16 October 2020

WRL Ref: WRL2020065 JTC LR20201016

Water Research Laboratory
School of Civil and Environmental Engineering

Catherine Knight
A/ Manager Coastal Management Unit
Crown Lands | Department of Planning, Industry and Environment
15 Regatta Avenue
Ballina NSW 2478

catherine.knight@crownland.nsw.gov.au

Dear Catherine,

Sand placement and geobag geometry for Clarkes Beach Café, Byron Bay

1. Introduction

With regard to recent discussions and emails with Principal Coastal Engineer James Carley, the Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering at UNSW Sydney is pleased to provide the following advice to DPIE. This advice supplements WRL's letter report dated 10 September 2020. Features and areas referred to in this letter are shown in Figure 1 and Figure 2.

Figure 1: Foreshore features (Image: Nearmap, 4 July 2020)

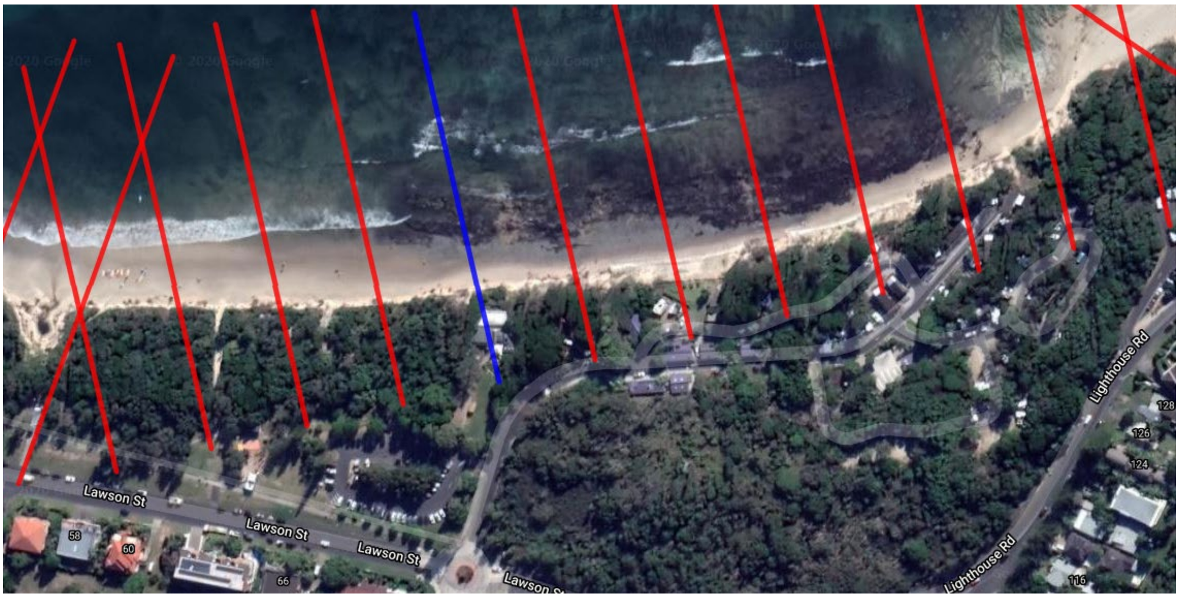
Figure 2: Geobag walls fronting Reflections Holiday Park (Photo: James Carley)

2. Sand-only protection

2.1 Sand-only profile

This section investigates the sand volumes required, if sand-only is placed in lieu of geobags. The following sand profiles are shown for the cross section in Figure 3:

- The required sand for geotechnical stability for the slope - this will require further confirmation by Ardill Payne if adopted (Figure 4)
- The required sand to restore the long term average accreted profile (Figure 5)



