FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

Ports North

CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

APPENDIX J: Assessment of Materials Proposed for Dredging Report (2016)

16 January 2017

ADDITIONAL STUDIES - DREDGED MATERIALS

Cairns Shipping Development Project

REPORT

Report Number. 1546223-008-R-Rev2

Distribution:

1 Electronic Copy - Flanagan Consulting Group

Golder Associates

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FIGURES

APPENDICES

1.0 INTRODUCTION

Flanagan Consulting Group (FCG) previously commissioned Golder Associates Pty Ltd (Golder) to provide geotechnical advice as part of the Revised Draft Environmental Impact Statement for the Cairns Shipping Development (CSD) Project. Geotechnical input related to the assessment of the values and constraints associated with the materials proposed to be dredged included the following:

- Assessment of subsurface conditions likely to be encountered in the proposed dredging;
- Assessment of the geotechnical properties of the materials to be dredged;
- Assessment of the ASS properties of the materials to be dredged.
- Preparation of a 3D model of ground conditions relevant to the proposed dredging.

The results of the previous studies were presented in Golder report 1546223-006-R-Rev1 in October 2016. Subsequent to the studies Golder was commissioned to re-assess the materials likely to be encountered during dredging based on revised channel design information provided by Ports North.

This report presents the results of our assessment. Note that this report should be read in conjunction with our previous report, and that where relevant this report supersedes the previous report.

2.0 GROUND MODEL

As outlined in our previous report an interpreted 3-dimensional (3D) model of ground conditions was developed using the VulcanTM geological modelling software. The main feature of the model was the top of stiff clay, with this boundary surface being equivalent to the base of soft clay where a soft clay layer is present or, coincident with the sea bed where stiff clay occurs at sea bed level.

The modelled surface of the stiff clay was used in combination with the bathymetric survey information and channel design information provided to estimate the expected volumes of different materials for maintenance and capital dredging.

The initial model was based on the following:

- Bathymetric survey – “Composite survey data.dxf” provided by email to Golder by BMT JFA on 2 August 2016;
- Capital Channel design – “Rev B Revised Draft EIS Channel design Model.dxf” provided by email to Golder by BMT JFA on 2 August 2016;
- Maintenance Channel design – “Existing channel design 2016-08-02.dxf” provided to Golder by BMT JFA on 2 August 2016;

The model has been revised based on the following:

- Post 2016 bathymetry – provided by email from Ports North on 27 October 2016; and
- Ports North mark up of channel cross sections prepared by Golder at 250 m intervals along the channel – provided in emails from Ports North on 28 November, 30 November and 12 December, 2016.

Based on the revised model, plans showing where dredging is proposed and the materials expected to be encountered in the proposed capital dredging are shown on Figures F001 to F002.

Cross sections of the channel showing the design dredging profiles and the materials expected to be encountered in the dredging are shown on Figures F003 to F012.

3.0 VOLUMES AND DISTRIBUTION OF MATERIALS

Based on the revised model the re-calculated volumes of materials to be dredged are summarised below.

Table 1: Volumes of Materials to be Dredged

Material Type	Volume (m^3)
Soft clays	698,755
Stiff clays	92,309
Total	**791,064**

The distribution of materials within the capital dredging was also calculated by chainage and is summarised below.

Table 2: Distribution of Materials to be Dredged by Chainage

Chainage	Volume of Soft Clays (m^3)	Volume of Stiff Clays (m^3)	Total Volume (m^3)
11000-11500	42558	2783	45340
11500-12000	356	0	356
12000-12500	880	2316	3196
12500-13000	21346	2160	23506
13000-13500	13812	579	14391
13500-14000	3337	1923	5260
14000-14500	6419	9541	15960
14500-15000	12923	30687	43610
15000-15500	31136	1280	32416
15500-16000	44424	15965	60390
16000-16500	47187	2997	50184
16500-17000	34641	380	35021
17000-17500	43571	6213	49784
17500-18000	57749	12499	70248
18000-18500	89979	2382	92361
18500-19000	77999	43	78041
19000-19500	71070	485	71555
19500-20000	34862	1	34863
20000-20500	16182	16	16198
20500-21000	18504	57	18562
21000-21500	10539	2	10541
21500-22000	8018	0	8018
22000-22500	4516	0	4516
22500-23000	1192	0	1192
23000-23500	1478	0	1478
23500-24000	3007	0	3007
24000-24500	1071	0	1071
Totals	**698755**	**92309**	**791064**

4.0 ACID SULFATE SOILS (ASS)

Our previous report indicated the following with regards to ASS materials that may be encountered in the capital dredging:

- The soft clays have potential acidity (chromium reducible sulfur) levels which would classify them as PASS. The total volume of these materials has been re-calculated as 698,755 m^3.
- Most of the PASS materials have sufficient neutralising capacity to classify them as self-neutralising PASS (SNP). The volume of these SNP materials has been re-calculated as 450,863 m^3.
- The locations where PASS materials (without sufficient neutralising capacity) have been identified are summarised below. The volume of these materials has been re-calculated as 247,892 m^3 made up as follows:
  - Main Swing Basin – 42,914 m^3
  - Crystal Swing Basin – 8,456 m^3
  - CH14750-CH15250 - 31,136 m^3
  - CH15250-CH16250 - 91,611 m^3
  - CH17500-CH18000 - 73,775 m^3

PASS was also detected at isolated investigation locations beyond CH19250 but at depths of 2m to 3m below the base of the channel. These results have not been considered further as these materials will not be disturbed by the proposed capital dredging. The stiff clays have been confirmed as non-ASS.

5.0 STIFF CLAYS

As indicated in Figures F001 to F002 and in Table 2, the locations where more significant volumes of stiff clays are likely to be encountered in the capital dredging are summarised below:

- CH14000-CH14500 – 9,541 m^3
- CH14500-CH15000 – 30,687 m^3
- CH15500-CH16000 – 15,965 m^3
- CH17000-CH17500 – 6,213 m^3
- CH17500-CH18000 – 12,499 m^3

The volume of stiff clays encountered during capital dredging in the outer channel beyond CH18500 is likely to be ~600m^3.

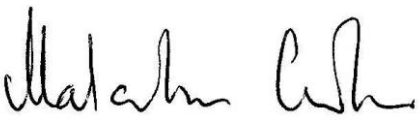
6.0 SANDS

As outlined in our previous report, sands were encountered at a number of inner harbour investigation locations (i.e. G1, G3, G4, G5 and G21), plus at CH 17500 (i.e. G10). The depth of the sands ranged from about 0.2 to 0.75 m, however the extent of the sands has not been assessed. It is noted that shell contents within the sands were inferred to range from about 20 to 40 % of the total mass based on visual observations.

7.0 IMPORTANT INFORMATION

Your attention is drawn to the document – “Important information relating to this report” which is included as an Appendix 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. We would be pleased to answer any questions about this important information from the reader of this report.

GOLDER ASSOCIATES PTY LTD



Malcolm Cook
Principal Geotechnical Engineer

MSC/PKS/ow

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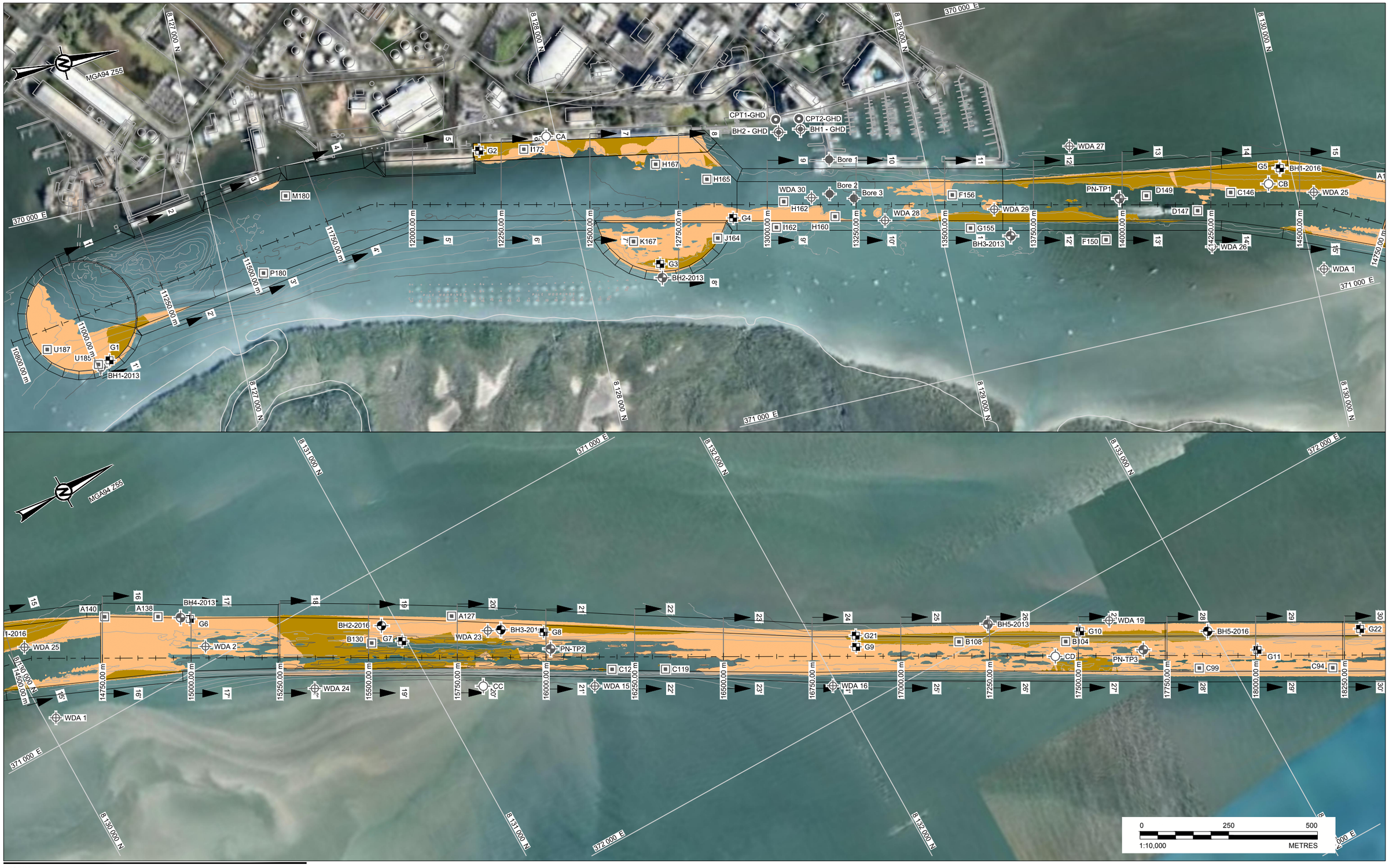
FIGURES



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

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-25
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

