CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

APPENDIX V: East Trinity Soils Values Assessment Report (2016)

29 September 2016

BASELINE SOILS REPORT - EAST TRINITY

Cairns Shipping Development Project

REPORT

Report Number. 1546223-004-R-Rev3

Distribution:

1 PDF electronic copy

Golder Associates

Executive Summary

The East Trinity site is underlain by young (Holocene age) alluvial deposits to depths of about 2m to 4m below the ground surface at the eastern end of the site, progressively increasing in depth towards the west. At the western margins of the site the thickness of Holocene deposits typically ranged between about 6.5m and 12m, increasing to a depth of about 22m between Hills Creek and Magazine Creek.

The younger alluvial deposits are underlain by older (Pleistocene age), consolidated alluvial deposits and then Permian age Granite bedrock at depths of at least 90 m near Trinity Inlet.

The Holocene age alluvium is typically soft and highly compressible. Design of ponds will need to consider total and differential settlements induced by the embankments and by the dredged materials. Areas where greatest potential settlement could be expected are marked on Figure 6.

The materials within the upper 1 m of the soil profile are expected to be generally clayey in nature, however their permeability and suitability for construction of embankments is not known at this time. Use of synthetic liners may need to be considered.

Acid sulfate soil conditions at the site have been extensively studied and partially remediated over the past 15 years. PASS and AASS materials underlie the entire site. It is recommended that areas underlain by AASS plus areaS where past remediation works have been carried out should be avoided to prevent disturbance and possible remobilisation of acid. A buffer distance of at least 10 m between such areas and dredged spoil ponds is also recommended.

Figure 7 shows areas where siting of the ponds should not result in disturbance of PASS. These areas typically occur above 1m AHD and can support excavations generally to depths of less than 1m below ground level. There is greater than 120 ha of land above 1m AHD. Some areas with site levels between 0.5m and 1m AHD should also be suitable for siting of ponds (providing excavation depths are less than 0.5m below ground level). When these areas are included the area potentially available for dredged spoil ponds is greater than 230 ha.

Table of Contents

FIGURES:

APPENDICES:

Acronyms

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 and assessment of soil issues as part of the Revised Draft Environmental Impact Statement for the Cairns Shipping Development (CSD) project.

The revised CSD project involves the following:

- Reduced channel widening and deepening plus dredging of the swing basin and berth pockets in the inner port area (capital dredging). This will result in a total capital dredging volume of about 860 000m^3. This is an in-situ material volume calculated as occurring between current maintenance dredging depths and the enlarged channel target depths including insurance depth and appropriate minimal over-dredging allowances.
- Land placement of capital dredge material at the following sites:
  - Northern Sands (an existing void in the Barron River delta created by sand extraction and now used for burial of ‘inert’ construction and demolition fill and a limited quantity of PASS).
  - East Trinity (a new bunded site or sites within the general East Trinity area).

Other aspects of the CSD Project described in the Draft EIS remain unchanged.

This report is based on a desktop review of available information and addresses the land placement of capital dredged material at “East Trinity” – a new bunded site or sites within the East Trinity Reserve area, see Figure 1. Conceptual land placement of dredged materials at East Trinity would have the following requirements:

- A pumping delivery line from Trinity Inlet to the dredged spoil ponds, including a pump out facility.
- A placement area of 60 ha (i.e. approximately 1.9 M m^3 of dredged spoil stored 3 m deep) plus an additional area of about 8 hectares for perimeter bund walls. It is expected that the bund walls would be formed using material sourced from the placement area footprint. This is expected to require excavation to depths of less than 0.5m across this area.
- A PASS treatment area ranging from about 6 ha to 12 ha (including allowance for bunding and stockpiling).
- Provision for tailwater treatment – subject to preliminary concept design.

The aims of this report are to describe the existing soil conditions associated with East Trinity and to identify:

- Key soils related constraints (and opportunities) to design and construction of the facilities required for placement of the dredged material.
- Potential soils related environmental impacts and mitigation/management measures (to be subject to a future detailed impact assessment).

2.0 DESKTOP ASSESSMENT – EAST TRINITY SITE

2.1 Site Background Information

The East Trinity Reserve covers an area of about 774 hectares and is located on what was formerly an estuarine floodplain. In the early 1970s, CSR constructed a 7.2km bund wall along the southern, western and northern site boundaries as the first step in draining the land to facilitate sugar cane cultivation. The bund included one-way floodgates on Hills Creek and Firewood Creek and completely cut-off other creeks which essentially eliminated tidal influence to the landward side of the bund wall.

Following bund construction, extensive vegetation clearing was conducted and in areas above about 0.5m AHD a series of drains were installed. Mangrove communities were reported to have originally been found in areas below 1m AHD with samphire communities generally located between 1m and 2m AHD.

Bunding and drainage works resulted in lowing the groundwater level in the pyritic sediments present over most of the site. This resulted in a major acid sulfate soil problem which produced ongoing discharge of acid, iron, aluminium and other heavy metals into Trinity Inlet and contributed to the abandonment of cane cultivation. Internal creeks became acidified and contained high levels of metals, resulting in fish kills and aquatic ecosystem damage.

Ownership of the land passed through several developers who failed to obtain planning approvals for canal and marina developments in the 1990s and who finally became bankrupt. The site was then neglected until purchased by the Queensland State Government in 2000. The government requested the Department of Natural Resources and Mines to develop a remediation plan to deal with the environmental issues posed by acid sulfate soils at East Trinity.

Implementation of the remediation plan commenced in 2001 and involved a range of engineering solutions to achieve the desired hydrology and applied a lime-assisted tidal exchange remediation strategy, firstly on a trial basis and then (following positive results) on a long term basis. Management of the remediation works subsequently passed to Queensland Department of Science, Information Technology and Innovation (DSITI).

In March 2016, H. Luke (2016) reported that remediation works have produced a spectrum of stages of remediation in the site sediments, with large areas fully remediated. Tidal inundation led to a binding-up of heavy metals in the sediments and the neutralisation of acidity to a pH of 6.5. Section 2.5 contains more detailed discussion on current ASS conditions.

Extensive soil and surface water studies and monitoring have been conducted across this site since the 1990s. This report draws upon this existing body of data to evaluate site conditions, constraints and potential impacts.

2.2 Topography

Levels across the site are typically below 2.5m AHD. Four creek systems (Firewood Creek, Magazine Creek, Hills Creek and Georges Creek, see Figure 1) originally flowed through the site prior to construction of the perimeter bund. Levels in the vicinity of these creek lines are typically below 0.5m AHD.

2.3 Geology

The East Trinity site is located on the eastern side of Trinity Inlet, opposite the Cairns CBD. This site has a lithology of coastal tidal flats, mangrove flats, supratidal flats, saltpans and grasslands. Published geological information from *Queensland Digital Geological Map Data 1:100,000 Cairns 8064 series Department of Natural Resources and Mines* indicates the site is dominated by Holocene aged alluvial deposits of silt, mud and sand sediments. A series of north east/south west trending, sand chenier ridges are also present across the site. The surficial geology is shown on Figure 2.

Interpreted stratigraphic sections for the East Trinity site, Smith et al (2003) are reproduced on Figures 3A and 3B, and indicate:

- The younger (Holocene age) alluvial deposits are generally present to depths of about 2m to 4m below the ground surface at the eastern end of the site, progressively increasing in depth towards the west. At the western margins of the site the thickness of Holocene deposits typically ranged between about 6.5m and 12m, increasing to a depth of about 22m between Hills Creek and Magazine Creek.
- The younger alluvial deposits are underlain by older (Pleistocene age), consolidated alluvial deposits.
- Permian age Granite bedrock underlie the alluvial deposits at depths of at least 90 m near Trinity Inlet.

2.4 Soils

The CSIRO 1996 *Soils of Cairns-Babinda Area, North Queensland* 1:50000 scale soils map shows the site as “Made Land”, presumably as a result of the earthworks carried out at the site in the 1970’s. Soil stratigraphy was mapped from a soil survey of the site in 2001 (Smith et al. 2003) as discussed further in Section 2.5.

