuykrotterdam.com
Website www.vuykrotterdam.com

VER project 98.315

Values are for presentation only

Trailing Suction Hopper Dredger BRISBANE

Classification

The 'Brisbane' is certified by Lloyd's Register of Shipping for the class:
✠100A1 +UMS TM Hopper Dredger Australian Coastal Service, not exceeding 200 nautical miles. Dredging between 15 and 30 miles from shore with maximum wave height of 1.5 m.

VER scope of work

Based on a long-term relationship and co-operation with Vuyk Engineering in the past, shipyard NQEA Australia of Cairns, awarded in September 1998, a contract to VER to deliver basic and detail construction drawings and production information for the trailing suction hopper dredger. Furthermore the stability booklet was made by VER.
The Vessel was ordered by the Port of Brisbane Corporation, based on a design delivered by the Yard in conjunction with the Owner and Subcontractors.

Vuyk Engineering Rotterdam B.V.
Naval architects, Marine engineers, Consultants

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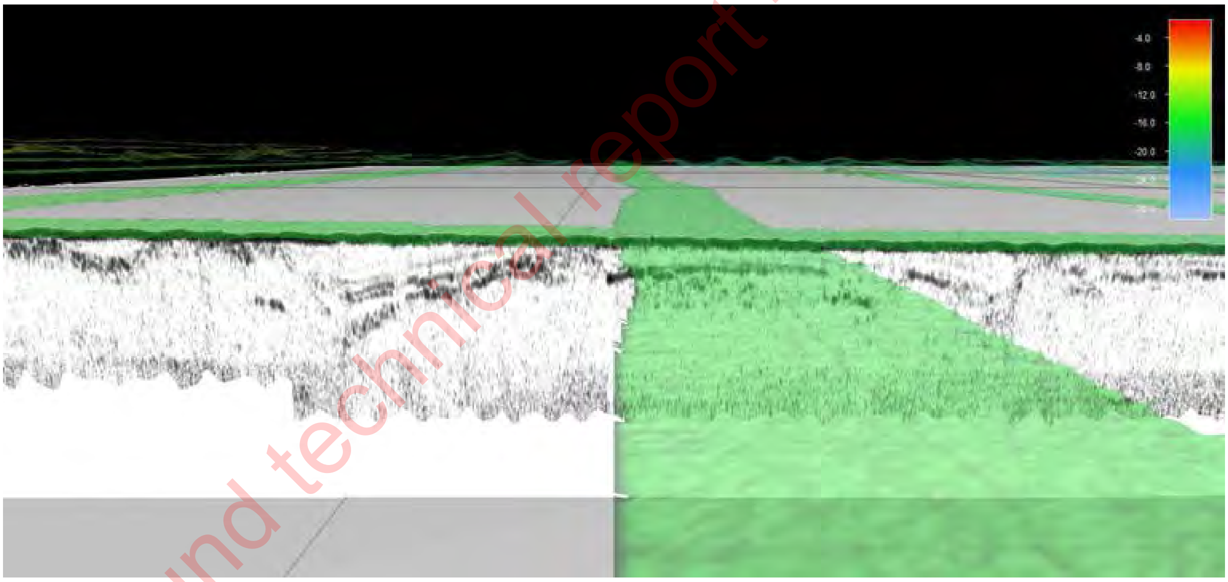
VER project 98.315

Appendix B Mooloolah Sand Survey Report (Acoustic Imaging, 2015)

Mooloolaba Sand Survey

Port of Brisbane



Assembled by D. Bergersen
April 27, 2015
Version 1.0

Introduction

Acoustic Imaging Pty Ltd (AI) was contracted by the Port of Brisbane (PoB) to acquire and interpret a subbottom profiler (SBP) data set off Mooloolaba River on the Sunshine Coast. SBP data acquisition occurred between May 9-10, 2015. Multibeam echo sounder (MBES) bathymetry was acquired prior to the SBP data and forms a part of the interpretation.

The purpose of the survey was to assess the sediment thickness across two areas north and east of the Mooloolaba Harbour (Alexandra Headland and Point Cartwright; Figure 1).

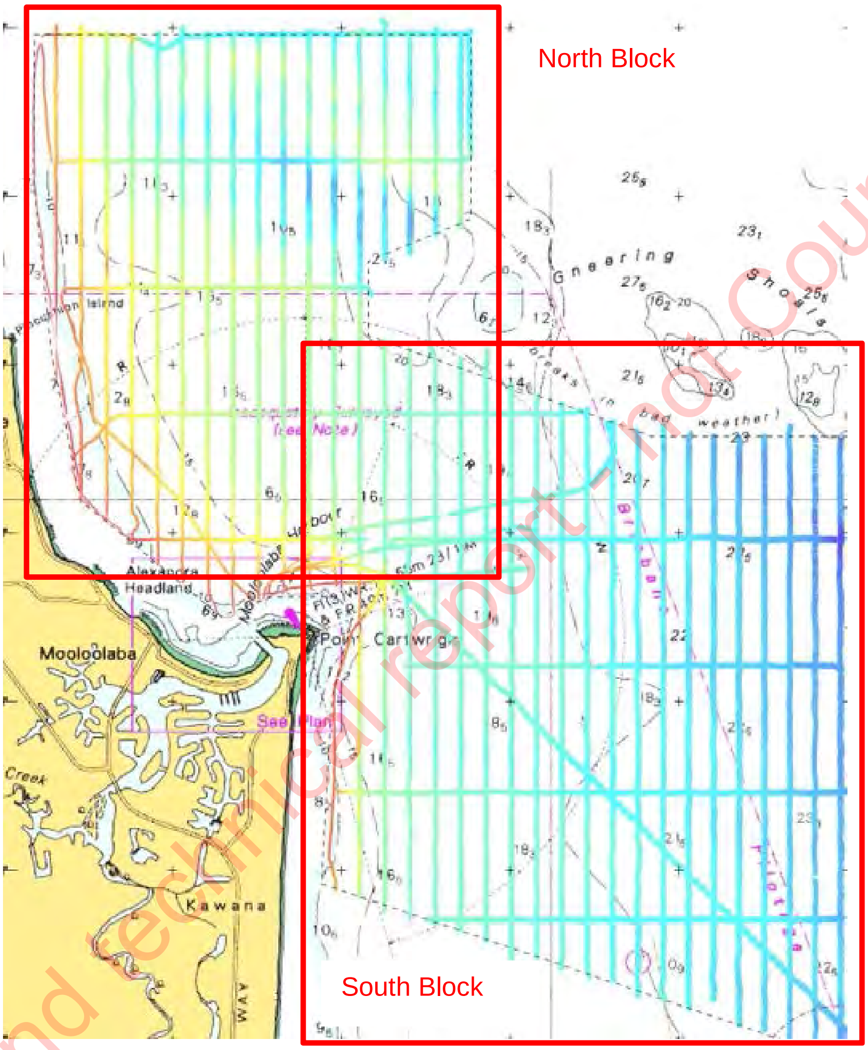


Figure 1: Bathymetry associated with SCW_BCN survey

The focus of this report is to describe the bedforms and subsurface stratigraphy located across the survey areas and provide a sediment thickness estimate based on interpreted SBP data.

Separate data deliverables include a Fledermaus Scene file showing representative data across the area and ASCII X,Y,Thickness files for the North and South blocks.

Survey Methodology and Data Processing

The MBES data were acquired by PoB's Reson 8125 system and details of its operation on this survey can be found in other reports / documents. Data supplied for this report consisted of processed and cleaned ungridded XYZ points in ASCII format. The data were gridded at a 1m bin size using a weighted moving average encoding algorithm with a weight diameter of 3.

The SBP data were acquired with an Innomar SES-2000 *compact* parametric sub-bottom profiler system. The North Block survey area consisted of a set of 7 main lines run in a N-S direction and 4 cross lines run perpendicular to the main lines. The South Block survey area was crossed by 10 main lines run in a N-S direction and 4 cross lines run perpendicular to the main lines.

The SBP system was operating at a 5 kHz low frequency with 2 pulse cycles producing a pulse length of 400 µsec. The resulting vertical resolution associated with this pulse length is approximately 30cm.

Parameter	Setting for pipeline location survey
Primary source level	> 236 dB re 1µPa @ 1 m
Secondary source level	> 200 dB re 1µPa @ 1 m
Primary centre frequency	100 kHz
Secondary frequency	5 kHz
Beam angle	2.0° @ -3 dB
Transmitter pulse length	400 µsec
Recording range	Variable dependent on water depth
Sampling interval	34 µs
Ping rate	approx. 10-20 s^{-1}

Table 1: Acquisition parameter for SES-2000 *compact* system

Data supplied for this report consisted of pre-filtered and demodulated .SES files and full wave form *.RAW files. Data were analysed with both the Innomar ISE software and Chesapeake SonarWiz software.

The Innomar SESConvert software package was used to generate SEG-Y files for import to SonarWiz.

The SBP data were enhanced through application of an Automatic Gain Control (AGC) algorithm and trace smoothing (combining multiple adjacent traces to reduce high-frequency noise).

Interpretation

Bathymetry

The bathymetry associated with the Mooloolaba survey is shown in Figures 1 and 2. As noted the entire survey area was arbitrarily divided into a North Block and South Block, each of which exhibits dimensions of approximately 6km x 6km. Depths across the blocks range from -1.4m to -29.6m.

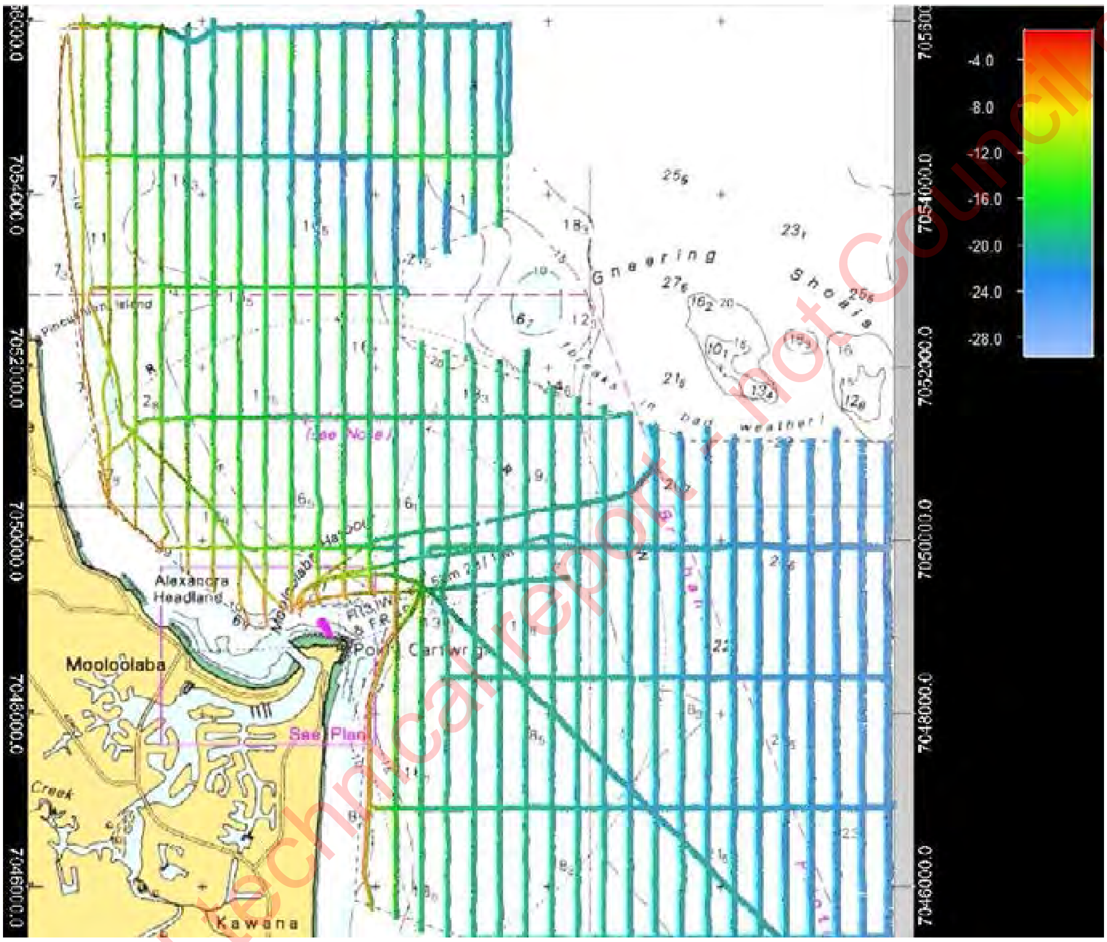


Figure 2: Bathymetry across Mooloolaba survey area.

Bathymetric coverage is not complete because of time limitations associated with the survey. As such, a completely accurate picture of the areal extent of identified seabed features is not possible and some inference must be made as part of the interpretation.

The majority of the survey area is covered by a surficial sand unit but rock outcrops exist in selected areas (Figure 3). The rock outcrops, presumably sandstone, are more prevalent in the North Block, and in particular around the nearshore areas of Point Cartwright and Alexander Headlands, and in the areas adjacent to the Gneering Shoals.

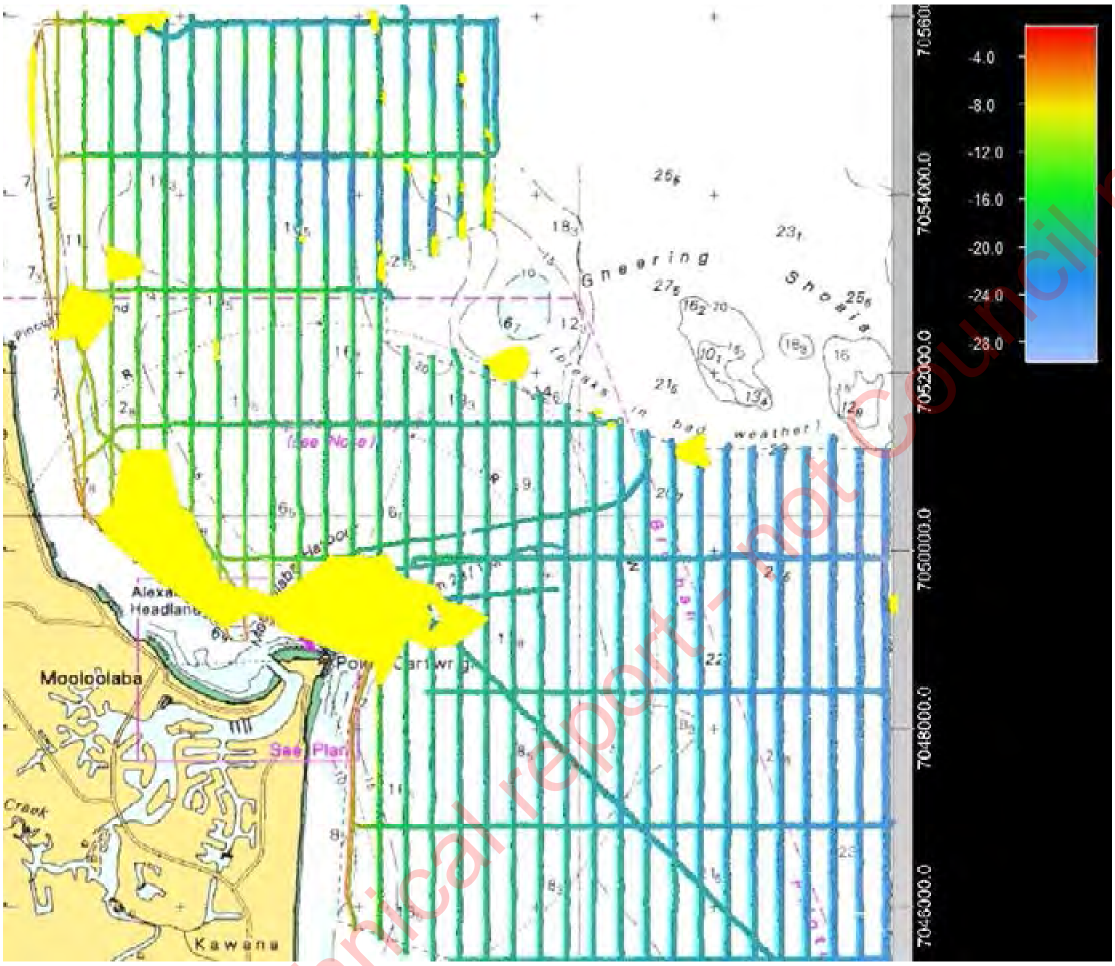


Figure 3: Rock outcrops (yellow polygons) across Mooloolaba survey area.

The rock outcrops are very distinctive in the bathymetry data from adjacent sand covered areas, and differ in their morphologic expression across the survey area.

Near the coast, in the area outside of Mooloolaba Harbour, the outcrops exhibit a high degree of roughness and irregularity (Figure 4). Pockets of sediment covered areas lie between the exposed rock areas so the yellow polygonal area shown in Figure 3 shouldn't be construed as a continuous rock platform.

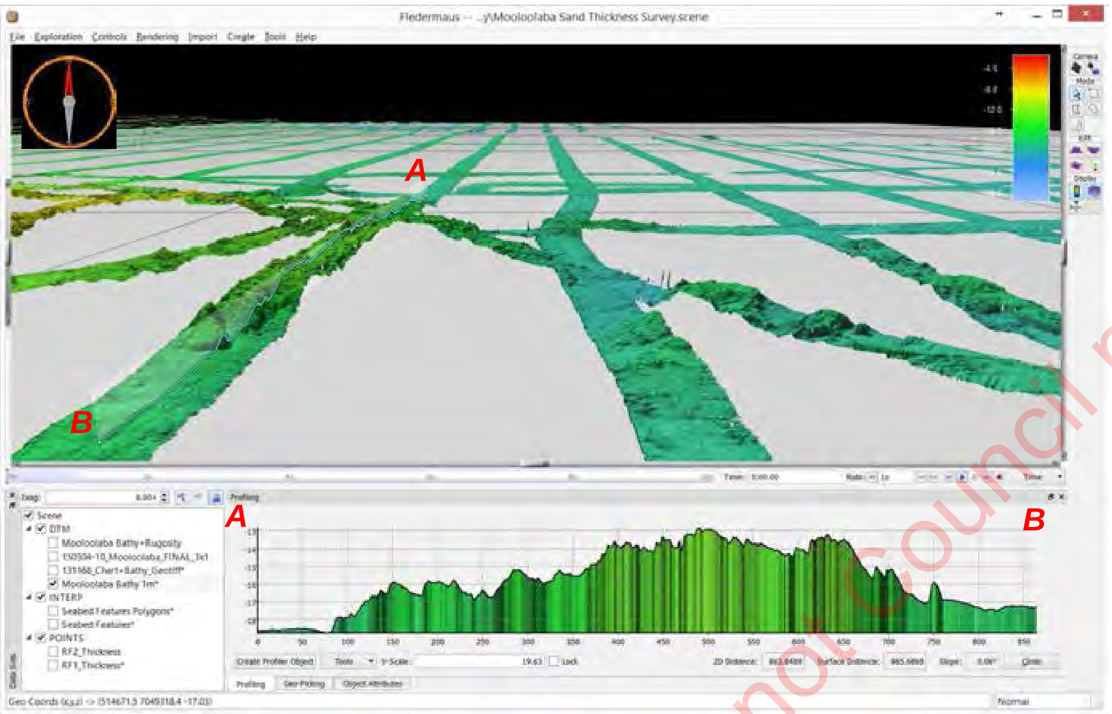


Figure 4: Example of rock outcrops outside Mooloolaba Harbour.

A series of stepped outcrops leads into Gneering Shoals from north to south (Figure 5). Relief on the steps ranges between 1.5m to 2.0m.

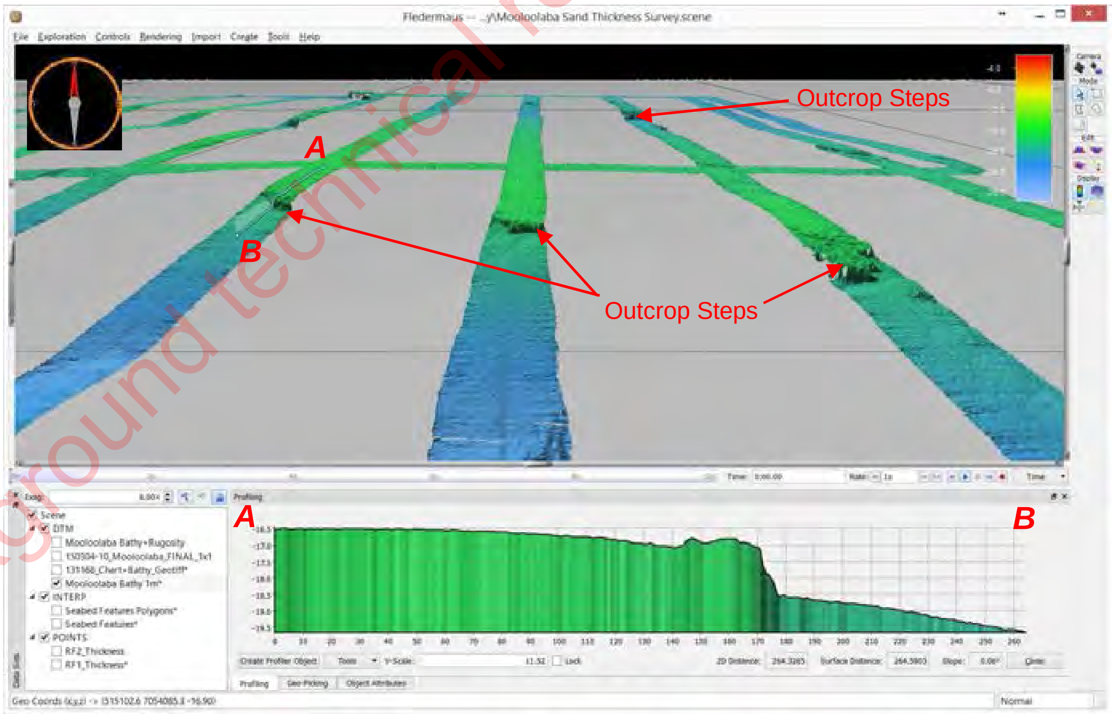


Figure 5: Example of rock platform north of Gneering Shoals

The areas where outcrops were crossed around Gneering Shoals shows them to be very similar to the inshore exposures (Figure 6). Relief across the exposed sections varies between 1.0m to 1.5m before transitioning into the sediment covered shelf regions.

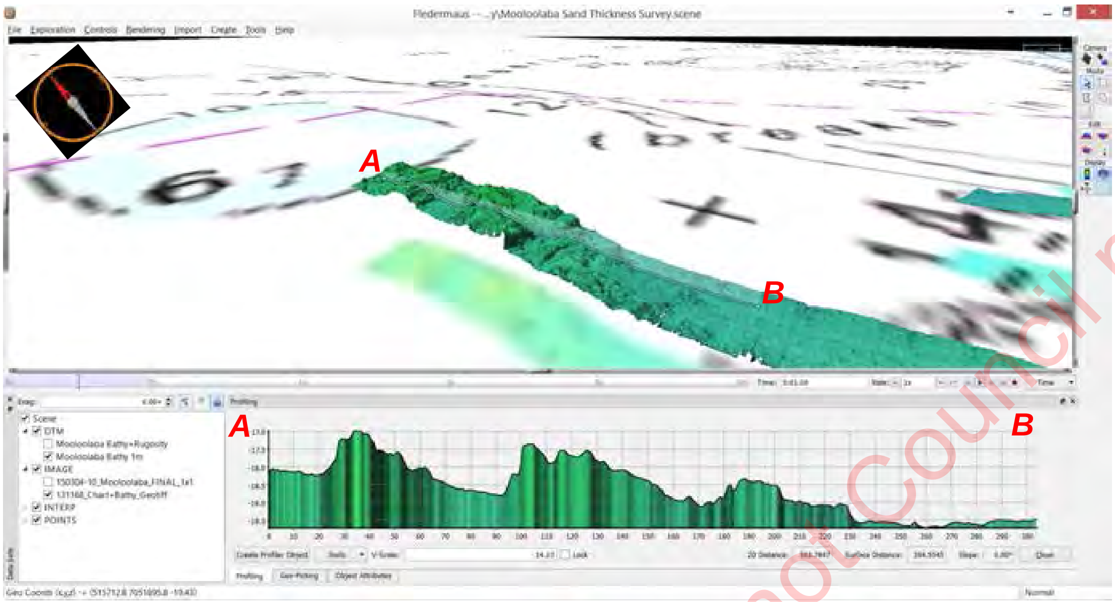


Figure 6: Example of rock outcrop along southwest edge of Gneering Shoals.

Other bedforms exist across the surveyed north and south blocks but these will be discussed in relation to the sediment structure observed in the SBP data.

Sediment Structure

Two primary reflectors were digitised across the survey blocks. One reflector represents the surface associated with the rock outcrops noted in the bathymetry, and the other surface presumably represents a localised cementation surface.

Neither reflector could be tracked across the entirety of the survey area. The “basement” reflector dips away from the rock exposures to a depth beyond the penetration of the Innomar SES-2000 system and the cementation horizon appears and disappears at intervals along each line.

The figure below shows an example of the reflector defining the rock outcrop dipping beneath the shelf sediment unit (presumably sand and silt). The shallower cementation horizon appears and disappears across the survey areas. The varying reflector amplitude probably represents a greater degree of cementation “hardness”, although the horizon as a whole isn’t deemed a hazard to dredging operations.

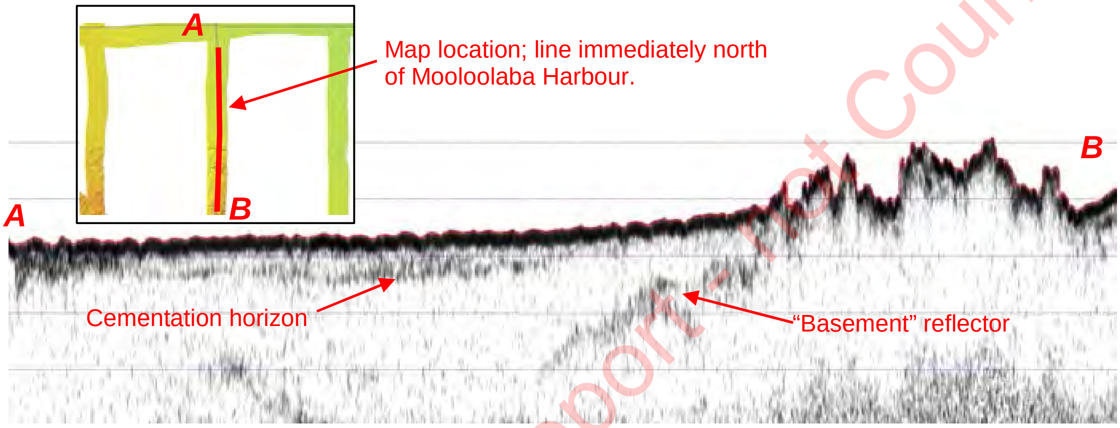


Figure 7: Example of rock outcrop (“basement”) reflector and cementation horizon reflector north of Mooloolaba Harbour. Horizontal scale lines at 2m intervals.

The surficial expression of the rock platform that steps down to Gneering Shoals exhibits 1.5m – 2.0m of relief but the SBP data shows that the cliff face is more pronounced (approximately 6m). Approximately two-thirds of the cliff is buried by sediment (figure below)

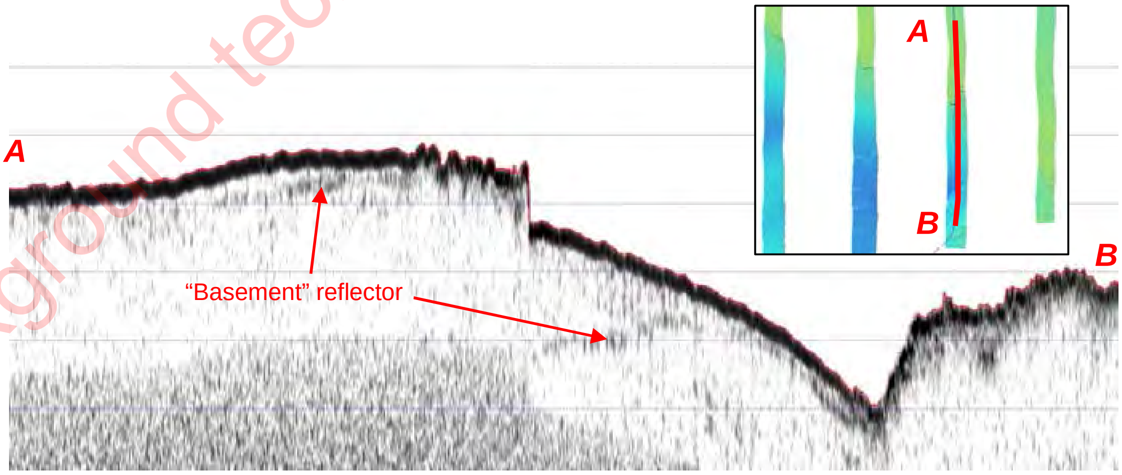


Figure 8: Example of rock platform that steps down to Gneering Shoals. Horizontal scale lines at 2m intervals.

The SBP stratigraphy in the northern block is much more dynamic than in the southern block. The basement reflector is more prominent throughout the northern block survey area and the cementation horizon also appears to be more prevelant.

Buried channels like those shown in the figure below are located across the northern block. Total penetration across these features ranged between 6-8m, providing confidence that the SBP equipment was suitable for imaging the basement reflector and assessing sediment unit thickness.

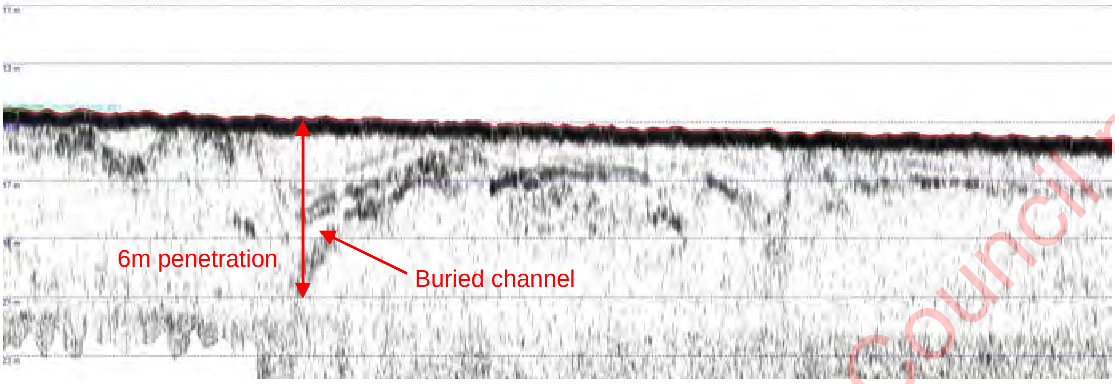


Figure 9: Example of penetration achieved with SBP. Buried channel in the northern survey block. Horizontal scale lines at 2m

In the southern block the basement reflector is visible in the shoreline sections of the SBP data and around Point Cartwright but for the most part is beyond the penetration of the sensor.

From the perspective of dredging operations, sediment thickness is much more favourable in the southern block than in the northern block. The map below shows a highly interpolated polygon where sediment thickness exceeds 3m (green areas). Rock outcrop areas are shown in yellow. The polygon boundaries were defined by presence and absence of the basement reflector, and the calculated thickness of the sediment unit where the basement reflector was visible. In areas where the basement reflector was not visible the sediment unit was assumed to be in excess of 3m (as SBP penetration was proven to be > 3m).

The “holes” shown in green polygon across the northern block represent areas where the basement reflector shoals such that sediment unit thickness becomes less than 3m. As noted previously, rock outcrops are much more prevalent across the northern block so more areas where sediment unit thickness diminishes makes sense.

Again, the polygons shown in the figure below are highly interpolated due to the sparseness of both the bathymetry and SBP data. I recommend that once a dredge site is identified a more densely-spaced SBP data set be acquired to confirm no subsurface hazards are present. A bathymetry data set with 100% coverage and associated backscatter mosaic would also be beneficial for identifying seabed features that might be affected by dredging operations.

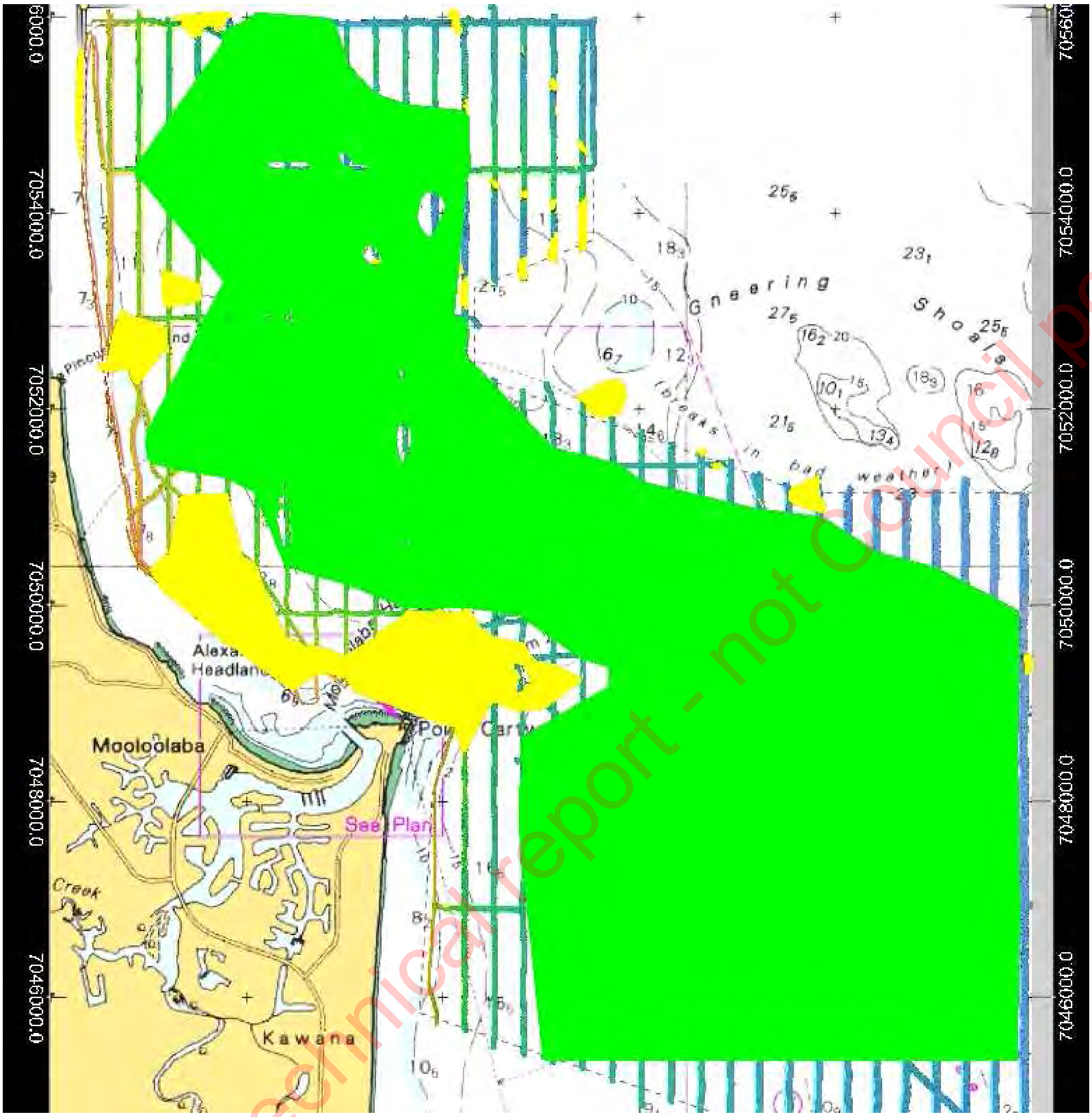


Figure 10: Interpolated polygons representing areas of thick (>3m) sediment cover (GREEN) and rock outcrops (YELLOW).

Finally, the cementation horizon mapped across both survey blocks is not interpreted to represent a hazard to dredging operations but knowing the location is useful information. The figure below shows the location and depth in the sediment unit for the southern block (as this is presumed to be the most favourable area for dredging operations).

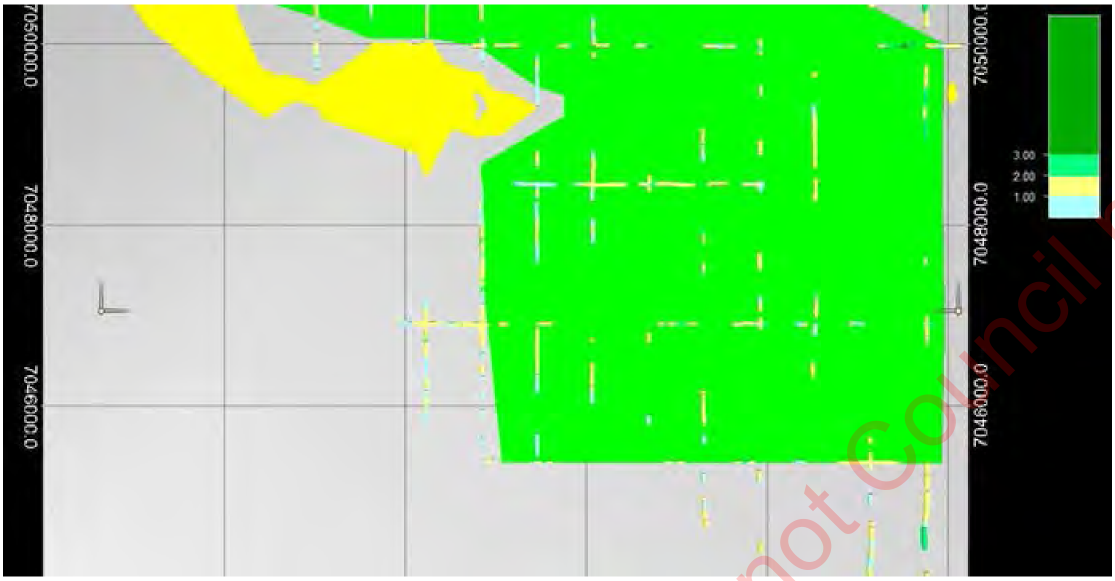


Figure 11: Location of cementation horizon (R1) across southern block. GREEN polygon represents sediment thickness areas >3m and the YELLOW polygon represents rock outcrop areas.

Summary

The bathymetry and SBP data set acquired offshore from Mooloolaba Harbour does not provide 100% coverage of the area but was adequate for identifying seabed features detrimental to dredging operations and areas where sediment thickness exceeded 3m.

The total survey area was broken down into a northern block and a southern block, each surveyed on a different day. The southern block is much more favourable for dredging operations in terms of greater sediment unit thickness and fewer seabed hazards.

This survey appears to be more of a reconnaissance mapping program as the data coverage is fairly sparse (limited budget and limited time). One recommendation is that once a dredge site is identified a more densely-spaced SBP data set be acquired to confirm no subsurface hazards are present.

Acquiring a bathymetry data set with 100% coverage is also recommended at this time, and using the associated backscatter data from the MBES to generate a seabed intensity mosaic would also be beneficial. Both data sets could be used for identifying seabed features that might be affected by dredging operations (i.e., habitats that might need further investigation or monitoring).

The reflector interpreted as a cementation horizon across both survey blocks (R1) is not presumed to represent a hazard to dredging operations.

Appendix C Pumicestone Passage Sediment Investigation Report (Cardno Bowler, 2011a)

Pumicestone Passage Sediment Investigation Report

Job Number: 3747/P/158

Prepared for Sunshine Coast Council

Date: 23 December 2011

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Document Control

Version	Date	Author		Reviewer	
1.0	23 December 2011	Paul Mayes	Pm	Matt Courtney	M

Executive Summary

Cardno Bowler Pty Ltd was engaged by Sunshine Coast Council to perform an investigation of the sediments in a section of the northern reaches of Pumicestone Passage to provide data to support an application to dredge this area for the purposes of a beach nourishment program.

A program of fieldwork and laboratory testing was designed and implemented with the aim of describing the nature of the sediments present within the proposed dredge area and to assess the extent and severity of any Acid Sulfate Soils within these sediments. Furthermore, three locations were sampled and tested for the presence and extent of contamination by metals and organic tins. These data could then be used to target dredging operations to areas likely to produce the best resource for a beach nourishment program. Supplementary to these sediment characterisations, a survey of the seagrass present within the area was also carried out to determine if the existing seagrass distribution would impact the selection of potential dredging sites.

A total of 20 boreholes were advanced during the investigation, with representative samples selected for particle size distribution and analytical laboratory testing for the presence of Acid Sulfate Soils. Subsurface strata at the site were dominated by fine to medium grained sands with varying, but generally very low, levels of silt. The results of the analytical laboratory testing on the samples collected support the presence of Acid Sulfate Soils within the material tested. As a result of intrinsic acid neutralising capacity held within the material tested, the potential acidity levels (as assessed by S_{Cr}) which ranged from nil to 0.849%S were often exceeded by acid neutralising capacity to give net acidity values for the majority of samples tested of nil. However, a total of three samples had net acidity values in excess of 0.03%S and as such liming rates were calculated to neutralise this acidity.

