CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

Supplementary Report

Appendix F: Golder Associates Acid Sulfate Management Plan

30 October 2017

CAIRNS SHIPPING DEVELOPMENT PROJECT

Acid Sulfate Soil Management Plan

ASSMP

Report Number. 1546223-025-R-Rev1

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1.0 INTRODUCTION

This Acid Sulfate Soil (ASS) Management Plan (ASSMP) has been developed as part of the Revised Draft Environmental Impact Statement for the Cairns Shipping Development Project (CSDP).

Acid Sulfate Soil (ASS) is a general term applying to both a soil horizon that contains sulfides (i.e. Potential Acid Sulfate Soil - PASS) and an acid soil horizon affected by oxidation of sulfides (i.e. Actual Acid Sulfate Soil - AASS). ASS may be peats, silts, clays, or sands.

The ASSMP has been based on available soils investigations previously completed for CSDP offshore works and the results of soils and water quality investigations at land based Dredged Material Placement Areas. The Procedures contained within this ASSMP should be updated and revised to address conditions encountered that vary from those indicated by investigations or where alternative construction methodologies are adopted.

The ASSMP was prepared with consideration of the following documents:

- *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines V4.0,* 2014. Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M. Department of Science, Information Technology, Innovation and the Arts, Queensland Government
- *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland*, 1998; Ahern, CR., Ahern, M.R. and Powell
- State Planning Policy, July 2017
- State Planning Policy – state interest guideline, Water quality, April 2016
- Environmental Protection Act 1994
- Environmental Protection Policy (Water) 2009

The purpose of the ASSMP is to mitigate or control potential impacts relating to on-shore placement of dredged material.

2.0 PROJECT OVERVIEW

The revised CSDP involves upgrading the following port infrastructure to enable larger cruise ships up to 300 m in length to berth at the Port of Cairns:

- Marine works to widen and deepen the shipping channel and Crystal swing basin, and establishment of a new shipping swing basin (Smith Creek Swing Basin) upstream of the existing Main Swing Basin involving:
  - Capital dredging works involving removal of up to 1,000,000 m^3 (insitu) of dredge material consisting of up to 900,000m^3 (insitu) of soft clays to be removed by a Trailer Suction Head Dredge (TSHD) and 100,000m^3 (insitu) of stiff clays to be removed by a Back–Hoe Dredge (BHD).
  - Construction of a temporary pump out facility located between 2.7 and 3.7 km offshore from Yorkeys Knob.
- Delivery and placement of dredged material to land based Dredged Material Placement Areas (DMPAs) including:
  - Construction of a temporary dredged material delivery pipeline from the pump out facility to the soft clay DMPA on the Barron Delta.
  - Placement of soft clay dredge material at the Barron Delta DMPA located on Lot 2/RP712954 and Lot 5 on SP245573.

- Placement of stiff clay dredged material at the Tingira St DMPA established on Port Land (Lot 27/SP 218291) located at Tingira St, Portsmith.

- Ancillary infrastructure/services upgrades.

3.0 DREDGED MATERIALS

3.1 Materials Characterisation

A baseline assessment of the geotechnical and ASS properties materials to be dredged was reported in Golder Report 1546223-006-R-Rev2. The assessment was based on a review of all historical information including results from fifty-five sampling locations by BMT-WBM from the original EIS in 2014 and the following supplementary investigations by Golder:

- Boreholes at 8 locations within the proposed channel widening for ASS sampling and testing.
- Grab sampling at 20 locations to ~0.8m depth in areas proposed for channel deepening (i.e. 16 locations in “sediments”), channel widening/deepening (i.e. 2 locations in “stiff clays”), and channel widening (i.e. 2 locations in “mud”).
- Geophysics – ~52km of longitudinal lines and traverse lines to assess the depth to the soft clay/stiff clay interface within the areas proposed for dredging, particularly in areas where stiff clays were expected to be encountered within the depth of proposed dredging.

The current and previous investigations indicated that the dredged materials will mainly comprise very soft to firm silty clays, with a relatively smaller quantity of stiff to hard clays and an even smaller quantity of sands. The very soft to firm clays include a quantity of transported sediment materials (recent deposits, mainly in the existing channel) as well as insitu marine clays (Holocene age deposits). The inferred sediment materials generally had significantly lower insitu bulk densities and insitu shear strengths compared to the very soft to firm insitu marine clays (i.e. those from “widening” investigation locations). The stiff to hard clays layers are consolidated Quaternary age deposits.

The following general material types were adopted for the purposes of reporting:

- Very soft to soft transported materials – “sediments”.
- Very soft to soft insitu materials – “mud”.
- Stiff to hard insitu materials – “stiff clays”.

In addition to these general materials, indications are that relatively isolated layers or zones of sandy and/or gravelly materials are also likely to be present.

The extents of soft clays (sediments and muds) and stiff clays to be dredged were reported in Golder Report 1546223-008-R-Rev2. Plans and sections from that report are reproduced as Figures 1A-1B and 2A to 2J.

3.2 ASS Characterisation

ASS results from all investigations were compiled and acid base accounting calculations were conducted to evaluate net acidity (refer Appendix C2 in Golder Report 1546223-006-R-Rev2). Whilst large shell fragments were removed from samples submitted for laboratory analysis, shell and fine shell grit were observed in most of the recovered sediments and muds. A “fineness factor” of 3 was applied to account for possible overstatement of neutralising capacity as a result of laboratory ring grinding of samples prior to analysis. This approach is consistent with consideration for self-neutralising soils outlined in the Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines V4.0.

The adoption of a more conservative fineness factor also changed the status of some previous BMT-WBM investigation results which had been reported as self-neutralising in the 2014 EIS.

Interpretation of the results of current and previous sampling and testing is summarised below:

- The sediment and mud materials have potential acidity (chromium reducible sulfur) levels which would classify these materials as potential acid sulfate soils (PASS). The total insitu volume of these materials has been conservatively calculated as 900,000 m^3.
- The majority of these PASS materials have sufficient neutralising capacity to classify them as self-neutralising PASS (SNP). The volume of these SNP materials has been calculated as 580,000 m^3.
- Locations where PASS materials (without sufficient neutralising capacity) have been identified are shown on Figures 3A and 3B along with their interpreted extents. The interpreted extents have been conservatively derived by assuming that:
    - PASS materials are present in all sediments and muds across the full width of channel sections at investigation locations where PASS materials were identified.
    - PASS extends up and down the channel in all sediments and muds from identified locations to the next investigation location where only SNP was identified.

  The calculated insitu volumes of sediments and muds to be dredged from identified PASS areas, as described above, comprise:
    - Main Swing Basin – 55,000 m^3
    - Crystal Swing Basin – 11,000 m^3
    - CH14750-CH15250 – 40,000 m^3
    - CH15250-CH16250 - 118,000 m^3
    - CH17500-CH18000 - 96,000 m^3
- The Quaternary aged stiff clays by definition were not expected to be acid sulfate soils. All tests conducted on the stiff clays confirmed them to be non-ASS.

The combined historical and supplementary investigations conducted do not meet spatial requirements of the QASSIT *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland* across the entire project area. However, dredging will not occur over the entire project areas (refer Figures 1A-1B). Elements such as the channel widening over an area of about 4 hectares have been sampled at a frequency compliant with the QASSIT guidelines (2 boreholes per hectare). Overall the findings are considered to be suitable to develop an ASSMP for onshore placement of PASS and SNP.

3.3 Marine Considerations

When left undisturbed and submerged in an anoxic environment, pyrite (in acid sulfate soil) is chemically inert. Pyrite oxidizes in the presence of oxygen and hydrogen to form sulfuric acid. There are a number of variables affecting the oxidation of pyrite, and the reactions are complex although predominantly limited by the rate of supply of oxygen:

- When ASS is excavated and allowed to dry, an almost infinite supply of atmospheric oxygen at relatively high concentrations (21 %) is available to exposed surfaces and within pore spaces between the soil particles. The oxygen is delivered to the soil via advection and diffusion. Under this scenario there is a high potential to generate acid.
- When ASS is saturated, the available supply of oxygen is significantly lower (typically 9 ppm). In still water, the oxygen is delivered to the soil surface via diffusion at a very slow rate and the risk of acid generation is very low. In dynamic, open water bodies, the oxygen is principally delivered via advection to suspended soil particles and oxygen delivery via diffusion to bottom sediments is negligible. The risk of acid generation is variable and dependent upon the rate and duration of suspension.

In open marine environments, the alkaline and relatively stable pH of seawater results in a slow rate of pyrite oxidation in suspended or resuspended sediments. The majority of the dredged or disturbed material not delivered to the Hopper will settle to the sea bed and return to an anoxic, reducing state.

Seawater contains the major buffering constituents - bicarbonate and carbonate in solution. When acid is generated, the neutralising reaction occurs instantaneously. In an open marine environment, the available buffering capacity is immense and surrounds the suspended soil particles.

In summary, the potential to generate acid underwater following disturbance of PASS material during dredging is very low and, if acid is generated it would be immediately neutralised. Therefore, from an ASS perspective, the dredging process does not pose a risk to the surrounding environment.

3.4 Transportation Considerations

During maintenance dredging of the Cairns Channel over the past 15 years using the *Brisbane* THSD, free water has been observed over dredged sediments within the hopper during loading and the 20-30 minute transit time to the placement area.

Dredged material collected during the capital dredging within the hopper of the dredge vessel will effectively remain saturated during transport to the pump out point. Under normal operating activities there is little opportunity for these materials to oxidise and generate acid. Contingency measures for equipment breakdown of longer than 24 hours are required to address the potential for dredged material oxidisation in the hopper.

On land spillage and/or pipeline breakages could result in PASS slurry release. Initially the slurry will have a very high water content and materials will be saturated with little opportunity for oxidisation. Contingency measures are required to address the potential for dredged material oxidisation in the event of a PASS slurry release.

4.0 BARRON DELTA DMPA SITE

4.1 Existing Site

The Northern Sands site is an operating sand extraction site with an existing Environmental Authority for acceptance and disposal of inert waste and potential acid sulfate soils within the water filled void resulting from sand extraction.

The Northern Sands void holds permanent water, consisting primarily of groundwater and seasonally influenced stormwater runoff. Monitoring since about 2005 indicates that the lowest seasonal water level across the site is approximately 0.0 m AHD.

The existing void at Northern Sands is being progressively enlarged to the north as part of ‘business as usual’ sand extraction operations. The sand extraction will provide a void of sufficient capacity below natural ground level to accommodate the settled soft clay after extraction of excess water used for material transport (pumping) and supernatant as a consequence of material consolidation. During dredging the 900,000 m^3 of insitu soft clay material will ‘bulk up’ to a larger volume. Concept design of the Barron Delta DMPA has been based on a Bulking Factor of 2.6. The adopted Bulking Factor (2.6) indicates a pre-consolidation volume of approximately 2,340,000 m^3 will be required to accommodate the soft clay material at the end of the dredging campaign. In order to provide sufficient containment capacity, the capacity of sand extraction void that will be provided to accept the placed material will be augmented through the construction of surrounding earth bunds up to a level of 5.5 m Australian Height Datum (AHD) with a 0.4m freeboard allowance. The concept design for the DMPA is shown on Figure 4.

4.2 DMPA Operations

The identified areas of PASS in the channel (about 320,000 m^3 insitu or 832,000 m^3 bulked), will be dredged from the start of the dredging campaign and deposited in deeper sections of the void. The DMPA has capacity to accommodate all of the identified PASS, at the time of placement, below the lowest seasonal water level. This will settle below -1.0 AHD to provide a long term minimum of coverage of 1m of groundwater over the PASS (in line with acceptable measures for internment of PASS described in Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines V4.0. Following completion of the dredging of the PASS material, the SNP materials will then be dredged and placed on the PASS to form a permanent cap to further ensure PASS is not remobilised or exposed to the air (removing the possibility of future oxidation).

Water levels will be managed to ensure that at least 1.5 m of water cover is maintained over the SNP, as it is placed, to prevent exposure to the air and the potential for oxidation of these materials. SNP materials placed above 0.0m AHD will be progressively sampled to confirm that:

- Placement and subsequent remixing of SNP has not resulted in particle size segregation and formation of fines "hotspots". (The risk of such hotspots materials generating acid, should PASS be present, under saturated conditions during placement is very low as the presence of sufficient oxygen is required to result in acid generation).
- The SNP materials remain self-neutralising (again adopting a fineness factor of 3 for conservatism).

Should insufficient neutralising capacity be detected, materials will be removed and treated. The water cover will be maintained until characterisation/validation testing of all SNP materials placed above 0.0m AHD has confirmed that they are self-neutralising or that they have been suitably treated to confirm there is negligible risk of acid generation from these materials when drained. SNP material will continue to settle in the void following placement.

All dredged materials will be delivered into the Barron Delta DMPA as a slurry through a pipeline. Multiple spigot points and weir boxes will be utilised along with diffusers and spreader devices to assist in spreading the material evenly, minimise disturbance of placed material and enhance overall settlement rates. Bed levelling equipment will also be employed, where required, to ensure all PASS is initially located below 0.0m AHD and to enhance SNP placement.

The weir boxes will be used to control the water depth through which the slurry is deposited and to control draw off water to achieve the required tailwater quality. Tailwater will be discharged via pumping to an outfall in the Barron River under the Captain Cook Highway Bridge in accordance with approval conditions.