2.5 Acid Sulfate Soils

Acid Sulfate Soil (ASS) is a general term applying to both a soil horizon that contains sulfides (ie. Potential Acid Sulfate Soil - PASS) and an acid soil horizon affected by oxidation of sulfides (ie. Actual Acid Sulfate Soil - AASS).

The Department of Environment and Resource Management 2009 *Acid Sulfate Soils of Cairns North Queensland* shows the East Trinity site as being mapped at a 1:25,000 scale. The presence of actual acid sulfate soils (AASS) and/or potential acid sulfate soils (PASS) was confirmed over the entire site. An extract of the DERM 2009 soil map covering East Trinity and showing the interpreted distribution of AASS and PASS is reproduced as Figure 4.

A pre-remediation soil survey of the site in 2001 (Smith et al. 2003) comprised drilling at 85 locations to depths ranging to 20 m and resulted in the development of soil stratigraphic sections through the site as reproduced as Figure 3. The pre-remediation survey is reported to have established the following relationships between soil properties and elevation:

- No acidified soil occurred above approximately 1 m AHD (pre-drainage aerial photography indicated that this area was dominated by mangrove communities).
- The most concentrated zone of acidification occurred on land below 0.5 m AHD.
- Self-neutralising ASS occurred at depths below 1 m AHD on land that previously supported samphire vegetation on salt flats.
- Some of the land originally at 1 m AHD had irreversibly settled by up to a metre as a consequence of drainage.
- Elongated curved sand ridges (cheniers) that occur across the site above the flat surface of the ASS are non-ASS.

The 85 locations and 10 sites regularly monitored during the remediation works were re-sampled in 2013 (Smith et al. 2016) to quantify the changes to soil properties in response to the remediation program. Smith et al. (2016) also reports that between 2001 and 2013, 150 additional sites were described across the whole site. Smith et al (2016) used this data to define the high level mapping units in terms of Holocene geomorphology and elevation. This mapping has been conducted at a significantly higher frequency than the 2009 ASS map and includes more up to date indications of improved conditions resulting from remediation works. On this basis, this mapping is considered the most appropriate for use in this assessment. Mapped areas are reproduced on Figure 5.

2.6 Groundwater

It is likely that upper surface of ASS across the site reflects the original groundwater level prior to bunding and installation of drains. Studies by Herbert et al (2003) prior to commencement of ASS remediation works in 2001 indicated:

- A shallow groundwater system generally below about 0m AHD.
- Seasonal groundwater fluctuations recorded over 2000/2001 ranged from 0.4m AHD to -2m AHD.
- Seasonal pH fluctuations ranging from about pH 4 to pH 8 at monitoring locations towards the western end of site. EC fluctuations ranging from about 10 mS/cm to 110 mS/cm.

Seasonal pH fluctuations ranging from about pH 6.2 to 7.5 at the monitoring location towards the eastern end of site. EC fluctuations ranging from about 1.5 mS/cm to 4 mS/cm.

A more detailed assessment of groundwater is presented in Golder report 1546233-007-R-Rev0.

2.7 Geotechnical Conditions

Geotechnical investigations at the site by Golder in the mid to late 1980s on the higher accessible portions of the site indicated that in general terms ground conditions comprised the following:

- Topsoil and stiff clays to depths ranging from about 0.8 m to 1.0 m (and locally to >1.0 m).
- Soft highly compressible clays to depths ranging from about 2 m to 20 m.
- Stiff to hard silty and sandy clays (with layers of dense sands) to depths ranging to about 23.5 m (the maximum depth investigated).

Sand ridges were noted at various locations across the site and groundwater was noted to be at shallow depth.

These ground conditions are consistent with the interpreted stratigraphy for the East Trinity site, Smith et al (2003) discussed previously and as shown on Figure 3.

3.0 DREDGED SPOIL MATERIAL

A geotechnical assessment of the dredge material properties has been undertaken by Golder 2016 (refer Values and Constraints Assessment: Dredge Material Properties, Report No. 1546223-006-R-Rev2).

The assessment confirmed that dredged materials will be comprised of:

- Stiff and very stiff materials have been confirmed as non-ASS; and
- Soft sediments, comprised of PASS and “self-neutralizing” PASS materials.

4.0 CONSTRAINTS AND OPPORTUNITIES

4.1 Opportunities

Opportunities related to the disposal of dredged spoil at East Trinity are as follows;

- The disposal ponds and associated tailwater ponds (if required) could be constructed for a staged dredging program for capital dredging.
- With appropriate drying and lime treatment (if required) the dredged material could become a resource suitable for reuse as bulk fill for farming purposes or earthworks for residential, commercial or industrial development.
- During the dredging operation, areas of self-neutralising PASS may be able to be dredged and stored separately from areas of PASS. This could substantially reduce treatment and reworking requirements.

4.2 Constraints

4.2.1 Pond and Pipeline Construction

Constraints related to pond construction are as follows:

- The materials within the upper 1 m of the soil profile are expected to be generally clayey in nature, however they may not be suitable for construction of embankments for water retaining ponds. Use of synthetic liners may need to be considered. Confirmation sampling of proposed disposal sites will be required at the design stage to confirm permeability (and need for lining) of soils beneath the pond footprint and if site materials are suitable for construction of embankments.
- The near surface soils are underlain by a varying thickness of highly compressible clays, typically increasing in thickness from the eastern to western side of the site. Design of the ponds will need to consider settlements induced by the embankments and by the dredged materials. Allowance for contingency measures may need to be made (e.g. topping up of embankments and/or remedial works on decant structures may be required). Figure 6 provides an indication of the expected variability of settlement.

4.2.2 Insitu ASS Materials

Constraints related to insitu ASS materials are as follows:

- Placement of fill over soil profiles containing zones of AASS may cause settlement of these materials below the groundwater table and allow release of acid into the groundwater system.
- Disturbed/excavated AASS and PASS materials have the potential to generate acid if not managed appropriately via lime treatment, or immediate placement back below the water table (PASS only).
- Dewatering of excavations and/or changes resulting in temporary or permanent lowering of the groundwater may expose in-situ AASS and PASS materials and result in release of acid.

PASS and AASS materials underlie the entire site. It is recommended that areas underlain by AASS plus area where past remediation works have been carried out should be avoided to prevent disturbance and possible remobilisation of acid. A buffer distance of at least 10 m between such areas and dredged spoil ponds is also recommended.

To avoid disturbing PASS materials during formation of the dredged spoil ponds, it is recommended siting of the ponds should be on the following soil mapping units (Figure 5) in order of priority:

- N6 - Non ASS, surface elevation >2m AHD
- S5 - Sulfidic (PASS) at depth, surface elevation >1m AHD
- Sch - Chenier, sulfidic at depth, surface elevation >1m AHD
- Sn5 - Sulfidic, self-neutralising, surface elevation >1m AHD
- Sn4 - Sulfidic, self-neutralising, surface elevation 0.5m to 1m AHD

A colour coded map of the site showing these constraints is presented as Figure 7.

Using the above rationale and buffer distances there is greater than 120 ha of land above 1m AHD. When Sn4 areas are included the area potentially available for dredged spoil ponds is greater than 230 ha.

Confirmation sampling of proposed disposal sites will be required at the design stage to confirm the absence of PASS within proposed excavation depths.

4.2.3 Placement of Dredge Spoil Materials

Constraints related to placement of dredged spoil materials are as follows:

- The proposed dredging operation will use a combination of mechanical and hydraulic excavation processes, with the end result being that the dredged material is a slurry mixture of soil and saltwater. It is likely that liming will be required for PASS treatment of some or all of the dredged material. Further characterisation of dredged materials (including self-neutralising sediments) placed in the spoil ponds may be required to confirm zones requiring treatment.
- Additional site area will be required to allow for drying and treatment of PASS materials.