Block K, Profile 8 shown in blue

Figure 3: Close up of photogrammetry profiles near Clarkes Beach Cafe

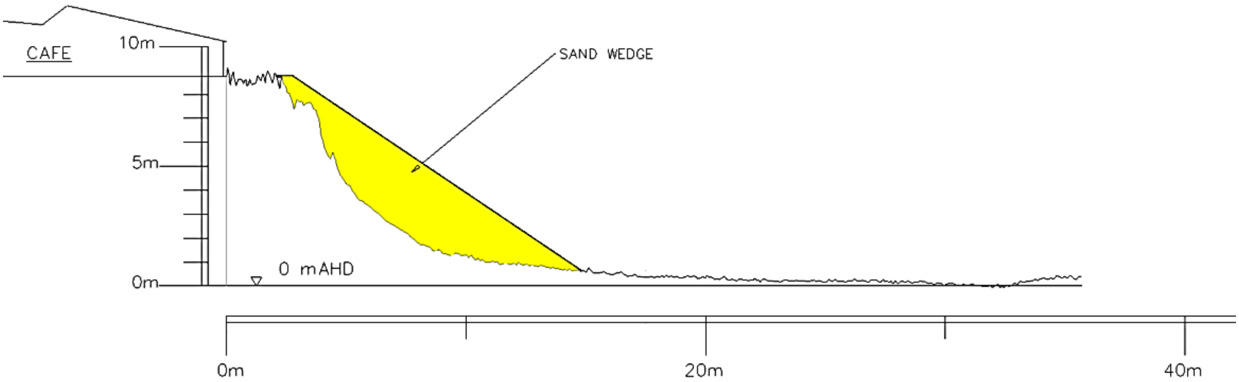


Figure 4: Sand profile required for geotechnical stability

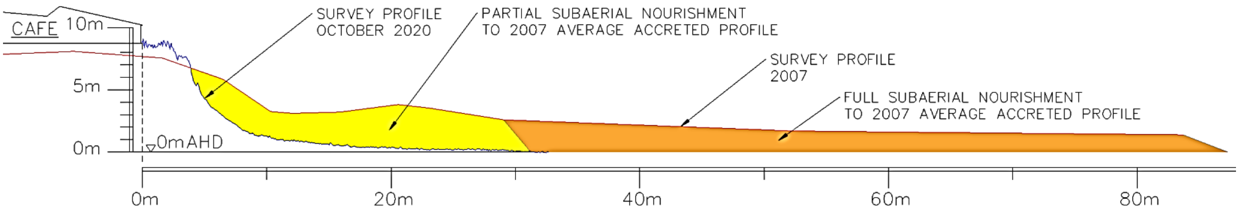


Figure 5: Sand profile required to restore 2007 profile

2.2 Sand volume

The sand volumes for these scenarios are as follows:

- Sand for geotechnical stability for the slope: 26.5 m^3/m x 90 m = 2,385 m^3, noting that this is primarily being driven by the north-western corner of the cafe
- Sand for to restore the long term average accreted profile: 72 to 170 m^3/m x 90 m = 6,480 to 15,300 m^3 (noting that this still does not include any underwater component or areas beyond the cafe

Both cases are for a single episode. The required replenishment frequency will depend on monitoring, and future waves and water levels, but a plausible frequency is fortnightly, that is, up to six (6) episodes may be required. This would also involve multiple truck movements and disruption to beach users.

The volume for the long term average is hypothetical only. This is because to fully accrete the profile would require sand to be placed out to approximately 10 m water depth and throughout the embayment. This volume would not be feasible through terrestrial quarries and trucking.

2.3 Sand sources

Sand from the following sources has been investigated:

- Dunloe Sand Quarry, Pottsville
- South Ballina Sand
- Ballina Sand and Gravel

The Dunloe sand quarry was used for the works fronting Reflections and is of acceptable composition. Based on parallel enquiries made by NSW Soil Conservation Service, Ballina Sand and Gravel presently has issues with potential acid sulfate soil. South Ballina Sand is more expensive than Dunloe. and hence Dunloe Sand is the preferred source.

Based on NSW Land and Environment Court order regarding Belongil, for Case number 40184 of 2010, dated 21 June 2011, the following sand specifications are recommended, with testing to Australian Standard AS1141.3.1 :

- Clay or silt content <2%
- Shell content <10%
- A colour similar to the existing beach
- Composed principally of silica-quartz

A suggested median grain size (D50) is 0.20 to 0.30 mm.

2.4 Sand costs

Sand cost would be \$60 per cubic metre, \$100 per tonne (ex GST) inclusive of the following:

- Supply from quarry
- Transport to site
- Placement on site

For a single episode, this would amount to:

- Sand for geotechnical stability for the slope: $143,000
- Sand to restore the long term average accreted profile: $389,000 to $918,000

For six episodes, this would amount to:

- Sand for geotechnical stability for the slope: $858,000
- Sand to restore the long term average accreted profile: $2,334,000 to $5,508,000

3. Geotechnical/structural engineering

WRL has liaised with Mr Bill Payne of Ardill Payne regarding geotechnical/structural engineering. The collapse of a beachfront building on sand is ultimately through a geotechnical failure mode (Figure 6).

Slope stability modelling by Ardill Payne for the following scenario is shown in Appendix A:

- Run 3 – Water table at toe due to tides (expected to be temporary), 5kPa surcharge at crest

Figure 6: Building collapse – Wamberal 1978

4. Hybrid structure of geobag wall with sand backfill

The geotechnical analysis indicates that the geobag wall needs to be located seaward of the existing escarpment to achieve geotechnical stability. Backfill is required for the geobags and additional sand is required to be placed on the steep areas of the slope (Section 9, Appendix A and Appendix B).

5. Risks and opportunities

5.1 Risks

5.1.1 Geobag option

The geobag design (Section 9) has reproduced the design fronting Reflections Holiday Park. This wall has prevailed without major damage for over 1 year, but neither the existing nor proposed structures have undergone rigorous design. This is justifiable due to the interim nature, but retention of the works for an extended time may result in damage and/or failure of the geobags.

The geobag option may cause additional end effect erosion if the beach remains eroded and the works remain in place (Section 6.3).

5.1.2 Sand-only option

A sand-only protection measure will be vulnerable to ongoing erosion if this trend prevails. Furthermore, there will be sand redistribution alongshore, even without a trend of future erosion/recession. The need for geotechnical stability means that ongoing replenishment is likely to be required. As stated above, up to six (6) episodes may be required, with associated truck movements and disruption to beach users.

Ongoing loss of recently placed sand may be perceived as wasteful and a project failure by some stakeholders.

5.1.3 Both options

There may be claims that the works (sand or geobags) alter surfing conditions.

5.2 Opportunities

5.2.1 Geobag option

The presence of geobags and sand backfill will improve alongshore pedestrian access and public beach space relative to the status quo. This option will also allow the removal of debris from the beach, reduce the risk of dead trees falling to the beach below and allow for the preservation of existing trees.

