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CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

APPENDIX Y: Soils Impact Assessment Proposed Pipelines: Northern Sands DMPA Report (2017)

2 June 2017

SOILS IMPACT ASSESSMENT - PROPOSED PIPELINES NORTHERN SANDS DMPA

Cairns Shipping Development Project

REPORT

Report Number. 1546223-022-R-Rev2

Distribution:

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Golder Associates

Executive Summary

The CSDP will require the land based placement of up to 900,000 m^3 of soft clays at the Northern Sands void DMPA.

The soft clays are to be dredged using a Trailer Suction Hopper Dredge (TSHD) discharging to a temporary floating pump out facility that will be situated between approximately 2.6 and 3.6 km north east of Yorkeys Knob. Dredge material will be pumped via a submerged steel pipeline, which will make landfall near Richters Creek mouth. From the mouth of the creek the pipeline will run to the Northern Sands DMPA mainly along cane farm headlands via a crossing of Richters Creek with up to three pipeline booster pumps being required. Tailwater is proposed to be discharged adjacent to the site or pumped to discharge at the Barron River at a location adjacent to the bridge on the Captain Cook Highway.

For most of the pipeline routes, earthworks are expected to involve clearing of vegetation where required, formation of access tracks and pipe unloading/assembly areas, and then formation of pipeline support pads. In areas where soft soils are present (e.g. mangrove areas) the pads are likely to comprise sand bags supported on a layer of geotextile placed for both separation (from underlying soils which are likely to be PASS) and reinforcement (for bearing capacity). In other areas not underlain by soft soils or PASS at the surface the pads are likely to comprise mounds of insitu soils.

At some locations (e.g. where the pipeline comes onshore, where the pipeline discharges to the Barron River and/or the banks of the creek crossing) engineered crane pads and more significant pipe support pads will probably be required. Such pads are expected to comprise imported crushed rock fill with geotextile reinforcement.

The Northern Sands site is located on the Barron River floodplain. The proposed delivery pipeline route traverses the flood plain from the shoreline to the site. Surface levels typically range from between 1 m to 2 m AHD near the shoreline rising to about 4 m AHD along the cane farm headlands to the north and south of Richters Creek and then to the Captain Cook Highway and the Northern Sands site.

Published geological information indicates that the delivery and discharge pipeline routes are underlain by Holocene aged alluvial deposits typically comprising clays, silts, sands and gravels. The surficial deposits are underlain by varying sequences of older sand and clay deposits.

Acid Sulfate Soils are present along the pipeline routes, with PASS present between the surface and depths ranging to 1 m near the banks of Richters Creek and the Barron River. Away from the creek and river banks acidic soil conditions (i.e. non PASS) are present from the surface, with PASS generally present within 2 m to 4 m of the surface.

Near the Northern Sands DMPA groundwater levels are typically between 2 m to 3 m below the ground surface or about 0.2 m to 0.5 m AHD. Groundwater levels along the pipelines routes are likely to be similar. Where the pipeline route runs close to Richters Creek or the Barron River, groundwater levels are likely to be similar to the water levels in the adjacent waterways.

Potential impacts relating to soils resulting from construction, operation and removal of the delivery and discharge pipelines include the following:

- Instability on the banks of Richters Creek or the Barron River resulting in ground displacement into the waterway.
- Instability on the banks of Richters Creek or the Barron River resulting in disturbance of PASS materials.
- Erosion on the banks of Richters Creek or the Barron River resulting in sediment discharge into the waterway.
- Earthworks required during construction of the pipeline resulting in disturbance of PASS materials and possibly generation of acidic water.

- Settlement and/or failure of pipeline support foundations, possibly resulting in disturbance of PASS materials and possibly generation of acidic water.
- Settlement and/or failure of pipeline support foundations, possibly resulting in burst or leaking pipelines.

Potential impacts related to instability are likely to be able to be mitigated by appropriate geotechnical input during detailed design and implementation of the proposed works. Other potential impacts are likely to be able to be mitigated under Construction Environmental Management Plans.

The potential impacts related to soils are assessed to be short term and reversible, irrespective of whether they are predictable or unpredictable. The risks associated with potential impacts related to soils are assessed to be low.

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Acronyms

CSDP: Cairns Shipping Development Project

DMPA: Dredged Material Placement Area

AHD: Australian Height Datum

ASS: Acid Sulfate Soil

AASS: Actual Acid Sulfate Soil .

PASS: Potential Acid Sulfate Soil

1.0 INTRODUCTION

Flanagan Consulting Group (FCG) commissioned Golder Associates Pty Ltd (Golder) to provide advice related to soils and groundwater issues as part of the Revised Draft Environmental Impact Statement for the Cairns Shipping Development Project (CSDP).

The CSDP will require the land based placement of approximately 900,000 m^3 of soft clays and up to 100,000 m^3 of stiff clays at separate Dredge Material Placement Areas (DMPA). The stiff clays are proposed to be placed at Port North's Tingira Street property. The soft clays are proposed to be placed in the Northern Sands void DMPA.

The soft clays are to be dredged via a 5,600 m^3 capacity Trailer Suction Hopper Dredge (TSHD) discharging to a temporary floating pump out facility that will be situated between approximately 2.6 and 3.6 km north east of Yorkeys Knob.

Dredge material will be pumped from the pump out facility via a submerged steel pipeline, which will make landfall near the Richters Creek mouth, thence to the Northern Sands DMPA mainly via cane farm headlands. Due to the ~8 km pipeline length that will be required to connect the pump out facility to the Northern Sands DMPA, up to three pipeline booster pumps may be required, depending on TSHD pumping capacity. Tailwater is proposed to be discharged adjacent to the site or pumped to an outfall at the Barron River highway bridge.

The aims of this report are to describe the existing soil conditions associated with delivery and discharge pipelines and to identify:

- Key soils related constraints (and opportunities) for the design and construction of the pipeline facilities required for placement of the dredged material; and
- Potential soil-related environmental impacts and mitigation/management measures.

As per advice from FCG, this report is limited to soil impacts associated with the delivery and discharge pipelines and excludes operations at the Northern Sands DMPA.

2.0 PIPELINE OPERATIONS

2.1 Pipeline construction

As outlined in Section 1.0, dredged material will be pumped from an off shore pump out facility via a submerged steel pipeline making landfall near the mouth of Richters Creek. From the shoreline the pipeline will be above ground generally running along existing cane farm headlands on the north side of the creek, prior to crossing to the south side. From the south side of the crossing the pipeline will generally run along cane farm headlands through the cane fields to the Captain Cook Highway. The pipeline will cross the highway via existing drainage culverts before entering the Northern Sands site for delivery of dredged materials. The proposed discharge pipeline will either run directly to the Barron River at a location adjacent to the site or run along existing cane farm headlands to discharge at the Barron River at a location adjacent to the bridge on the Captain Cook Highway.

It is expected that construction of the pipelines will generally only require relatively minor clearing and earthworks, however works to provide access for construction vehicles and construction plant will be required.

For most of the pipeline route, earthworks are expected to involve clearing of vegetation where required, formation of access tracks and unloading/pipe assembly areas, and then formation of pipeline support pads. In areas where soft soils are present (e.g. mangrove areas) the pads are likely to comprise sand bags supported on a layer of geotextile placed for both separation (from underlying soils which are likely to be PASS) and reinforcement (for bearing capacity). In other areas not underlain by soft soils or PASS the pads are likely to comprise mounds of insitu soils.

At some locations (e.g. where the pipeline comes onshore, where the pipeline discharges to the Barron River and/or the banks of the creek crossing) engineered crane pads and more significant pipe support pads will probably be required. Such pads are expected to comprise imported crushed rock fill with geotextile reinforcement.

As most of the pipeline routes are proposed along existing cane farm headlands, earthworks for access tracks are expected to be relatively minor. The headlands generally provide all weather access, particularly during the dry season when construction is proposed. If soft ground conditions are encountered on existing or proposed tracks, “bridging” layers comprising imported crushed rock fill (with geotextile separation and/or reinforcement if required) can be placed.

Booster pump stations are expected to comprise portable equipment supported on engineered pads comprising insitu soils. The pumps may need to be surrounded by earth bunds likely comprising insitu soils for noise reduction.

Conventional erosion and sediment control (ESC) measures would need to be implemented during the construction works (e.g. in accordance with FNQROC requirements).

2.2 Placement operations

During placement operations access will need to be maintained for fuel trucks plus other plant required during pumping. No earthworks are expected to be required during this period, other than if the pipeline breaches and discharges dredged material over the surface. If this was to occur, plant would be required for access to and “clean-up” of dredged materials. Such clean-up operations would need to involve the following:

- Containment of the dredged materials if required (e.g. by temporary bunding);
- Liming of the dredged materials to neutralise PASS and to allow “re-handling” by excavators or front end loaders;
- Excavation and transportation of the dredged materials to the Northern Sands DMPA; and
- Revegetation of disturbed areas.

2.3 Post placement operations

Following placement of the dredged material it is expected that the pipeline will be removed using similar plant to that required for construction. Pads and bunds constructed with insitu soils are likely to be excavated with material spread in nearby areas. Pads in soft soil areas are likely to be excavated with materials removed from site. Bridging layers on access tracks are likely to be excavated with materials removed from site. Bridging layers on cane farm headlands are likely to remain in place.

All disturbed areas would need to be revegetated following removal of the pipeline and access tracks (other than cane farm headlands).

3.0 DESKTOP ASSESSMENT

3.1 Background information

The Northern Sands DMPA comprises an operating sand extraction pit which is licenced to receive ‘inert wastes’ and potential acid sulfate soils (PASS), both of which are placed into the excavated pit below the water table. The proposed delivery pipeline route to the site is shown on Figure 1. Options for the discharge pipeline routes are also shown on Figure 1.

The proposed delivery pipeline will cross the shoreline at the mouth of Richters Creek and then generally run along existing cane headlands on the north side of the creek prior to crossing to the south side of the creek. From the south side of the creek crossing the pipeline will generally run along cane headlands across the cane fields to the Captain Cook Highway. The pipeline will cross the highway via existing drainage culverts before entering the Northern Sands site. The proposed discharge pipeline will either run directly to the Barron River at a location adjacent to the site or run along existing cane headlands to discharge at the Barron River at a location adjacent to the bridge on the Captain Cook highway.

Information on topography, geology, soils and ground conditions along the pipeline routes is presented in the following sections.

3.2 Topography

The Northern Sands site is located on the Barron River floodplain. The proposed delivery pipeline route traverses the flood plain from the shoreline to the site. Surface levels typically range from between 1 m to 2 m AHD near the shoreline rising to about 4 m AHD along the cane farm headlands to the north and south of Richters Creek and then to the Captain Cook Highway and the Northern Sands site. Surface levels across the Northern Sand site typically range from about 2 m to 5 m AHD. The Barron River runs immediately south and west of the Northern Sands site.

3.3 Geology

Published geological information from *Queensland Digital Geological Map Data 1:100,000 Cairns 8064 series Department of Natural Resources and Mines* indicates that the delivery and discharge pipeline routes are underlain by Holocene aged alluvial deposits comprising clays, silts, sands and gravels. The surficial deposits are underlain by varying sequences of older sand and clay deposits, underlain by bedrock comprising Silurian/Devonian meta-sediments. A map showing the surface geology along the pipeline routes is reproduced on Figure 2.

3.4 Soils

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) *Soils of Babinda -Cairns Area, North QLD* 1996 (1:50,000 scale) soils map indicates the presence of several soil units along the pipeline routes. These units are summarised below.

Route section	Soil units present
Delivery pipeline - Mouth of Richters Creek to creek crossing	Mangrove, Hull and Liverpool
Delivery pipeline - Creek crossing to Northern Sands	Mangrove, Hull, Brosnan and Liverpool
Discharge pipeline - Northern Sands to Barron River	Liverpool and Mangrove

The soil units are reproduced on Figure 3 and described below.