5.0 POTENTIAL IMPACTS

5.1 ASS Materials

5.1.1 Potential Level of Risk

Given the size of the proposed development and the volume of dredged spoil to be placed, management of existing and potential acidity would be classified as XH (extra high level) treatment as per the Soil Management Guidelines V4 (Dear et al. 2014) - Table 4.2. As such, the Guidelines require that a comprehensive environmental management plan must be formulated including detailed closure reporting and handover testing procedures. This plan should also provide for ongoing management and monitoring of the effects of the disturbance/placement of ASS through the entire construction and operation period of spoil ponds.

5.1.2 Potential Impacts Associated with ASS

When ASS is exposed to oxygen as a result of disturbance (via excavation or displacement) or drainage (via dewatering or other means), pyrite can oxidise and forms 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 aquatic environments (especially estuarine) 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 $Fe2+$ consuming oxygen and lowering the level of dissolved oxygen in surface waters.

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

5.2 Dredged Spoil

5.2.1 ASS

If left untreated, zones of PASS within the placed dredge spoil will dry and oxidise. Acid generated from this process may leach through unlined bunded areas and has the same potential impacts as discussed in Section 5.1.2.

5.2.2 Treatment Options

Following disposal into ponds, the processes of settling and decanting, plus solar drying will reduce the moisture content significantly to provide a soil material that can be excavated and reworked to enable lime treatment. Options for lime treatment include the following;

- Re-dredging and in-line lime dosing
- Land farming
- Pug mill treatment

5.3 Geotechnical

Potential geotechnical impacts resulting from construction and operation of the dredged material deposition process include the following:

- Settlement and/or failure of pipeline support foundations, possibly resulting in burst or leaking pipelines.
- Seepage through pond walls as a result of dispersive soil properties, possibly resulting in a breach of the pond wall.
- Instability of the pond walls as a result of over-steep profiles and/or soft foundation conditions, possibly resulting in overtopping of ponds.
- Settlement of pond walls as a result of soft foundation conditions, possibly resulting in in overtopping of ponds.

It is noted that all of the above impacts are likely to be able to be mitigated by appropriate geotechnical investigation and design.

6.0 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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Herbert GC, Martens MA and Hopgood GL (2003). Groundwater Characterisation. In: Demonstration of Management and Rehabilitation of Acid Sulfate Soils at East Trinity: Technical Report. Smith CD, Martens MA, Ahern CR, Eldershaw VJ, Powell B, Barry EV, Hopgood GL and Watling KM (eds). Department of Natural Resources and Mines, Indooroopilly, Queensland, Australia.

Manders J.A. O'Brien L.E. Morrison DW (2009). *Acid Sulfate Soils of Cairns, North Queensland* Department of Environment and Resource Management, Indooroopilly, Queensland, Australia.

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Smith C.D., Manders J.A. and Brough D.M. (2016). *East Trinity acid sulfate soil remediation project – Changes in soil properties after 13 years of remediation*. (Department of Science, Information Technology and Innovation), Queensland Government, Brisbane.

H. Luke (2016). *East Trinity remediation and rehabilitation after Acid Sulfate Soil contamination, north Queensland*. Southern Cross University. Sourced from https://site.emrprojectsummaries.org/2016/03/13/east-trinity-remediation-and-rehabilitation-after-acid-sulfate-soil-contamination-north-queensland/

7.0 IMPORTANT INFORMATION

Your attention is drawn to the document - "Important Information relating to this report", 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.

GOLDER ASSOCIATES PTY LTD

Paul Scells
Principal Geo-Environmental Engineer

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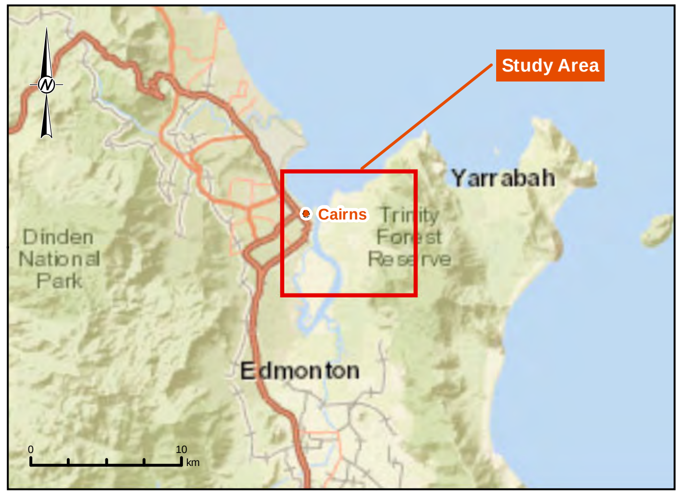
LOCATION MAP



LEGEND

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

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

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT EIS
BASELINE SOILS REPORT EAST TRINITY

TITLE
SITE LOCATION

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-09-01
PREPARED	DP
DESIGNED	DP
REVIEWED	PS
APPROVED	PS

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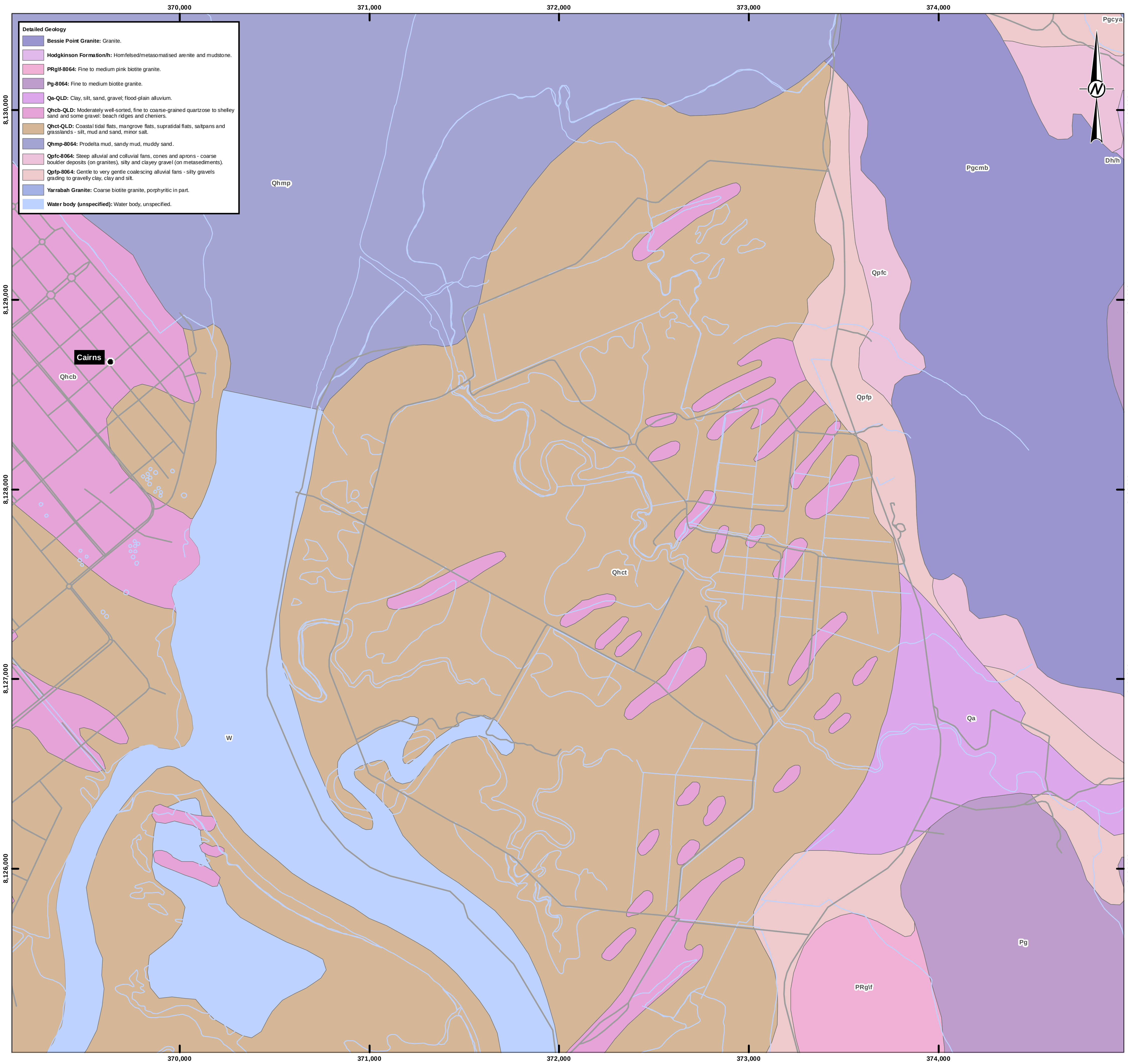
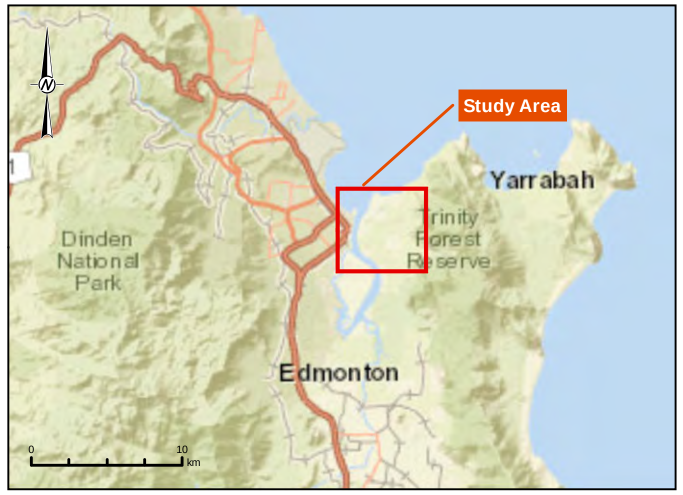