Paul Mayes (PhD.)
Principal Environmental Scientist

Table of Contents

Executive Summary ii

Glossary 3

Introduction 4

Site Description 6

Methodology 7

- Desktop Survey 7
- Fieldwork 7
- Laboratory Testing 8

Results and Discussion 9

- Desktop Survey 9
- Subsurface Conditions 9
- Analytical Laboratory Analysis 9
- Material Quality 11
- Seagrass Survey 12

Summary 13

List of Annexes

Annex A - Site Plan

Annex B – Sampling Locations

Annex C – Borehole Logs

Annex D - Particle Size Distribution Test Results

Annex E – Acid Sulfate Soils Test Results

Annex F – Metal and Organic Tin Test Results

Annex G – Seagrass Survey Results

Glossary

Acid Sulfate Soil (ASS): Soil or sediment containing highly acidic soil horizons or layers affected by the oxidation of iron sulfides (actual ASS) and/or sediment containing iron sulfides or other sulfidic material that has not been exposed to air and oxidised (potential ASS). The term Acid Sulfate Soils generally includes both actual and potential Acid Sulfate Soils.

Agricultural Lime: A neutralising agent commonly used to treat acidic soils.

AHD (Australian Height Datum): The datum used for the determination of elevations in Australia.

Borehole: The actual hole created when an auger or push-tube is inserted into the soil body.

BSL (Below Surface Level): The depth as measured from the existing site surface level, generally recorded in metres.

Clay: Cohesive Soil with a particle size less than 0.02mm.

Groundwater: Subsurface water in the zone of saturation, including water below the water table and water occupying cavities, pores and openings in underlying soil and rock.

Leachate: The soil constituent that is washed out from a mixture of soil solids.

Oxidised: Process of chemical change involving the addition of oxygen following exposure to air.

Piezometer: A pipe of small diameter installed in a borehole that is used to measure the height (elevation) of the water table.

Pyrite: Pale bronze or pale yellow, isometric mineral: FeS_2 ; the most widespread and abundant of the sulfide minerals.

pH_F: The pH of the soil in soil/distilled water paste.

pH_{FOX}: The pH of the soil after the addition of a small quantity of Hydrogen Peroxide.

%S: Percentage oxidisable sulfur.

Sand: Non-cohesive soil with a particle size between 2.36mm and 0.075mm.

Silt: Non-cohesive soil with a particle size between 0.075mm and 0.02mm.

SPP 2/02: State Planning Policy 2/02: Planning and Managing Developments involving Acid Sulfate Soils.

Soil and Sediment: The natural accumulation of unconsolidated mineral particles (derived from weathered rocks) and organic matter that covers much of the earth’s surface.

Water table: Portion of the ground saturated with water, often used specifically to refer to the upper limit of the saturated ground.

Introduction

The following report details the results of the Sediment Investigation performed within the northern reaches of the Pumicestone Passage in South East Queensland. It is understood that the works proposed for the site are to include the dredging of suitable sand resources from within the passage for the purposes of beach nourishment in the local area. The study area identified by council had an area of approximately 60 hectares and extended from Bells Creek in the south to approximately Jellicoe Street in the north and bordered the western bank of the passage. The scope of work covered in this investigation included the following:

- General description of the sediment profile at selected locations within study area;
- Particle size distribution testing of representative sediment samples;
- Acid Sulfate Soils testing of representative sediment samples; and
- A survey of the study area for the presence of seagrass beds greater than $50m^2$ in area.

The nature of the sediments present within the study area will be integral to the ultimate selection of the material to be dredged for two reasons:

- non-cohesive soils (ie sands) are logistically more suitable for dredging, and
- lightly coloured, clean sands will be more suitable for use in beach nourishment programs.

The Acid Sulfate Soils conditions within the areas proposed to be dredged may also be incorporated into the decision making process regarding which areas are most suitable to be used for the beach nourishment program. Acid Sulfate Soils are common in low-lying coastal areas of Queensland, especially in areas below 5.0 metres AHD. Such areas are often characterised by the presence of estuaries, swamps, floodplains, salt marshes and mangroves. The affected soils are characterised by iron sulfides, most frequently pyrite, and when these soils are maintained in anaerobic conditions these iron sulfides are unable to oxidise and therefore the Acid Sulfate Soils are stable. However, if a disturbance exposes the Acid Sulfate Soils to air, the iron sulfides can oxidise and form sulphuric acid, resulting in the soil becoming strongly acidic. This acidity has the potential to mobilise metals such as Iron, Aluminium and Manganese which are naturally present in the soil, thereby producing a leachate contaminated by both high levels of acidity and metals. Such leachate, if released into the environment, can have significant adverse effects including; degradation of the water quality in receiving areas, fish disease/kills, reduced crop productivity, corrosion of structures and health related issues. In view of these potential effects, it is critical that any development that occurs within an area likely to contain Acid Sulfate Soils is planned, managed and monitored appropriately so as to minimise or remove the risk of adverse environmental outcomes.

In response to the potential for such adverse environmental outcomes to occur as a result of the disturbance of Acid Sulfate Soils, the Queensland Department of Environment and Resource Management developed the “State Planning Policy 2/02: Planning and Managing Developments involving Acid Sulfate Soils: and its supporting guidelines”. The SPP 2/02 provides assistance and recommendations on best practice for developments involving Acid Sulfate Soils.

The State Planning Policy 2/02 applies to all land, soil or sediment at or below 5 metres AHD where the natural surface level is below 20 metres AHD and applies to development that would result in:

(a) the excavation of, or otherwise removing, 100m^3 or more of soil or sediment; or

(b) filling of land involving 500m^3 or more of material with an average depth of 0.5 of a metre or greater.

As the entire site has an existing surface level below AHD 5.0m any disturbance of soil or sediment within this area must consider the consequences of Acid Sulfate Soils when assessing the overall project risk. The preferred mechanism to circumvent potential adverse environmental outcomes concerning Acid Sulfate Soils is avoidance, that is, where possible, areas identified to contain Acid Sulfate Soils should not be disturbed. Where avoidance is not possible, appropriate management mechanisms must be implemented to reduce the risk of adverse environmental outcomes resulting from the disturbance of the Acid Sulfate Soils.

The aim of this sediment investigation was to make an assessment of the quality of the sediments present within the study area with respect to the use of these sediments as part of a beach nourishment program. The parameters considered integral to the potential use of the sediments were; the nature of the insitu sediments and the Acid Sulfate Soils content of these sediments along with proximity to existing seagrass beds.

It should be noted that this report is not intended to be, nor should it be attempted to be used as, a fully QASSIT compliant Acid Sulfate Soils investigation of the site to support a specific proposed soil disturbance. Rather, this investigation is intended to provide general information regarding the sediments present at the site with the goal of informing the decision making process regarding the overall beach nourishment project. Furthermore, it is recognised that there are numerous other factors that will be incorporated into the final selection of any dredging locations for this project.

This report should be read in conjunction with the attached “General Notes” and the ASFE publication “Important Information about your Geotechnical Report”.

Site Description

The subject site was located within the northern reaches of Pumicestone Passage from Bells Creek north to approximately Jellicoe Street and is shown in Annex A. See Figure 1 below for a locality plan of the study site.

Figure 1: Locality Plan

The study site was heavily influenced by tidal flows. Water depths within the subject area was significantly influenced by tidal movements, with some areas completely exposed at low tide and maximum water depths in excess of 3.5m at high tide in other areas. This area of Pumicestone Passage is heavily utilised by recreational users for swimming, boating and fishing activities.

Methodology

Desktop Survey

Prior to the commencement of the fieldwork program, a review of the existing Acid Sulfate Soils maps produced by Department of Environment and Resource Management was performed. The results of this desktop survey are shown in the Results section below. Furthermore, a general assessment of the site was made by reviewing the available aerial photographs of the site and the Department of Mines and Energy geological maps.

Fieldwork

A total of 20 boreholes (BH01 to BH20) were advanced across the site. After a review of the available aerial photography and a visit to site, the boreholes were distributed to give representative information about the sediments throughout the study area, see Annex B for a plan showing the borehole locations and three specified metals and organic tin sampling locations.

The boreholes were advanced using a pneumatic vibracore drilling rig mounted on a self propelled working barge. The vibracore and barge were operated by Abyss Commercial Diving Services who are experienced in the collection of soft sediments in estuarine environments such as Pumicestone Passage. The vibracore rig collects a continuous core of the soft strata which is suitable for investigations of this nature. The target depth of the boreholes was 3.0 metres below the existing sediment surface level, however some boreholes were terminated prior to this target depth due to vibracore refusal in stiffer sediments. Detailed geotechnical boreholes logs of the material encountered at each location are shown in Annex C. The entire core from each location was retained and returned to our Kunda Park laboratory for the required laboratory analysis via AS1289 for particle size distribution testing and the Chromium Test Suite for Acid Sulfate Soils. Three additional locations were identified within the project brief for the collection of sediment samples for laboratory testing for metals and organic tin testing.

Borehole locations were initially selected digitally, using the provided site plans and aerial photographs to produce GPS co-ordinates for each borehole location. In the majority of cases these locations were accessible to the barge and could be drilled as selected, however, where necessary due to extremely shallow conditions, borehole locations were moved to allow successful completion of the fieldwork program.

The seagrass survey of the study area was undertaken in a systematic manner using GPS coordinates to divide the areas into a 25m grid to allow the identification of any seagrass patches present at the site. The seagrass survey was then undertaken using a small dingy and snorkelling equipment.

It should also be noted that the sampling locations and seagrass areas were identified with recreational quality GPS equipment, this equipment has an average accuracy of approximately 5m. Whilst this level of accuracy is considered sufficient for the purposes of this investigation, more accurate survey data may be required in the future, particularly in relation to the location and extent of the seagrass areas.

Laboratory Testing

Particle Size Distribution

Representative samples covering a variety of depths were selected and dried at 105°C to a constant mass before testing. A single sample was selected from each borehole and the samples were isolated to 0.5m intervals from within borehole cores. The samples were tested to determine their particle size distribution via AS1289. The results of the particle size distribution testing are presented in Annex D.

Acid Sulfate Soils

Representative samples covering a variety of depths were selected from each borehole and dried at 85°C to a constant mass before testing. Two samples were selected from each borehole and the samples were isolated to 0.5m intervals from within borehole cores. The samples were tested analytically via the Chromium Suite of testing. The results of the Acid Sulfate Soils testing are presented in Annex E.

Metal and Organic tin testing

Representative samples of the near-surface sediments were collected at each of the three locations identified in the project brief, the locations were numbered 1 through 3 from north to south. These samples were submitted to the Australian Laboratory Services testing laboratory for analytical testing for the concentrations of 13 heavy metals and organic tine compounds. The results of this testing are summarised in the results section below with the full test certificate presented in Annex F.

Results and Discussion

Desktop Survey

The Queensland Government Department of Environment and Resources Management "Acid Sulfate Soils-Maroochy Caloundra Acid Sulfate Sustainable Land Management Project" Map 2, does not specifically provide information regarding the sediments within the Pumicestone Passage bed itself. And map limits do not include the entire study area. However, this map does indicate that disturbed land on the western bank of Pumicestone Passage is likely to contain Acid Sulfate Soils. Whilst not definitive, these data tend to support a high probability of the presence of Acid Sulfate Soils within the subject site.

The Queensland Government Department of Mines and Energy 'NAMBOUR SPECIAL' geological map sheet 9444 and part 9544 scale 1:100,000, classifies the sediments of the site as "estuarine channel and banks; sandy mud, muddy sand, minor gravels".

Subsurface Conditions

Detailed logs for the boreholes advanced during this investigation are shown in Annex C. The subsurface strata encountered at the site were dominated by poorly fine to medium grained sands with generally low silt contents.

Analytical Laboratory Analysis

Particle Size Distribution

The samples of material tested for particle size distribution showed a relatively consistent pattern of composition across all 20 borehole locations. The subsurface strata are dominated by fine to medium grained sands with generally low silt contents. Particles larger than 1.18mm were very rare and when present were often shell fragments rather than sand particles or gravel. Furthermore, the proportion of material smaller than 0.075mm in the samples tested was also very small, generally not exceeding 5% by mass of the total. These extremely low proportions of material passing the 0.075mm sieve negated the need to undertake additional testing on the silt and clay fractions in all but one of the samples tested. The AS1289 method specifically excludes samples which have less than 10% passing 0.075mm from the hydrometer based portion of the test method.

Acid Sulfate Soils

The maximum S_{Cr} level detected in the samples tested during this investigation was 0.849% oxidisable sulfur, with a small number of samples returning results in the 0.1%S to 0.5%S range, while the remaining samples returned low levels of S_{Cr}, at or around the 0.03%S level (often below the detection limit of the test method), see Annex D. These results confirm the presence of Acid Sulfate Soils within the samples tested during this investigation.

However, the results also showed that only three of the 40 samples tested had a net acidity value in excess of the 0.03% oxidisable sulfur threshold for coarse grained soils such as those encountered at the subject site. This result is due to a combination of the presence of intrinsic acid neutralising capacity (ANC) and the generally low levels of oxidisable sulfur within the majority of samples tested. As such, the testing indicates that for the majority of samples tested no further treatment would be required. The extent to which this trend is applicable to the sediments present within the entire study area is a function of the degree to which the samples tested during this investigation are representative of the material to be disturbed as a whole. To this end, it is recommended that a detailed management plan outlining appropriate best practice techniques to deal with any acidity generated during the works be developed prior to the commencement of any dredging operations.

Metals and Organic Tins

The results of the analytical laboratory testing (see Annex F) are summarised in the table below.

Parameter	**LOR**	**units**	**Location 1**	**Location 2**	**Location 3**
Metals					
Arsenic	5	mg/kg	<5	14	<5
Barium	10	mg/kg	<10	20	<10
Beryllium	1	mg/kg	<1	<1	<1
Cadmium	1	mg/kg	<1	<1	<1
Chromium	2	mg/kg	<2	30	<2
Cobalt	2	mg/kg	<2	8	<2
Copper	5	mg/kg	<5	11	<5
Lead	5	mg/kg	<5	13	<5
Manganese	5	mg/kg	<5	197	9
Nickel	2	mg/kg	<2	14	<2
Vanadium	5	mg/kg	<5	43	<5
Zinc	5	mg/kg	<5	58	<5
Mercury	0.1	mg/kg	<0.1	<0.1	<0.1
Organic Tins					
Monobutyltin	1	µgSn/kg	<1	<1	<1
Dibutyltin	1	µgSn/kg	<1	<1	<1
Tributyltin	0.5	µgSn/kg	<0.5	<0.5	<0.5

Locations 1 and 3 generally showed levels of the 13 metals examined during this investigation below the detection limits for the selected test methods. Conversely, Location 2 showed detectable levels of the majority of parameters tested. Organic tin levels for the three samples tested during this investigation were all below the detection limits of the test methods.

Material Quality

The quality of the material present at each borehole location, in terms of its use in a beach nourishment program, was assessed on the basis of a combination of the information shown on the geotechnical logs and the particle size distribution. The particle size distribution testing suggests that there is limited variation in the sediments encountered at the 20 boreholes, with the exception of borehole 2 which has a relatively high proportion of fine material passing 0.075mm. This material may be less suitable for a dredging program given this higher proportion of fine material.

Whilst the particle size distribution of the sediments tested from the southern sections of the study area (borehole 1 through 12) would generally be suitable for the logistics of the dredging process and would also provide the non-cohesive materials generally sort for beach nourishment programs, this material is of variable make up. Colour and silt content, along with strata depth in this section are significantly more variable than in the northern section of the study area.

The soil profiles at the boreholes from the northern sampling locations (borehole 13 through 20) were generally more uniform and the material was generally paler in colour than that sampled from the southern borehole locations. These data suggest the sediments present within the northern section of study area would be the best quality (of those tested throughout this investigation) for the purposes of beach nourishment programs and it is recommended that this area be the primary source of the resource for the intended dredging program.

If the logistics of transporting the dredged material to destinations within the Pumicestone Passage are problematic and/or additional material is required, there may be opportunity to recover some smaller quantities of suitable material from the southern section of the study area, however the data presented here suggest that these opportunities would not yield the same quantity or quality of resource for beach nourishment purposes as the sediments from the northern sections of the study area. Furthermore, the distribution of seagrass within the southern section of the study area would also need to be considered prior to any decision to dredge within this area.

Seagrass Survey

The seagrass survey of the study area revealed significant patches of seagrass (greater than $50m^2$ in area) present at a number locations within the study area, see Annex G for a site plan showing the seagrass patches identified during the survey. Significant areas of seagrass were identified in the shallow waters fringing the southern portion of the study area and also towards the north of the study area, adjacent to Monash Street and the Power Boat Club.

Consistent with the general scientific consensus regarding the importance of seagrass beds in terms of the habitat they provide within estuarine ecosystems, all seagrass beds identified during this investigation were observed to support significant marine life, including molluscs, crustaceans and fish species.

The locations of these seagrass patches will need to be considered when determining what if any sections of the study area are appropriate sources of material for the proposed beach nourishment program.

Two significant patches of seagrass were also identified adjacent to the study area at its northern boundary (see Annex G). Whilst not strictly within the identified study area, given the proximity of these seagrass patches to the boundary of a potential dredging zone it is considered that their location should inform the final selection of areas to be dredged for the beach nourishment program and/or management techniques to be implemented during the dredging program.

Summary

The following points summarise the findings of the sediment investigation of Pumicestone Passage.

- Sediments tested at the selected sampling locations were generally quite consistent and were dominated by sands with generally low levels of silt.
- In general, the southern section of the study area showed more variable soil profiles with darker materials closer to the surface than those identified in the northern sections.
- Soil profiles at the northern boreholes were generally more uniform and paler in colour.
- Acid Sulfate Soils were identified at the site within the areas proposed to be disturbed, however intrinsic acid neutralising capacity exceeded potential acidity in all but three of the samples tested.
- Significant seagrass patches were identified during this investigation, particularly in the shallow waters of the study area. The location of these seagrass patches will need to be considered when identifying potential dredge sites.
- It is recommended that the northern section of the study area (between the Power Boat club and Jellicoe Street be used as the primary source of material for the beach nourishment program/s.

Annex A - Site Plan

Study Area for Proposed Dredging - Pumicestone Passage

Moreton Bay Marine Park Legend

Entry and use guide	General use zone	Habitat protection zone	Conservation park zone	Marine national park zone
Boating	Yes	Yes	Yes	Yes
Line fishing	Yes	Yes	Yes^a	No^b
Crabbing	Yes	Yes	Yes^c	No^b
Trolling	Yes	Yes	Yes	No^b
Bait gathering	Yes	Yes	Yes	No^b
Bait netting	Yes	Yes	Yes	No^b
Netting (other than bait netting)	Yes	Yes	No^b	No^b
Limited spearfishing	Yes	Yes	Yes	No^b
Limited collecting	Yes^d	Yes^d	Yes^d	No^b
Trawling	Yes	No^b	No^b	No^b

Legend

▨ Study area for proposed dredging

🟩 Protected Areas of Queensland (estate)

☐ FishHabitatAreas

● Proposed Heavy Metal Testing Site

Please Note: Distances on map are indicative only.

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S

1:7,936

At Paper Size A3

0 65 130 260 390 520
Metres

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Last Printed on September 8, 2011

Path: W:\SCC\RP\EP\6WATERWAYS\WATERWAYS NEW\5 COASTAL MGT O.4212\Shoreline Erosion Management Plans\Sand sourcing study

Annex B – Sampling Locations

PUMISTONE PASSAGE - MAINTENANCE DREDGING AREA

BOREHOLES

Pumicestone Locations.DWG

CARDNO BOWLER

Revision A

Annex C – Borehole Logs

Cardno BOWLER

BOREHOLE LOG SHEET

32 Hi-Tech Drive
Kunda Park/QLD/4556
Telephone: +61 7 54501544
Fax: +61 7 54051533

BOREHOLE No: 3747-P158-BH01
SHEET: 1 of 1

DATE STARTED 11/11/11 **COMPLETED** 11/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 510921 7031064
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 0.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0		SP	**SAND**, fine to medium grained, brown, trace silt, shell fragments present, ALLUVIAL		
			1.5 2.0		SP	**SAND**, fine to medium grained, grey to dark grey, trace silt, shell fragments present, ALLUVIAL		
			2.5 3.0		SP	**SAND**, fine to medium grained, dark grey, ALLUVIAL		
			3.5			Borehole 3747-P158-BH01 terminated at 3m		

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P158-BH02

SHEET: 1 of 1

DATE STARTED 11/11/11 **COMPLETED** 11/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511276 7031058

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 2.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, dark grey, trace silt, shell fragments present, ALLUVIAL		
			0.5		SP	**SAND**, fine to medium grained, very dark brown, trace low plasticity clay, ALLUVIAL		
			1.0					
			1.5					
			2.0					
			2.5			Borehole 3747-P158-BH02 terminated at 2.5m		Borehole terminated due to vibracore refusal.
			3.0					
			3.5					

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P158-BH03
SHEET: 1 of 1

DATE STARTED 11/11/11 **COMPLETED** 11/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511532 7031099
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 0.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5 2.0		SP	**SAND**, fine to medium grained, grey-brown, shell fragments present, ALLUVIAL		
			2.5		SP	**SAND**, fine to medium grained, grey to dark grey, trace silt, ALLUVIAL		
			3.0		SP	**SAND**, fine to medium grained, dark grey, dark brown, trace silt, ALLUVIAL		
			3.5			Borehole 3747-P158-BH03 terminated at 3m		

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P158-BH04

SHEET: 1 of 1

DATE STARTED 11/11/11 **COMPLETED** 11/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511658 7031214

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 1.7m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, grey, trace silt, shell fragments present, ALLUVIAL		
			0.5					
			1.0					
					SP	**SAND**, fine to medium grained, pale grey, shell fragments present, ALLUVIAL		
			1.5					
			2.0					
					SP	**SAND**, fine to medium grained, pale grey, ALLUVIAL		
			2.5					
			3.0					
						Borehole 3747-P158-BH04 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P158-BH05
SHEET: 1 of 1

DATE STARTED 11/11/11 **COMPLETED** 11/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511747 7031363
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 2.1m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5		SP	**SAND**, fine to medium grained, grey-brown, shell fragments present, ALLUVIAL		
			2.0 2.5		SP	**SAND**, fine to medium grained, dark to very dark brown, trace silt, ALLUVIAL		
			3.0 3.5			Borehole 3747-P158-BH05 terminated at 2.7m		Borehole terminated due to vibracore refusal.

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P158-BH06
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511876 7031572

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 2.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, grey-brown, trace silt, shell fragments present, ALLUVIAL		
			1.0 1.5 2.0 2.5 3.0		SP	**SAND**, fine to medium grained, pale grey, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P158-BH06 terminated at 3m		

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P158-BH07
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511980 7031850
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 1.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0		SP	**SAND**, fine to medium grained, pale brown to brown, ALLUVIAL		
			1.5		SP	**SAND**, fine to medium grained, grey, trace silt, shell fragments present, ALLUVIAL		
			2.0 2.5		SP	**SAND**, fine to medium grained, grey-brown, trace silt, shell fragments present, ALLUVIAL		
			3.0 3.5			Borehole 3747-P158-BH07 terminated at 2.9m		Borehole terminated due to vibracore refusal.

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BOREHOLE No: 3747-P158-BH08

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512078 7032061

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 1.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, brown, trace silt, shell fragments present, ALLUVIAL		
			1.0 1.5		SP	**SAND**, fine to medium grained, grey, shell fragments present, ALLUVIAL		
			2.0 2.5 3.0		SP	**SAND**, fine to medium grained, pale grey, ALLUVIAL		
			3.5			Borehole 3747-P158-BH08 terminated at 3m		

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BOREHOLE No: 3747-P158-BH09
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511799 7032180
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 3.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				▨	SP	**SAND**, fine to medium grained, brown, shell fragments present, ALLUVIAL		
			0.5	▨	SP	**SAND**, fine to medium grained, grey-brown, trace silt, shell fragments present, ALLUVIAL		
			1.0	▨	SP	**SAND**, fine to medium grained, very dark brown, trace silt, ALLUVIAL		
			1.5					
			2.0					
			2.5			Borehole 3747-P158-BH09 terminated at 2.5m		Borehole terminated due to vibracore refusal.
			3.0					
			3.5					

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P158-BH10
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512170 7032267
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 2.0m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0		SP	**SAND**, fine to medium grained, pale brown to brown, shell fragments present, ALLUVIAL		
			1.5 2.0 2.5		SP	**SAND**, fine to medium grained, grey, shell fragments present, ALLUVIAL		
			3.0 3.5			Borehole 3747-P158-BH10 terminated at 2.9m		Borehole terminated due to vibracore refusal.

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BOREHOLE No: 3747-P158-BH11

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512033 7032332

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 1.0m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, brown, shell fragments present, ALLUVIAL		
			0.5		SP	**SAND**, fine to medium grained, dark grey, ALLUVIAL		
			1.0		SP	**SAND**, fine to medium grained, pale grey to grey, shells present, ALLUVIAL		
			1.5					
			2.0		SP	**SAND**, fine to medium grained, very dark grey, with silt, ALLUVIAL		
			2.5					
			3.0			Borehole 3747-P158-BH11 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P158-BH12

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512131 7032480

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 0.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, grey, trace silt, shell fragments present, ALLUVIAL		
			1.0		SP	**SAND**, fine to medium grained, grey, ALLUVIAL		
			1.5		SP	**SAND**, fine to medium grained, grey, ALLUVIAL		
			2.0 2.5 3.0		SP	**SAND**, fine to medium grained, pale grey, trace silt, ALLUVIAL		
			3.5			Borehole 3747-P158-BH12 terminated at 3m		

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BOREHOLE No: 3747-P158-BH13

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512166 7032591

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 1.1m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0	▨	SP	**SAND**, fine to medium grained, pale grey to grey, shell fragments present, ALLUVIAL		
			1.5 2.0 2.5 3.0	▨	SP	**SAND**, fine to medium grained, pale grey, ALLUVIAL		
			3.5			Borehole 3747-P158-BH13 terminated at 3m		

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BOREHOLE No: 3747-P158-BH14
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512160 7032712
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 0.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, very pale grey to pale grey, ALLUVIAL		
			0.5					
			1.0					
			1.5					
			2.0					
			2.5					
			3.0					
						Borehole 3747-P158-BH14 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P158-BH15

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512145 7032820

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 0.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5	░	SP	**SAND**, fine to medium grained, vey pale brown to brown, shell fragments present, ALLUVIAL		
			1.0	░	SP	**SAND**, fine to medium grained, pale grey to grey, trace silt, ALLUVIAL		
			1.5 2.0 2.5 3.0	░	SP	**SAND**, fine to medium grained, very pale grey to grey, ALLUVIAL		
			3.5			Borehole 3747-P158-BH15 terminated at 3m		

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P158-BH16

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512156 7032951

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 0.8m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, vey pale grey to grey, ALLUVIAL		
			0.5					
			1.0					
			1.5					
			2.0					
			2.5					
			3.0					
						Borehole 3747-P158-BH16 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P158-BH17
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512153 7033050
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 0.9m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5		SP	**SAND**, fine to medium grained, pale grey, ALLUVIAL		
			2.0 2.5 3.0		SP	**SAND**, fine to medium grained, dark grey, trace silt, ALLUVIAL		
			3.5			Borehole 3747-P158-BH17 terminated at 3m		

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P158-BH18
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512166 7033146
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 1.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5 2.0 2.5 3.0		SP	**SAND**, fine to medium grained, very pale grey to grey, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P158-BH18 terminated at 3m		

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P158-BH19
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512150 7033247
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 2.0m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5 2.0	▨	SP	**SAND**, fine to medium grained, very pale grey to grey, ALLUVIAL		
			2.5 3.0	▨	SP	**SAND**, fine to medium grained, dark grey, trace silt, ALLUVIAL		
			3.5			Borehole 3747-P158-BH19 terminated at 3m		

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P158-BH20
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512138 7033343
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 2.0m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5		SP	**SAND**, fine to medium grained, pale grey to grey, ALLUVIAL		
			2.0 2.5		SP	**SAND**, fine to medium grained, pale grey to grey, trace silt, ALLUVIAL		
			3.0 3.5			Borehole 3747-P158-BH20 terminated at 2.7m		

Annex D - Particle Size Distribution Test Results

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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

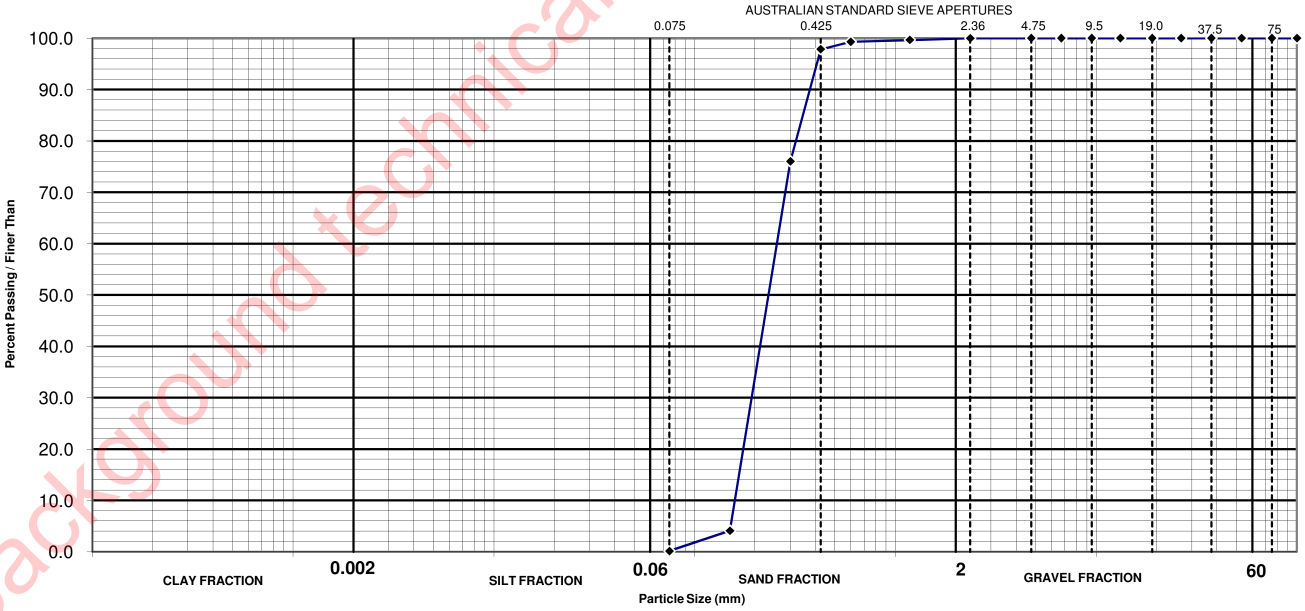
Sample Number: **3747-S-12633**
Sample Identification: **BH1: 0.0-0.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12633Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	98		
37.5		0.300	76		
26.5		0.150	4		
19.0		0.075	0		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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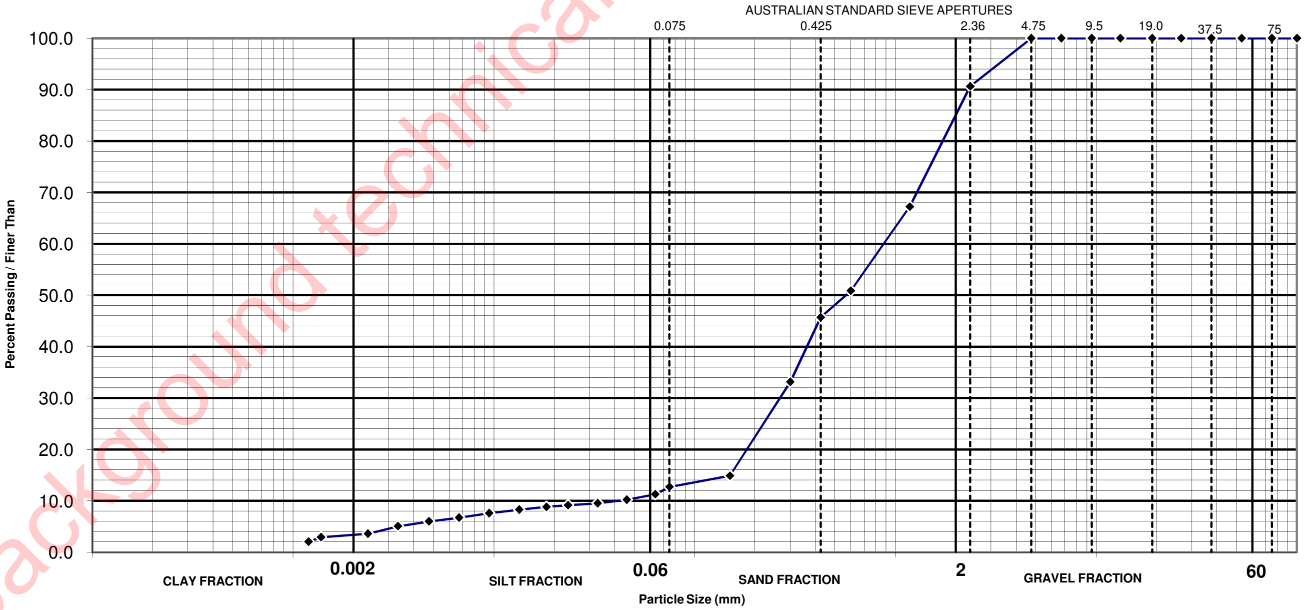
Particle Size Distribution-Hydrometer

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12642Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.3** **AS1289.3.6.2**
Sample Number:	**3747-S-12642**	Pre-treatment Loss:	**n/a**
Sample Identification:	**BH2: 1.5-2.0**	Dispersion Method:	**mechanical**
Date Sampled:	**10/11/2011**	Hydrometer Type:	**grams/Litre**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	67	0.0134	8
75		0.600	51	0.0095	8
53		0.425	46	0.0067	7
37.5		0.300	33	0.0048	6
26.5		0.150	15	0.0033	5
19.0		0.075	13	0.0024	4
13.2		0.064	11	0.0014	3
9.5		0.046	10		
6.7		0.033	9		
4.75	100	0.023	9		
2.36	91	0.018	9		

PARTICLE SIZE DISTRIBUTION - HYDROMETER



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

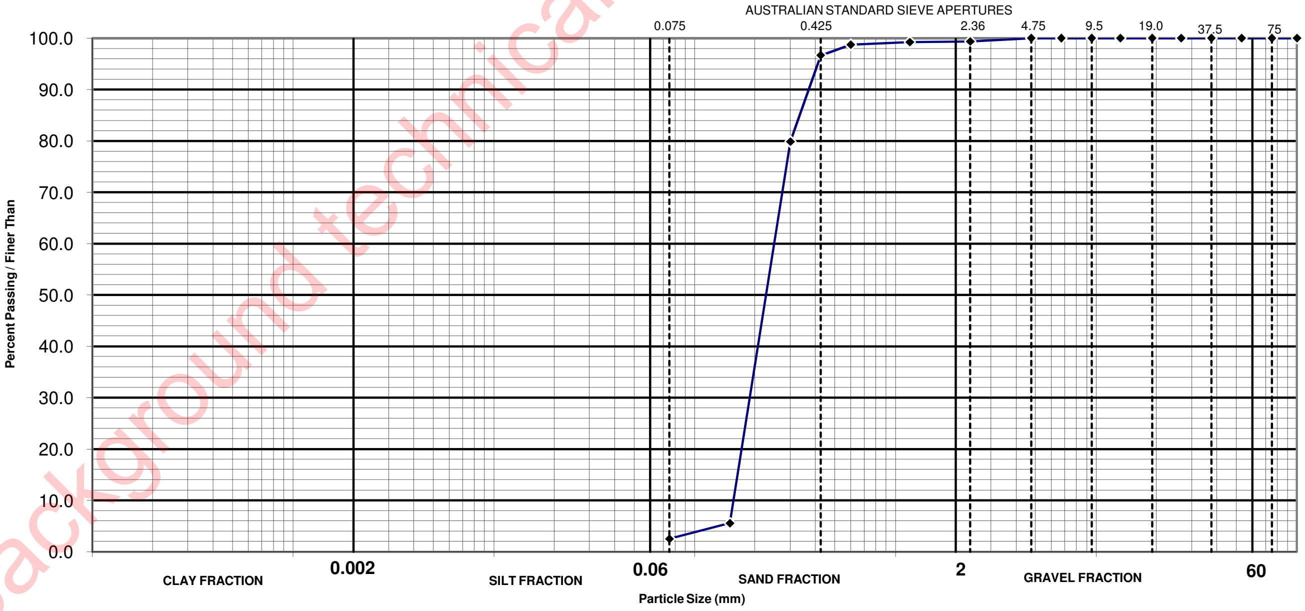
Sample Number: **3747-S-12645**
Sample Identification: **BH3: 0.0-0.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12645Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	99		
75		0.600	99		
53		0.425	97		
37.5		0.300	80		
26.5		0.150	6		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

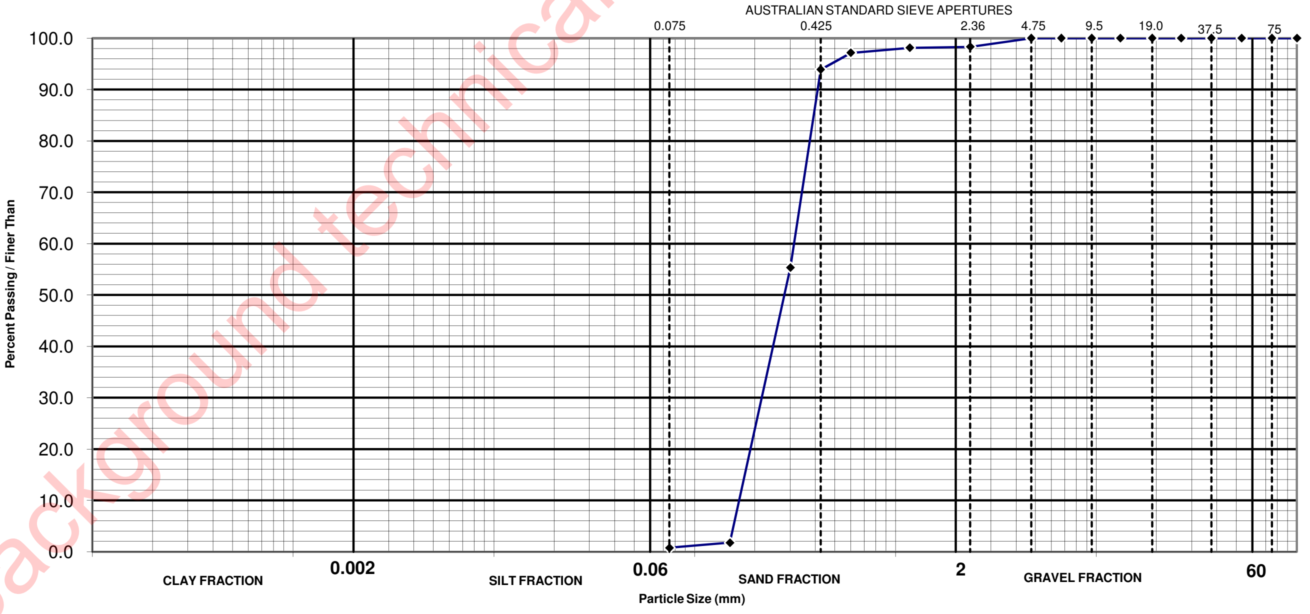
Sample Number: **3747-S-12655**
Sample Identification: **BH4: 2.0-2.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12655Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	98		
75		0.600	97		
53		0.425	94		
37.5		0.300	55		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	98				

PARTICLE SIZE DISTRIBUTION



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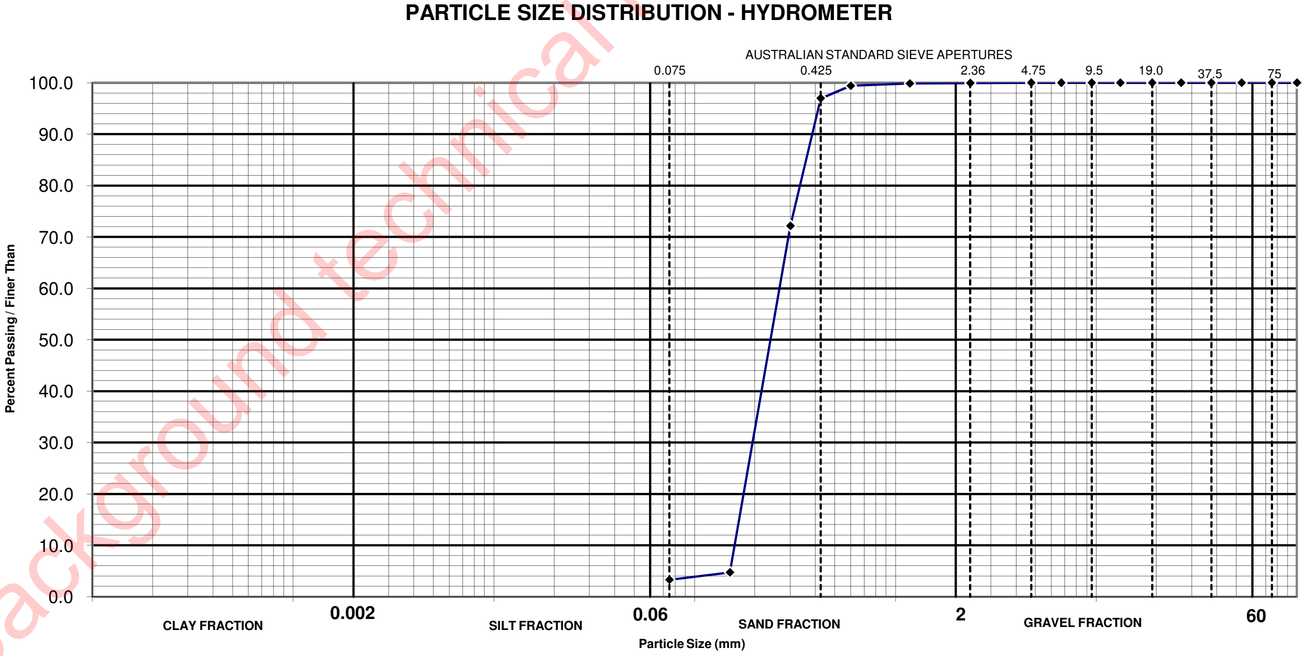
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12657Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12657**		
Sample Identification:	**BH5: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	97		
37.5		0.300	72		
26.5		0.150	5		
19.0		0.075	3		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