Unit name	Typical origin	Soil description
Mangrove	Swamps and Intertidal Zone	Saline soils of the intertidal zone.
Hull	Beach Dunes	Deep sandy soils (Tenosols).
Brosnan	Alluvium	Soils formed on beach ridges (Red Kandosol) comprising brown sandy loam over yellowish red or red sandy loam to sandy light clay.
Liverpool	Alluvium	Well drained soils formed on alluvium (Orthic Tenosol) comprising dark grey brown silty loams over yellow brown silty loam and silty clay loam to about 0.6m overlying fine sands.

3.5 Acid Sulfate Soils

Acid Sulfate Soil (ASS) is a general term applying to both a soil horizon that contains sulfides (i.e. Potential Acid Sulfate Soil - PASS) and an acid soil horizon affected by oxidation of sulfides (i.e. Actual Acid Sulfate Soil - AASS). The Department of Environment and Resource Management 2009 *Acid Sulfate Soils of Cairns North Queensland* shows the proposed pipeline routes as being mapped at a 1:50,000 scale. An extract of the DERM 2009 soil map covering the pipeline routes and showing the interpreted distribution of PASS is reproduced as Figure 4.

3.6 Groundwater

A review of groundwater levels from bores installed by Golder at the Northern Sands site indicates groundwater levels typically between 2 m to 3 m below the ground surface or about 0.2 m to 0.5 m AHD. Groundwater levels along the pipelines routes are likely to be similar. Where the pipeline route runs close to Richters Creek or the Barron River, groundwater levels are likely to be similar to the water levels in the adjacent waterways. A more detailed assessment of groundwater conditions in the area of the Northern Sands site is presented in Golder report 1546233-023-R-Rev0.

4.0 SITE INVESTIGATIONS

4.1 Site inspection

Initial fieldwork involved a walk-over/drive-over assessment of surface conditions along the proposed pipeline routes. An assessment of surface conditions at the location of the proposed creek crossing on the delivery pipeline route and at the proposed discharge point on the Barron River was made by boat. Photographs showing various features along the proposed pipeline routes are presented below.

Richters Creek where pipeline comes ashore

Typical headland around cane farm - north side of Richters Creek

North bank of creek crossing

South bank of creek crossing

Typical headland through cane farm south side of Richters Creek

4.2 Subsurface investigations and laboratory testing

A sampling program was undertaken to ground truth published information and develop a better understanding of near surface conditions along the proposed pipeline routes. Investigation locations were selected to assess identified geological units and soil units, and areas identified from ASS mapping.

The sampling program included:

- Eight hand auger boreholes: Seven boreholes (namely, BH01 to BH07) were located along the proposed delivery pipeline route and one borehole was located on the proposed discharge pipeline route. The boreholes were positioned within soil units with a higher potential for ASS materials being encountered. Note boreholes BH03 to BH06 were located in inferred natural soils adjacent to the cane farm headlands on the proposed pipeline route. Borehole BH02 encountered inferred fill materials from the headland. Boreholes BH01, BH07 and BH08 were located in inferred natural soils on the proposed pipeline route.
- Overwater sampling: A sample of soil (Boat Sample 1) was collected from the bed of the creek at the location where the pipeline crosses Richters Creek.

The locations of the boreholes and the boat sample are shown on Figure 5 and the borehole reports are presented in Appendix A.

Soil samples were collected from each investigation location at approximately 0.25 m depth intervals and screened with field testing for indicators of acid sulfate soil. On the basis of these field screening tests, nine samples were selected and sent for laboratory Chromium Suite analysis.

Soil sample handling, field screening and laboratory analysis were undertaken in line with the *Queensland State Planning Policy 2/02 Guideline - Acid Sulfate Soils*. Laboratory test certificates, field screening results and a summary of the laboratory test results are presented in Appendix B.

Selected sub-samples from the acid sulfate soil testing were sent for laboratory plasticity and grading tests in order to confirm field classifications of the soils encountered. Laboratory test certificates for the classification testing are also presented in Appendix B.

5.0 GROUND CONDITIONS

In general terms the soils encountered along the pipeline routes are consistent with those indicated on the geology, soils and ASS maps (Figures 2 to 4). Soil properties and ASS potential are summarised below.

Soil unit (refer Figure 3)	Relevant borehole (refer Figure 5)	Near surface soil conditions	ASS Potential
Mangrove	BH01, BH04	Soft to very soft clays and loose sands	PASS in top 0.5 m.
Hull	BH06	Loose silty/clayey sands	Acidic soils to 0.5 m, PASS below 3 m
Brosnan		Firm to stiff silty/sandy clays	Acidic soils to 0.5 m, PASS below 3 - 4 m
Liverpool	BH03, BH05, BH07, BH08	Firm to stiff silty/sandy clays	Acidic soils to 0.5 m, PASS below 2 - 3 m

From an ASS perspective the following ground conditions are inferred along the delivery pipeline route:

- The first 400 m to 500 m of the route from the mouth of Richters Creek has PASS present at depths between 1 m and the surface. From there to the crossing of Richters Creek, PASS is again present at depths between 1 m and the surface near the creek bank. Away from the creek bank acidic soil conditions (i.e. non PASS) are present from the surface, with PASS generally present within 2 m to 4 m of the surface;
- At the creek crossing PASS is present at depths between 1 m and the surface;

- Between Richters Creek and the Captain Cook Highway, acidic soil conditions (i.e. non PASS) are generally present from the surface with PASS generally present within 2 m to 4 m of the surface; and
- Surrounding the Northern Sands pit, acidic soil conditions (i.e. non PASS) are present from the surface, with PASS generally present within 4 m to 5m of the surface.

The following conditions are inferred along the discharge pipeline route to the Barron River bridge:

- From the Northern Sands pit to the bank of the Barron River, acidic soil conditions (i.e. non PASS) are present from the surface, with PASS generally present within 2 m to 4m of the surface; and
- At the river bank PASS is present at depths between 1 m and the surface.

6.0 CONSTRAINTS AND OPPORTUNITIES

6.1 Opportunities

Opportunities related to the construction and operation of the proposed pipelines to and from the Northern Sands DMPA are as follows:

- The proposed pipeline routes maximise the use of existing cane farm headlands.
- The proposed pipeline routes minimise the distance where PASS/soft clays need to be traversed.
- Construction of the pipeline above ground reduces the potential to disturb PASS if no significant excavations are to be carried out.
- Near surface conditions along most of the proposed routes are likely to comprise non PASS, firm to stiff silty/sandy clays (note these soils are generally adjacent to the cane farm headlands). These conditions are suitable for the likely construction methodology (i.e. supporting the pipes on pads of soil).

6.2 Constraints

Constraints related to the construction and operation of the proposed pipelines to and from the Northern Sands DMPA are as follows:

- Some areas along the delivery and discharge pipeline routes comprise soft clays at or near the surface. The presence of these soils will make construction difficult and require engineered construction access, crane pads and pipe support. There is also a potential for settlement and/or failure of pipeline support foundations to occur.
- The banks of Richters Creek and the Barron River comprise soft clays with a potential for instability to occur under increased loads induced by the pipelines and/or construction equipment.
- The banks of Richters Creek and the Barron River comprise PASS materials with a potential for disturbance during construction or if instability occurs.
- Clearing of vegetation on the banks of Richters Creek and the Barron River will be required for construction of the pipeline. This could lead to a higher potential for erosion to occur.

7.0 POTENTIAL IMPACTS

Potential impacts relating to soils resulting from construction, operation and removal of the delivery and discharge pipelines include the following:

- Instability on the banks of Richters Creek or the Barron River resulting in ground displacement into the waterway.
- Instability on the banks of Richters Creek or the Barron River resulting in disturbance of PASS materials.
- Erosion on the banks of Richters Creek or the Barron River resulting in sediment discharge into the waterway.

- Earthworks required during construction of the pipeline resulting in disturbance of PASS materials and possibly generation of acidic water.
- Settlement and/or failure of pipeline support foundations, possibly resulting in disturbance of PASS materials and possibly generation of acidic water.
- Settlement and/or failure of pipeline support foundations, possibly resulting in burst or leaking pipelines.

As outlined in Section 2.0, engineered crane pads and pipe support pads will probably be required in some areas. This will likely mitigate potential impacts related to soft ground conditions (e.g. instability and/or settlement). It is noted that all of the other impacts are also likely to be able to be mitigated. However, in relation to PASS impacts it is important to note that when PASS is exposed to oxygen by disturbance (via excavation or displacement) or by drainage (via dewatering or other means of lowering the water table), pyrite can oxidise and form sulfuric acid when combined with water. Sulfuric acid can leach out of these affected soils and strip metals (including iron, aluminum and heavy metals) from the surrounding soils. Acidic and metals impacted water can migrate into surface waters and groundwater.

These processes can lead to degradation of terrestrial vegetation through:

- Stunting of root growth;
- Increased toxicity from higher concentrations of aluminum, iron and manganese;
- Reduced plant minerals and nutrients; and
- Reduced resistance to pathogen attack.

Longer term impacts may include species die off and changes to vegetation cover (domination by more acid tolerant species).

The discharge of acidic water to estuarine environments may cause the following impacts:

- Increased acidity and increased iron and aluminum concentrations may be toxic to some aquatic organisms and may cause fish diseases (eg. red spot).
- Iron and aluminum precipitates can affect water quality and coat stream banks, benthic (sediment-dwelling) organisms and aquatic vegetation.
- Aquatic vegetation communities may change to become dominated by acid tolerant species.
- Deoxygenated water may also result from the secondary oxidation of the Fe^{2+} consuming oxygen and lowering the level of dissolved oxygen in surface waters.

Acidic waters can also weaken concrete and steel infrastructure such as culverts, pipes and piles.

Further assessment of soils related impacts is presented in Section 8.0

8.0 IMPACT ASSESSMENT – SOILS

8.1 Methodology

In order to address the terms of reference, guidelines and other requirements for the currently defined project, the following methodology was adopted:

- Assess impacts (based on the risk assessment format outlined below);
- Provide recommendations for mitigation by design changes; and
- Provide recommendations for mitigation by management.

Flanagan Consulting Group has extracted relevant items from the Queensland Government Terms of Reference and the Commonwealth Government Guidelines for soils studies. These items and relevant details are presented in Appendix C.

The initial assessment of impacts utilises a significance table based on that shown in **Table 1**.

Table 1: Significance criteria

Impact significance / consequence	Description of significance (examples)
Very High	The impact is considered critical to the decision-making process. Impacts tend to be permanent or irreversible or otherwise long term and can occur over large scale areas.
High	The impact is considered likely to be important to decision-making. Impacts tend to be permanent or irreversible or otherwise long to medium term. Impacts can occur over large or medium scale areas.
Moderate	The effects of the impact are relevant to decision making including the development of environmental mitigation measures Impacts can range from long term to short term in duration Impacts can occur over medium scale areas or otherwise represents a significant impact at the local scale
Minor	Impacts are recognisable/detectable but acceptable. These impacts are unlikely to be of importance in the decision making process. Nevertheless, they are relevant in the consideration of standard mitigation measures. Impacts tend to be short term or temporary and/or occur at local scale.
Negligible	Minimal change to the existing situation. This could include, for example, impacts which are beneath levels of detection, impacts that are within the normal bounds of variation, or impacts that are within the margin of forecasting error.

The approach to classifying the duration of identified impacts is presented in **Table 2**.

Table 2: Classifications of the duration of identified impacts

Relative Duration Of Impacts	
Temporary	Days to months
Short Term	Up to one year
Medium Term	From one to five years
Long Term	From five to 50 years
Permanent/Irreversible	In excess of 50 years

The likelihood of an impact occurring is assessed as per **Table 3**.