LOCATION MAP



LEGEND

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

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1:20,000 at A3 METRES
PROJECTION: GDA 1994 MGA Zone 55

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT EIS
BASELINE SOILS REPORT EAST TRINITY

TITLE
SURFICAL GEOLOGY

CONSULTANT

Golder Associates

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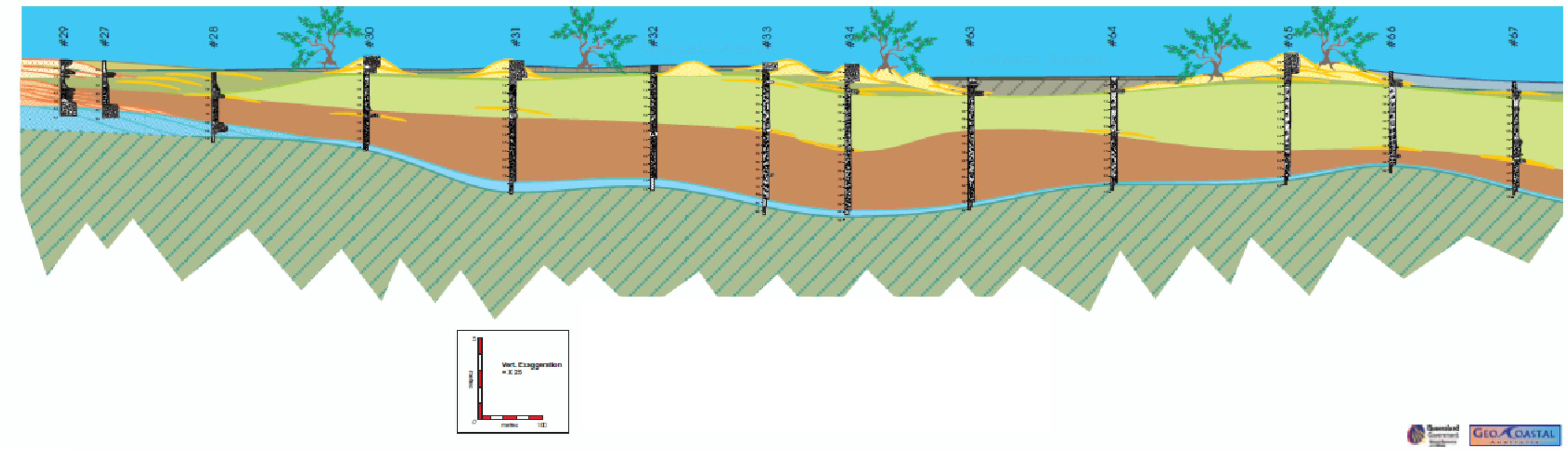
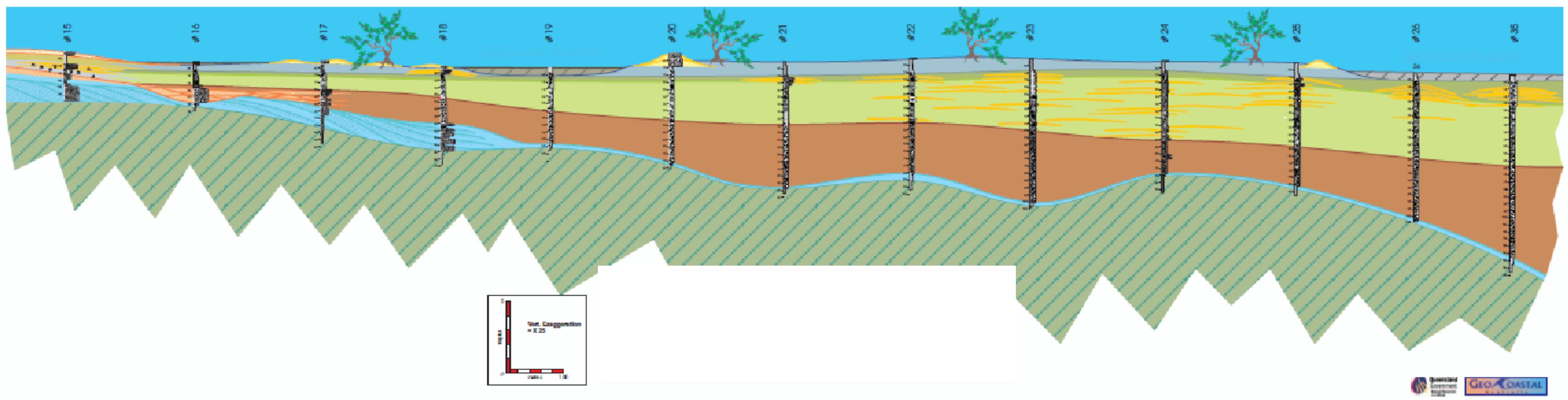
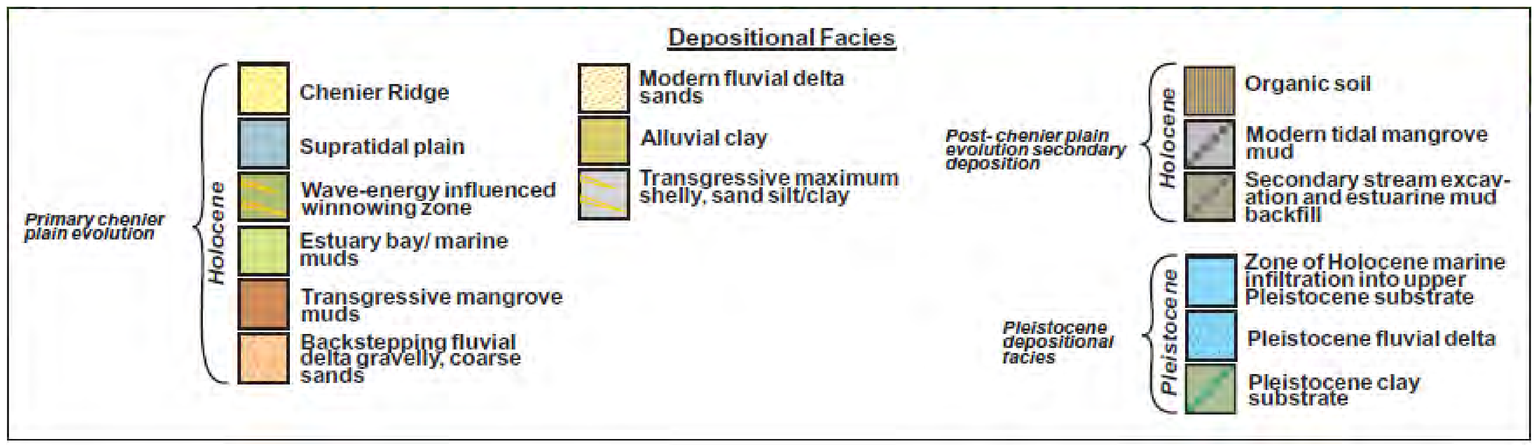