TITLE
INVESTIGATION LOCATION PLAN - SHEET 1

PROJECT NO.	DOCUMENT No	REV.	FIGURE
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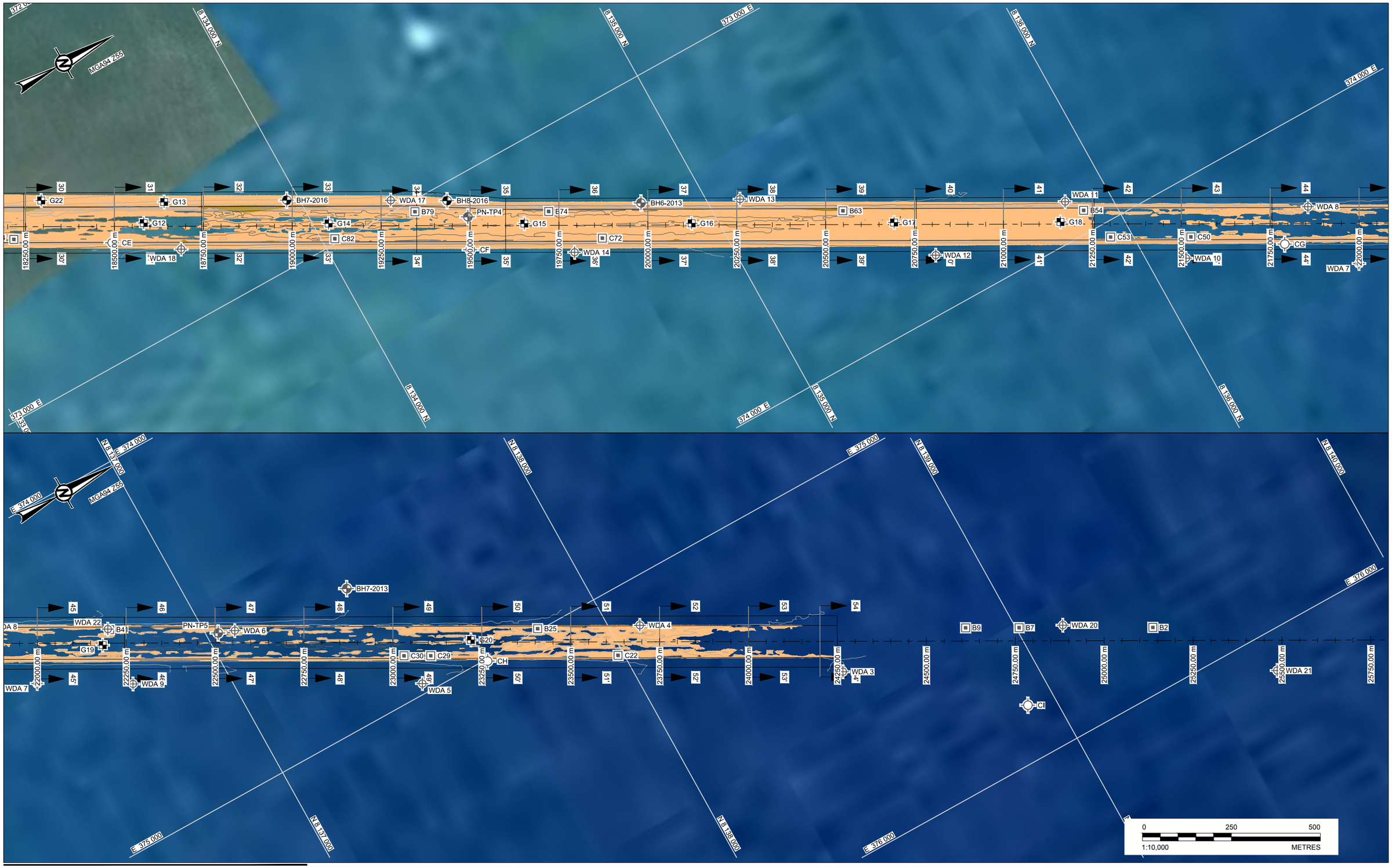

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PROJECT
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REVIEWED	MC
APPROVED	MC

TITLE
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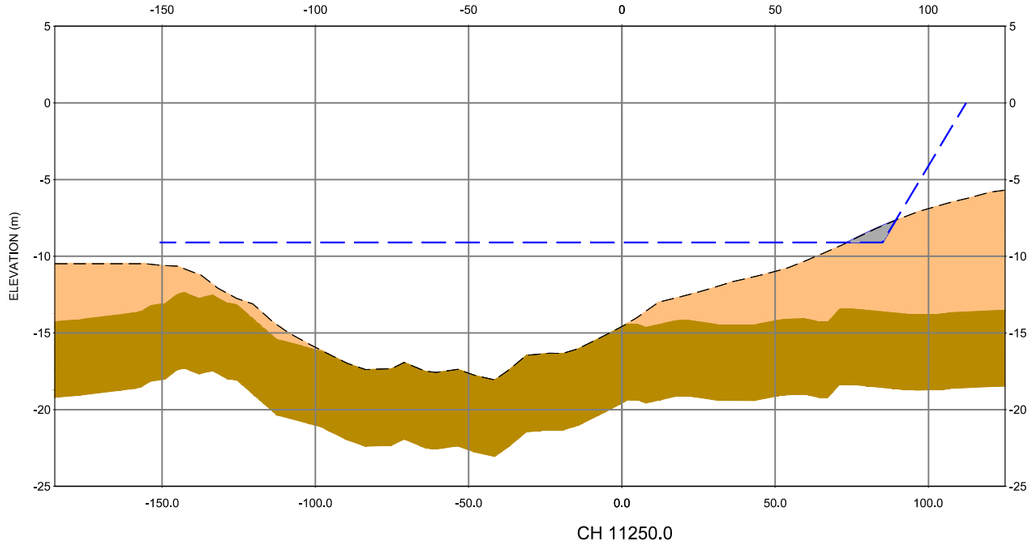

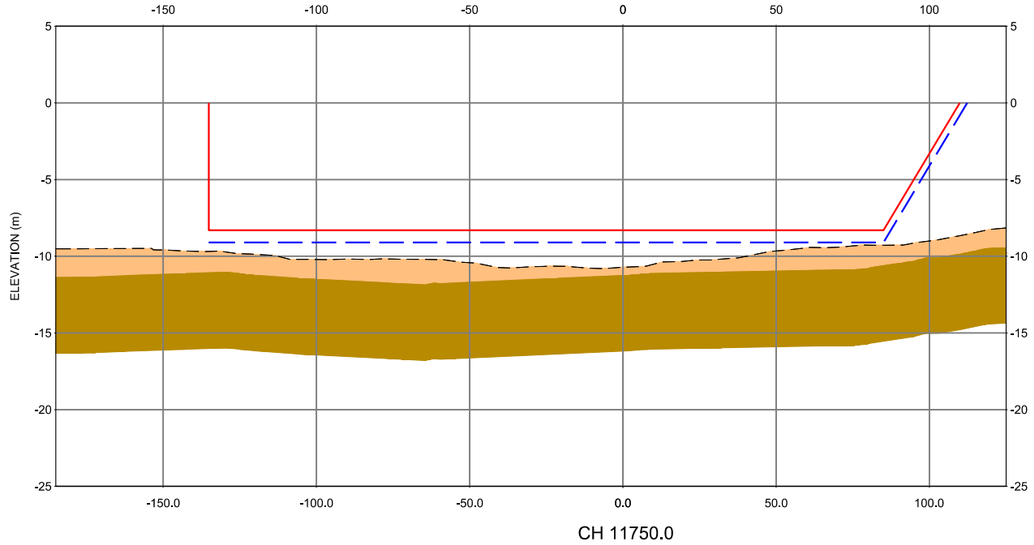

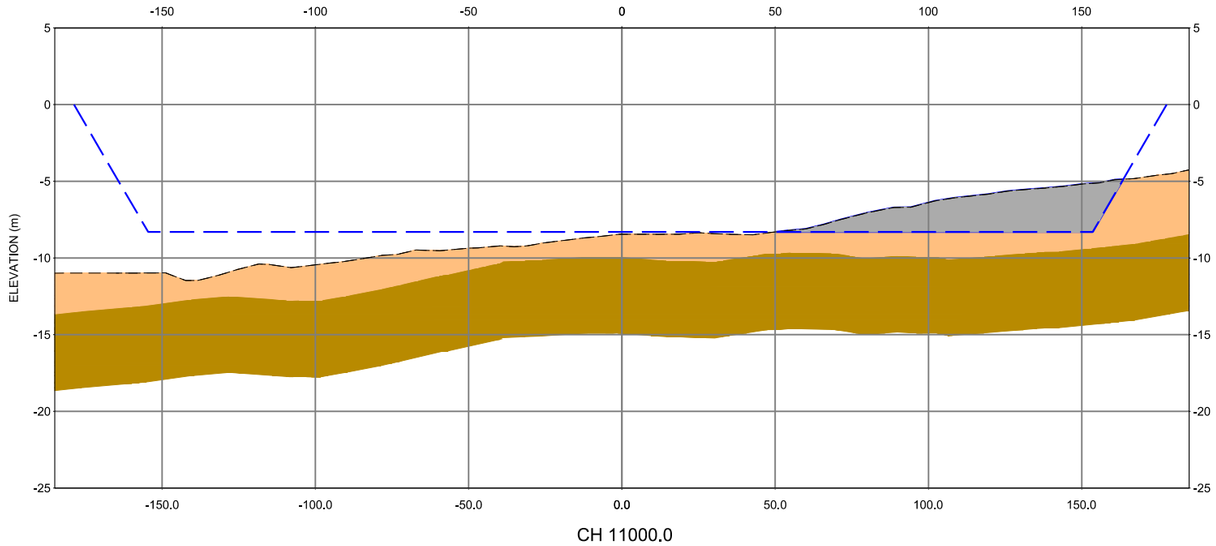

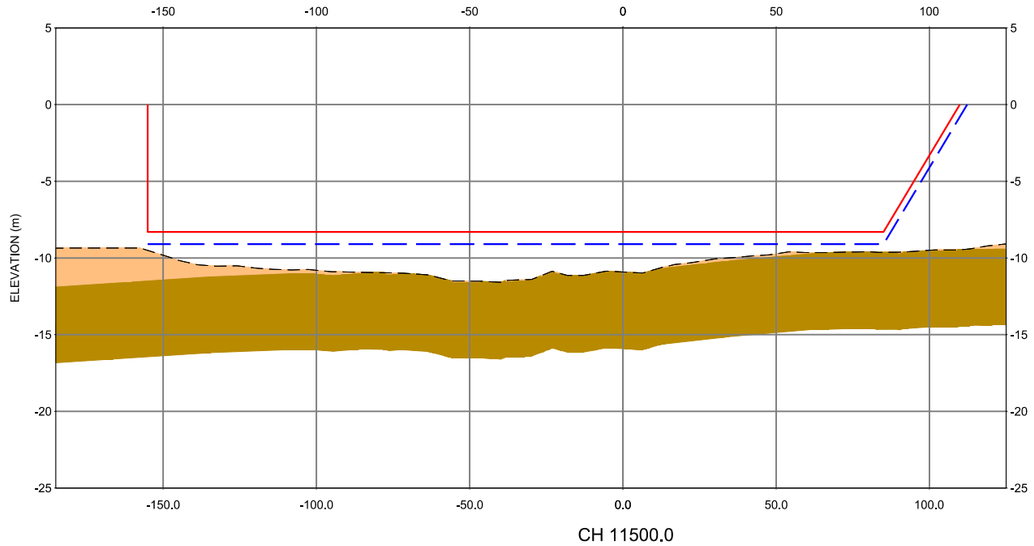

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- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 — 1:400 METRES

