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Report

GLNG EIS Supplement

Common Pipeline Infrastructure Corridor - ASS assessment of additional field data

Prepared for

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Abbreviations

Abbreviation	Description
AASS	Actual Acid Sulfate Soils
ANC	Acid Neutralising Capacity
ASS	Acid Sulphate Soils
ASSMP	Acid Sulfate Soils Management Plan
CICSDA	Callide Infrastructure Corridor State Development Area
CPIC	Common Pipeline Infrastructure Corridor
CRS	Chromium reducing sulphur
DERM	Department of Environment Resource Management
DNRW	Department of Natural Resources and Water
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
GSDA	Gladstone State Development Area
GHD	GHD Pty Ltd
GLNG	Gladstone Liquefied Natural Gas
GTP	Gas transmission pipeline
ha	Hectares
km	Kilometre
LOR	Level of reporting
m	Metre
mbgl	Meters below ground level
PASS	Potential Acid Sulfate Soils
QASSIT	Queensland Acid Sulphate Soils Investigation Team
SPOCAS	Suspended Peroxide Oxidation Combined Acidity and Sulphur
sTAA	Titratable Actual Acidity
URS	URS Australia Pty

1 Introduction

URS Australia Pty Ltd (URS) was commissioned by Santos Ltd (Santos) to undertake a review of acid sulfate soil (ASS) data obtained by GHD Pty Ltd (GHD) during recent geotechnical investigations, carried out along a 3 km section of the GSDA section of the Common Pipeline Infrastructure Corridor (CPIC (GSDA Section) Route) leading to Friend Point, south of Kangaroo Island.

The CPIC (GSDA Section) Route is a shared infrastructure corridor for multiple proponents proposed by the Queensland Government within the GSDA. There is potential for the CPIC (GSDA Section) Route corridor to be utilised for the gas transmission pipeline (GTP) for the Gladstone Liquefied Natural Gas (GLNG) project. The various LNG proponents, including Santos, are currently working with the Queensland Government to finalise the location of the CPIC (GSDA Section) Route. As the CPIC (GSDA Section) Route was not finalised at the time the GLNG EIS was submitted, only limited assessment of the corridor was possible. The GLNG GTP (September 2009) is the route alternatives identified by Santos since March 2009 (as a single alignment) as the result of further engineering, geotechnical, environmental and other investigations. Santos is continuing to consider the EIS GTP (March 2009), the CPIC (CICSDA Section) Route, the CPIC (GSDA Section) Route, and the Callide Range Alternative Route.

The final gas transmission pipeline (GTP) route corridor will be determined once the final engineering design for the GTP has been developed and is subject to Santos and/or the government obtaining the necessary underlying land interest and negotiation of access terms and conditions with respect to the CPIC Route.

Attached Figure 1 (Appendix A) shows previous GeoCoastal locations investigated in relation to the GLNG GTP (September 2009); Figure 2 (Appendix A) shows a section of the CPIC (GSDA Section) Route along with part of the GLNG GTP (September 2009) and the GHD investigation locations. Appendix C details the Acid Sulfate Soil studies completed to date, including methods of study, information collected and management plans.

Objectives

The specific objectives for this study were as follows:

- Processing of ASS data and associated sample locations provided by GHD, in relation to the CPIC (GSDA Section) Route;
- Description of any ASS identified for the sample locations based on the data provided; and
- Establishing the suitability of the data to characterise the CPIC (GSDA Section) Route for ASS to a level considered suitable to establish management requirements.

All data and information used in this report has been provided to URS by GHD on behalf of Santos. Accordingly, the conclusions and recommendations made in this report have been made, based on data provided to URS. URS has made no independent verification of this information except as expressly stated in the body of this report.

Until such time as the GTP design, precise route alignment and construction methods are finalised, the location and specific detail of material disturbance and hence the exact nature of the ASS disturbance, is not available.

Accordingly, the objective of this investigation was to review sampling and ASS results undertaken with respect to the section of the CPIC (GSDA Section) Route leading to Friend Point, south of Kangaroo Island, to identify occurring lithologies, ASS risks and possible management approaches.

Acid Sulfate Soils Background

2.1 Acid Sulfate Soils

ASS is a common name for naturally occurring clays, muds and sands rich in iron sulfides (pyrite). ASS typically occurs in coastal and estuarine sediments. When such sediments are exposed to the air by excavation, dredging, placement of fill or by lowering the local ground water table, the iron sulfides react with oxygen to form sulfuric acid according to the following overall reaction:

$$FeS_2 + \frac{15}{4}O_2 + \frac{7}{2}H_2O \dashrightarrow Fe(OH)_3 + 2\,SO_4^{2-} + 2\,H_2^{+}$$

The decrease in pH also causes iron, aluminum and other metals to become soluble. The flushing or leaching of disturbed ASS potentially enables mobilization of the dissolved metals and acidic leach waters. This can cause significant impact to the environment, engineered structures and human health in the receiving areas.

In their natural (usually anaerobic) environments, the iron sulfides in the soil are relatively stable. These stable ASS are called Potential Acid Sulfate Soils (PASS) because they have the potential to produce acidity when exposed to oxygen, but have not yet done so. PASS materials have a pH close to neutral (pH 6.5 – 7.5) when undisturbed. Disturbed PASS materials that have been subjected to oxidation are referred to as Actual Acid Sulfate Soils (AASS). AASS are acidic and have a pH of less than 4.

2.2 Investigation Requirements

The *State Planning Policy 2/02 Guideline – Acid Sulfate Soils* (SPP 2/02), the *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland 1988* (Ahern et al. 1998) and the *Soil Management Guidelines – Queensland Acid Sulfate Soils Technical Manual* (Moore et al. 2002), outline the requirements for investigation, treatment and management of ASS. Additionally, the *Acid Sulfate Soils Laboratory Methods Guidelines* (Ahern et al., 2004) outline the analytical methods for ASS laboratories, as well as having determinations for establishing neutralisation targets (where required).

The SPP2/02 outlines the criteria for the volume, elevation and type of soil disturbance, which trigger the requirements for ASS investigation, as follows:

Where surface elevation ≤5 m AHD:

- Filling ≥500 m^3 with average depth ≥0.5 m; and
- Excavations ≥100 m^3.

Where surface elevation >5 mAHD and <20 mAHD:

- If excavations include ≥100 m^3 of material from <5 mAHD.

2.3 Sampling Frequency for Trenches

The *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland 1988* states "more detailed transect sampling (50 m intervals) will usually be required along proposed excavations e.g. canals, lakes, drainage channels and borrows pits."

However, with proven consistency of spatial and vertical lithology and consistency in the related analytical ASS results, reduced sampling frequencies can be justified. This would require confirmatory sampling in the areas of disturbance.

2.4 Action Criteria

In Queensland, action criteria defined in SPP2/02 indicate when ASS disturbed at a site will need to be managed. Action criteria are based on the sum of actual (existing) plus potential acidity and are shown in Table 2-1. The action criteria are differentiated on the basis of soil textural characteristics depending on the scale of the project.

Given the scale of the proposed works and the texture within the marine sediments, the most conservative trigger value was assumed of 0.03%S Equivalent Sulphur (existing + potential acidity).

Table 2-1 Action Criteria Based on ASS Analysis for Three Broad Texture Categories

Type of Material		Action Criteria if 1 to 1000		Action Criteria if more than 1000	
		Existing + Potential Acidity		Existing + Potential Acidity	
Texture Range	Approximate clay content	Equivalent Sulphur (oven-dry basis)	Equivalent Acidity (oven-dry basis)	Equivalent Sulphur (oven-dry basis)	Equivalent Acidity (oven-dry basis)
Coarse Texture Sands to loamy sand	≤5 (%)	0.03 (%S)	18 (mol H^+/tonne)	0.03 (%S)	18 (mol H^+/tonne)
Medium texture Sandy loams to light clays	5-40 (%)	0.06 (%S)	36 (mol H^+/tonne)	0.03 (%S)	18 (mol H^+/tonne)
Fine texture (Medium to heavy clays and silty clays)	≥40 (%)	0.1 (%S)	62 (mol H^+/tonne)	0.03 (%S)	18 (mol H^+/tonne)

2.5 Indicative (Field Screening) ASS Testing

Field pH (pH_F) and oxidised field pH (pH_{FOX}) are indicative tests and involve the addition of water and hydrogen peroxide (to simulate full oxidation) respectively, to soil samples. These tests are used to indicate the likelihood of a soil becoming AASS or PASS, according to the following:

- pH_F value of less than 4 may indicate that AASS is present;
- pH_{FOX} value of less than 3 may indicate that PASS is present;
- pH_{FOX} values 1 pH unit below the associated pH_F value may indicate PASS, with larger reductions in pH_{FOX} generally providing a stronger indication of PASS; and
- A strong reaction to peroxide in the pH_{FOX} test may also indicate PASS. The oxidation of organic matter may also result in strong reaction rates.

3

Regional Geology and ASS Risk Maps

3.1 Regional Geology

The lithology of the proposed CPIC (GSDA Section) Route leading to Friend Point, south of Kangaroo Island is Holocene sediment and surficial alluvial material, occurring as coastal tidal flats, mangrove flats, supratidal flats and grasslands, is comprised of mud, sandy mud, muddy sand, and minor gravel ("Geological Series 1:100,000 Map for Gladstone (Sheet 9150), Department of Mines (1998)").

3.2 ASS Risk Maps

ASS risk maps are generated and published by the Queensland Department of Natural Resources and Water (DNRW) now Department of Environment and Resource Management (DERM). At the time of this investigation, several ASS studies had been commissioned by DERM in the area around Gladstone (Tannum Sands and The Narrows) as well as numerous industry commissioned ASS surveys; however, no ASS risk map had been published for the Gladstone area by DERM or previously by DNRW.

Given the presence of Holocene tidal flats and marine muds, this area of proposed works may contain acidic or potentially acidic marine clays.

4 Previous Studies

4.1 GeoCoastal (2008) – GLNG GTP (September 2009)

Santos commissioned GeoCoastal to carry out a preliminary assessment of ASS as part of the EIS for the GLNG GTP, being the GTP route proposed by Santos in September 2009 between the CSG fields and the LNG facility on Curtis Island..