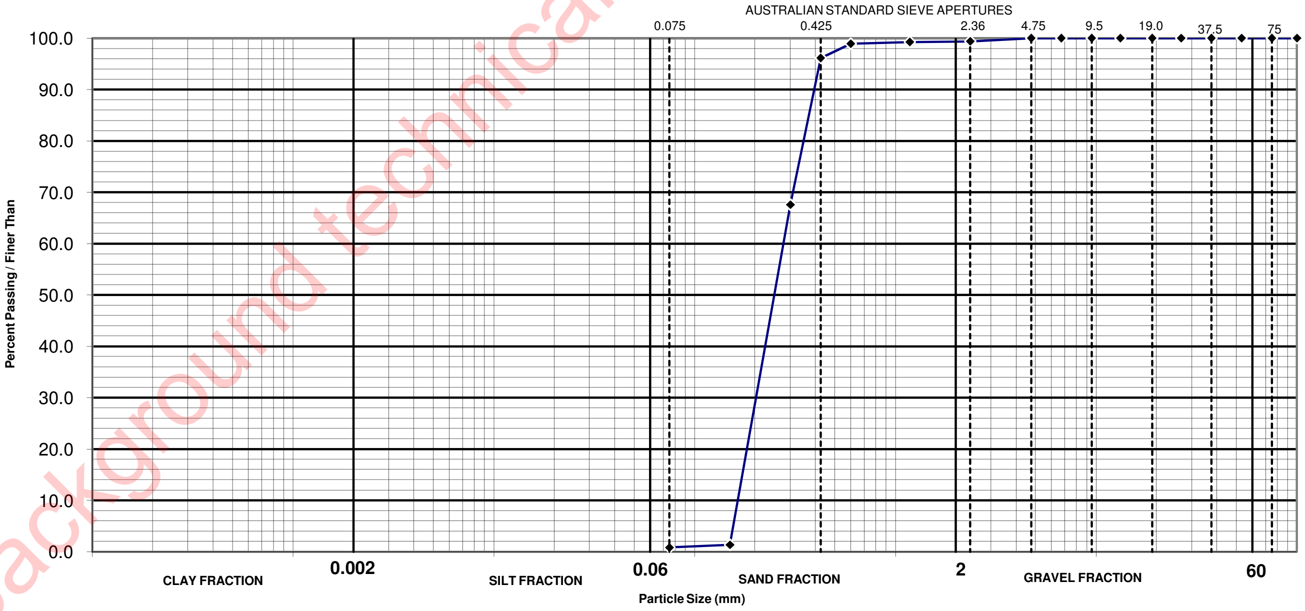
Sample Number: **3747-S-12668**
Sample Identification: **BH6: 2.5-3.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12668Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	99		
75		0.600	99		
53		0.425	96		
37.5		0.300	68		
26.5		0.150	1		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



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Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

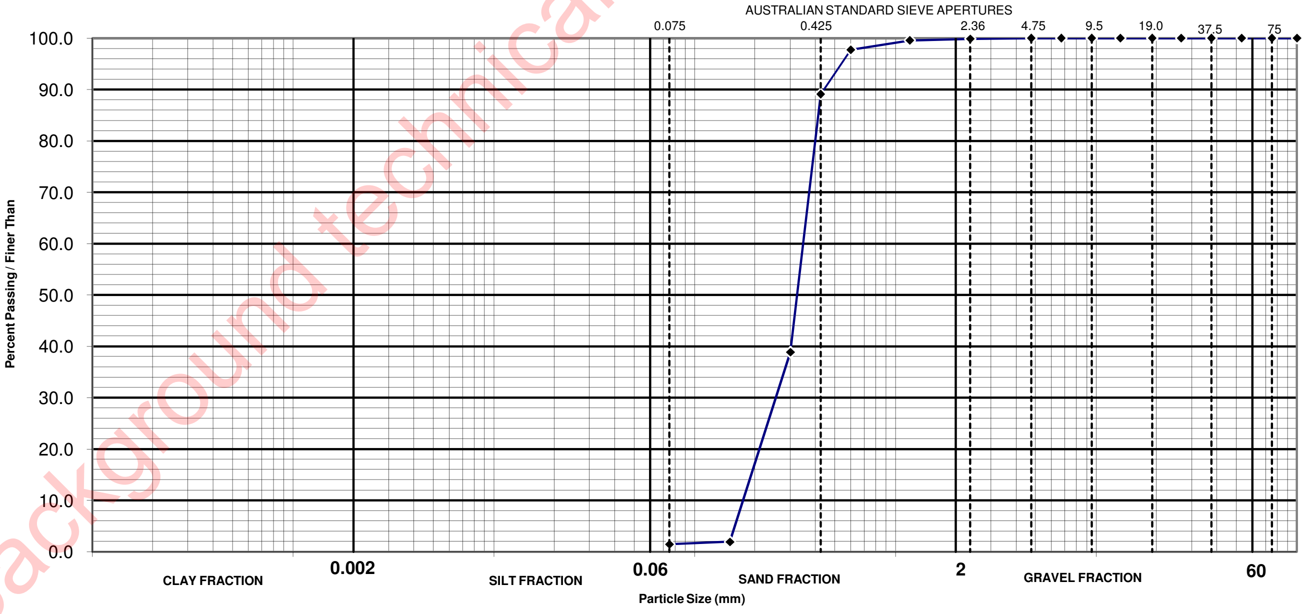
Sample Number: **3747-S-12670**
Sample Identification: **BH7: 0.5-1.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12670Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	98		
53		0.425	89		
37.5		0.300	39		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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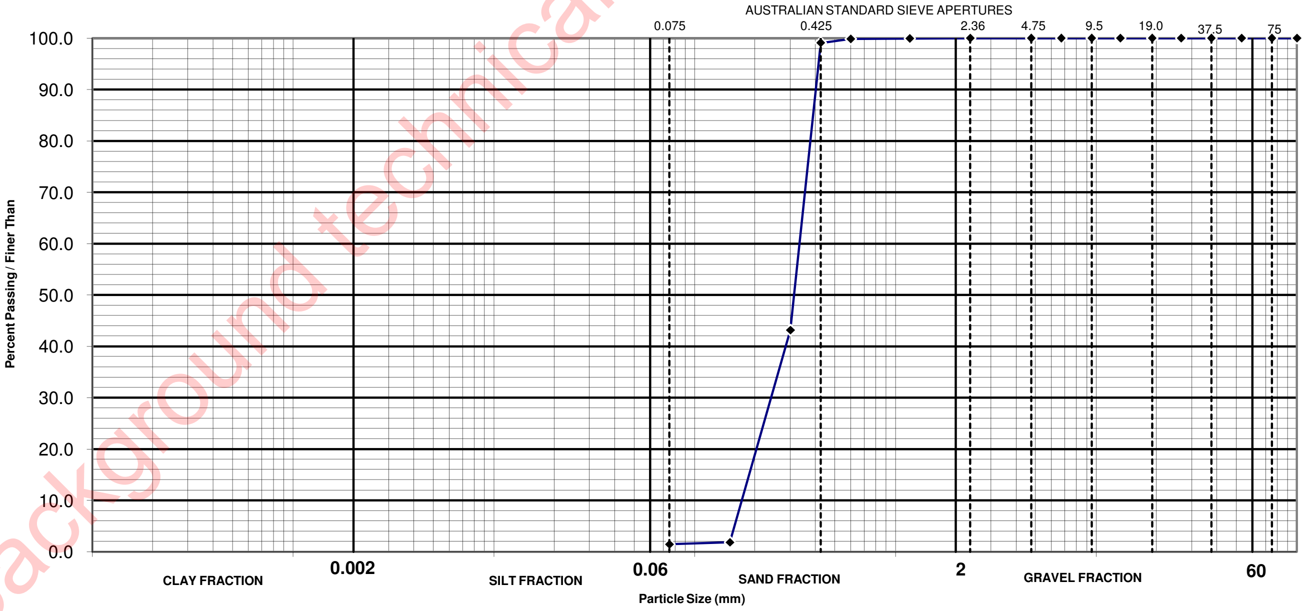
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12679Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12679**		
Sample Identification:	**BH8: 2.0-2.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	99		
37.5		0.300	43		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

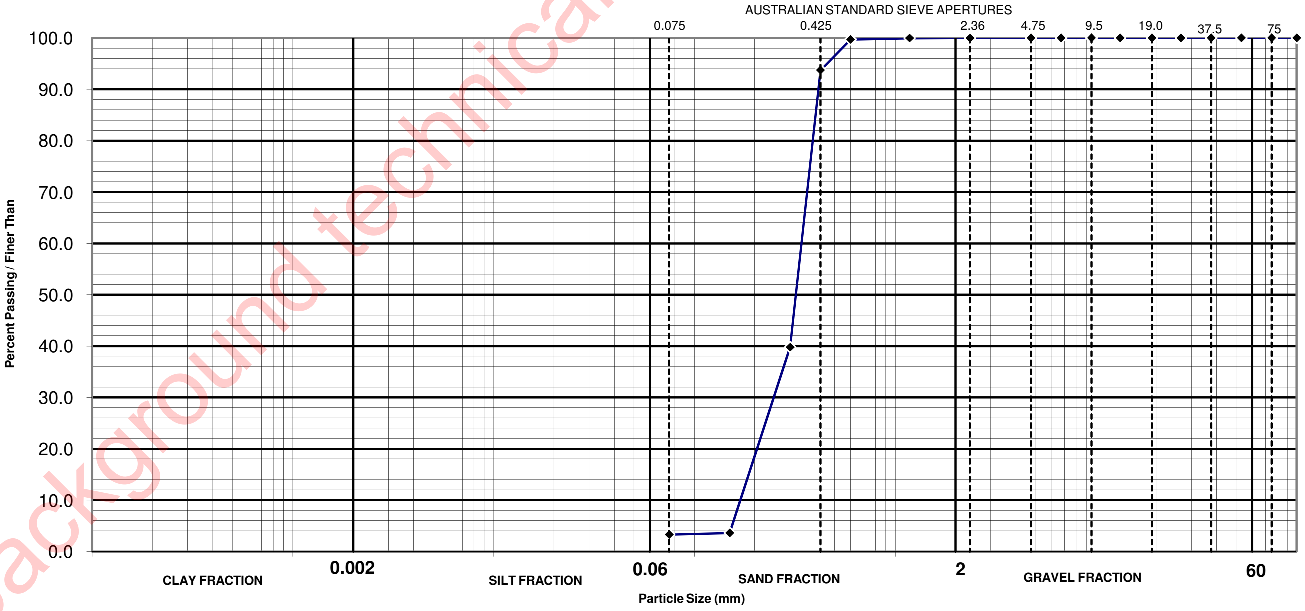
Sample Number: **3747-S-12683**
Sample Identification: **BH9: 1.0-1.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12683Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	94		
37.5		0.300	40		
26.5		0.150	4		
19.0		0.075	3		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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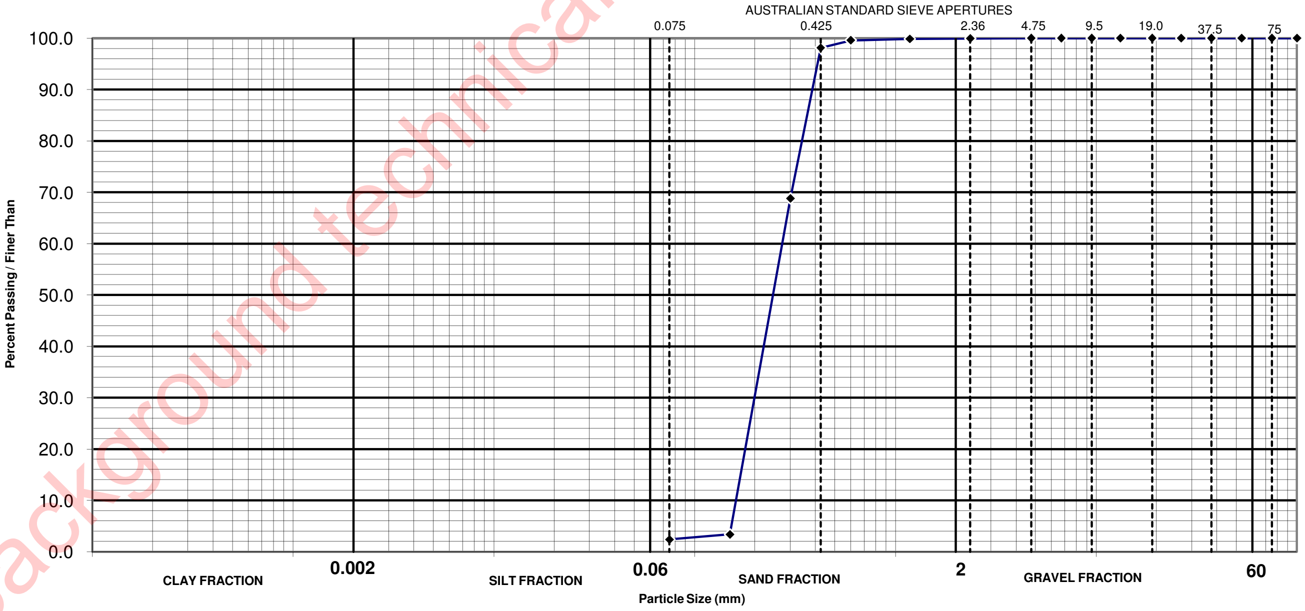
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12688Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12688**		
Sample Identification:	**BH10: 0.5-1.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	98		
37.5		0.300	69		
26.5		0.150	3		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

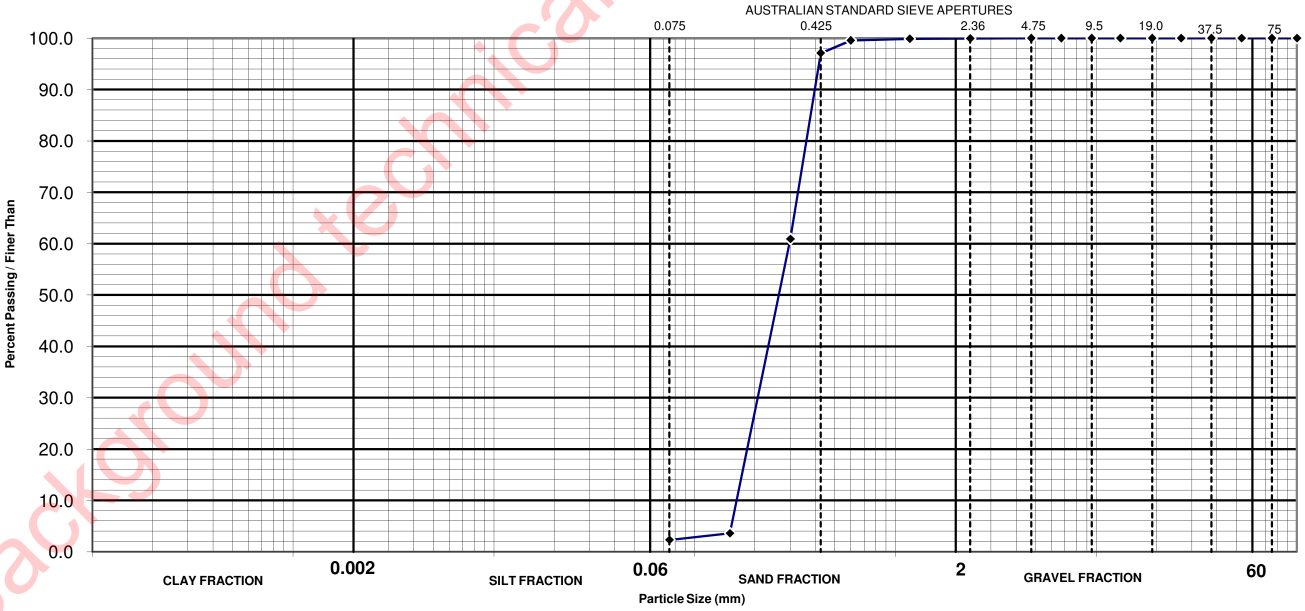
Sample Number: **3747-S-12693**
Sample Identification: **BH11: 0.0-0.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12693Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	97		
37.5		0.300	61		
26.5		0.150	4		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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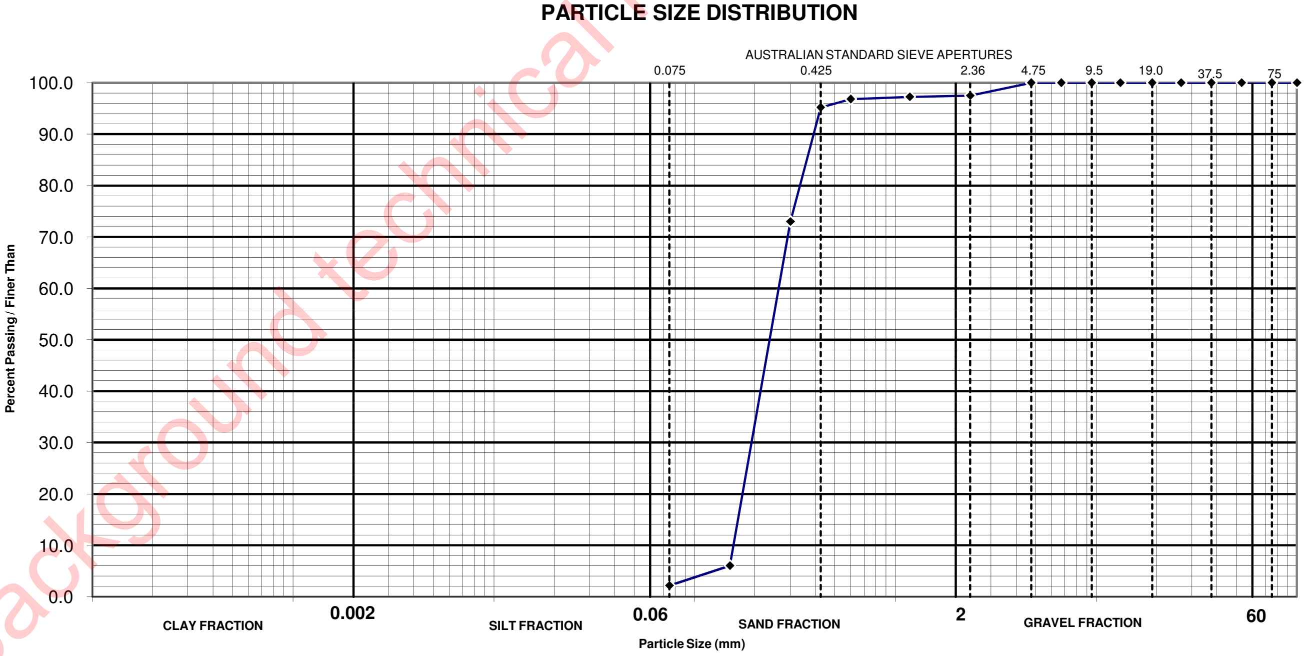
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12700Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12700**		
Sample Identification:	**BH12: 0.5-1.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	97		
75		0.600	97		
53		0.425	95		
37.5		0.300	73		
26.5		0.150	6		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	97				



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

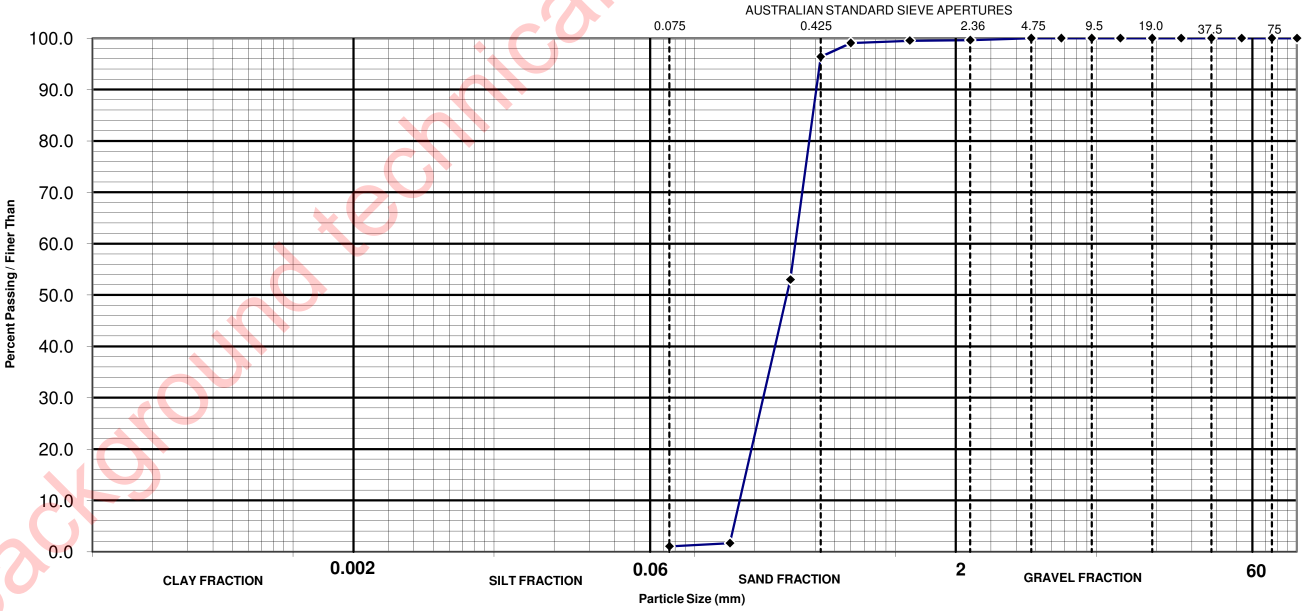
Sample Number: **3747-S-12707**
Sample Identification: **BH13: 1.0-1.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12707Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	96		
37.5		0.300	53		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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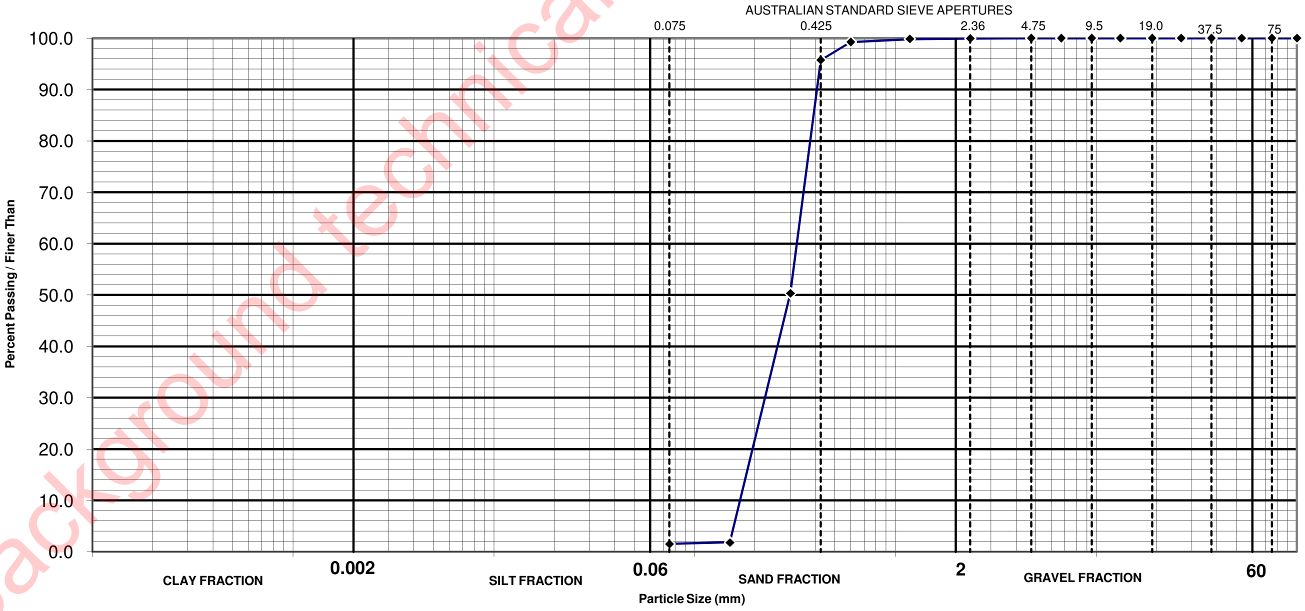
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12714Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12714**		
Sample Identification:	**BH14: 1.5-2.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	96		
37.5		0.300	50		
26.5		0.150	2		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

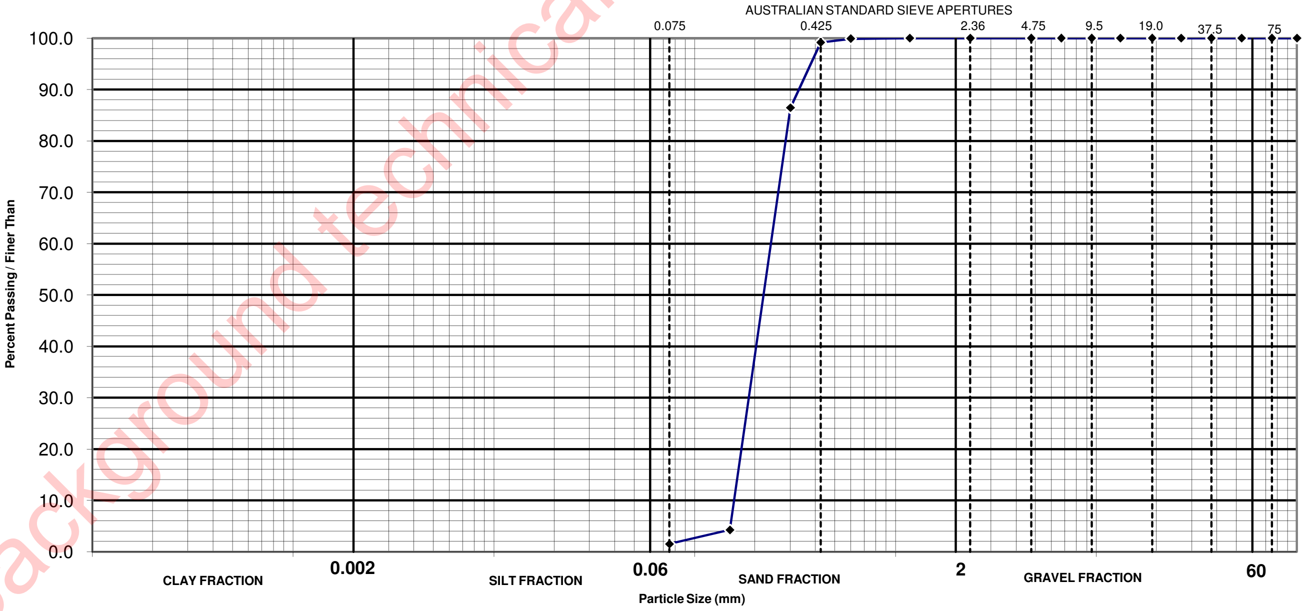
Sample Number: **3747-S-12721**
Sample Identification: **BH15: 2.0-2.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12721Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	99		
37.5		0.300	86		
26.5		0.150	4		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75					
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

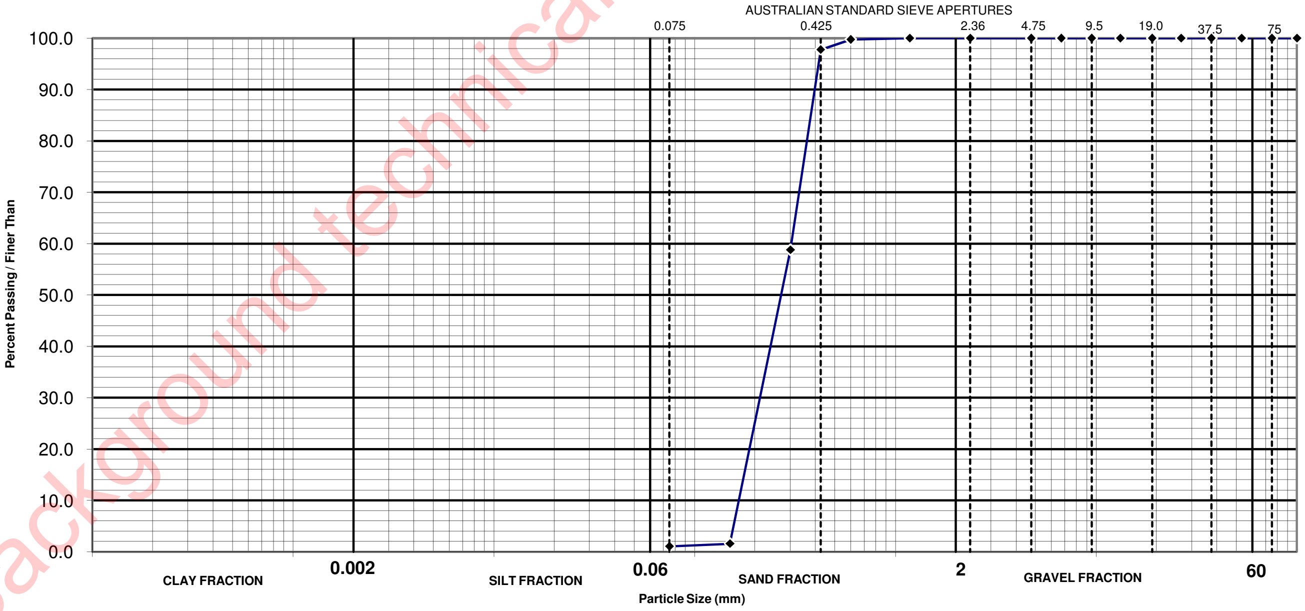
Sample Number: **3747-S-12728**
Sample Identification: **BH16: 2.5-3.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12728Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	98		
37.5		0.300	59		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75					
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

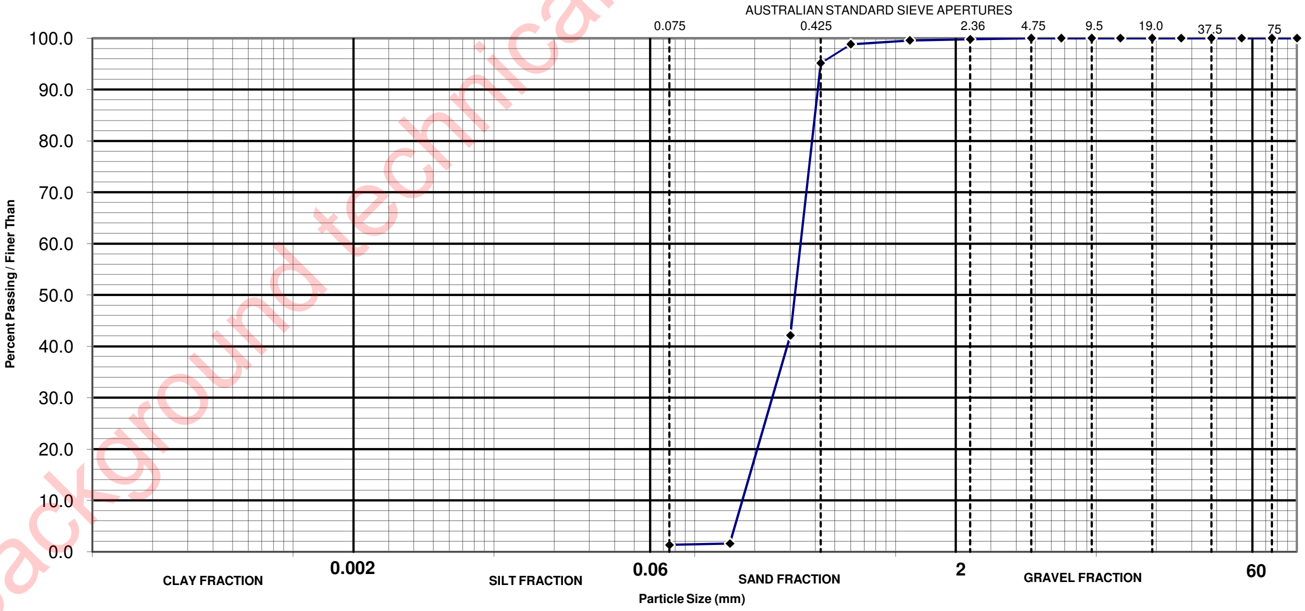
Sample Number: **3747-S-12730**
Sample Identification: **BH17: 0.5-1.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12730Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	95		
37.5		0.300	42		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

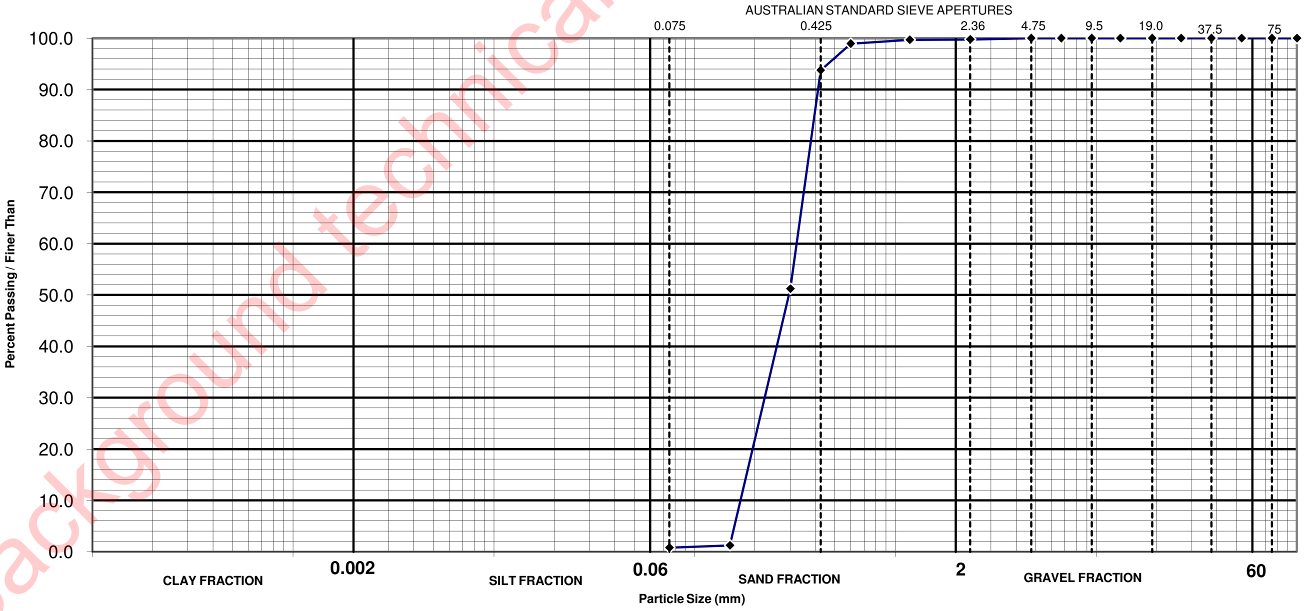
Sample Number: **3747-S-12735**
Sample Identification: **BH18: 0.0-0.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12735Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	94		
37.5		0.300	51		
26.5		0.150	1		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



% Finer than 0.02mm: n/a
% Finer than 0.005mm: n/a

This document is issued in accordance with
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NATA Accreditation No: 3747

SIGNATORY: Paul Mayes

Form Number

REP HYD-2

Cardno Bowler Pty Ltd
ABN 74 128 806 735

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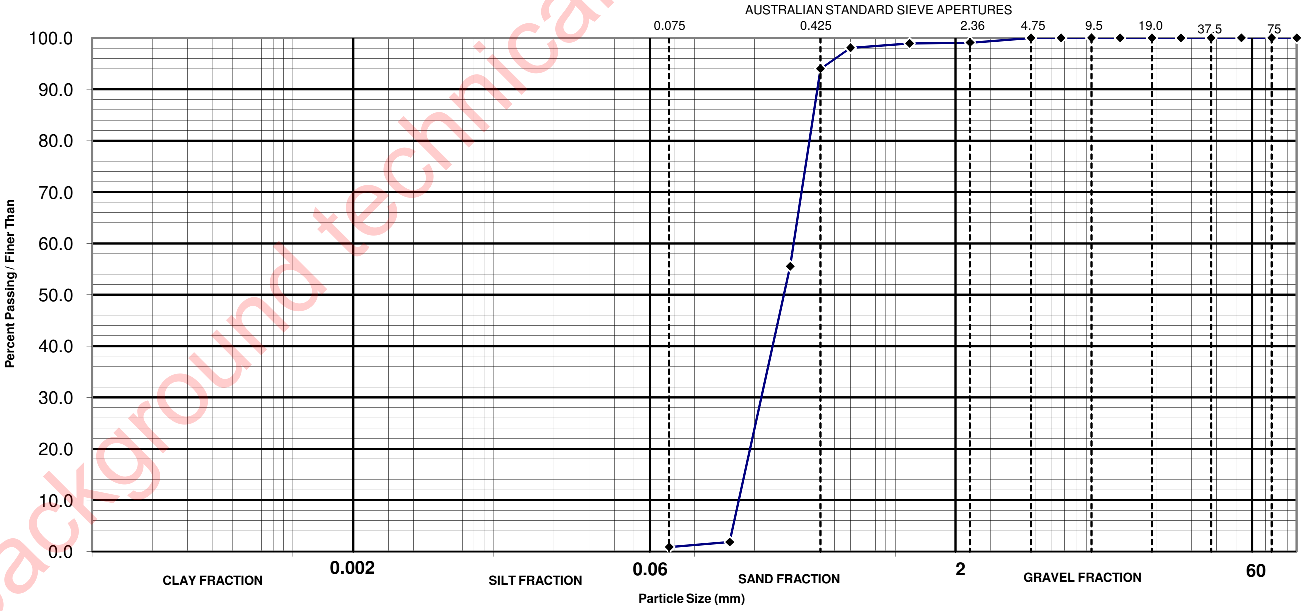
Cardno Bowler Offices:
Brisbane, Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Sunshine Coast, Gold Coast, Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12743Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12743**		
Sample Identification:	**BH19: 1.0-1.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	99		
75		0.600	98		
53		0.425	94		
37.5		0.300	55		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



% Finer than 0.02mm:	n/a
% Finer than 0.005mm:	n/a

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NATA Accreditation No: 3747

SIGNATORY: Paul Mayes

Form Number

REP HYD-2

Cardno Bowler
Shaping the Future

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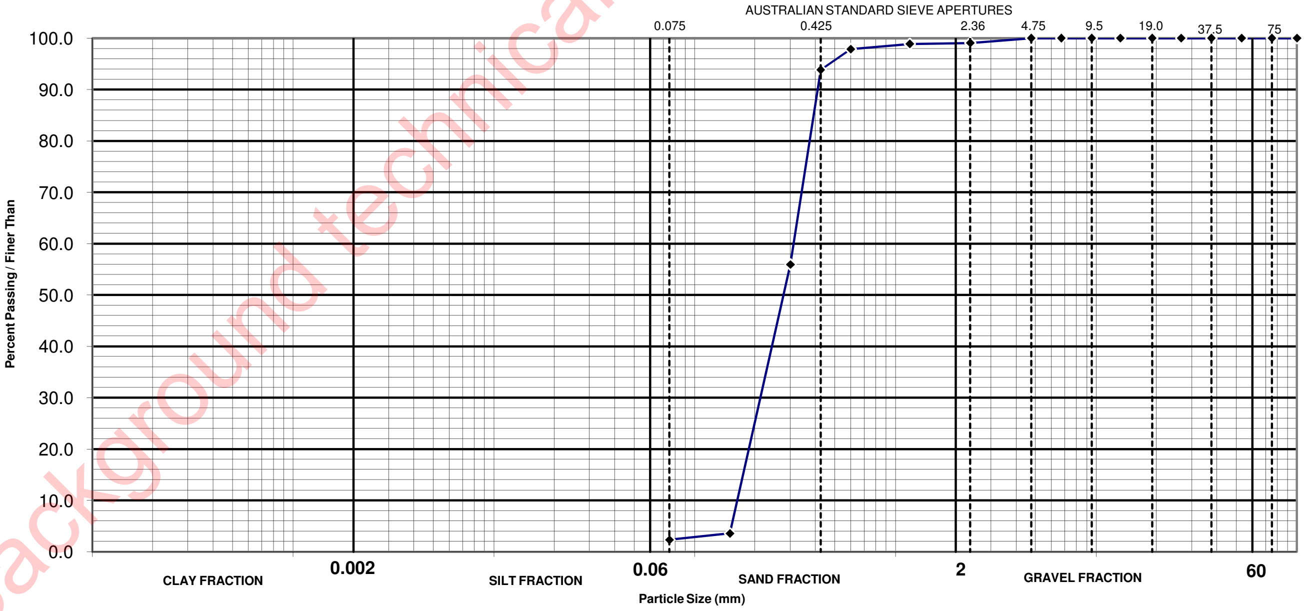
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12748Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12748**		
Sample Identification:	**BH20: 0.5-1.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	99		
75		0.600	98		
53		0.425	94		
37.5		0.300	56		
26.5		0.150	4		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



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% Finer than 0.005mm:	n/a

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SIGNATORY: Paul Mayes

Form Number

REP HYD-2

Annex E – Acid Sulfate Soils Test Results

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Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12633CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Pumicestone Passage Sediment Investigation
Job no. 3747/P/1
Sampled by: Cardno Bowler (Sunshine Coast)
Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 2/12/2011
Date Reported: 5/12/2011
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) [a]	(% S)	(% S)	(%$CaCO_3$) [#]	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	1	0.001	0.1
3747/S/12633	Borehole 1 0.0-0.5	6.6	0	0.000	0.011	<0.02	nr	0.55	-228	-0.366	No Liming Required
3747/S/12636	Borehole 1 1.5-2.0	6.7	0	0.000	0.023	0.112	nr	0.49	-134	-0.215	No Liming Required
3747/S/12639	Borehole 2 0.0-0.5	7.4	0	0.000	0.055	0.341	nr	0.59	-34	-0.054	No Liming Required
3747/S/12642	Borehole 2 1.5-2.0	6.8	0	0.000	0.023	0.518	nr	0.63	60	0.096	8.5
3747/S/12645	Borehole 3 0.0-0.5	9.1	0	0.000	<0.007	0.051	nr	0.39	-131	-0.209	No Liming Required
3747/S/12649	Borehole 3 2.0-2.5	5.2	17	0.027	0.066	0.549	nr	nr	359	0.575	50.9
3747/S/12653	Borehole 4 1.0-1.5	9.3	0	0.000	<0.007	0.038	nr	0.53	-195	-0.313	No Liming Required
3747/S/12655	Borehole 4 2.0-2.5	8.1	0	0.000	<0.007	<0.02	nr	0.34	-143	-0.229	No Liming Required
3747/S/12657	Borehole 5 0.0-0.5	8.6	0	0.000	0.010	0.044	nr	0.46	-163	-0.261	No Liming Required
3747/S/12661	Borehole 5 2.0-2.5	7.7	0	0.000	<0.007	0.117	nr	0.47	-120	-0.193	No Liming Required
3747/S/12665	Borehole 6 1.0-1.5	9.3	0	0.000	<0.007	0.033	nr	0.58	-221	-0.355	No Liming Required
3747/S/12668	Borehole 6 2.5-3.0	9.1	0	0.000	<0.007	<0.02	nr	0.46	-190	-0.304	No Liming Required
3747/S/12670	Borehole 7 0.5-1.0	9.3	0	0.000	<0.007	<0.02	nr	0.50	-206	-0.330	No Liming Required
3747/S/12673	Borehole 7 2.0-2.5	8.6	0	0.000	<0.007	0.566	nr	0.84	5	0.008	No Liming Required
3747/S/12676	Borehole 8 0.5-1.0	9.1	0	0.000	0.044	0.130	nr	0.56	-153	-0.246	No Liming Required
3747/S/12679	Borehole 8 2.0-2.5	8.2	0	0.000	0.018	0.030	nr	0.43	-161	-0.258	No Liming Required
3747/S/12681	Borehole 9 0.0-0.5	8.5	0	0.000	0.013	<0.02	nr	0.46	-193	-0.310	No Liming Required
3747/S/12683	Borehole 9 1.0-1.5	7.6	0	0.000	<0.007	<0.02	nr	0.30	-127	-0.203	No Liming Required
Blank		5.5	0.5	0.001							

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
[#] if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
[a] S_{KCl} determined as sulfate by turbidimetric method.
Where liming is specified, lime should be fine grained agricultural lime of at least 90% purity.
Any liming rate provided is a recommended rate only, and is based on the total of TAA Equivalent % Oxidisable Sulphur plus Potential Acidity (S_{Cr}) plus Retained Acidity (S_{NAS}) minus effective ANC; with a factor of safety of 1.5.
Any recommended liming rate is based on the 0.03%S action criteria.
A placed dry density of 1.7 tonnes/cubic metre has been used in calculating liming rate/s.
The recommended liming rate is derived from a mathematical equation and will need to be field validated.
Cardno Bowler Pty Ltd accepts no responsibility for any loss associated with use of the calculated liming rate/s.