Table 3: Likelihood of impact

Likelihood of Impacts	Risk probability categories
Highly Unlikely	Highly unlikely to occur but theoretically possible
Unlikely	May occur during construction of the project but probability well below 50%; unlikely, but not negligible
Possible	Less likely than not but still appreciable; probability of about 50%
Likely	Likely to occur during construction or during a 12 month timeframe; probability greater than 50%
Almost Certain	Very likely to occur as a result of the proposed project construction and/or operations; could occur multiple times during relevant impacting period

A risk rating is assigned by assessing significance versus likelihood within a risk matrix. Risk is described as the product of likelihood and significance as shown in **Table 4**.

Table 4: Risk matrix

Likelihood	Significance				
	Negligible	Minor	Moderate	High	Very high
Highly Unlikely/ Rare	Negligible	Negligible	Low	Medium	High
Unlikely	Negligible	Low	Low	Medium	High
Possible	Negligible	Low	Medium	Medium	High
Likely	Negligible	Medium	Medium	High	Extreme
Almost Certain	Low	Medium	High	Extreme	Extreme

The rating of risk assessed in the risk matrix is presented in **Table 5**.

Table 5: Risk Rating Legend

Extreme Risk	An issue requiring change in project scope; almost certain to result in a 'significant' impact on the environment
High Risk	An issue requiring further detailed investigation and planning to manage and reduce risk; likely to result in a 'significant' impact on the environment
Medium Risk	An issue requiring project specific controls and procedures to manage
Low Risk	Manageable by standard mitigation and similar operating procedures
Negligible Risk	No additional management required

After assessing the nature and severity of impacts they are summarised under the following categories:

- Adverse/beneficial;
- Consequential;
- Cumulative;
- Short-term/long term;
- Reversible/irreversible; and
- Predictable/unpredictable.

8.2 Results of impact assessment

Potential impacts related to soils have been outlined in Section 7.0. All of the potential impacts are assessed as being *temporary* or *short term*. It is noted that impacts related to disturbance are likely to be able to be mitigated by appropriate geotechnical design and implementation of appropriate construction management plans.

An assessment of these impacts is presented in **Table 6**.

Table 6: Assessment of impacts

Primary impacting processes	Initial assessment with standard (statutory) mitigation measures in Place			Residual assessment with additional (proposed) mitigation measures in place		
	Significance of impact	Likelihood of impact	Risk rating	Significance of impact	Likelihood of impact	Risk rating
Instability on the banks of Richters Creek or the Barron River resulting in ground displacement into the waterway	Moderate	Possible	Medium	Moderate	Unlikely	Low
Instability on the banks of Richters Creek or the Barron River resulting in disturbance of PASS materials	Moderate	Possible	Medium	Moderate	Unlikely	Low
Erosion on the banks of Richters Creek or the Barron River resulting in sediment discharge into the waterway	Minor	Unlikely	Low	Minor	Unlikely	Low
Earthworks required during construction of the pipeline resulting in disturbance of PASS materials	Minor	Possible	Low	Minor	Possible	Low
Disturbance of PASS results in acidic water being generated	Moderate	Unlikely	Low	Moderate	Unlikely	Low
Settlement and/or failure of pipeline support foundations, possibly resulting in burst or leaking pipelines	Moderate	Unlikely	Low	Moderate	Unlikely	Low

Based on the above, the risks associated with potential impacts related to soils are assessed to be low. A summary of assessed impacts is presented in Table 7.

Table 7: Summary of assessed impacts

Element	Adverse impact	Beneficial impact	Consequential impact	Cumulative impact	Short term	Long term	Reversible	Irreversible	Predictable	Unpredictable
Soils – Soft Ground	Potential instability into the waterways. Failed material could extend into waterway. Could impact waterways if appropriate remedial works not carried out		Minimal impact as risk can be managed in design (e.g. reinforcement with high strength geotextiles or ground support with soil nails) and construction or operations (e.g. excavation of failed material and treatment if required)		X		X			X
Soils – Soft Ground	Potential failure of pipeline support foundations resulting in burst or leaking pipelines. Possible discharge of dredged materials could impact waterways if appropriate remedial works not carried out		Minimal impact as risk can be managed in design (e.g. reinforcement with high strength geotextiles) and construction or operations (e.g. containment bunds, excavation of discharged material and treatment if required)		X		X			X
Soils - ASS	Potential instability of slopes and/or foundations. PASS could be disturbed. Acidic waters could be generated if appropriate remedial works not carried out		Minimal impact as risk can be managed in design (e.g. reinforcement with high strength geotextiles or ground support with soil nails) and construction or operations (e.g. excavation of failed material and treatment if required)		X		X			X
Soils - ASS	Potential disturbance of PASS during construction or removal of pipelines Acidic waters could be generated if appropriate remedial works not carried out		Minimal impact as risk can be managed in construction (e.g. excavation of disturbed material and treatment if required)		X		X			X
Soils - Erosion	Erosion results in sediment discharge into the waterway. Could impact water quality if appropriate remedial works not carried out		Minimal impact as risk can be managed in design, construction and operations with implementation of appropriate erosion and sediment control plans/measures		X		X		X	

Based on the above, the potential impacts related to soils are assessed to be short term and reversible irrespective of whether they are predictable or unpredictable.

9.0 REFERENCES

Queensland Digital *Geological Map Data 1:100,000 Cairns 8064 series* Department of Natural Resources and Mines

Commonwealth Scientific and Industrial Research Organisation (CSIRO) 2013 *Soils of Babinda -Cairns Area, North QLD 1996 (1:50,000 scale)*. Sourced from QGIS 9/2013 (DP_QLD_LAN_BBC_50K)

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10.0 IMPORTANT INFORMATION

Your attention is drawn to the document - "Important Information", which is included as an attachment to this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

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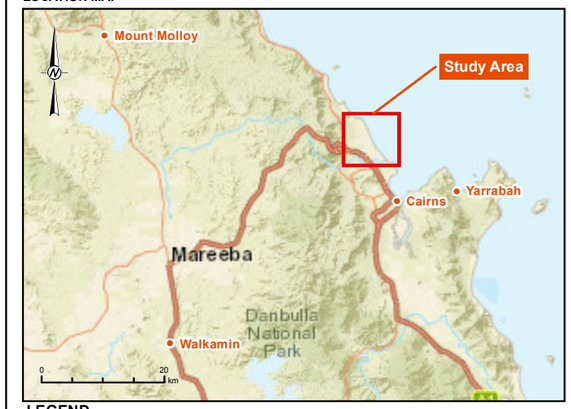
8,136,000

Trinity Beach
Yorkeys Knob
Booster #1
Booster #1
Booster #2
Booster #2
Booster #3
Holloways Beach
Machans Beach
VARLEY STREET
YORKEYS KNOB ROAD
KAMERUNGA ROAD
CAPTAIN COOK HIGHWAY
WISTARIA STREET
HOLLOWAY BEACH ROAD
MACHANS STREET
MACHANS BEACH ROAD

LOCATION MAP



LEGEND

- Localities
- Roads and Tracks
- Drainage (25k)

Pipeline Routes

Delivery Pipeline

- Booster Locations (with Marine Booster)
- Booster Locations (no Marine Booster)
- Delivery Pipeline
- Discharge Pipeline
- Northern Sands DMPA
- Dredge Pumpost and Marine Booster Areas

0 1 2
Kilometres
1:30,855 at A3
PROJECTION: GDA 1994 MGA Zone 55

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CSDP NORTHERN SANDS DMPA

TITLE
PROPOSED PIPELINE ROUTES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-20
PREPARED	DP
DESIGNED	DP
REVIEWED	MSC
APPROVED	MSC

PROJECT NO.	CONTROL	REV.	FIGURE
1546223	022	2	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: A3
25mm
0

Path: \\golder.gds\GAP\Cairns\Jobs\Geo\2015\1546223 - FCG - EIS Stage 1 - Port Development\GIS\MXD\Soils_Geology_Figures\Northern_Sands\022\1546223-020-R-Rev0_F001_Nth_Sands_Locality.mxd

362,000 364,000 366,000 368,000

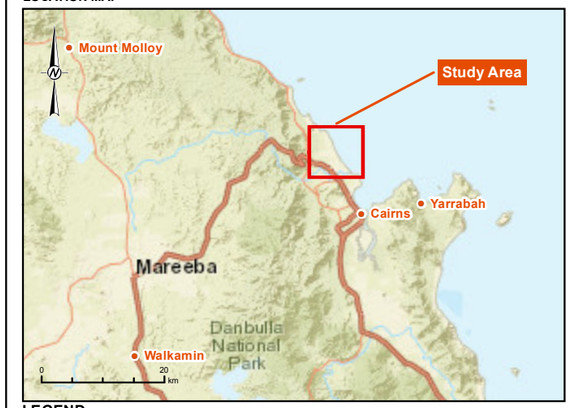
8,142,000 8,140,000 8,138,000 8,136,000

Detailed Geology

- **Dgf:** Muscovite-biotite granite, strongly foliated and sheared.
- **Dh/h:** Hornfelsed/metasomatised arenite and mudstone.
- **Dh/m:** Mainly dark grey, thin bedded, mudstone, subordinate thin to thick bedded arenite beds, minor chert and basalt.
- **Qha/1:** Younger creek alluvium, lowest terraces and channel deposits - silt, clay, sand and gravel.
- **Qha/2:** Younger creek alluvium, intermediate terraces - silt, clay, sand and gravel.
- **Qha:** Sand, gravel, silt and clay; active stream channels and low terraces.
- **Qhcb:** Moderately well-sorted, fine to coarse-grained quartzose to shelley sand and some gravel: beach ridges and cheniers.
- **Qhct:** Coastal tidal flats, mangrove flats, supratidal flats, saltpans and grasslands - silt, mud and sand, minor salt.
- **Qhmd:** Deltaic sand.
- **Qhmp:** Prodelta mud, sandy mud, muddy sand.
- **Qhms:** Shoreface/fringing coral reef: lithofeldspathic sublabile sand, muddy sand, sandy mud.
- **Qpcb:** Silty and loamy quartz sand in degraded beach ridges.
- **Qpfc:** Steep alluvial and colluvial fans, cones and aprons - coarse boulder deposits (on granites), silty and clayey gravel (on metasediments).
- **W:** Water body, unspecified.

Booster #1
Booster #2
Booster #3
Booster #1
Booster #2
Booster #3
Qhmp
Qhms
Qha
Qha/2
Qhct
Qhcb
Qhmd
Qha/1
W
Richter Creek
Barron River
Holloways Beach
Machans Beach
YORKEYS KNOB ROAD
CAPTAIN COOK HIGHWAY
WISTARIA STREET
HOLLOWAY BEACH ROAD
MACHANS STREET
MACHANS BEACH ROAD

LOCATION MAP



LEGEND

- Localities
- Roads and Tracks
- Drainage (25k)

Pipeline Routes

Delivery Pipeline

- Booster Locations (with Marine Booster)
- Booster Locations (no Marine Booster)
- Delivery Pipeline
- Discharge Pipeline
- Northern Sands DMPA
- Dredge Pumpost and Marine Booster Areas

0 1 2

1:30,000 at A3 Kilometres

PROJECTION: GDA 1994 MGA Zone 55

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CSDP NORTHERN SANDS DMPA

TITLE
SURFACE GEOLOGY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-20
PREPARED	DP
DESIGNED	DP
REVIEWED	MSC
APPROVED	MSC

PROJECT NO.	CONTROL	REV.	FIGURE
1546223	022	2	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: A3