As part of that preliminary study GeoCoastal undertook ASS sampling along the coast of Kangaroo Island from Fisherman's Landing to Friend Point. GeoCoastal's report is included as EIS Appendix L4.

GeoCoastal's report provides data regarding the ASS condition on the coast south of Kangaroo Island and can be considered indicative of the condition along the CPIC (GSDA Section) Route, given the consistent published and observed lithology reported between the two alignments.

Of the 23 boreholes GeoCoastal located along the coast of Kangaroo Island south of Friend Point (the GLNG GTP (September 2009)), 11 are considered relevant to the ASS condition of the material along the CPIC (GSDA Section) Route. These are GeoCoastal locations 44 to 54 (shown in attached Figure 1 – Appendix A) with a maximum investigation depth of 3.0 mbgl.

Samples collected by GeoCoastal were submitted for acid sulfate soils indicative field testing (pH_{Field} and pH_{Fox}) and the chromium reducible sulphur (CRS) suite of analyses.

4.1.1 Summary of Results

Relevant results from the GeoCoastal report indicate that the Holocene sediments in this area were noted as being subtidal, very dark grey, silt/clay with noted shell fragments between approximately 2-3 mbgl. These sediments were overlain by very dark grey silty clayey sands with abundant mangrove debris between approximately 0.4 to 2 mbgl.

Analytical results for relevant samples locations, returned titratable actual acidity (TAA) values of 0.02 – 0.32 %S, consistently through the Holocene mangrove and subtidal lithology, which continued through to depths of 3 mbgl. No jarosite (an iron sulfate mineral formed as a byproduct of ASS oxidation) was noted in the lithology descriptions. The pH KCL and pH_{Field} values were above pH 6.5 (ranging from pH 7.0 to 8.5).

Actual chromium reducible sulphur (S_{Cr}) results from relevant sample locations indicated moderate to high levels of S_{Cr} (ranging from 0.02 to 1.76 %S). Moderate levels of acid neutralising capacity (ANC) were noted with a maximum result of 4.08%S equivalent.

The maximum net acidity value was noted as ranging from 0.02 to 1.1 5%S.

The GeoCoastal report concluded that the soils are not considered AASS but are classified as moderate PASS.

Liming rates associated with these samples ranged from <1 to 58 kg $CaCO_3$/tonne.

No obvious trend was noted pursuant to depth or location along the coastline.

GHD Methodology

A total of 44 boreholes were sampled for ASS as part of the GHD FEED geotechnical investigation (Appendix A – Figure 2). URS has relied upon the data received from GHD, which did not include supply, collection or analytical QA/QC information.

Additional soil sampling and analyses were undertaken subsequent to the original EIS work. Some of this work included a more detailed investigation along the GLNG GTP (September 2009), , as well as broader locations, to assess the general area conditions of these, eight locations fall directly within the CPIC (GSDA Section) Route; four samples (K136, K129, K132 and K148) were field analysed and four samples (K125, K126, K127 and K149) were field and laboratory analysed. Appendix A – Figure 2 shows sample locations.

Another six boreholes were located within 500 m north and south of the CPIC (GSDA Section) Route (KI30, KI33, KI34, KI35, KI41 and KI46) where samples were submitted for full laboratory analysis.

A total of 280 soil samples were analysed for indicative testing including pH $_{Field}$ and pH $_{Fox}$. Of these samples, 26 selected samples were submitted for one of two types of detailed analytical laboratory testing; Chromium Reducible Sulphur (CRS) Suite (11 samples) and Suspended Peroxide Oxidation Combined Acidity and Sulphur (SPOCAS) suite (15 samples).

Both methods of assessing ASS are recommended by the Queensland Acid Sulfate Soils Investigation Team (QASSIT) guidelines and either of these methods can be used to analyse soils for net acidity. The CRS method extracts inorganic sulphur only (e.g. pyrite) compared to the SPOCAS method which includes both organic and inorganic sulphur.

The analytical results for indicative field testing are given in Appendix B Table 1, the CRS and SPOCAS results are provided in Appendix B Table 2.

The results provided by GHD have been discussed as follows:

- Boreholes located along the coast for the GLNG EIS Assessed Route within 500m of the CPIC (GSDA Section) Route, providing additional ASS information on the area south of Kangaroo Island in conjunction with the GeoCoastal report;
- Boreholes located within 500m (north and south) of the CPIC (GSDA Section) Route providing an indicative assessment of the area around the CPIC (GSDA Section) Route; and
- Boreholes located within the CPIC (GSDA Section) Route.

Review of the GHD Data

6.1 Geology and Lithology

Information on the local lithology encountered as part of the GHD investigation was provided in the form of borehole drilling logs completed by Coffey Geotechnics. It was noted that the lithology identified on the logs provided by GHD was marine clay, which concurred with the GeoCoastal investigation. This was consistent along the base case alignment and in those locations within and surrounding the CPIC (GSDA Section) Route. Specific visual observations from all the boreholes noted the soils as being marine soils comprising clays with some sands and silts.

The marine clays were detailed as being grey to brown, high plasticity clays with some trace of organic material and shell fragments. Some boreholes also had fine to medium grained greyish to brownish silts and sands and trace gravel. The depth of these marine soils found in this area range from 0.0 to 4.2 mbgl (maximum depth of borehole K130). As such no underlying residual material was noted. This is also consistent with the published geology of the area.

Shell fragments and trace organic material was also noted in most locations, generally to depths of between 1.5 and 2.0 mbgl.

6.2 ASS Field Screening and Analytical Data

6.2.1 Boreholes located along the GLNG GTP (September 2009) Route

Twenty one (21) boreholes were located along the base case alignment to within 500 m of the CPIC (GSDA Section) Route, namely K101-K118, K143 to K145 (Appendix A- Figure 2). Boreholes were advanced to a maximum depth of 4.1 mbgl (Kl18). In total 127 samples were analysed for indicative field testing, 14 samples were analysed for detailed laboratory testing of which 11 were submitted for CRS and three were submitted for SPOCAS.

Indicative field ASS results (pH_F and pH_{FOX})

- The pH_{Field} results indicated all the 127 samples analysed returned values ranging from pH 6.9 to pH 9.2, indicative of no existing acidity and a low likelihood of AASS;
- The pH_{Fox} values ranged from pH 1.3 to 6.9. Of the 127 samples submitted from this area, eight were above pH 3.0 for pH_{Fox} (K101-K105, K108 and K144 at depths ranging from 0.9 to 2.6 mbgl), indicating the lithology may contain potential acidity; and
- The reaction rate varied from moderate (2) to a very vigorous reaction (4), further indicating presence of high levels of sulphides related with potential acidity; oxidation of organic matter may also result in strong reaction rates as was noted in the material sampled.

Actual Acidity

- All 14 samples returned pH potassium chloride (pH KCl) values ranging from pH 4.6 to pH 8.5 which indicates presence of minimal or no existing acidity, consistent with the indicative data;
- Of these 14 samples, 12 samples had sulfidic Titratable Actual Acidity (sTAA) values less than LOR (<0.02%S). This further indicates absence of existing acidity at these locations and depths; and
- Positive sTAA values of 0.02%S and 0.04%S was noted for only two samples analysed at K101 and K109 at depths of 2.0-2.1 mbgl and 0.4-0.5 mbgl respectively.

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Retained Acidity

- Retained acidity was not recorded in any sample analysed as no sample retuned a pH KCl value of less than pH 4.5.

Potential Acidity

- Of the 14 samples submitted from these areas for detailed analytical testing, 11 were tested by CRS. All 11 samples returned significant amount of S_{Cr} ranging from 0.57 to 1.73 %S (KI04 3.05-3.14 mbgl), indicative of the presence of residual potential acidity; and
- Of the three samples tested by SPOCAS, two samples returned oxidized pH (pH_{OX}) of less than pH 2.5 indicating presence of residual potential acidity. Sample K116 1.5 mbgl returned a pH_{OX} value of pH 4.6 which may indicate absence of potential acidity or the presence of ANC for this location (trace shell material was noted):
  - Two samples at K113 0.4–0.5 mbgl and K144 0.9–1.0 mbgl returned positive titratable peroxide acidity (TPA) of 0.77 and 1.57 %S; and
  - Peroxide Oxidisable Sulfur (S_{POS}) was also recorded in all three samples: 0.02 %S (KI16 1.5 mbgl - the low value is likely due to the shell fragment noted in the log), 0.71 %S (KI13) to 1.8S % (KI44), indicating moderate potential of soil to generate acid.

Excess Acid Neutralising Capacity (ANC)

ANC is indicative of buffering capacity inherent in soils; however the availability of ANC *insitu* can be overestimated during laboratory analysis. Under natural conditions shell fragments are usually coarse with minimal surface area. Under laboratory conditions shell fragments are ground, increasing the surface area/volume ratio for reaction (neutralisation). Additionally, large shell fragments may often be coated in reaction by-products such as gypsum, rendering the bulk of the $CaCO_3$ of the shell unavailable for neutralisation. ANC can also be present in the microscopic range (such as foraminiferal content) and provide larger reactive surface area ratios.

Moderate to large amount of ANC was noted in six samples ranging in value from 0.07 %S (KI08 3.0-3.1 mbgl) to 3.53 %S (KI01 0.9-1.0 mbgl). These boreholes are situated close to the coastline, with the reported lithology comprising shell fragments, consistent with noted lithologies from the GeoCoastal investigation.

Net acidity and Liming Rates

Net Acidity is a derived value comprising the actual, retained and potential acidity, less any detected ANC. The adopted trigger value for net acidity is 0.03 % (as per Section 2.4).

- Net acidity for these 14 samples (excluding ANC) ranged from 0.03 %S to 1.80%S relating directly to the potential acidity as no actual acidity was recorded:
  - The inclusion of detected ANC does not significantly reduce net acidity with adjusted values ranging from 0.03 to 1.80 %S, except for one sample (KI01 0.9-1.0 mbgl) returning an adjusted net acidity value of less than LOR (<0.02 %S);
- The overall liming rate (excluding ANC) comprising all samples analysed within this area ranged from 1 to 84 kg $CaCO_3$/tonne, the inclusion of ANC does not reduce the liming rate except for sample KI01 0.9-1.0 mbgl (< 1 kg $CaCO_3$/tonne) as noted in the net acidity results.