5.2.2 Both options

Sand and/or geobag works will allow the restoration of at least one pedestrian access point in the vicinity of the café – the condition of the present access point is shown in Figure 9.

The interim works, especially geobags, will allow time for a more comprehensive review of options for the café and Reflections.

6. Geometry (cross section and plan)

6.1 Cross section and plan

A cross section and plan of proposed geobags and backfill are shown in Appendix B. The alignment at the eastern end is determined by the need to tie in with the geobags fronting Reflections. The cross shore position fronting the café is largely determined by the geotechnical stability at the north-western corner of the café deck. A landward shift in geobag position can be undertaken in association with a landward retreat of part of the café deck.

The eastern extent is governed by the need to tie in with the geobags fronting Reflections. The western extent is governed by the need to extend beyond the café, return into the embankment and incorporate pedestrian beach access (Section 10).

The geobag works are proposed to be in place for up to 90 days. Due to this short design life, and the observed performance of the neighbouring Reflections geobags, no detailed coastal engineering calculations have been undertaken. The design has relied upon coastal engineering judgement and experience, including observation of the neighbouring and other geobag structures.

Therefore, the geobag design has replicated that used on the neighbouring Reflections site. This has remained without major damage for more than 1 year.

A double layer design is recommended for the following reasons:

- Failure has been found to occur rapidly in single layer designs (Coghlan et al, 2009)
- The project is likely to be in place for November, December 2020 and January 2021 – and therefore has a reasonable probability of encountering cyclonic conditions and king/spring tides
- Many structures of this type remain in place for longer than their initial design life, and for this project the 90 day life will be reached during the January 2021 holiday period

Any major gaps or discontinuities in the geobag structure would pose a risk of flanking failure of the remaining works, or unravelling of their ends, and therefore the works fronting Reflections and those of the café will comprise a single structure.

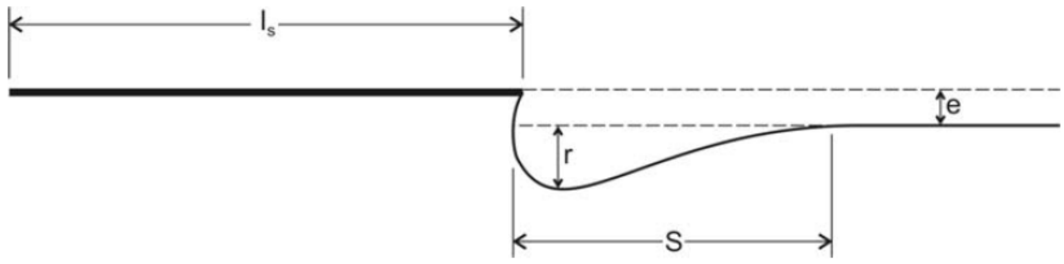
6.2 Quantities and costs

The following quantities and costs (ex GST) are estimated:

- Geobag number: ~600
- Geobag cost to supply, fill, transport and place: $450,000
- Sand backfill for geotechnical stability: 1,222 m^3, 1955 tonnes
- Sand backfill supply, transport, place: $195,000
- Sand ramp for pedestrian access: 100 m^3, 160 tonnes
- Sand ramp supply, transport, place: $16,000
- Total cost: $660,000

6.3 Seawall end effect

It is well accepted that seawalls have "end effects", that is, additional erosion where they terminate. The concept of end effect is illustrated in Figure 7 and Figure 8.



(Source: McDougal et al, 1987)

Figure 7: Seawall end effect

Gold Coast, 1967 (Source: Delft, 1970)

Figure 8: Example of seawall end effect

The classic work of McDougal et al (1987) estimated that the end effect distance (S) was 70% of the seawall length and the end effect additional depth (r) was 10% of the seawall length. While this work is one of the few studies available, it does not consider the seawall position on the active profile, nor the time required to reach the eroded planform.

The end effect estimates would hypothetically take years to eventuate, rather than the 90 day life for this project, however, the time to eventuate is dependent on waves and water levels, together with the movement of the nearby sand slug. If natural accretion occurs and the works become predominantly buried, no end effect will be observed from the works.

Additional more detailed calculations and/or modelling could be undertaken, but initial estimates of the long term end effect for the combined works fronting Reflections and the café are (noting that these are unlikely to eventuate over 90 days):

- Alongshore extent: 180 to 250 m (versus 750 m to Byron Bay SLSC)
- Excess landward erosion: 4 to 10 m (versus 50 m from the present scarp to the nearest carpark and 75 to 100 m from the scarp to Lawson Street)

As stated above, further detailed calculations and/or modelling would be needed to quantify the end effect and its temporal development, which is further complicated by the presence of bedrock, coffee rock, cobbles and exposed reefs.

7. Beach access

The present beach access point is not usable (October 2020) due to erosion (Figure 9). The NSW Government Manual of Coastal Dune Management (2001) recommends a maximum dune gradient for pedestrian access of 1V:4H (about 14°). An all ability access point further west is also presently unusable and will require further consideration. As per Appendix B, a cone of sand for pedestrian access can be placed at a gradient of 1V:4H from the existing access path to the top of the geobags and over the western face of the geobags.

Figure 9: Beach access point (Photo: Catherine Knight)

8. Summary

This letter has presented options for interim protection for the Clarkes Beach café. A sand-only option involves higher risk due to the sand not remaining where it is needed, high cost due to the need for monitoring and replenishment, and high disruption from trucks and machinery if/when replenishment is required.