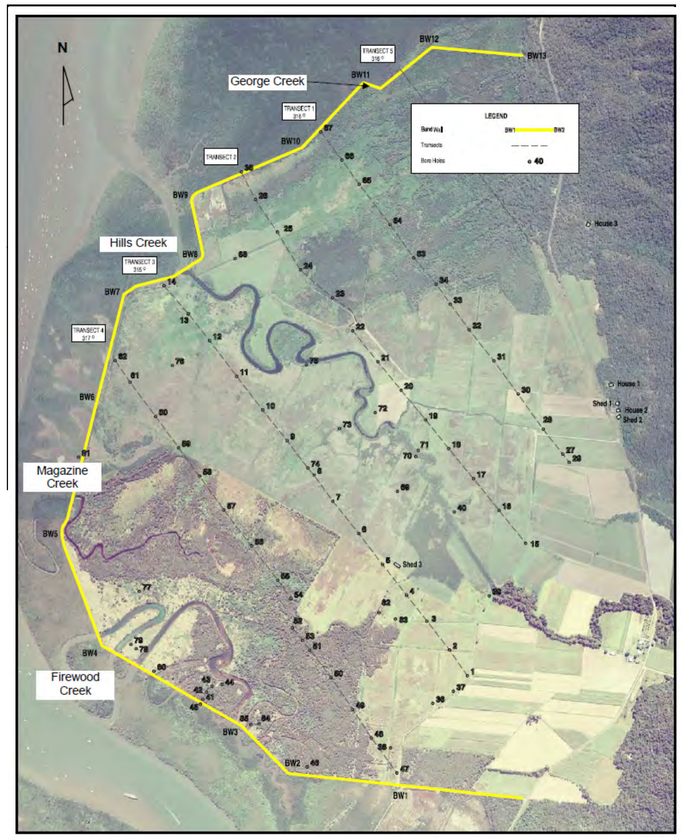
Stratigraphic cross-section along Transect 1, East Trinity.



Stratigraphic cross-section along Transect 2, East Trinity.



TRANSECT MAP



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CLIENT

FLANAGAN CONSULTING GROUP

PROJECT

CAIRNS SHIPPING DEVELOPMENT EIS
BASELINE SOILS REPORT EAST TRINITY

TITLE

SOIL STRATIGRAPHIC SECTIONS

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-25
PREPARED	DP
DESIGNED	DP
REVIEWED	DS
APPROVED	DS

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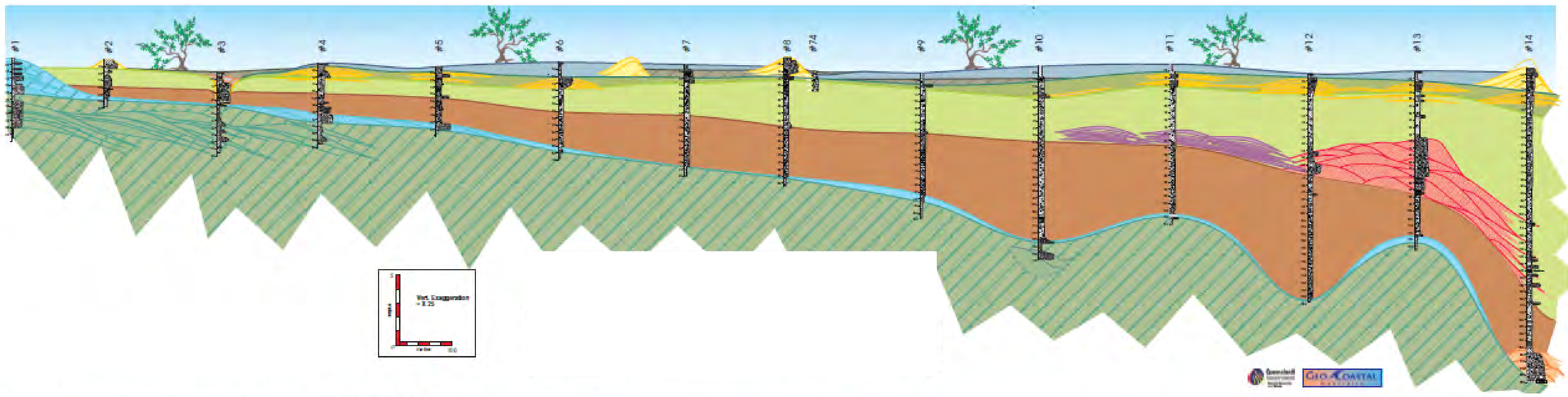
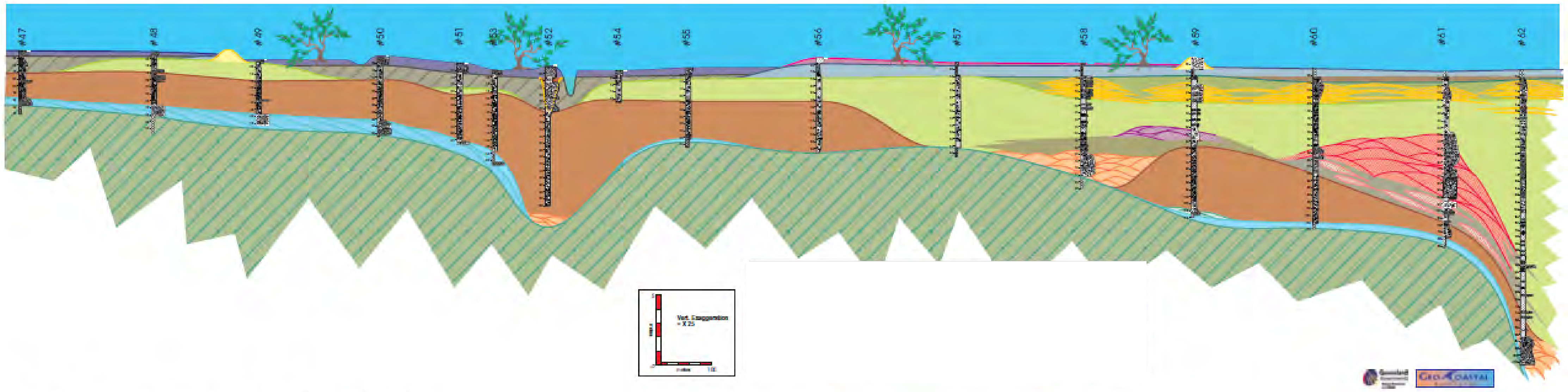


Stratigraphic cross-section along Transect 3, East Trinity.



Stratigraphic cross-section along Transect 4, East Trinity.