HORIZ. 0 50 100 — 1:2,000 METRES

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TITLE
CHANNEL CROSS SECTIONS SHEET 1

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REVIEWED	MC
APPROVED	MC

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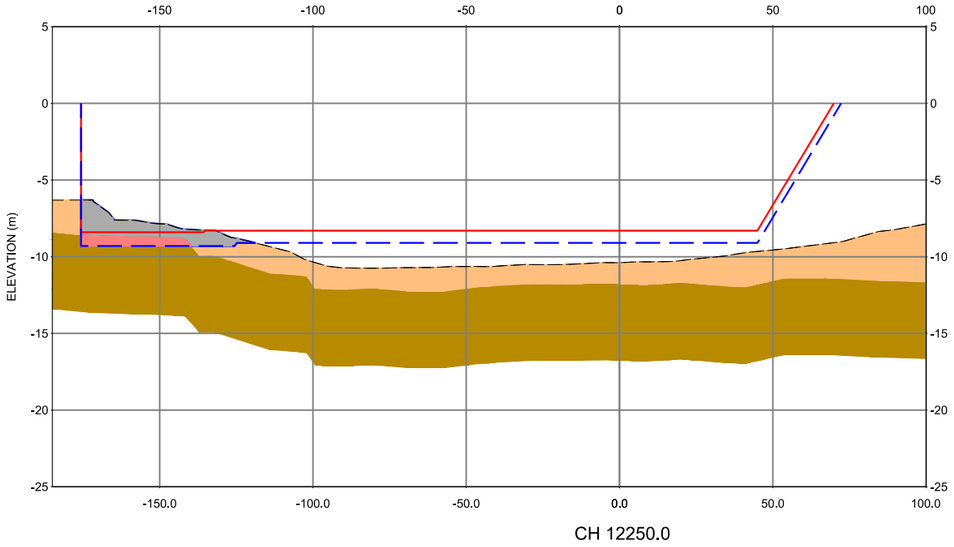

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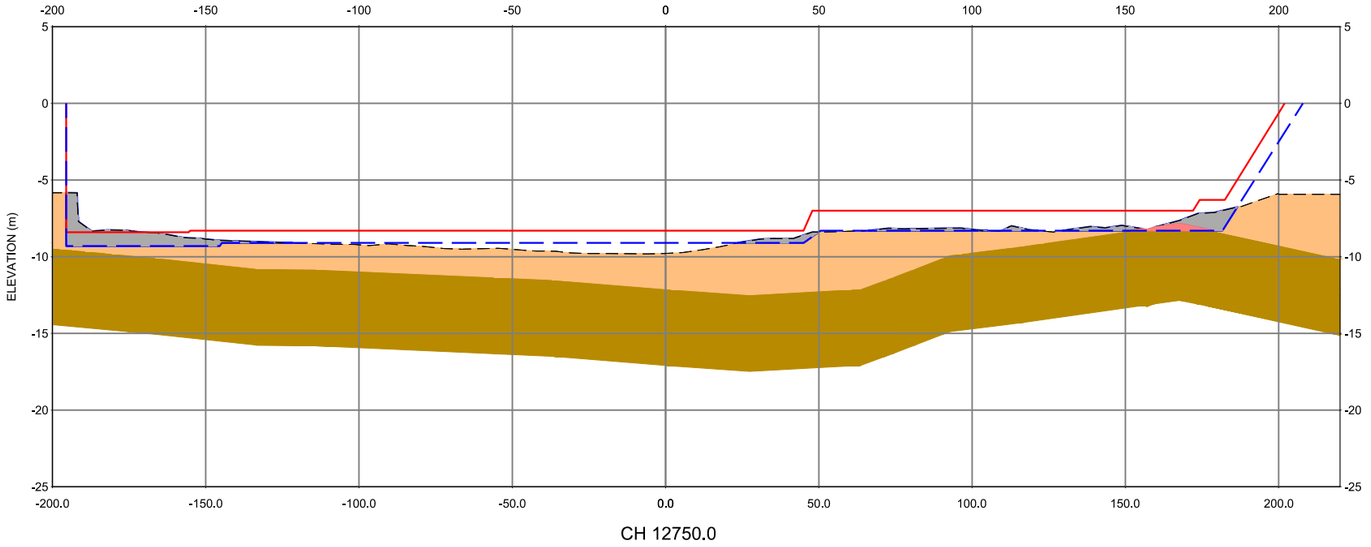

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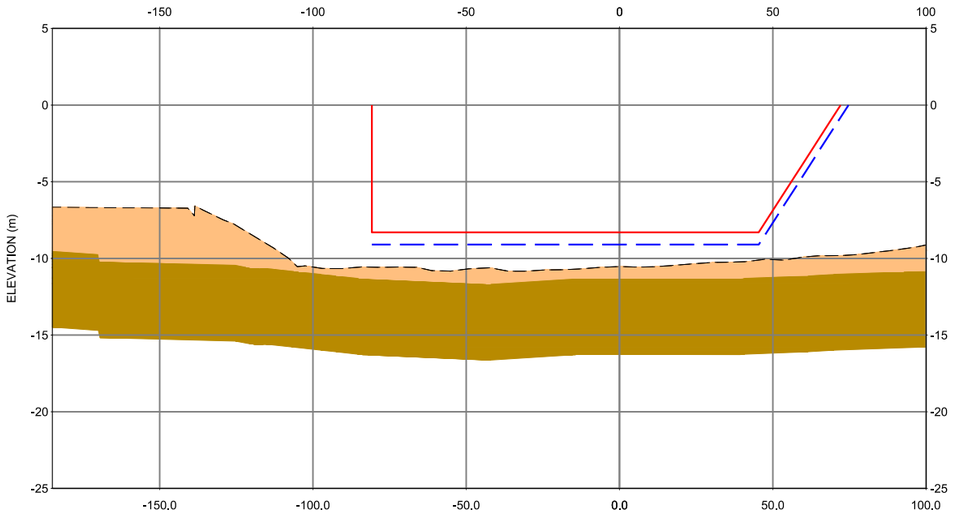

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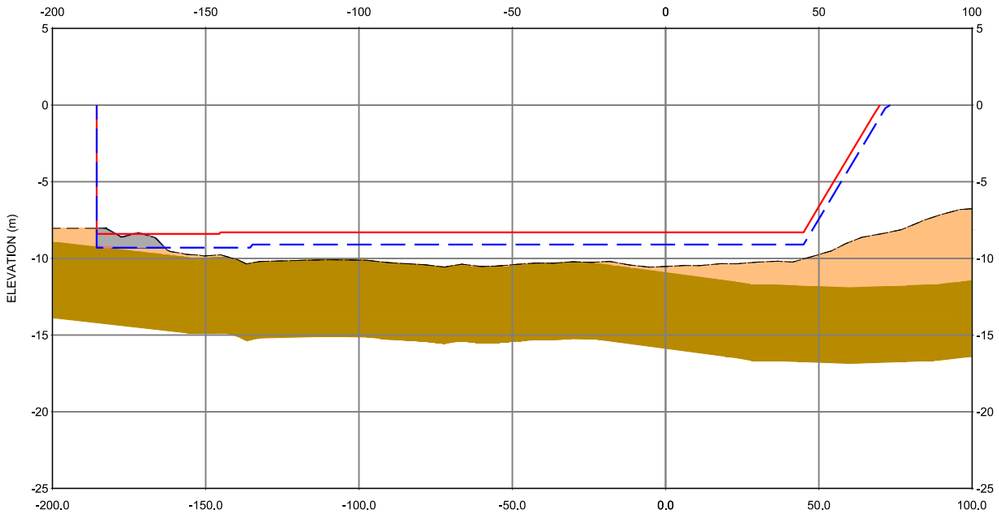

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- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 — 1:400 METRES

HORIZ. 0 50 100 — 1:2,000 METRES

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CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
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PREPARED	GPG
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APPROVED	MC

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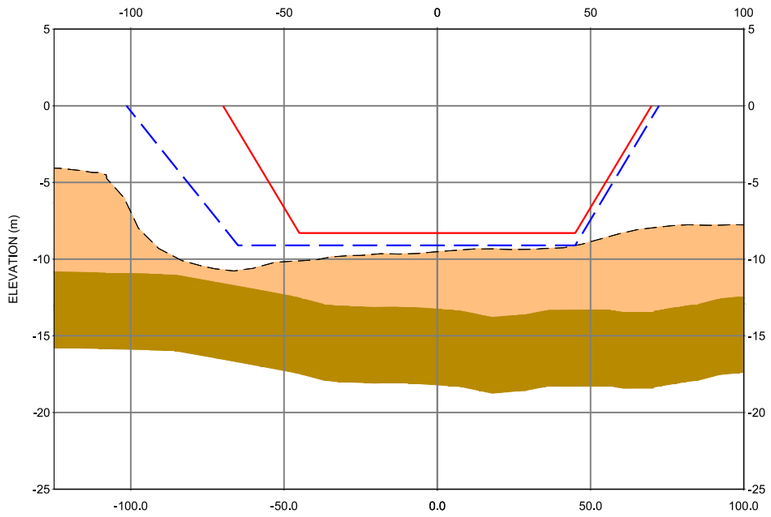

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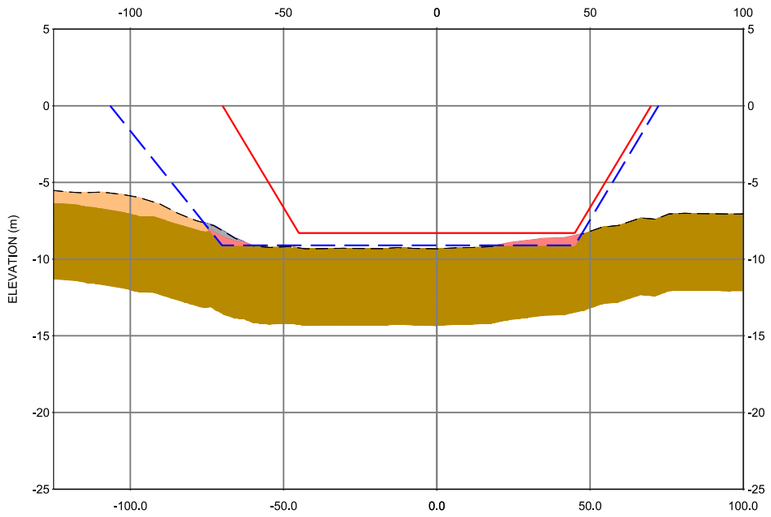