6.2.2 Boreholes located within 500 m of the CPIC (GSDA Section) Route

15 boreholes were located within 500 m to the north and to the south (but not within) the CPIC (GSDA Section) Route, specifically K119 to K124, K130, K133, K134, K135, K141, K147, K146, K150, and K151 (Appendix A - Figure 2). Boreholes were advance to maximum depth of 4.2 mbgl (KI30, KI34 and KI50). In total 103 samples were analysed for indicative field testing of which samples from six boreholes were submitted for SPOCAS analysis (all except KI20-KI23, KI47 and KI50).

Indicative field ASS results (pH_F and pH_{FOX})

- The pH_{Field} results indicated all 103 samples analysed returned values ranging from pH 4.8 to pH 9.0, indicative of no existing acidity and a low likelihood of AASS;
- The pH_{Fox} values were noted as being below pH 3.0 for all samples. Indicating a likelihood of the lithology containing potential acidity; and
- The reaction rate varied from vigorous (3) to a very vigorous reaction (4) further indicating the presence of high levels of sulphides related with potential acidity; oxidation of organic matter may also result in strong reaction rates as was noted in the material sampled.

Actual Acidity

- Nine samples returned pH KCl values above pH 4.5 Two samples, being K30 0.4-0.5 mbgl (pH KCl 4.4) and KI33 0.5mbgl (pH KCl 4.3) were below pH 4.5. These results are generally consistent with the indicative data; and
- Six samples returned sTAA values less than LOR (<0.02 %S). Samples KI19, KI24, K34, K41 and KI50 at depths between 0.4 and 4.2 mbgl, reported a range of sTAA results between 0.02 and 0.1 %S, indicative of some occasional minimal acidity at these locations and depths at levels approaching the level of detection (0.02 %S).

Retained Acidity

- Surface samples (0.4-0.5 mbgl) at two locations KI30 and KI33 had pH KCl values less than 4.5, potentially indicating the presence of retained acidity;
- The HCl extractable sulphur (S_{HCl}) values at KI30 and KI133 were 0.47 and 0.83 %S respectively, indicative of the presence of insoluble sulphate compounds. This is also evident from the drilling logs where KI33 shows presence of trace pyrite at 0.4-0.5 mbgl;
- The KCl extractable sulphur (S_{KCl}) values were reported as 0.42 and 0.58%S respectively consistent with the actual acidity and S_{HCl} values for these samples, indicating the presence of sulphate compounds; and
- The difference between S_{HCl} and S_{KCl} given as net acid soluble sulphur (S_{NAS}) is referred to as retained acidity. The S_{NAS} for these samples are calculated as 0.04 and 0.26 %S respectively, which are in excess of the adopted action criteria of 0.03 %S.

Potential Acidity

- The pH_{OX} results supported the indicative pH_{FOX} values. All 11 samples returned pH_{OX} values less than pH 2.5, indicating of the presence of residual potential acidity;
- All the samples returned positive TPA results in the range of 0.73 to 2.35 %S, indicative of the ppresence of some residual potential acidity in these samples;
- The titratable sulfidic acidity (TSA) values for all 11 samples ranged from 0.72 to 2.26 %S indicating inherent potential acidity may be due to the presence of high amounts of inorganic sulphate compounds; and
- S_{POS} values were recorded in 11 samples between 0.70 and 2.42 %S. This parameter is indicative of the potential of soil to generate acid.

Potential Acidity

- The pH_{OX} results supported the indicative pH_{FOX} values. All 11 samples returned pH_{OX} values less than pH 2.5, indicating of the presence of residual potential acidity;
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- S_{POS} values were recorded in 11 samples between 0.70 and 2.42 %S. This parameter is indicative of the potential of soil to generate acid.

Excess Acid Neutralising Capacity (ANC)

ANC was not recorded in any samples from the borehole locations situated within the 500 m of the CPIC route.

Net acidity and Liming Rates

The net acidity for all 14 samples submitted for full SPOCAS analyses which were collected from nine boreholes located within 500m north or south of the CPIC Route (but not within the CPIC Route corridor), ranged from 0.71 %S to 2.70 %S. These are in excess of the adopted net acidity trigger value of 0.03 %S.

The overall liming rate comprising all samples analysed within the area, ranged from 33 to 126 kg $CaCO_3$/tonne.

6.2.3 Boreholes located on the CPIC (GSDA Section) Route

Within the CPIC (GSDA Section) Route, eight boreholes, K125, K126, K127, K129, K132, K136, K148 and K149 (Appendix A - Figure 2) were advanced to a maximum depth of 4.1 mbgl (KI132).

In total 50 samples were submitted for indicative field testing, with one sample (KI27 0.9-1.0 mbgl), submitted for SPOCAS analyses. KI27 was located on the coast south of Kangaroo Island at Friend Point.

Indicative field ASS results (pH_F and pH_{FOX})

- The pH_{Field} results indicated all 50 samples analysed returned values ranging from pH 7.2 to pH 9.0, indicative of no existing acidity and a low likelihood of AASS;
- The pH_{Fox} values were noted as being below pH 3.0 for all samples, indicating a likelihood of the lithology containing potential acidity; and
- The reaction rate varied from moderate (2) to a very vigorous reaction (4) further indicating presence of high levels of sulphides related with potential acidity; oxidation of organic matter may also result in strong reaction rates as was noted in the material sampled.

Actual, Retained and Potential Acidity, ANC, Net Acidity and Liming Rate

- pH KCl value of 5.0 indicated the presence of some minimal actual acidity supported by an sTAA value of 0.04 %S;
- pH_{OX} value of 2.2 indicated presence of potential acidity due to presence of sulphides which is also indicated by the TSA value of 1.46 %S;

- ANC was not recorded in sample KI27 0.9-1.0 m;
- The net acidity value of 1.70 %S for this sample exceeds the action criteria (>0.03 %S); and
- The calculated liming rate for K127 at 0.9-1.0 mbgl is 80 Kg $CaCO_3$/tonne.

Conclusions and Trends

Based on this assessment of the ASS analytical data provided to URS by GHD, the following is concluded:

- The lithology was consistent as marine sediments, being sandy clays and clays;
- Minimal existing acidity was noted in the results, as such the material is not considered to contain AASS;
- Retained acidity was noted in two boreholes located within 500 m both north (KI30) and south (KI33) of the CPIC (GSDA Section) Route;
- Consistent potential for acid generation was identified throughout the area south of Kangaroo Island in most of the samples for all lithologies encountered, as such the material is considered to comprise moderate PASS;
- Low amounts of ANC were noted in boreholes located close to the coast. The ANC noted is insufficient to buffer the potential acidity; and
- The net acidity values exceeded the QASSIT guidelines action criteria of 0.03 %S. As such, ASS management of any disturbed material will be required.

It was noted based on the data provided that material on the area south of Kangaroo Island comprises slightly higher net acidity values away from the coastline; however, this was not a strong trend and is in consideration of the limited data set available away from the coastline. Accordingly liming rates varied across the area sampled with sample depth and reflect the slight trend noted with the highest liming rates (126 kg $CaCO_3$/tonne in KI33 at 0.5 mbgl and 97 kg $CaCO_3$/tonne in KI30 at 0.4-0.5 mbgl) being away from the coastline.

No general trends are apparent for ASS with depth.

8 Recommendations

The assessment data from GeoCoastal and GHD which has been reviewed is considered to provide an appropriate level of ASS assessment of the base case alignment and the general overview assessment of the ASS condition.

Based on the sampling and analysis completed to date, PASS are likely to be disturbed during pipeline construction through the CPIC (GSDA Section) Route. A conservative blanket liming rate for the area around the CPIC (GSDA Section) Route of 126kg $CaCO_3$/tonne has been derived based on the information from the GLNG GTP (September 2009) and the sampling undertaken around the CPIC (GSDA Section) Route; as such, in the absence of CPIC (GSDA Section) Route specific data, this is a conservative value and may be in excess of the actual rate required for the material along the CPIC (GSDA Section) Route.

As part of the construction process, an ASS management plan will be produced.

To develop an ASS management plan which mitigates the site and project specific environmental issues associated with ASS disturbance, the extent and method of disturbance and construction must be known to allow volumes of disturbed ASS to be estimated and details such as the locations of stockpile locations and sumps (if required) to be established. Whether the excavated material is intended for backfill will also affect the type of management strategies implemented. Additionally, any CEMP or EMP will comprise monitoring aspects which would otherwise be required for ASSMP impact monitoring.

References

Ahern CR, Ahern MR, and Powell B 1998. *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998, QASSIT*, Department of Natural Resources, Resources Sciences Centre, Indooroopilly, Queensland.

Ahern CR, McElnea AE, Sullivan LA 2004. *Acid Sulfate Soils Laboratory Methods Guidelines*, Queensland Department of Natural Resources, Mines and Energy, Indooroopilly, Queensland.

ANZECC/ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, *Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, October 2000*

AS4482.1 – 2005 *Guide to the investigation and sampling of sites with potentially contaminated soil – non volatile and semi volatile compounds (AS4482.1-2005).*

Dear SE, Moore NG, Dobos SK, Watling KM and Ahern CR (2002) *Soil Management Guidelines*. In *Queensland Acid Sulfate Technical Manual*. Department of Natural Resources and Mines, Indooroopilly, Queensland, Australia.

Douglas Partners 2005. *Report on Soils Investigation for the Proposed Dredging Works, Existing Shipping Channels, Gladstone.* Project Number. 33597A. Douglas Partners Pty Ltd, West End, QLD, September 2005.