5.0 TINGIRA STREET DMPA SITE

The stiff clays to be placed at the Tingira Street DMPA have been confirmed as non-ASS materials. Therefore these materials do not require specific ASS management measures.

Contingency measures are required to address the potential for material oxidisation should the presence of soft, darker hued materials be observed in these excavated materials. These measures may require segregation and possible treatment of these materials if confirmed as PASS.

6.0 MITIGATION STRATEGIES AND CONTINGENCY OPTIONS

Potential environmental considerations associated with ASS disturbance and onshore placement of dredged material are summarised in Table 1 below. Also included are proposed management strategies and contingency options that may be used individually or in combination to mitigate potential impacts if required.

Table 1: Summary of mitigation strategies and contingency options based on expected behaviour of ASS Material

Activity	Issue	Expected Behaviour of ASS Material	Perceived Level of Impact to the Environment	Mitigation Strategies	Contingency Options
Dredging of marine sediments	Aeration of ASS materials during dredging operations.	The majority of marine sediments which are disturbed during the dredging activities but not recovered for onshore disposal will settle to the ocean floor and return to an anoxic, reducing state. These residual materials will not generate acid and do not represent a risk to the marine environment. Prior to settling, aerated sediment in suspension may partially oxidise and generate acid. The available oxygen in saturated conditions is significantly smaller than in air and therefore the potential for acid generation is similarly smaller. In the open marine environment the available buffering capacity is immense and surrounds the suspended soil particles to immediately neutralise the generated acidity. Therefore suspended sediments do not represent a risk to the marine environment.	**Negligible to low potential for environmental impact.**	Water quality monitoring and management as outlined in separate Dredge Management Plan.	Addressed in Dredge Management Plan,
Transport and placement of stiff clays at Tingira Street DMPA	Accidental excavation and comingling of PASS with stiff clays.	PASS materials are typically dark grey and soft whilst the stiff clays are typically yellow to orange hued. The presence of PASS in the excavated stiff clays would be easily discerned by visual inspection. Very little oxidisation of comingled PASS will occur during transportation to Tingira Street DMPA.	**Negligible to low potential for environmental impact.**	Stiff clays are to be placed in bunded cells at the DMPA. If present in significant amounts, pockets of PASS can be segregated from stiff clays and treated with lime at the DMPA.	Lime can be added to stiff clays with comingled PASS materials as it is being spread and compacted.
Transport of dredged marine sediments to Barron Delta DMPA	Oxidisation of ASS materials in dredge hopper during transport.	Dredged material collected within the hopper of the dredge vessel will effectively remain saturated during transport to the pump out point near Yorkeys Knob. Under normal operating activities there is little opportunity for these materials to oxidise and generate acid.	**Negligible to low potential for environmental impact.**	Dredged materials will not be stored in hoppers for more than 24 hrs (Dredge Management Plan requirement).	Contingency measures for equipment breakdown are addressed in the Dredge Management Plan.

Activity	Issue	Expected Behaviour of ASS Material	Perceived Level of Impact to the Environment	Mitigation Strategies	Contingency Options
	Onshore spillage/pipeline breakage allowing oxidisation of ASS materials	Saturated and predominantly clay materials have a low potential to oxidise and generate acid over a short period of time.	**Negligible to low potential for environmental impact.**	Containment of spillage or discharges to the ground surface. Excavation and removal/treatment within 42 hours (based on short term stockpiling of ASS – Table 11.1 Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines V4.0).	Contingency measures for equipment breakdown are addressed in the Dredge Management Plan.
Dredged Material Placement in the Barron Delta DMPA	Acid generation from dredged PASS material and release to groundwater.	Dredged PASS materials will remain saturated during placement and internment below the groundwater table. These saturated conditions represent a low potential for acid generation.	**Negligible to low potential for environmental impact.**	PASS to be placed below the lowest recorded groundwater level. Long term internment will be at least 1m below the permanent groundwater level (as per Section 10.1 of Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines V4.0). PASS to be capped with SNP to prevent remobilisation. Groundwater quality monitoring surrounding the DMPA as outlined in the Dredge Management Plan.	Lime dosing during placement or lime treatment post placement.
	Acid generation from dredged SNP material and release to groundwater.	Finer particles may be segregated from coarser particles during pumping and placement of SNP. This may result in placed SNP having neutralising capacities which vary from that indicated from offshore sampling and create the potential to produce “pockets” of PASS that may generate future unbuffered acidity when dried. If pockets of PASS are present in surface materials, this could result in acid formation in these exposed materials (following draining of the water cover) which may be mobilised by rainfall and require surface runoff to be treated. Deeper materials (at least those 2m below the surface) are expected to remain saturated for at least several years following draining of water	There is a low to moderate potential for the SNP materials to generate excess acidity. There is a low potential for PASS materials to generate acid during the placement works whilst they remain saturated with a water cover in place. **Low to moderate potential for environmental impact**	Maintenance of water cover over (and saturated conditions within) placed SNP until the presence of suitable neutralising capacity is confirmed. Progressive characterisation/verification testing as SNP materials are placed. Strategies to be reviewed and updated if a higher level of risk is indicated. Removal of identified zones with insufficient neutralising capacity, treatment and reinternment. Groundwater quality monitoring surrounding the DMPA as outlined in the Dredge Management Plan.	Lime dosing during placement or lime treatment post placement.

Activity	Issue	Expected Behaviour of ASS Material	Perceived Level of Impact to the Environment	Mitigation Strategies	Contingency Options
		cover. If pockets of PASS were present in these materials, they are unlikely to generate acid within this time frame. If these deeper pockets of PASS were allowed to drain over time, they may oxidise and generate acid. This acid may leach through the soil, strip heavy metals from the soils and could result in groundwater impacts. It is not intended that saltwater and/or groundwater buffering capacities would be relied upon as the primary neutralisation mechanisms.			
	Release of acidic and/or metals impacted water to groundwater or through tailwater outflow.	Dredged materials will remain saturated during placement. These saturated conditions represent a low potential for acid generation.	**Negligible to low potential for environmental impact.**	Groundwater quality monitoring surrounding the DMPA as outlined in the Dredge Management Plan. Tailwater monitoring and management as outlined in the Dredge Management Plan.	Treatment of return water prior to discharge.

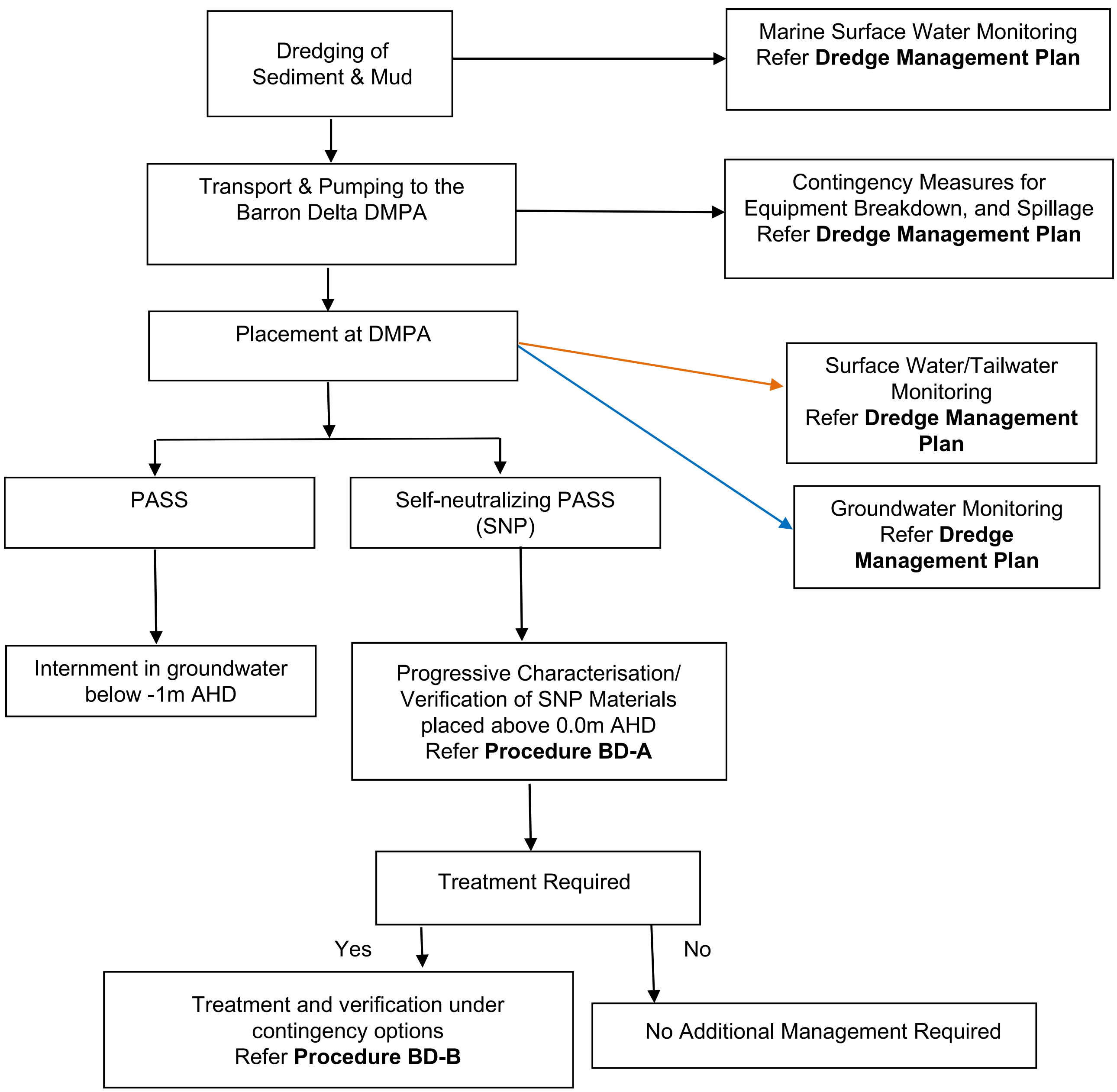
7.0 MANAGEMENT PROCEDURES

The following provides representative management procedures related to phases of activity by use of a visual summary of the mitigation strategies and contingency options identified for the ASS materials in the DMPAs. These procedures will be reviewed and revised as the project matures and additional information becomes available.

7.1 Sediment & Mud Dredged Materials

Flow Chart 1 summarises the mitigation strategies, including contingency options, for dredged materials to be placed at the Barron Delta DMPA.

Flow Chart 1: Summary of Sediment and Mud Dredged Materials ASS Management

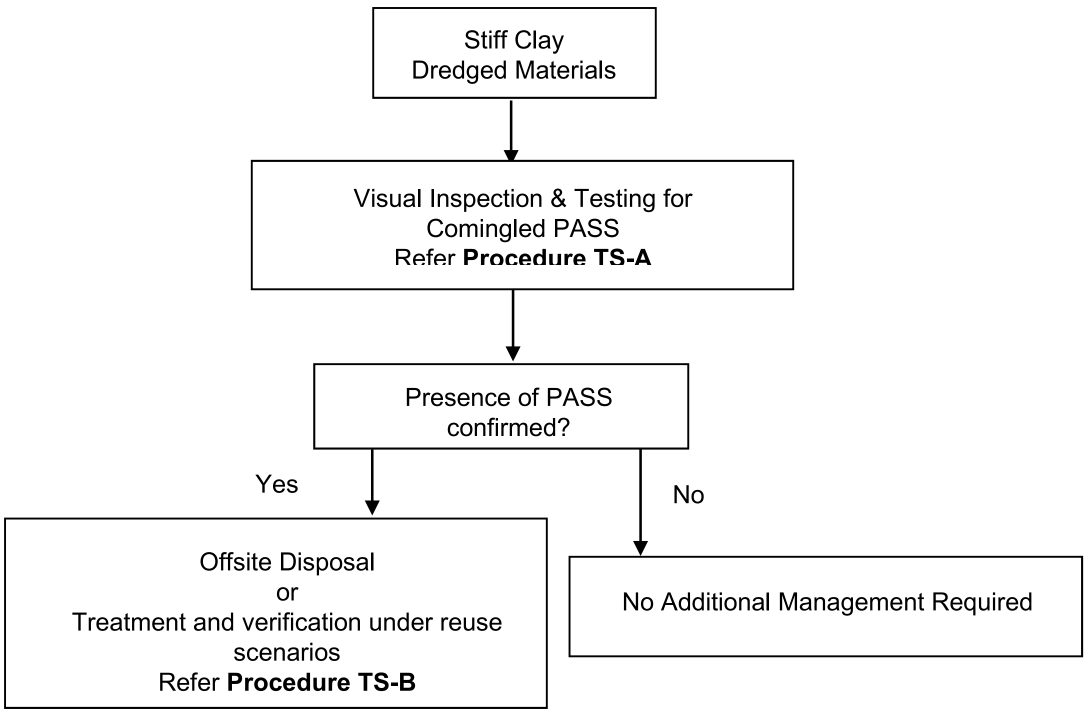


The management procedures and contingency options for the Barron Delta DMPA, including characterisation / verification of placed SNP are presented in APPENDIX A.

7.2 Stiff Clay Dredged Materials

Flow Chart 2 summarises the mitigation strategies, including contingency options, for dredged materials to be placed at the Tingira Street DMPA, if necessary.

Flow Chart 2: Summary of Stiff Clay Material Placement Management



The management procedures and contingency options for the Tingira Street DMPA are presented in APPENDIX B.