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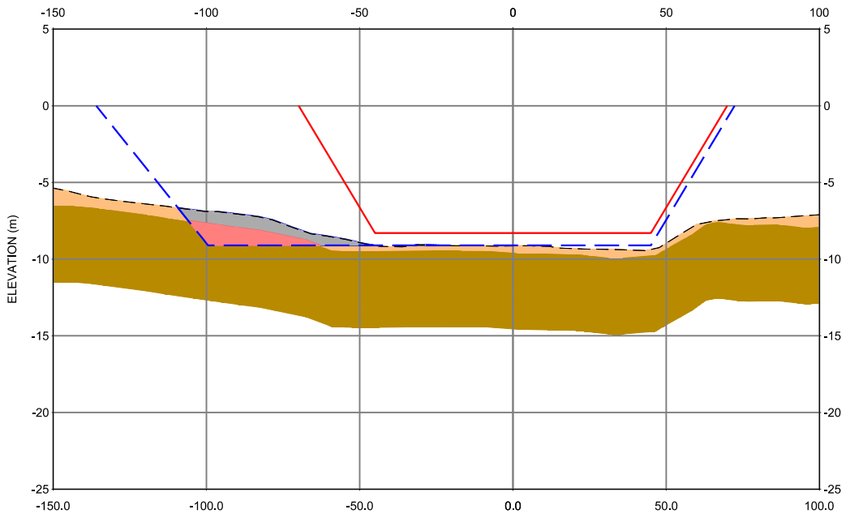

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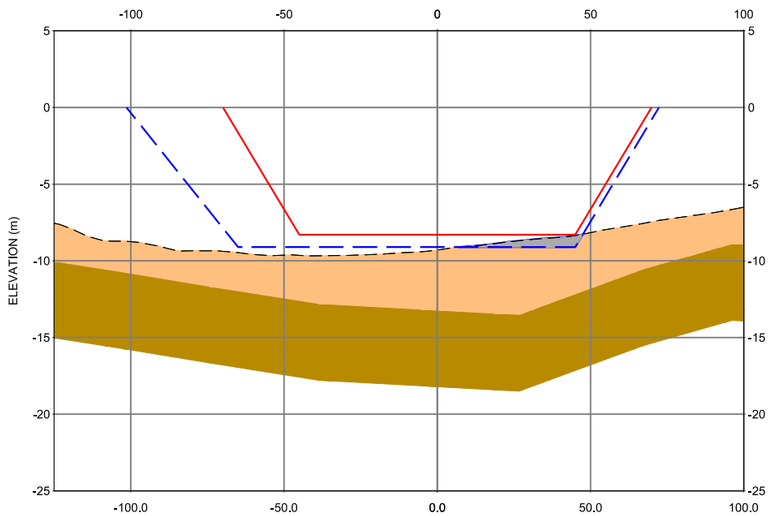

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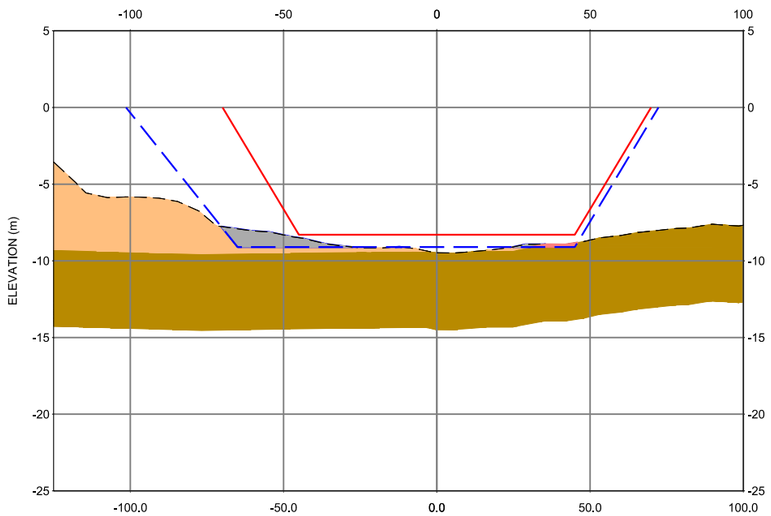

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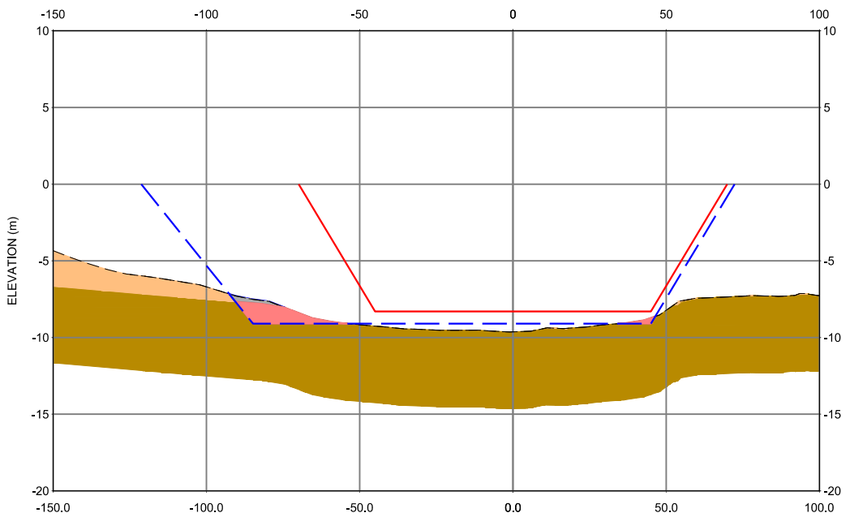

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- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 METRES 1:400

HORIZ. 0 50 100 METRES 1:2,000

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REVIEWED	MC
APPROVED	MC

PROJECT
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TITLE
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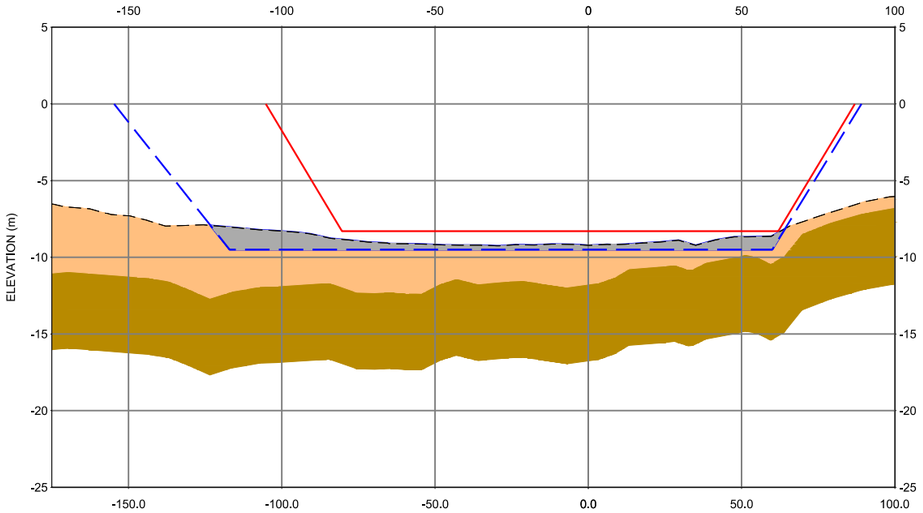

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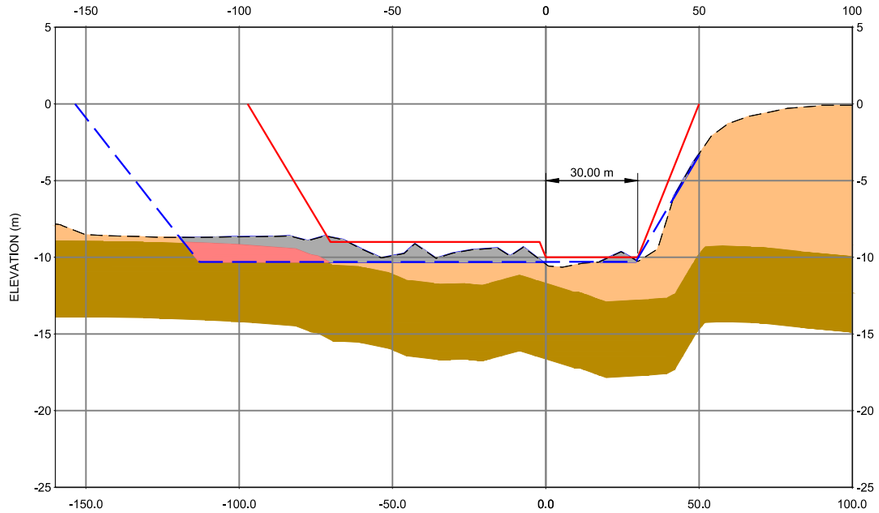

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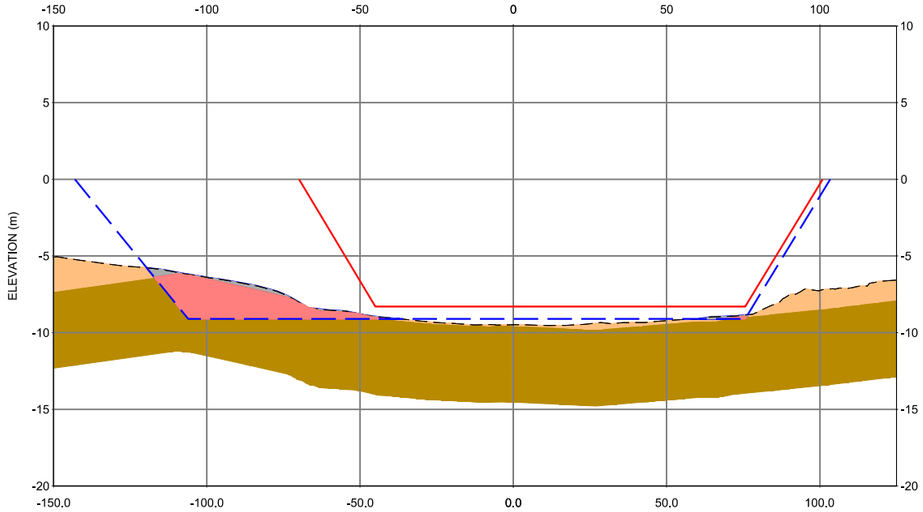

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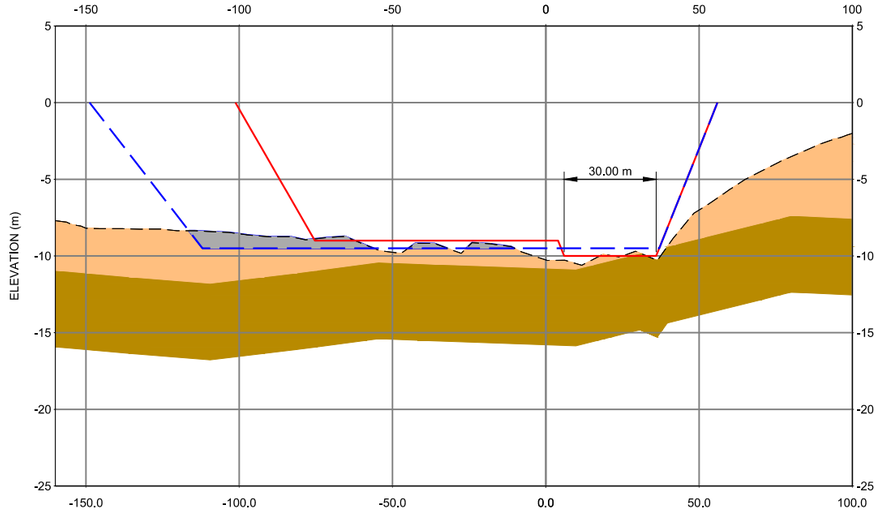