25mm

0

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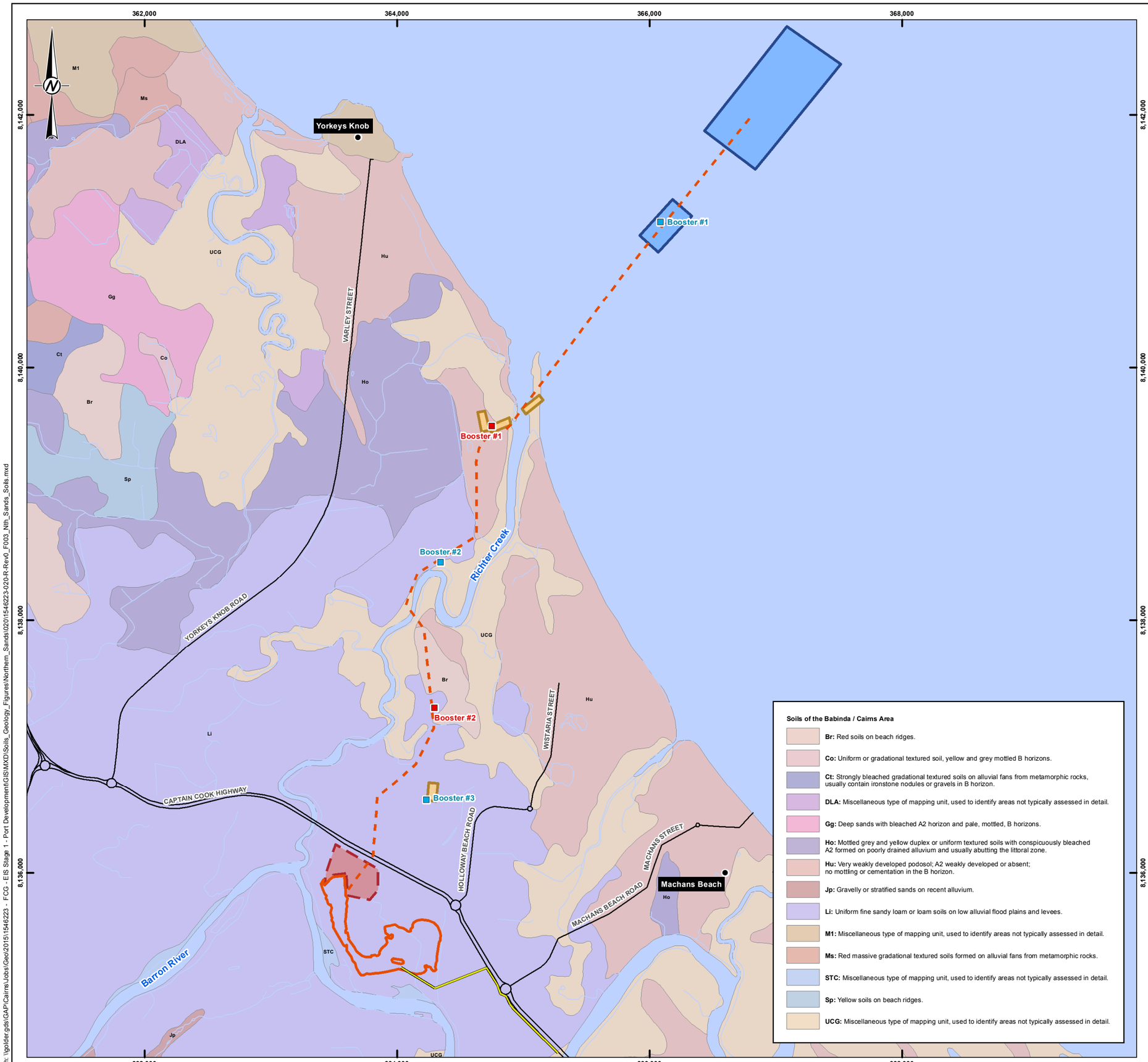
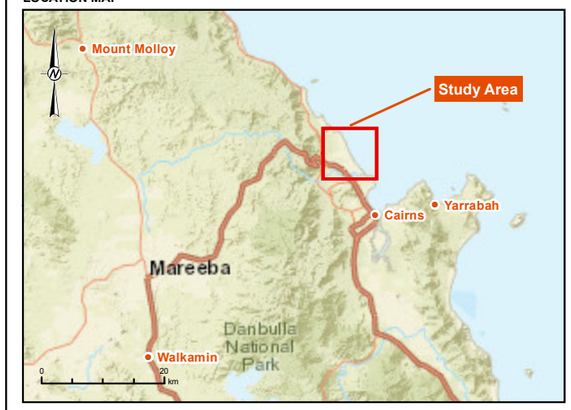


LOCATION MAP



LEGEND

- Localities
- Roads and Tracks
- Drainage (25k)

Pipeline Routes

Delivery Pipeline

- Booster Locations (with Marine Booster)
- Booster Locations (no Marine Booster)
- Delivery Pipeline
- Discharge Pipeline
- Northern Sands DMPA
- Dredge Pumpost and Marine Booster Areas
- Storage and Laydown Areas
- Pit Expansion Area

0 1 2
1:30,000 at A3 Kilometres
PROJECTION: GDA 1994 MGA Zone 55

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CSDP NORTHERN SANDS DMPA

TITLE
SOILS MAP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-20
PREPARED	DP
DESIGNED	DP
REVIEWED	MSC
APPROVED	MSC

PROJECT NO.	CONTROL	REV.	FIGURE
1546223	022	2	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: A3
0 25mm

Path: \\golder.gds\GAP\Cairns\Jobs\Geo\2015\1546223 - FCG - EIS Stage 1 - Port Development\GIS\MXD\Soils_Geology_Figures\Northern_Sands\022015462223-022-R-Rev0_F003_Nth_Sands_Soils.mxd

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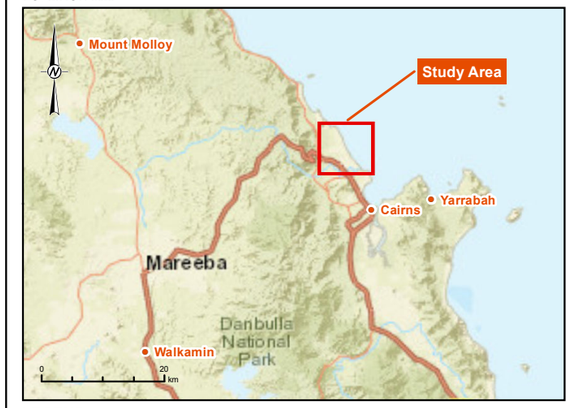
Acid Sulphate Soils (ASS)

- ASS overlie Potential ASS
- **A0S0:** Actual and/or Potential ASS in top 0.5m.
- **A0S1:** Actual ASS in top 0.5m, Potential ASS starting at 0.5 to 1m.
- **A0S2:** Actual ASS in top 0.5m, Potential ASS starting at 1 to 2m.
- **A0S3:** Actual ASS in top 0.5m, Potential ASS starting at 2 to 3m.
- **A0S4:** Actual ASS in top 0.5m, Potential ASS starting at 3 to 4m.
- **A1S1:** Actual and/or Potential ASS starting at 0.5 to 1m.
- **A2S2:** Actual and/or Potential ASS starting at 1 to 2m.
- **S0:** Potential ASS starting in top 0.5m.
- **S1 / S1N:** Potential ASS with self-neutralising capacity starting at 0.5 to 1m.
- **S2 / S2N:** Potential ASS with self-neutralising capacity starting at 1 to 2m.
- **S3 / S3N:** Potential ASS with self-neutralising capacity starting at 2 to 3m.
- **S4:** Potential ASS starting at 3 to 4m.
- **S5 / S5+:** Potential ASS starting at 4 to 5m.
- **a0A1S1:** Acidic soil in top 0.5m, Actual and/or Potential ASS starting at 0.5 to 1m.
- **a0A2S3:** Acidic soil in top 0.5m, Actual ASS starting at 1 to 2m, Potential ASS starting at 2 to 3m.
- **a0A3S3:** Acidic soil in top 0.5m, Actual and/or Potential ASS starting at 2 to 3m.
- **a0S1:** Acidic soil in top 0.5m, Potential ASS starting at 0.5 to 1m.
- **a0S2:** Acidic soil in top 0.5m, Potential ASS starting at 1 to 2m.
- **a0S3:** Acidic soil in top 0.5m, Potential ASS starting at 2 to 3m.
- **a0S4:** Acidic soil in top 0.5m, Potential ASS starting at 3 to 4m.
- **a0S5 / a0S5+:** Acidic soil in top 0.5m, Potential ASS starting at >5m.
- **a3S3:** Acidic soil and/or Potential ASS at 2 to 3m below land surface.
- **a3S5:** Acidic soil starting at 2 to 3m, Potential ASS starting at 4 to 5m.
- **LP / LP5:** Land at or above 5m AHD with low probability of ASS.
- **SDL:** Disturbed land with probability of ASS.

Yorkeys Knob
Booster #1
Booster #2
Booster #3
Holloways Beach
Machans Beach
Richter Creek
Barron River
YORKEYS KNOB ROAD
CAPTAIN COOK HIGHWAY
HOLLOWAY BEACH ROAD
WISTARIA STREET
MACHANS STREET
MACHANS BEACH ROAD

LOCATION MAP



LEGEND

- Localities
- Roads and Tracks
- Drainage (25k)

Pipeline Routes

Delivery Pipeline

- Booster Locations (with Marine Booster)
- Booster Locations (no Marine Booster)
- Delivery Pipeline
- Discharge Pipeline
- Northern Sands DMPA
- Dredge Pumpost and Marine Booster Areas

0 1 2

1:30,000 at A3 Kilometres

PROJECTION: GDA 1994 MGA Zone 55

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CSDP NORTHERN SANDS DMPA

TITLE
ASS MAP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-20
PREPARED	DP
DESIGNED	DP
REVIEWED	MSC
APPROVED	MSC

PROJECT NO.	CONTROL	REV.	FIGURE
1546223	022	2	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: A3

0 25mm

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362,000
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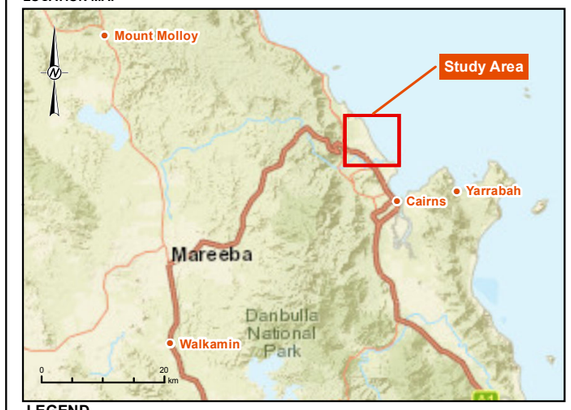
366,000
368,000
8,142,000
8,140,000
8,138,000
8,136,000

Yorkeys Knob
YARLEY STREET
BH01
Booster #1
BH02
BH03
BH04
BH05
Boat Grab Sample 1
BH06
Booster #2
BH07
BH08
YORKEYS KNOB ROAD
CAPTAIN COOK HIGHWAY
HOLLOWAY BEACH ROAD
WISTARIA STREET
Holloways Beach
MACHANS STREET
MACHANS BEACH ROAD
Machans Beach

Path: \\golder.gds\GAP\Cairns\Jobs\Geo\2015\1546223 - FCG - EIS Stage 1 - Port Development\GIS\MXD\Soils_Geology_Figures\Northern_Sands\g2015462223-020-R-Rev0_F005_Nth_Sands_Boreholes.mxd

LOCATION MAP



LEGEND

- Localities
- Roads and Tracks
- Drainage (25k)

Pipeline Routes

- Approximate Borehole Locations
- Booster Locations (no Marine Booster)
- Delivery Pipeline
- Discharge Pipeline
- Northern Sands DMPA

0 1 2
Kilometres
1:30,000 at A3
PROJECTION: GDA 1994 MGA Zone 55

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CSDP NORTHERN SANDS DMPA

TITLE
INVESTIGATION LOCATIONS - PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-20
PREPARED	DP
DESIGNED	DP
REVIEWED	MSC
APPROVED	MSC

PROJECT NO.	CONTROL	REV.	FIGURE
1546223	022	2	5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: A3
25mm
0