8.0 RESPONSIBILITIES

This section outlines the responsibilities to manage, document and report on ASS issues for the project.

- The *Site Manager* is responsible for ensuring that all requirements of the ASSMP are met during the project.
- The *Site Foreman* is responsible for ensuring the strategies and procedures prescribed in the ASSMP are implemented at the site in accordance with the specified performance criteria.
- The *Environmental Manager* is responsible for reviewing compliance with the ASSMP and development of actions to address non-conformance.
- All other site personnel are responsible for implementing strategies and procedures prescribed in the ASSMP, as applicable to their work activities.

9.0 NON-CONFORMANCE AND CORRECTIVE ACTION

Any non-conformance to the ASSMP must be addressed as soon as is practical. The personnel responsible for the non-conformance must be notified immediately for purposes of issuing rectification instructions.

10.0 AUDITING

The Environmental Manager will be responsible for ensuring that an auditing program is implemented for construction and treatment works. The audit program shall aim to ensure compliance with the ASSMP and relevant statutory requirements.

The Environmental Manager shall appoint an experienced ASS practitioner to conduct regular auditing of activities and ASS management measures. Given the expected construction period a weekly, auditing schedule is recommended. The frequency of these audits may gradually decrease if a high level of compliance with the ASSMP is evident.

The audit shall take the form of a visual inspection of the works and treatment sites and associated control measures and a review of monitoring data. A written record of auditing undertaken shall be maintained, including details on the date of the audit, activities undertaken, observations made and any non-conformances identified. A copy of the audit report shall be forwarded to the Environmental Manager within 2 days of the audit.

11.0 COMMUNITY RELATIONS

Concerns or complaints raised by the community (or other parties) in relation to ASS will be directed to the Environmental Manager for action.

The Environmental Manager shall maintain a concern register recording the following information:

1) Details: Name, address and phone number of party raising the concern.
2) Nature of concern: Detail of issue, date of incident, people involved, and location.
3) Action taken or required: Any action proposed or undertaken to address the concern, including time and date.
4) Response to action: Was the complainant satisfied with the outcome of the actions taken, if not, what else needs to be done, or is it outside the scope of the development works.
5) Prevention or re-occurrence: What action has been taken by the nominated responsible person to ensure the problem will not re-occur.

12.0 TRAINING

All equipment operators, supervisors and subcontractors engaged in DMPA works shall participate in induction training for ASS. This training will include basic recognition and identification of ASS, plus an outline of the requirements of the ASSMP. The Site Foreman shall verify attendance at induction training prior to commencement of site works.

Report Signature Page

GOLDER ASSOCIATES PTY LTD

Paul Scells
Principal Environmental Engineer

PKS/MSC/ps

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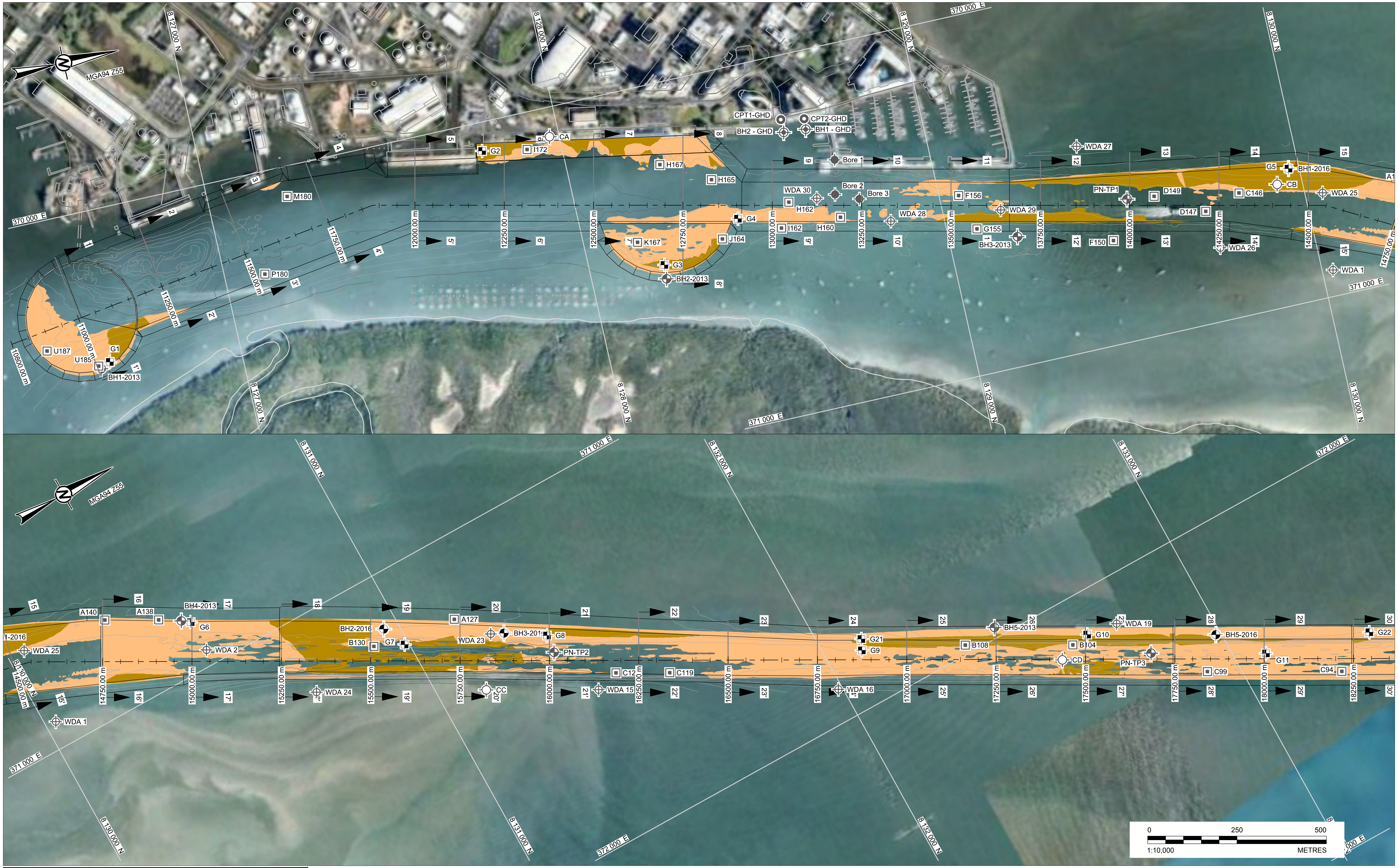

LEGEND

BORE HOLE GOLDER ASSOCIATES (CURRENT INVESTIGATION)	BORE HOLE CH (PREVIOUS INVESTIGATION)
GRAB SAMPLE GOLDER ASSOCIATES (CURRENT INVESTIGATION)	BORE HOLE BMT-WBM (PREVIOUS INVESTIGATION)
BORE HOLE GOLDER ASSOCIATES (PREVIOUS INVESTIGATION)	CPT GHD (PREVIOUS INVESTIGATION)
BORE HOLE GHD (PREVIOUS INVESTIGATION)	SOFT CLAY (CAPITAL DREDGING)
BORE HOLE DOUGLAS PARTNERS (PREVIOUS INVESTIGATION)	STIFF CLAY (CAPITAL DREDGING)
BORE HOLE WDA (PREVIOUS INVESTIGATION)	

CLIENT
FLANAGAN CONSULTING GROUP

CONSULTANT
Golder Associates

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PREPARED	GPG
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APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
EXTENT OF MATERIALS TO BE DREDGED - SHEET 1

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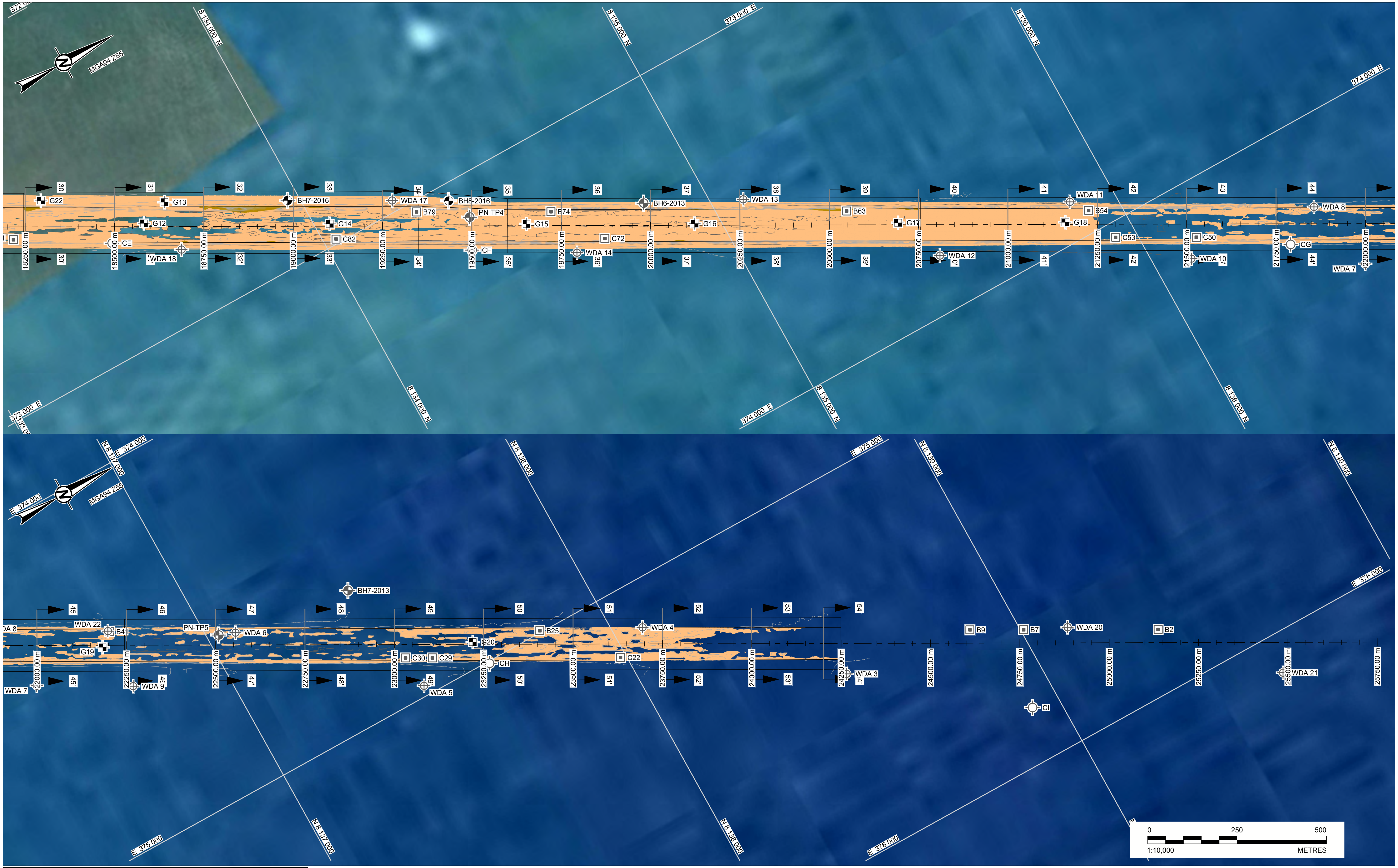

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GRAB SAMPLE GOLDER ASSOCIATES (CURRENT INVESTIGATION)	BORE HOLE BMT-WBM (PREVIOUS INVESTIGATION)
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BORE HOLE WDA (PREVIOUS INVESTIGATION)	

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TITLE
EXTENT OF MATERIALS TO BE DREDGED - SHEET 2

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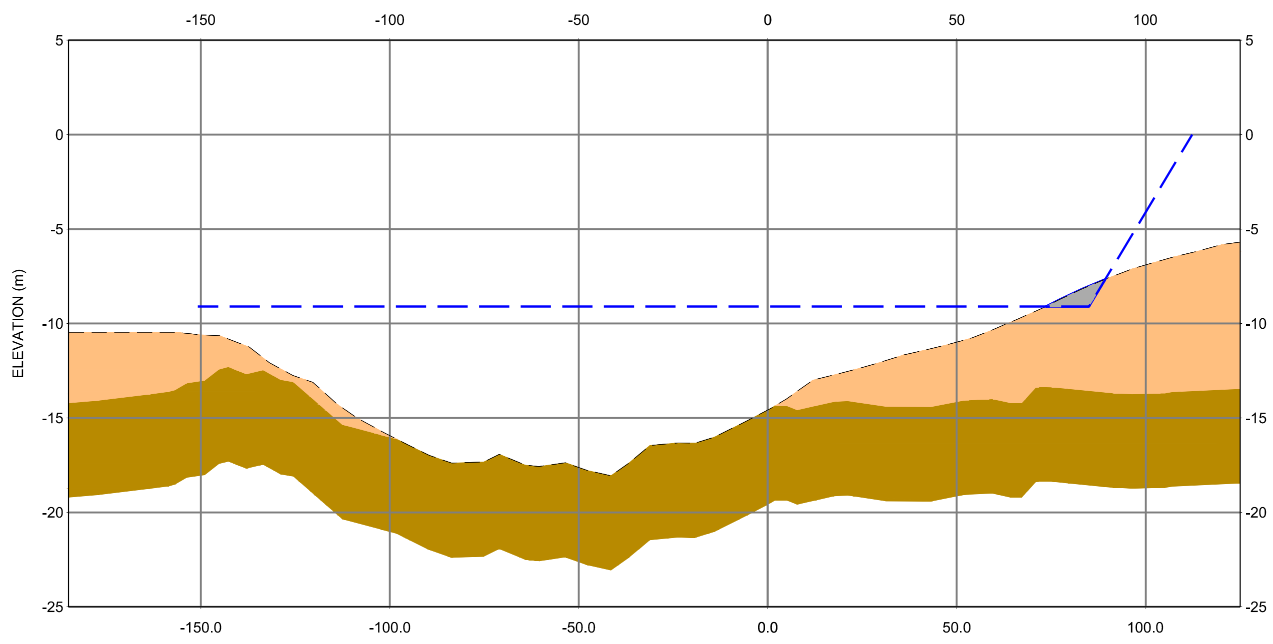