GeoCoastal 2008. *Terrain Soils and Land Capability – Gladstone LNG Facility: Acid Sulfate Soil and Geomorphological Modelling Report Gladstone Facility.* GeoCoastal (Australia) Pty Ltd, 111 Stanbrough Road, Gumdale, QLD, 4154

Geological Series 1:100,000 Map for Gladstone (Sheet 9150), published by the Queensland Department of Mines,

Imray, P, Moore, MR, Callan, PW & Lock, W (1998). Aluminium. Report of an International Meeting, 20-21 April 1995, Brisbane, National Environmental Health Forum Monographs Metal Series No. 1

NEPC 1999. *National Environmental Protection Council Guidelines, Schedule B(1), Guideline on the Investigation Levels for Soil and Groundwater*.

State Planning Policy 2/02 Guideline. *Planning and Managing Development Involving Acid Sulfate Soils Version 2*.

Queensland Environmental Protection Agency (1998),Draft Guidelines for the Assessment and management of Contaminated Land in Queensland 1998.

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in Section 1 of this report and as per the GLNG EIS Supplement Proposal, dated 15th July 2009.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 19th October 2009 and 2nd November 2009 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

A

Appendix A Figures (GeoCoastal Report Figures 1 and 2)

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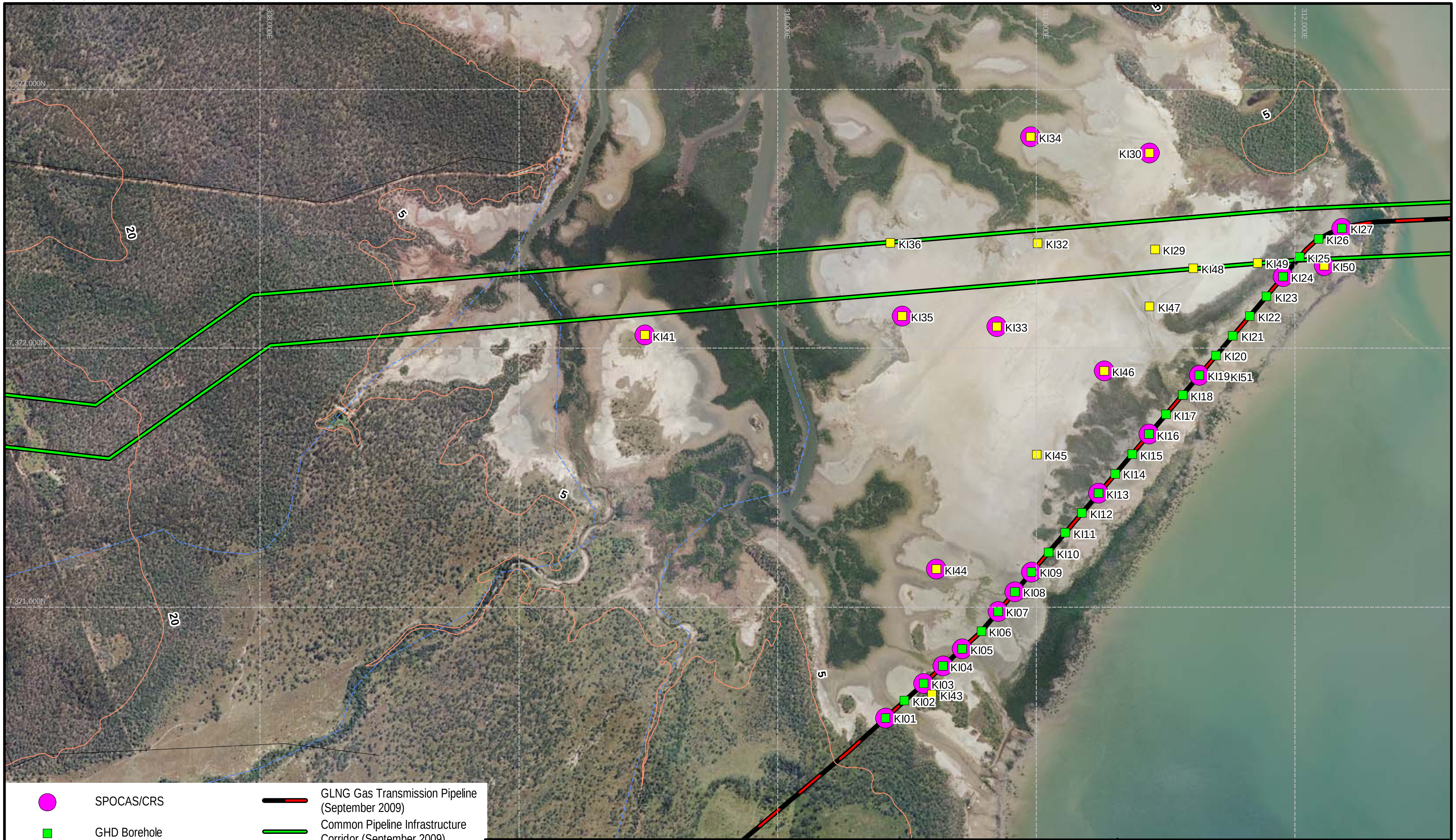
FIGURE 1-2 Acid sulfate core site and stratigraphic transect locations.



Magenta circle	SPOCAS/CRS
Green square	GHD Borehole
Yellow square	GHD Borehole (Digitised)
Black/red line	GLNG Gas Transmission Pipeline (September 2009)
Green line	Common Pipeline Infrastructure Corridor (September 2009)
Black line	Minor Road
Orange line	Contour (5m, 20m as shown)
Blue dashed line	Drainage

N, E, S, W

0 250m 500m

Scale: 1:20,000 (A4)
Datum: GDA94

Source: Client Supplied Data; Post Corrected GPS Field Recorded Data.

Client: LNG

URS

Project: GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT
SUPPLEMENT
ACID SULFATE ASSESSMENT
COMMON PIPELINE INFRASTRUCTURE CORRIDOR

Title: **COMMON PIPELINE INFRASTRUCTURE CORRIDOR ASS FIELD INVESTIGATION LOCATIONS**

Drawn: RG	Approved: JB	Date: 23-10-2009
Job No: **42626220/440**	File No: 42626440-g-2142.wor	

Figure: **2**

Rev:B

A4

B

Appendix B Analytical Data Tables: Table 1 and Table 2

Table 1: Analytical results for Acid Sulphate Soils Indicative Field Testing (Data provided by GHD)

Borehole No.	Sample Date	Sample Depth (m)	pH_F value	pH_{FOX} value	pH_{FOX} Reaction Rate[1]	Δ pH
K101	26/06/2009	0.4-0.5m	8.4	1.9	4	6.5
K101	26/06/2009	0.9-1.0m	8.8	3.1	4	5.7
K101	26/06/2009	1.4-1.5m	8.8	2.4	4	6.4
K101	26/06/2009	2.0-2.1m	8.6	2.1	4	6.5
K102	26/06/2009	0.4-0.5m	6.9	2	4	4.9
K102	26/06/2009	0.9-1.0m	8.9	2.6	4	6.3
K102	26/06/2009	1.4-1.5m	8.9	6.9	4	2
K102	26/06/2009	1.9-2.0m	9	2.6	4	6.4
K102	26/06/2009	2.55-2.65m	9.1	2.4	4	6.7
K103	27/06/2009	0.4-0.5m	8.2	2	4	6.2
K103	27/06/2009	0.9-1.0m	8.7	2.2	3	6.5
K103	27/06/2009	1.4-1.5m	8.9	3.7	4	5.2
K103	27/06/2009	1.75-1.85m	8.8	2.3	4	6.5
K104	27/06/2009	0.4-0.5m	8.1	1.9	4	6.2
K104	27/06/2009	0.9-1.0m	8.8	2.2	4	6.6
K104	27/06/2009	1.4-1.5m	8.8	4.9	4	3.9
K104	27/06/2009	2.4-2.5m	9	2.5	4	6.5
K104	27/06/2009	3.05-3.15m	8.5	1.8	4	6.7
K104	27/06/2009	1.9-2.0m	9.1	2.1	4	7
K105	27/06/2009	0.4-0.5m	8.1	1.8	4	6.3
K105	27/06/2009	0.9-1.0m	8.9	3.3	4	5.6
K105	27/06/2009	1.4-1.5m	8.9	6.8	4	2.1
K105	27/06/2009	1.9-2.0m	9	2.5	4	6.5
K105	27/06/2009	2.4-2.5m	9	2.3	4	6.7
K105	27/06/2009	2.7-2.8m	8.4	1.6	4	6.8
K106	28/06/2009	0.4-0.5m	8.8	2.4	4	6.4
K106	28/06/2009	0.9-1.0m	8.5	2	4	6.5
K106	28/06/2009	1.8-1.9m	8.7	2.9	4	5.8
K106	28/06/2009	1.4-1.5m	8.2	1.9	4	6.3
K107	28/06/2009	0.4-0.5m	8.7	1.7	4	7
K107	28/06/2009	0.9-1.0m	8	1.6	4	6.4
K107	28/06/2009	1.4-1.5m	8.6	2	4	6.6
K107	28/06/2009	2.4-2.5m	8.8	2.2	4	6.6
K107	28/06/2009	2.9-3.0m	7.7	1.8	4	5.9
K107	28/06/2009	3.2-3.3m	9.1	2.1	3	7
K107	28/06/2009	1.9-2.0m	8.8	2.3	4	6.5
K108	28/06/2009	0.4-0.5m	7.8	1.6	4	6.2
K108	28/06/2009	0.9-1.0m	7.8	1.8	4	6
K108	28/06/2009	1.4-1.5m	8.8	1.9	4	6.9
K108	28/06/2009	1.9-2.0m	8.6	4	4	4.6
K108	28/06/2009	2.4-2.5m	8.9	2.4	4	6.5
K108	28/06/2009	3.0-3.1m	9	1.9	4	7.1
K109	28/06/2009	0.4-0.5m	7.6	1.7	4	5.9
K109	28/06/2009	0.5-1.0	8.1	1.9	4	6.2
K109	28/06/2009	1.4-1.5m	8.4	2.3	4	6.1
K109	28/06/2009	1.9-2.0m	8.8	2.5	4	6.3
K109	28/06/2009	2.4-2.5m	8.7	2	4	6.7
K109	28/06/2009	2.8-2.9m	9.2	2.1	4	7.1
K110	29/06/2009	0.4-05 m	8.1	1.7	4	6.4
K110	29/06/2009	0.9-1.0 m	8.4	1.8	4	6.6
K110	29/06/2009	1.4-1.5 m	8.5	2	4	6.5
K110	29/06/2009	1.9-2.0 m	8.4	2.1	4	6.3
K110	29/06/2009	2.4-2.5 m	8.5	2.2	4	6.3
K110	29/06/2009	2.9-3.0 m	8.3	1.6	4	6.7
K110	29/06/2009	3.4-3.5 m	8.9	2.1	4	6.8
K110	29/06/2009	3.6-3.7 m	9.2	2.4	4	6.8
K111	29/06/2009	0.4-0.5 m	8.8	1.8	4	7