APPENDIX A

Borehole Reports

REPORT OF BOREHOLE: BH01

SHEET: 1 OF 1

CLIENT: Flanagan Consulting Group
COORDS: 364896.0 m E 8139549.0 m N MGA94 56
DRILL RIG: Hand Auger

PROJECT: CSDP
SURFACE RL: DATUM: AHD
CONTRACTOR: Golder

LOCATION: Northern Sands Pipeline
INCLINATION: -90°
LOGGED: DIS DATE: 8/3/17

JOB NO: 1546223
HOLE DEPTH: 1.00 m
CHECKED: GZL DATE: 29/3/17

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
HA	L		0.0		0.00-0.25 m			CL	Silty Sandy CLAY low to medium plasticity, brown, grey		S - F		HW
				0.30	0.25-0.50 m			SC	Silty Clayey SAND coarse to medium grained, grey, brown	W			
			0.5		0.50-0.75 m						L		
					0.75-1.00 m								
			1.0						END OF BOREHOLE @ 1.00 m				
			1.5										
			2.0										
			2.5										
			3.0										

DCP TEST (AS1289.6.3.2) Blows per 100 mm: 0 5 10 15 20 25

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01h RL3

REPORT OF BOREHOLE: BH02

SHEET: 1 OF 1

CLIENT: Flanagan Consulting Group
COORDS: 364607.0 m E 8138892.0 m N MGA94 56
DRILL RIG: Hand Auger

PROJECT: CSDP
SURFACE RL: DATUM: AHD
CONTRACTOR: Golder

LOCATION: Northern Sands Pipeline
INCLINATION: -90°
LOGGED: DIS DATE: 8/3/17

JOB NO: 1546223
HOLE DEPTH: 0.35 m
CHECKED: GZL DATE: 29/3/17

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
HA	L		0.0		0.00-0.25 m			CL	Silty CLAY low to medium plasticity, brown, (possible Fill)	W	S - F		HW
				0.30	0.25-0.50 m								
	H								Silty Clayey GRAVEL medium grained, angular, (possible Fill)		D		
									END OF BOREHOLE @ 0.35 m REFUSAL				
			0.5										
			1.0										
			1.5										
			2.0										
			2.5										
			3.0										

DCP TEST (AS1289.6.3.2) Blows per 100 mm: 0 5 10 15 20 25

REPORT OF BOREHOLE: BH03

SHEET: 1 OF 1

CLIENT: Flanagan Consulting Group
COORDS: 364648.0 m E 8138585.0 m N MGA94 56
DRILL RIG: Hand Auger

PROJECT: CSDP
SURFACE RL: DATUM: AHD
CONTRACTOR: Golder

LOCATION: Northern Sands Pipeline
INCLINATION: -90°
LOGGED: DIS DATE: 8/3/17

JOB NO: 1546223
HOLE DEPTH: 1.00 m
CHECKED: GZL DATE: 29/3/17

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
HA	M		0.0		0.00-0.25 m			SC	Clayey SAND fine grained, brown	W	L		0 5 10 15 20 25
				0.10									
			0.5		0.25-0.50 m 0.50-0.75 m			CL	Silty CLAY low to medium plasticity, orange brown, trace sand	M	S - St		
				0.80	0.75-1.00 m			SM	Silty Clayey SAND medium grained, grey	W	L		
			1.0						END OF BOREHOLE @ 1.00 m TARGET DEPTH				
			1.5										
			2.0										
			2.5										
			3.0										

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01h RL3

REPORT OF BOREHOLE: BH04

SHEET: 1 OF 1

CLIENT: Flanagan Consulting Group
PROJECT: CSDP
LOCATION: Northern Sands Pipeline
JOB NO: 1546223

COORDS: 364344.0 m E 8138454.0 m N MGA94 56
SURFACE RL: DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 1.00 m

DRILL RIG: Hand Auger
CONTRACTOR: Golder
LOGGED: DIS DATE: 8/3/17
CHECKED: GZL DATE: 29/3/17

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
HA	L		0.0		0.00-0.25 m			CL	Silty CLAY low plasticity, grey, brown	W	VS - S		0 5 10 15 20 25
			0.5		0.25-0.50 m								
					0.50-0.75 m								
			1.0		0.75-1.00 m				END OF BOREHOLE @ 1.00 m TARGET DEPTH				
			1.5										
			2.0										
			2.5										
			3.0										

REPORT OF BOREHOLE: BH05

SHEET: 1 OF 1

CLIENT: Flanagan Consulting Group
PROJECT: CSDP
LOCATION: Northern Sands Pipeline
JOB NO: 1546223

COORDS: 364043.0 m E 8138054.0 m N MGA94 56
SURFACE RL: DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 1.00 m

DRILL RIG: Hand Auger
CONTRACTOR: Golder
LOGGED: DIS DATE: 8/3/17
CHECKED: GZL DATE: 29/3/17

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
HA	L		0.0		0.00-0.25 m				Silty CLAY medium plasticity, brown, trace sand	W	S		HW
			0.5		0.25-0.50 m								HW
					0.50-0.75 m								HW
			1.0		0.75-1.00 m				END OF BOREHOLE @ 1.00 m TARGET DEPTH				
			1.5										
			2.0										
			2.5										
			3.0										

DCP TEST (AS1289.6.3.2) Blows per 100 mm: 0 5 10 15 20 25

REPORT OF BOREHOLE: BH06

SHEET: 1 OF 1

CLIENT: Flanagan Consulting Group
PROJECT: CSDP
LOCATION: Northern Sands Pipeline
JOB NO: 1546223

COORDS: 364186.0 m E 8137948.0 m N MGA94 56
SURFACE RL: DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 1.00 m

DRILL RIG: Hand Auger
CONTRACTOR: Golder
LOGGED: DIS DATE: 8/3/17
CHECKED: GZL DATE: 29/3/17

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm (0 5 10 15 20 25)
HA	L		0.0		0.00-0.25 m			SM	Silty Clayey SAND fine to medium grained, grey brown	M	L		
			0.5		0.25-0.50 m								
					0.50-0.75 m								
				0.60					decreasing clay content				
					0.75-1.00 m					W			
			1.0						END OF BOREHOLE @ 1.00 m TARGET DEPTH				
			1.5										
			2.0										
			2.5										
			3.0										

REPORT OF BOREHOLE: BH07

SHEET: 1 OF 1

CLIENT: Flanagan Consulting Group
COORDS: 363916.0 m E 8136606.0 m N MGA94 56
DRILL RIG:

PROJECT: CSDP
SURFACE RL: DATUM: AHD
CONTRACTOR:

LOCATION: Northern Sands Pipeline
INCLINATION: -90°
LOGGED: DIS DATE: 8/3/17

JOB NO: 1546223
HOLE DEPTH: 1.00 m
CHECKED: GZL DATE: 29/3/17

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
HA	M		0.0		0.00-0.25 m			ML	Clayey SILT low liquid limit, brown, dark brown, trace sand	M	S		0 5 10 15 20 25
				0.30	0.25-0.50 m			CL	Silty CLAY low plasticity, brown, dark brown		F - St		
			0.5		0.50-0.75 m								
					0.75-1.00 m								
			1.0						END OF BOREHOLE @ 1.00 m TARGET DEPTH				
			1.5										
			2.0										
			2.5										
			3.0										

REPORT OF BOREHOLE: BH08

SHEET: 1 OF 1

CLIENT: Flanagan Consulting Group
COORDS: 365317.0 m E 8134549.0 m N MGA94 56
DRILL RIG:

PROJECT: CSDP
SURFACE RL: DATUM: AHD
CONTRACTOR:

LOCATION: Northern Sands Pipeline
INCLINATION: -90°
LOGGED: DIS DATE: 8/3/17

JOB NO: 1546223
HOLE DEPTH: 1.00 m
CHECKED: GZL DATE: 29/3/17

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm 0 5 10 15 20 25
HA	L		0.0		0.00-0.25 m			CI	Silty Sandy CLAY medium plasticity, brown	W	VS - S		
			0.5		0.25-0.50 m 0.50-0.75 m 0.75-1.00 m								
			1.0						END OF BOREHOLE @ 1.00 m TARGET DEPTH				
			1.5										
			2.0										
			2.5										
			3.0										

METHOD OF SOIL DESCRIPTION USED ON BOREHOLE AND TEST PIT REPORTS


FILL


GRAVEL (GP or GW)


SAND (SP or SW)


SILT (ML or MH)


CLAY (CL, CI or CH)


ORGANIC SOILS (OL or OH or Pt)


COBBLES or BOULDERS

Combinations of these basic symbols may be used to indicate mixed materials such as sandy clay.

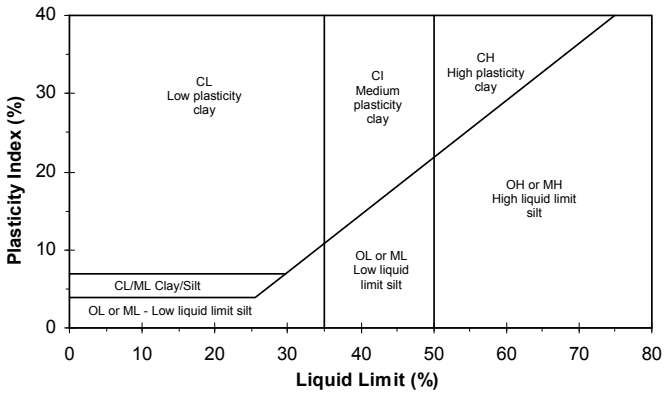
CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil and Rock is classified and described in Reports of Boreholes and Test Pits using the preferred method given in AS1726 – 1993, (Amdt1 – 1994 and Amdt2 – 1994), Appendix A. The material properties are assessed in the field by visual/tactile methods.

Particle Size

Major Division	Sub Division	Particle Size
BOULDERS		> 200 mm
COBBLES		63 to 200 mm
GRAVEL	Coarse	20 to 63 mm
	Medium	6.0 to 20 mm
	Fine	2.0 to 6.0 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties



MOISTURE CONDITION

AS1726 - 1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays & Silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition & may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726 - 1993

Symbol	Term	Undrained Shear Strength
VS	Very Soft	0 to 12 kPa
S	Soft	12 to 25 kPa
F	Firm	25 to 50 kPa
St	Stiff	50 to 100 kPa
VSt	Very Stiff	100 to 200 kPa
H	Hard	Above 200 kPa

Symbol	Term	Density Index %	SPT "N" #
VL	Very Loose	Less than 15	0 to 4
L	Loose	15 to 35	4 to 10
MD	Medium Dense	35 to 65	10 to 30
D	Dense	65 to 85	30 to 50
VD	Very Dense	Above 85	Above 50

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.

SPT correlations are not stated in AS1726 – 1993, and may be subject to corrections for overburden pressure and equipment type.

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT REPORTS

DRILLING/EXCAVATION METHOD

AS*	Auger Screwing	RD	Rotary blade or drag bit	NQ	Diamond Core - 47 mm
AD*	Auger Drilling	RT	Rotary Tricone bit	NMLC	Diamond Core - 52 mm
*V	V-Bit	RAB	Rotary Air Blast	HQ	Diamond Core - 63 mm
*T	TC-Bit, e.g. ADT	RC	Reverse Circulation	HMLC	Diamond Core – 63mm
HA	Hand Auger	PT	Push Tube	BH	Tractor Mounted Backhoe
ADH	Hollow Auger	CT	Cable Tool Rig	EX	Tracked Hydraulic Excavator
DTC	Diatube Coring	JET	Jetting	EE	Existing Excavation
WB	Washbore or Bailer	NDD	Non-destructive digging	HAND	Excavated by Hand Methods

PENETRATION/EXCAVATION RESISTANCE

L **Low resistance.** Rapid penetration possible with little effort from the equipment used.

M **Medium resistance.** Excavation/possible at an acceptable rate with moderate effort from the equipment used.

H **High resistance** to penetration/excavation. Further penetration is possible at a slow rate and requires significant effort from the equipment.