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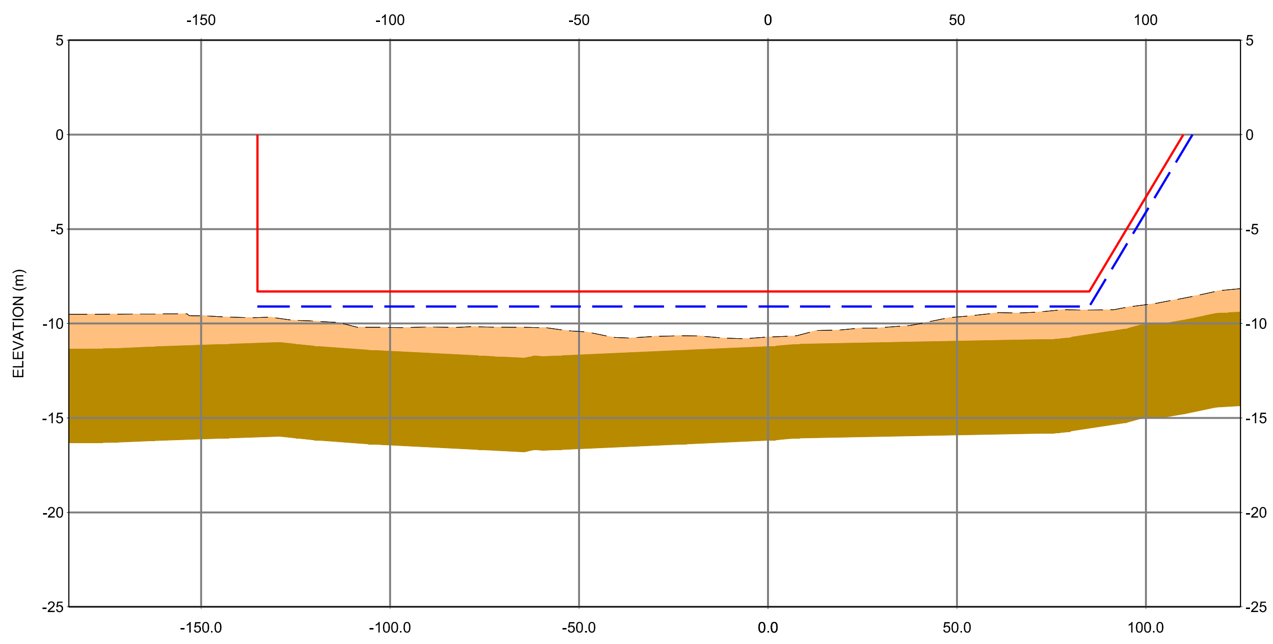

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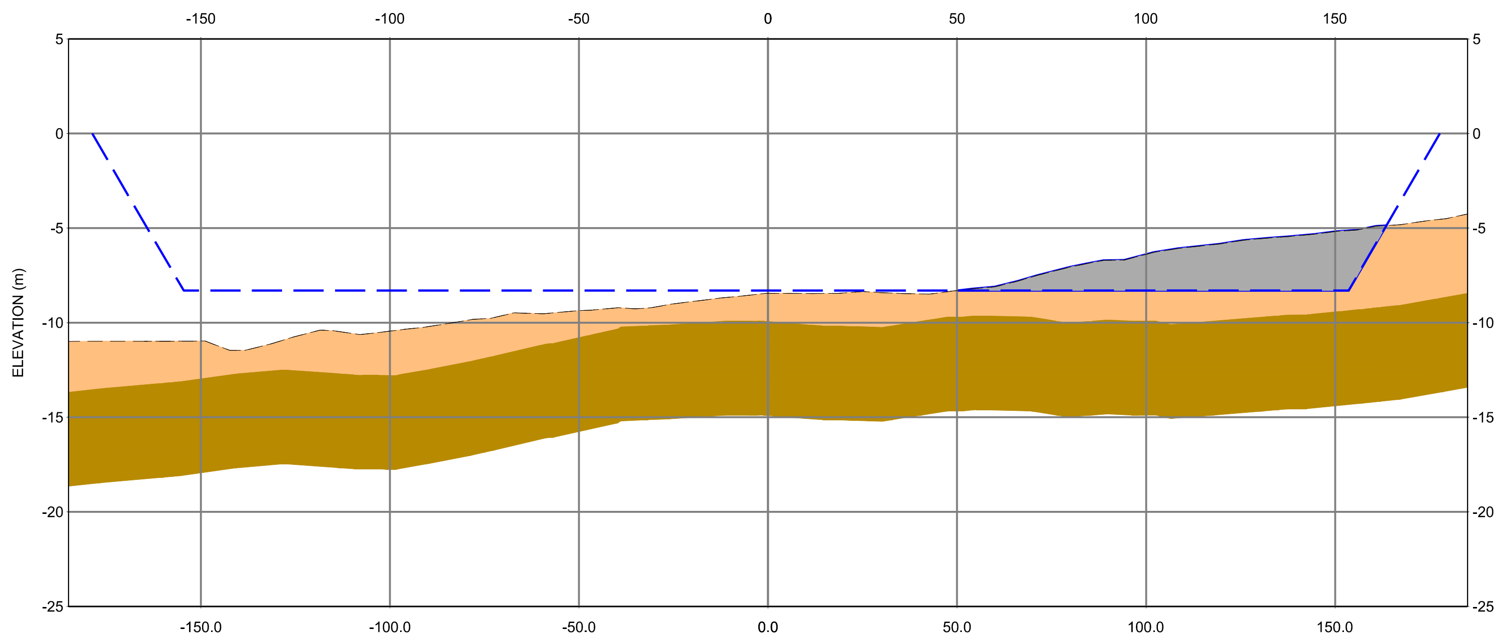
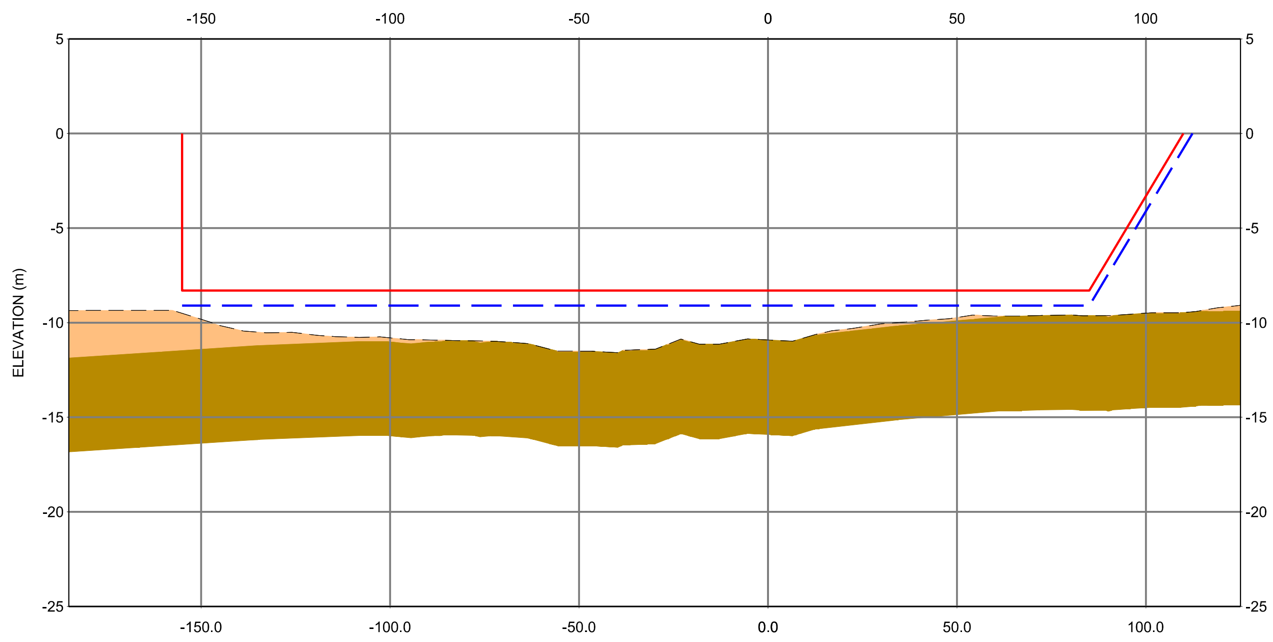


CH 11000.0



CH 11500.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 1:400 METRES

HORIZ. 0 50 100 1:2,000 METRES

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

TITLE
CHANNEL CROSS SECTIONS SHEET 1

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2A

Path: \\golder.gds\gap\Brisbane\Geomatics\FLANAGAN CONSULTING GROUP\CAIRNS_PORT_DEVELOPMENT_NORTHERN_SANDS\99_PROJECTS\1546223_CAIRNS_PORT_DEVELOPMENT_NORTHERN_SANDS\02_PRODUCTION\DWG\ | File Name: 1546223-006-R-F001.dwg