A hybrid scheme involving geobags and sand backfill is presented in Appendix B. The cross shore alignment of the geobags is determined by the geotechnical stability of the north-western corner of the café. The alignment of the geobags could be more landward if the deck of the café was retreated landward. The eastern alongshore extent is governed by the need to tie in with the geobags fronting Reflections. The western extent is governed by the need to extend beyond the café, return into the embankment and incorporate pedestrian beach access. For this option, the global stability of the slope meets geotechnical engineering standards provided the geobags and backing sand remain intact, so the option provides lower overall risk.

Please contact James Carley should you require further information.

Yours sincerely,

Grantley Smith
Director, Industry Research

9. References and bibliography

BMT WBM (2013), Byron Shire Coastline Hazards Assessment Update, Final report for Byron Shire Council, September.

Carley, J. T., Shand, T. D., Mariani, A., and Cox, R. J. (2013), "Technical Advice to Support Guidelines for Assessing and Managing the Impacts of Long-Term Coastal Protection Works", Final Draft WRL Technical Report 2010/32.

Delft (1970), "Gold Coast, Queensland, Australia - Coastal Erosion and Related Problems". Report R 257, Delft Hydraulics Laboratory, The Netherlands.

Coghlan, I R, Carley J T, Cox, R J, Blacka, M J, Mariani, A, Restall, S, Hornsey, W P and Sheldrick, S (2009), "Two-Dimensional Physical Modelling of Sand Filled Geocontainers for Coastal Protection", Proceedings of Australasian Coasts and Ports Conference 2009, Wellington NZ, The Institution of Engineers Australia.

McDougal W. G., Sturtevant, M. A. and Komar, P. D. (1987), "Laboratory and Field Investigations of the Impact of Shoreline Stabilization Structures and Adjacent Properties. Proceedings of Coastal Sediments '87, ASCE, 962-973.

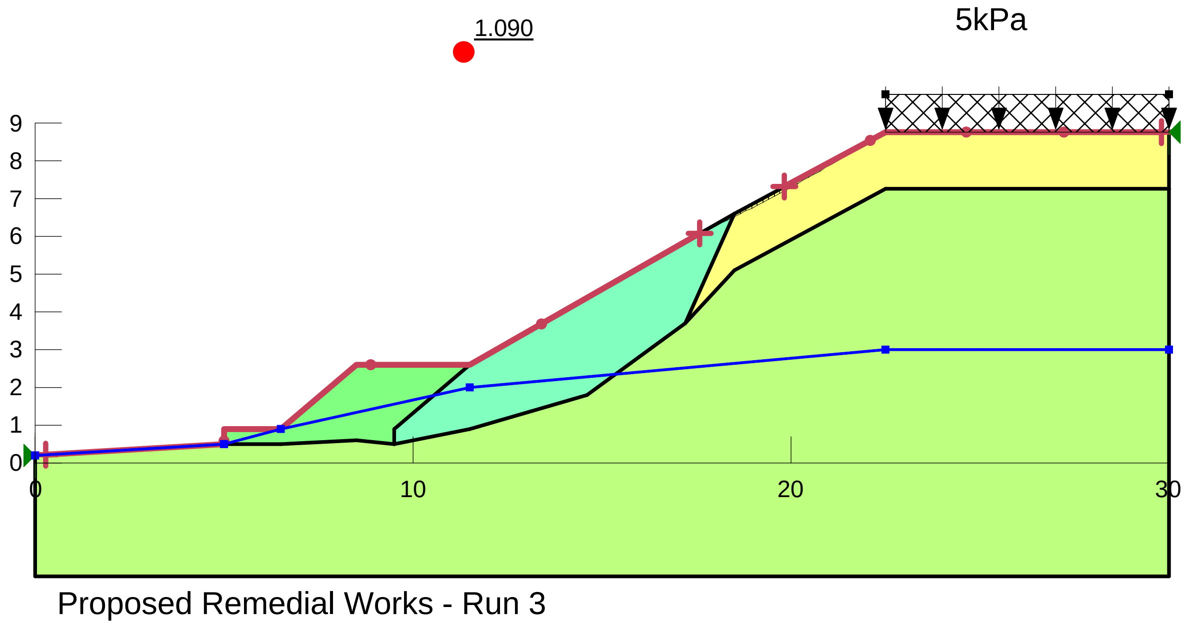
Nielsen, A. F., Lord, D. B. and Poulos, H. G. (1992), "Dune Stability Considerations for Building Foundations", Australian Civil Engineering Transactions, The Institution of Engineers, Australia, Volume CE34, Number 2, p. 167 – 174.

NSW Government (2001), Coastal dune management: a manual of coastal dune management and rehabilitation techniques, by R. Kidd Published 2001

Stephens, A. W., Roy, P. S. and Jones, M. R. (1981), "Model of Erosion on a Littoral Drift Coast", Proceedings of the Fifth Australian Conference on Coastal and Ocean Engineering, Perth. WA. pp. 171-6. Sydney: The Institute of Engineers. Australia.