R **Refusal or Practical Refusal.** No further progress possible without the risk of damage or unacceptable wear to the digging implement or machine.

These assessments are subjective and are dependent on many factors including the equipment power, weight, condition of excavation or drilling tools, and the experience of the operator.

WATER

▽	Water level at date shown	◁	Partial water loss
▷	Water inflow	◀	Complete water loss

GROUNDWATER NOT OBSERVED	The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.
GROUNDWATER NOT ENCOUNTERED	The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following 150mm seating
30/80mm	Where practical refusal occurs, the blows and penetration for that interval are reported
RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB	Hammer double bouncing on anvil
DS	Disturbed sample
BDS	Bulk disturbed sample
G	Gas Sample
W	Water Sample
FP	Field permeability test over section noted
FV	Field vane shear test expressed as uncorrected shear strength (s_v = peak value, s_r = residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressuremeter test over section noted
PP	Pocket penetrometer test expressed as instrument reading in kPa
U63	Thin walled tube sample - number indicates nominal sample diameter in millimetres
WPT	Water pressure tests
DCP	Dynamic cone penetration test
CPT	Static cone penetration test
CPTu	Static cone penetration test with pore pressure (u) measurement

Ranking of Visually Observable Contamination and Odour (for specific soil contamination assessment projects)

R = 0	No visible evidence of contamination	R = A	No non-natural odours identified
R = 1	Slight evidence of visible contamination	R = B	Slight non-natural odours identified
R = 2	Visible contamination	R = C	Moderate non-natural odours identified
R = 3	Significant visible contamination	R = D	Strong non-natural odours identified

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100$$

SCR = Solid Core Recovery (%)

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum \text{Axial lengths of core} > 100 \text{ mm}}{\text{Length of core run}} \times 100$$

APPENDIX B

Laboratory Test Results

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Shed 3, 5 Commercial Place
Earlville QLD 4870

Laboratory: Cairns Laboratory
Phone: 0740337815 **Fax:** 0740546632

Email: Cairns@constructionsciences.net

EMERSON CLASS NUMBER REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/12538-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/699
Project:	Northern Sands	Lot Number:	
Location:	Holloways Beach	Internal Test Request:	11512/T/7317
Component:	Material Classification	Client Reference/s:	Submitted Samples: 29.03.2017
Area Description:	Northern Sands - Holloways Beach	Report Date / Page:	3/04/2017 Page 1 of 1

Test Procedures:	AS1289.3.8.1

Sample Number	11512/S/35727	11512/S/35728	11512/S/35729	11512/S/35730
ID / Client ID	-	-	-	-
Lot Number	-	-	-	-
Date / Time Sampled	8/03/2017	8/03/2017	8/03/2017	8/03/2017
Material Source	Northern Sands	Northern Sands	Northern Sands	Northern Sands
Material Type	Insitu Material	Insitu Material	Insitu Material	Insitu Material
Sampling Method	-	-	-	-
Water Type	Potable	Potable	Potable	Potable
Water Temperature (C°)	24	24	24	24
	BH-01	BH-05	BH-07	BH-08
	0.75 - 1.0	0.25-0.5	0.75-1.0	0.75-1.0
Soil Description	sand	Clay	clay and silt	silt and clay
Emerson Class Number	**6**	**5**	**5**	**5**

Remarks

NATA

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Accredited for compliance with ISO/IEC 17025

Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Anton Wespe
Form ID: W34Rep Rev 1

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
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Earlville QLD 4870

Laboratory: **Cairns Laboratory**
Phone: 0740337815 **Fax:** 0740546632

Email: Cairns@constructionsciences.net

MOISTURE CONTENT REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/12536-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/699
Project:	Northern Sands	Lot Number:	
Location:	Holloways Beach	Internal Test Request:	11512/T/7317
Component:	Material Classification	Client Reference/s:	Submitted Samples: 29.03.2017
Area Description:	Northern Sands - Holloways Beach	Report Date / Page:	3/04/2017 Page 1 of 1

Test Procedures:	AS1289.2.1.1

Sample Number	11512/S/35727	11512/S/35728	11512/S/35729	11512/S/35730
ID / Client ID	-	-	-	-
Lot Number	-	-	-	-
Date / Time Sampled	8/03/2017	8/03/2017	8/03/2017	8/03/2017
Sampling Method	-	-	-	-
Date Tested	29/03/2017	29/03/2017	29/03/2017	29/03/2017
Material Source	Northern Sands	Northern Sands	Northern Sands	Northern Sands
Material Type	Insitu Material	Insitu Material	Insitu Material	Insitu Material
	BH-01	BH-05	BH-07	BH-08
	0.75 - 1.0	0.25-0.5	0.75-1.0	0.75-1.0
Moisture Content (%)	**26.5**	**36.7**	**25.3**	**61.5**

Sample Number				
ID / Client ID				
Lot Number				
Date / Time Sampled				
Sampling Method				
Date Tested				
Material Source				
Material Type				
Moisture Content (%)				

Remarks

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Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Anton Wespe
Form ID: W20Rep Rev 1

Construction Sciences

Construction Sciences Pty Ltd
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Shed 3, 5 Commercial Place
Earlville QLD 4870

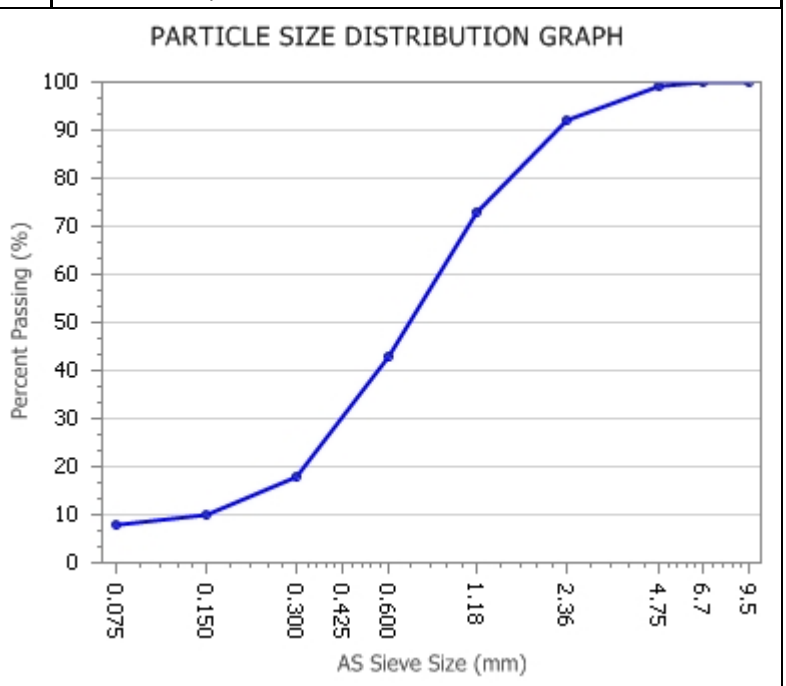
Laboratory: Cairns Laboratory
Phone: 0740337815 **Fax:** 0740546632
Email: Cairns@constructionsciences.net

QUALITY OF MATERIALS REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/12537-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/699
Project:	Northern Sands	Lot Number:	
Location:	Holloways Beach	Internal Test Request:	11512/T/7317
Component:	Material Classification	Client Reference/s:	Submitted Samples: 29.03.2017
Area Description:	Northern Sands - Holloways Beach	Report Date / Page:	3/04/2017 Page 1 of 4

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS 1289.3.3.1		
Sample Number	11512/S/35727		BH-01
Sampling Method	-		0.75 - 1.0
Date Sampled	8/03/2017		
Sampled By	Client Sampled		
Date Tested	30/03/2017	Material Source	Northern Sands
Att. Drying Method	-	Material Type	Insitu Material
Atterberg Preparation	-	Material Description	sand

AS Sieve (mm)	Specification Minimum	Percent Passing (%)	Specification Maximum
9.5		**100**	
6.7		**100**	
4.75		**99**	
2.36		**92**	
1.18		**73**	
0.600		**43**	
0.300		**18**	
0.150		**10**	
0.075		**8**	



Test Result	Specification Minimum	Result	Specification Maximum	Test Result	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)		**Not Obtainable**		0.075/0.425 Fines Ratio		-	
Plastic Limit (%)		**Not Obtainable**		PI x 0.425 Ratio (%)		-	
Plastic Index (%)		**Non Plastic**		LS x 0.425 Ratio (%)		-	
Linear Shrinkage (%)		**0.5**		Linear Shrinkage Defects	-		

Remarks

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Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Anton Wespe
Form ID: W85Rep Rev 1

Construction Sciences

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Laboratory: Cairns Laboratory
Phone: 0740337815 **Fax:** 0740546632
Email: Cairns@constructionsciences.net

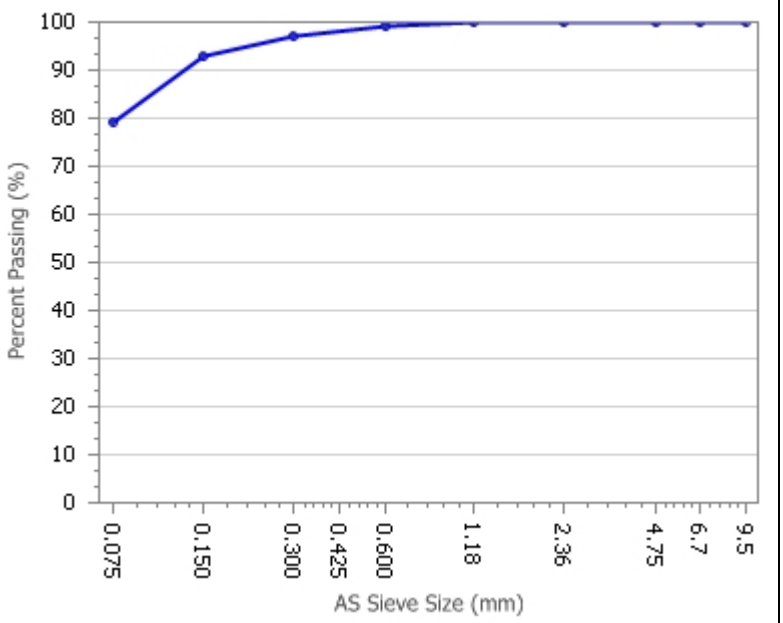
QUALITY OF MATERIALS REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/12537-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/699
Project:	Northern Sands	Lot Number:	
Location:	Holloways Beach	Internal Test Request:	11512/T/7317
Component:	Material Classification	Client Reference/s:	Submitted Samples: 29.03.2017
Area Description:	Northern Sands - Holloways Beach	Report Date / Page:	3/04/2017 Page 2 of 4

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1		
Sample Number	11512/S/35728		BH-05
Sampling Method	-		0.25-0.5
Date Sampled	8/03/2017		
Sampled By	Client Sampled		
Date Tested	30/03/2017	Material Source	Northern Sands
Att. Drying Method	Oven Dried	Material Type	Insitu Material
Atterberg Preparation	Dry Sieved	Material Description	Clay

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
9.5		**100**	
6.7		**100**	
4.75		**100**	
2.36		**100**	
1.18		**100**	
0.600		**99**	
0.300		**97**	
0.150		**93**	
0.075		**79**	

PARTICLE SIZE DISTRIBUTION GRAPH



Test Result	Specification Minimum	**Result**	Specification Maximum	Test Result	Specification Minimum	**Result**	Specification Maximum
Liquid Limit (%)		**31**		0.075/0.425 Fines Ratio		**-**	
Plastic Limit (%)		**19**		PI x 0.425 Ratio (%)		**-**	
Plastic Index (%)		**12**		LS x 0.425 Ratio (%)		**-**	
Linear Shrinkage (%)		**4.5**		Linear Shrinkage Defects	-		