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Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

Shaping the Future

CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12688CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Pumicestone Passage Sediment Investigation
Job no. 3747/P/158
Sampled by: Cardno Bowler (Sunshine Coast)
Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 5/12/2011
Date Reported: 5/12/2011
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) [a]	(% S)	(% S)	(%$CaCO_3$) [#]	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	1	0.001	0.1
3747/S/12688	Borehole 10 0.5-1.0	9.0	0	0.000	<0.007	0.050	nr	0.53	-190	-0.304	No Liming Required
3747/S/12692	Borehole 10 2.5-3.0	9.3	0	0.000	<0.007	0.036	nr	0.98	-385	-0.618	No Liming Required
3747/S/12693	Borehole 11 0.0-0.5	8.7	0	0.000	<0.007	0.044	nr	0.59	-218	-0.350	No Liming Required
3747/S/12696	Borehole 11 1.5-2.0	9.3	0	0.000	<0.007	0.094	nr	1.06	-382	-0.612	No Liming Required
3747/S/12700	Borehole 12 0.5-1.0	9.0	0	0.000	0.016	0.158	nr	0.59	-145	-0.233	No Liming Required
3747/S/12704	Borehole 12 2.5-3.0	8.3	0	0.000	<0.007	0.023	nr	0.50	-193	-0.310	No Liming Required
3747/S/12707	Borehole 13 1.0-1.5	9.3	0	0.000	<0.007	0.029	nr	0.54	-205	-0.329	No Liming Required
3747/S/12710	Borehole 13 2.5-3.0	9.3	0	0.000	<0.007	0.029	nr	0.53	-201	-0.322	No Liming Required
3747/S/12711	Borehole 14 0.0-0.5	7.7	0	0.000	<0.007	<0.02	nr	0.48	-199	-0.319	No Liming Required
3747/S/12714	Borehole 14 1.5-2.0	8.9	0	0.000	<0.007	<0.02	nr	0.52	-217	-0.348	No Liming Required
3747/S/12717	Borehole 15 0.0-0.5	7.8	0	0.000	<0.007	<0.02	nr	0.43	-179	-0.287	No Liming Required
3747/S/12721	Borehole 15 2.0-2.5	7.0	0	0.000	<0.007	0.025	nr	0.27	-97	-0.155	No Liming Required
3747/S/12724	Borehole 16 0.5-1.0	7.1	0	0.000	<0.007	0.024	nr	0.46	-176	-0.283	No Liming Required
3747/S/12728	Borehole 16 2.5-3.0	6.7	0	0.000	<0.007	<0.02	nr	0.31	-128	-0.205	No Liming Required
3747/S/12730	Borehole 17 0.5-1.0	9.2	0	0.000	<0.007	0.021	nr	0.43	-164	-0.263	No Liming Required
3747/S/12734	Borehole 17 2.5-3.0	8.4	0	0.000	0.019	0.849	nr	0.94	138	0.221	19.6
3747/S/12735	Borehole 18 0.0-0.5	8.7	0	0.000	<0.007	<0.02	nr	0.45	-189	-0.302	No Liming Required
3747/S/12739	Borehole 18 2.0-2.5	7.3	0	0.000	<0.007	0.051	nr	0.49	-173	-0.278	No Liming Required
Blank		5.3	3.9	0.006							

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
[#] if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
[a] S_{KCl} determined as sulfate by turbidimetric method.
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CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12743CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Pumicestone Passage Sediment Investigation
Job no. 3747/P/158
Sampled by: Cardno Bowler (Sunshine Coast)
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 5/12/2011
Date Reported: 5/12/2011

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) [a]	(% S)	(% S)	(%$CaCO_3$) [#]	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	1	0.001	0.1
3747/S/12743	BH19 1.0-1.5	9.3	0	0.000	<0.007	0.044	nr	0.52	-187	-0.300	No Liming Required
3747/S/12744	BH19 1.5-2.0	7.0	0	0.000	0.017	0.069	nr	0.40	-125	-0.201	No Liming Required
3747/S/12748	BH20 0.5-1.0	6.9	0	0.000	<0.007	0.084	nr	0.40	-113	-0.181	No Liming Required
3747/S/12752	BH20 2.5-3.0	7.1	0	0.000	<0.007	0.062	nr	0.49	-167	-0.268	No Liming Required
Blank		6.4	0.0	0.000							

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
[#] if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
[a] S_{KCl} determined as sulfate by turbidimetric method.
Where liming is specified, lime should be fine grained agricultural lime of at least 90% purity.
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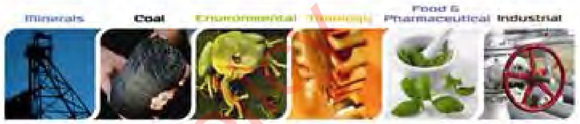
Annex F – Metal and Organic Tin Test Results

ALS Group
Environmental Division



CERTIFICATE OF ANALYSIS

Work Order : **EB1125708**
Client : **CARDNO BOWLER- SUNSHINE COAST**
Contact : MR PAUL MAYES
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KUNDA PARK QLD, AUSTRALIA 4556
E-mail : paul.mayes@cardno.com.au
Telephone : +61 54501544
Facsimile : +61 07 54501533
Project : ----
Order number : ----
C-O-C number : ----
Sampler : Paul Mayes
Site : ----

Quote number : EN/024/10

Page : 1 of 4
Laboratory : Environmental Division Brisbane
Contact : Customer Services
Address : 32 Shand Street Stafford QLD Australia 4053
E-mail : Brisbane.Enviro.Services@alsglobal.com
Telephone : +61 7 3243 7222
Facsimile : +61 7 3243 7218
QC Level : NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Date Samples Received : 01-DEC-2011
Issue Date : 13-DEC-2011

No. of samples received : 3
No. of samples analysed : 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Matheson	Senior Organic Instrument Chemist	Brisbane Inorganics
Matt Frost	Senior Organic Chemist	Brisbane Inorganics
Matt Frost	Senior Organic Chemist	Brisbane Organics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EG005T (Total Metals) - Sample EB1125623-072 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.**
- **Organotins: Sample Location 2 shows poor matrix spike recovery due to matrix interference. Confirmed by re-extraction and re-analysis.**

Analytical Results

Sub-Matrix: **SEDIMENT**			*Client sample ID*	**Location 1**	**Location 2**	**Location 3**	----	----
			Client sampling date / time	29-NOV-2011 14:30	29-NOV-2011 15:00	29-NOV-2011 15:30	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1125708-001**	**EB1125708-002**	**EB1125708-003**	----	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	**17.0**	**68.8**	**23.4**	----	----
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	**14**	<5	----	----
Barium	7440-39-3	10	mg/kg	<10	**20**	<10	----	----
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	----	----
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	----	----
Chromium	7440-47-3	2	mg/kg	<2	**30**	<2	----	----
Cobalt	7440-48-4	2	mg/kg	<2	**8**	<2	----	----
Copper	7440-50-8	5	mg/kg	<5	**11**	<5	----	----
Lead	7439-92-1	5	mg/kg	<5	**13**	<5	----	----
Manganese	7439-96-5	5	mg/kg	<5	**197**	**9**	----	----
Nickel	7440-02-0	2	mg/kg	<2	**14**	<2	----	----
Vanadium	7440-62-2	5	mg/kg	<5	**43**	<5	----	----
Zinc	7440-66-6	5	mg/kg	<5	**58**	<5	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	----	----
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	----	----
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	----	----
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	----	----
EP090S: Organotin Surrogate								
Tripropyltin	----	0.1	%	**87.5**	**65.2**	**91.9**	----	----

Surrogate Control Limits

Sub-Matrix: **SEDIMENT**

Compound	*CAS Number*	*Recovery Limits (%)* Low	*Recovery Limits (%)* High
EP090S: Organotin Surrogate			
Tripropyltin	----	35	130

Annex G – Seagrass Survey Results

PUMISTONE PASSAGE - MAINTENANCE DREDGING AREA

Cardno

SEAGRASS LOCATIONS

Pumicestone Locations.DWG

CARDNO BOWLER

Revision A

IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions that any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE / The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise, *your geotechnical engineering report should not be used:*

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership, or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their report's development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent testing are extrapolated by geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed construction activity and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predications. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimise their impact.* For this reason, *most experienced owners retain their geotechnical consultants through the construction stage,* to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS

CAN CHANGE

Subsurface conditions may be modified by constantly changing natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional test are necessary.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, *give contractors ready access to the complete geotechnical engineering report* prepared or authorized for their use*. Those who do not provide such access may proceed under the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are *not* exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. Your geotechnical engineer will be pleased to give full and frank answers to your questions.

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE has developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by The Institution of Engineers Australia, National Headquarters, Canberra, 1987.

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PRACTICING IN THE GEOSCIENCES

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GENERAL NOTES

GENERAL

This report comprises the results of an investigation carried out for a specific purpose and client as defined in the document. The report should not be used by other parties or for other purposes, as it may not contain adequate or appropriate information.

TEST HOLE LOGGING

The information on the test hole logs has been based on a visual and tactile assessment, except at the discrete locations where test information is available (field and/or laboratory results).

GROUNDWATER

Unless otherwise indicated, the water levels given on the test hole logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater level may differ from this recorded level, depending on material permeabilities. Further variations of this level could occur with time due to such effects as seasonal and tidal fluctuations or construction activities. Final confirmation of levels can only be made by appropriate instrumentation techniques and programmes.

INTERPRETATION OF RESULTS

The discussion/recommendations contained in this report are normally based on site evaluation from discrete test hole data. Generalised or idealised subsurface conditions (including any cross-sections contained in this report) have been assumed or prepared by interpolation/extrapolation of these data. As such, these conditions are an interpretation, and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in the generalised ground conditions used for this report can occur, particularly between discreet test hole locations. Furthermore, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed in this report should be referred to this firm for appropriate assessment and comment.

FOUNDATION DEPTH

Where referred to in the report, the recommended depth of any foundation (piles, caissons, footings, etc) is an engineering estimate of the depth to which they should be constructed. The estimate is influenced and perhaps limited by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The depth remains, however, an *estimate* and is therefore liable to variations to the final depth depending on the ground conditions at each point of support.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in this report for the inclusion in the contract documents or engineering specification of the subject development, such reproduction should include at least all of the relevant trial hole and test data, together with the appropriate standard description sheets and remarks made in the written report of a factual or descriptive nature.

This report is the subject of copyright, and shall not be reproduced either totally or in part without the express permission of this firm.

Appendix D Maroochy River Sediment Investigation Report (Cardno Bowler, 2011b)

Maroochy River Sediment Investigation Report

Job Number: 3747/P/137

Prepared for Sunshine Coast Council

Date: 19 December 2011

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Document Control

Version	Date	Author		Reviewer	
1.0	19 December 2011	Paul Mayes	PM	Matt Courtney	M

Executive Summary

Cardno Bowler Pty Ltd was engaged by Sunshine Coast Regional Council to perform an investigation of the sediment in sections of the lower reaches of the Maroochy River for the purposes of supporting an application to dredge these areas for the purposes of beach nourishment both to the south of the Maroochy River mouth and within the lower reaches Maroochy River itself.

A program of fieldwork and laboratory testing was designed and implemented with the aim of describing the nature of the sediments present within the proposed dredge areas and to assess the extent and severity of the Acid Sulfate Soils at these sites. These data could then be used to target dredging operations to areas likely to produce the best resource for the beach nourishment program. Supplementary to these sediment characterisations a survey of the seagrass present within the area was also carried out to determine if existing marine plant distribution would impact potential dredging sites.

A total of 20 boreholes were advanced during the investigation, with representative samples selected for particle size distribution and analytical laboratory testing for Acid Sulfate Soils. Subsurface strata at the site were dominated by fine to medium grained sand with varying, but generally very low, levels of silt. The results of the analytical Acid Sulfate Solis laboratory testing on the samples collected support the presence of Acid Sulfate Soils within the material tested. However, as a result of intrinsic acid neutralising capacity held within the material tested, the potential acidity levels (as assessed by S_{Cr}) which ranged from nil to 0.139%S were always exceeded by acid neutralising capacity to give net acidity values for all samples tested of nil. Hence, no liming rates are defined within this report.

Paul Mayes (PhD.)
Principal Environmental Scientist

Table of Contents

Executive Summary ii

Glossary 3

Introduction 4

Site Description 6

Methodology 7

- Desktop Survey 7
- Fieldwork 7
- Laboratory Testing 8

Results and Discussion 9

- Desktop Survey 9
- Subsurface Conditions 9
- Analytical Laboratory Analysis 9
- Material Quality 10
- Seagrass Survey 10

Summary 11

List of Annexes

Annex A - Site Plan

Annex B – Borehole locations

Annex C – Borehole Logs

Annex D – Particle Size Distribution results

Annex E – Acid Sulfate Soil results

Glossary

Acid Sulfate Soil (ASS): Soil or sediment containing highly acidic soil horizons or layers affected by the oxidation of iron sulfides (actual ASS) and/or sediment containing iron sulfides or other sulfidic material that has not been exposed to air and oxidised (potential ASS). The term Acid Sulfate Soils generally includes both actual and potential Acid Sulfate Soils.

Agricultural Lime: A neutralising agent commonly used to treat acidic soils.

AHD (Australian Height Datum): The datum used for the determination of elevations in Australia.

Borehole: The actual hole created when an auger or push-tube is inserted into the soil body.

BSL (Below Surface Level): The depth as measured from the existing site surface level, generally recorded in metres.

Clay: Cohesive Soil with a particle size less than 0.02mm.

Groundwater: Subsurface water in the zone of saturation, including water below the water table and water occupying cavities, pores and openings in underlying soil and rock.

Leachate: The soil constituent that is washed out from a mixture of soil solids.

Oxidised: Process of chemical change involving the addition of oxygen following exposure to air.

Piezometer: A pipe of small diameter installed in a borehole that is used to measure the height (elevation) of the water table.

Pyrite: Pale bronze or pale yellow, isometric mineral: FeS_2 ; the most widespread and abundant of the sulfide minerals.

pH_F: The pH of the soil in soil/distilled water paste.

pH_{FOX}: The pH of the soil after the addition of a small quantity of Hydrogen Peroxide.

%S: Percentage oxidisable sulfur.

Sand: Non-cohesive soil with a particle size between 2.36mm and 0.075mm.

Silt: Non-cohesive soil with a particle size between 0.075mm and 0.02mm.

SPP 2/02: State Planning Policy 2/02: Planning and Managing Developments involving Acid Sulfate Soils.

Soil and Sediment: The natural accumulation of unconsolidated mineral particles (derived from weathered rocks) and organic matter that covers much of the earth's surface.

Water table: Portion of the ground saturated with water, often used specifically to refer to the upper limit of the saturated ground.

Introduction

The following report details the results of the Sediment Investigation performed within the lower reaches of the Maroochy River in South East Queensland. It is understood that the works proposed for the site are to include the dredging of suitable sand resources from within the river mouth for the purposes of beach nourishment in the local area. Four specific areas within the river mouth were identified by council as potential dredging zones and this investigation concentrates on these areas and the assessment of the insitu sediments with respect to their potential use in beach nourishment programs. The scope of work covered in this investigation included the following:

- General description of the sediment profile at selected locations within the four specified zones;
- Particle size distribution testing of representative samples from each of the zones;
- Acid Sulfate Soils testing of representative samples from each of the zones; and
- A survey of the proposed areas for the presence of any areas of seagrass beds greater than $50m^2$ in area.

The nature of the sediments present within the four selected areas will be integral to the ultimate selection of the material to be dredged for two reasons:

- non-cohesive soils (ie sands) are logistically more suitable for dredging, and
- lightly coloured clean sands will be more suitable for use in beach nourishment programs.

The Acid Sulfate Soils conditions within the areas proposed to be dredged may also be incorporated into the decision making process regarding which areas are most suitable to be used for the beach nourishment program. Acid Sulfate Soils are common in low-lying coastal areas of Queensland, especially in areas below 5.0 metres AHD. Such areas are often characterised by the presence of estuaries, swamps, floodplains, salt marshes and mangroves. The affected soils are characterised by iron sulfides, most frequently pyrite, and when these soils are maintained in anaerobic conditions these iron sulfides are unable to oxidise and therefore the Acid Sulfate Soils are stable. However, if a disturbance exposes the Acid Sulfate Soils to air, the iron sulfides can oxidise and form sulphuric acid, resulting in the soil becoming strongly acidic. This acidity has the potential to mobilise metals such as Iron, Aluminium and Manganese which are naturally present in the soil, thereby producing a leachate contaminated by both high levels of acidity and metals. Such leachate, if released into the environment, can have significant adverse effects including; degradation of the water quality in receiving areas, fish disease/kills, reduced crop productivity, corrosion of structures and health related issues. In view of these potential effects, it is critical that any development that occurs within an area likely to contain Acid Sulfate Soils is planned, managed and monitored appropriately so as to minimise or remove the risk of adverse environmental outcomes.

In response to the potential for such adverse environmental outcomes to occur as a result of the disturbance of Acid Sulfate Soils, the Queensland Department of Environment and Resource Management developed the “State Planning Policy 2/02: Planning and Managing Developments involving Acid Sulfate Soils: and its supporting guidelines”. The SPP 2/02 provides assistance and recommendations on best practice for developments involving Acid Sulfate Soils.

The State Planning Policy 2/02 applies to all land, soil or sediment at or below 5 metres AHD where the natural surface level is below 20 metres AHD and applies to development that would result in:

(a) the excavation of, or otherwise removing, 100m^3 or more of soil or sediment; or

(b) filling of land involving 500m^3 or more of material with an average depth of 0.5 of a metre or greater.

As the entire site has an existing surface level below AHD 5.0m any disturbance of soil or sediment within this area must consider the consequences of Acid Sulfate Soils when assessing the overall project risk. The preferred mechanism to circumvent potential adverse environmental outcomes concerning Acid Sulfate Soils is avoidance, that is, where possible, areas identified to contain Acid Sulfate Soils should not be disturbed.

The aim of this sediment investigation was to make an assessment of the quality of the sediments present within each of the four proposed target areas with respect to the use of these sediments as part of a beach nourishment program. The parameters considered integral to the potential use of the sediments were; the nature of the insitu sediments and the Acid Sulfate Soils content of these sediments.

It should be noted that this report is not intended to be, nor should it be attempted to be used as, a fully QASSIT compliant Acid Sulfate Soils investigation of the site to support a specific proposed soil disturbance. Rather, this investigation is intended to provide general information regarding the sediments present at the site with the goal of informing the decision making process regarding the overall beach nourishment project. Furthermore, it is recognised that there are numerous other factors that will be incorporated into the final selection of dredging locations for this project.

This report should be read in conjunction with the attached “General Notes” and the ASFE publication “Important Information about your Geotechnical Report”.

Site Description

The four target zones were located within the lower reaches of the Maroochy River downstream of the Sunshine Motorway bridge, the locations are shown in Annex A and will be referred to throughout this report as Area 1 through 4 as shown on this plan. See Figure 1 below for a locality plan of the subject site.

Figure 1: Locality Plan

The subject site was contained within the lower reaches of the Maroochy River and is heavily influenced by tidal flows. Water depths at the four areas were significantly influenced by tidal movements, with some areas completely exposed at low tide and maximum water depths in excess of 3.0m at high tide in other areas. This area of the river is heavily utilised by recreational users for swimming, boating and fishing activities.

Methodology

Desktop Survey

Prior to the commencement of the fieldwork program a review of the existing Acid Sulfate Soils maps produced by Department of Environment and Resource Management was performed. The results of this desktop survey are shown in the Results section below. Furthermore, a general assessment of the site was made by reviewing the available aerial photographs of the site.

Fieldwork

A total of 20 boreholes (BH1 to BH20) were advanced across the site. The boreholes were divided across the four areas on the basis of the size of the individual areas and expected sand resource distribution as follows: Area 1: Borehole 1, Areas 2: Borehole 2-4, Area 3: Boreholes 5-9, Area 4: Borehole 10-20, see Annex B for a plan showing the borehole locations. It is noted that the identified location of area 2 was indicative only, and open to relocation on the basis existing site conditions, as such the three locations assigned to area 2 were outside the actual area identified. With respect to area 4, the logistics of sample collection and actual dredging was also considered when selecting sampling locations. The high wave action zone at the river bar was considered incompatible with either the collection of samples for testing during this investigation or actual dredging process and as such this area was not sampled during this investigation. Furthermore, the extremely shallow nature of some sections of area 4 (less than 0.5m of water cover at high tide) meant it was not possible to collect samples from these sections. It should also be noted that the sampling locations were marked with recreational quality GPS equipment with an average accuracy of approximately 5m.

The boreholes were advanced using a pneumatic vibracore drilling rig mounted on a self propelled working barge. The vibracore and barge were operated by Abyss Commercial Diving Services who are experienced in the collection of soft sediments in estuarine environments such are the Maroochy River. The vibracore rig collects a continuous core of the soft strata which is suitable for investigations of this nature. The target depth of the lake boreholes was 3.0 metres below the existing sediment surface level, however some boreholes were terminated prior to this target depth due to the vibracore refusal in stiffer sediments. Detailed geotechnical boreholes logs of the material encountered at each location are shown in Annex C. The entire core from each location was retained and returned to our Kunda Park laboratory for the required laboratory analysis via AS1289 for particle size distribution testing and the Chromium Test Suite for Acid Sulfate Soils.

Borehole locations were initially selected digitally, using the provided site plans with overlays of the four investigation areas to produce GPS co-ordinates for each borehole location. In the majority of cases these locations were accessible to the barge and could be drilled as selected, however, where necessary due to extremely shallow conditions, borehole locations were moved to allow successful completion of the fieldwork program.

The seagrass survey of the four areas was undertaken in a systematic manner using GPS coordinates to divide the areas into a 25m grid to allow the identification of any seagrass patches present at the site. The ground survey was then undertaken using a small dingy and snorkelling equipment.

Laboratory Testing

Particle Size Distribution

Representative samples covering a variety of depths were selected and dried at 105°C to a constant mass before testing. A single sample was selected from each borehole and the samples were isolated to 0.5m intervals from within borehole cores. The samples were tested to determine their particle size distribution via AS1289. The results of the particle size distribution testing are presented in Annex D.

Acid Sulfate Soils

Representative samples covering a variety of depths were selected from each borehole and dried at 85°C to a constant mass before testing. Two samples were selected from each borehole and the samples were isolated to 0.5m intervals from within borehole cores. The samples were tested analytically via the Chromium Suite of testing. The results of the Acid Sulfate Soils testing are presented in Annex E.

Results and Discussion

Desktop Survey

The Queensland Government Department of Environment and Resources Management "Acid Sulfate Soils-Maroochy Caloundra Acid Sulfate Sustainable Land Management Project" Map 2, does not specifically provide information regarding the sediments within the Maroochy River bed itself. However, this map does indicate that land on the northern bank of the river is likely to contain potential Acid Sulfate Soils within 0.5m of the surface. Furthermore, this map indicates that disturbed land on the southern bank of the river is likely to contain Acid Sulfate Soils. Whilst not definitive, these data tend to support a high probability of the presence of Acid Sulfate Soils within the subject site.

The Queensland Government Department of Mines and Energy 'NAMBOUR SPECIAL' geological map sheet 9444 and part 9544 scale 1:100,000, classifies the sediments of the site as "estuarine channel and banks; sandy mud, muddy sand, minor gravels".

Subsurface Conditions

Detailed logs for the boreholes advanced during this investigation are shown in Annex C. The subsurface strata encountered at the site were dominated by poorly graded sands with generally low silt contents.

Analytical Laboratory Analysis

Particle Size Distribution

The samples of material tested for particle size distribution showed a relatively consistent pattern of composition across all areas. The strata are dominated by fine to medium grained sands with generally low silt contents. Particles larger than 1.18mm were very rare and when present were often shell fragments rather than sand particles or gravel. Furthermore, the proportion of material smaller than 0.075mm in the samples tested was also very small, generally not exceeding 5% by mass of the total. These extremely low proportions of material passing the 0.075mm sieve negated the need to undertake additional testing on the silt and clay fractions. The AS1289 method specifically excludes samples which have less than 10% passing 0.075mm from the hydrometer based portion of the test method.

Acid Sulfate Soils

The results of the analytical laboratory analysis (see Annex D) showed that none of the 40 samples tested had a net acidity value in excess of the 0.03% oxidisable sulfur threshold for coarse grained soils such as those encountered at the subject site. This is due to a combination of the presence of intrinsic acid neutralising capacity (ANC) and generally low levels of oxidisable sulfur within the samples tested. The maximum S_{Cr} level detected in the samples tested during this investigation was 0.139% oxidisable sulfur, however the majority of samples returned very low levels of S_{Cr}, at or around the 0.03% level (often below the detection limit of the test method). These results confirm the presence of Acid Sulfate Soils within the samples tested during this investigation, however in the vast majority of samples the levels of acidity are very low and in all cases the materials intrinsic acid neutralising capacity exceeds the potential of the material to generate acidity. As such no further treatment of the materials tested would be required.

Material Quality

The quality of the material present at each borehole location, in terms of its use in a beach nourishment program, was assessed on the basis of a combination of the information shown on the geotechnical logs and the particle size distribution. These results suggest that there will be limited high quality harvestable sand resources at areas 1 through 3. Whilst the particle size distribution of the sediments tested from these areas would generally be suitable for the logistics of the dredging process and would also provide the non-cohesive materials generally sort for beach nourishment programs, this material is of variable make up. Colour and silt content, along with strata depth in areas 1 through 3 are significantly more variable than at area 4.

The soil profiles at area 4 were generally more uniform and the material was generally paler in colour than that sampled from areas 1 though 3. The exceptions to this generalisation were boreholes 18 through 20 (located in the north-eastern section of area 4) which were slightly more variable and darker in colour than the rest of the boreholes within area 4 and were more similar to the boreholes within areas 1 through 3. These data suggest the sediments present within the western section of area 4 would be the best quality (of those tested throughout this investigation) for the purposes of beach nourishment programs and it is recommended that this area be the primary source of the resource for the intended dredging program.

If the logistics of transporting the dredged material to destinations within the Maroochy River mouth are problematic there may be opportunity to recover some smaller quantities of suitable material from areas 1 through 3, however the data presented here suggest that these opportunities would not yield the same quantity or quality of resource for beach nourishment purposes.

Seagrass Survey

The seagrass survey of the proposed dredging areas revealed no significant (greater than 50m^2) patches of seagrass present within the areas recommended for dredging.

There are some very small patches of seagrass adjacent to area 3 which may need to be considered if dredging is to be undertaken in this area. However, the general higher quality and consistency of the material identified in area 4 means dredging from area 3 (or areas 1 and 2) should be considered as a secondary option to dredging within area 4. If the quantity of resource available in area 4 is insufficient for the requirements of the beach nourishment program/s or the logistics of transporting the material from area 4 to its destinations are difficult, further consideration of the use of sediments from area 3 (or areas 1 and 2) will be required.

If dredging is isolated to area 4, there will be no need to consider the location of seagrass beds when selecting material for the beach nourishment programs.

Summary

The following points summarise the findings of the Sediment Investigation of the Maroochy River.

- Sediments tested at the selected sampling locations were dominated by sands with generally low levels of silt.
- Areas 1 through 3 showed more variable soil profiles with darker materials closer to the surface than those identified at area 4.
- Soil profiles at area 4 were generally more uniform and paler in colour.
- Acid Sulfate Soils were identified at the site within the areas proposed to be disturbed, however intrinsic acid neutralising capacity exceeded potential acidity in all samples tested.
- It is recommended that area 4 be used as the primary source of material for the beach nourishment program/s.

Annex A - Site Plan

Resource Investigation Area - Maroochy

Coordinates of resource investigation area points

Location	Longitude	Latitude
1	153.078375	-26.640441
2	153.078326	-26.641273
3	153.082078	-26.640504
4	153.082127	-26.641314
5	153.077927	-26.643047
6	153.077750	-26.643313
7	153.080231	-26.643846
8	153.080232	-26.644099
9	153.082872	-26.643832
10	153.082951	-26.644036
11	153.084134	-26.643031
12	153.086848	-26.642976
13	153.086278	-26.643786
14	153.090117	-26.647805
15	153.089755	-26.648346
16	153.093089	-26.650654
17	153.094438	-26.653341
18	153.097585	-26.653500
19	153.098104	-26.650998
20	153.101138	-26.648987
21	153.097723	-26.645427
22	153.099275	-26.643173

Legend

- 🟩 Protected Areas of Queensland (estate)
- ▬ Coastal Structures
- ▭ FishHabitatAreas
- - - - Fish Habitat 100m Buffer
- ▨ Resource Investigation Area
- ━ Proposed Beach Nourishment

Please Note: Area 1 is indicative only. Refer to navigation channel markers for exact location

N
W E
S

1:8,444

0 70 140 280 420 Meters

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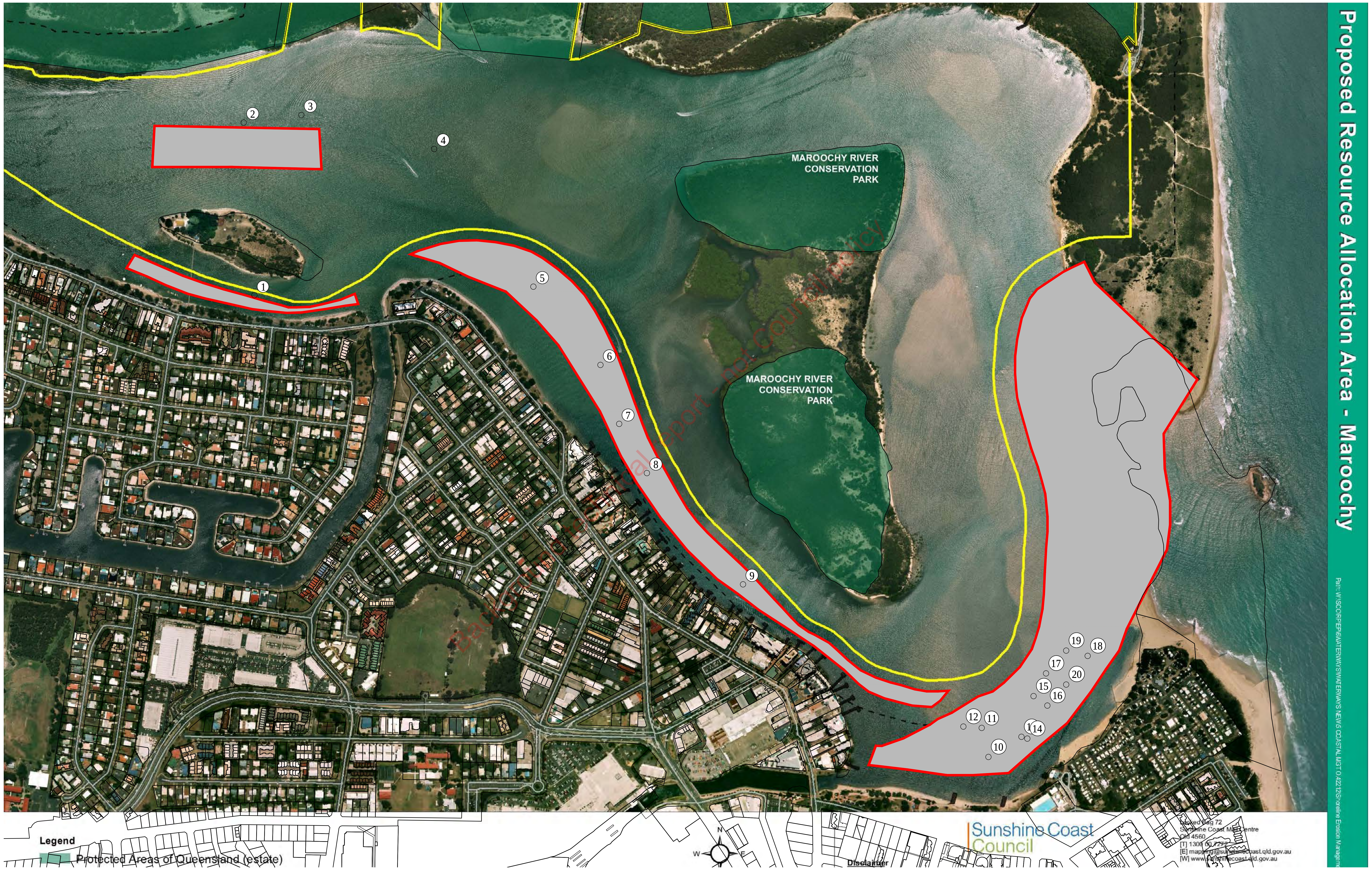
Prepared by: TJM *At Paper Size A3* *Last Printed on December 20, 2011*

Path: W:\SCC\RP\EP\6WATERWAYS\WATERWAYS NEW5 COASTAL MGT O.42212\Shoreline Erosion Management Plans\Sand sourcing study

Annex B – Sampling Locations

MAROOCHY RIVER - MAINTENANCE DREDGING AREA



50 0 50 100 150 200 250m

1:5000 - A1 1:10000 - A3

LAYOUT PLAN

Maroochy River Locations 2.DWG

CARDNO BOWLER

Revision A

Annex C – Borehole Logs

BOREHOLE LOG SHEET

Cardno Bowler
32 Hi-Tech Drive
Kunda Park/QLD/4556
Telephone: +61 7 54501544
Fax: +61 7 54051533

BOREHOLE No: 3747-P137-BH01
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508024 7053007
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 0.7m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, grey-brown, trace silt, shell fragments present, ALLUVIAL		
			1.0		SP	**SAND**, fine to medium grained, grey to dark grey, trace silt, shell fragments present, ALLUVIAL		
			1.5 2.0		SP	**SAND**, fine to medium grained, very dark brown, with silt, ALLUVIAL		
			2.5 3.0		SP	**SAND**, fine to medium grained, grey-brown, with silt, ALLUVIAL		
			3.5			Borehole 3747-P137-BH01 terminated at 3m		

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BOREHOLE No: 3747-P137-BH02
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508000 7053393
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 1.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5		SP	**SAND**, fine to medium grained, grey-brown, trace silt, shell fragments present, ALLUVIAL		
			2.0		SP	**SAND**, fine to medium grained, dark brown, with silt, ALLUVIAL		
			2.5 3.0 3.5			Borehole 3747-P137-BH02 terminated at 2.4m		Borehole terminated due to vibracore refusal.

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BOREHOLE No: 3747-P137-BH03
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508129 7053410
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 1.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, grey-brown, with silt, ALLUVIAL		
			1.0		SP	**SAND**, fine to medium grained, grey, with silt, ALLUVIAL		
			1.5 2.0 2.5		SP	**SNAD**, fine grained, dark brown, with silt, ALLUVIAL		
			3.0 3.5			Borehole 3747-P137-BH03 terminated at 2.8m		Borehole terminated due to vibracore refusal.