1. pHFOX Reaction Rate: 1 - slight, 2 - Moderate, 3 - Vigorous, 4 - Very vigorous

Table 1: Analytical results for Acid Sulphate Soils Indicative Field Testing (Data provided by GHD)

Borehole No.	Sample Date	Sample Depth (m)	pH_F value	pH_{FOX} value	pH_{FOX} Reaction Rate[1]	Δ pH
K111	29/06/2009	0.9-1.0 m	8.4	1.8	4	6.6
K111	29/06/2009	1.4-1.5 m	8.3	2.1	4	6.2
K111	29/06/2009	1.9-2.0 m	8.4	2.2	4	6.2
K111	29/06/2009	2.4-2.5 m	8.5	2	4	6.5
K111	29/06/2009	2.9-3.0 m	8.2	1.3	4	6.9
K111	29/06/2009	3.4-3.5 m	8.7	1.8	4	6.9
K111	29/06/2009	3.6-3.7 m	9.1	2.2	4	6.9
K112	29/06/2009	0.4-0.5 m	8.6	2.1	4	6.5
K112	29/06/2009	0.9-1.0 m	8.6	1.8	4	6.8
K112	29/06/2009	1.4-1.5 m	8.6	2.1	4	6.5
K112	29/06/2009	1.9-2.0 m	8.4	2.3	4	6.1
K112	29/06/2009	2.4-2.5 m	8.5	2.2	4	6.3
K112	29/06/2009	2.9-3.0 m	8.6	2	4	6.6
K112	29/06/2009	3.4-3.5 m	8.6	2.2	4	6.4
K112	29/06/2009	3.65-3.75 m	8.6	2.2	4	6.4
K113	29/06/2009	0.4-0.5 m	8.5	2	4	6.5
K113	29/06/2009	0.9-1.0 m	8.4	1.5	4	6.9
K113	29/06/2009	1.4-1.5 m	8.7	1.9	4	6.8
K113	29/06/2009	1.9-2.0 m	8.6	2.5	4	6.1
K113	29/06/2009	2.4-2.5 m	8.6	2.2	4	6.4
K113	29/06/2009	2.9-3.0 m	8.8	2.3	4	6.5
K113	29/06/2009	3.3-3.4 m	8.7	2.1	4	6.6
K114	1/07/2009	0.5m	8.4	1.7	4	6.7
K114	1/07/2009	1.0m	8.4	1.7	4	6.7
K114	1/07/2009	1.5m	8.4	2.1	4	6.3
K114	1/07/2009	2.0m	8.2	2	4	6.2
K114	1/07/2009	2.5m	8.7	2.3	4	6.4
K114	1/07/2009	3.0m	8.6	1.9	4	6.7
K115	1/07/2009	0.5m	8.6	2.2	4	6.4
K115	1/07/2009	1.0m	8.4	1.7	4	6.7
K115	1/07/2009	1.5m	8.5	1.6	4	6.9
K115	1/07/2009	2.0m	8.5	2.3	4	6.2
K115	1/07/2009	2.5m	8.5	2.3	4	6.2
K115	1/07/2009	3.0m	8.6	2.3	4	6.3
K115	1/07/2009	3.7m	8.6	2	4	6.6
K116	1/07/2009	0.5m	8.5	2	4	6.5
K116	1/07/2009	1.0m	8.5	1.8	4	6.7
K116	1/07/2009	1.5m	8.4	1.6	4	6.8
K116	1/07/2009	2.0m	8.5	2.7	4	5.8
K116	1/07/2009	2.5m	8.6	2.6	4	6
K116	1/07/2009	3.0m	8.4	1.7	4	6.7
K116	1/07/2009	3.5m	8.5	2	4	6.5
K116	1/07/2009	3.75m	8.7	1.9	4	6.8
K117	1/07/2009	0.5m	8.3	1.9	4	6.4
K117	1/07/2009	1.0m	8.4	1.6	4	6.8
K117	1/07/2009	1.5m	8.4	1.4	4	7
K117	1/07/2009	2.0m	8.4	2.9	4	5.5
K117	1/07/2009	2.5m	8.6	2.1	4	6.5
K117	1/07/2009	3.0m	8.7	2.1	4	6.6
K117	1/07/2009	3.6m	8.6	1.8	4	6.8
K118	2/07/2009	0.4-0.5m	8.5	1.8	4	6.7
K118	2/07/2009	0.9-1m	8.7	1.7	4	7
K118	2/07/2009	1.4-1.5m	8.9	1.7	4	7.2
K118	2/07/2009	1.9-2m	8.5	1.8	4	6.7
K118	2/07/2009	2.4-2.5m	8.7	2.1	4	6.6
K118	2/07/2009	2.9-3m	8.7	1.8	4	6.9
K118	2/07/2009	3.4-3.5m	8.5	1.6	4	6.9

1. pHFOX Reaction Rate: 1 - slight, 2 - Moderate, 3 - Vigorous, 4 - Very vigorous

Table 1: Analytical results for Acid Sulphate Soils Indicative Field Testing (Data provided by GHD)

Borehole No.	Sample Date	Sample Depth (m)	pH_F value	pH_{FOX} value	pH_{FOX} Reaction Rate[1]	Δ pH
K118	2/07/2009	4.0-4.1m	8.4	1.6	2	6.8
K119	2/07/2009	0.4-0.5m	8.7	2	4	6.7
K119	2/07/2009	0.9-1m	8.6	2.2	4	6.4
K119	2/07/2009	1.4-1.5m	8.8	1.7	4	7.1
K119	2/07/2009	1.9-2m	8.6	1.6	4	7
K119	2/07/2009	2.4-2.5m	8.7	2.3	4	6.4
K119	2/07/2009	2.9-3m	8.7	2.1	4	6.6
K119	2/07/2009	3.4-3.5m	8.7	2.1	4	6.6
K119	2/07/2009	3.9-4m	8.5	1.8	4	6.7
K120	2/07/2009	0.4-0.5m	8.6	1.9	4	6.7
K120	2/07/2009	0.9-1m	8.6	1.8	4	6.8
K120	2/07/2009	1.4-1.5m	8.3	1.6	4	6.7
K120	2/07/2009	1.9-2m	8.7	1.8	4	6.9
K120	2/07/2009	2.4-2.5m	8.6	2.3	4	6.3
K120	2/07/2009	2.9-3m	8.6	2.2	4	6.4
K120	2/07/2009	3.4-3.5m	8.8	2.1	4	6.7
K120	2/07/2009	3.65-3.75m	8.6	2	4	6.6
K121	2/07/2009	0.4-0.5m	7.8	1.8	4	6
K121	2/07/2009	0.9-1m	8.4	1.7	4	6.7
K121	2/07/2009	1.4-1.5m	8.6	1.9	4	6.7
K121	2/07/2009	1.9-2m	8.5	1.9	4	6.6
K121	2/07/2009	2.4-2.5m	8.5	2	4	6.5
K121	2/07/2009	2.9-3m	8.6	2.1	4	6.5
K121	2/07/2009	3.4-3.5m	8.5	1.8	4	6.7
K121	2/07/2009	3.9-4m	8.4	2	4	6.4
K122	2/07/2009	0.4-0.5M	8	1.8	4	6.2
K122	2/07/2009	0.9-1m	7.9	1.7	4	6.2
K122	2/07/2009	1.4-1.5m	8	1.6	4	6.4
K122	2/07/2009	1.9-2m	8.2	1.9	4	6.3
K122	2/07/2009	2.4-2.5m	8.4	2	4	6.4
K122	2/07/2009	2.9-3m	8.4	2.3	4	6.1
K122	2/07/2009	3.4-3.5m	8.5	2	4	6.5
K122	2/07/2009	3.9-4m	8.3	1.7	4	6.6
K123	8/07/2009	0.5m	7.8	1.3	4	6.5
K123	8/07/2009	1.5m	8.6	1	4	7.6
K123	8/07/2009	1m	8.6	1	4	7.6
K123	8/07/2009	2.5m	8.7	1.3	4	7.4
K123	8/07/2009	2m	8.7	1.2	4	7.5
K123	8/07/2009	3m	9	2	3	7
K124	8/07/2009	0.5m	8.8	1.4	4	7.4
K124	8/07/2009	1.0m	8.7	1.3	4	7.4
K124	8/07/2009	1.5m	8.1	1.4	4	6.7
K125	8/07/2009	0.5m	8.3	1.5	4	6.8
K125	8/07/2009	1.0m	8.6	1.4	4	7.2
K125	8/07/2009	1.5m	8.5	1.1	4	7.4
K125	8/07/2009	2.5m	8.9	2	3	6.9
K125	8/07/2009	2m	8.5	1.1	4	7.4
K125	8/07/2009	3m	9	2	2	7
K126A	8/07/2009	0.5m	8.3	1.4	4	6.9
K126A	8/07/2009	1.0m	8.6	1.5	4	7.1
K126A	8/07/2009	1.5m	8.5	1.2	4	7.3
K126A	8/07/2009	2.5m	8.9	1.3	4	7.6
K126A	8/07/2009	2m	8.7	1.6	4	7.1
K127	8/07/2009	0.4-0.5m	8.3	1.6	4	6.7
K127	8/07/2009	0.9-1m	8.5	1.5	4	7
K127	8/07/2009	1.4-1.5m	8.9	1.7	4	7.2
K127	8/07/2009	1.9-2m	8.9	2.6	4	6.3