Remarks

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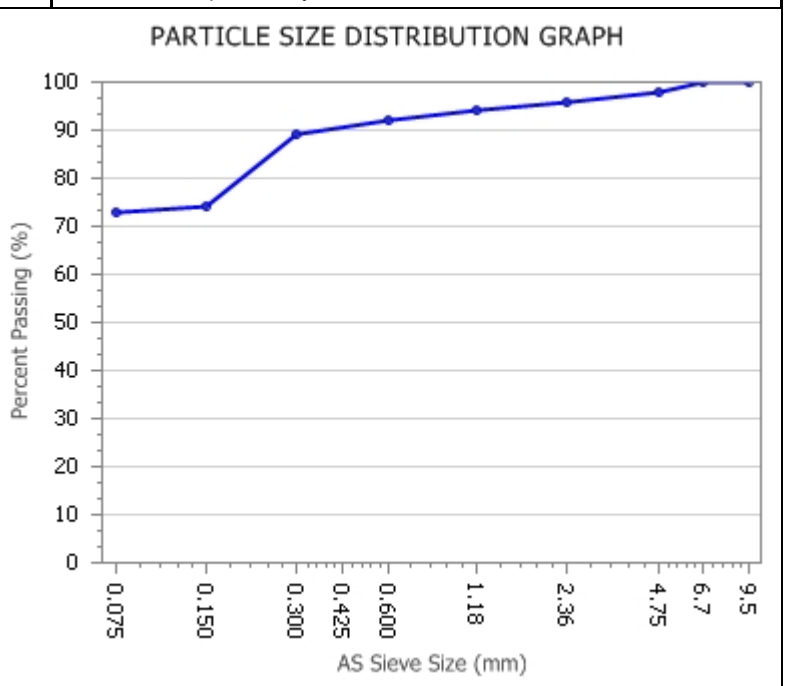
QUALITY OF MATERIALS REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/12537-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/699
Project:	Northern Sands	Lot Number:	
Location:	Holloways Beach	Internal Test Request:	11512/T/7317
Component:	Material Classification	Client Reference/s:	Submitted Samples: 29.03.2017
Area Description:	Northern Sands - Holloways Beach	Report Date / Page:	3/04/2017 Page 3 of 4

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1		
Sample Number	11512/S/35729		BH-07
Sampling Method	-		0.75-1.0
Date Sampled	8/03/2017		
Sampled By	Client Sampled		
Date Tested	30/03/2017	Material Source	Northern Sands
Att. Drying Method	Oven Dried	Material Type	Insitu Material
Atterberg Preparation	Dry Sieved	Material Description	clay and silt

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
9.5		**100**	
6.7		**100**	
4.75		**98**	
2.36		**96**	
1.18		**94**	
0.600		**92**	
0.300		**89**	
0.150		**74**	
0.075		**73**	



Test Result	Specification Minimum	**Result**	Specification Maximum	Test Result	Specification Minimum	**Result**	Specification Maximum
Liquid Limit (%)		**33**		0.075/0.425 Fines Ratio		-	
Plastic Limit (%)		**20**		PI x 0.425 Ratio (%)		-	
Plastic Index (%)		**13**		LS x 0.425 Ratio (%)		-	
Linear Shrinkage (%)		**4.5**		Linear Shrinkage Defects	-		

Remarks

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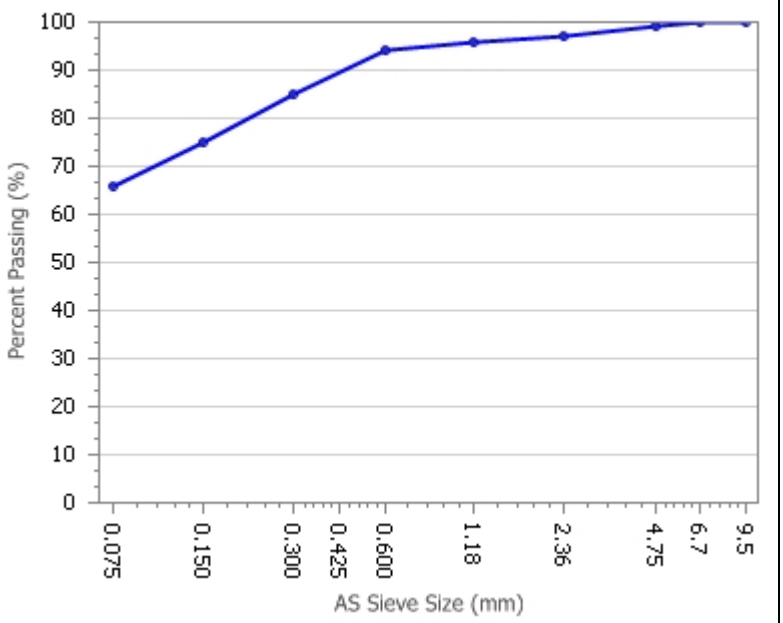
QUALITY OF MATERIALS REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/12537-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/699
Project:	Northern Sands	Lot Number:	
Location:	Holloways Beach	Internal Test Request:	11512/T/7317
Component:	Material Classification	Client Reference/s:	Submitted Samples: 29.03.2017
Area Description:	Northern Sands - Holloways Beach	Report Date / Page:	3/04/2017 Page 4 of 4

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1		
Sample Number	11512/S/35730		BH-08
Sampling Method	-		0.75-1.0
Date Sampled	8/03/2017		
Sampled By	Client Sampled		
Date Tested	30/03/2017	Material Source	Northern Sands
Att. Drying Method	Oven Dried	Material Type	Insitu Material
Atterberg Preparation	Dry Sieved	Material Description	silt and clay

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
9.5		**100**	
6.7		**100**	
4.75		**99**	
2.36		**97**	
1.18		**96**	
0.600		**94**	
0.300		**85**	
0.150		**75**	
0.075		**66**	

PARTICLE SIZE DISTRIBUTION GRAPH



Test Result	Specification Minimum	**Result**	Specification Maximum	Test Result	Specification Minimum	**Result**	Specification Maximum
Liquid Limit (%)		**44**		0.075/0.425 Fines Ratio		-	
Plastic Limit (%)		**28**		PI x 0.425 Ratio (%)		-	
Plastic Index (%)		**16**		LS x 0.425 Ratio (%)		-	
Linear Shrinkage (%)		**6.5**		Linear Shrinkage Defects	-		

Remarks

NATA

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Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Anton Wespe
Form ID: W85Rep Rev 1

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Darcy Simpson
Client	GOLDER ASSOCIATES PTY LTD
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Telephone	07 4054 8200
Facsimile	07 4054 8201
Email	dasimpson@golder.com.au
Project	**1546223**
Order Number	**1546223**
Samples	1

LABORATORY DETAILS

Manager	Jon Dicker
Laboratory	SGS Cairns Environmental
Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	+61 07 4035 5111
Facsimile	+61 07 4035 5122
Email	AU.Environmental.Cairns@sgs.com
SGS Reference	**CE126763 R0**
Date Received	10 Apr 2017
Date Reported	13 Apr 2017

COMMENTS

Accredited for compliance with ISO/IEC 17025- Testing. NATA accredited laboratory 2562(3146)

SIGNATORIES

Anthony Nilsson
Operations Manager

Jon Dicker
Manager Northern QLD

Leanne Orsmond
Quality & Microbiology Coordinator

Parameter	Units	LOR	Sample Number CE126763.001 Sample Matrix Soil Sample Depth 0.0-0.3 Sample Date 10 Apr 2017 Sample Name BOAT SAMPLE 1
Moisture Content Method: AN002 Tested: 10/4/2017			
% Moisture	%w/w	0.5	**51**
TAA (Titratable Actual Acidity) Method: AN219 Tested: 13/4/2017			
pH KCl	pH Units	-	**4.5**
Titratable Actual Acidity	kg H2SO4/T	0.25	**2.6**
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5	**52**
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01	**0.08**
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 13/4/2017			
Chromium Reducible Sulphur (Scr)	%	0.005	**1.9**
Chromium Reducible Sulphur (Scr)	moles H+/T	5	**1200**

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Chromium Reducible Sulphur (CRS) **Method: ME-(AU)-[ENV]AN217**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chromium Reducible Sulphur (Scr)	LB045269	%	0.005	<0.005	0%	86%
Chromium Reducible Sulphur (Scr)	LB045269	moles H+/T	5	<5		

TAA (Titratable Actual Acidity) **Method: ME-(AU)-[ENV]AN219**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH KCl	LB045270	pH Units	-	5.9	0%	101%
Titratable Actual Acidity	LB045270	kg H2SO4/T	0.25	<0.25	0%	NA
Titratable Actual Acidity (TAA) moles H+/tonne	LB045270	moles H+/T	5	<5	0%	92%
Titratable Actual Acidity (TAA) S%w/w	LB045270	%w/w S	0.01	<0.01	0%	92%

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN217	Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulfide (H2S) which is collected and titrated with iodine (I2(aq)) to measure SCR.
AN219	Dried pulped sample is extracted for 4 hours in a 1 M KCl solution. The ratio of sample to solution is 1:40. The extract is titrated for acidity. Calcium, magnesium, and sulfur are determined by ICP-AES.

FOOTNOTES

IS	Insufficient sample for analysis.
LNR	Sample listed, but not received.
*	NATA accreditation does not cover the performance of this service.
**	Indicative data, theoretical holding time exceeded.
LOR	Limit of Reporting
↑↓	Raised or Lowered Limit of Reporting
QFH	QC result is above the upper tolerance
QFL	QC result is below the lower tolerance
-	The sample was not analysed for this analyte
NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

Test Location	Depth Range (m - BGL)		Material Description	pH_{FIELD}	pH_{KCl}	sTAA Converted to %S*	Existing Acidity %S (sTAA + 0.75 x S_{NAS})	Chromium Reducible Sulfur (S_{CR}) %S	Acid Neutralising Capacity %CaCO3 (if pH more than 6.5)	Net Acidity %S (S_{CR}+Existing Acidity - ANC/FF)	Is This AASS	Is This PASS	Liming Rate for Existing Acidity (Neutralises AASS only) (kg/m3)	Liming Rate for Net Acidity (Neutralises both AASS & PASS) (kg/m3)
BH01	0.25	0.50	Clayey SAND	8.96	5.3	0.020	0.020	0.880		0.900	No	YES	NA	68.1
BH02	0.00	0.25	Silty CLAY	4.75	4.5	0.040	0.040	< 0.005		0.040	Possible Organic Acidity	No	3.0	NA
BH03	0.75	1.00	Clayey SAND	8.00	5.7	< 0.010	0.000	< 0.005		0.000	No	No	NA	NA
BH04	0.00	0.25	Silty CLAY	7.97	6.4	< 0.010	0.000	0.150		0.150	No	YES	NA	11.3
BH05	0.75	1.00	Silty CLAY	4.60	5.0	0.030	0.030	< 0.005		0.030	No	No	NA	NA
BH06	0.00	0.25	Clayey SAND	4.80	6.2	< 0.010	0.000	< 0.005		0.000	No	No	NA	NA
BH07	0.25	0.50	Silty CLAY	4.20	4.6	0.020	0.020	< 0.005		0.020	No	No	NA	NA
BH08	0.25	0.50	Silty CLAY	5.60	6.4	< 0.010	0.000	0.006		0.006	No	No	NA	NA
BOAT SAMPLE 1	0.00	0.30	Silty CLAY	5.75	4.5	0.080	0.080	1.900		1.980	YES	YES	6.0	149.7

Note: * Equivalent oxidisable sulfur calculated as TAA/30.59

Liming rates assume a bulk density of 1.60 t/m3

Fineness Factor = 1.5

Golder Associates

TABLE 1
SUMMARY OF ACID SULFATE TEST RESULTS

Client: FCG

Job Title: Cairns Port Development

Location: Holloways Beach

pH FIELD TESTS

Method: As per the Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998.