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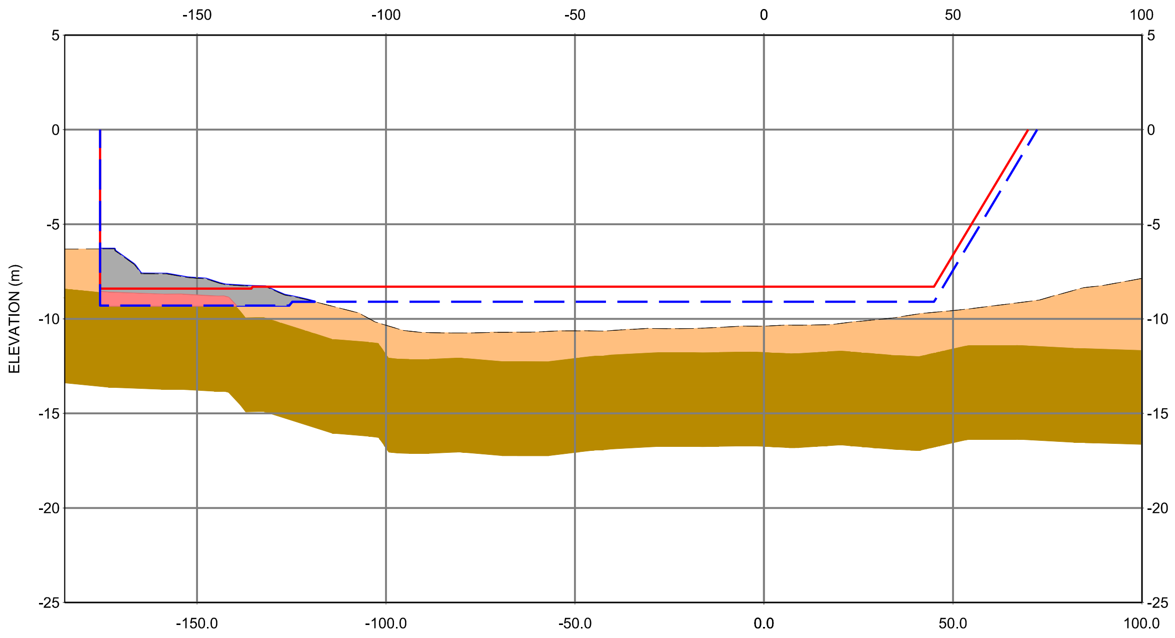
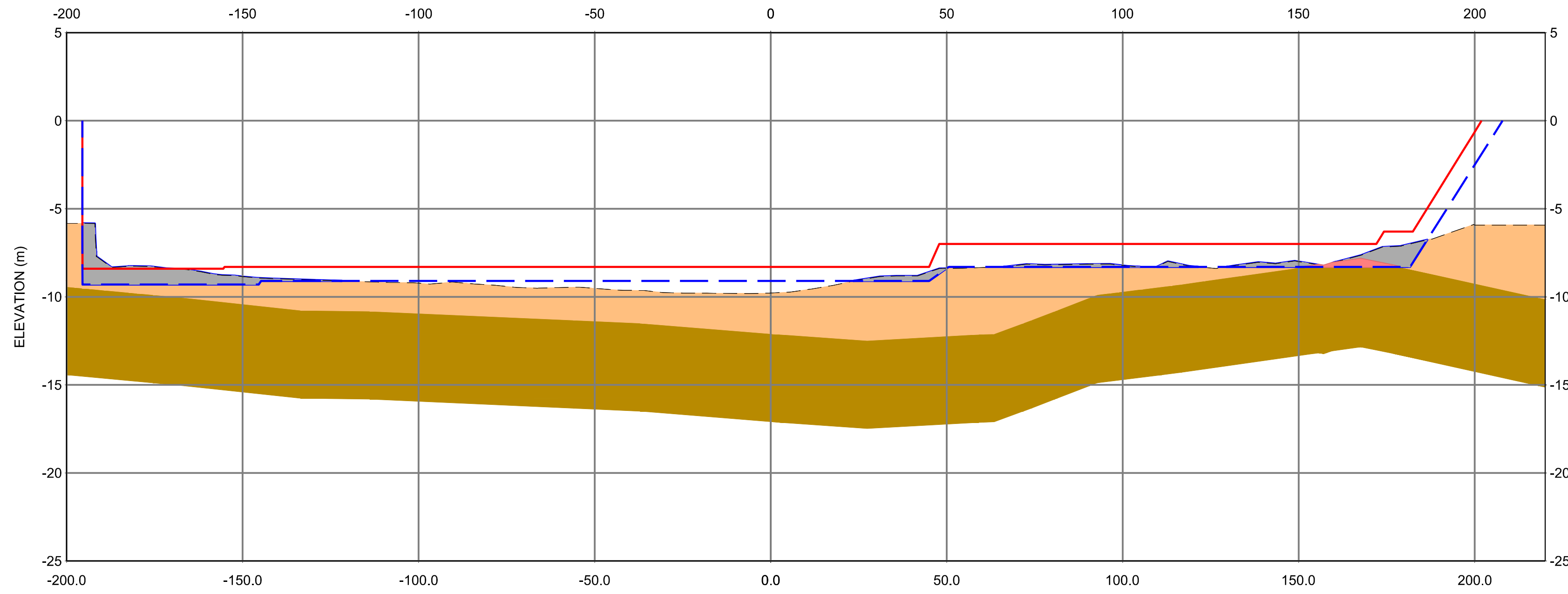
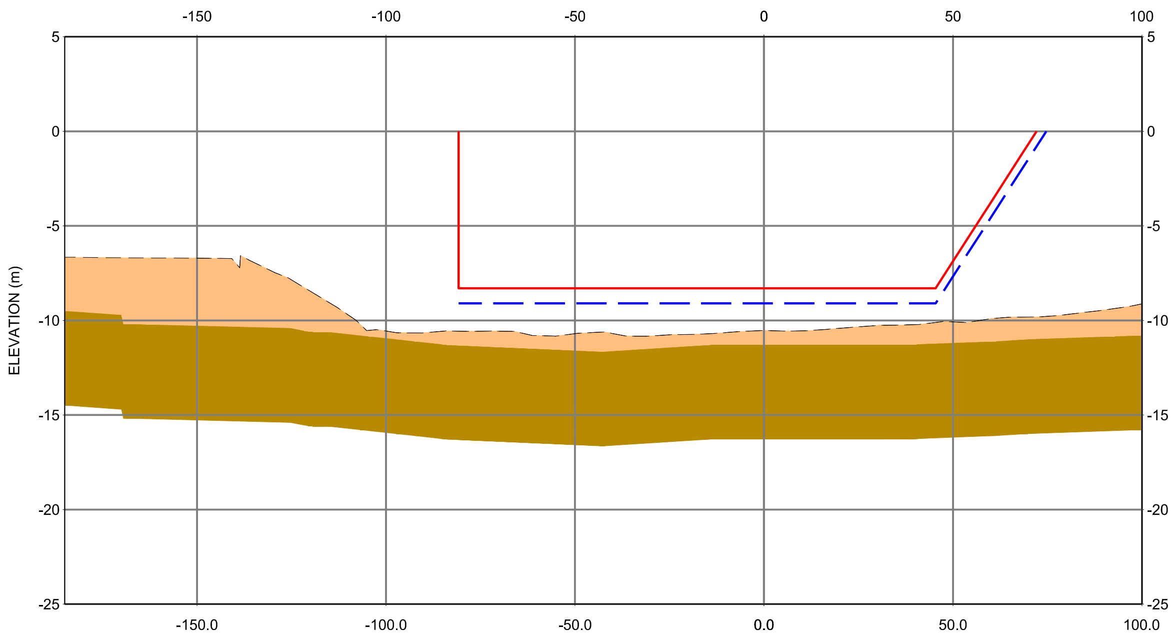


CH 12250.0



CH 12750.0



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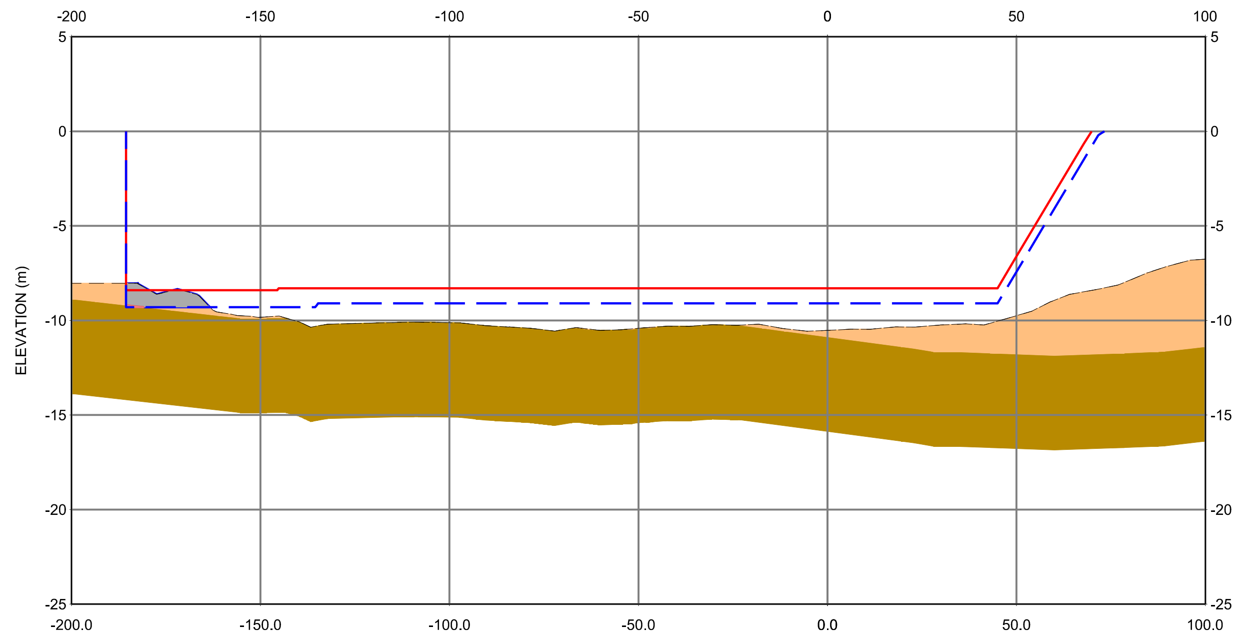


CH 12500.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 1:400 METRES

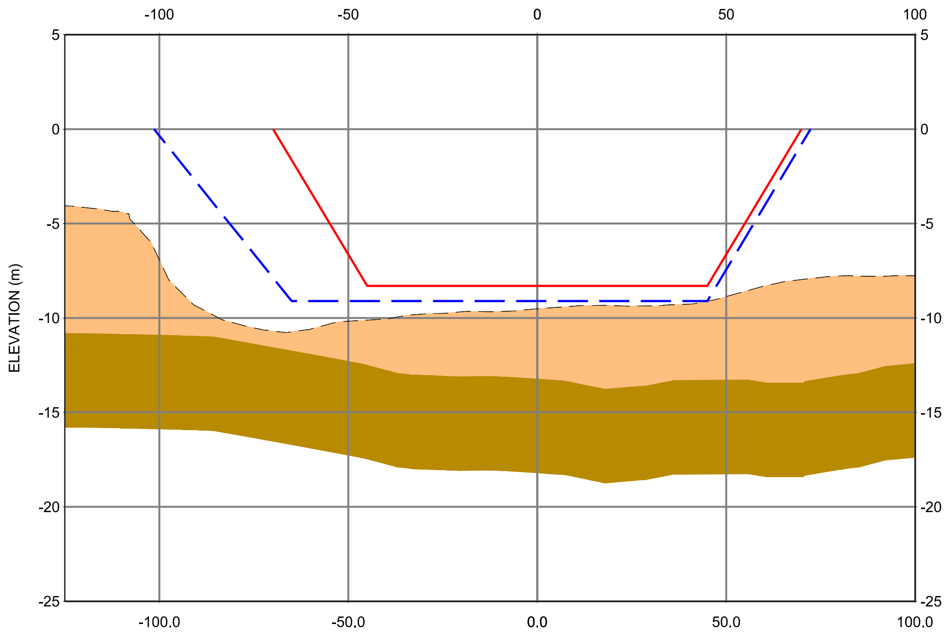
HORIZ. 0 50 100 1:2,000 METRES

CLIENT	FLANAGAN CONSULTING GROUP
PROJECT	CAIRNS SHIPPING DEVELOPMENT PROJECT
CONSULTANT	Golder Associates
YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC
TITLE	**CHANNEL CROSS SECTIONS SHEET 2**
PROJECT NO.	1546223
DOCUMENT No	025
REV.	1
FIGURE	2B

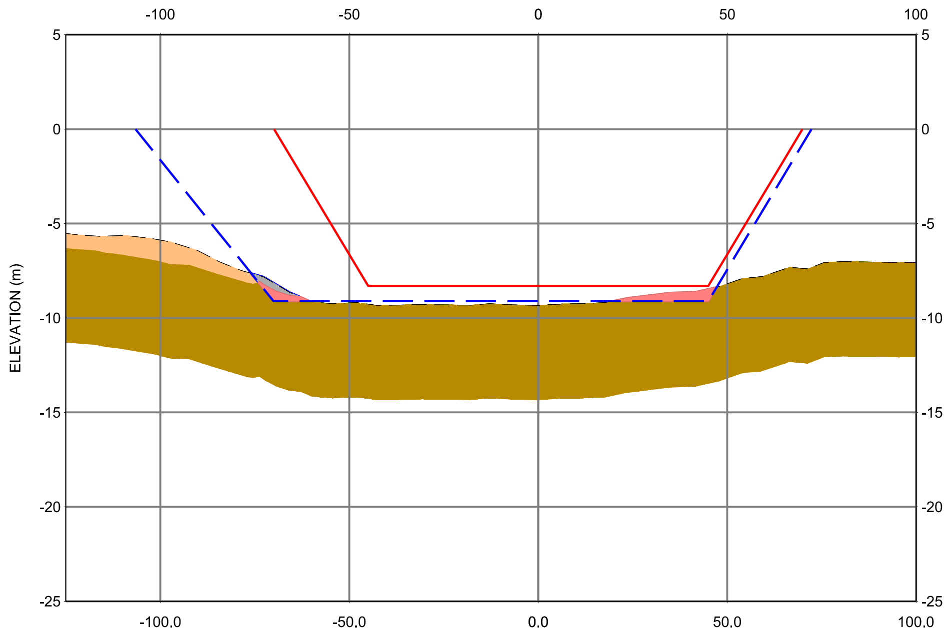
Path: \\golder.gds\gap\Brisbane\Geomatics\FLANAGAN CONSULTING GROUP\CAIRNS_PORT_DEVELOPMENT_NORTHERN_SANDS\99_PROJECTS\1546223_CAIRNS_PORT_DEVELOPMENT_NORTHERN_SANDS\02_PRODUCTION\DWG\ | File Name: 1546223-006-R-F001.dwg