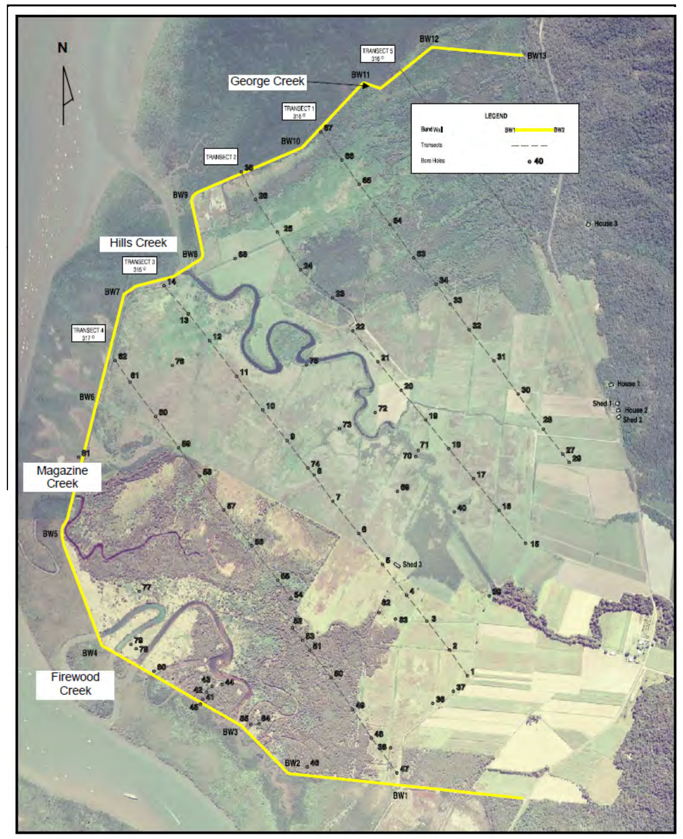
Depositional Facies

Primary chenier plain evolution — *Holocene*
- Chenier Ridge
- Supratidal plain
- Wave-energy influenced winnowing zone
- Estuary bay/ marine muds
- Backstepping fluvial pro-delta fine, laminated sands
- Pro-delta influenced estuary bay deposits
- Backstepping fluvial delta gravelly, coarse sands
- Shelf-edge backstepping fluvial delta deposits
- Fluvial delta influenced estuary bay sandy muds
- Transgressive mangrove muds
- Transgressive sandy lag deposits

Post-chenier plain evolution secondary deposition — *Holocene*
- Feather of Firewood Creek levee deposits
- Alluvial levee and sandy surface veneer
- Secondary stream excavation and estuarine mud backfill

Pleistocene depositional facies — *Pleistocene*
- Zone of Holocene marine infiltration into upper Pleistocene substrate
- Pleistocene fluvial delta
- Pleistocene clay substrate

TRANSECT MAP



Smith CD, Graham TL, Barry EV, Adams JJ and Ahern CR (2003). Acid Sulfate Soil and Stratigraphic Assessment. In: Demonstration of Management and Rehabilitation of Acid Sulfate Soils at East Trinity: Technical Report. Smith CD, Martens MA, Ahern CR, Eldershaw VJ, Powell B, Barry EV, Hopgood GL and KM Watling (eds). Department of Natural Resources and Mines, Indooroopilly, Queensland, Australia.

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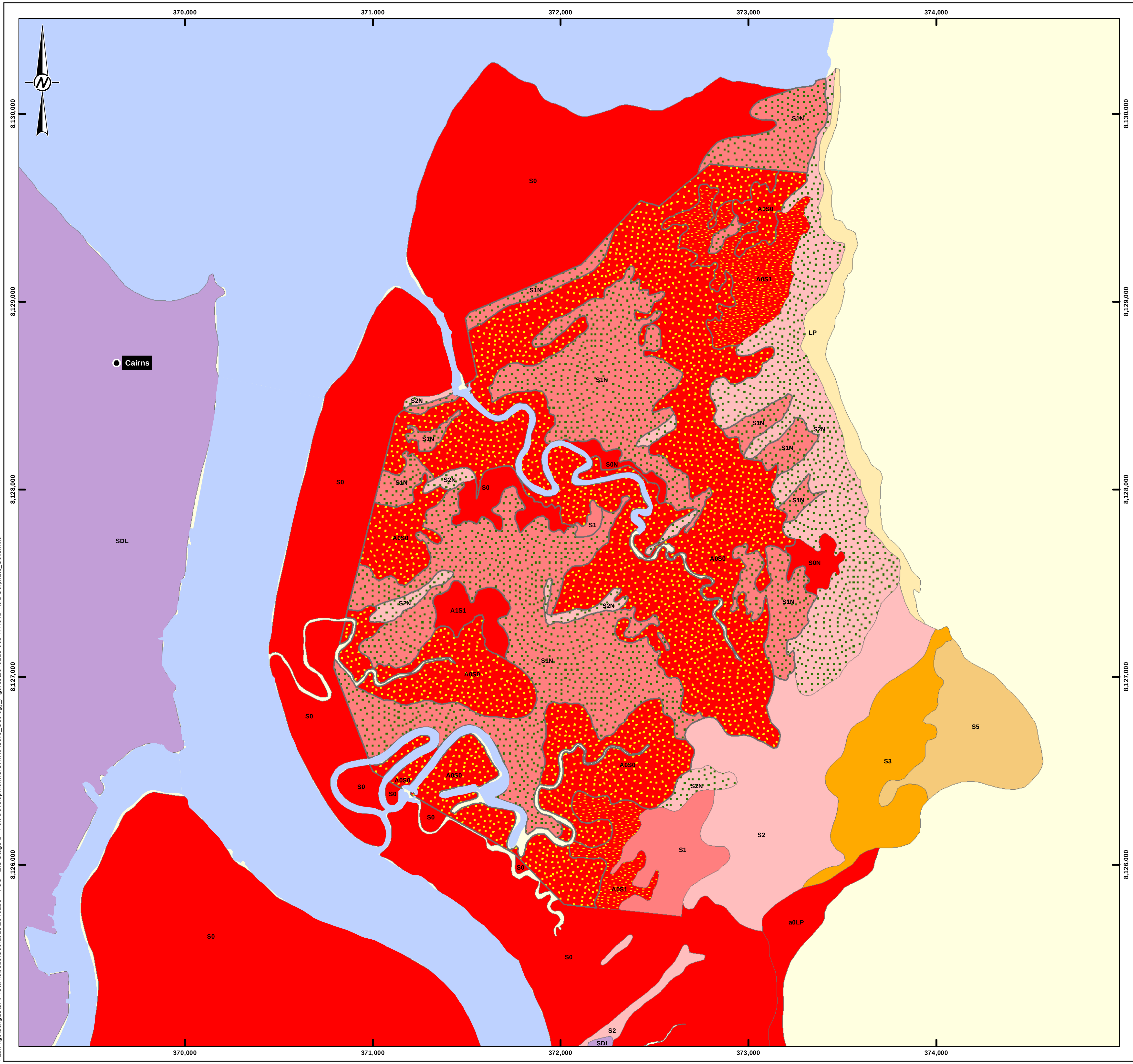
PROJECT
CAIRNS SHIPPING DEVELOPMENT EIS
BASELINE SOILS REPORT EAST TRINITY

TITLE
SOIL STRATIGRAPHIC SECTIONS

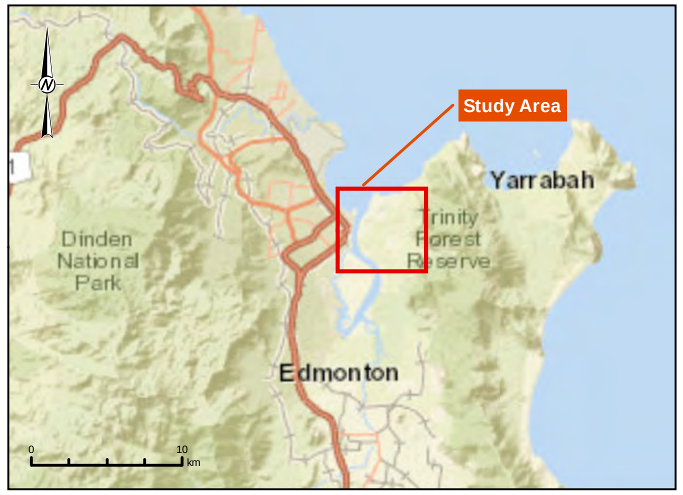
CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-25
PREPARED	DP
DESIGNED	DP
REVIEWED	DS
APPROVED	DS

PROJECT NO.	CONTROL	REV.	FIGURE
1546223	004	3	3B



LOCATION MAP



LEGEND

- ASS overlie Potential ASS
- Potential ASS with Self-Neutralising Capacity
- **S0:** Potential ASS in top 0.5m.
- **S1:** Potential ASS starting at 0.5 to 1m.
- **S2:** Potential ASS starting at 1 to 2m.
- **S3:** Potential ASS starting at 2 to 3m.
- **S5:** Potential ASS starting at 4 to 5m.
- **SDL:** Disturbed land with probability of ASS.
- **LP:** Land at or below 5m AHD with low probability of ASS.
- **A0:** Actual ASS starting in top 0.5m.
- **A1:** Actual ASS starting at 0.5 to 1m.