Client :	**FCG**	**Project Number :**	1546223
Project :	**Northern Sands Pipeline**	**Tested By/Date :**	8/03/2017
Location :	**Holloways Beach**	**Checked By / Date :**	13/04/2017

pH Meter No. :	-	**pH Peroxide :**	5.5
Date pH Meter Calibrated :	**8/03/2017**	**pH Distilled Water :**	6.8

Hole No.	Depth (m)		Soil Type	pH	pH fox	reaction	PASS Potential high	PASS Potential medium	PASS Potential low
BH01	0	0.25		9.0	2.6	1	x		
	0.25	0.5		9.0	1.8	4	x		
	0.5	0.75		8.4	1.8	4	x		
	0.75	1		8.2	1.8	4	x		
BH02	0	0.25		4.8	2.9	1	x		
BH03	0	0.25		8.0	4.9	1			x
	0.25	0.5		8.1	7.1	1			x
	0.5	0.75		8.1	2.9	1	x		
	0.75	1		8.0	2.4	1	x		
BH04	0	0.25		8.0	2.9	1	x		
	0.25	0.5		8.0	2.7	1	x		
	0.5	0.75		7.5	2.7	1	x		
	0.75	1		7.6	2.8	1	x		
BH05	0	0.25		5.5	4.3	1			x
	0.25	0.5		5.2	4.1	1			x
	0.5	0.75		4.6	3.7	1			x
	0.75	1		4.6	3.3	1			x
BH06	0	0.25		4.8	4.7	1			x
	0.25	0.5		4.5	4.6	1			x
	0.5	0.75		4.5	4.6	1			x
	0.75	1		4.4	4.6	1			x
BH07	0	0.25		4.5	2.7	1	x		
	0.25	0.5		4.2	2.4	1	x		
	0.5	0.75		4.3	3.2	1		x	
	0.75	1		4.7	4.8	3			x
BH08	0	0.25		5.8	3.8	1			x
	0.25	0.5		5.6	2.7	1	x		
	0.5	0.75		5.4	3.9	1			x
	0.75	1		5.8	2.3	3	x		
BOAT SAMPLE 1	0	0.3		5.8	1.1	4	x		

APPENDIX C

Queensland Government Terms of Reference
Commonwealth Guidelines

Queensland Government Terms of Reference

Flanagan Consulting Group has extracted relevant items from the Queensland Government Terms of Reference for soils studies. These items and relevant details are presented below. Items that are not in scope are shaded grey in the table. The section of this report where each item is discussed is also shown in the table.

Relevant Queensland Government ToR - Soils

ToR	Title	Details	Comments
4.1.2	Dredge spoil disposal	Bore logs at a frequency and depth, and with material characterisation sufficient to determine potential displacement of material and/or the need for excavation	Refer Section 4.2, Fig 5
		Contaminant assessment of material potential displaced or excavated consistent with the NAGD	
		Acid sulfate soil survey of material potentially displaced or excavated consistent with the Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998 (Ahern et al. 1998)	Refer Section 3.5, 4.2 & 5.0
4.2	Location	Location of natural features including intertidal sand and mud banks, wetland areas including Port of Cairns and Trinity Inlet Wetland	Refer Fig 1
5.2.3	Topography, geology and soils	Provide a description, map and a series of cross-sections of the geology of the project area relevant to the project components.	Refer Figs 1 to 4
		Assess the potential for acid sulfate soils in accordance with:	
		• Queensland Acid Sulfate Soil Technical Manual	Refer Section 3.5, 4.2 & 5.0
		• Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998 (Ahern et al. 1998)	Refer Section 3.5, 4.2 & 5.0
		• State Planning Policy 2/02: Planning and Managing Development Involving Acid Sulfate Soils (Department of Natural Resources and Mines & Department of Local Government and Planning 2002a)	Refer Section 3.5, 4.2 & 5.0
		• State Planning Policy 2/02 Guideline: Acid Sulfate Soils (Department of Natural Resources and Mines & Department of Local Government and Planning 2002b).	Refer Section 3.5, 4.2 & 5.0
		Provide geotechnical information on the soils' stability and suitability for construction of project facilities.	Refer Section 2.0
		Identify any erosion management techniques to be used. Provide details of an erosion monitoring program (including rehabilitation measures for erosion problems identified during construction), and detail acceptable mitigation strategies. Summarise methods proposed to prevent or control erosion with regard to:	

ToR	Title	Details	Comments
		• the Soil Erosion and Sediment Control—Engineering Guidelines for Queensland Construction Sites (Institution of Engineers Australia 1996)	Refer Section 2.1
		• the Guideline: EPA Best Practice Urban Stormwater Management—Erosion and Sediment Control (Environmental Protection Agency 2008a)	Refer Section 2.1
		• preventing soil loss in order to maintain land capability/suitability	Refer Section 2.1
		• preventing degradation of local waterways.	Refer Section 2.1
		Discuss the potential for acid generation from disturbance of acid sulfate soils during earthworks and construction, and propose measures to manage soils and mitigate impacts for all site earthworks and construction activities. Should action criteria be triggered by acid generating potential as a result of testing, provide a site-specific acid sulfate soils management plan prepared in accordance with: Queensland Acid Sulfate Soil Technical Manual)	Refer Section 2.0, 3.5, 4.2 & 5.0
		• State Planning Policy 2/02: Planning and Managing Development Involving Acid Sulfate Soils (Department of Natural Resources and Mines & Department of Local Government and Planning 2002a)	Refer Section 2.0, 3.5, 4.2 & 5.0
		Provide details of any potential impacts to the topography or geomorphology associated with the project and proposed mitigation measures, including: - a discussion of the project in the context of major topographic features and any measures taken to avoid or minimise impact to such. - relevant coastal geomorphology, characterised and supported by illustrative mapping	Refer Section 2.0, 3.2 & 5.0
5.2.3	Topography, geology and soils	Provide details of any potential impacts to the topography or geomorphology associated with the project and proposed mitigation measures, including:	Refer Section 2.0, 3.2 & 5.0
5.2.3	Topography, geology and soils	Discussion of the project in the context of major topographic features and any measures taken to avoid or minimise impact to such.	Refer Section 2.0, 3.2 & 5.0

Commonwealth Guidelines

Flanagan Consulting Group has extracted relevant items from the Commonwealth Guidelines for soils studies. These items and relevant details are presented below. Items that are not in scope are shaded grey in the table. The section of this report where each item is discussed is also shown in the table.

Relevant Commonwealth Government Guidelines

Guideline	Title	Details	Comments
5.9	The Existing Environment	This section must provide a description of the project area including baseline condition and trends of coastal, terrestrial and marine environments, including hydrology, sediment characteristics, sediment flows, geography, flora and fauna, cultural and heritage values, and all relevant socio-economic considerations. This section must link to the proposal description, potential impacts, and proposed avoidance, mitigation, adaptive management framework and/or offset measures throughout the life of the project including pre-construction, construction, operation, and any decommissioning. This section is to also identify and reference any relevant (published and unpublished) studies undertaken in the area which will assist in describing patterns and trends in the environment. Acute and chronic) from geotechnical activities (such as blasting (such as blasting (such as blasting (such as blasting pile driving), impacts of increased marine underwater marine species, including the impacts from noise at varying from each project component (considering the variables e.g. depth, wave height, bottom profile); impacts from proposal on air quality impacts; dredged material and impacts from increased shipping	Refer Sections 3.0, 4.0 and 5.0
5.9	The Existing Environment	The section must include a description of the environment of the proposal site and the surrounding areas that may be affected by the action. This must include the following information:	Refer Sections 3.0, 4.0 and 5.0
5.9	The Existing Environment	b) A detailed assessment of the nature, extent, likelihood and consequence of the likely short-term and long-term impacts including but not limited to: description of the risks and potential impacts disposal impacts	Refer Section 8.0
5.9	The Existing Environment	e) Any technical data, including modelling, and other information used or needed to make a detailed assessment of the relevant impacts;	Refer Sections 3.0, 4.0 and 5.0
5.9	The Existing Environment	h) Consideration of potential impacts throughout the life of the proposal – from preconstruction, construction through to operation and any decommissioning;	Refer Sections 7.0 & 8.0
5.9	The Existing Environment	I) Impacts on the existing use of the area and nearby areas that may be affected by the proposed action;	Refer Sections 7.0 & 8.0

Guideline	Title	Details	Comments
5.10	Relevant Impact of the Proposed Action	The EIS must include a description of all of the relevant impacts of the action. Relevant impacts (both direct and indirect) are impacts that the action will have or is likely to have on a matter protected by a controlling provision (as listed in the preamble of this document). This section must provide clear linkages with the existing environmental values described in section 5.9 and proposed avoidance, safeguards, management and mitigation measures described in section 5.11. Impacts during all phases of the project must be addressed. This section must include:	Refer Sections 7.0 and 8.0
5.10	Relevant Impact of the Proposed Action	a) A description of the framework used to assess impacts, including risk assessment processes based on an approved standard;	Refer Section 8.0
5.10	Relevant Impact of the Proposed Action	b) A detailed assessment of the nature, extent, likelihood and consequence of the likely short-term and long-term impacts including but not limited to: description of the risks and potential impacts (acute and chronic) from geotechnical activities (such as blasting and pile driving), impacts of increased marine underwater noise on marine species, including the impacts from noise at varying distances from each project component (considering the environmental variables e.g. depth, wave height, bottom profile); impacts from the proposal on air quality impacts; dredging and dredged material disposal impacts and impacts from increased shipping;	Refer Section 8.0
5.10	Relevant Impact of the Proposed Action	c) A statement whether any relevant impacts are likely to be unknown, unpredictable, irreversible or sub-lethal (reversible over time) and what confidence level is placed on the predictions of relevant impacts;	Refer Section 8.0
5.10	Relevant Impact of the Proposed Action	d) Analysis of the significance of the impacts;	Refer Section 8.0
5.10	Relevant Impact of the Proposed Action	e) Any technical data, including modelling, and other information used or needed to make a detailed assessment of the relevant impacts;	Refer Sections 3.0, 4.0 and 5.0
5.10	Relevant Impact of the Proposed Action	f) Consideration of potential impacts throughout the life of the proposal – from preconstruction, construction through to operation and any decommissioning;	Refer Sections 7.0 and 8.0
5.10.9	Dredging and Dredged Material	h) Assessment of the risk and potential impacts of acid sulfate soils (ASS) and potential acid sulfate soils (PASS);	Refer Section 3.4, 4.2 & 5.0

Guideline	Title	Details	Comments
5.11	Proposed avoidance, safeguards, management and mitigation measures	The EIS must provide information on proposed avoidance, safeguards and mitigation measures to deal with the impacts of the action. Specific and detailed descriptions of proposed measures must be provided and substantiated, based on best available practices/standards and must include the following elements.	Refer Section 8.0
5.11	Proposed avoidance, safeguards, management and mitigation measures	a) Identify the level of risk associated with potential impacts already identified and those that require mitigation, monitoring or management to avoid or reduce impacts to an acceptable level;	Refer Section 8.0
5.11	Proposed avoidance, safeguards, management and mitigation measures	b) A consolidated list of measures proposed to be undertaken to avoid, prevent, minimise or compensate (in priority order) for the impacts of the action (as specified in section 5.10), including: i. A description of proposed avoidance, safeguards and mitigation measures to deal with impacts of the action, including measures proposed to be taken by State governments, local governments or the proponent; ii. Assessment of the expected or predicted effectiveness of the measures; iii. Any statutory or policy basis for the mitigation measures; iv. The cost of the mitigation measures; and v. The resulting risk level for that impact post- avoidance, mitigation and/or management.	Refer Section 8.0
5.11	Proposed avoidance, safeguards, management and mitigation	c) Particular focus must be given to: i. Determining factors in the planning of the proposal so as to avoid damage to the environment;	Refer Section 8.0

APPENDIX D

Important Information

IMPORTANT INFORMATION RELATING TO THIS REPORT

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

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Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

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Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification.

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