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BOREHOLE No: 3747-P137-BH04
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508426 7053334
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 0.4m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5		SP	**SAND**, fine grained, pale grey, shell fragments present, ALLUVIAL		
			2.0 2.5 3.0		SP	**SAND**, fine to medium grained, grey to dark grey, with silt, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P137-BH04 terminated at 3m		

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BOREHOLE No: 3747-P137-BH05
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508648 7053026
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 0.8m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, brown, trace silt, ALLUVIAL		
			0.5		SP	**SAND**, fine to medium grained, grey, with silt, ALLUVIAL		
			1.0					
			1.5					
			2.0					
			2.5					
					SP	**SAND**, fine grained grained, very dark brown, with silt, ALLUVIAL		
						Borehole 3747-P137-BH05 terminated at 2.9m		Borehole terminated due to vibracore refusal.
			3.0					
			3.5					

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BOREHOLE No: 3747-P137-BH06
SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508798 7052851
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 1.0m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				▨	SP	**SAND**, fine grained, pale grey to grey, trace silt, shells fragments present, ALLUVIAL		
			0.5	▨				
			1.0	▨	SP	**SAND**, fine to medium grained, brown, trace silt, ALLUVIAL		
			1.5	▨				
			2.0	▨				
			2.5	▨				
			3.0			Borehole 3747-P137-BH06 terminated at 3m		
			3.5					

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P137-BH07
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508840 7052719
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 1.2m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to coarse grained, dark grey, trace silt, ALLUVIAL		
			1.0		SP	**SAND**, fine to medium grained, grey, trace silt, shell fragments present, ALLUVIAL		
			1.5 2.0 2.5 3.0		SP	**SAND**, fine to medium grained, pale grey to grey, trace silt, ALLUVIAL		
			3.5			Borehole 3747-P137-BH07 terminated at 3m		

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P137-BH08
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508902 7052609
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 1.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, grey, trace silt, ALLUVIAL		
			0.5					
			1.0					
			1.5					
			2.0					
					SP	**SAND**, fine to medium grained, grey and dark grey, trace silt, trace low plasticity clay, ALLUVIAL		
					SP	**SAND**, fine to medium grained, dark grey, trace silt, ALLUVIAL		
			2.5					
			3.0					
						Borehole 3747-P137-BH08 terminated at 3m		
			3.5					

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P137-BH09
SHEET: 1 of 1

DATE STARTED 8/11/11
COMPLETED 8/11/11
R.L. SURFACE
DATUM
DRILLING CONTRACTOR Abyss Commercial Diving
SLOPE 90°
BEARING ---
EQUIPMENT Vibracore
HOLE LOCATION 56 J 509117 7052360
HOLE SIZE 50mm
LOGGED BY PM
CHECKED BY DC
NOTES Water Depth 1.1m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5 2.0 2.5 3.0		SP	**SAND**, fine grained, grey, with silt, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P137-BH09 terminated at 3m		

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P137-BH10
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509666 7051974
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 1.1m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, brown to dark brown, ALLUVIAL		
			1.0 1.5 2.0 2.5 3.0		SP	**SAND**, fine to medium grained, grey, ALLUVIAL		
			3.5			Borehole 3747-P137-BH10 terminated at 3m		

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BOREHOLE No: 3747-P137-BH11

SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509890 7052260

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water Depth 1.2m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				⁘	SP	**SAND**, fine to coarse grained, pale brown to brown, trace silt, ALLUVIAL		
			0.5	⁘				
			1.0	⁘	SP	**SAND**, fine to coarse grained, grey, trace silt, ALLUVIAL		
			1.5	⁘				
			2.0	⁘				
			2.5	⁘				
						Borehole 3747-P137-BH11 terminated at 2.8m		Borehole terminated due to vibracore refusal.
			3.0					
			3.5					

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P137-BH12

SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509610 7052042

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5 2.0 2.5 3.0		SP	**SAND**, fine to medium grained, pale brown, trace silt, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P137-BH12 terminated at 3m		

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BOREHOLE No: 3747-P137-BH13

SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509740 7052019

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, pale brown, trace silt, shell fragments present, ALLUVIAL		
			0.5					
			1.0					
			1.5					
			2.0					
			2.5					
			3.0			Borehole 3747-P137-BH13 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P137-BH14

SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509753 7052015

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				▨	SP	**SAND**, fine grained, pale brown, trace silt, shell fragments present, ALLUVIAL		
			0.5					
			1.0					
			1.5					
			2.0					
			2.5					
			3.0					
						Borehole 3747-P137-BH14 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P137-BH15
SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509767 7052110
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5	▨	SP	**SAND**, fine grained, pale brown, trace silt, ALLUVIAL		
			2.0 2.5 3.0	▨	SP	**SAND**, fine to medium grained, pale brown, trace silt, ALLUVIAL		
			3.5			Borehole 3747-P137-BH15 terminated at 3m		

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P137-BH16

SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509798 7052089

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine grained, pale brown, trace silt, shell fragments present, ALLUVIAL		
			0.5					
			1.0					
			1.5					
			2.0					
			2.5					
			3.0			Borehole 3747-P137-BH16 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P137-BH17

SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509795 7052161

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, brown, trace silt, shell fragments present, ALLUVIAL		
			0.5					
			1.0					
			1.5					
			2.0					
			2.5					
					SM	**SILTY SAND**, fine grained, very dark brown, trace low plasticity clay, ALLUVIAL		
			3.0					
						Borehole 3747-P137-BH17 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P137-BH18
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509888 7052200
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 1.1m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, brown, trace silt, ALLUVIAL		
			1.0 1.5 2.0 2.5		SP	**SAND**, fine to medium grained, grey, trace silt, ALLUVIAL		
			3.0 3.5			Borehole 3747-P137-BH18 terminated at 2.9m		Borehole terminated due to vibracore refusal.

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BOREHOLE No: 3747-P137-BH19

SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509840 7052212

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water Depth 1.1m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, brown, trace silt, ALLUVIAL		
			0.5 1.0 1.5		SP	**SAND**, fine to medium grained, pale grey to grey, ALLUVIAL		
			2.0 2.5		SP	**SAND**, fine to coarse grained, grey, trace silt, ALLUVIAL		
			3.0		SC	**CLAYEY SAND**, fine grained grained, dark grey, low plasticity clay, ALLUVIAL		
			3.5			Borehole 3747-P137-BH19 terminated at 3m		

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BOREHOLE No: 3747-P137-BH20
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509840 7052136
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 0.7m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				░	SP	**SAND**, fine to medium grained, brown, trace silt, ALLUVIAL		
			0.5 1.0	░	SP	**SAND**, fine to coarse grained, dark brown, trace silt, ALLUVIAL		
			1.5 2.0 2.5	░	SP	**SAND**, fine to medium grained, grey, trace silt, ALLUVIAL		
			3.0	▨	CH	**SILTY CLAY**, high plasticity, dark grey, ALLUVIAL		
			3.5			Borehole 3747-P137-BH20 terminated at 3m		

Annex D - Particle Size Distribution Test Results

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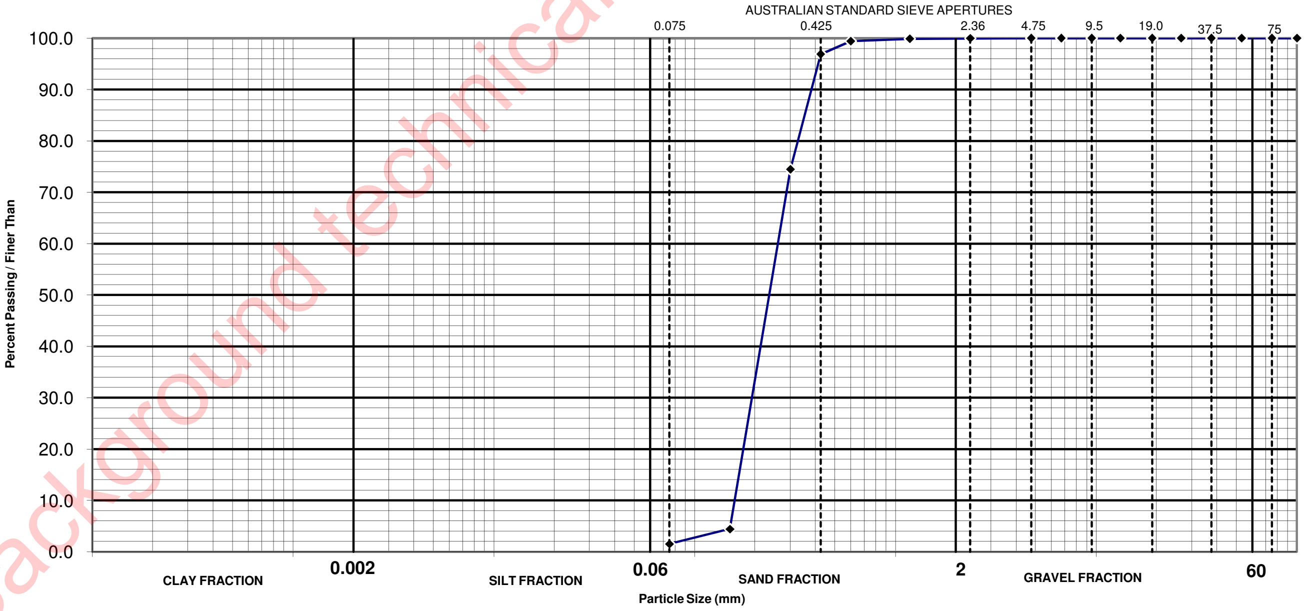
Shaping the Future

Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12753Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12753**		
Sample Identification:	**BH1: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	97		
37.5		0.300	74		
26.5		0.150	4		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



% Finer than 0.02mm:	na
% Finer than 0.005mm:	na

This document is issued in accordance with
NATA's accreditation requirements.

NATA Accreditation No: 3747

SIGNATORY: Paul Mayes

Form Number

REP HYD-2

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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

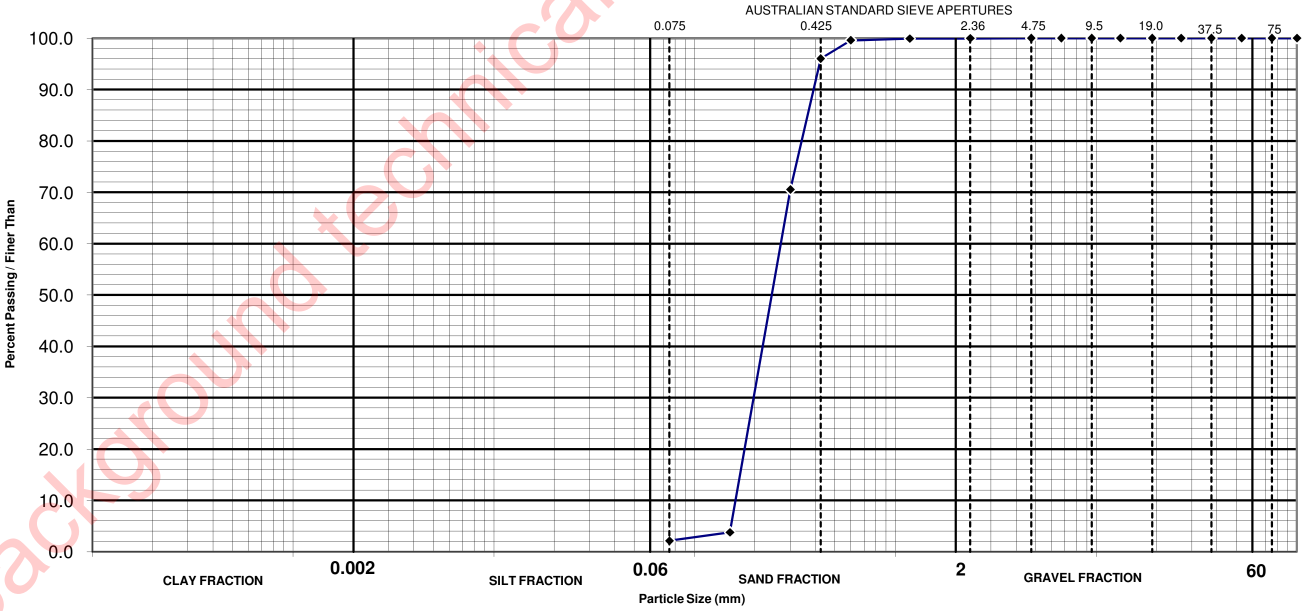
Sample Number: **3747/S/12760**
Sample Identification: **BH2: 0.5-1.0**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12760Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	96		
37.5		0.300	71		
26.5		0.150	4		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



% Finer than 0.02mm:	na
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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

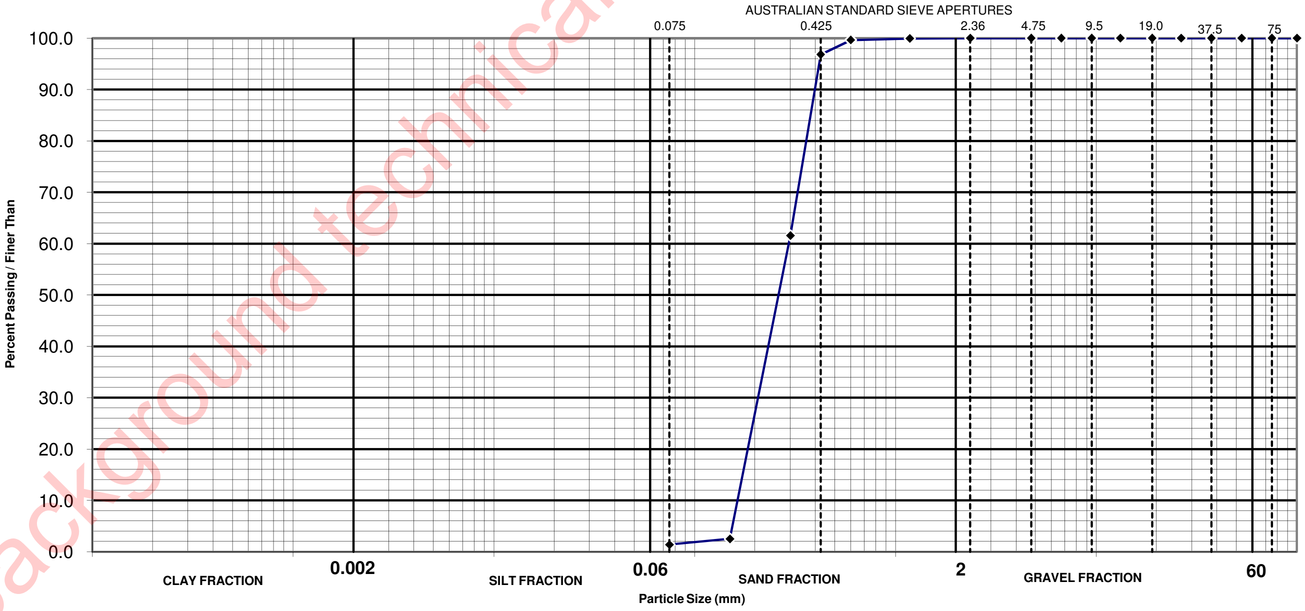
Sample Number: **3747/S/12765**
Sample Identification: **BH 3: 0.0-0.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12765HYD**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	97		
37.5		0.300	62		
26.5		0.150	3		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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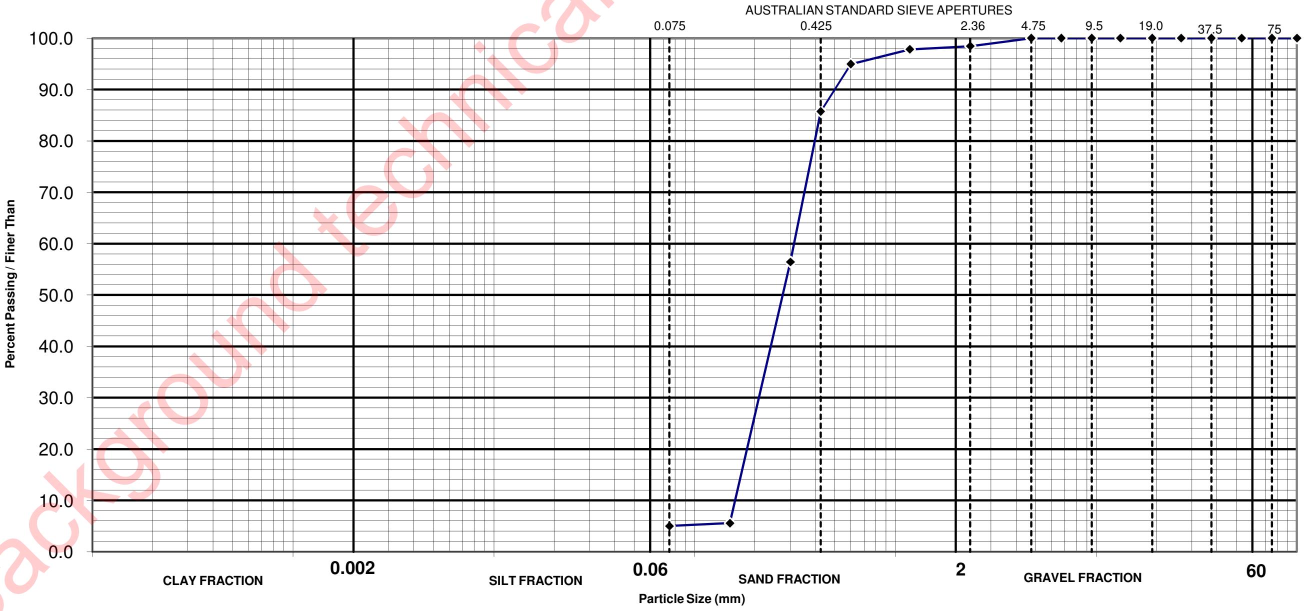
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12776Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12776**		
Sample Identification:	**BH4: 2.5-3.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	98		
75		0.600	95		
53		0.425	86		
37.5		0.300	56		
26.5		0.150	6		
19.0		0.075	5		
13.2					
9.5					
6.7					
4.75	100				
2.36	98				

PARTICLE SIZE DISTRIBUTION



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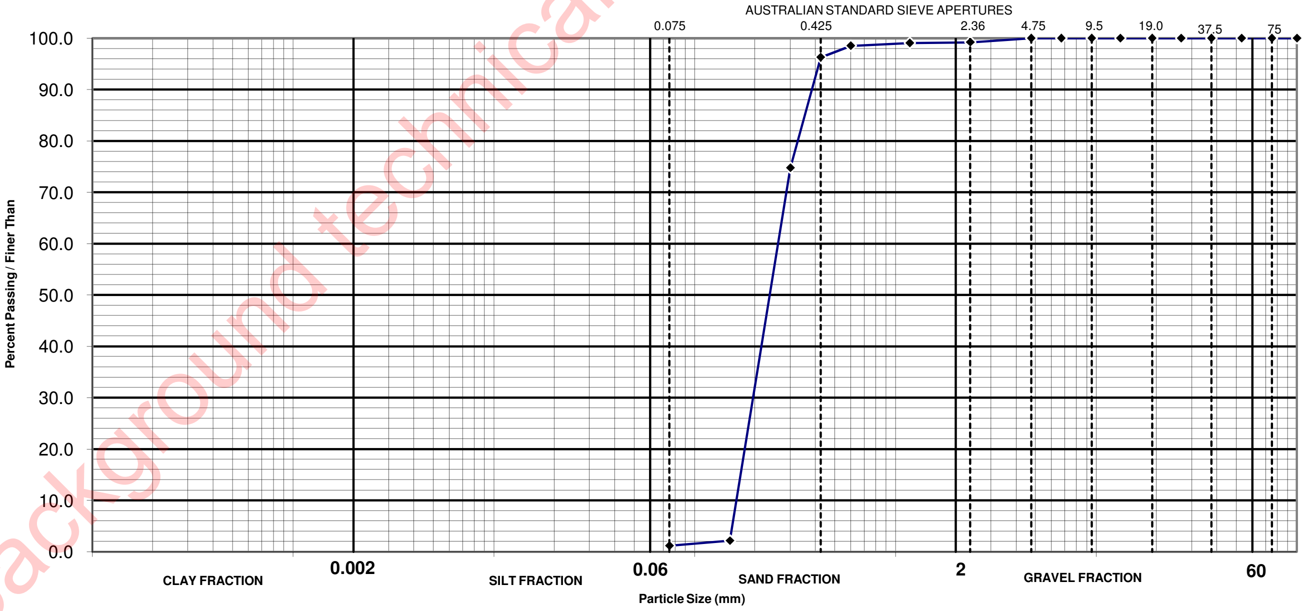
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12777Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12777**		
Sample Identification:	**BH5: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing
100	
75	
53	
37.5	
26.5	
19.0	
13.2	
9.5	
6.7	
4.75	100
2.36	99
1.180	99
0.600	99
0.425	96
0.300	75
0.150	2
0.075	1

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

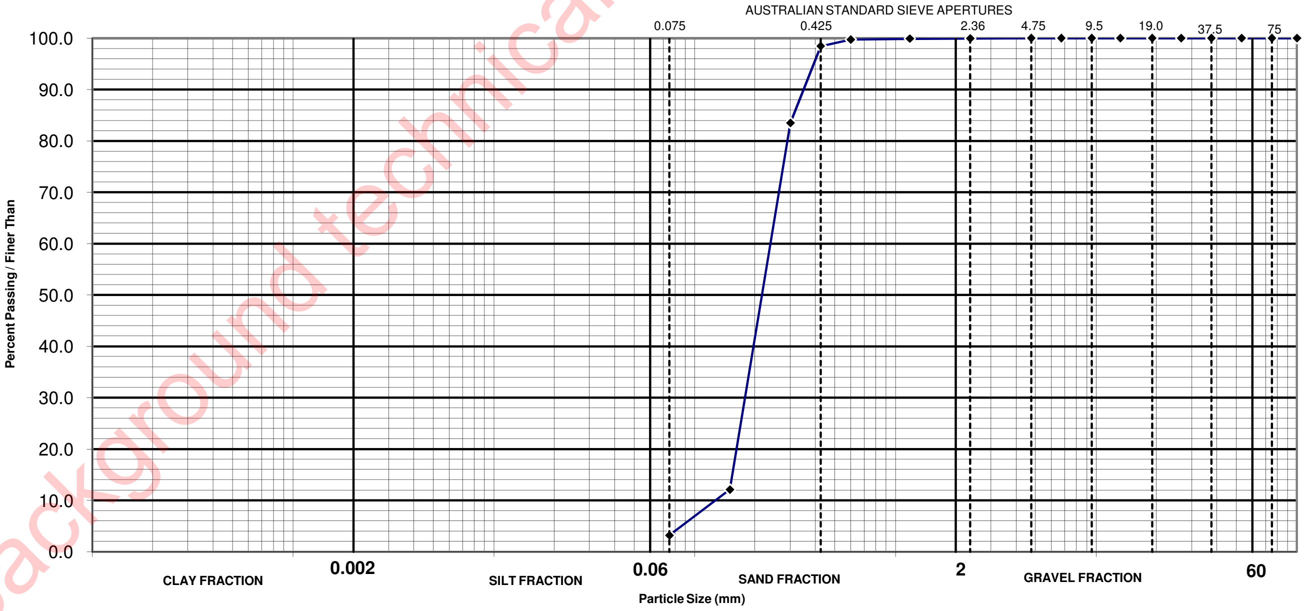
Sample Number: **3747/S/12784**
Sample Identification: **BH6: 0.5-1.0**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12784Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	98		
37.5		0.300	83		
26.5		0.150	12		
19.0		0.075	3		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

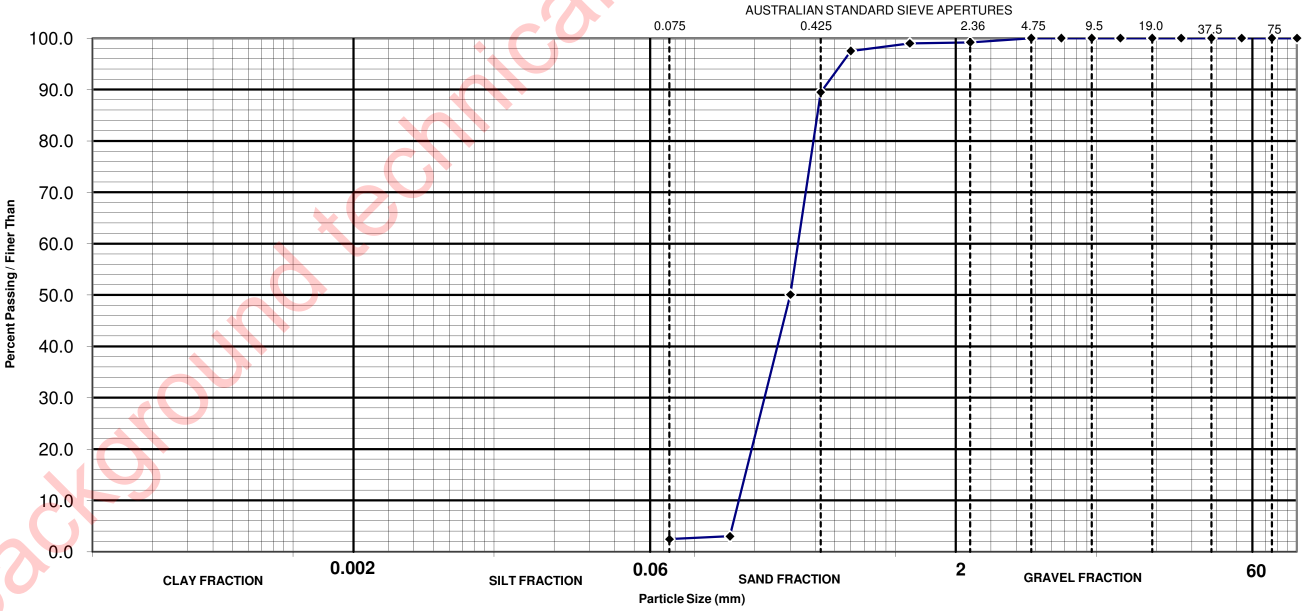
Sample Number: **3747/S/12870**
Sample Identification: **BH7: 1.5-2.0**
Date Sampled: **9/11/2011**

Report Number: **3747/S/12870Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	99		
75		0.600	98		
53		0.425	89		
37.5		0.300	50		
26.5		0.150	3		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

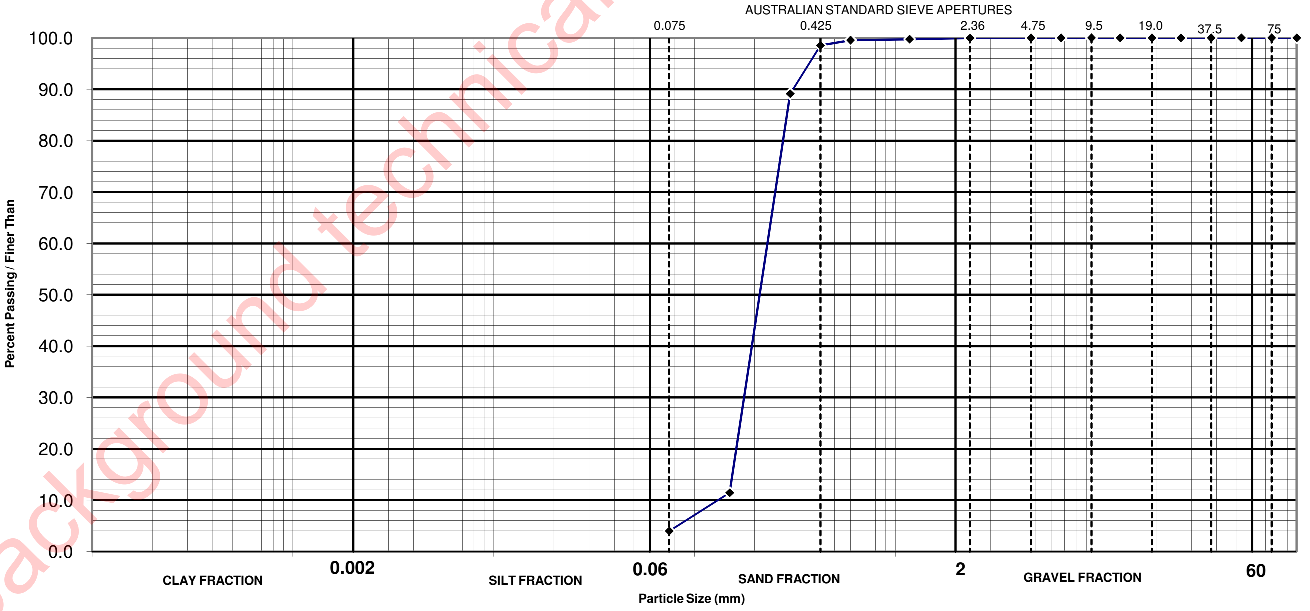
Sample Number: **3747/S/12789**
Sample Identification: **BH8: 0.0-0.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12789Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	99		
37.5		0.300	89		
26.5		0.150	11		
19.0		0.075	4		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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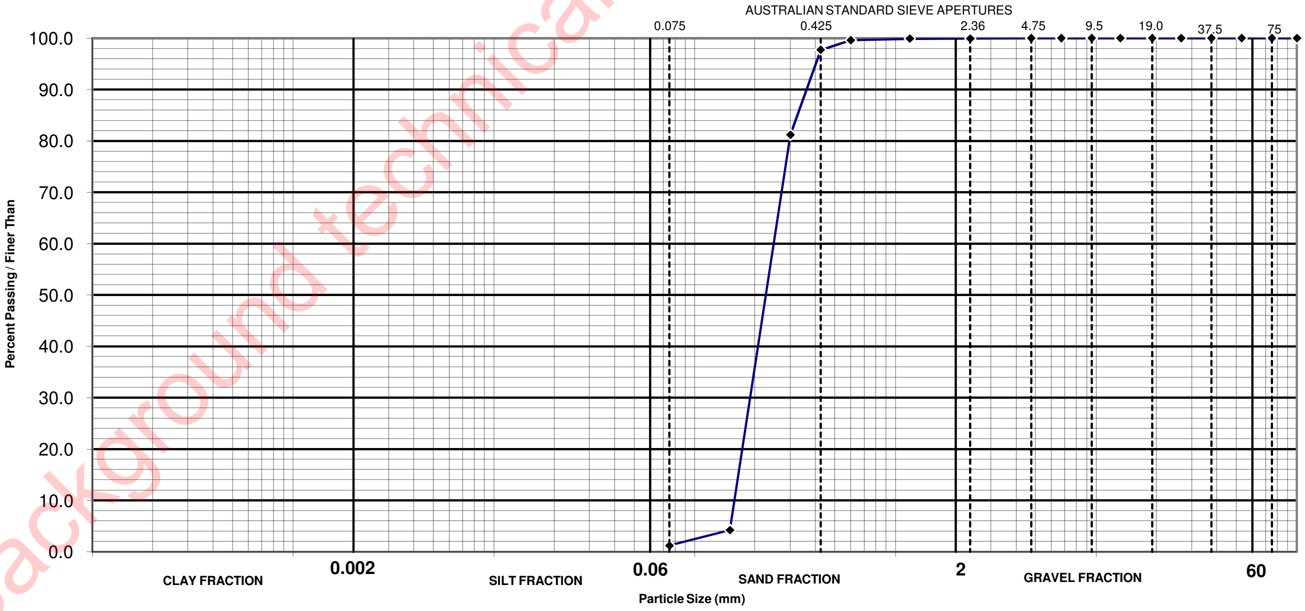
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12799Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12799**		
Sample Identification:	**BH9: 2.0-2.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**9/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	98		
37.5		0.300	81		
26.5		0.150	4		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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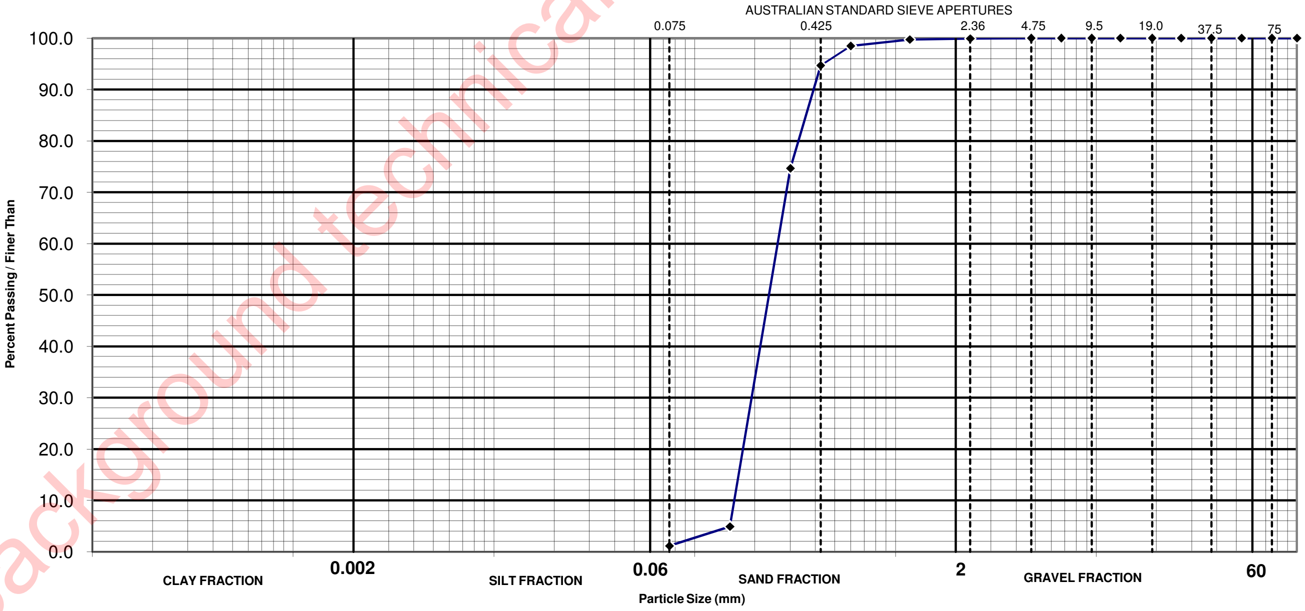
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12802Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12802**		
Sample Identification:	**BH10: 0.5-1.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**9/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	98		
53		0.425	95		
37.5		0.300	75		
26.5		0.150	5		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

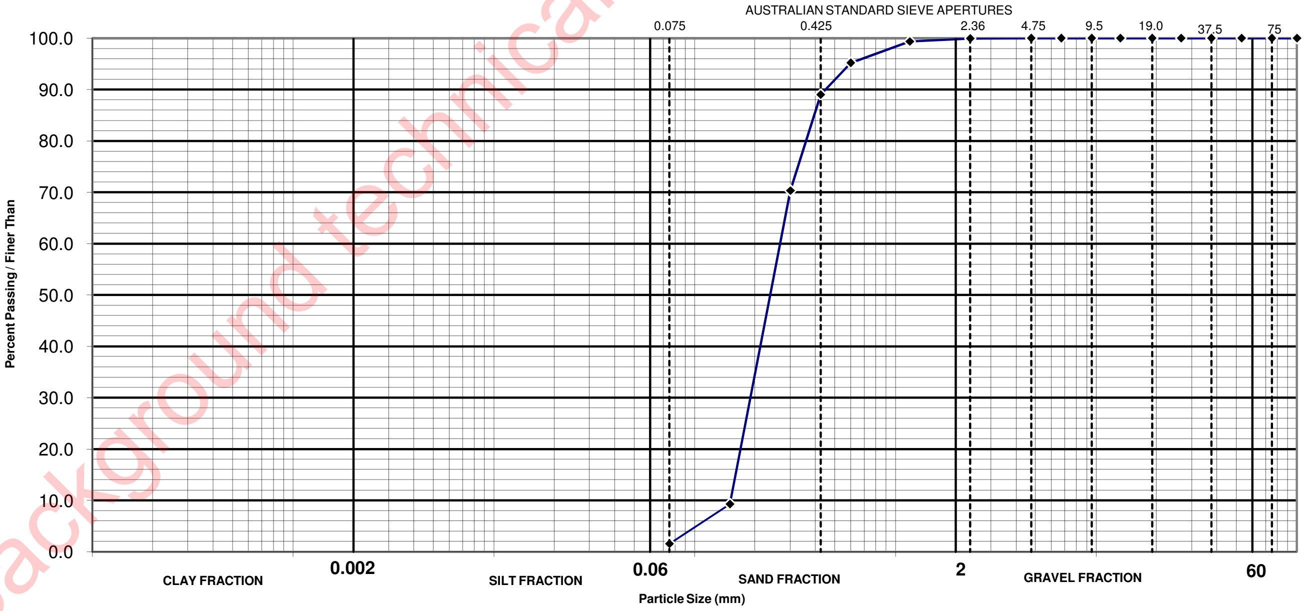
Sample Number: **3747/S/12807**
Sample Identification: **BH11: 0.0-0.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12807Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	99		
75		0.600	95		
53		0.425	89		
37.5		0.300	70		
26.5		0.150	9		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

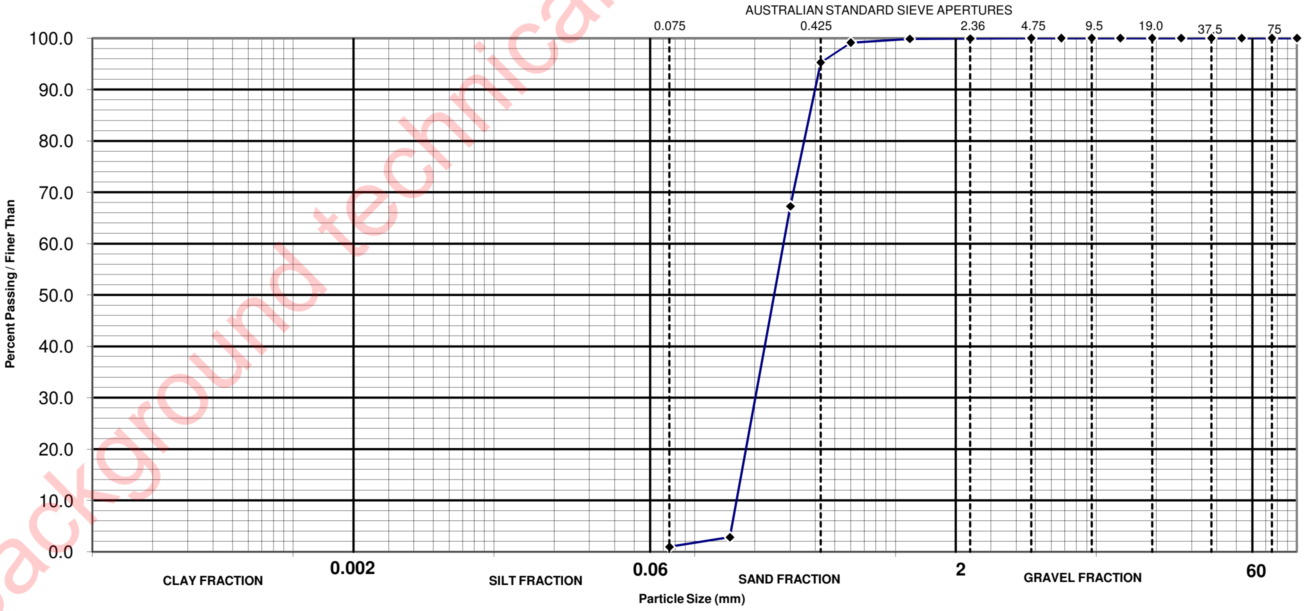
Sample Number: **3747/S/12815**
Sample Identification: **BH12: 1.0-1.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12815Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	95		
37.5		0.300	67		
26.5		0.150	3		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

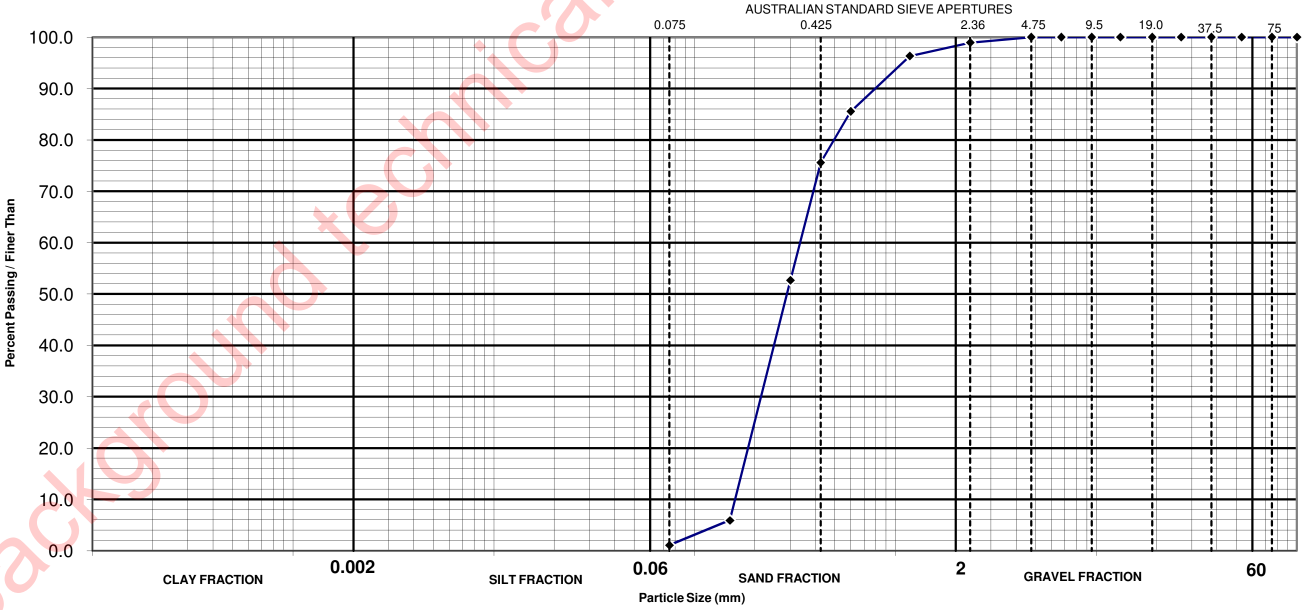
Sample Number: **3747/S/12819**
Sample Identification: **BH13: 0.0-0.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12819Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	96		
75		0.600	86		
53		0.425	76		
37.5		0.300	53		
26.5		0.150	6		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