N: Indicated Self-Neutralising

0 250 500 750 1,000

1:20,000 at A3 METRES

PROJECTION: GDA 1994 MGA Zone 55

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PROJECT

CAIRNS SHIPPING DEVELOPMENT EIS
BASELINE SOILS REPORT EAST TRINITY

TITLE

ASS MAP 2009

CONSULTANT

Golder Associates

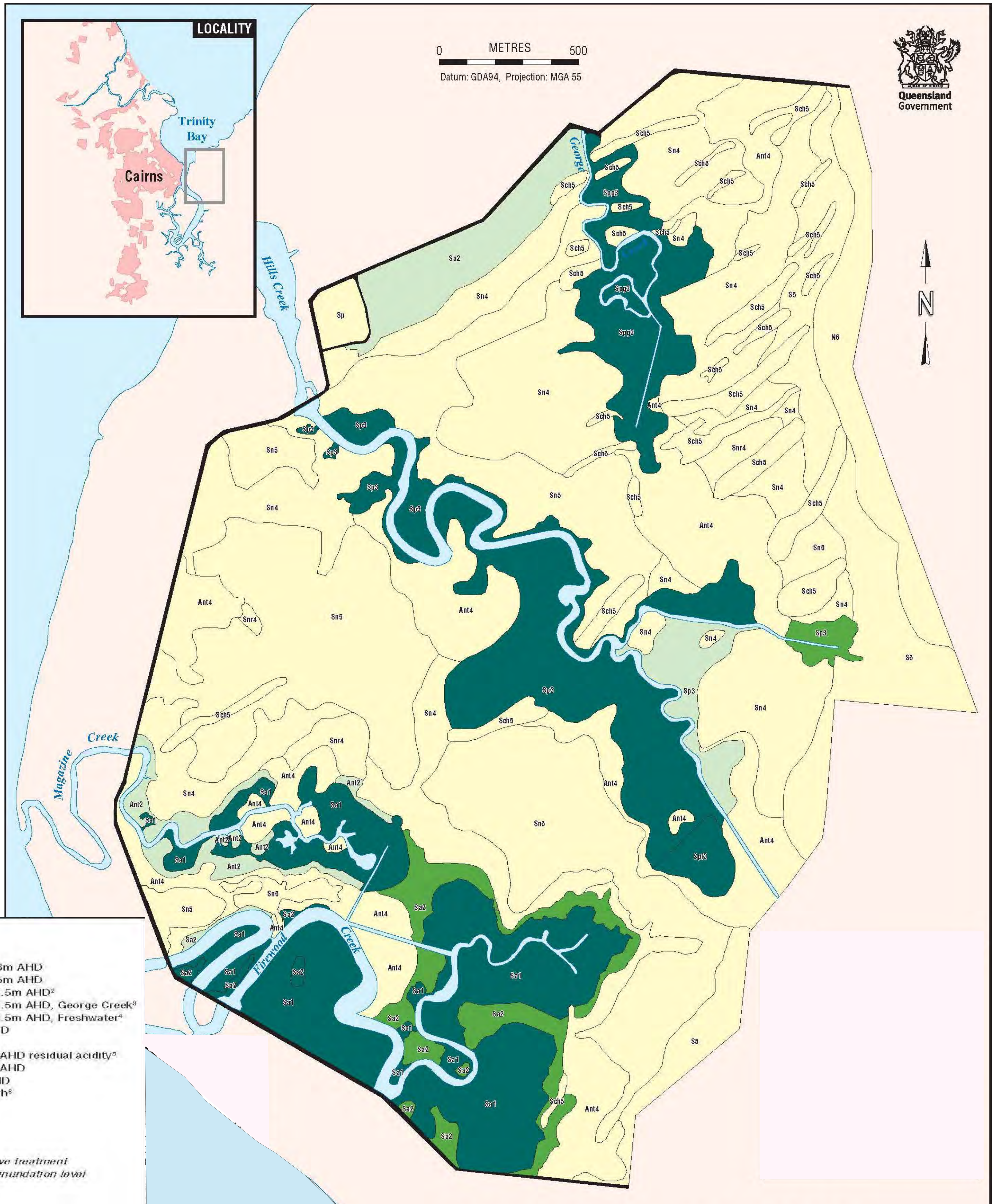
YYYY-MM-DD	2016-08-25
PREPARED	DP
DESIGNED	DP
REVIEWED	DS
APPROVED	DS

PROJECT NO.	CONTROL	REV.	FIGURE
1546223	004	3	4

Path: \\golder.gds\GAP\Cairns\Jobs\Geo\2015\1546223 - FCG - EIS Stage 1 - Port Development\GIS\MXD\Soils_Geology_Figures\1546223-001-R-RevB-Acid-Sulphate_Soils.mxd

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

25mm



MAPPING UNIT CODES

Map Unit	Description
Sa1	Sulfidic[1], Active Treatment, 0.0-0.3m AHD
Sa2	Sulfidic[1], Active Treatment, 0.3-0.5m AHD
Sp3	Sulfidic[1], Passive Treatment, 0.0-0.5m AHD[2]
Spg3	Sulfidic[1], Passive Treatment, 0.0-0.5m AHD, George Creek[3]
Spf3	Sulfidic[1], Passive Treatment, 0.0-0.5m AHD, Freshwater[4]
Ant2	Sulfidic, Not Treated, 0.3-0.5m AHD
Ant4	Sulfidic, Not Treated, 0.5-1m AHD
Snr4	Sulfidic, Self Neutralising, 0.5-1m AHD residual acidity[5]
Sn4	Sulfidic, Self Neutralising, 0.5-1m AHD
Sn5	Sulfidic, Self Neutralising, >1m AHD
Sch5	Chenier >1m AHD, Sulfidic at Depth[6]
S5	Sulfidic at depth >1m AHD[7]
N6	Non ASS >2m AHD
Sp	Sulfidic Spoil

[1] *Sulfuric prior to treatment*
[2] *7 years active treatment, 4 years passive treatment*
[3] *Responding to recent increase in tidal inundation level*
[4] *Permanent freshwater inundation*
[5] *Thin band of residual acidity present*
[6] *Some cheniers have sulfuric material at depth*
[7] *Typical depth to sulfidic layer is 1.5m, typical thickness 1m*

Maps Reproduced from:

Smith C.D., Manders J.A. and Brough D.M. (2016). East Trinity acid sulfate soil remediation project - Changes in soil properties after 13 years of remediation. (Department of Science, Information Technology and Innovation), Queensland Government, Brisbane.