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- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
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- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

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HORIZ. 0 50 100 METRES 1:2,000

CLIENT
FLANAGAN CONSULTING GROUP

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YYYY-MM-DD	2016-08-25
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REVIEWED	MC
APPROVED	MC

PROJECT
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TITLE
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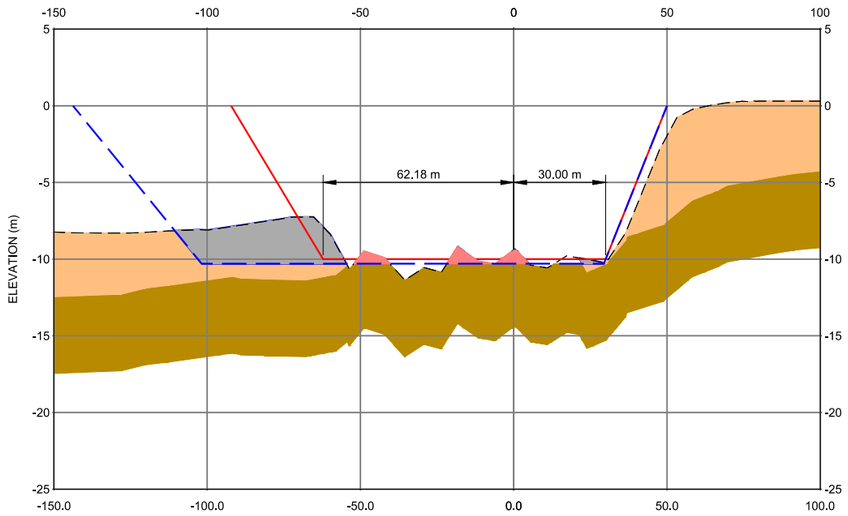

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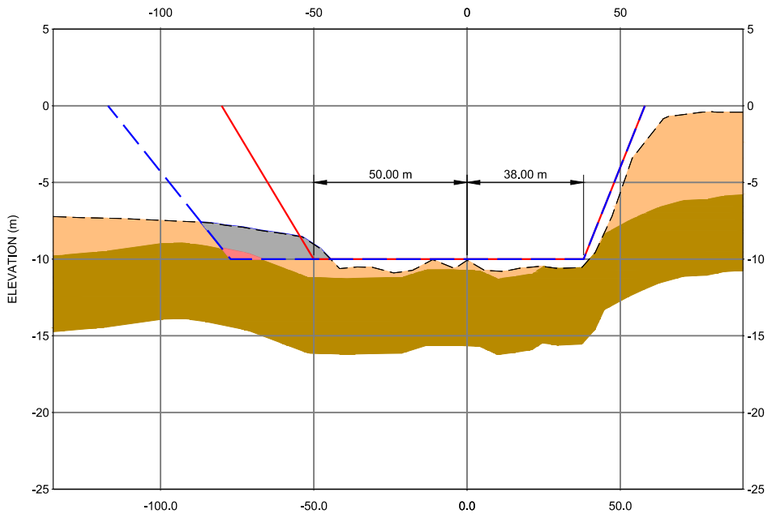

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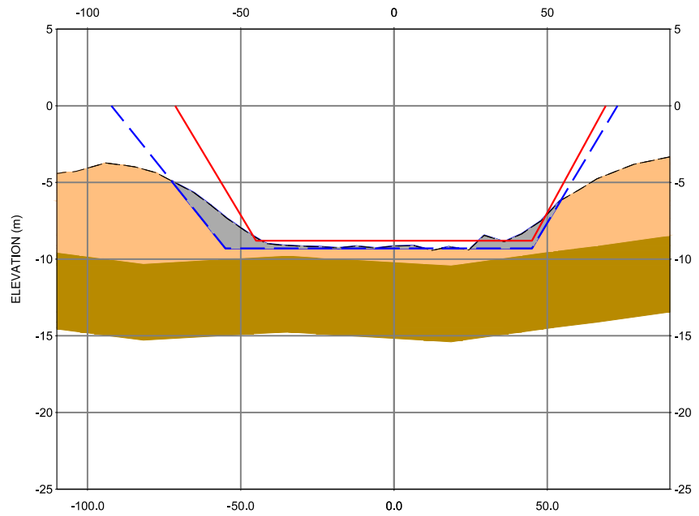

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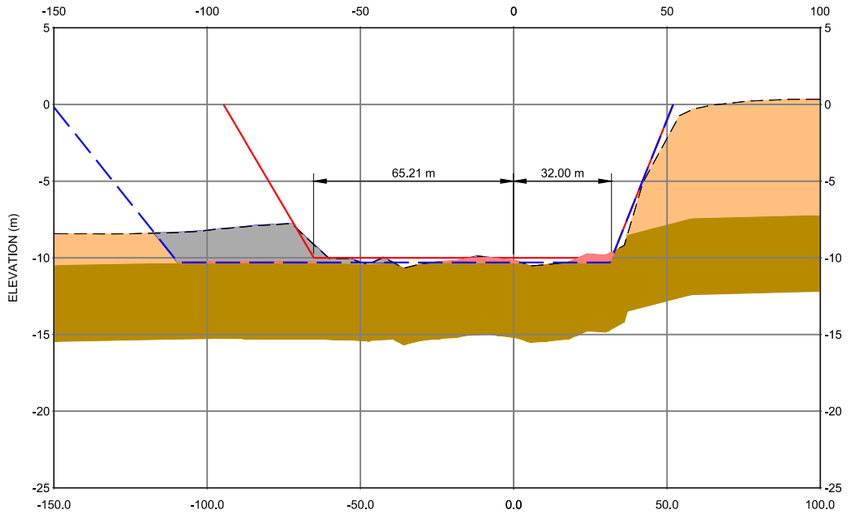

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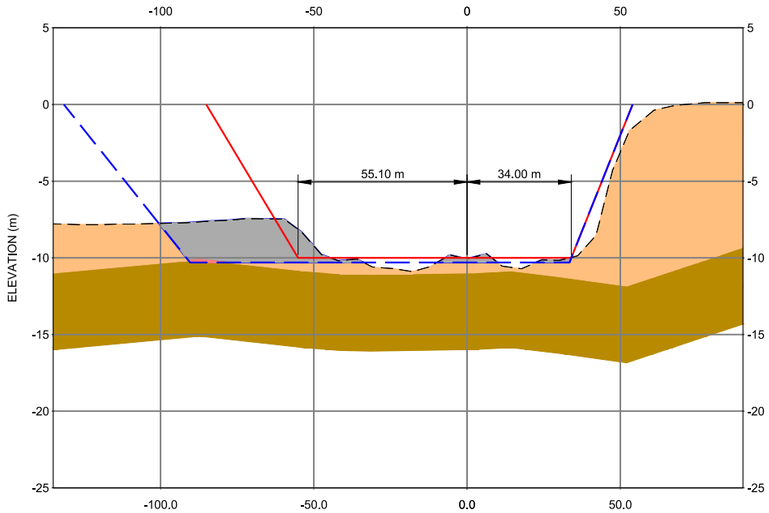

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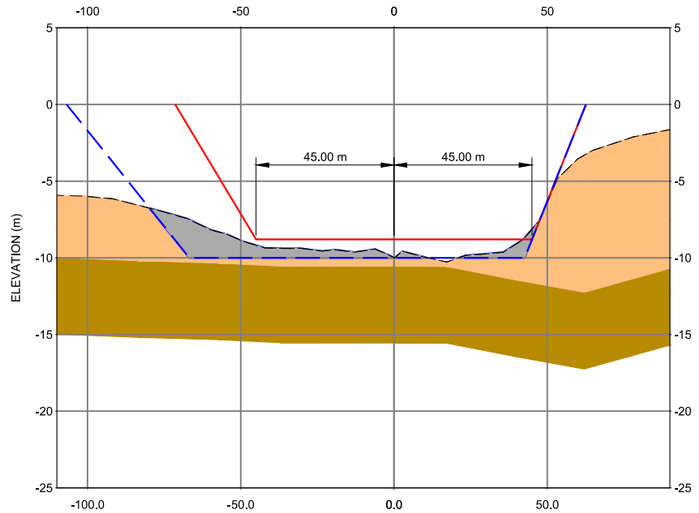

CH 16500.0

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 — 1:400 METRES

HORIZ. 0 50 100 — 1:2,000 METRES

CLIENT
FLANAGAN CONSULTING GROUP

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-25
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 5

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	008	2	F007

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

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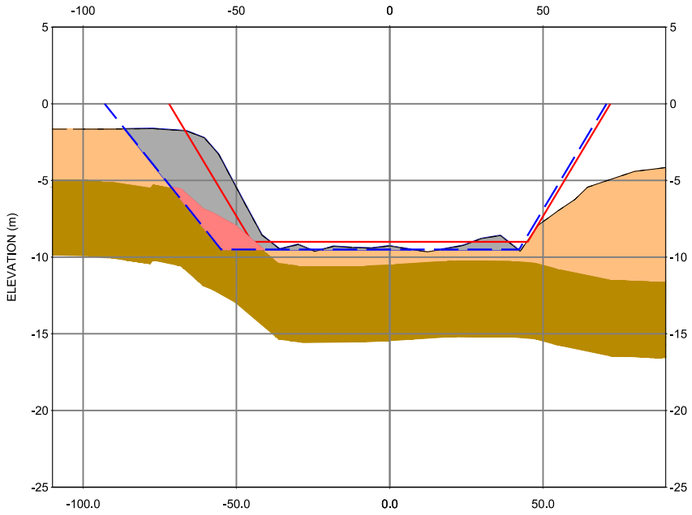

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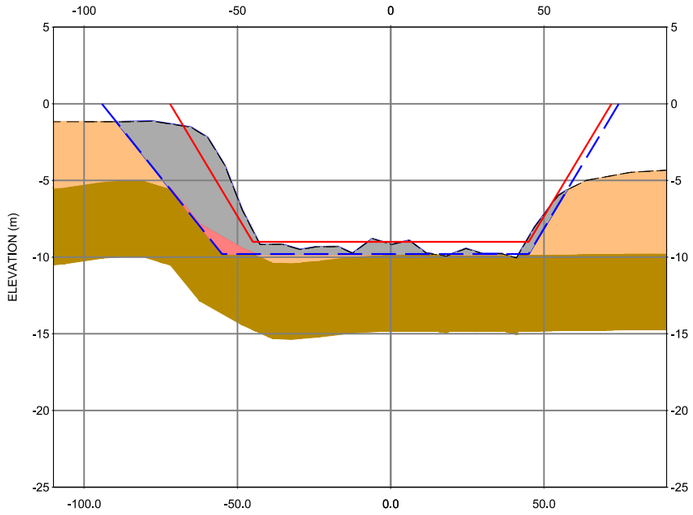