1. pHFOX Reaction Rate: 1 - slight, 2 - Moderate, 3 - Vigorous, 4 - Very vigorous

Table 1: Analytical results for Acid Sulphate Soils Indicative Field Testing (Data provided by GHD)

Borehole No.	Sample Date	Sample Depth (m)	pH_F value	pH_{FOX} value	pH_{FOX} Reaction Rate[1]	Δ pH
K127	8/07/2009	2.4-2.5m	8.5	2.1	4	6.4
K127	8/07/2009	3.0-3.1m	8.8	2.3	4	6.5
K129	8/07/2009	0.5m	8.6	1.2	4	7.4
K129	8/07/2009	1.5m	7.9	1.6	4	6.3
K129	8/07/2009	1m	7.4	1.9	3	5.5
K129	8/07/2009	2.5m	8.7	1.9	3	6.8
K129	8/07/2009	2m	8.5	1.3	4	7.2
K129	8/07/2009	3.5m	8.6	1.3	4	7.3
K129	8/07/2009	3m	8.8	1.5	4	7.3
K130	3/07/2009	0.4-0.5m	6.8	1.5	4	5.3
K130	3/07/2009	0.9-1m	8.4	1.7	4	6.7
K130	3/07/2009	1.4-1.5m	8.1	1.8	4	6.3
K130	3/07/2009	1.9-2m	8.7	2.1	4	6.6
K130	3/07/2009	2.4-2.5m	8.7	2	4	6.7
K130	3/07/2009	3.0-3.1m	8.8	2.1	4	6.7
K130	3/07/2009	3.4-3.5m	8.4	1.8	4	6.6
K130	3/07/2009	4.1-4.2m	8.2	1.5	4	6.7
K132	8/07/2009	0.5m	8.2	1	4	7.2
K132	8/07/2009	1.5m	8.3	1.2	4	7.1
K132	8/07/2009	1m	7.5	1.3	4	6.2
K132	8/07/2009	2.5m	8.6	1.5	3	7.1
K132	8/07/2009	2m	8.8	1.7	3	7.1
K132	8/07/2009	3.5m	8.8	1.5	4	7.3
K132	8/07/2009	3m	8.7	1.2	4	7.5
K133	7/07/2009	0.5m	4.8	0.9	4	3.9
K133	7/07/2009	1.0m	5.6	1.3	4	4.3
K133	7/07/2009	1.5m	7.4	1.3	4	6.1
K133	7/07/2009	2.0m	8.9	1.6	4	7.3
K133	7/07/2009	2.5m	8.9	1.7	4	7.2
K133	7/07/2009	3.5m	8.8	1.8	4	7
K133	7/07/2009	3m	8.8	1.6	4	7.2
K134	3/07/2009	0.4-0.5m	8.2	1.8	4	6.4
K134	3/07/2009	0.9-1m	8.2	1.7	4	6.5
K134	3/07/2009	1.4-1.5m	8.3	1.9	4	6.4
K134	3/07/2009	1.9-2m	8.6	2	4	6.6
K134	3/07/2009	2.4-2.5m	8.8	2.1	4	6.7
K134	3/07/2009	3.0-3.1m	8.9	2.1	4	6.8
K134	3/07/2009	3.4-3.5m	9	2.1	4	6.9
K134	3/07/2009	4.1-4.2m	8.8	2.1	4	6.7
K135	7/07/2009	0.5m	8.1	1.3	4	6.8
K135	7/07/2009	1.5m	8.6	1.4	4	7.2
K135	7/07/2009	1m	8.3	1.4	4	6.9
K135	7/07/2009	2.5m	8.5	1.3	4	7.2
K135	7/07/2009	2m	8.7	1.9	3	6.8
K135	7/07/2009	3m	8.6	1.7	3	6.9
K136	8/07/2009	0.5m	7.2	1.2	4	6
K136	8/07/2009	1.0m	7.9	1.4	4	6.5
K136	8/07/2009	1.5m	8.5	1.4	4	7.1
K136	8/07/2009	2.5m	8.8	1.5	4	7.3
K136	8/07/2009	2m	8.8	1.4	4	7.4
K136	8/07/2009	3.5m	8.5	1.4	4	7.1
K136	8/07/2009	3m	8.7	1.1	4	7.6
K141	5/07/2009	0.8m	8.5	1.5	4	7
K143	5/07/2009	0.5-0.6m	7.6	2.3	4	5.3
K143	5/07/2009	1.1-1.2m	8.8	2.6	4	6.2
K144	5/07/2009	0.4-0.5m	7.9	1.7	4	6.2
K144	5/07/2009	0.9-1m	8.2	1.9	4	6.3

1. pHFOX Reaction Rate: 1 - slight, 2 - Moderate, 3 - Vigorous, 4 - Very vigorous

Table 1: Analytical results for Acid Sulphate Soils Indicative Field Testing (Data provided by GHD)

Borehole No.	Sample Date	Sample Depth (m)	pH_F value	pH_{FOX} value	pH_{FOX} Reaction Rate[1]	Δ pH
K144	5/07/2009	1.4-1.5m	8.3	2.1	4	6.2
K144	5/07/2009	1.9-2m	8.4	2	4	6.4
K144	5/07/2009	2.5-2.6m	9.1	4	3	5.1
K145	5/07/2009	0.4-0.5m	7.7	2	4	5.7
K145	5/07/2009	0.9-1m	8	2	4	6
K145	5/07/2009	1.4-1.5m	8.1	2.8	4	5.3
K145	5/07/2009	1.9-2m	8.1	2	4	6.1
K145	5/07/2009	2.4-2.5m	8.6	2.4	4	6.2
K146	5/07/2009	0.4-0.5m	7.8	1.9	4	5.9
K146	5/07/2009	0.9-1m	8	1.7	4	6.3
K146	5/07/2009	1.4-1.5m	8	1.8	4	6.2
K146	5/07/2009	1.9-2m	8.2	2.3	4	5.9
K146	5/07/2009	2.4-2.5m	8.3	2.1	4	6.2
K146	5/07/2009	2.9-3m	8.3	2.1	4	6.2
K146	5/07/2009	2.9-3m	8.4	2	4	6.4
K146	5/07/2009	3.35-3.45m	8.1	1.7	4	6.4
K147	5/07/2009	0.4-0.5m	7.4	1.7	4	5.7
K147	5/07/2009	0.9-1m	8	1.7	4	6.3
K147	5/07/2009	1.4-1.5m	8.2	1.8	4	6.4
K147	5/07/2009	1.9-2m	8.3	2	4	6.3
K147	5/07/2009	2.4-2.5m	8.4	2.4	4	6
K147	5/07/2009	2.9-3m	8.6	2	4	6.6
K147	5/07/2009	3.4-3.5m	8.5	2.1	4	6.4
K147	5/07/2009	3.9-4m	8.6	2	4	6.6
K148	5/07/2009	0.4-0.5m	7.5	1.9	4	5.6
K148	5/07/2009	0.9-1m	7.8	1.7	4	6.1
K148	5/07/2009	1.4-1.5m	8.1	1.8	4	6.3
K148	5/07/2009	1.9-2m	8.4	1.9	4	6.5
K148	5/07/2009	2.4-2.5m	8.3	2.3	4	6
K148	5/07/2009	2.9-3m	8.4	2.2	4	6.2
K148	5/07/2009	3.4-3.5m	8.4	2.2	4	6.2
K148	5/07/2009	3.9-4m	8.5	2.1	4	6.4
K149	5/07/2009	0.4-0.5m	7.4	2.1	2	5.3
K149	5/07/2009	0.9-1m	8	1.7	4	6.3
K149	5/07/2009	1.4-1.5m	8.4	1.8	4	6.6
K149	5/07/2009	1.75-1.85m	8.3	2	4	6.3
K150	5/07/2009	0.4-0.5m	8.5	1.8	4	6.7
K150	5/07/2009	0.9-1m	8.5	2	4	6.5
K150	5/07/2009	1.4-1.5m	8.6	1.9	4	6.7
K150	5/07/2009	1.9-2m	8.7	1.9	4	6.8
K150	5/07/2009	2.4-2.5m	8.7	2.2	4	6.5
K150	5/07/2009	2.9-3m	8.8	2	4	6.8
K150	5/07/2009	3.4-3.5m	8.7	2	4	6.7
K150	5/07/2009	4.1-4.2m	8.6	2.2	4	6.4
K151	5/07/2009	0.4-0.5m	8.3	1.9	4	6.4
K151	5/07/2009	0.9-1m	8.7	2	4	6.7
K151	5/07/2009	0.9-2m	8.6	2.2	4	6.4
K151	5/07/2009	1.4-1.5m	8.6	2	4	6.6
K151	5/07/2009	2.4-2.5m	8.5	2.2	4	6.3
K151	5/07/2009	2.9-3m	8.6	2.4	4	6.2
K151	5/07/2009	3.4-3.5m	8.6	2.2	4	6.4
K151	5/07/2009	3.7-3.8m	8.5	2.1	4	6.4

1. pHFOX Reaction Rate: 1 - slight, 2 - Moderate, 3 - Vigorous, 4 - Very vigorous

Table 2 : Analytical results for Acid Sulphate Soils (ASS) detailed Laboratory Testing (Data provided by GHD)