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PROJECT
CAIRNS SHIPPING DEVELOPMENT EIS
BASELINE SOILS REPORT EAST TRINITY

TITLE
SOILS MAP 2015

CONSULTANT
Golder Associates

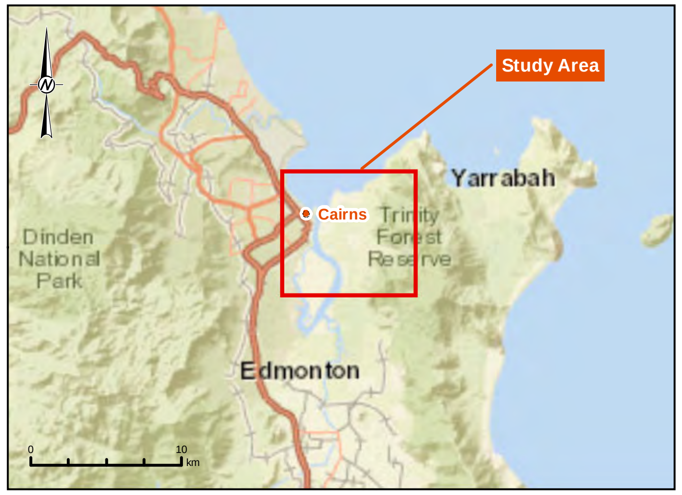
YYYY-MM-DD	2016-08-25
PREPARED	DP
DESIGNED	DP
REVIEWED	DS
APPROVED	DS

PROJECT NO.	CONTROL	REV.	FIGURE
1546223	004	3	5

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\1546223-001-R-RevB-Acid-Sulphate_Soils.mxd

LOCATION MAP



LEGEND

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

0 1 2

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

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PROJECT
CAIRNS SHIPPING DEVELOPMENT EIS
BASELINE SOILS REPORT EAST TRINITY

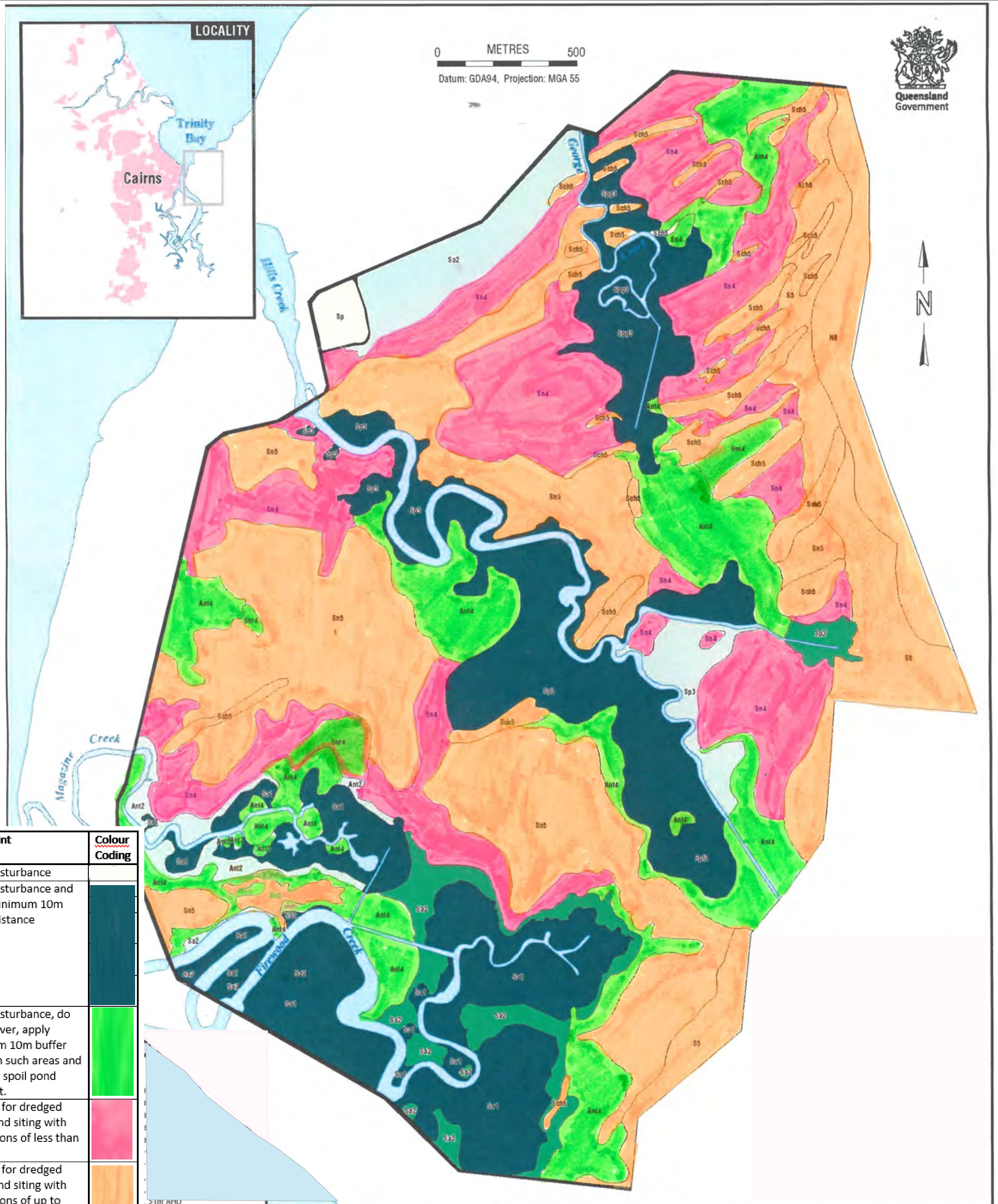
TITLE
CONSTRUCTION CONSTRAINT MAP

CONSULTANT		
Golder Associates	YYYY-MM-DD	2016-09-01
	PREPARED	DP
	DESIGNED	DP
	REVIEWED	PS
	APPROVED	PS

PROJECT NO.	CONTROL	REV.	FIGURE
1546223	004	3	6

Path: \\golder.gds\gap\Cairns\Jobs\Geo\2015\1546223 - FCG - EIS Stage 1 - Port Development\GIS\MXD\Cairns_Shipping_Project_181546223-001-R-RevA_F001_East_Trinity_Locality.mxd

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



Map Unit	Description	Constraint	Colour Coding
Sp	Sulfidic Spoil	Avoid Disturbance	
Sa1	Sulfidic, Active Treatment, 0.0-0.3m AHD	Avoid Disturbance and apply minimum 10m buffer distance	
Sa2	Sulfidic, Active Treatment, 0.3-0.5m AHD		
Sp3	Sulfidic, Passive Treatment, 0.0-0.5m AHD		
Spg3	Sulfidic, Passive Treatment, 0.0-0.5m AHD, George Ck		
Spf3	Sulfidic, Passive Treatment, 0.0-0.5m AHD, Freshwater		
Ant2	Sulfidic, Not Treated, 0.3-0.5m AHD	Avoid Disturbance, do not fill over, apply minimum 10m buffer between such areas and dredged spoil pond footprint.	
Ant4	Sulfidic, Not Treated, 0.5-1.0m AHD		
Snr4	Sulfidic, Self Neutralising, 0.5-1m AHD residual acidity		
Sn4	Sulfidic, Self Neutralising, 0.5-1m AHD	Suitable for dredged spoil pond siting with excavations of less than 0.5m	
Sn5	Sulfidic, Self Neutralising, >1m AHD	Suitable for dredged spoil pond siting with excavations of up to about 1m.	
Sch5	Chenier >1m AHD, Sulfidic at Depth		
S5	Sulfidic at depth >1m AHD		
N6	Non ASS >2m AHD	Unconstrained	

Maps Reporduced from:

Smith C.D., Manders J.A. and Brough D.M. (2016). East Trinity acid sulfate soil remediation project - Changes in soil properties after 13 years of remediation. (Department of Science, Information Technology and Innovation), Queensland Government, Brisbane.

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PROJECT
CAIRNS SHIPPING DEVELOPMENT EIS
BASELINE SOILS REPORT EAST TRINITY

TITLE
ASS CONSTRAINT MAP

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-31
PREPARED	DP
DESIGNED	DP
REVIEWED	PKS
APPROVED	PKS

PROJECT NO.	CONTROL	REV.	FIGURE
1546223	004	3	7

Path: \\golder.gds\GAP\Cairns\Jobs\Geo\2015\1546223 - FCG - EIS Stage 1 - Port Development\GIS\MXD\1546223-001-R-RevB-Acid-Sulphate_Soils.mxd

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

APPENDIX A

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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