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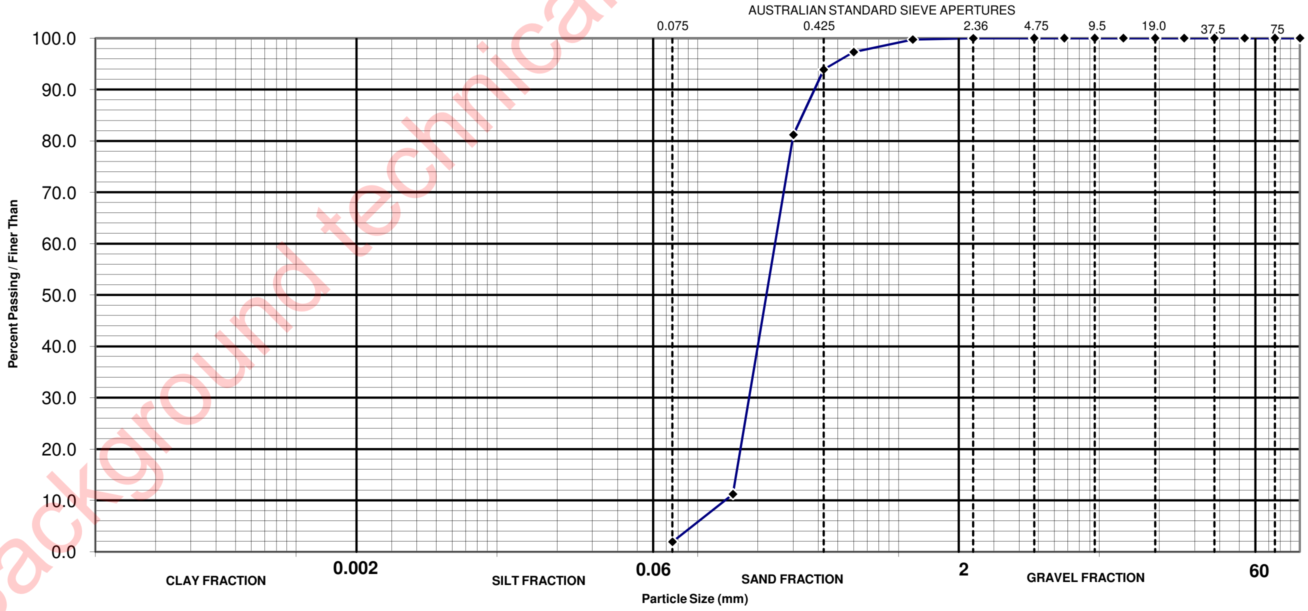
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/13808Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/13808**		
Sample Identification:	**BH14: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**9/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	97		
53		0.425	94		
37.5		0.300	81		
26.5		0.150	11		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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REP HYD-2

Cardno Bowler
Shaping the Future

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Cardno Bowler Offices:
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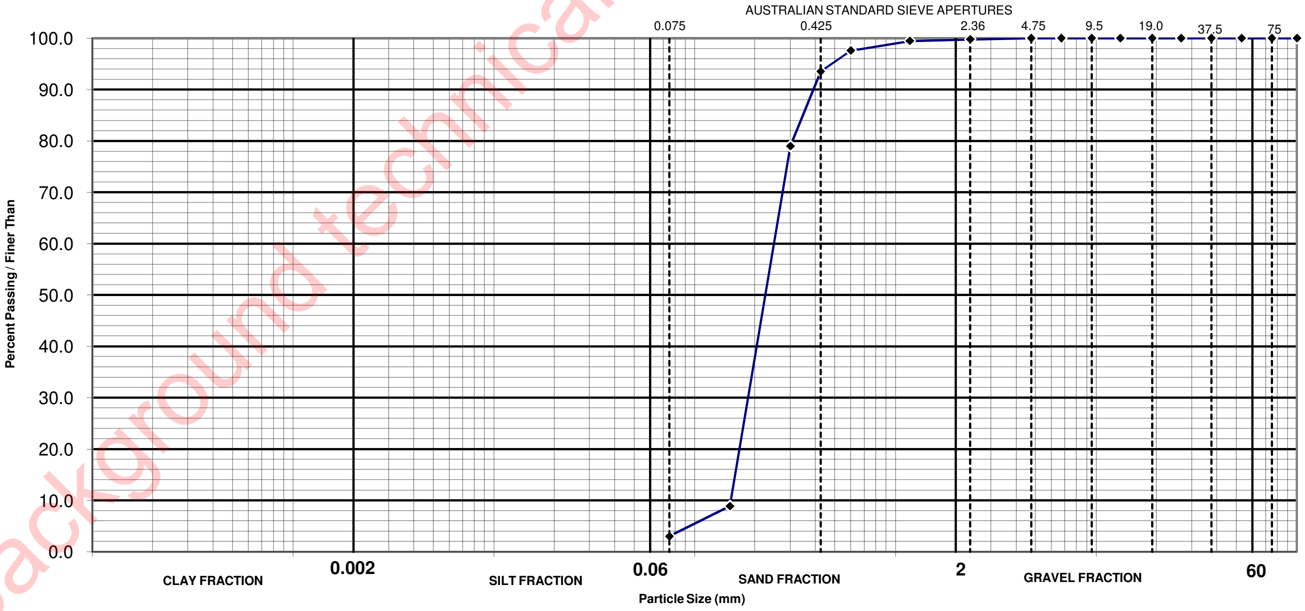
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12826Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12826**		
Sample Identification:	**BH15: 0.5-1.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	99		
75		0.600	98		
53		0.425	94		
37.5		0.300	79		
26.5		0.150	9		
19.0		0.075	3		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Maroochy River Sediment Investigation**

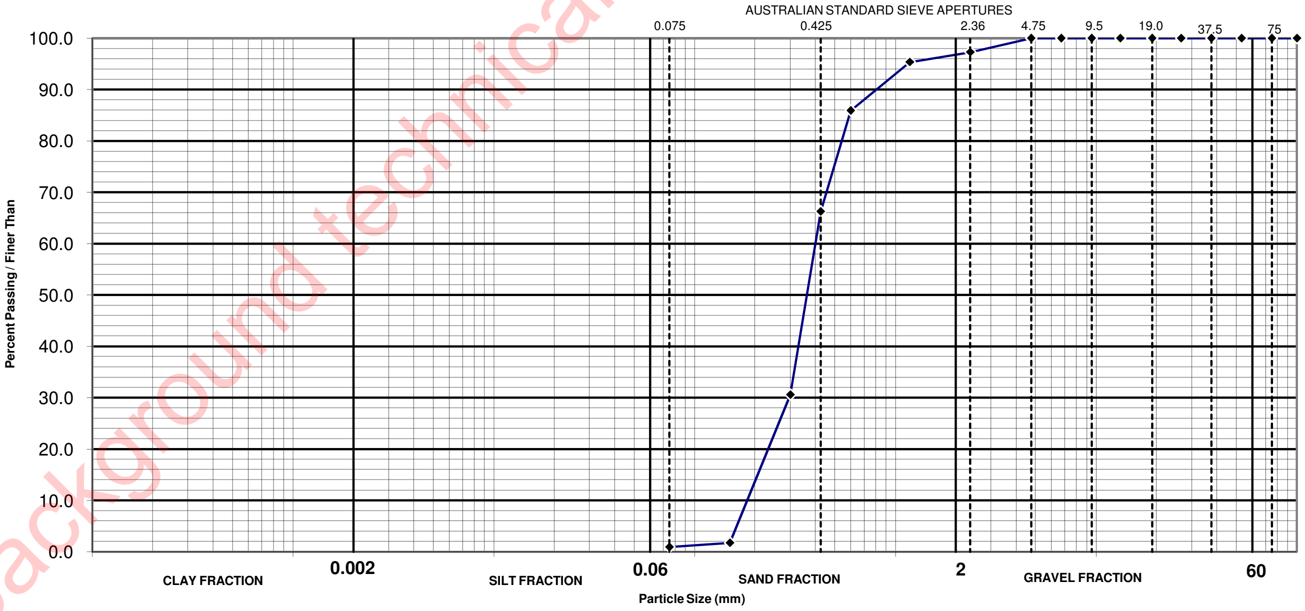
Sample Number: **3747/S/12831**
Sample Identification: **BH16: 0.0-0.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12831Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	95		
75		0.600	86		
53		0.425	66		
37.5		0.300	31		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	97				

PARTICLE SIZE DISTRIBUTION



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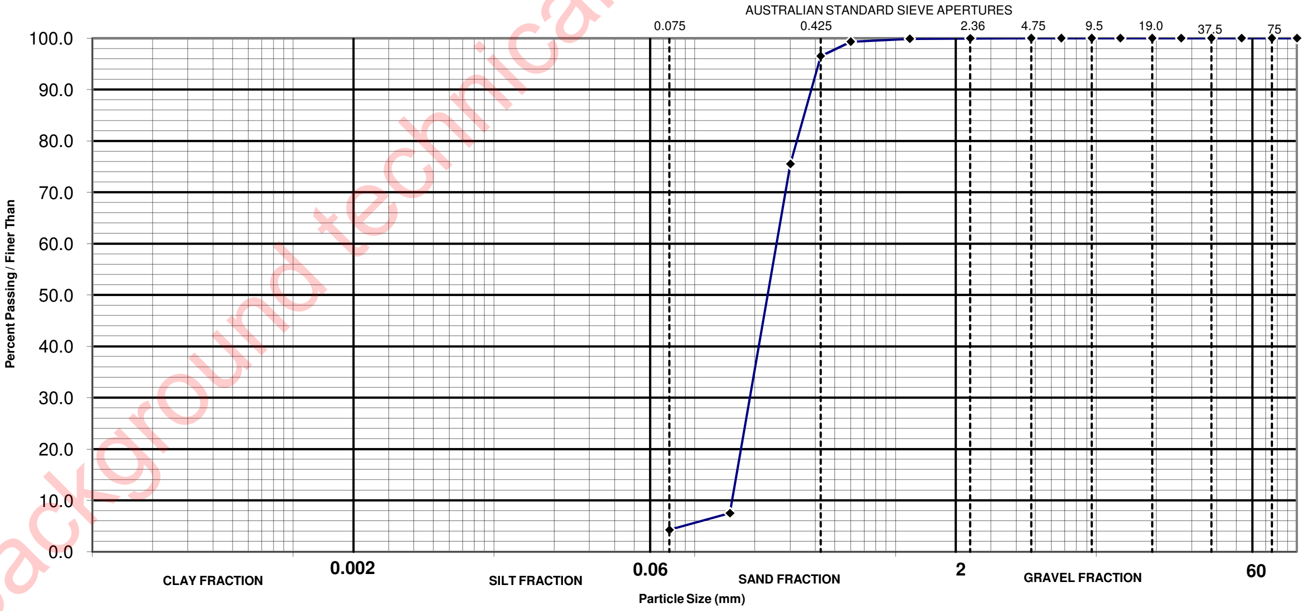
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12841Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12841**		
Sample Identification:	**BH17: 2.0-2.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	96		
37.5		0.300	76		
26.5		0.150	8		
19.0		0.075	4		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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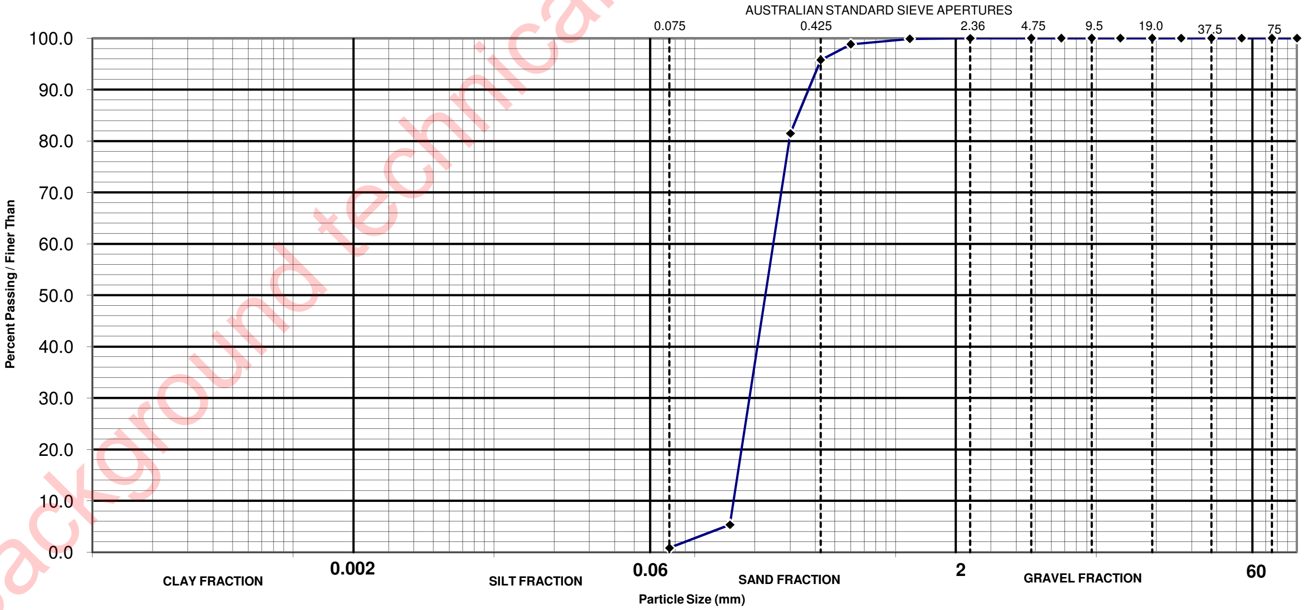
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12843Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12843**		
Sample Identification:	**BH18: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	Dispersion Method:	**mechanical**
		Hydrometer Type:	**grams/Litre**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	96		
37.5		0.300	81		
26.5		0.150	5		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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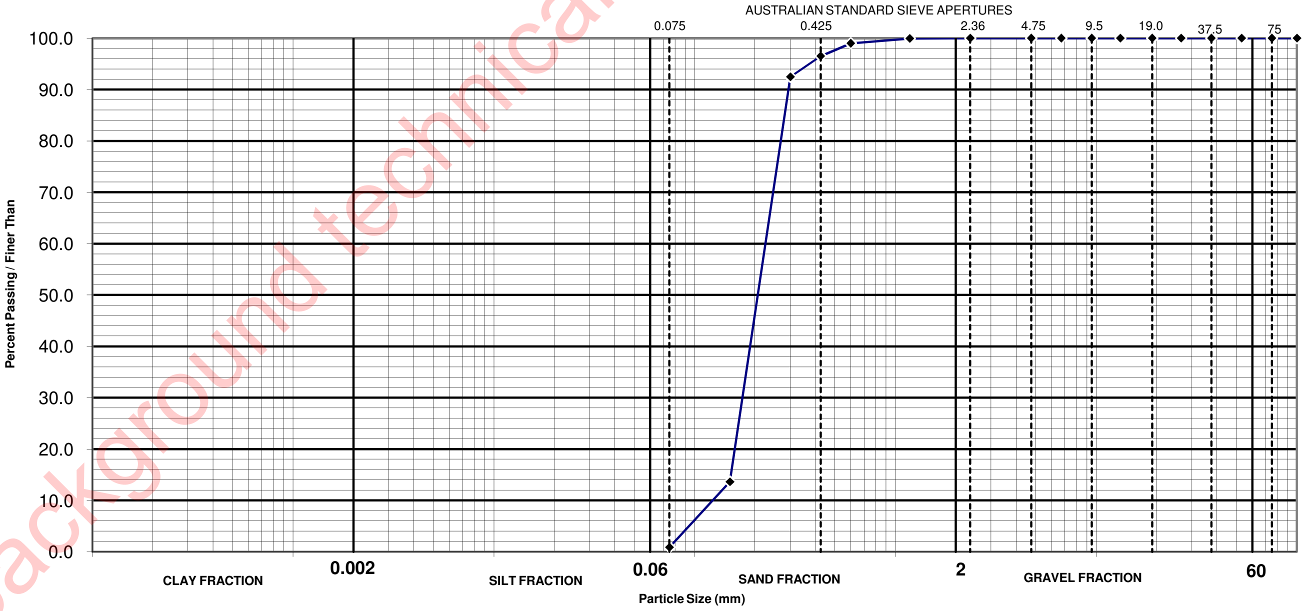
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12857Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12857**		
Sample Identification:	**BH19: 1.0-1.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	97		
37.5		0.300	92		
26.5		0.150	14		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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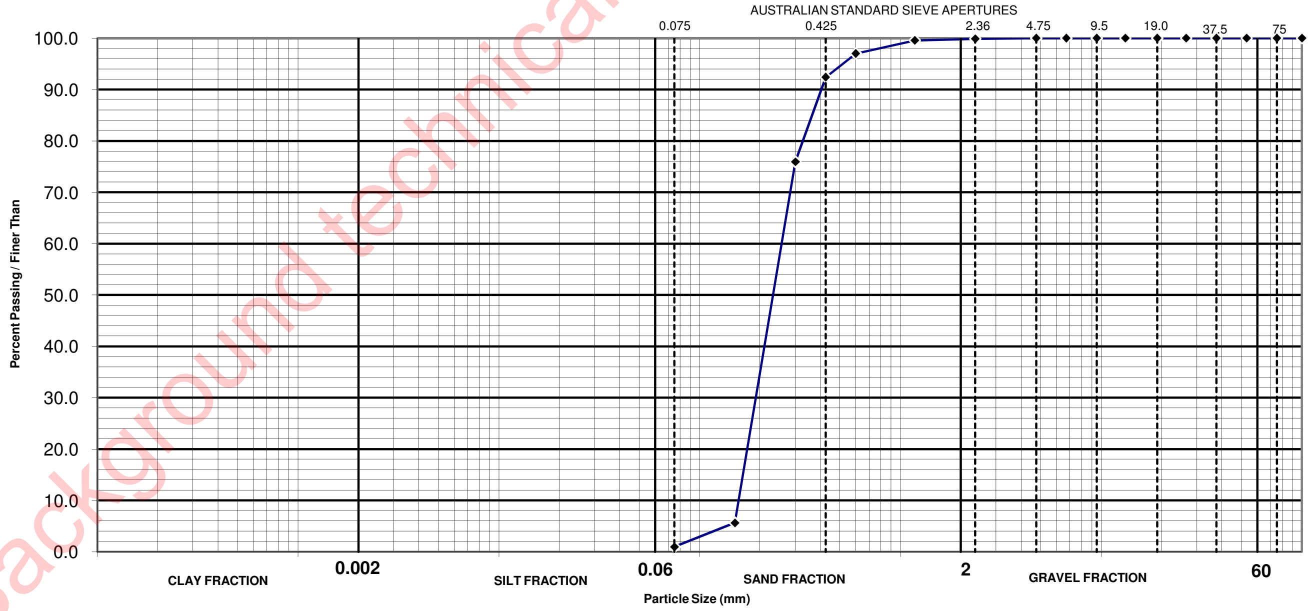
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12866Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12866**		
Sample Identification:	**BH20: 2.5-3.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**9/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	97		
53		0.425	92		
37.5		0.300	76		
26.5		0.150	6		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Annex E – Acid Sulfate Soils Test Results

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Shaping the Future

CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12819CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Maroochy River Sediment Investigation
Job no. 3747/P/137
Sampled by: Cardno Bowler (Sunshine Coast)
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 28/11/2011
Date Reported: 28/11/2011

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) [a]	(% S)	(% S)	(%$CaCO_3$) [#]	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	1	0.001	0.1
3747/S/12819	BH13 0.0-0.5	9.8	0	0.000	0.008	<0.02	nr	2.11	-876	-1.404	No Liming Required
3747/S/12820	BH13 0.5-1.0	9.7	0	0.000	<0.007	0.020	nr	1.62	-661	-1.060	No Liming Required
3747/S/13808	BH14 0.0-0.5	9.8	0	0.000	<0.007	<0.02	nr	1.52	-632	-1.013	No Liming Required
3747/S/13810	BH14 1.0-1.5	9.8	0	0.000	<0.007	<0.02	nr	1.57	-654	-1.049	No Liming Required
3747/S/12826	BH15 0.5-0.1	9.6	0	0.000	<0.007	<0.02	nr	1.22	-506	-0.812	No Liming Required
3747/S/12828	BH15 1.5-2.0	9.6	0	0.000	<0.007	<0.02	nr	1.78	-741	-1.187	No Liming Required
3747/S/12831	BH16 0.0-0.5	9.7	0	0.000	<0.007	<0.02	nr	1.13	-472	-0.756	No Liming Required
3747/S/12833	BH16 1.0-1.5	9.5	0	0.000	<0.007	<0.02	nr	1.06	-439	-0.704	No Liming Required
3747/S/12840	BH17 1.5-2.0	9.7	0	0.000	<0.007	<0.02	nr	1.17	-487	-0.780	No Liming Required
3747/S/12841	BH17 2.0-2.5	9.6	0	0.000	<0.007	0.022	nr	1.42	-576	-0.923	No Liming Required
3747/S/12843	BH18 0.0-0.5	9.7	0	0.000	<0.007	<0.02	nr	1.26	-523	-0.838	No Liming Required
3747/S/12845	BH18 1.0-1.5	9.8	0	0.000	<0.007	<0.02	nr	1.41	-587	-0.941	No Liming Required
3747/S/12857	BH19 1.0-1.5	9.7	0	0.000	<0.007	<0.02	nr	1.20	-498	-0.799	No Liming Required
3747/S/12858	BH19 1.5-2.0	9.7	0	0.000	<0.007	<0.02	nr	1.57	-652	-1.045	No Liming Required
3747/S/12861	BH20 0.0-0.5	9.8	0	0.000	<0.007	<0.02	nr	1.66	-688	-1.104	No Liming Required
3747/S/12866	BH20 2.5-3.0	9.7	0	0.000	<0.007	<0.02	nr	1.09	-453	-0.726	No Liming Required
Blank		5.6	2.5	0.004							

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
[#] if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
[a] S_{KCl} determined as sulfate by turbidimetric method.
Where liming is specified, lime should be fine grained agricultural lime of at least 90% purity.
Any liming rate provided is a recommended rate only, and is based on the total of TAA Equivalent % Oxidisable Sulphur plus Potential Acidity (S_{Cr}) plus Retained Acidity (S_{NAS}) minus effective ANC; with a factor of safety of 1.5.
Any recommended liming rate is based on the 0.03%S action criteria.
A placed dry density of 1.7 tonnes/cubic metre has been used in calculating liming rate/s.
The recommended liming rate is derived from a mathematical equation and will need to be field validated.
Cardno Bowler Pty Ltd accepts no responsibility for any loss associated with use of the calculated liming rate/s.

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CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12753CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Maroochy River Sediment Investigation
Job no. 3747/P/137
Sampled by: Cardno Bowler (Sunshine Coast)
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 28/11/2011
Date Reported: 28/11/2011

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) [a]	(% S)	(% S)	(%$CaCO_3$) [#]	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	1	0.001	0.1
3747/S/12753	BH1 0.0-0.5	9.1	0	0.000	<0.007	<0.02	nr	0.65	-269	-0.431	No Liming Required
3747/S/12757	BH1 2.5-2.5	7.3	0	0.000	<0.007	0.021	nr	0.52	-202	-0.323	No Liming Required
3747/S/12760	BH2 0.5-1.0	8.3	0	0.000	<0.007	<0.02	nr	0.57	-237	-0.381	No Liming Required
3747/S/12761	BH2 1.0-1.5	8.6	0	0.000	<0.007	0.030	nr	0.68	-265	-0.426	No Liming Required
3747/S/12765	BH3 0.0-0.5	8.7	0	0.000	<0.007	0.022	nr	0.50	-195	-0.313	No Liming Required
3747/S/12767	BH3 1.0-1.5	8.1	0	0.000	<0.007	0.041	nr	0.51	-186	-0.299	No Liming Required
3747/S/12772	BH4 0.5-1.0	8.9	0	0.000	0.020	0.032	nr	0.46	-170	-0.272	No Liming Required
3747/S/12776	BH4 2.5-3.0	9.0	0	0.000	<0.007	0.041	nr	0.63	-235	-0.377	No Liming Required
3747/S/12777	BH5 0.0-0.5	9.3	0	0.000	<0.007	<0.02	nr	0.61	-254	-0.407	No Liming Required
3747/S/12780	BH5 1.5-2.0	9.2	0	0.000	<0.007	0.037	nr	0.62	-233	-0.373	No Liming Required
3747/S/12783	BH6 0.0-0.5	9.4	0	0.000	<0.007	<0.02	nr	0.69	-286	-0.459	No Liming Required
3747/S/12784	BH6 0.5-1.0	9.3	0	0.000	<0.007	<0.02	nr	0.66	-273	-0.438	No Liming Required
3747/S/12869	BH7 1.0-1.5	9.1	0	0.000	<0.007	0.023	nr	0.63	-247	-0.396	No Liming Required
3747/S/12870	BH7 1.5-2.0	9.0	0	0.000	<0.007	0.033	nr	0.57	-216	-0.346	No Liming Required
3747/S/12789	BH8 0.0-0.5	9.3	0	0.000	<0.007	0.030	nr	0.68	-266	-0.426	No Liming Required
3747/S/12790	BH8 0.5-1.0	9.2	0	0.000	<0.007	0.033	nr	0.63	-242	-0.389	No Liming Required
3747/S/12797	BH9 1.0-1.5	9.1	0	0.000	<0.007	0.027	nr	0.59	-229	-0.368	No Liming Required
3747/S/12799	BH9 2.0-2.5	9.1	0	0.000	<0.007	0.034	nr	0.71	-275	-0.441	No Liming Required
Blank		5.8	2.0	0.003							

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
[#] if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
[a] S_{KCl} determined as sulfate by turbidimetric method.
Where liming is specified, lime should be fine grained agricultural lime of at least 90% purity.
Any liming rate provided is a recommended rate only, and is based on the total of TAA Equivalent % Oxidisable Sulphur plus Potential Acidity (S_{Cr}) plus Retained Acidity (S_{NAS}) minus effective ANC; with a factor of safety of 1.5.
Any recommended liming rate is based on the 0.03%S action criteria.
A placed dry density of 1.7 tonnes/cubic metre has been used in calculating liming rate/s.
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Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12802CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Maroochy River Sediment Investigation
Job no. 3747/P/137
Sampled by: Cardno Bowler (Sunshine Coast)
Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 28/11/2011
Date Reported: 28/11/2011
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) ^{a}	(% S)	(% S)	(%$CaCO_3$) $^\#$	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	1	0.001	0.1
3747/S/12802	BH10 0.5-1.0	9.5	0	0.000	0.010	<0.02	nr	1.04	-432	-0.693	No Liming Required
3747/S/12804	BH10 1.5-2.0	9.1	0	0.000	<0.007	0.139	nr	1.58	-570	-0.915	No Liming Required
3747/S/12807	BH11 0.0-0.5	9.7	0	0.000	0.013	<0.02	nr	1.25	-521	-0.836	No Liming Required
3747/S/12808	BH11 0.5-1.0	9.6	0	0.000	<0.007	<0.02	nr	0.95	-395	-0.634	No Liming Required
3747/S/12815	BH12 1.0-1.5	9.6	0	0.000	<0.007	<0.02	nr	1.03	-430	-0.689	No Liming Required
3747/S/12818	BH12 2.5-3.0	9.6	0	0.000	0.023	0.024	nr	1.02	-411	-0.659	No Liming Required
Blank		5.8	2.0	0.003							

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
$^\#$ if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
^{a} S_{KCl} determined as sulfate by turbidimetric method.
Where liming is specified, lime should be fine grained agricultural lime of at least 90% purity.
Any liming rate provided is a recommended rate only, and is based on the total of TAA Equivalent % Oxidisable Sulphur plus Potential Acidity (S_{Cr}) plus Retained Acidity (S_{NAS}) minus effective ANC; with a factor of safety of 1.5.
Any recommended liming rate is based on the 0.03%S action criteria.
A placed dry density of 1.7 tonnes/cubic metre has been used in calculating liming rate/s.
The recommended liming rate is derived from a mathematical equation and will need to be field validated.
Cardno Bowler Pty Ltd accepts no responsibility for any loss associated with use of the calculated liming rate/s.

IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions that any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE / The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise, *your geotechnical engineering report should not be used:*

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership, or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their report's development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent testing are extrapolated by geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed construction activity and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predications. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimise their impact.* For this reason, *most experienced owners retain their geotechnical consultants through the construction stage,* to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS

CAN CHANGE

Subsurface conditions may be modified by constantly changing natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional test are necessary.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, *give contractors ready access to the complete geotechnical engineering report* prepared or authorized for their use*. Those who do not provide such access may proceed under the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are *not* exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. Your geotechnical engineer will be pleased to give full and frank answers to your questions.

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE has developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

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* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by The Institution of Engineers Australia, National Headquarters, Canberra, 1987.

Published by

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PRACTICING IN THE GEOSCIENCES

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GENERAL NOTES

GENERAL

This report comprises the results of an investigation carried out for a specific purpose and client as defined in the document. The report should not be used by other parties or for other purposes, as it may not contain adequate or appropriate information.

TEST HOLE LOGGING

The information on the test hole logs has been based on a visual and tactile assessment, except at the discrete locations where test information is available (field and/or laboratory results).

GROUNDWATER

Unless otherwise indicated, the water levels given on the test hole logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater level may differ from this recorded level, depending on material permeabilities. Further variations of this level could occur with time due to such effects as seasonal and tidal fluctuations or construction activities. Final confirmation of levels can only be made by appropriate instrumentation techniques and programmes.

INTERPRETATION OF RESULTS

The discussion/recommendations contained in this report are normally based on site evaluation from discrete test hole data. Generalised or idealised subsurface conditions (including any cross-sections contained in this report) have been assumed or prepared by interpolation/extrapolation of these data. As such, these conditions are an interpretation, and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in the generalised ground conditions used for this report can occur, particularly between discreet test hole locations. Furthermore, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed in this report should be referred to this firm for appropriate assessment and comment.

FOUNDATION DEPTH

Where referred to in the report, the recommended depth of any foundation (piles, caissons, footings, etc) is an engineering estimate of the depth to which they should be constructed. The estimate is influenced and perhaps limited by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The depth remains, however, an *estimate* and is therefore liable to variations to the final depth depending on the ground conditions at each point of support.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in this report for the inclusion in the contract documents or engineering specification of the subject development, such reproduction should include at least all of the relevant trial hole and test data, together with the appropriate standard description sheets and remarks made in the written report of a factual or descriptive nature.

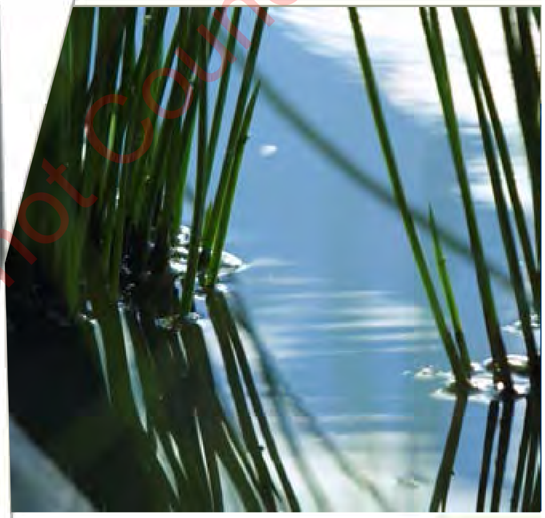
This report is the subject of copyright, and shall not be reproduced either totally or in part without the express permission of this firm.

Appendix E Maroochy River Sediment Investigation Report (Cardno Bowler, 2015)

Sediment Investigation

Maroochy River

3740/P/742



Prepared for
Sunshine Coast Council

4 June 2015

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Version	Effective Date	Description of Revision	Prepared by:	Reviewed by:
1.0		Release to Client	Paul Mayes	Dan Courtney

Executive Summary

Cardno Construction Sciences Pty Ltd was engaged by Sunshine Coast Regional Council to undertake an investigation of the sediment in sections of the lower reaches of the Maroochy River for the purposes of supporting an application to dredge these areas for the purposes of beach nourishment.

A program of fieldwork and laboratory testing was designed and implemented with the aim of describing the nature of the sediments present within the proposed dredge areas and to assess the extent and severity of the Acid Sulfate Soils at select sites. These data could then be used to target dredging operations to areas likely to produce the best resource for the beach nourishment program.

A total of ten (10) boreholes were advanced during the investigation, with representative samples selected for particle size distribution. Subsurface strata at the site were dominated by fine to medium grained sand with very low, levels of silt and clay. The results of the analytical Acid Sulfate Solis laboratory testing on the samples collected do not support the presence of Acid Sulfate Soils within the material tested. Hence, no liming rates are defined within this report.

Glossary

Acid Sulfate Soil (ASS): Soil or sediment containing highly acidic soil horizons or layers affected by the oxidation of iron sulfides (actual ASS) and/or sediment containing iron sulfides or other sulfidic material that has not been exposed to air and oxidised (potential ASS). The term Acid Sulfate Soils generally includes both actual and potential Acid Sulfate Soils.

Agricultural Lime: A neutralising agent commonly used to treat acidic soils.

AHD (Australian Height Datum): The datum used for the determination of elevations in Australia.

Borehole: The actual hole created when an auger or push-tube is inserted into the soil body.

BSL (Below Surface Level): The depth as measured from the existing site surface level, generally recorded in metres.

Clay: Cohesive Soil with a particle size less than 0.02mm.

Groundwater: Subsurface water in the zone of saturation, including water below the water table and water occupying cavities, pores and openings in underlying soil and rock.

Leachate: The soil constituent that is washed out from a mixture of soil solids.

Oxidised: Process of chemical change involving the addition of oxygen following exposure to air.

Piezometer: A pipe of small diameter installed in a borehole that is used to measure the height (elevation) of the water table.

Pyrite: Pale bronze or pale yellow, isometric mineral: FeS_2 ; the most widespread and abundant of the sulfide minerals.

pH_F: The pH of the soil in soil/distilled water paste.

pH_{FOX}: The pH of the soil after the addition of a small quantity of Hydrogen Peroxide.

%S: Percentage oxidisable sulfur.

Sand: Non-cohesive soil with a particle size between 2.36mm and 0.075mm.

Silt: Non-cohesive soil with a particle size between 0.075mm and 0.02mm.

Soil and Sediment: The natural accumulation of unconsolidated mineral particles (derived from weathered rocks) and organic matter that covers much of the earth's surface.

Water table: Portion of the ground saturated with water, often used specifically to refer to the upper limit of the saturated ground.

Table of Contents

1 Introduction 1

2 Site Description 3

3 Methodology 4

3.1 Fieldwork 4

3.2 Laboratory Testing 4

3.2.1 Particle Size Distribution 4

3.2.2 Acid Sulfate Soils 4

4 Results and Discussion 5

4.1 Subsurface Conditions 5

4.2 Analytical Laboratory Analysis 5

Appendices

Appendix A Sampling locations

Appendix B borehole logs

Appendix C test certificates

Figures

Figure 2-1 Locality Plan 3

1 Introduction

The following report details the results of the Sediment Investigation performed within the lower reaches of the Maroochy River in South East Queensland. It is understood that the works proposed for the site are to include the dredging of suitable sand resources from within the river mouth for the purposes of beach nourishment in the local area. Specific areas within the river mouth were identified by council as potential dredging zones and this investigation concentrates on these areas and the assessment of the insitu sediments with respect to their potential use in beach nourishment programs. The scope of work covered in this investigation included the following:

- General description of the sediment profile at selected locations within the four specified zones;
- Particle size distribution testing of representative samples from each of the zones;
- Acid Sulfate Soils testing of representative samples from each of the zones; and

The nature of the sediments present within the four selected areas will be integral to the ultimate selection of the material to be dredged for two reasons:

- non-cohesive soils (ie sands) are logistically more suitable for dredging, and
- lightly coloured clean sands will be more suitable for use in beach nourishment programs.

The Acid Sulfate Soils conditions within the areas proposed to be dredged may also be incorporated into the decision making process regarding which areas are most suitable to be used for the beach nourishment program. Acid Sulfate Soils are common in low-lying coastal areas of Queensland, especially in areas below 5.0 metres AHD. Such areas are often characterised by the presence of estuaries, swamps, floodplains, salt marshes and mangroves. The affected soils are characterised by iron sulfides, most frequently pyrite, and when these soils are maintained in anaerobic conditions these iron sulfides are unable to oxidise and therefore the Acid Sulfate Soils are stable. However, if a disturbance exposes the Acid Sulfate Soils to air, the iron sulfides can oxidise and form sulphuric acid, resulting in the soil becoming strongly acidic. This acidity has the potential to mobilise metals such as Iron, Aluminium and Manganese which are naturally present in the soil, thereby producing a leachate contaminated by both high levels of acidity and metals. Such leachate, if released into the environment, can have significant adverse effects including; degradation of the water quality in receiving areas, fish disease/kills, reduced crop productivity, corrosion of structures and health related issues. In view of these potential effects, it is critical that any development that occurs within an area likely to contain Acid Sulfate Soils is planned, managed and monitored appropriately so as to minimise or remove the risk of adverse environmental outcomes.

In response to the potential for such adverse outcomes to occur as a result of the disturbance of Acid Sulfate Soils, the Department of State Development, Infrastructure and Planning have developed the “State Planning Policy-state interest guideline Water Quality August 2014”. This policy recommends that local planning schemes make the following developments assessable against the ASS overlay code.

1. Works (not associated with a material change of use) on land below 5 metres AHD, where such works involve either:

- excavating or otherwise removing 100 metres^3 or more of soil or sediment, or
- filling of land involving 500 metres^3 or more of material with an average depth of 0.5 metres or greater.

2. Works (not associated with a material change of use) on land between 5 metres and 20 metres AHD where such works involve excavating or otherwise removing 100m^3 or more of soil or sediment at or below 5 metres AHD.

3. Material changes of use on land within the overlay area where any associated works as described by 1 and 2 above are a component of the use.

The purpose of the code is to ensure that activities with the potential to disturb ASS are undertaken so that disturbance of ASS is avoided, or where unavoidable, the generation or release of acid and metal contaminants from disturbed ASS do not have adverse impacts on the natural and built environment or human health.

As the entire site has an existing surface level below AHD 5.0m any disturbance of soil or sediment within this area must consider the consequences of Acid Sulfate Soils when assessing the overall project risk. The preferred mechanism to circumvent potential adverse environmental outcomes concerning Acid Sulfate Soils is avoidance, that is, where possible, areas identified to contain Acid Sulfate Soils should not be disturbed. Given the goals of the project, soil disturbance will be essential and as such information regarding the extent and severity of the Acid Sulfate Soils within the target dredging areas is essential to the planning and execution of the project.

It should be noted that this report is not intended to be, nor should it be attempted to be used as, a fully compliant Acid Sulfate Soils investigation of the site to support a specific proposed soil disturbance. Rather, this investigation is intended to provide general information regarding the sediments present at the site with the goal of informing the decision making process regarding the overall beach nourishment project. Furthermore, it is recognised that there are numerous other factors that will be incorporated into the final selection of dredging locations for this project.

2 Site Description

The target zones for this investigation were located within the lower reaches of the Maroochy River, the specific sampling locations are shown in Appendix A. See Figure 2-1 below for a locality plan of the subject site.

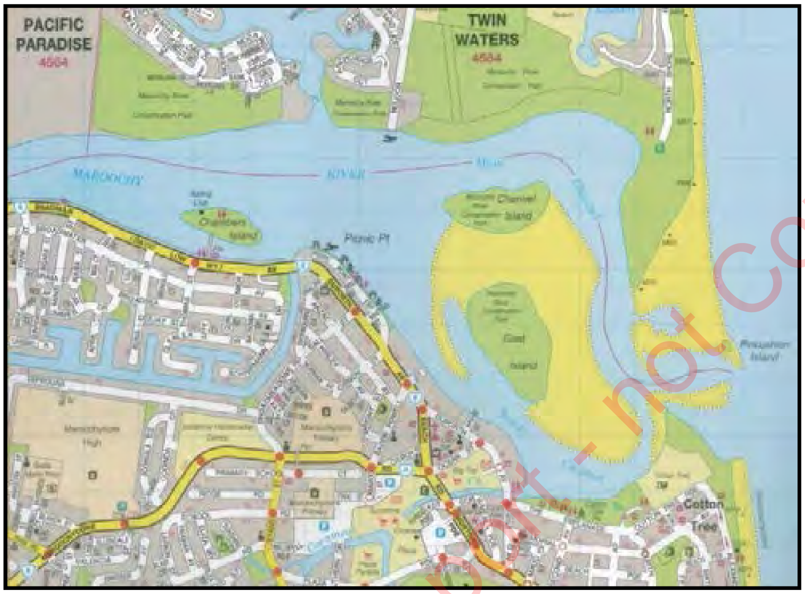

Figure 2-1 Locality Plan

The subject site was contained within the lower reaches of the Maroochy River and is heavily influenced by tidal flows. Water depths at the sampling locations were significantly influenced by tidal movements, with some areas completely exposed at low tide and maximum water depths in excess of 3.0m at high tide in other areas. This area of the river is heavily utilised by recreational users for swimming, boating and fishing activities.

3 Methodology

3.1 Fieldwork

A total of ten (10) boreholes were advanced across the site. The borehole locations were agreed upon via consultation council staff and with due consideration of the limitations to sampling imposed by the nature of the site. It should also be noted that the sampling locations were marked with recreational quality GPS equipment, with an average accuracy of approximately 5m.