Section	Sample Depth	Sample Date	pH_F value	pH_{FOX} value	pH_{FOX} Reaction Rate[1]	Δ pH	pH KCl	pH OX	TAA (Titratable Actual Acidity)	TPA (Titratable Peroxide Acidity)	TSA (Titratable Sulfidic Acidity)	S_{KCL} (KCl Extractable Sulfur)	S_P (Peroxide Sulfur)	S_{POS} (Peroxide Oxidisable Sulfur)	S_{Cr} (Chromium reducible Sulfur)	S_{HCL} (HCL Extractable Sulfur)	S_{NAS} (Net Acid Soluble Sulfur)	Ca_A (Reacted Ca)	Mg_A (Reacted Mg)	ANC_E (Excess ANC)	Net Acidity[2] (includes ANC)	Net Acidity[3] (excludes ANC)	Liming Rate[4] (includes ANC)	Liming Rate[4] (excludes ANC)
							pH Units	pH Units	% S	% S	% S	% S	% S	% S	% S	% S	% S	% S	% S	% S	% S	% S	(kg Aglime /tonne)	(kg Aglime /tonne)
Chromium Reducible Sulphur Suite Results																								
KI01	0.9-1.0m	26-Jun-09	8.8	3.1	4	5.7	8.5	-	<0.02	-	-	-	-	-	1.49	-	-	-	-	3.53	<0.02	1.51	<1	71
KI01	2.0-2.1m	26-Jun-09	8.6	2.1	4	6.5	5.4	-	0.02	-	-	-	-	-	0.64	-	-	-	-	-	-	0.67	31	-
KI03	0.9-1.0m	27-Jun-09	8.7	2.2	3	6.5	7.9	-	<0.02	-	-	-	-	-	1.42	-	-	-	-	0.43	1.13	1.44	53	67
KI04	0.9-1.0m	27-Jun-09	8.8	2.2	4	6.6	8.4	-	<0.02	-	-	-	-	-	1.64	-	-	-	-	1.05	0.94	1.66	44	78
KI04	3.05-3.15m	27-Jun-09	8.5	1.8	4	6.7	5.8	-	<0.02	-	-	-	-	-	1.73	-	-	-	-	-	-	1.74	82	-
KI05	2.4-2.5m	27-Jun-09	9	2.3	4	6.7	8.1	-	<0.02	-	-	-	-	-	0.76	-	-	-	-	0.33	0.54	0.78	25	37
KI05	2.7-2.8m	27-Jun-09	8.4	1.6	4	6.8	5.5	-	<0.02	-	-	-	-	-	0.57	-	-	-	-	-	-	0.59	28	-
KI07	2.9-3.0m	28-Jun-09	7.7	1.8	4	5.9	6.3	-	<0.02	-	-	-	-	-	0.88	-	-	-	-	-	-	0.88	41	-
KI07	3.2-3.3m	28-Jun-09	9.1	2.1	3	7	7.7	-	<0.02	-	-	-	-	-	0.59	-	-	-	-	0.16	0.48	0.61	23	29
KI08	3.0-3.1m	28-Jun-09	9	1.9	4	7.1	7.2	-	<0.02	-	-	-	-	-	1.61	-	-	-	-	0.07	1.56	1.63	73	76
KI09	0.5-1.0	28-Jun-09	8.1	1.9	4	6.2	4.6	-	0.04	-	-	-	-	-	1.36	-	-	-	-	-	-	1.39	65	-
SPOCAS Suite Results																								
KI13	0.4-0.5 m	29-Jun-09	8.5	2	4	6.5	6.2	2.1	<0.02	0.77	0.77	0.24	0.95	0.71	-	-	-	<0.02	<0.02	-	-	0.71	33	-
KI16	1.5m	01-Jul-09	8.4	1.6	4	6.8	6.3	4.6	<0.02	<0.02	<0.02	<0.02	0.02	0.02	-	-	-	0.02	<0.02	-	-	0.03	1	-
KI19	0.4-0.5m	02-Jul-09	8.7	2	4	6.7	5.9	2.2	<0.02	0.73	0.72	0.21	0.9	0.7	-	-	-	<0.02	<0.02	-	-	0.71	33	-
KI19	3.9-4m	02-Jul-09	8.5	1.8	4	6.7	6.8	2.1	<0.02	1.37	1.37	0.24	2.12	1.89	-	-	-	0.05	0.07	-	-	1.54	72	-
KI24	0.5m	07-Jul-09	8.8	1.4	4	7.4	6	2.3	<0.02	1.06	1.04	0.28	1.58	1.3	-	-	-	<0.02	0.04	-	-	1.31	61	-
KI27	0.9-1m	03-Jul-09	8.5	1.5	4	7	5	2.2	0.04	1.5	1.46	0.47	2.13	1.66	-	-	-	<0.02	0.03	-	-	1.70	80	-
KI30	0.4-0.5m	03-Jul-09	6.8	1.5	4	5.3	4.4	2.1	0.1	1.8	1.7	0.42	2.36	1.94	-	0.47	0.04	<0.02	<0.02	-	-	2.07	97	-
KI33	0.5m	07-Jul-09	4.8	0.9	4	3.9	4.3	2	0.09	2.35	2.26	0.58	2.99	2.42	-	0.83	0.26	<0.02	0.02	-	-	2.70	126	-
KI34	1.4-1.5m	03-Jul-09	8.3	1.9	4	6.4	6	2.2	<0.02	1.09	1.07	0.4	1.64	1.24	-	-	-	<0.02	<0.02	-	-	1.26	59	-
KI35	0.5m	07-Jul-09	8.1	1.3	4	6.8	4.9	2.2	0.04	1.11	1.06	0.37	1.54	1.17	-	-	-	<0.02	<0.02	-	-	1.22	57	-
KI41	0.8m	06-Jul-09	8.5	1.5	4	7	6.7	2.3	<0.02	0.81	0.81	0.18	1.13	0.95	-	-	-	<0.02	<0.02	-	-	0.86	40	-
KI44	0.9-1m	05-Jul-09	8.2	1.9	4	6.3	6.4	2.1	<0.02	1.57	1.56	0.34	2.14	1.8	-	-	-	<0.02	0.04	-	-	1.80	84	-
KI46	0.4-0.5m	05-Jul-09	7.8	1.9	4	5.9	5.7	2.2	0.02	1.19	1.17	0.37	1.78	1.41	-	-	-	<0.02	0.07	-	-	1.43	67	-
KI50	1.4-1.5m	05-Jul-09	8.6	1.9	4	6.7	4.9	2.1	0.04	1.52	1.48	0.48	2.26	1.78	-	-	-	<0.02	0.09	-	-	1.82	85	-
KI50	4.1-4.2m	05-Jul-09	8.6	2.2	4	6.4	6.8	2.2	<0.02	0.78	0.78	0.15	1.1	0.96	-	-	-	<0.02	0.03	-	-	0.84	39	-

Notes:

1. pH_{FOX} Reaction Rate: 1 - slight, 2 - Moderate, 3 - Vigorous, 4 - Very vigorous
2. net acidity including ANC = (sTAA)+($S_{CR)}$)+($sS_{NAS)}$)-(ANC/Fineness Factor) or (sTAA)+($S_{POS)}$)+(sS_{NAS})-(ANC/Fineness Factor)
3. net acidity excluding ANC = s-TAA + S_{CR} + s-S_{NAS} or s-TAA + S_{POS}+s-S_{NAS}
4. Liming rate = %S x 30.59 x 1.02 x 1.5 where 30.59 converts to H_2SO_4, 1.02 converts to $CaCO_3$ and 1.5 is the safety factor

Appendix C ASS Assessment Table

Project Component: Name	Project Component: Description	EIS or Supplement Study	EIS or Supplement Section	Consultant and Investigation	ASS Intrusive Investigations: Field Screening (pHField and pHFox)	ASS Intrusive Investigations: Analytical Tests (SPOCAS or Chromium Suite)	Approach Rationale	ASS Characterisation Data Gaps	ASS Management Plan (ASSMP)
LNG facility.	Relates to LNG facility on Curtis Island, inland from China Bay, and north of Hamilton Point.	Completed as part of EIS.	EIS Section 8.3 and EIS Appendix L4	GEOCOASTAL (ASS INVESTIGATION) Terrain Soils and Land Capability LNG facility 12 February 2009.	Yes - Limited spatial coverage (≤5 mAHD only).	Yes - Limited spatial coverage (≤5 mAHD only).	GeoCoastal were engaged to undertake an ASS assessment of the proposed LNG facility location to address the TOR regarding ASS in areas at or below 5 mAHD.	Sample locations were selected along the coastal area of the LNG facility to target areas ≤5 mAHD. Specific analysis will also be required when the final construction method is known.	Specific management strategies based on the extent, location and method of disturbance will be prepared, based on the characterisation completed to date, and specific construction details. These details will be submitted as part of any application for authorities to undertake work.
Dredge Area Marine Sediments.	Relates to the marine sediment within the area proposed for dredging in Port Curtis, including both the swing basin and approach channel.	Completed as part of EIS.	EIS Section 8.3 and EIS Appendix L4	GEOCOASTAL (ASS INVESTIGATION) Terrain Soils and Land Capability LNG facility 12 February 2009.	Yes - Limited spatial coverage.	Yes - Limited spatial coverage.	The GeoCoastal investigation was undertaken as part of on and off-shore ASS investigations; however, the marine sediment data was limited (as an initial study) and additional samples were required for a more spatial representative assessment. The GeoCoastal data was used to develop a more targeted second round of sampling which was undertaken by URS for analytical samples (excluding field screen testing), and was also included in the URS report to provide a more complete spatial ASS assessment of the area. In addition to ASS, URS requested analyses and reported results on metals, nutrients, radionuclide and organic compounds.	The ASS data available should be sufficient for assessment and characterisation of any ASS in the marine sediment within the dredge area, and provide adequate data for the development of any management strategies for any identified ASS material, disturbed within the dredge area.	The management of any ASS identified within the marine sediment proposed for dredging will depend on the method of dredging and the handling of dredge spoils. This is because different dredge methods and spoil placement approaches can affect the way in which sediments settle or separate (which will also affect the distribution of shell fragment and thereby the distribution of one form of natural acid neutralisation), homogenise, dewater or break apart. As such, any management plan for ASS (if required) should be developed in parallel or as part of the final dredge management plan (DMP); this would relate the results of the investigation to the methods of dredging, and the placement and handling of spoils and dredge waters.
		Completed as part of EIS.	EIS Section 8.3 and EIS Appendix R3	URS (ASS INVESTIGATION) Marine Sediment Investigation - Environmental Investigations of Proposed Dredging at China Bay and Pipeline Crossing at The Narrows, Gladstone 28 January 2009.	No - used GeoCoastal data.	Yes.			
		Completed as part of EIS Supplement.	Supplement Attachment G5.	URS (MARINE SEDIMENT LEACHABLE CONTAMINANTS INVESTIGATION).	NA.	NA.	A data gap was identified by URS regarding leachable metals from the dredged spoils (i.e. how readily and in what concentrations metals can mobilise into water from the dredged marine sediment). URS undertook an investigation to close the data gap. Mobilisation of metals is more likely to occur in acidic conditions.		
DMPF.	Relates to the tidal flat area and surrounding hills on the western side of Curtis Island just south of Laird Point; identified as a possible location for placement of dredging spoils.	Completed as part of EIS.	EIS Section 8.17 and EIS Appendix L4.	GEOCOASTAL (ASS INVESTIGATION) Terrain Soils and Land Capability LNG facility 12 February 2009 - Subsection D Preliminary assessment of adjacent South Curtis Island tidal flat areas for Actual Acid Sulfate Soil.	Yes - Limited investigation depth.	Yes - Limited investigation depth.	GeoCoastal undertook sampling to approximately 1m. URS identified a data gap regarding the need for deeper sampling, as a result of possible excavation during bund construction and the extent of proposed spoil filling, and accordingly undertook additional sampling. Additionally, URS undertook metals and leachable metals sampling in the tidal flat and surrounding hills, to provide an indicative assessment of the likelihood of metals mobilising from the tidal flat lithology and surrounding hills into the groundwater, which may occur in the event that infiltration into the tidal flat of	The ASS data available should be sufficient for assessment and characterisation of any ASS filling activities associated with the DMPF. However there is insufficient data to characterise the area beneath the proposed western embankment where excavation to 5mbgl over an area approximately 100m x 600m, is proposed. The data available in that specific area provides a general ASS assessment and will be used to develop a more targeted approach to additional sampling pursuant to	Specific management strategies based on the extent, location and method of disturbance will be prepared, based on the characterisation completed to date, and specific construction details. These details will be submitted as part of any application for authorities to undertake work. The management of any ASS in the DMPF tidal flat should also factor in the method of spoil placement and dredge waters (should be detailed in the final DMP for the dredge area).