Watson, P J (2020), "Updated Mean Sea-Level Analysis: Australia", Journal of Coastal Research
Coastal Education and Research Foundation (CERF), Coconut Creek, FL 33073, U.S.A. DOI: 10.2112/JCOASTRES-D-20-00026.1

APPENDIX A – Geotechnical analyses by Ardill Payne

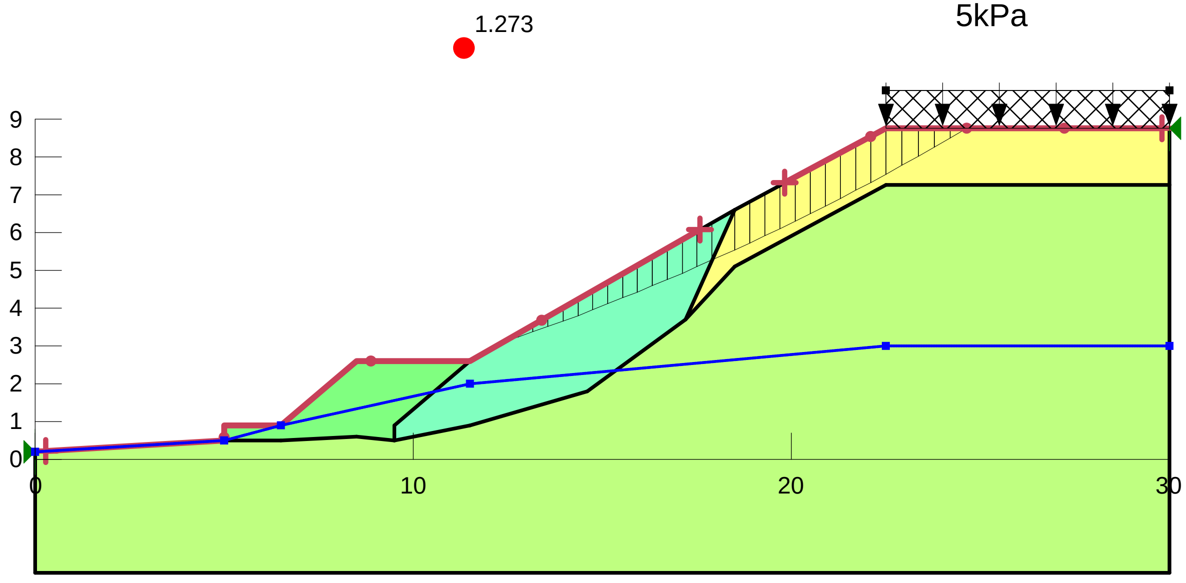


Name: Loose Sand
Model: Mohr-Coulomb
Unit Weight: 16 kN/m³
Cohesion': 0 kPa
Phi': 30 °
Phi-B: 0 °
Piezometric Line: 1

Name: Medium Dense Sand
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 0 kPa
Phi': 34 °
Phi-B: 0 °
Piezometric Line: 1

Name: Sand Bags
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 10 kPa
Phi': 34 °
Phi-B: 0 °
Piezometric Line: 1

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 0 kPa
Phi': 34 °
Phi-B: 0 °
Piezometric Line: 1



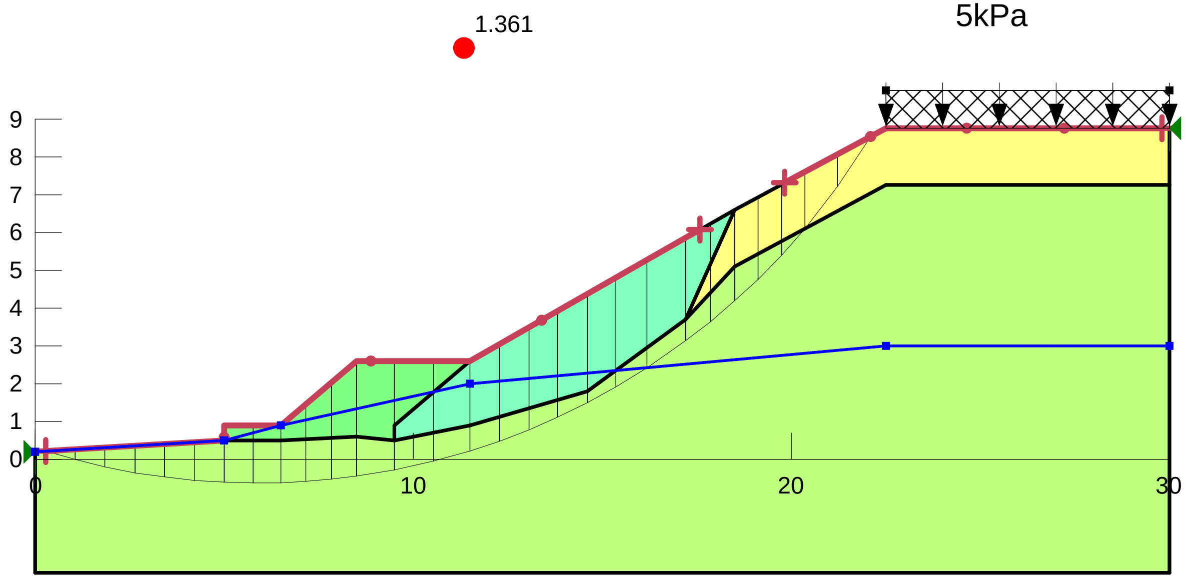
Name: Loose Sand
Model: Mohr-Coulomb
Unit Weight: 16 kN/m³
Cohesion': 0 kPa
Phi': 30 °
Phi-B: 0 °
Piezometric Line: 1

Name: Medium Dense Sand
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 0 kPa
Phi': 34 °
Phi-B: 0 °
Piezometric Line: 1