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

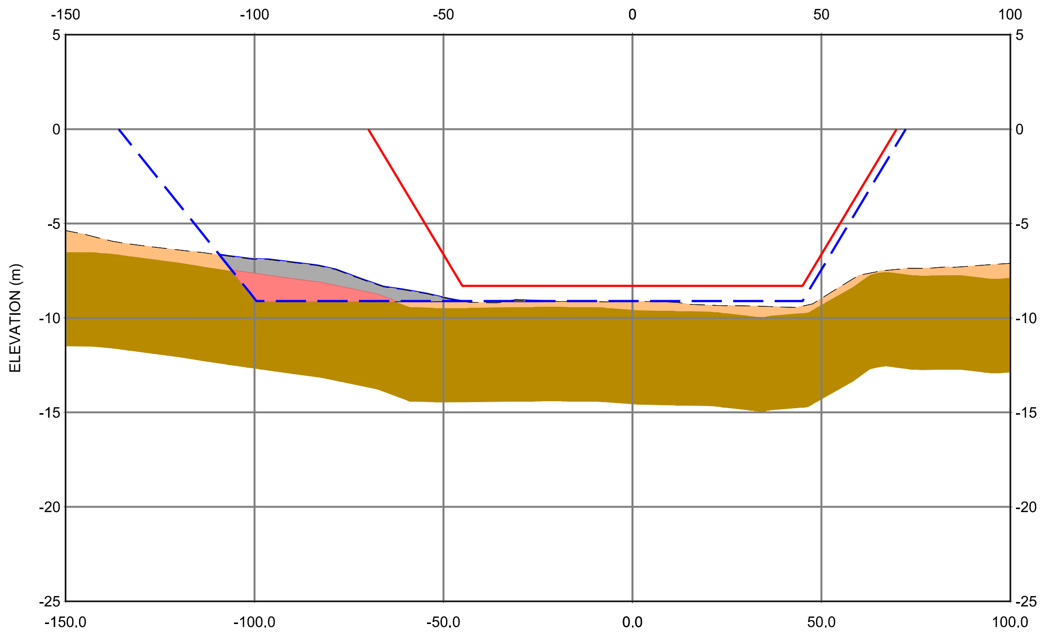
25 mm



CH 13250.0



CH 13750.0



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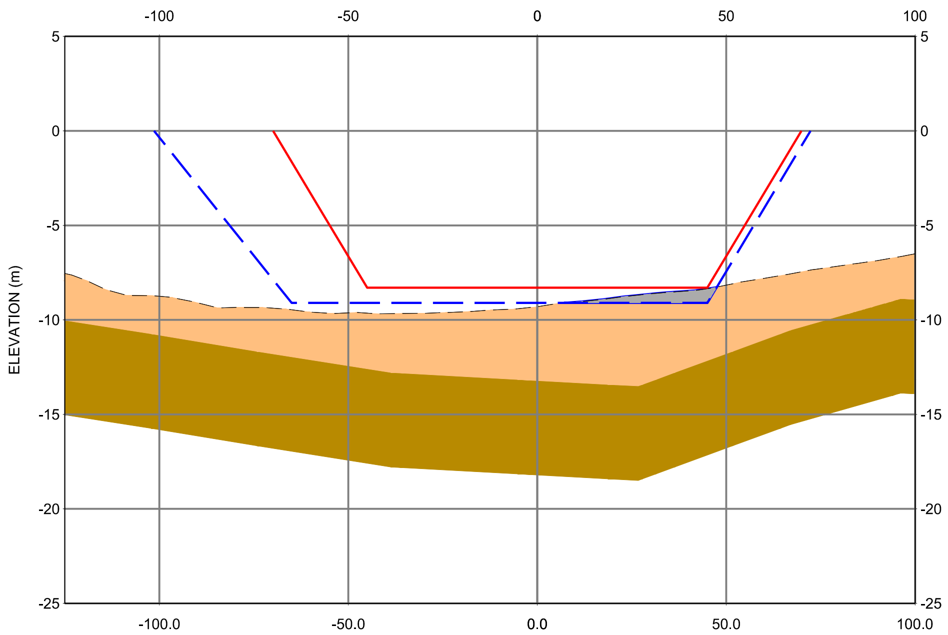

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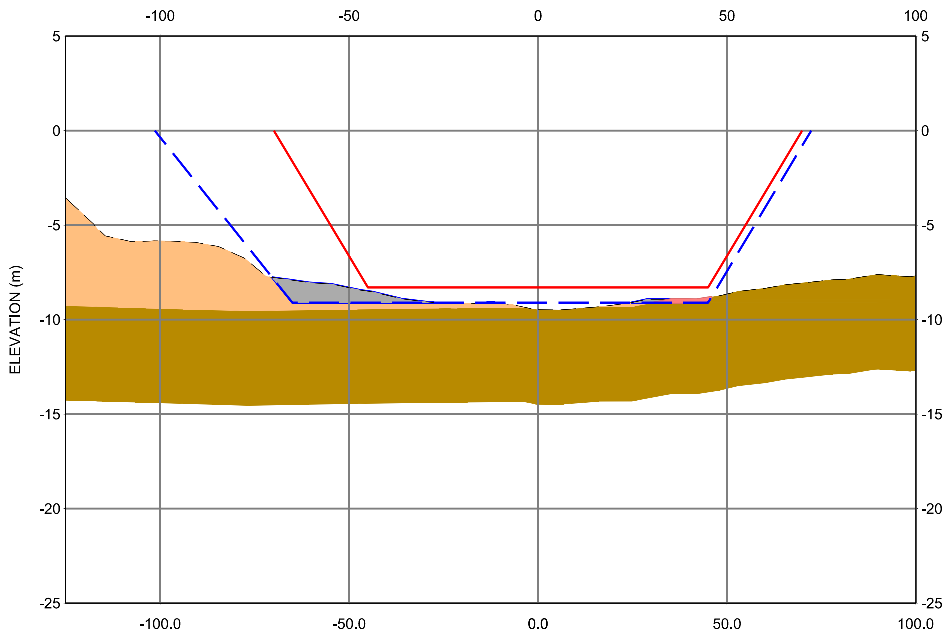
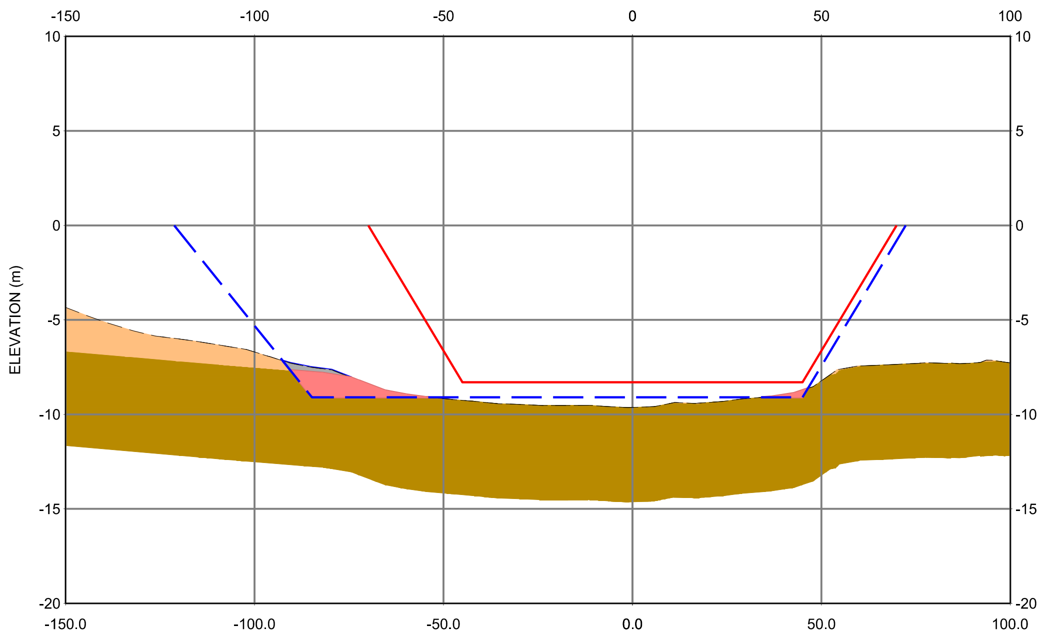


CH 13500.0



CH 14000.0

LEGEND

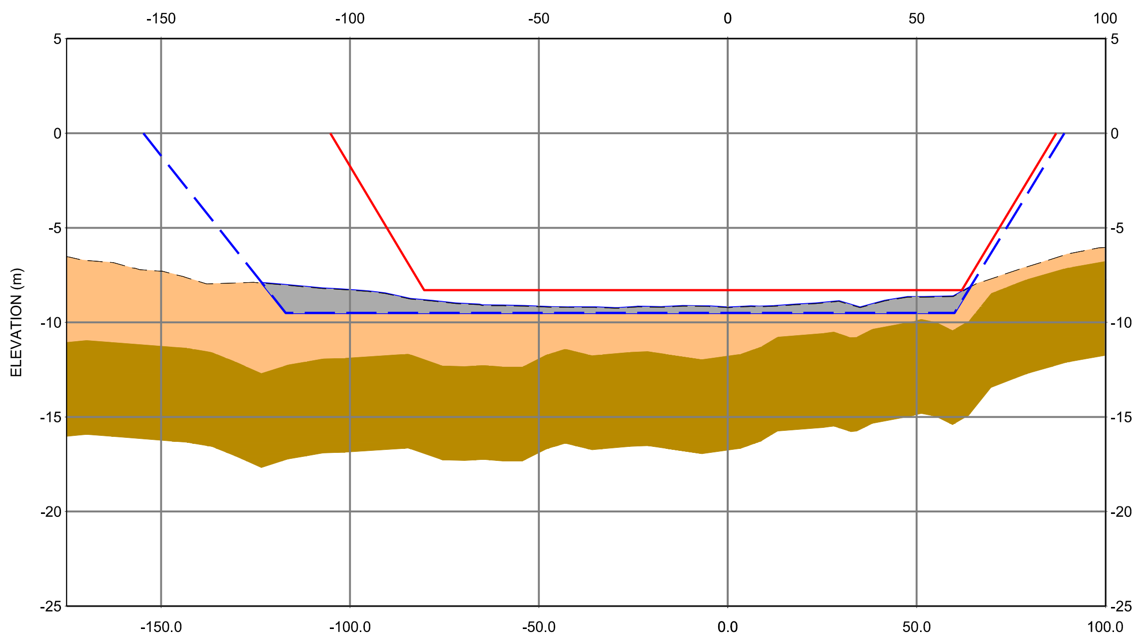
- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 1:400 METRES

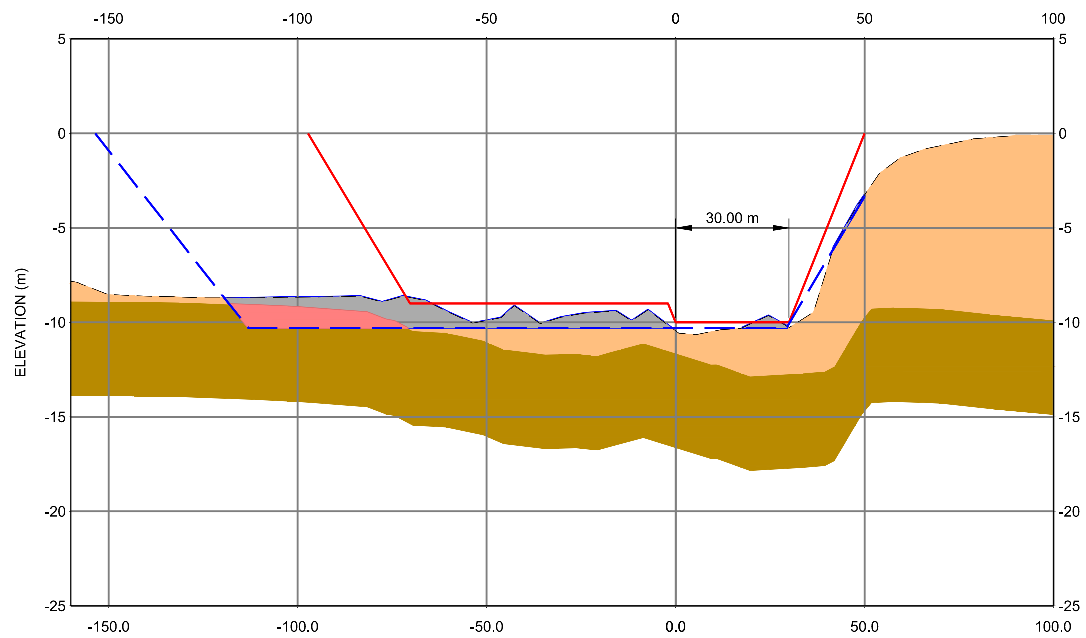
HORIZ. 0 50 100 1:2,000 METRES

CLIENT	FLANAGAN CONSULTING GROUP	PROJECT	CAIRNS SHIPPING DEVELOPMENT PROJECT
CONSULTANT	YYYY-MM-DD 2017-10-30	TITLE	CHANNEL CROSS SECTIONS SHEET 3
Golder Associates	DESIGNED PB		
	PREPARED GPG		
	REVIEWED MC	PROJECT NO. 1546223	DOCUMENT No 025
	APPROVED MC	REV. 1	FIGURE 2C

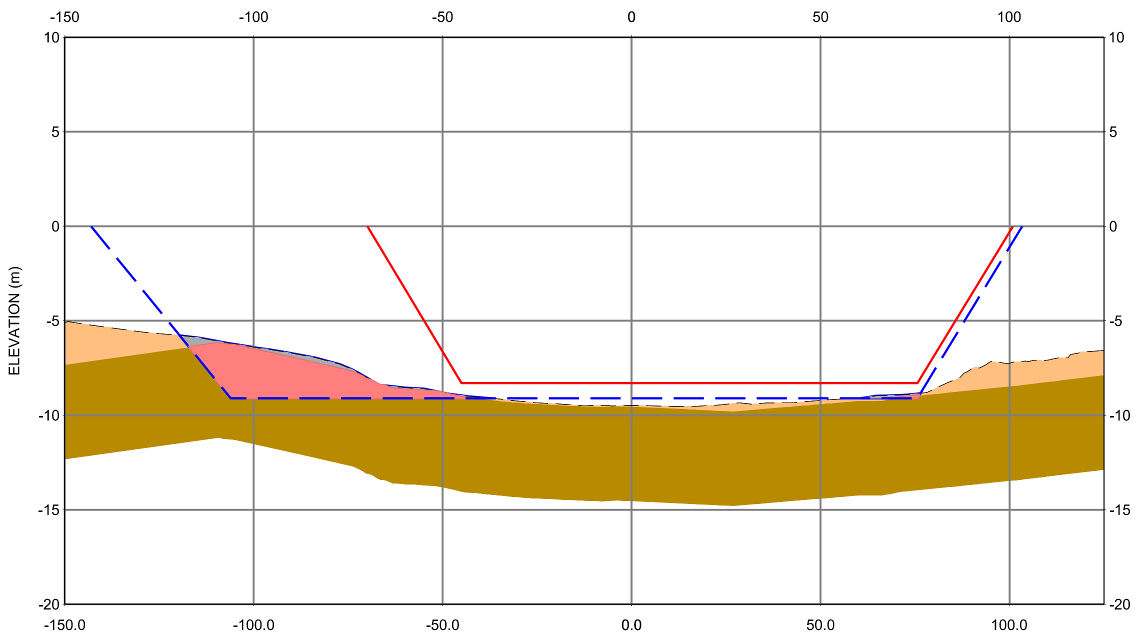
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
25 mm