Project Component Name	Project Component Description	EIS or Supplement Study	EIS or Supplement Section	Consultant and Investigation	ASS Intrusive Investigations: Field Screening (pHField and pHFox)	ASS Intrusive Investigations: Analytical Tests (SPOCAS or Chromium Suite)	Approach Rationale	ASS Characterisation Data Gaps	ASS Management Plan (ASSMP)
		Completed as part of EIS Supplement.	Supplement Attachment G6	URS (GEOTECHNICAL ASSESSMENT OF DMPF).	NA.	NA.	acidic leachate from the dredge spoil occurs. This represents a worst case scenario as the spoil will be managed under an ASSMP if required, to minimise acid production.	specific proposed design of the embankment excavation.	
		Completed as part of EIS Supplement.	Supplement Attachment G2	URS (ASS INVESTIGATION) GLNG Dredge Placement Material facility Curtis Island: Acid Sulfate Soils Investigation, October 2009.	Yes.	Yes.			
Bridge and Marine Pipeline Trench.	Relates to the span of water between Friend Point on the mainland and Laird Point on Curtis Island. Proposed method of pipeline trenching is dredging.	Completed as part of EIS.	EIS Section 7.3 and EIS Appendix L4.	GHD (PIPELINE FEED GEOTECH).	Yes.	No.	GHD had been engaged to undertake a geotechnical assessment along the off-shore section, at which time additional ASS samples were collected. The results of this work were assessed and presented in the EIS.	There is sufficient data to broadly characterise the ASS condition for various lithologies and their occurrences; if the final route is closely aligned with the sample locations.	Management of ASS that may have been identified within the marine sediment, across which a pipeline trench is proposed, will depend on the method of dredging and the handling of dredge spoils. This is because various dredge methods and spoil placement approaches can affect the way in which sediments settle or separate (which will also affect the distribution of shell fragment and thereby the distribution of one form of natural acid neutralisation), homogenise, dewater or break apart. Specific management strategies based on the extent, location and method of disturbance will be prepared, based on the characterisation completed to date, and specific construction details. These details will be submitted as part of any application for authorities to undertake work This would relate the results of the investigation to the methods of dredging, and the placement and handling of spoils and dredge waters.
		Completed as part of EIS.	EIS Section 8.3 and EIS Appendix R3.	URS (ASS INVESTIGATION) Marine Sediment Investigation - Environmental Investigations of Proposed Dredging at China Bay and Pipeline Crossing at The Narrows, Gladstone 28 January 2009.	Yes.	Yes.	As part of the EIS, URS undertook ASS, metals, nutrients, radionuclide and organic compounds sampling along 2 proposed bridge and trench alignments, with 3 sample locations along each.		
Pipeline (EIS Assessed Route), road construction and bridge abutment piling.	Relates to the gas transmission pipeline mainland EIS base case. The base case proposed route approaches the GSDA from the south-east, veering slightly north to run roughly parallel with the mainland coast (offset between 100 m and 500 m inland from the coastline) for approximately 2500m, where it reaches Friend Point. Additionally considers the ASS aspect of road and bridge abutment construction.	Completed as part of EIS.	EIS Section 7.3 and EIS Appendix L4.	GEOCOASTAL (ASS INVESTIGATION) Terrain Soils and Land Capability LNG facility 12 February 2009.	Yes.	Yes.	GeoCoastal undertook sampling along the mainland coastline at 23 locations, starting in the south from approximately 1000m north of Fisherman's Landing Wharf up to Friend Point in the north. Of the 23 locations, 13 were located along the general alignment of the mainland EIS base case pipeline route, allowing for an ASS assessment along this particular general alignment.	The ASS data available should be sufficient for assessment and characterisation of any ASS along the mainland EIS base case pipeline alignment, and provide adequate data for the development of any management strategies for any identified ASS material, disturbed during construction along the mainland EIS base case pipeline alignment.	The management of any ASS identified along the mainland EIS base case, should be developed in parallel with the CEMP and any EMP for the proposed works. To develop an ASSMP which mitigates the site and project specific environmental issues associated with ASS disturbance, the extent and method of disturbance and construction must be known to allow volumes of disturbed ASS to be estimated and details such as the locations of stockpile locations and sumps (if required) to be established. Whether the excavated material is intended for backfill will also affect the type of management strategies implemented. Additionally, any CEMP or EMP will comprise monitoring aspects which would otherwise be required for ASSMP impact monitoring.
		Completed as part of EIS Supplement.	Supplement Attachment E5.	GHD (PIPELINE FEED GEOTECH).	Yes.	Yes.	GHD had been engaged to undertake pre FEED geotechnical assessment of the mainland EIS base case pipeline route. During intrusive sampling, ASS samples were also collected and submitted for analyses, to ensure that any ASS data gap was closed and analytical data was available along the precise alignment of the pipeline, to be used in conjunction with the GeoCoastal data.		

Project Component		EIS or Supplement Study	EIS or Supplement Section	Consultant and Investigation	ASS Intrusive Investigations		Approach Rationale	ASS Characterisation Data Gaps	ASS Management Plan (ASSMP)
Name	Description				Field Screening (pHField and pHFox)	Analytical Tests (SPOCAS or Chromium Suite)			
Pipeline (Curtis Island), road construction and bridge abutment piling.	Relates to the route of the gas transmission pipeline on Curtis Island from Laird Point heading inland in an easterly direction, along which a road is also proposed. Additionally considers the ASS aspect of road and bridge abutment construction.	Completed as part of EIS.	EIS Section 7.3 and EIS Appendix L4.	GEOCOASTAL (ASS INVESTIGATION) Terrain Soils and Land Capability LNG facility 12 February 2009.	Yes - Limited lineal coverage (≤5 mAHD only).	Yes - Limited lineal coverage (≤5 mAHD only).	GeoCoastal undertook sampling at 7 locations on Curtis Island, starting from Laird Point and heading in an easterly direction. GeoCoastal's report outlined the proposed activities along this sampling run as being for roadway and bridge abutment construction; however, the proposed alignment of the pipeline also follows the route sampled by GeoCoastal. Geocoastal focused on low lying areas and areas they considered as requiring ASS assessment along the route. Geocoastal sampled to depths of approximately 1m on the assumption that roadway construction would be mostly filling activities.	The suitability of ASS data obtained for the Curtis Island pipeline route cannot be confirmed until the alignment of this section of pipeline and the method of construction is finalised, to compare the investigation locations against the final alignment route and the depth to which soils will be disturbed. Also, sample locations were selected to target areas ≤5 mAHD; if the soil disturbance criteria for ASS investigation are triggered for areas >5mAHD and ≤20 mAHD, additional data in those areas may be required.	Specific management strategies based on the extent, location and method of disturbance will be prepared, based on the characterisation completed to date, and specific construction details. These details will be submitted as part of any application for authorities to undertake work.
Pipeline CPIC Route	Relates to the CPIC Route which runs direct to Friend Point in an easterly direction originating inland and which continues without deviation across Port Curtis.	Completed as part of EIS Supplement.	Supplement Attachment E5.	GHD (PIPELINE FEED GEOTECH).	Yes - Limited spatial coverage (no lineal representa tion).	No - SPOCAS sample locations outside of alignment.	The GHD data will permit a more targeted investigation (target specific depth profiles which are now known to comprise ASS in the area). However, as no laboratory data is available in the proposed northern alignment, additional ASS investigations will be carried out post EIS once final alignment is confirmed, to ensure the conditions are known along the final alignment.	The data provides an ASS assessment of the general area and will be used to develop a more targeted approach to additional sampling once the exact route is finalised as the ASS condition for general area has been established.	Specific management strategies based on the extent, location and method of disturbance will be prepared, based on the characterisation completed to date, and specific construction details. These details will be submitted as part of any application for authorities to undertake work.
		Completed as part of EIS Supplement.	Supplement Attachment G6.	GLNG EIS Supplement. Common Pipeline Infrastructure Corridor - Acid Sulfate Soils assessment of additional field data.	NA.	NA.	URS undertook a review of the GHD data and produced a report assessing the ASS condition in the general area of the northern alignment.		

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