Name: Sand Bags
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 10 kPa
Phi': 34 °
Phi-B: 0 °
Piezometric Line: 1

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 0 kPa
Phi': 34 °
Phi-B: 0 °
Piezometric Line: 1

Proposed Remedial Works - Run 3



Proposed Remedial Works - Run 3

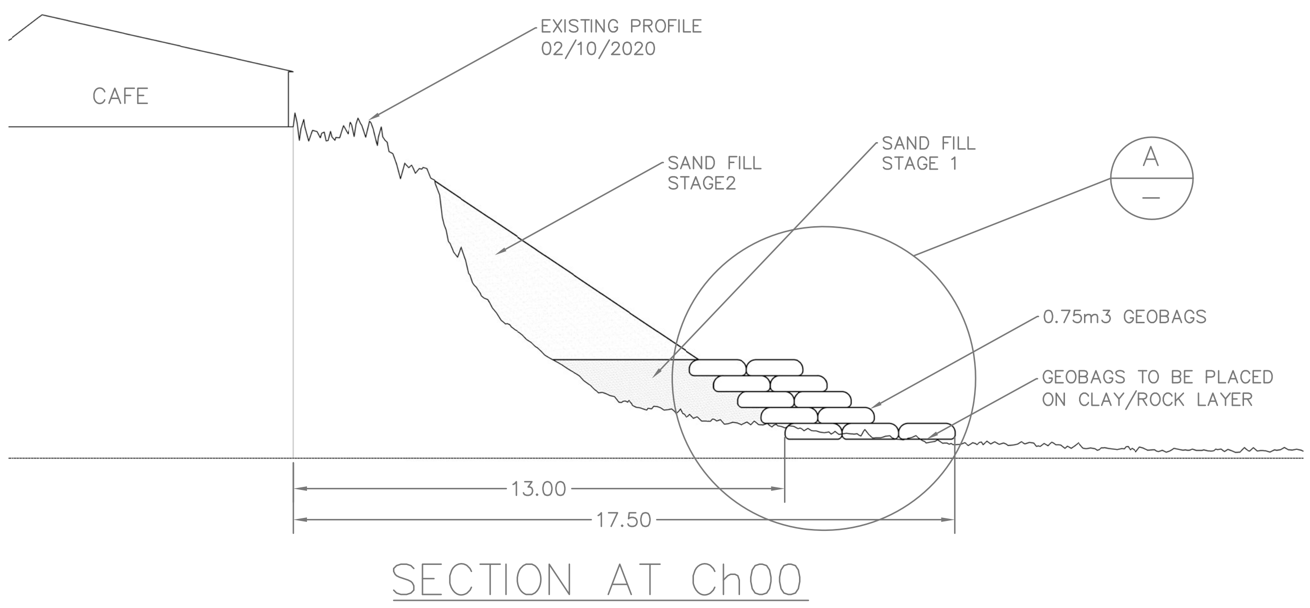
Name: Loose Sand
Model: Mohr-Coulomb
Unit Weight: 16 kN/m³
Cohesion': 0 kPa
Phi': 30 °
Phi-B: 0 °
Piezometric Line: 1

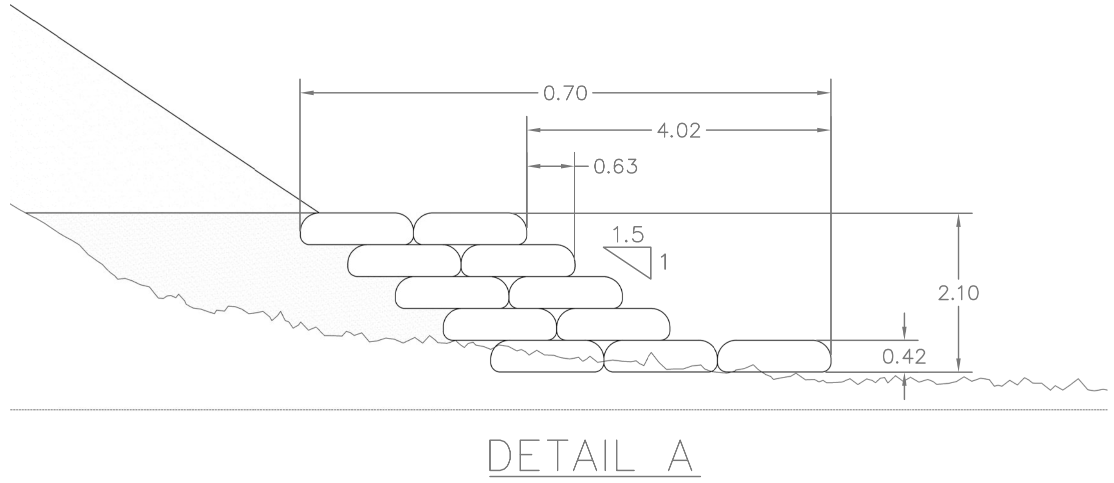
Name: Medium Dense Sand
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 0 kPa
Phi': 34 °
Phi-B: 0 °
Piezometric Line: 1

Name: Sand Bags
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 10 kPa
Phi': 34 °
Phi-B: 0 °
Piezometric Line: 1

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion': 0 kPa
Phi': 34 °
Phi-B: 0 °
Piezometric Line: 1