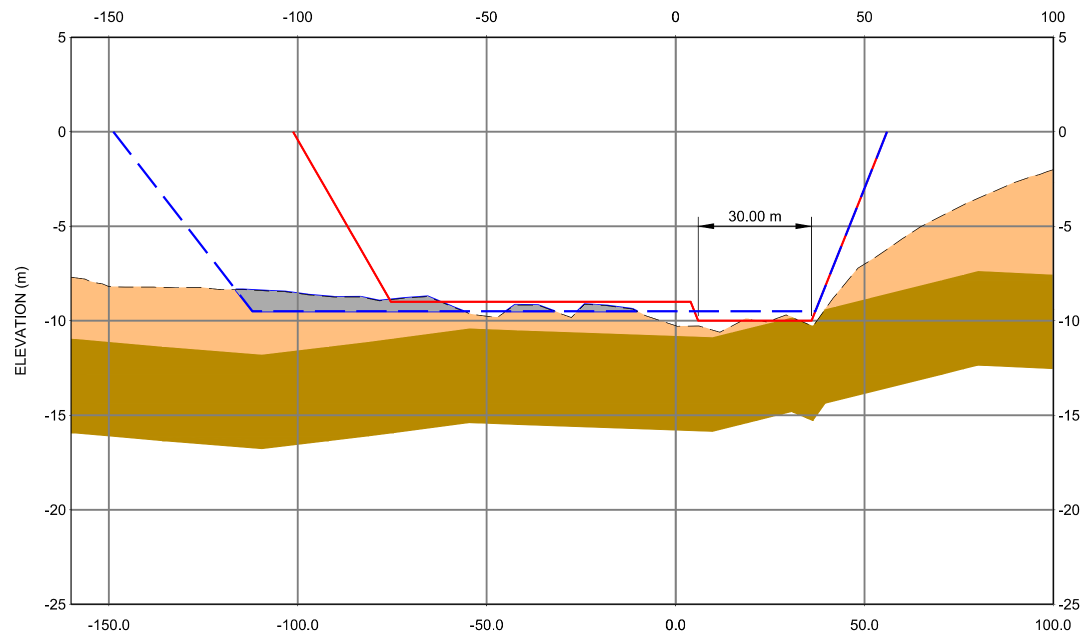
CH 14750.0



CH 15250.0



CH 14500.0



CH 15000.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

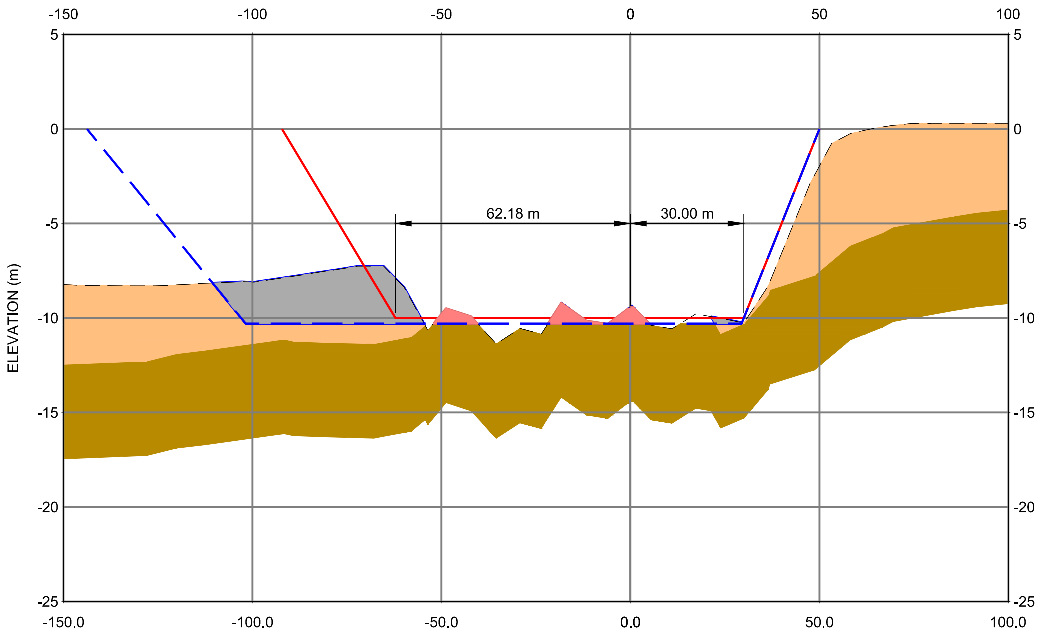
VERT. 0 10 20 1:400 METRES

HORIZ. 0 50 100 1:2,000 METRES

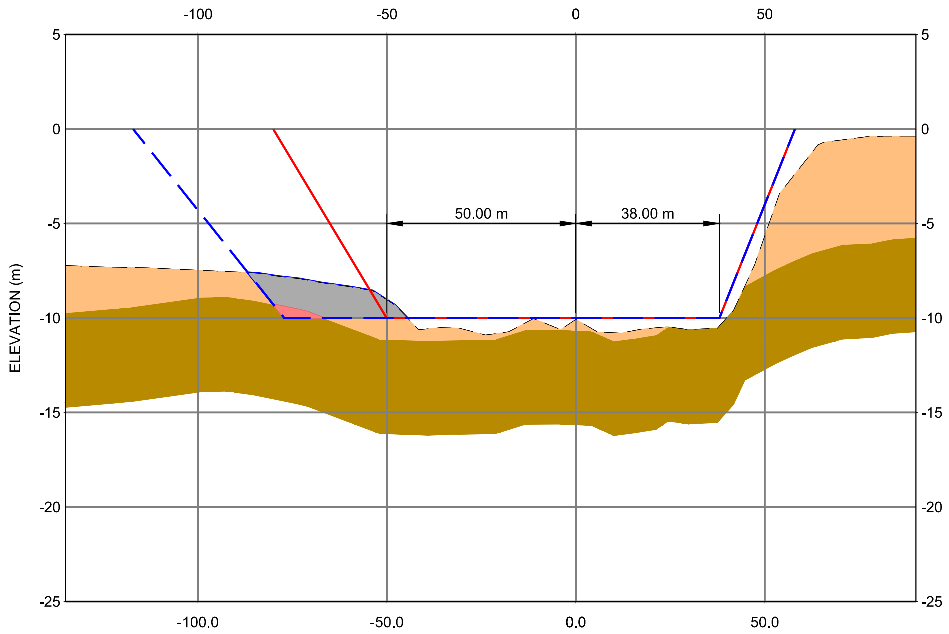
CLIENT FLANAGAN CONSULTING GROUP		PROJECT CAIRNS SHIPPING DEVELOPMENT PROJECT	
CONSULTANT Golder Associates	YYYY-MM-DD: 2017-10-30	TITLE **CHANNEL CROSS SECTIONS SHEET 4**	
	DESIGNED: PB		
	PREPARED: GPG		
	REVIEWED: MC	PROJECT NO. 1546223	DOCUMENT No 025
	APPROVED: MC	REV. 1	FIGURE 2D

Path: \\golder.gds\gap\Brisbane\Geomatics\FLANAGAN CONSULTING GROUP\CAIRNS_PORT_DEVELOPMENT_NORTHERN_SANDS\99_PROJECTS\1546223_CAIRNS_PORT_DEVELOPMENT_NORTHERN_SANDS\02_PRODUCTION\DWG\ | File Name: 1546223-006-R-F001.dwg

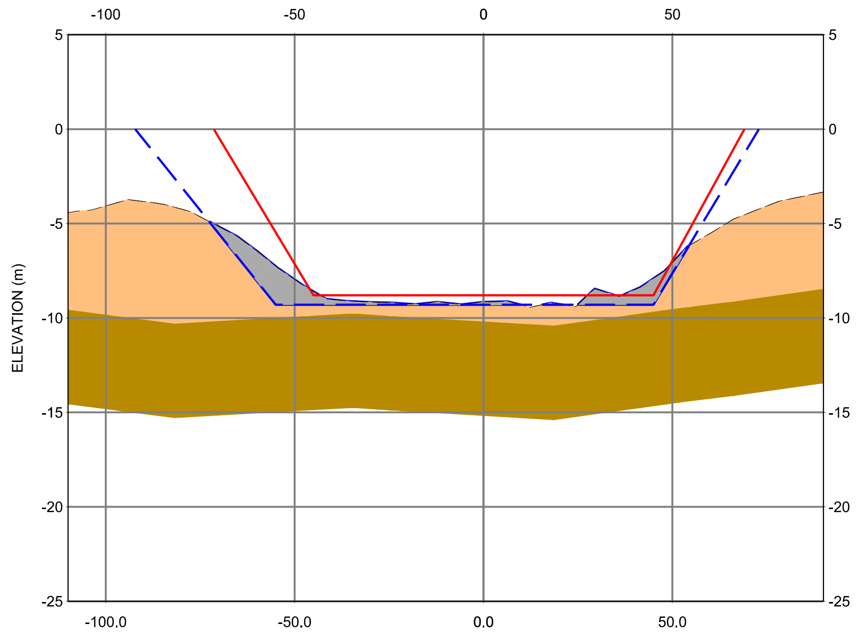
25 mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3



CH 15750.0



CH 16250.0



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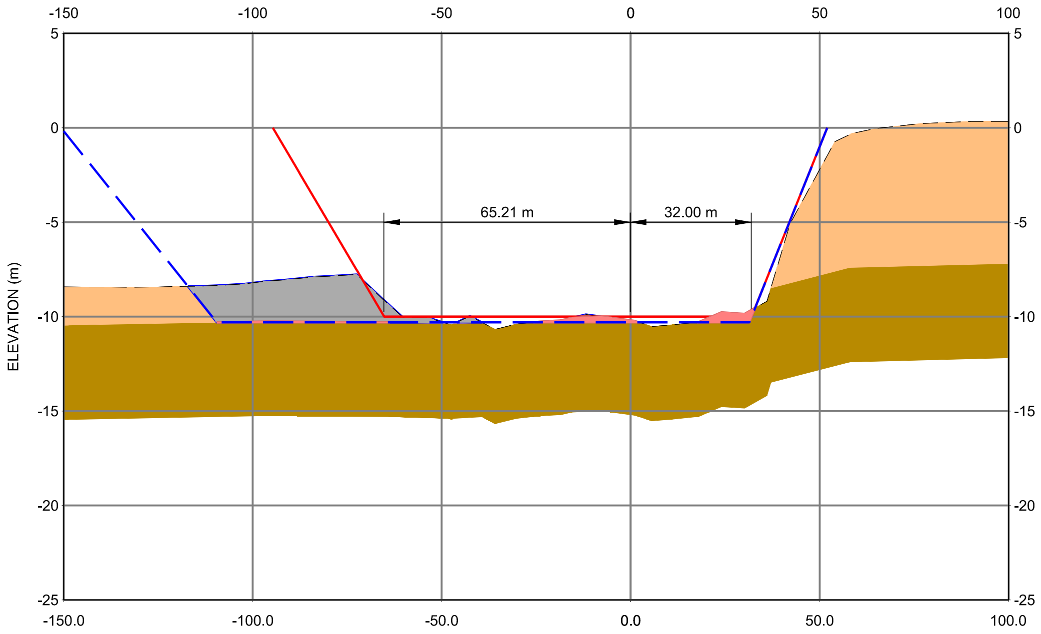
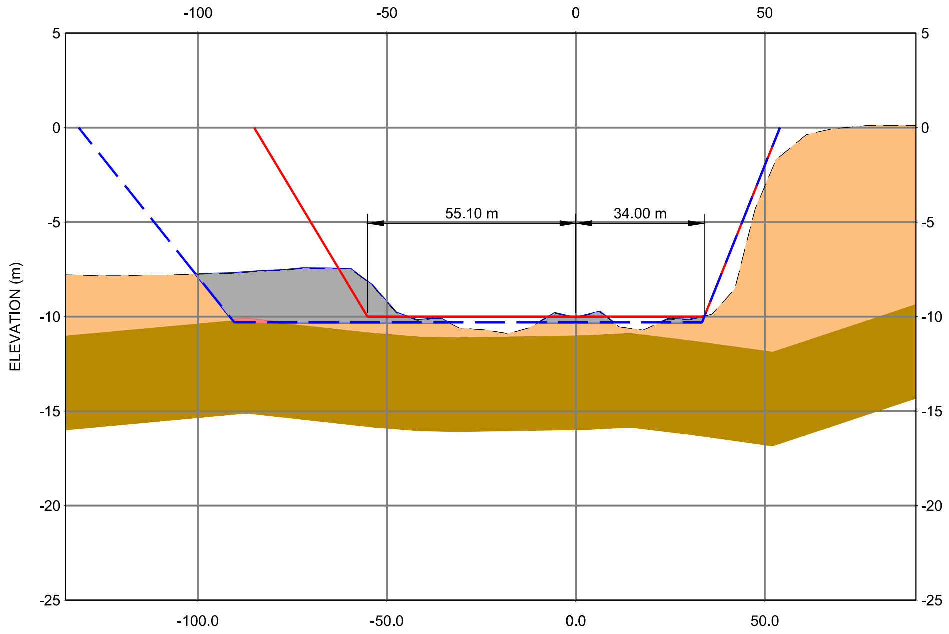