The boreholes were advanced using a pneumatic vibracore drilling rig mounted on an aluminium vessel. The vibracore rig collects a continuous core of the soft strata which is suitable for investigations of this nature. The target depth of the boreholes was 4.0 metres below the existing sediment surface level, the majority of boreholes achieved this target depth, all boreholes were advanced to a depth of no less than 3.0 metres below the existing surface level. Detailed geotechnical boreholes logs of the material encountered at each location are shown in Appendix B. The entire core from each location was retained and returned to our Kunda Park laboratory for the required laboratory analysis via AS1289 for particle size distribution testing and the Chromium Test Suite for Acid Sulfate Soils.

3.2 Laboratory Testing

3.2.1 Particle Size Distribution

Representative samples from specific locations and depths were selected by council for laboratory testing. The samples were tested to determine their particle size distribution via AS1289. The results of the particle size distribution testing are presented in Appendix C.

3.2.2 Acid Sulfate Soils

Representative samples at 0.5m intervals from specific locations were selected by council for laboratory Acid Sulfate Soils testing. The samples were tested analytically via the Chromium Suite of testing. The results of the Acid Sulfate Soils testing are presented in Appendix C.

4 Results and Discussion

4.1 Subsurface Conditions

Detailed logs for the boreholes advanced during this investigation are shown in Appendix B. The subsurface strata encountered at the site were dominated by poorly graded sands with very low silt contents. With clay encountered at the base of the boreholes at WP6, WP8, WP9 and WP10

4.2 Analytical Laboratory Analysis

Particle Size Distribution

The samples of material tested for particle size distribution showed a relatively consistent pattern of composition across all areas. The strata are dominated by fine to medium grained sands with generally low silt contents. Particles larger than 2.36mm were rare and the majority of material sampled would be best described as fine grained sand. The proportion of material smaller than 0.075mm in the samples tested was also very small, generally not exceeding 5% by mass. These extremely low proportions of material passing the 0.075mm sieve negated the need to undertake additional testing on the silt and clay fractions. The AS1289 method specifically excludes samples which have less than 10% passing 0.075mm from the hydrometer based portion of the test method.

Acid Sulfate Soils

The results of the analytical laboratory analysis (see Appendix C) showed that none of the samples tested had a net acidity value in excess of the 0.03% oxidisable sulfur threshold. This is due to a combination of the presence of intrinsic acid neutralising capacity (ANC) and a lack of potential acidity within the samples tested. These results do not confirm the presence of Acid Sulfate Soils within the samples tested during this investigation, as such no further treatment of the materials tested would be required.

APPENDIX

A

SAMPLING LOCATIONS


WP38
WP37
WP5
WP36
WP10
WP6
WP7
WP9
WP8
WP39

Maroochy River

APPENDIX

B

BOREHOLE LOGS

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Laboratory: **Sunshine Coast Laboratory**
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Client: Sunshine Coast Council
Project: Maroochy River Sediment Investigation
Driller: PG
Logged By: Paul Mayes
Drilling Commenced: 04/05/2015
Drilling Completed: 04/05/2015
Rig Type: Vibracore
Date Logged: 05/05/2015
Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°
Borehole Number: WP5
Lab Reference: 3740/S/42811
Location: WP5
S26.649916 E153.09828

Depth (m)	RL	DCP	Auger 'V' Bit Auger 'TC' Bit Washbore Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine to coarse grained, brown
0.5								
1.0								
1.5							SP	SAND, fine to coarse grained, grey
2.0								
2.5								
3.0								
3.5								
4.0								Borehole Terminated at 4.00m.

See Standard Sheets for details of abbreviations & basis of descriptions

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BOREHOLE LOG SHEET

Client: Sunshine Coast Council
Project: Maroochy River Sediment Investigation
Driller: PG
Logged By: Paul Mayes
Drilling Commenced: 04/05/2015
Drilling Completed: 04/05/2015
Rig Type: Geoprobe
Date Logged: 05/05/2015
Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°
Borehole Number: WP6
Lab Reference: 3740/S/42812
Location: WP6
S26.651337 E153.098393

Depth (m)	RL	DCP	Auger 'V' Bit Auger 'TC' Bit Washbore Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0						⠿	SP	SAND, fine to medium grained, grey to dark grey
0.5								
1.0								
1.5								
2.0								
2.5								
						▨	CH	SILTY CLAY, high plasticity, very dark grey
3.0								
								Borehole Terminated at 3.40m.
3.5								
4.0								

See Standard Sheets for details of abbreviations & basis of descriptions

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Laboratory: **Sunshine Coast Laboratory**
Phone: 07 5452 0100
Fax: 07 5452 0133

BOREHOLE LOG SHEET

Client: Sunshine Coast Council
Project: Maroochy River Sediment Investigation
Driller: PG
Logged By: Paul Mayes
Drilling Commenced: 04/05/2015
Drilling Completed: 04/05/2015
Rig Type: Vibracore
Date Logged: 05/05/2015
Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°
Borehole Number: WP7
Lab Reference: 3740/S/42813
Location: WP7
S26.651503 E153.098537

Depth (m)	RL	DCP	Auger 'V' Bit Auger 'TC' Bit Washbore Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0						▨	SP	SAND, fine to medium grained, brown and dark grey
0.5								
1.0						▨	SP	SAND, fine to medium grained, brown
1.5						▨	SP	SAND, fine to medium grained, brown and dark grey
2.0						▨	SP	SAND, fine to medium grained, grey to dark grey
2.5								
3.0								
3.5								

See Standard Sheets for details of abbreviations & basis of descriptions

Borehole Terminated at 3.90m.

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BOREHOLE LOG SHEET

Page 1 of 1

Client: Sunshine Coast Council	Drilling Commenced: 04/05/2015	Relative Level: -	**Borehole Number: WP8**
Project: Maroochy River Sediment Investigation	Drilling Completed: 04/05/2015	Groundwater: -	Lab Reference: 3740/S/42814
	Rig Type: Vibracore	Casing Diameter: -	Location: WP8
Driller: PG Logged By: Paul Mayes	Date Logged: 05/05/2015	Angle From Horizontal: 90.0°	S26.651833 E153.098431

Depth (m)	RL	DCP	Auger 'V' Bit Auger 'TC' Bit Washbore Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0						░	SP	SAND, fine to medium grained, grey
0.5								
1.0								
1.5								
2.0								
2.5						░	SP	SAND, fine to medium grained, dark grey
3.0								
						▨	CH	SILTY CLAY, high plasticity, very dark grey
3.5								
4.0								

See Standard Sheets for details of abbreviations & basis of descriptions

Borehole Terminated at 4.00m.

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ABN: 74 128 806 735
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Laboratory: **Sunshine Coast Laboratory**
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Fax: 07 5452 0133

BOREHOLE LOG SHEET

Client: Sunshine Coast Council
Project: Maroochy River Sediment Investigation
Driller: PG
Logged By: Paul Mayes

Drilling Commenced: 04/05/2015
Drilling Completed: 04/05/2015
Rig Type: Vibracore
Date Logged: 05/05/2015

Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°

Borehole Number: WP9
Lab Reference: 3740/S/42815
Location: WP9
S26.651689 E153.098208

Depth (m)	RL	DCP	Auger 'V' Bit Auger 'TC' Bit Washbore Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0						░	SP	SAND, fine to medium grained, grey
2.5						░	SP	SAND, fine to medium grained, dark grey to very dark grey
3.0						▨	CH	SILTY CLAY, high plasticity, dark grey
3.5								Borehole Terminated at 3.60m.
4.0								

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BOREHOLE LOG SHEET

Page 1 of 1

Client: Sunshine Coast Council
Project: Maroochy River Sediment Investigation
Driller: PG
Logged By: Paul Mayes

Drilling Commenced: 04/05/2015
Drilling Completed: 04/05/2015
Rig Type: Vibracore
Date Logged: 05/05/2015

Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°

Borehole Number: WP10
Lab Reference: 3740/S/42816
Location: WP10
S26.650821 E153.099702

Depth (m)	RL	DCP	Auger 'V' Bit Auger 'TC' Bit Washbore Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0						⁘	SP	SAND, fine to medium grained, grey-brown
0.5						⁘		
1.0						⁘		
1.5						⁘		
2.0						⁘	SP	SAND, fine grained, dark grey
						▨	CH	SILTY CLAY, high plasticity, very dark grey
2.5						▨		
3.0								Borehole Terminated at 3.00m.
3.5								
4.0								

See Standard Sheets for details of abbreviations & basis of descriptions

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BOREHOLE LOG SHEET

Page 1 of 1

Client: Sunshine Coast Council
Project: Maroochy River Sediment Investigation
Driller: PG
Logged By: Paul Mayes
Drilling Commenced: 04/05/2015
Drilling Completed: 04/05/2015
Rig Type: Vibracore
Date Logged: 05/05/2015
Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°
Borehole Number: WP36
Lab Reference: 3740/S/42817
Location: WP36
S26.65036 E153.09880

Depth (m)	RL	DCP	Auger 'V' Bit Auger 'TC' Bit Washbore Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine grained, brown
0.5								
1.0							SP	SAND, fine to coarse grained, grey
1.5								
2.0								
2.5								
3.0								
3.5								
4.0								Borehole Terminated at 4.00m.

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BOREHOLE LOG SHEET

Client: Sunshine Coast Council
Project: Maroochy River Sediment Investigation
Driller: PG
Logged By: Paul Mayes

Drilling Commenced: 04/05/2015
Drilling Completed: 04/05/2015
Rig Type: Vibracore
Date Logged: 05/05/2015

Relative Level: -
Groundwater: -
Casing Diameter: -
Angle From Horizontal: 90.0°

Borehole Number: WP37
Lab Reference: 3740/S/42818
Location: WP37
S26.64982 E153.09845

Depth (m)	RL	DCP	Auger 'V' Bit Auger 'TC' Bit Washbore Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine grained, brown
0.5							SP	SAND, fine to coarse grained, brown
1.0								
1.5							SP	SAND, fine grained, brown
2.0								
2.5								
3.0								
3.5							SP	SAND, fine to coarse grained, grey-brown
4.0								Borehole Terminated at 4.00m.

See Standard Sheets for details of abbreviations & basis of descriptions

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BOREHOLE LOG SHEET

Page 1 of 1

Client: Sunshine Coast Council	Drilling Commenced: 04/05/2015	Relative Level: -	**Borehole Number: WP38**
Project: Maroochy River Sediment Investigation	Drilling Completed: 04/05/2015	Groundwater: -	Lab Reference: 3740/S/42819
	Rig Type: Vibracore	Casing Diameter: -	Location: WP38
Driller: PG Logged By: Paul Mayes	Date Logged: 05/05/2015	Angle From Horizontal: 90.0°	S26.64923 E153.09818

Depth (m)	RL	DCP	Auger 'V' Bit	Auger 'TC' Bit	Washbore	Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0										SP	SAND, fine grained, brown
0.5										SP	SAND, fine to coarse grained, dark grey
										SP	SAND, fine to coarse grained, grey
1.0											
1.5											
2.0											
2.5											
3.0											
3.5											
4.0											

See Standard Sheets for details of abbreviations & basis of descriptions

Borehole Terminated at 4.00m.

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BOREHOLE LOG SHEET

Client: Sunshine Coast Council	Drilling Commenced: 04/05/2015	Relative Level: -	**Borehole Number: WP39**
Project: Maroochy River Sediment Investigation	Drilling Completed: 04/05/2015	Groundwater: -	Lab Reference: 3740/S/42820
	Rig Type: Vibracore	Casing Diameter: -	Location: WP39
Driller: PG Logged By: Paul Mayes	Date Logged: 05/05/2015	Angle From Horizontal: 90.0°	S26.65285 E153.09705

Depth (m)	RL	DCP	Auger 'V' Bit Auger 'TC' Bit Washbore Casing	Groundwater	Sample or Field Test	Graphic Log	USCS Symbol	DESCRIPTION (SOIL NAME, plasticity/particle characteristics, colour, minor components, moisture, consistency, structure, ORIGIN)
0.0							SP	SAND, fine to medium grained, brown
0.5							SP	SAND, fine to medium grained, grey to dark grey
1.0								
1.5								
2.0								
2.5								
3.0								
3.5							SP	SAND, fine to medium grained, dark brown
								Borehole Terminated at 3.80m.
4.0								

See Standard Sheets for details of abbreviations & basis of descriptions

APPENDIX

C

TEST CERTIFICATES

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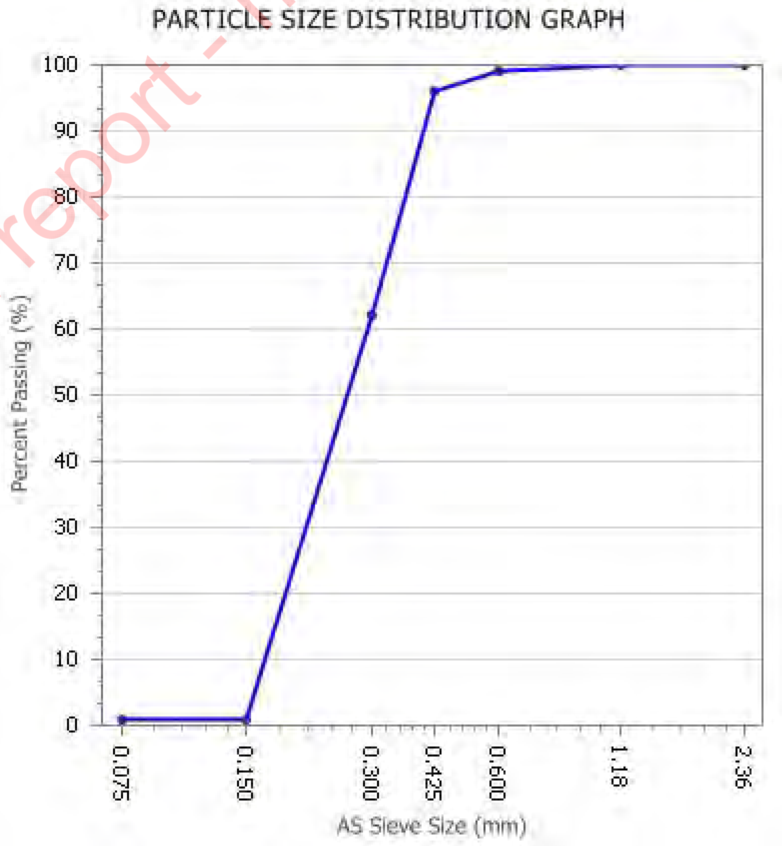
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 1 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42918	Sample Location	
Sampling Method		Location1	WP36
Date Sampled	04/05/2015 09:00	Location2	0.0-0.5
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
2.36		**100**	
1.18		**100**	
0.600		**99**	
0.425		**96**	
0.300		**62**	
0.150		**1**	
0.075		**1**	



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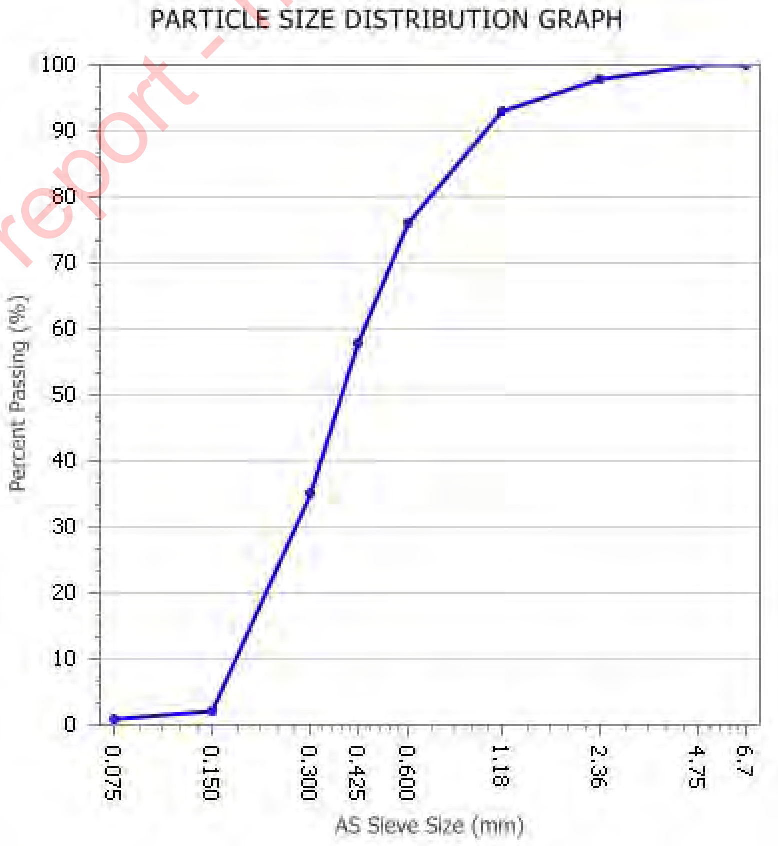
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 2 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42919		
Sampling Method		Location1	WP36
Date Sampled	04/05/2015 09:00	Location2	0.5-1.0
Sampled By	Paul Mayes	Location3	
Date Tested	13/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
6.7		**100**	
4.75		**100**	
2.36		**98**	
1.18		**93**	
0.600		**76**	
0.425		**58**	
0.300		**35**	
0.150		**2**	
0.075		**1**	



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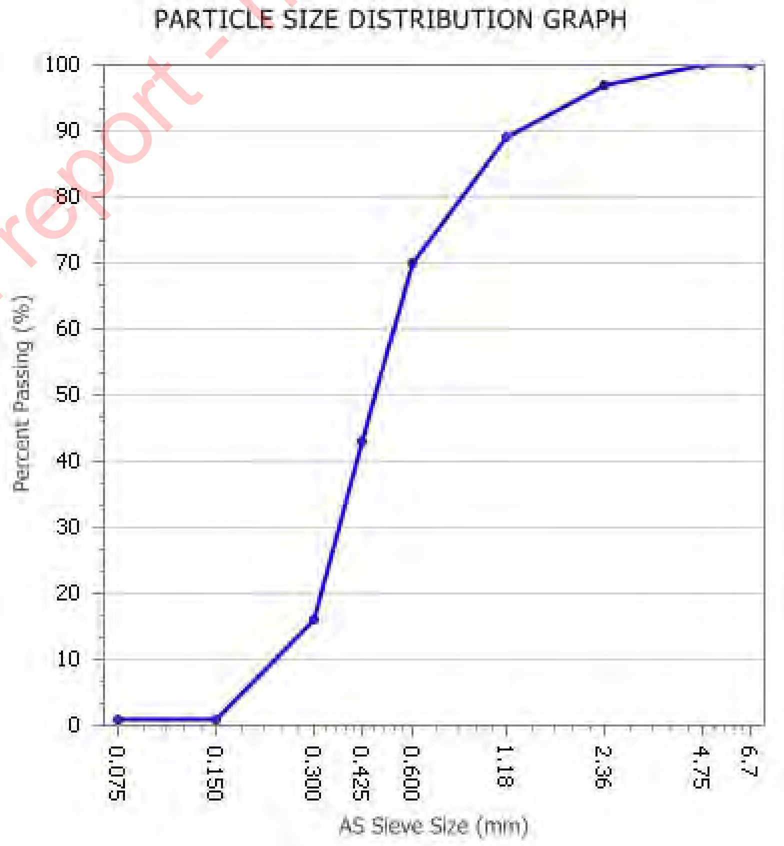
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 3 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42920	Sample Location	
Sampling Method		Location1	WP36
Date Sampled	04/05/2015 09:00	Location2	1.0-1.5
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	Percent Passing (%)	Specification Maximum
6.7		**100**	
4.75		**100**	
2.36		**97**	
1.18		**89**	
0.600		**70**	
0.425		**43**	
0.300		**16**	
0.150		**1**	
0.075		**1**	



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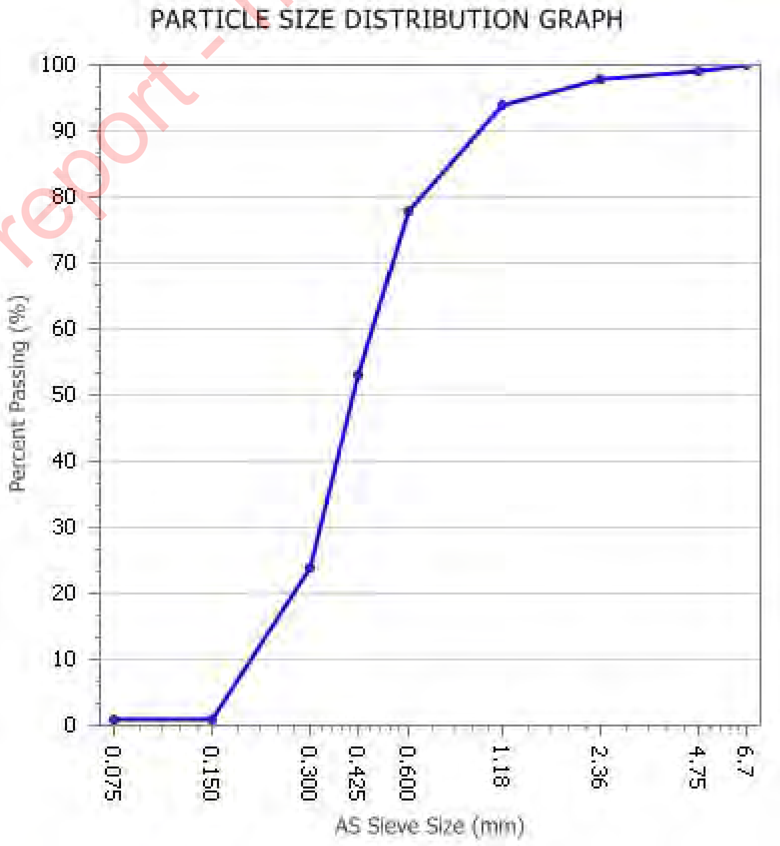
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 4 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42921		
Sampling Method		Location1	WP36
Date Sampled	04/05/2015 09:00	Location2	1.5-2.0
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
6.7		**100**	
4.75		**99**	
2.36		**98**	
1.18		**94**	
0.600		**78**	
0.425		**53**	
0.300		**24**	
0.150		**1**	
0.075		**1**	



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PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 5 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42922	Sample Location	
Sampling Method		Location1	WP36
Date Sampled	04/05/2015 09:00	Location2	2.0-2.5
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
4.75		**100**	
2.36		**98**	
1.18		**93**	
0.600		**71**	
0.425		**49**	
0.300		**25**	
0.150		**2**	
0.075		**1**	

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PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 6 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42923		
Sampling Method		Location1	WP36
Date Sampled	04/05/2015 09:00	Location2	2.5-3.0
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
4.75		**100**	
2.36		**98**	
1.18		**88**	
0.600		**67**	
0.425		**45**	
0.300		**21**	
0.150		**1**	
0.075		**1**	

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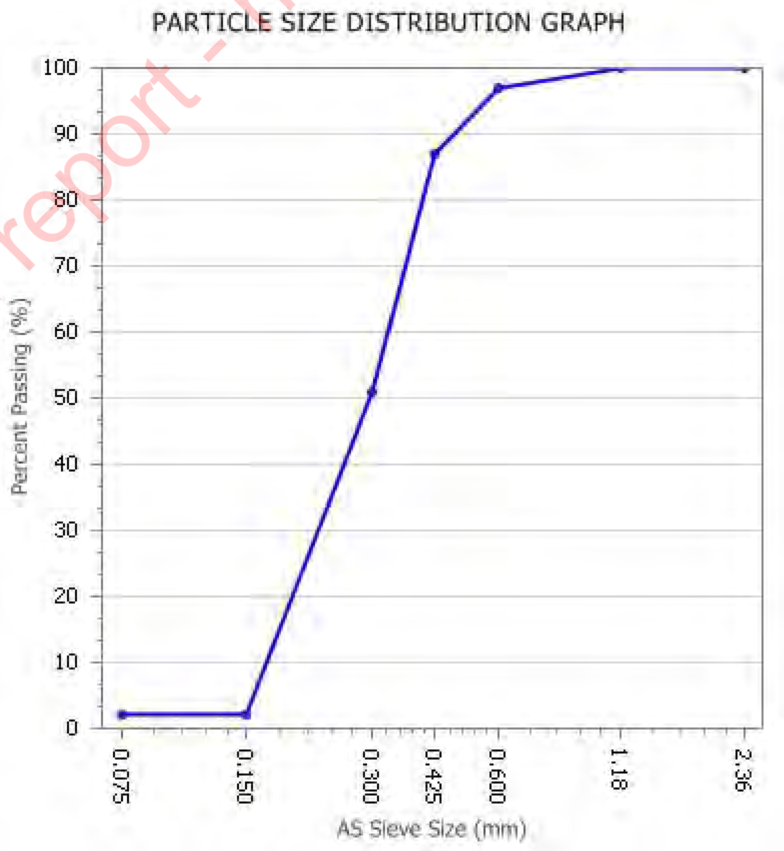
Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 7 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42924		
Sampling Method		Location1	WP36
Date Sampled	04/05/2015 09:00	Location2	3.0-3.5
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
2.36		**100**	
1.18		**100**	
0.600		**97**	
0.425		**87**	
0.300		**51**	
0.150		**2**	
0.075		**2**	



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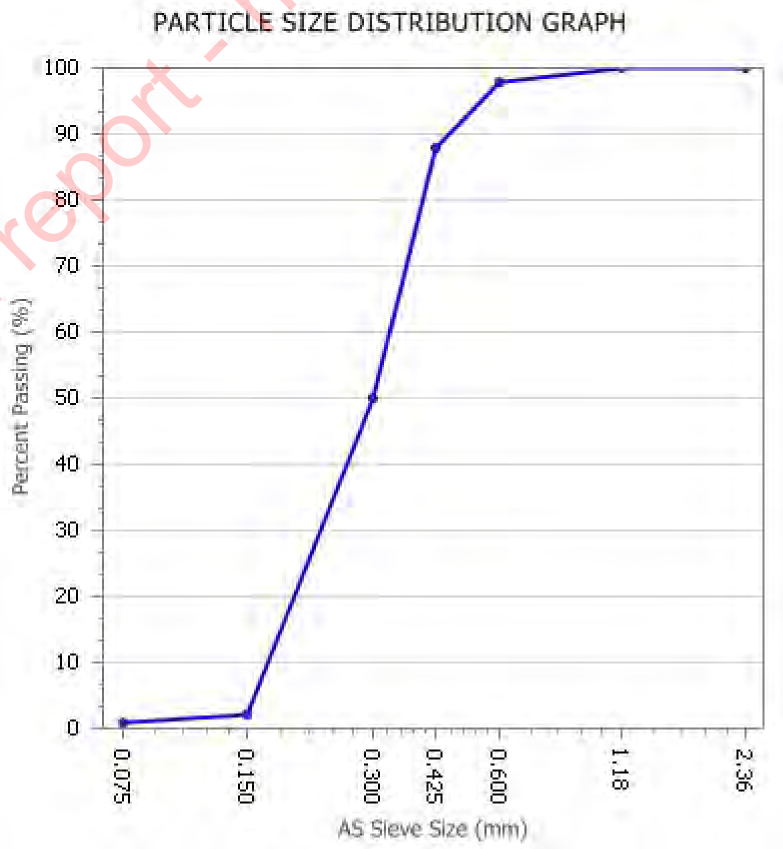
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 8 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42925		
Sampling Method		Location1	WP36
Date Sampled	04/05/2015 09:00	Location2	3.5-4.0
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
2.36		**100**	
1.18		**100**	
0.600		**98**	
0.425		**88**	
0.300		**50**	
0.150		**2**	
0.075		**1**	



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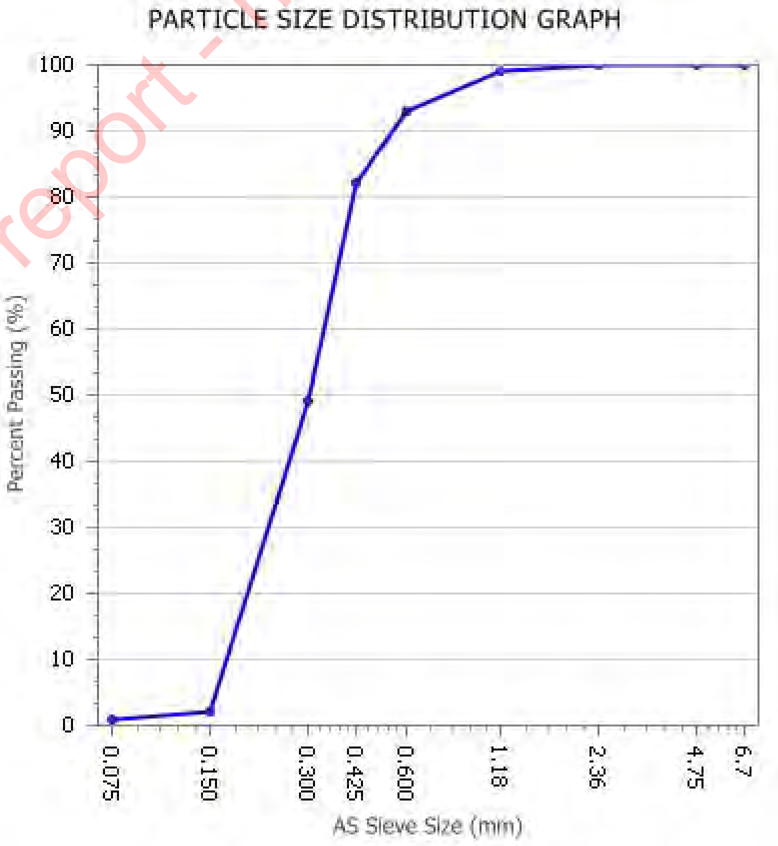
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 9 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42926	Location1	WP37
Sampling Method		Location2	0.0-0.5
Date Sampled	04/05/2015 09:00	Location3	
Sampled By	Paul Mayes	Location4	
Date Tested	13/05/2015		
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
6.7		**100**	
4.75		**100**	
2.36		**100**	
1.18		**99**	
0.600		**93**	
0.425		**82**	
0.300		**49**	
0.150		**2**	
0.075		**1**	



Remarks

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Accreditation Number: 1986
Corporate Site Number: 3740

Approved Signatory: David Hammelswang
Form ID: W9Rep Rev 2

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Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

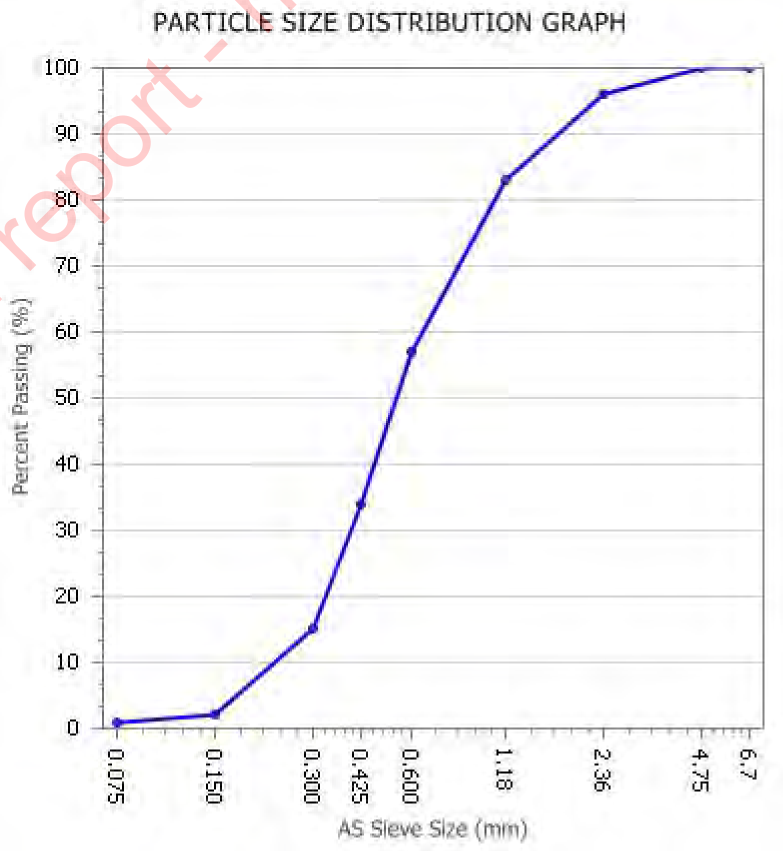
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 10 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42927	Sample Location	
Sampling Method		Location1	WP37
Date Sampled	04/05/2015 09:00	Location2	0.5-1.0
Sampled By	Paul Mayes	Location3	
Date Tested	13/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
6.7		**100**	
4.75		**100**	
2.36		**96**	
1.18		**83**	
0.600		**57**	
0.425		**34**	
0.300		**15**	
0.150		**2**	
0.075		**1**	



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Website: www.cardno.com.au

PARTICLE SIZE DISTRIBUTION REPORT

Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre, Nambour
Project: Maroochy River Sediment Investigation
Location: Cotton Tree
Component:
Area Description:

Report Number: 3740/R/7024-1
Project Number: 3740/P/756
Lot Number:
Internal Test Request: 3740/T/8584
Client Reference/s: Sediment Investigation
Report Date / Page: 27/05/2015 Page 11 of 32

Test Procedures: AS1289.3.6.1

Sample Number 3740/S/42928
Sampling Method
Date Sampled 04/05/2015 09:00
Sampled By Paul Mayes
Date Tested 13/05/2015
Material Source Insitu

Sample Location
Location1 WP37
Location2 1.0-1.5
Location3
Location4
Material Type Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
6.7		**100**	
4.75		**100**	
2.36		**96**	
1.18		**83**	
0.600		**58**	
0.425		**34**	
0.300		**10**	
0.150		**1**	
0.075		**1**	

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PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 12 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42929	Sample Location	
Sampling Method		Location1	WP37
Date Sampled	04/05/2015 09:00	Location2	1.5-2.0
Sampled By	Paul Mayes	Location3	
Date Tested	13/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
4.75		**100**	
2.36		**100**	
1.18		**99**	
0.600		**93**	
0.425		**73**	
0.300		**38**	
0.150		**2**	
0.075		**1**	

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PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 13 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42930	Sample Location	
Sampling Method		Location1	WP37
Date Sampled	04/05/2015 09:00	Location2	2.0-2.5
Sampled By	Paul Mayes	Location3	
Date Tested	13/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
1.18		**100**	
0.600		**100**	
0.425		**98**	
0.300		**79**	
0.150		**4**	
0.075		**2**	

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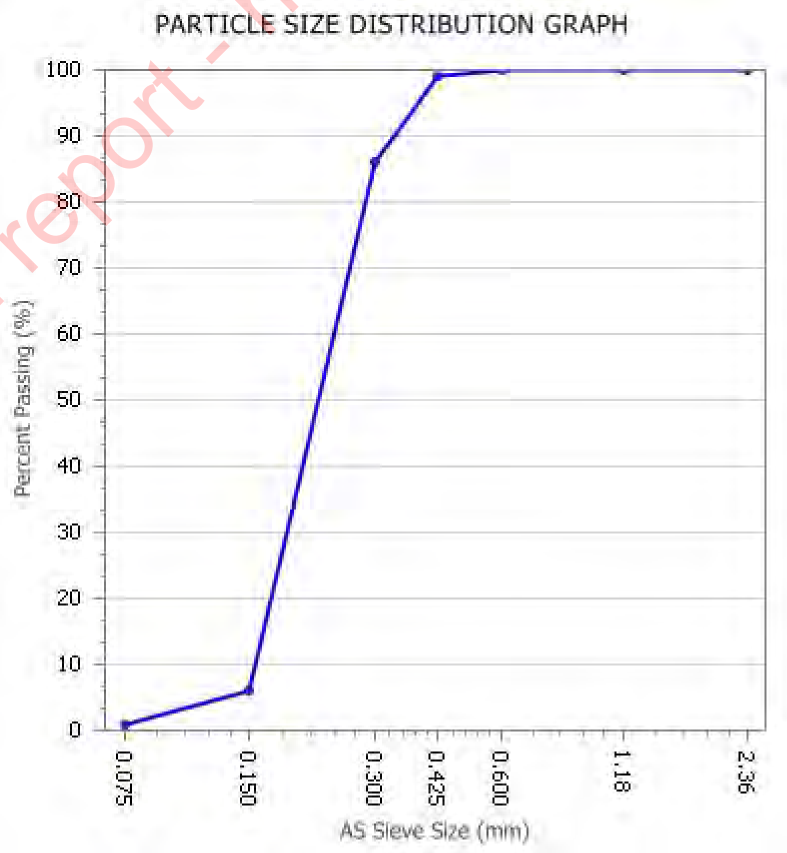
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 14 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42931	Sample Location	
Sampling Method		Location1	WP37
Date Sampled	04/05/2015 09:00	Location2	2.5-3.0
Sampled By	Paul Mayes	Location3	
Date Tested	11/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
2.36		**100**	
1.18		**100**	
0.600		**100**	
0.425		**99**	
0.300		**86**	
0.150		**6**	
0.075		**1**	



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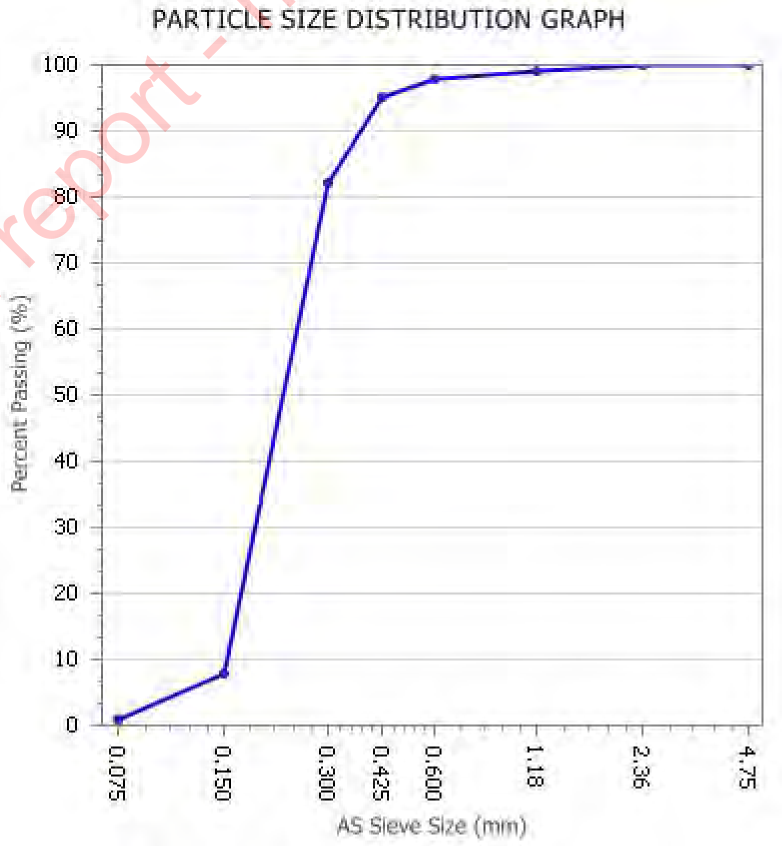
Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 15 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42932	Sample Location	
Sampling Method		Location1	WP37
Date Sampled	04/05/2015 09:00	Location2	3.0-3.5
Sampled By	Paul Mayes	Location3	
Date Tested	11/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	Percent Passing (%)	Specification Maximum
4.75		**100**	
2.36		**100**	
1.18		**99**	
0.600		**98**	
0.425		**95**	
0.300		**82**	
0.150		**8**	
0.075		**1**	



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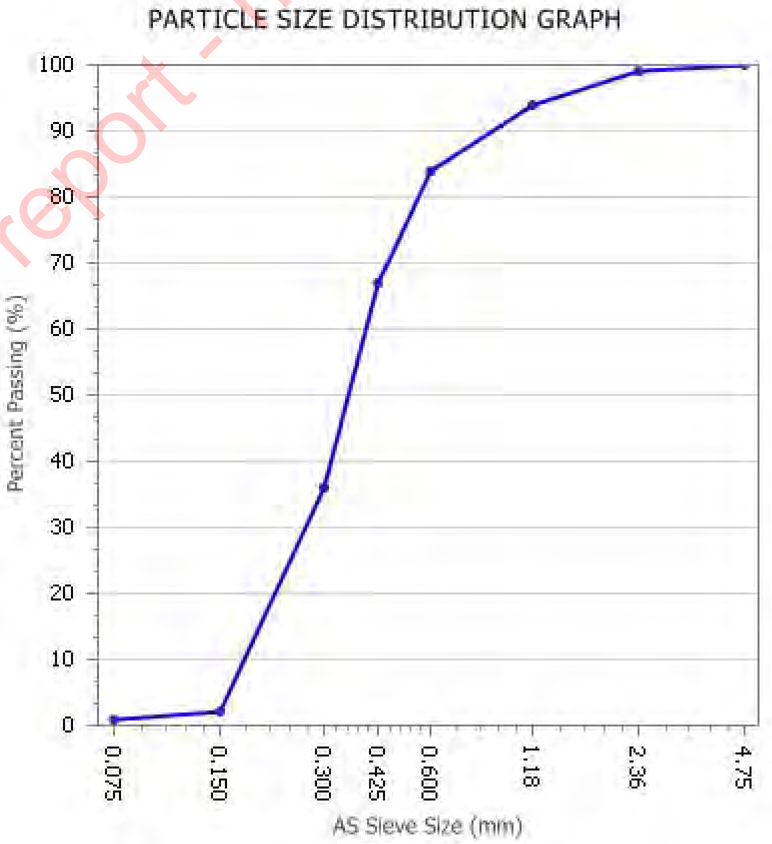
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 16 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42933	Sample Location	
Sampling Method		Location1	WP37
Date Sampled	04/05/2015 09:00	Location2	3.5-4.0
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	Percent Passing (%)	Specification Maximum
4.75		**100**	
2.36		**99**	
1.18		**94**	
0.600		**84**	
0.425		**67**	
0.300		**36**	
0.150		**2**	
0.075		**1**	