APPENDIX B – Geometry and cross section

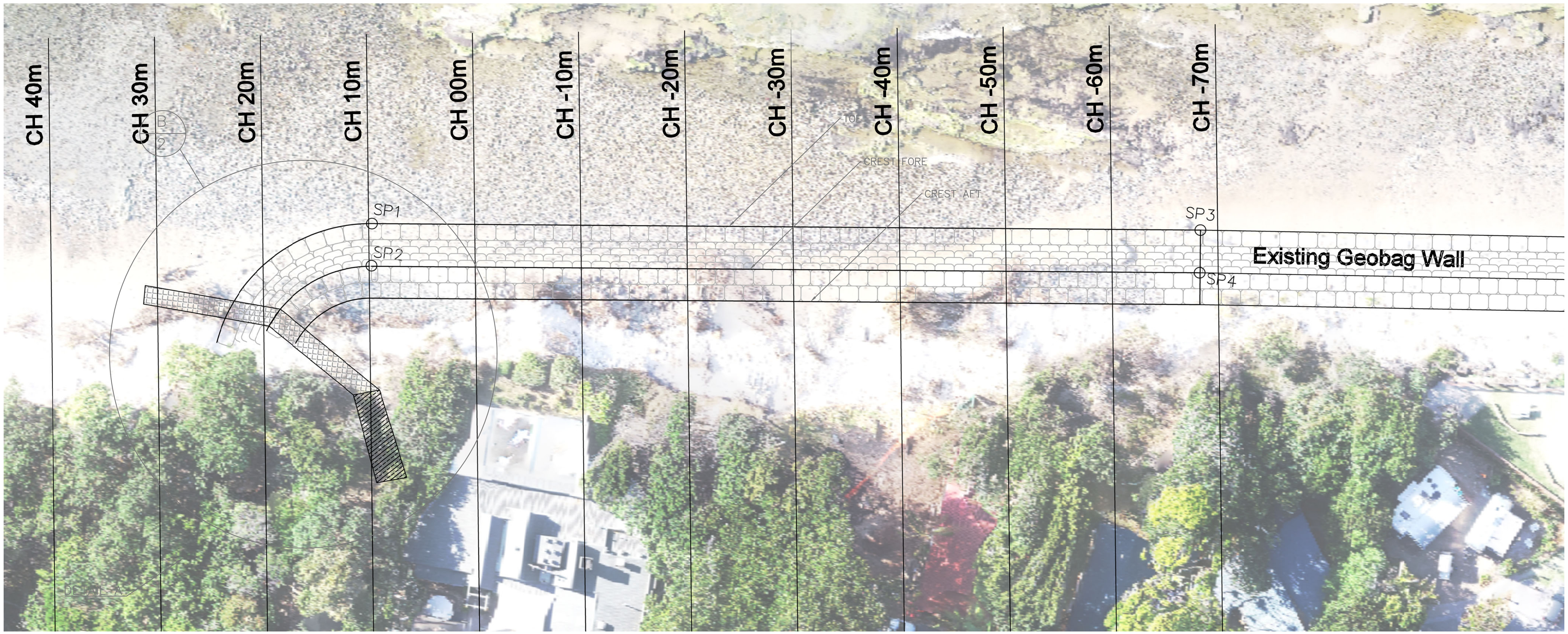




NOTES:
1. ALL DIMENSIONS IN METRES.
2. TIE IN WITH EXISTING REFLECTIONS GEOBAG WALL AND MAKE GOOD.
3. CREST LEVEL OF NEW WORKS TO APPROXIMATE THOSE OF THE EXISTING REFLECTIONS GEOBAGS.
4. REMOVE COBBLES AND LOOSE ROCK FROM GEOBAG FOOTPRINT PRIOR TO PLACING GEOBAGS.
5. INCLUDE GETEXTILE UNDERLAYER IN ACCORDANCE WITH GEOFABRICS AUSTRALASIA GUIDELINES.
6. COMPACT SAND BACKFILL BEHIND GEOBAGS.
7. PEDESTRIAN ACCESS RAMP FROM EXISTING PATH TO MEET TOP OF GEOBAG WALL WITH MAX SLOPE 1V: 4H
8. PEDESTRIAN ACCESS PATH FROM TOP OF GEOBAG WALL TO BEACH WITH MAX SLOPE 1V: 4H

SETOUT

POINT	EASTING	NORTHING
SP1	560812.67	6831479.92
SP2	560813.08	6831475.97
SP3	560890.30	6831488.34
SP4	560890.70	6831484.35



Rev.	Date	Description	Approval
r1	14/10/2020	PRELIMINARY GEOMETRY	JTC
r0	09/10/2020	PRELIMINARY GEOMETRY	JTC