CH 15500.0



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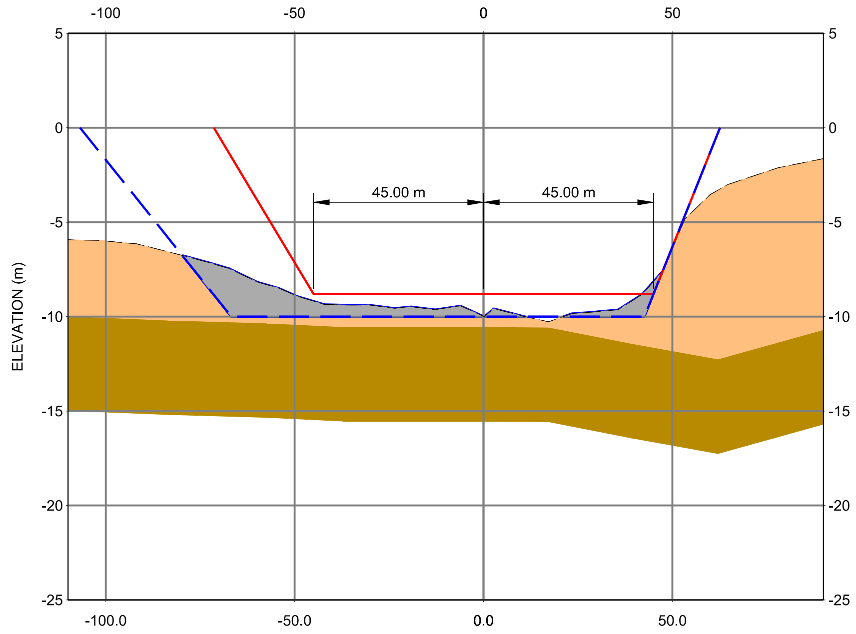

CH 16500.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 METRES 1:400

HORIZ. 0 50 100 METRES 1:2,000

CLIENT FLANAGAN CONSULTING GROUP	PROJECT CAIRNS SHIPPING DEVELOPMENT PROJECT
CONSULTANT Golder Associates	TITLE **CHANNEL CROSS SECTIONS SHEET 5**

YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2E

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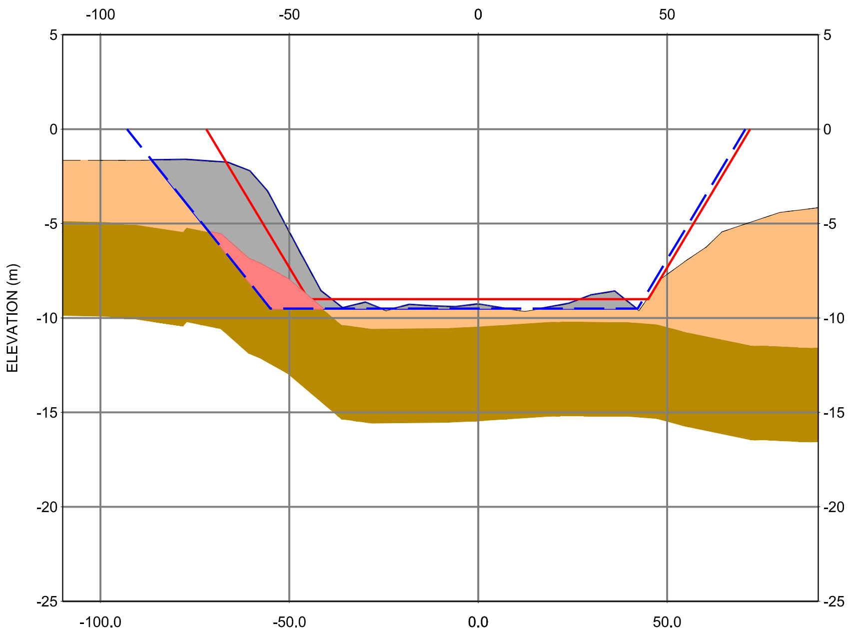
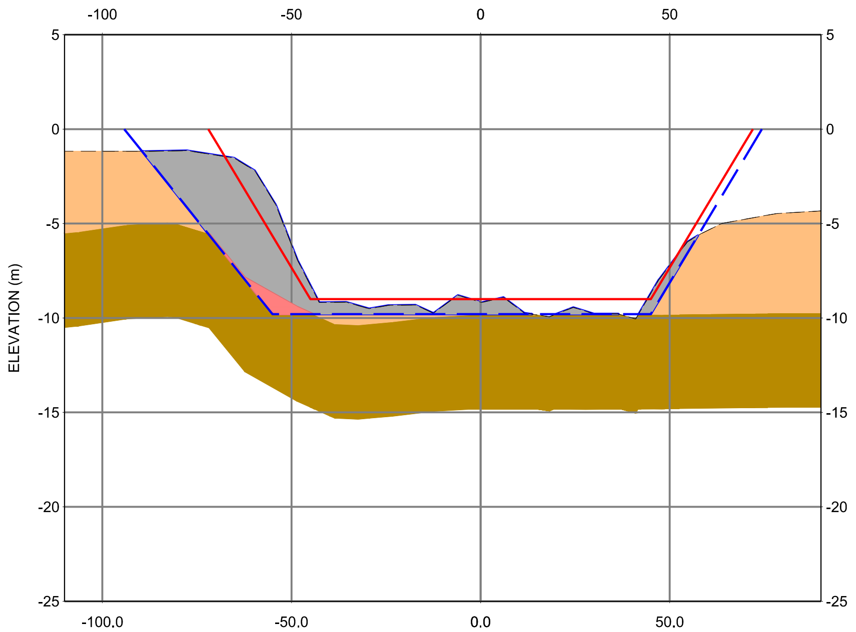
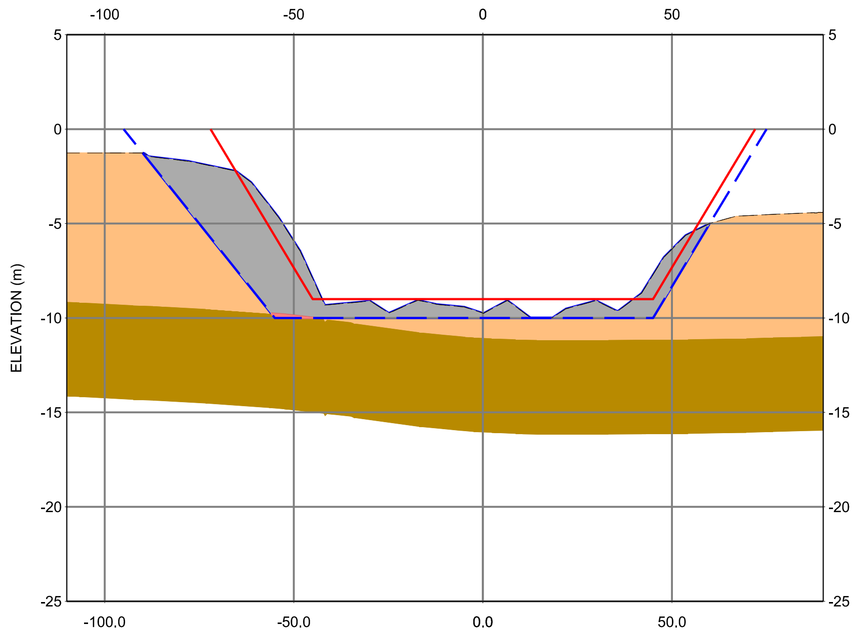
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
25 mm
0



CH 17250.0



CH 17750.0



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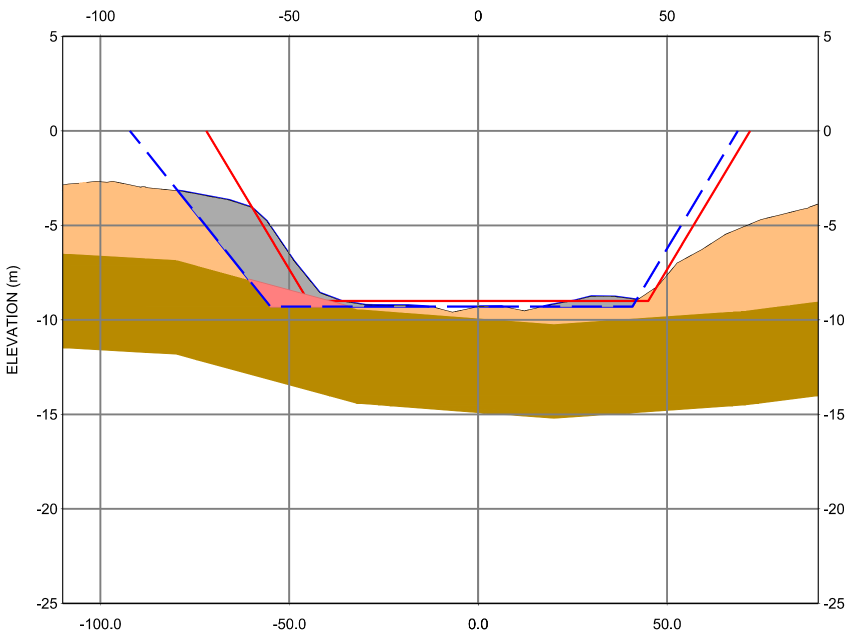
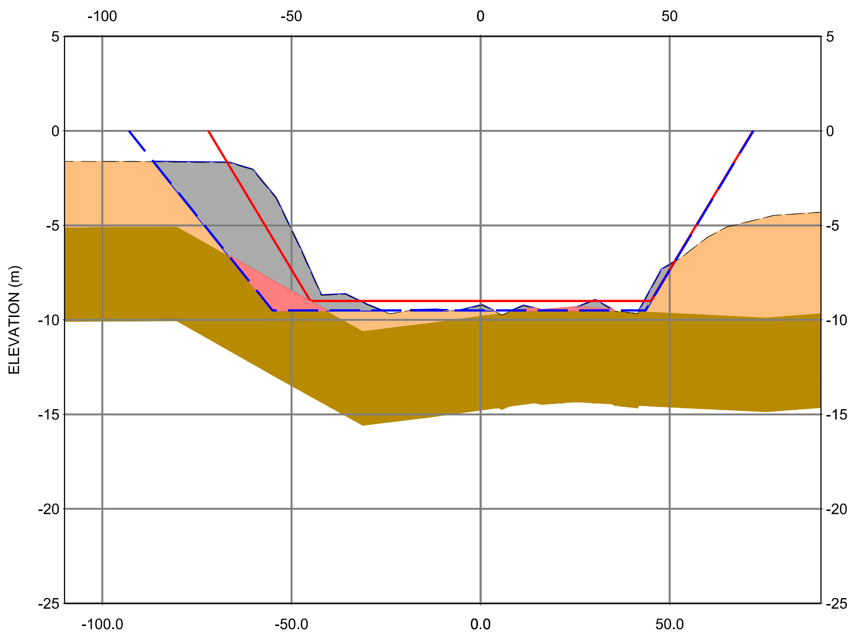


CH 17000.0



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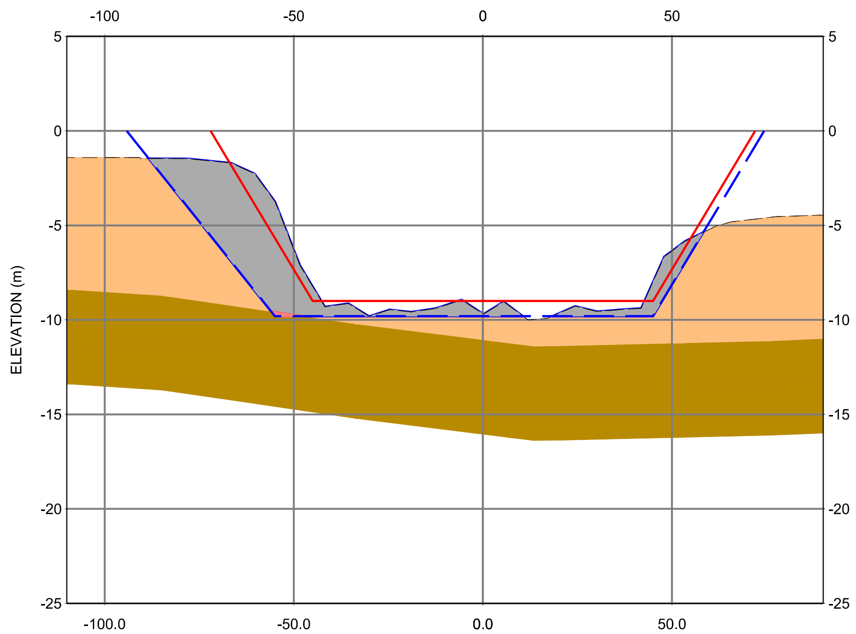

CH 18000.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 1:400 METRES

HORIZ. 0 50 100 1:2,000 METRES

CLIENT FLANAGAN CONSULTING GROUP			PROJECT CAIRNS SHIPPING DEVELOPMENT PROJECT
CONSULTANT Golder Associates	YYYY-MM-DD	2017-10-30	TITLE **CHANNEL CROSS SECTIONS SHEET 6**
	DESIGNED	PB	
	PREPARED	GPG	
	REVIEWED	MC	PROJECT NO. 1546223 · DOCUMENT No 025 · REV. 1 · FIGURE 2F
	APPROVED	MC	

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

25 mm

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