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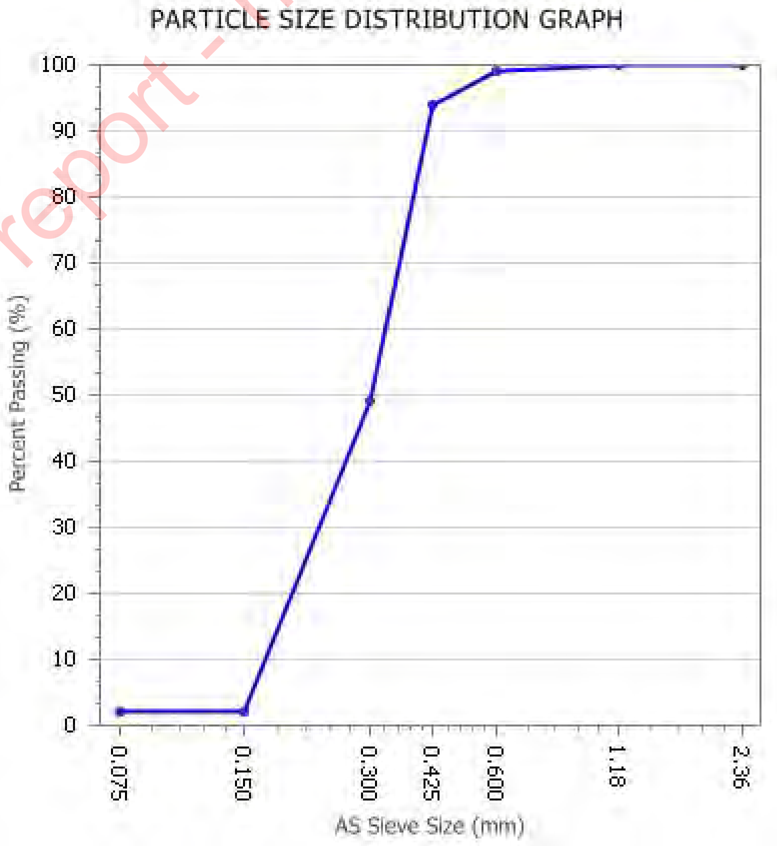
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 17 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42934		
Sampling Method		Location1	WP38
Date Sampled	04/05/2015 09:00	Location2	0.0-0.5
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
2.36		**100**	
1.18		**100**	
0.600		**99**	
0.425		**94**	
0.300		**49**	
0.150		**2**	
0.075		**2**	



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PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 18 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42935	Sample Location	
Sampling Method		Location1	WP38
Date Sampled	04/05/2015 09:00	Location2	0.5-1.0
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
4.75		**100**	
2.36		**98**	
1.18		**92**	
0.600		**80**	
0.425		**70**	
0.300		**46**	
0.150		**2**	
0.075		**1**	

Remarks

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Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 19 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42936	Location1	WP38
Sampling Method		Location2	1.0-1.5
Date Sampled	04/05/2015 09:00	Location3	
Sampled By	Paul Mayes	Location4	
Date Tested	13/05/2015		
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
4.75		**100**	
2.36		**100**	
1.18		**97**	
0.600		**90**	
0.425		**81**	
0.300		**61**	
0.150		**2**	
0.075		**1**	

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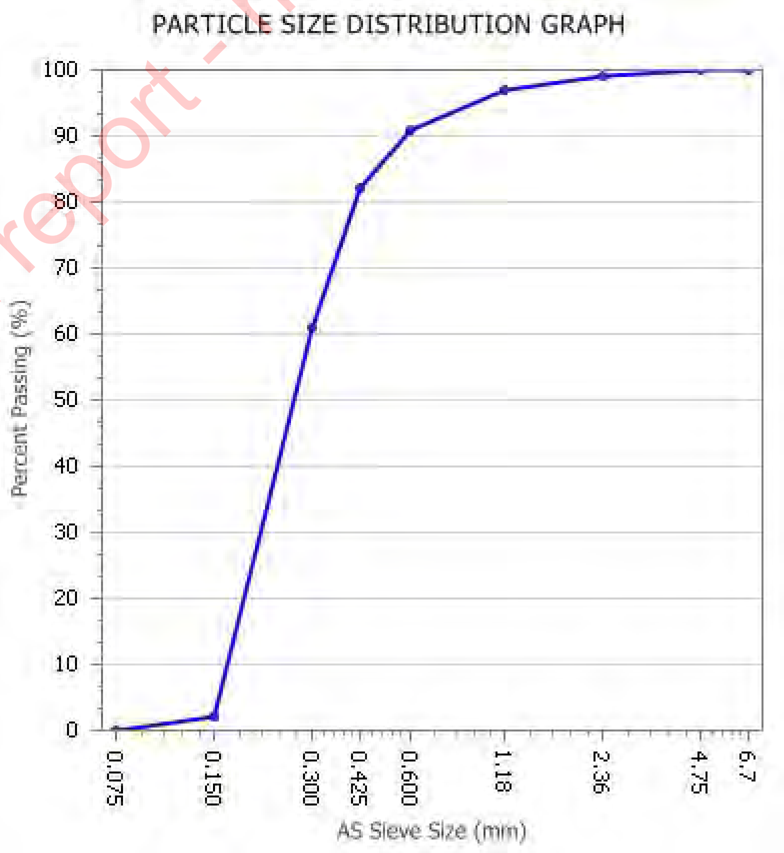
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 20 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42937	Location1	WP38
Sampling Method		Location2	1.5-2.0
Date Sampled	04/05/2015 09:00	Location3	
Sampled By	Paul Mayes	Location4	
Date Tested	12/05/2015		
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
6.7		**100**	
4.75		**100**	
2.36		**99**	
1.18		**97**	
0.600		**91**	
0.425		**82**	
0.300		**61**	
0.150		**2**	
0.075		**0**	



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PARTICLE SIZE DISTRIBUTION REPORT

Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre, Nambour
Project: Maroochy River Sediment Investigation
Location: Cotton Tree
Component:
Area Description:

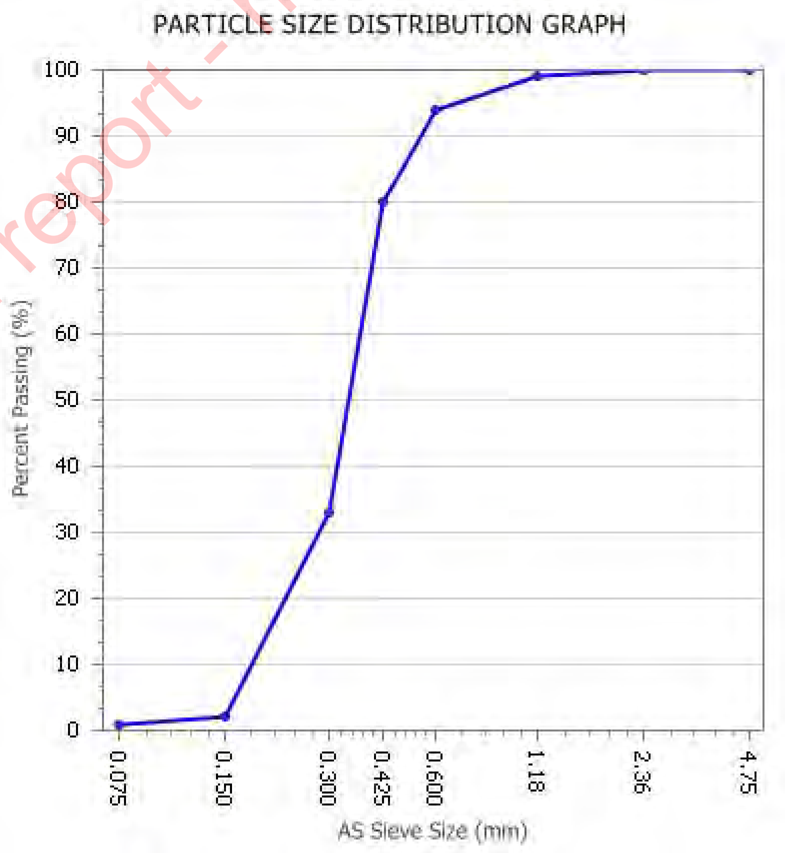
Report Number: 3740/R/7024-1
Project Number: 3740/P/756
Lot Number:
Internal Test Request: 3740/T/8584
Client Reference/s: Sediment Investigation
Report Date / Page: 27/05/2015 Page 21 of 32

Test Procedures: AS1289.3.6.1

Sample Number 3740/S/42938
Sampling Method
Date Sampled 04/05/2015 09:00
Sampled By Paul Mayes
Date Tested 12/05/2015
Material Source Insitu

Sample Location
Location1 WP38
Location2 2.0-2.5
Location3
Location4
Material Type Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
4.75		**100**	
2.36		**100**	
1.18		**99**	
0.600		**94**	
0.425		**80**	
0.300		**33**	
0.150		**2**	
0.075		**1**	



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PARTICLE SIZE DISTRIBUTION REPORT

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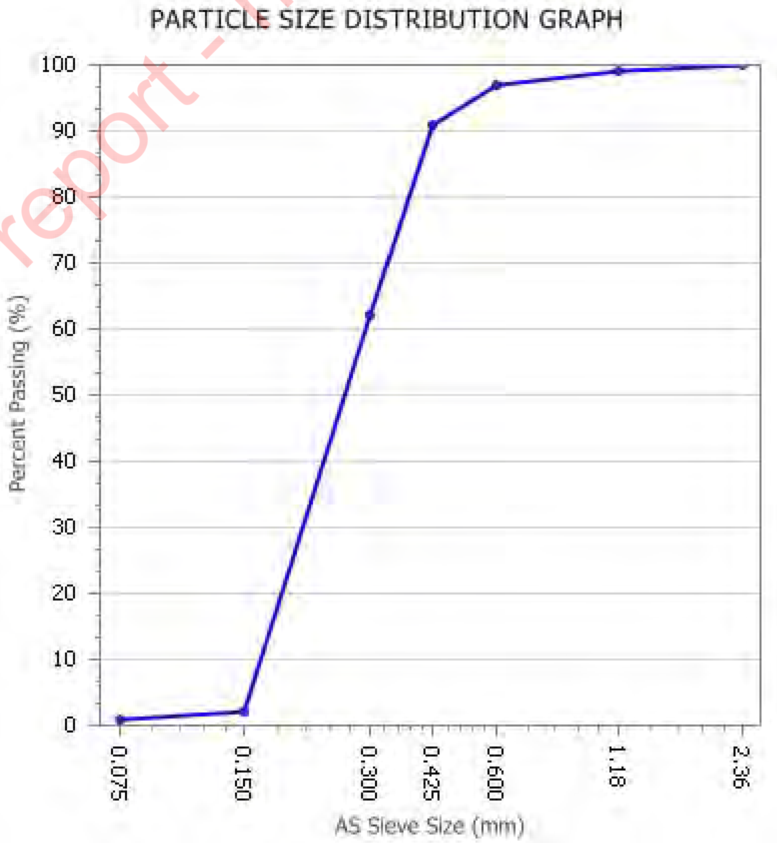
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 22 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42939	Sample Location	
Sampling Method		Location1	WP38
Date Sampled	04/05/2015 09:00	Location2	2.5-3.0
Sampled By	Paul Mayes	Location3	
Date Tested	13/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
2.36		**100**	
1.18		**99**	
0.600		**97**	
0.425		**91**	
0.300		**62**	
0.150		**2**	
0.075		**1**	



Remarks

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Accreditation Number: 1986
Corporate Site Number: 3740

Approved Signatory: David Hammelswang
Form ID: W9Rep Rev 2

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Cardno Construction Sciences
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Laboratory: **Sunshine Coast Laboratory**
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Email: cardnobowlerkp@cardno.com.au
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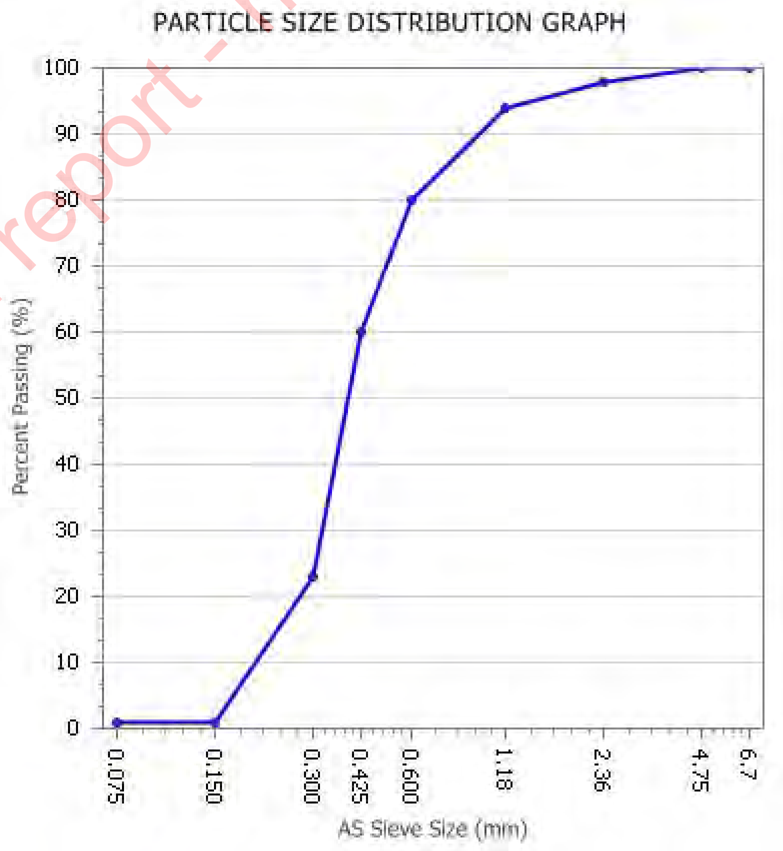
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 23 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42940	Sample Location	
Sampling Method		Location1	WP38
Date Sampled	04/05/2015 09:00	Location2	3.0-3.5
Sampled By	Paul Mayes	Location3	
Date Tested	13/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
6.7		**100**	
4.75		**100**	
2.36		**98**	
1.18		**94**	
0.600		**80**	
0.425		**60**	
0.300		**23**	
0.150		**1**	
0.075		**1**	



Remarks

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PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 24 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42941	Location1	WP38
Sampling Method		Location2	3.5-4.0
Date Sampled	04/05/2015 09:00	Location3	
Sampled By	Paul Mayes	Location4	
Date Tested	13/05/2015		
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
6.7		**100**	
4.75		**100**	
2.36		**99**	
1.18		**95**	
0.600		**80**	
0.425		**60**	
0.300		**28**	
0.150		**2**	
0.075		**1**	

Remarks

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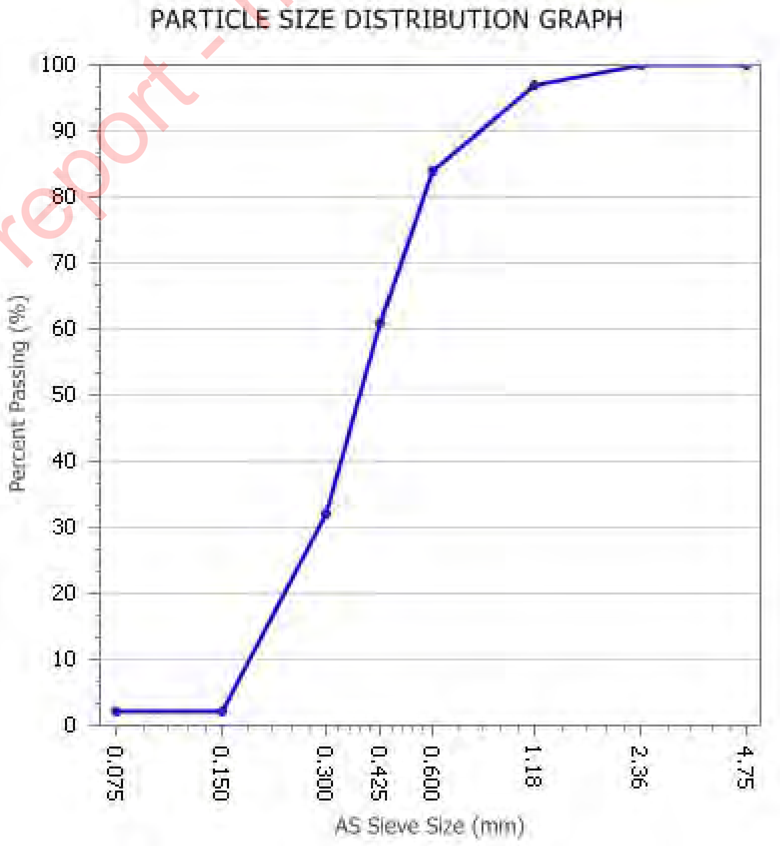
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 25 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42942	Location1	WP5
Sampling Method		Location2	0.0-0.5
Date Sampled	04/05/2015 09:00	Location3	
Sampled By	Paul Mayes	Location4	
Date Tested	13/05/2015	Material Type	Suspected ASS
Material Source	Insitu		

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
4.75		**100**	
2.36		**100**	
1.18		**97**	
0.600		**84**	
0.425		**61**	
0.300		**32**	
0.150		**2**	
0.075		**2**	



Remarks

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PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 26 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42943	Sample Location	
Sampling Method		Location1	WP5
Date Sampled	04/05/2015 09:00	Location2	0.5-1.0
Sampled By	Paul Mayes	Location3	
Date Tested	13/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
6.7		**100**	
4.75		**99**	
2.36		**97**	
1.18		**93**	
0.600		**82**	
0.425		**65**	
0.300		**39**	
0.150		**2**	
0.075		**1**	

Remarks

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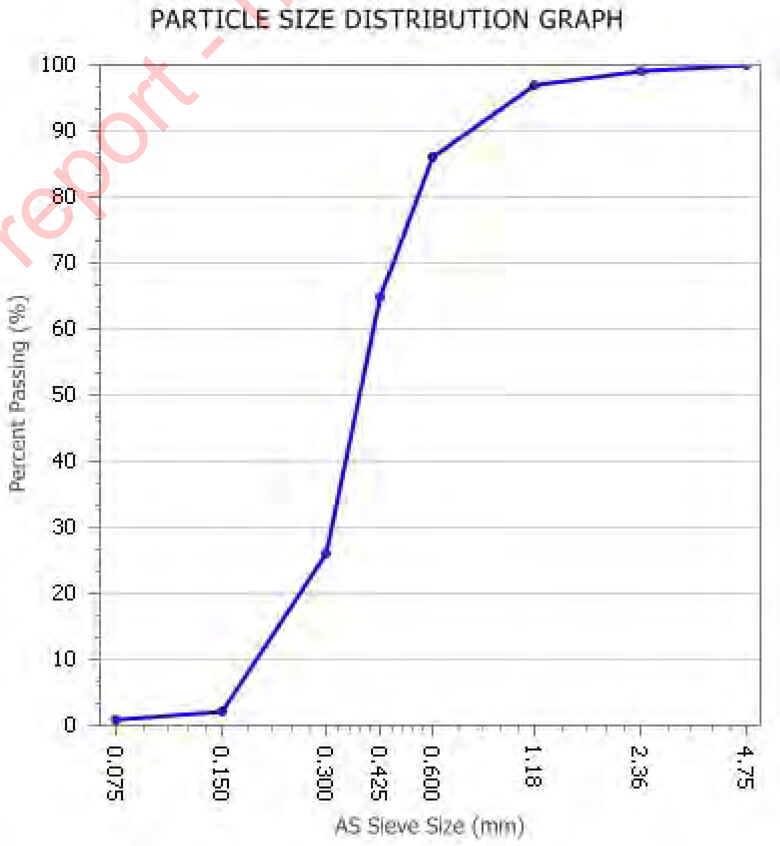
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 27 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42944		
Sampling Method		Location1	WP5
Date Sampled	04/05/2015 09:00	Location2	1.0-1.5
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	Percent Passing (%)	Specification Maximum
4.75		**100**	
2.36		**99**	
1.18		**97**	
0.600		**86**	
0.425		**65**	
0.300		**26**	
0.150		**2**	
0.075		**1**	



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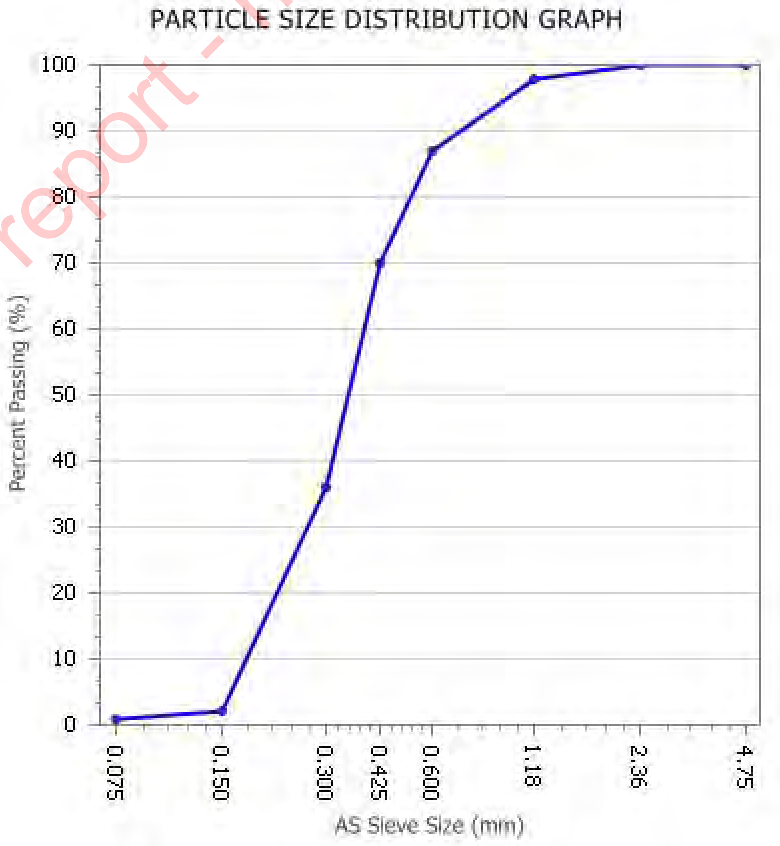
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 28 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42945	Location1	WP5
Sampling Method		Location2	1.5-2.0
Date Sampled	04/05/2015 09:00	Location3	
Sampled By	Paul Mayes	Location4	
Date Tested	12/05/2015		
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	Percent Passing (%)	Specification Maximum
4.75		**100**	
2.36		**100**	
1.18		**98**	
0.600		**87**	
0.425		**70**	
0.300		**36**	
0.150		**2**	
0.075		**1**	



Remarks

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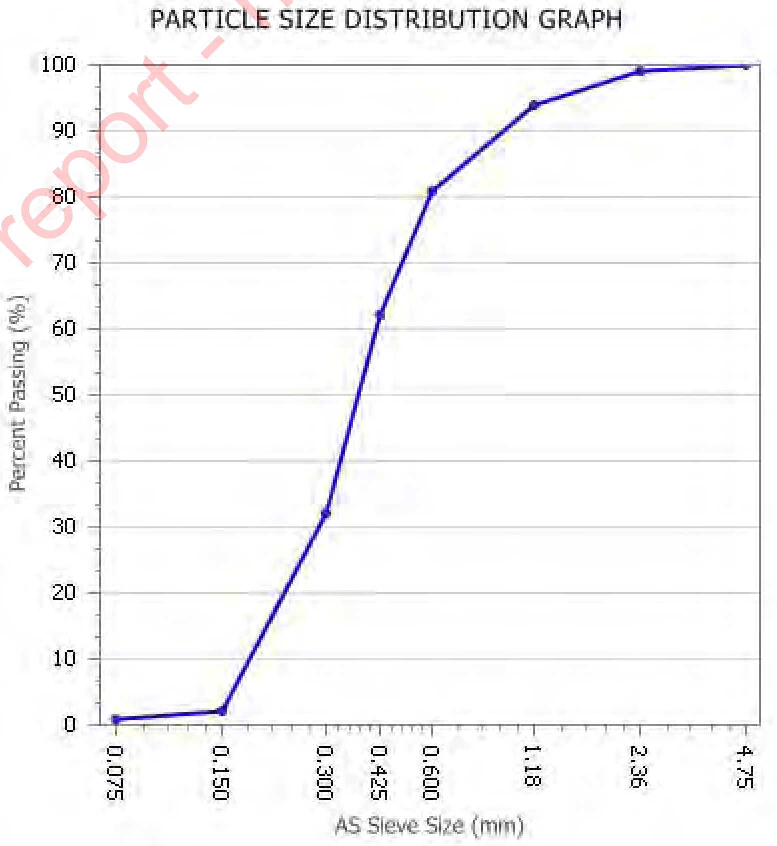
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 29 of 32

Test Procedures: AS1289.3.6.1

		Sample Location	
Sample Number	3740/S/42946		
Sampling Method		Location1	WP5
Date Sampled	04/05/2015 09:00	Location2	2.0-2.5
Sampled By	Paul Mayes	Location3	
Date Tested	13/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	Percent Passing (%)	Specification Maximum
4.75		**100**	
2.36		**99**	
1.18		**94**	
0.600		**81**	
0.425		**62**	
0.300		**32**	
0.150		**2**	
0.075		**1**	



Remarks

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Website: www.cardno.com.au

PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 30 of 32

Test Procedures:	AS1289.3.6.1		
Sample Number	3740/S/42947	Sample Location	
Sampling Method		Location1	WP5
Date Sampled	04/05/2015 09:00	Location2	2.5-3.0
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
4.75		**100**	
2.36		**99**	
1.18		**91**	
0.600		**67**	
0.425		**47**	
0.300		**19**	
0.150		**2**	
0.075		**1**	

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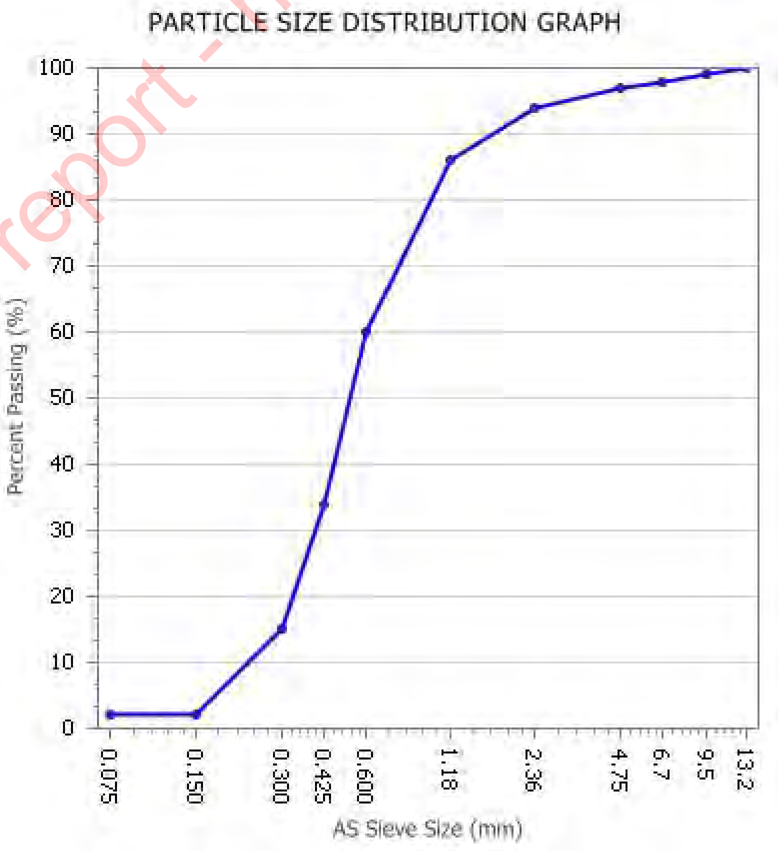
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 31 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42948	Sample Location	
Sampling Method		Location1	WP5
Date Sampled	04/05/2015 09:00	Location2	3.0-3.5
Sampled By	Paul Mayes	Location3	
Date Tested	13/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	Percent Passing (%)	Specification Maximum
13.2		**100**	
9.5		**99**	
6.7		**98**	
4.75		**97**	
2.36		**94**	
1.18		**86**	
0.600		**60**	
0.425		**34**	
0.300		**15**	
0.150		**2**	
0.075		**2**	



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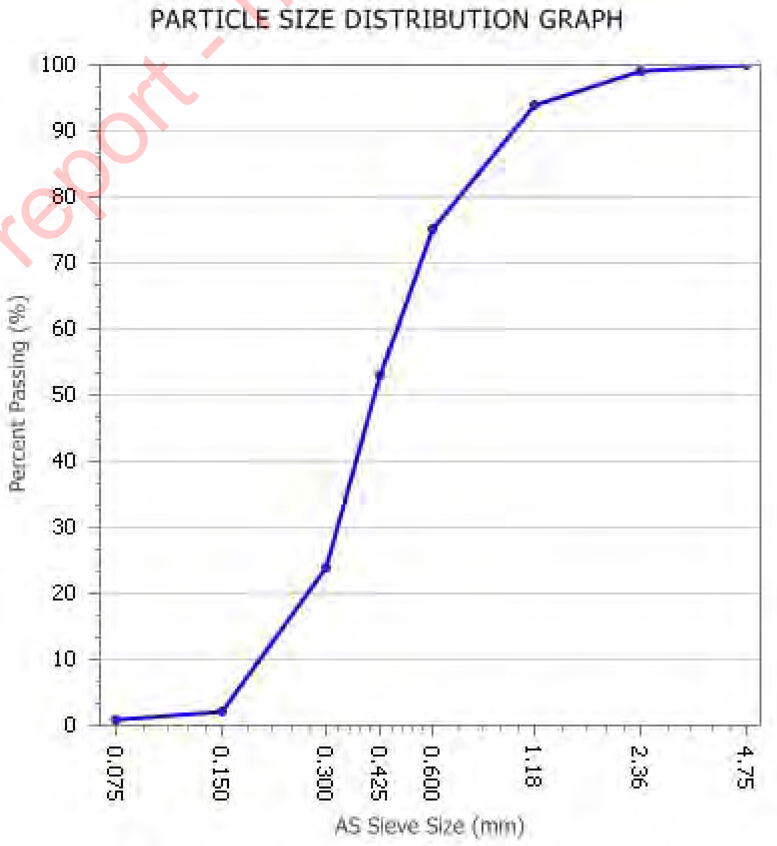
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Sunshine Coast Council	Report Number:	3740/R/7024-1
Client Address:	Locked Bag 72, Sunshine Coast Mail Centre, Nambour	Project Number:	3740/P/756
Project:	Maroochy River Sediment Investigation	Lot Number:	
Location:	Cotton Tree	Internal Test Request:	3740/T/8584
Component:		Client Reference/s:	Sediment Investigation
Area Description:		Report Date / Page:	27/05/2015 Page 32 of 32

Test Procedures: AS1289.3.6.1

Sample Number	3740/S/42949	Sample Location	
Sampling Method		Location1	WP5
Date Sampled	04/05/2015 09:00	Location2	3.5-4.0
Sampled By	Paul Mayes	Location3	
Date Tested	12/05/2015	Location4	
Material Source	Insitu	Material Type	Suspected ASS

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
4.75		**100**	
2.36		**99**	
1.18		**94**	
0.600		**75**	
0.425		**53**	
0.300		**24**	
0.150		**2**	
0.075		**1**	



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Shaping the Future

CHROMIUM SUITE TEST REPORT

Report Number: **3740/S/42918CRS**
Client: **Sunshine Coast Council**
Client Address: **Locked Bag 72, Sunshine Coast Mail Centre Nambour Qld 4560**
Project: **Maroochydore River Sediment Investigation**
Project no. **3740/P/756**
Sampled by: **Cardno Construction Sciences (Sunshine Coast)**
Methods: **AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14**

Date Sampled: **4/05/2015**
Date Received: **4/05/2015**
Date Tested: **13/05/2015**
Date Reported: **17/05/2015**

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) ^{a}	(% S)	(% S)	(%$CaCO_3$) $^\#$	(%S) $^\#$	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	0.01	1	0.001	0.1
3740/S/42918	WP 36 0.0-0.5	9.5	0	0.000	<0.007	<0.02	nr	1.23	0.39	-164	-0.263	No Liming Required
3740/S/42919	WP 36 0.5-1.0	9.8	0	0.000	<0.007	<0.02	nr	2.97	0.95	-396	-0.635	No Liming Required
3740/S/42920	WP 36 1.0-1.5	9.9	0	0.000	<0.007	<0.02	nr	4.19	1.34	-558	-0.895	No Liming Required
3740/S/42921	WP 36 1.5-2.0	9.8	0	0.000	<0.007	<0.02	nr	2.77	0.89	-369	-0.592	No Liming Required
3740/S/42922	WP 36 2.0-2.5	9.8	0	0.000	<0.007	<0.02	nr	3.72	1.19	-496	-0.796	No Liming Required
3740/S/42923	WP 36 2.5-3.0	9.8	0	0.000	<0.007	<0.02	nr	3.31	1.06	-441	-0.708	No Liming Required
3740/S/42924	WP 36 3.0-3.5	9.7	0	0.000	0.018	<0.02	nr	1.70	0.54	-226	-0.362	No Liming Required
3740/S/42925	WP 36 3.5-4.0	9.7	0	0.000	<0.007	<0.02	nr	1.46	0.47	-194	-0.311	No Liming Required
3740/S/42926	WP 37 0.0-0.5	9.7	0	0.000	0.022	<0.02	nr	1.86	0.59	-247	-0.396	No Liming Required
3740/S/42927	WP 37 0.5-1.0	9.9	0	0.000	<0.007	<0.02	nr	4.78	1.53	-637	-1.022	No Liming Required
3740/S/42928	WP 37 1.0-1.5	9.9	0	0.000	<0.007	<0.02	nr	4.20	1.35	-560	-0.897	No Liming Required
3740/S/42929	WP 37 1.5-2.0	9.7	0	0.000	0.015	<0.02	nr	2.34	0.75	-312	-0.501	No Liming Required
3740/S/42930	WP 37 2.0-2.5	9.7	0	0.000	0.015	<0.02	nr	1.89	0.60	-251	-0.403	No Liming Required
3740/S/42931	WP 37 2.5-3.0	9.9	0	0.000	0.026	<0.02	nr	2.65	0.85	-353	-0.566	No Liming Required
3740/S/42932	WP 37 3.0-3.5	9.8	0	0.000	0.022	<0.02	nr	2.82	0.90	-376	-0.603	No Liming Required
3740/S/42933	WP 37 3.5-4.0	9.6	0	0.000	<0.007	<0.02	nr	2.60	0.83	-346	-0.555	No Liming Required
Blank		6.4	1.5	0.002								

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
$^\#$ if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
Effective ANC is ANC_{BT}/Fineness Factor of 1.5.
^{a} S_{KCl} determined as sulfate by turbidimetric method.
Where liming is specified, lime should be fine grained agricultural lime of at least 90% purity.
Any liming rate provided is a recommended rate only, and is based on the total of TAA Equivalent % Oxidisable Sulphur plus Potential Acidity (S_{Cr}) plus Retained Acidity (S_{NAS}) minus effective ANC; with a factor of safety of 1.5.
Any recommended liming rate is based on the 0.03%S action criteria.
A placed dry density of 1.7 tonnes/cubic metre has been used in calculating liming rate/s.
The recommended liming rate is derived from a mathematical equation and will need to be field validated.
Cardno accepts no responsibility for any loss associated with use of the calculated liming rate/s.
The test results contained within this report relate only to the samples as they were received.

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Accreditation No.: 1986
Corporate Site Number: 3740

APPROVED SIGNATORY: **Paul Mayes**
Form Number: REP CRS 9/02/2015 Revision 8

Cardno
Shaping the Future

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CHROMIUM SUITE TEST REPORT

Report Number: 3740/S/42934CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre Nambour Qld 4560
Project: Maroochydore River Sediment Investigation
Project no. 3740/P/756
Sampled by: Cardno Construction Sciences (Sunshine Coast)
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Date Sampled: 4/05/2015
Date Received: 4/05/2015
Date Tested: 13/05/2015
Date Reported: 17/05/2015

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) [a]	(% S)	(% S)	(%$CaCO_3$) #	(%S) #	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	0.01	1	0.001	0.1
3740/S/42934	WP 38 0.0-0.5	9.8	0	0.000	<0.007	<0.02	nr	2.86	0.92	-381	-0.611	No Liming Required
3740/S/42935	WP 38 0.5-1.0	9.8	0	0.000	<0.007	<0.02	nr	3.17	1.02	-422	-0.677	No Liming Required
3740/S/42936	WP 38 1.0-1.5	9.9	0	0.000	0.007	<0.02	nr	2.95	0.95	-393	-0.630	No Liming Required
3740/S/42937	WP 38 1.5-2.0	9.9	0	0.000	0.007	<0.02	nr	2.62	0.84	-349	-0.559	No Liming Required
3740/S/42938	WP 38 2.0-2.5	9.6	0	0.000	<0.007	<0.02	nr	2.16	0.69	-288	-0.462	No Liming Required
3740/S/42939	WP 38 2.5-3.0	9.7	0	0.000	0.008	<0.02	nr	1.70	0.55	-227	-0.364	No Liming Required
3740/S/42940	WP 38 3.0-3.5	9.7	0	0.000	<0.007	<0.02	nr	2.32	0.74	-310	-0.496	No Liming Required
3740/S/42941	WP 38 3.5-4.0	9.9	0	0.000	<0.007	<0.02	nr	3.30	1.06	-440	-0.706	No Liming Required
Blank		6.4	1.5	0.002								

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
 # if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
Effective ANC is ANC_{BT}/Fineness Factor of 1.5.
[a] S_{KCl} determined as sulfate by turbidimetric method.
Where liming is specified, lime should be fine grained agricultural lime of at least 90% purity.
Any liming rate provided is a recommended rate only, and is based on the total of TAA Equivalent % Oxidisable Sulphur plus Potential Acidity (S_{Cr}) plus Retained Acidity (S_{NAS}) minus effective ANC; with a factor of safety of 1.5.
Any recommended liming rate is based on the 0.03%S action criteria.
A placed dry density of 1.7 tonnes/cubic metre has been used in calculating liming rate/s.
The recommended liming rate is derived from a mathematical equation and will need to be field validated.
Cardno accepts no responsibility for any loss associated with use of the calculated liming rate/s.
The test results contained within this report relate only to the samples as they were received.

NATA

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CHROMIUM SUITE TEST REPORT

Report Number: 3740/S/42942CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre Nambour Qld 4560
Project: Maroochydore River Sediment Investigation
Project no. 3740/P/756
Sampled by: Cardno Construction Sciences (Sunshine Coast)
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Date Sampled: 4/05/2015
Date Received: 4/05/2015
Date Tested: 15/05/2015
Date Reported: 17/05/2015

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) [a]	(% S)	(% S)	(%$CaCO_3$) [#]	(%S) [#]	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	0.01	1	0.001	0.1
3740/S/42942	WP 5 0.0-0.5	9.7	0	0.000	0.015	<0.02	nr	3.31	1.06	-441	-0.706	No Liming Required
3740/S/42943	WP 5 0.5-1.0	9.7	0	0.000	<0.007	<0.02	nr	2.84	0.91	-378	-0.606	No Liming Required
3740/S/42944	WP 5 1.0-1.5	9.7	0	0.000	0.018	<0.02	nr	2.10	0.67	-279	-0.448	No Liming Required
3740/S/42945	WP 5 1.5-2.0	9.8	0	0.000	<0.007	<0.02	nr	2.31	0.74	-307	-0.493	No Liming Required
3740/S/42946	WP 5 2.0-2.5	9.8	0	0.000	0.011	<0.02	nr	2.09	0.67	-278	-0.446	No Liming Required
3740/S/42947	WP 5 2.5-3.0	9.8	0	0.000	<0.007	<0.02	nr	3.52	1.13	-469	-0.752	No Liming Required
3740/S/42948	WP 5 3.0-3.5	9.8	0	0.000	0.007	<0.02	nr	2.91	0.93	-388	-0.622	No Liming Required
3740/S/42949	WP 5 3.5-4.0	9.8	0	0.000	<0.007	<0.02	nr	3.91	1.25	-520	-0.834	No Liming Required
Blank		6.3	1.8	0.003								

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
[#] if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
Effective ANC is ANC_{BT}/Fineness Factor of 1.5.
[a] S_{KCl} determined as sulfate by turbidimetric method.
Where liming is specified, lime should be fine grained agricultural lime of at least 90% purity.
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Any recommended liming rate is based on the 0.03%S action criteria.
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