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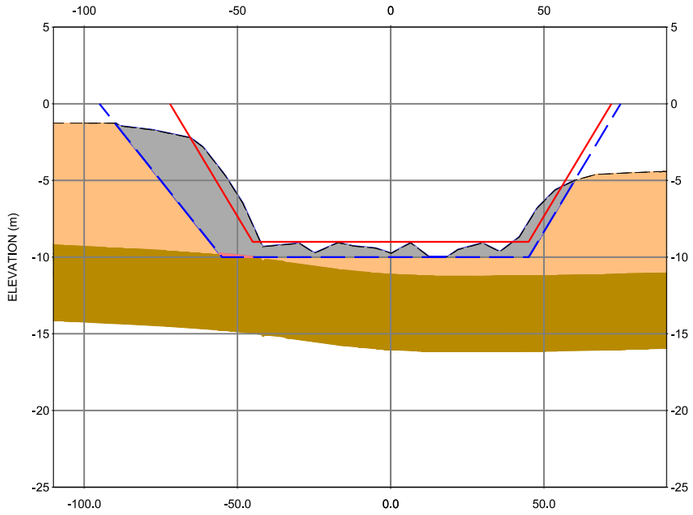

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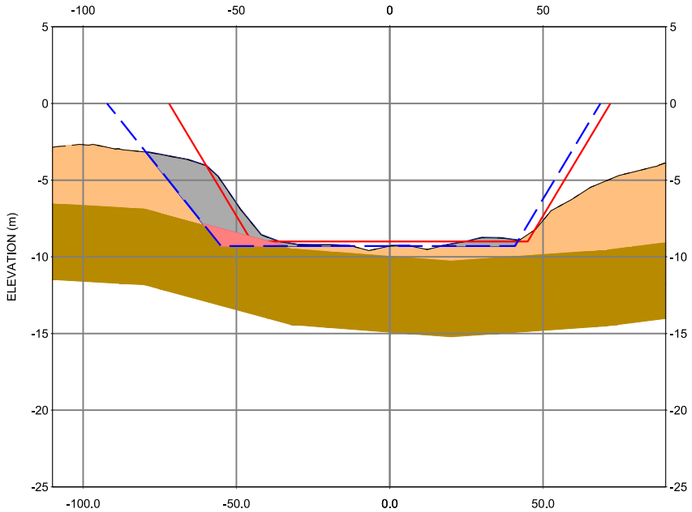

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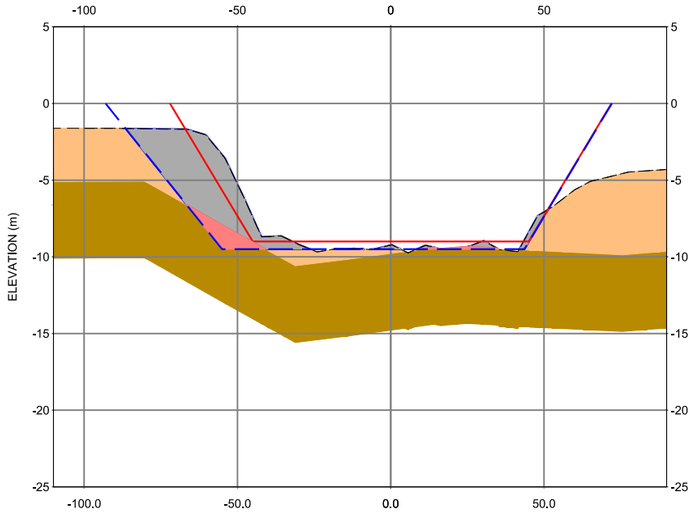

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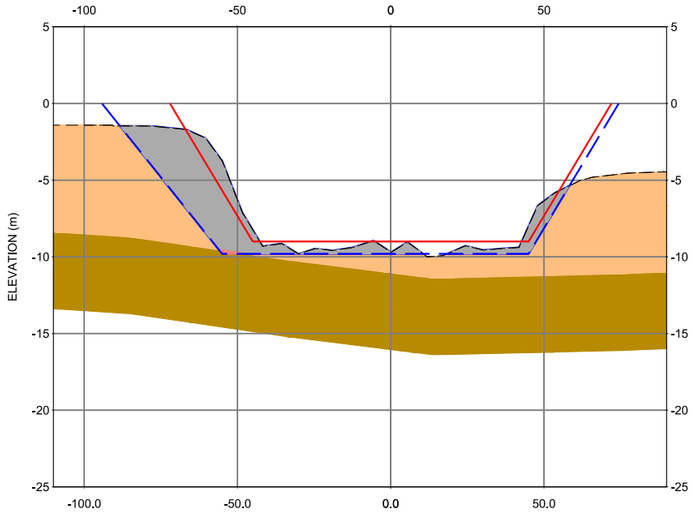

CH 18000.0

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

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-25
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 6

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	008	2	F008

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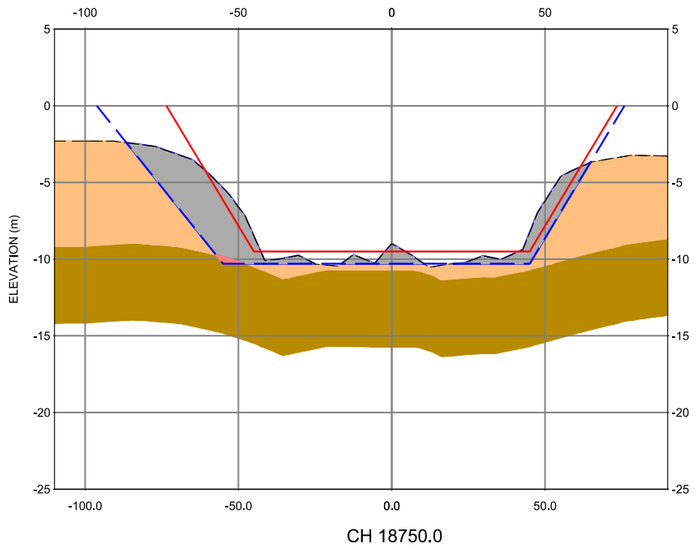

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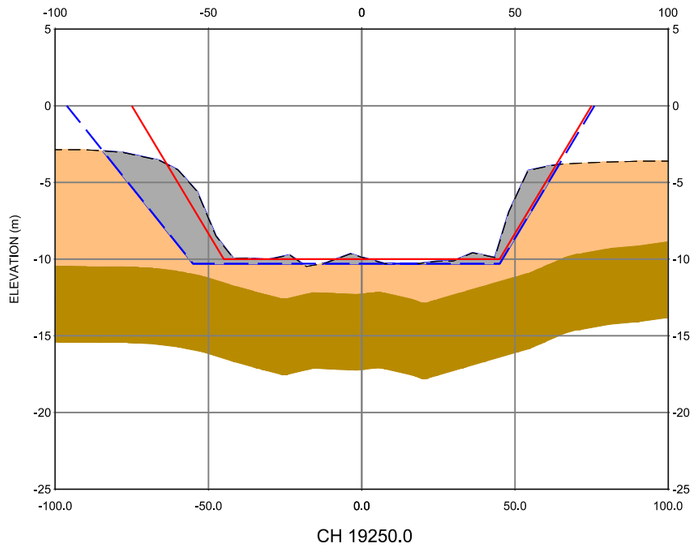

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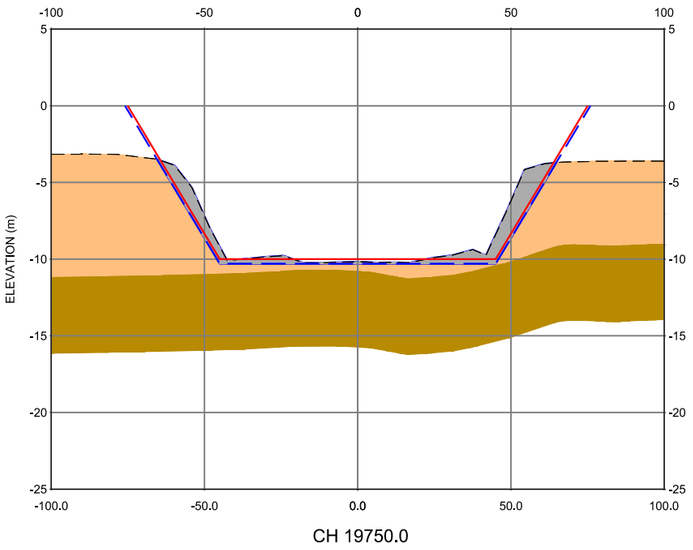

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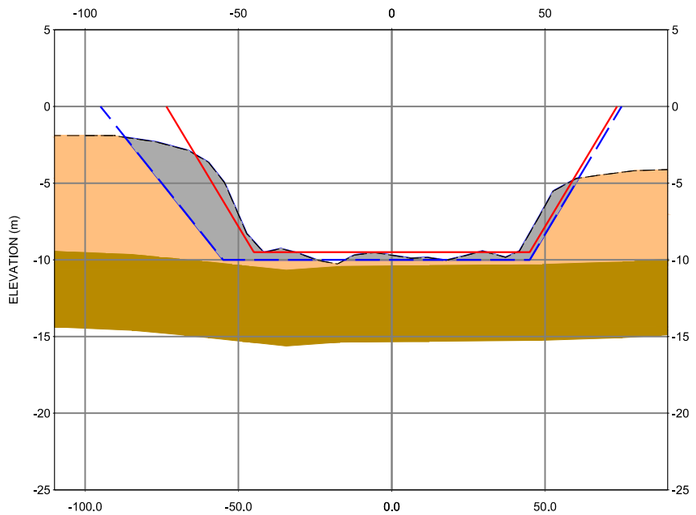

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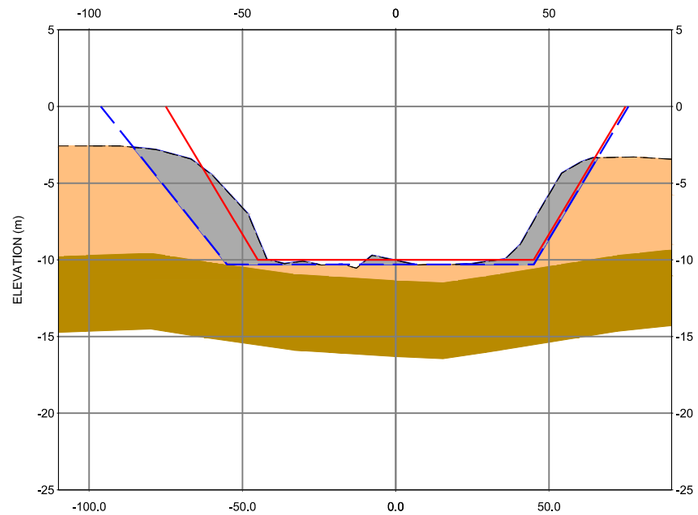

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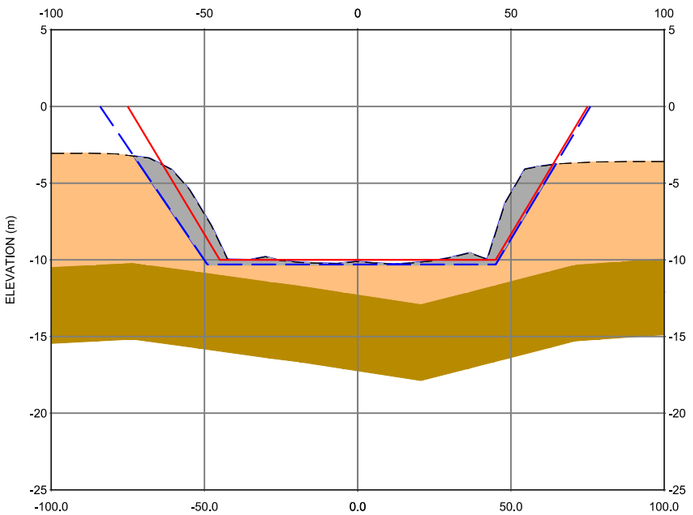

CH 19500.0

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

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-25
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 7

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	008	2	F009

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

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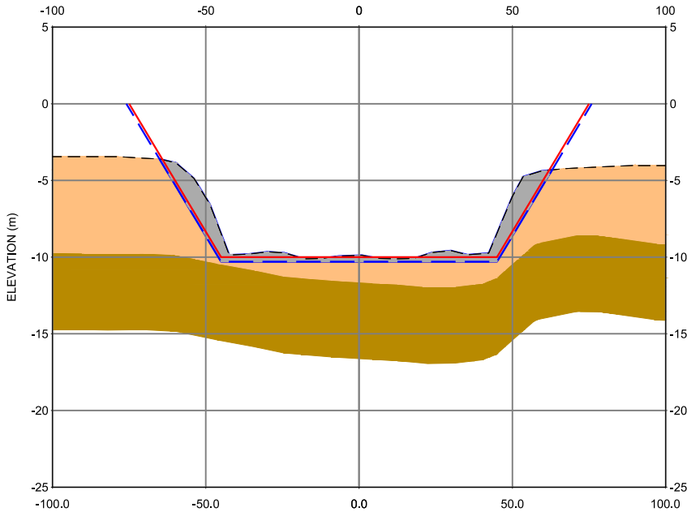

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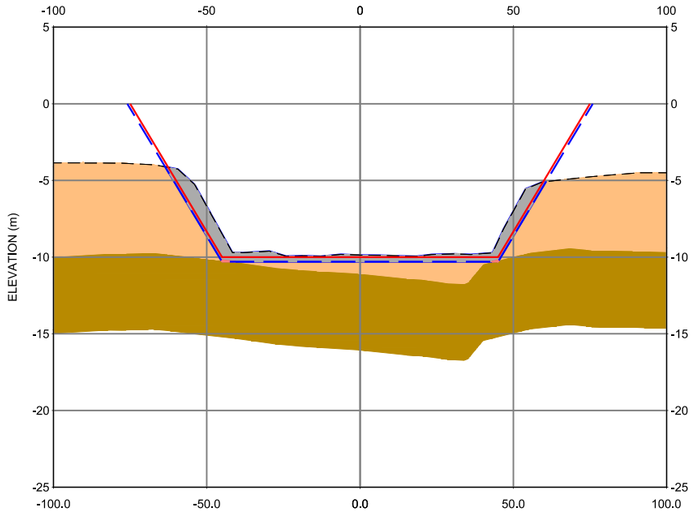

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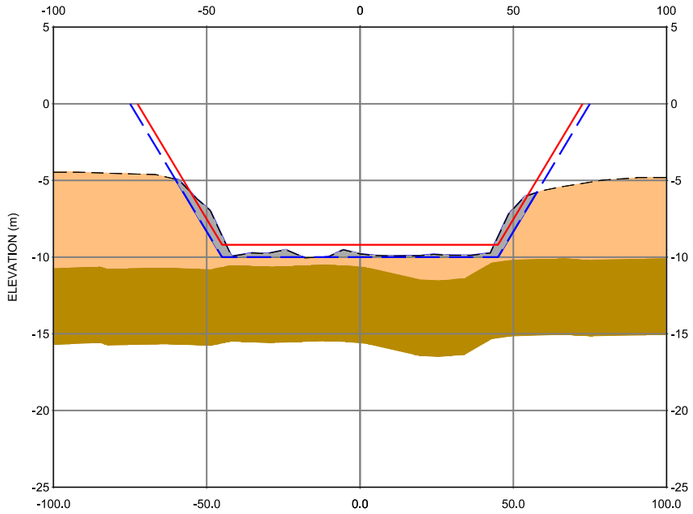

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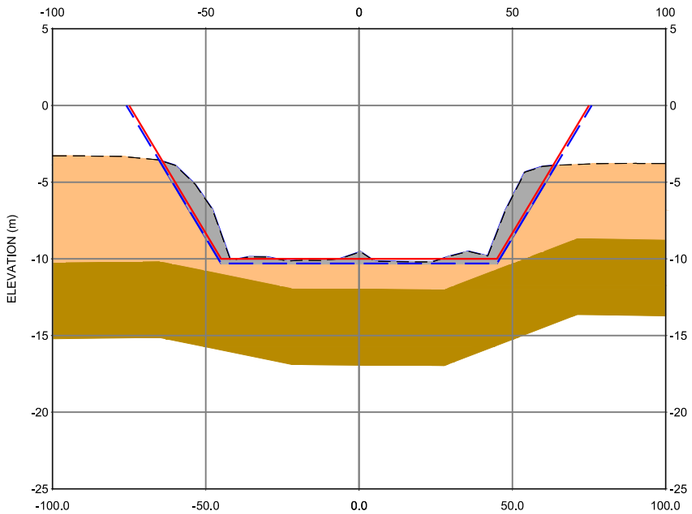

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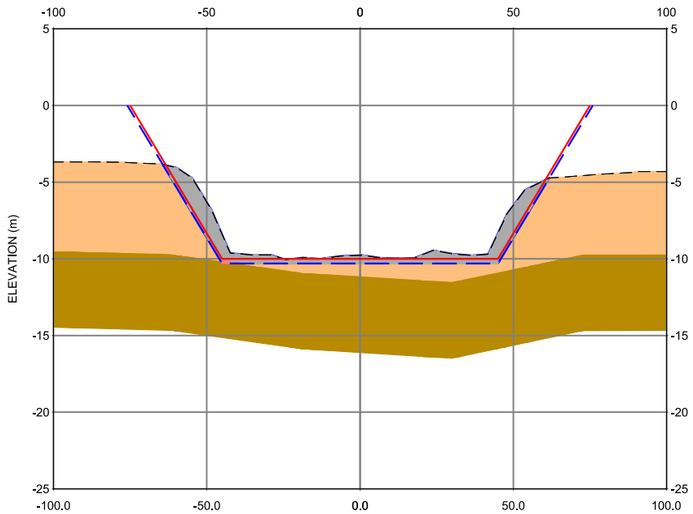

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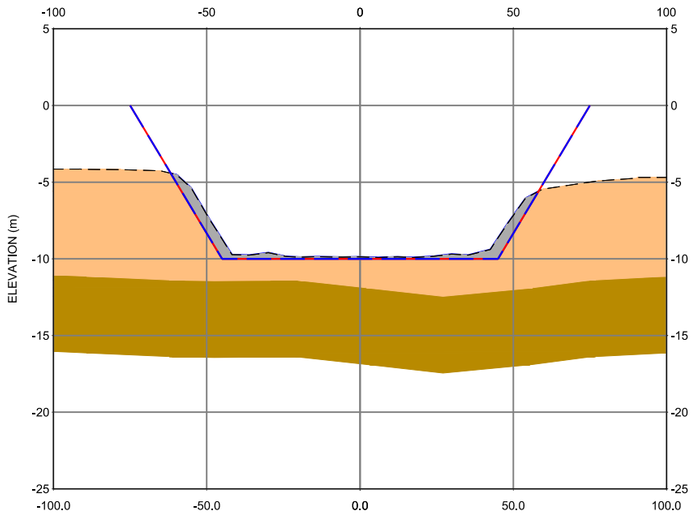

CH 21000.0

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

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-25
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 8

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	008	2	F010

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

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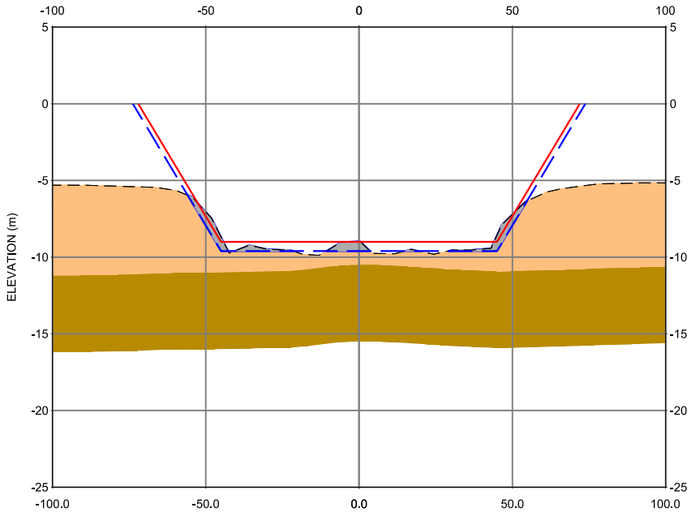

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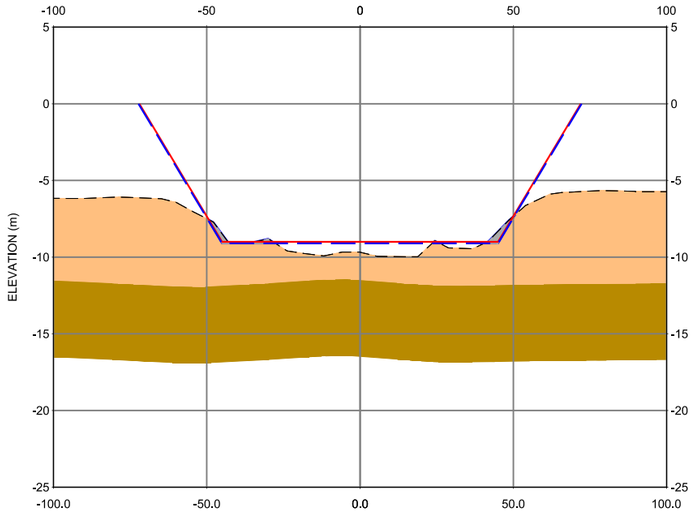

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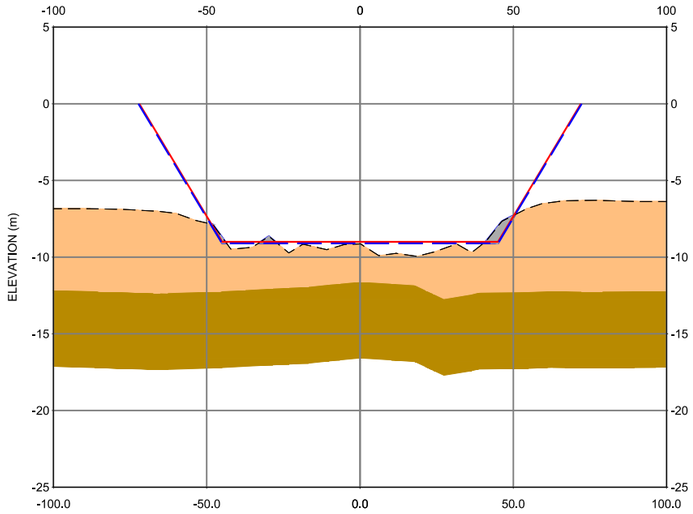

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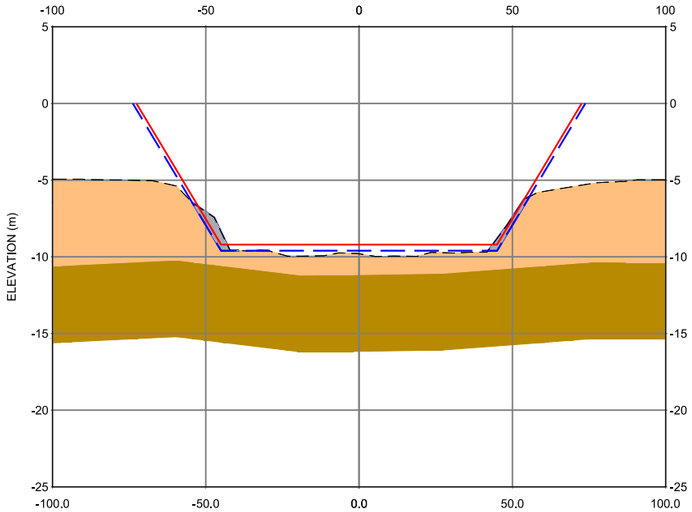

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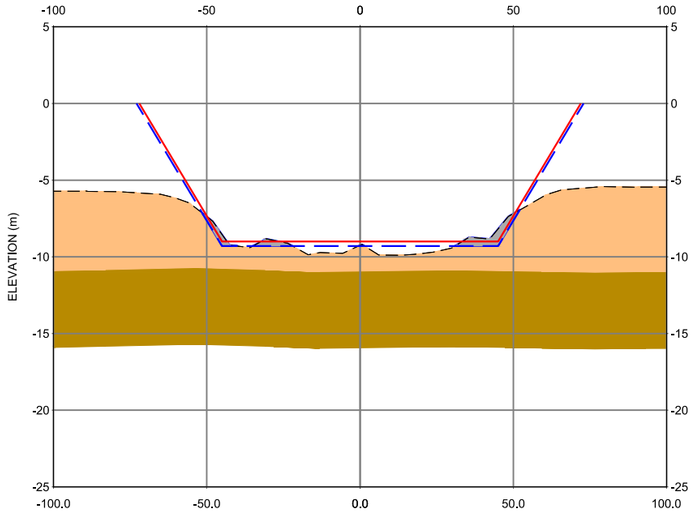

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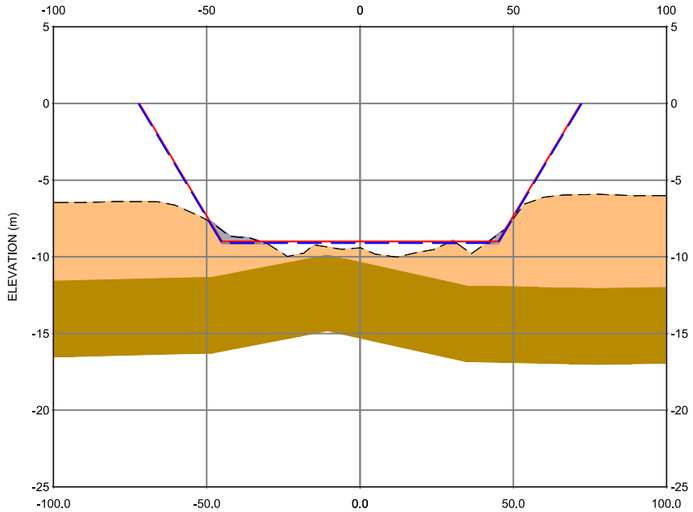

CH 22500.0

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

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-25
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 9

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	008	2	F011

25 mm
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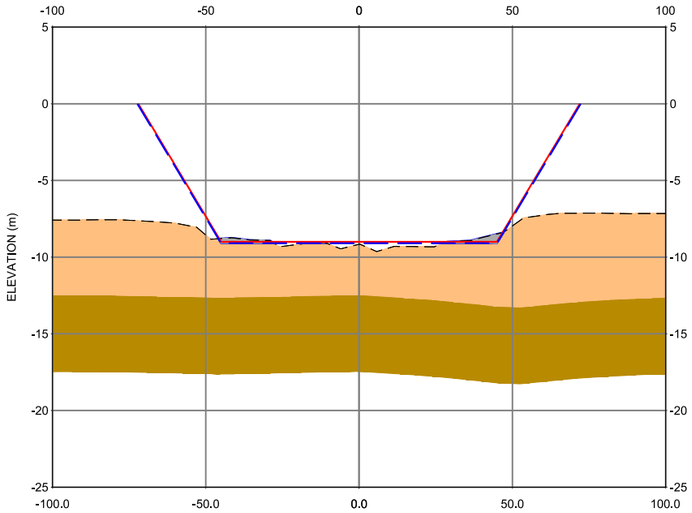

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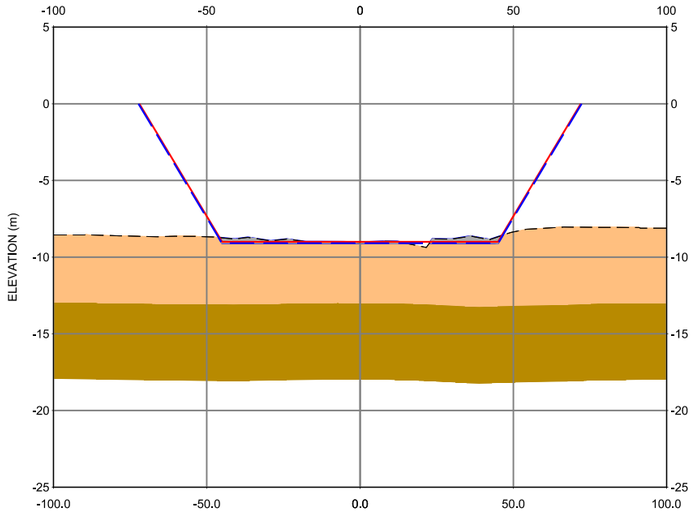

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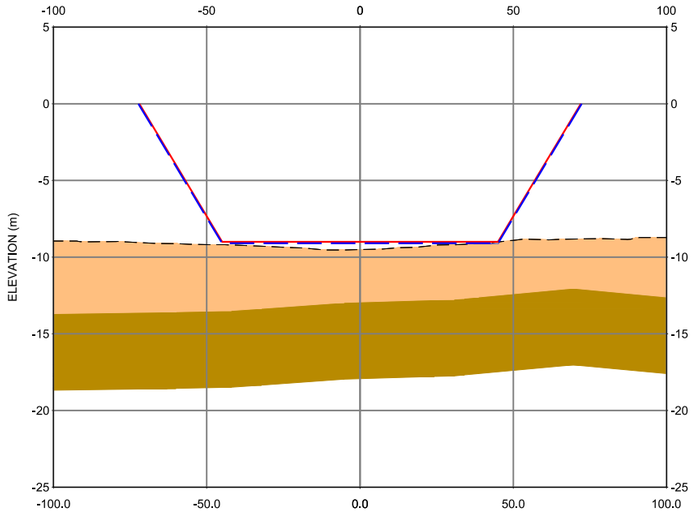

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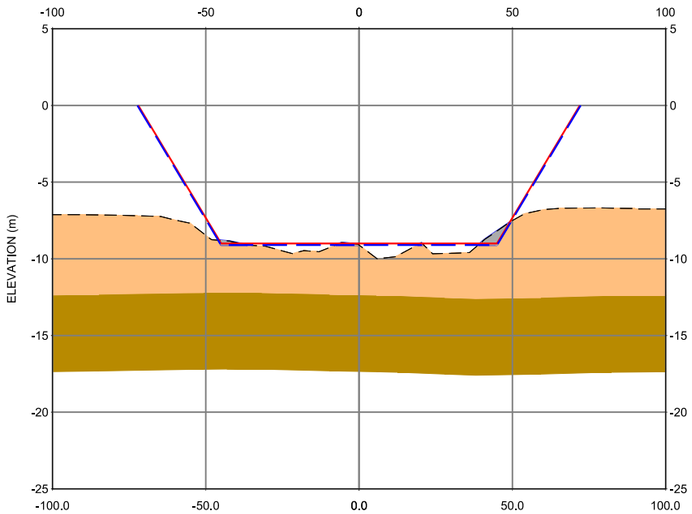

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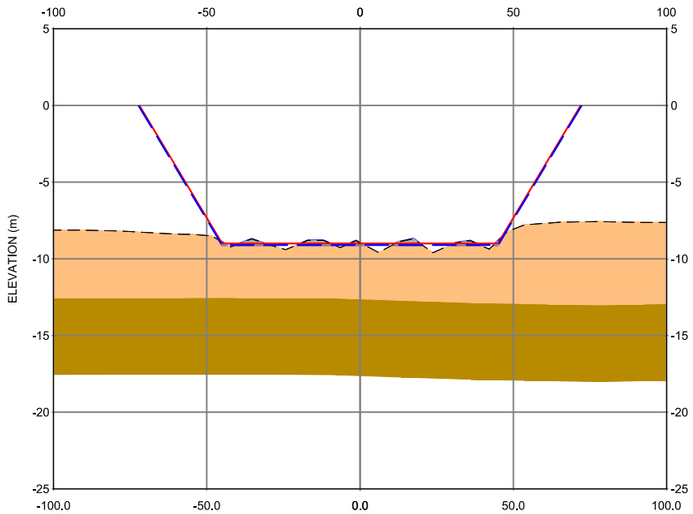

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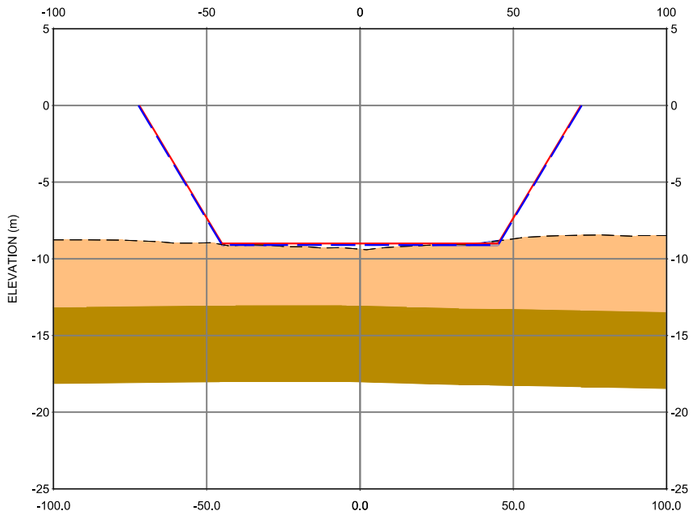

CH 24000.0

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

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-25
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 10

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	008	2	F012

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APPENDIX A

Important information relating to this report

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.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

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

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

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

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Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

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