JTC

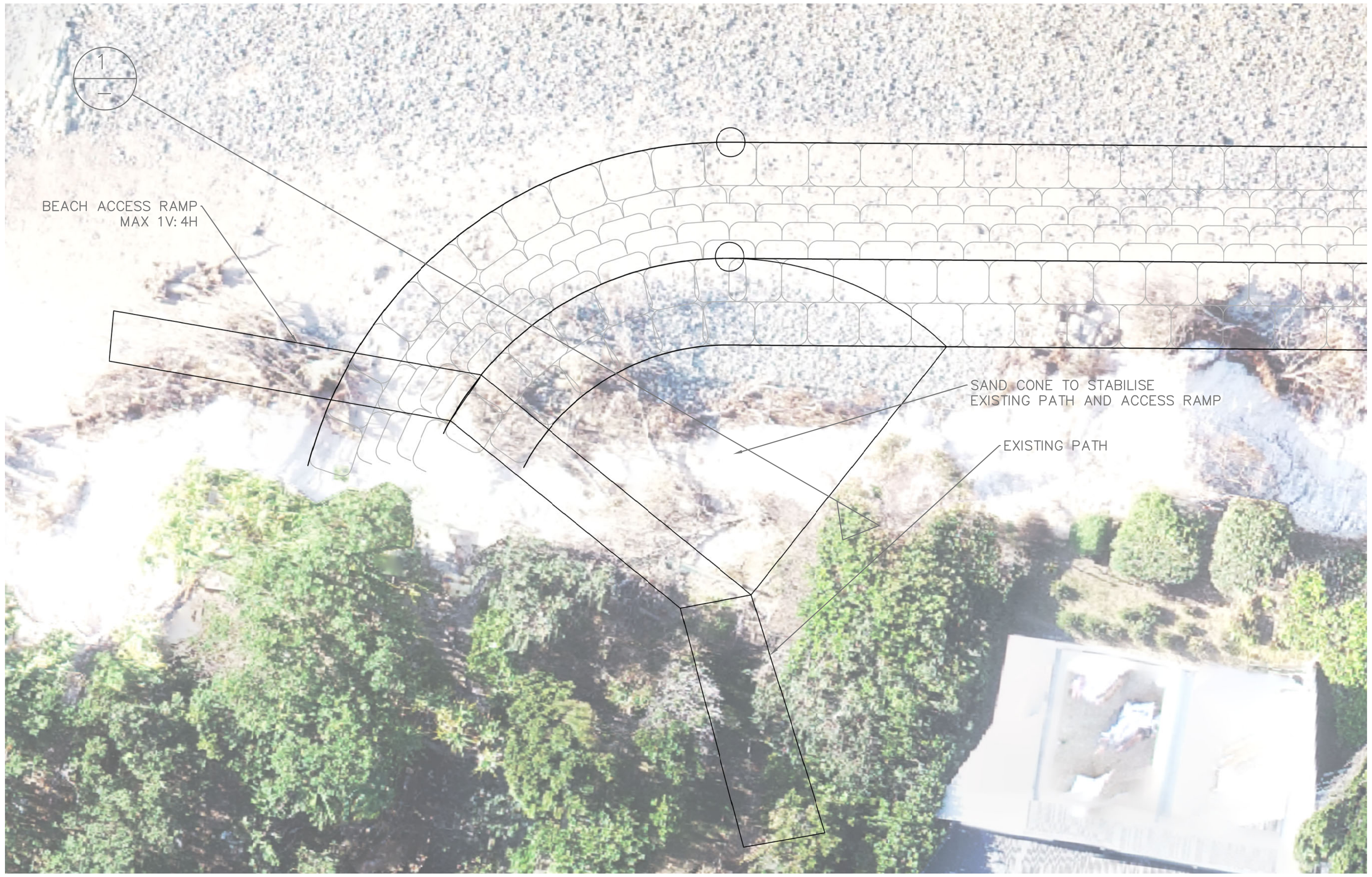
UNSW SYDNEY
WATER RESEARCH LABORATORY

CLARKES BEACH
INTERIM GEOBAGS
Scale

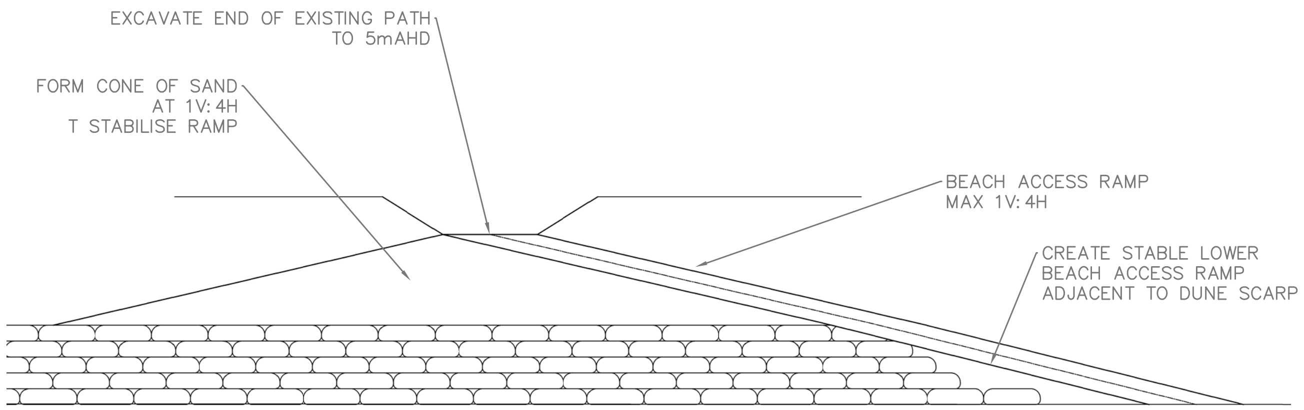
Drawn: BDM
Surveyed: Bluecoast
Coordinate System: GDA2020/MGA Z56
Origin of Levels: N/A
File Path/Name:

CLARKES BEACH INTERIM GEOBAGS
CONCEPT GEOMETRY
0.75m3 GEOBAG OPTION

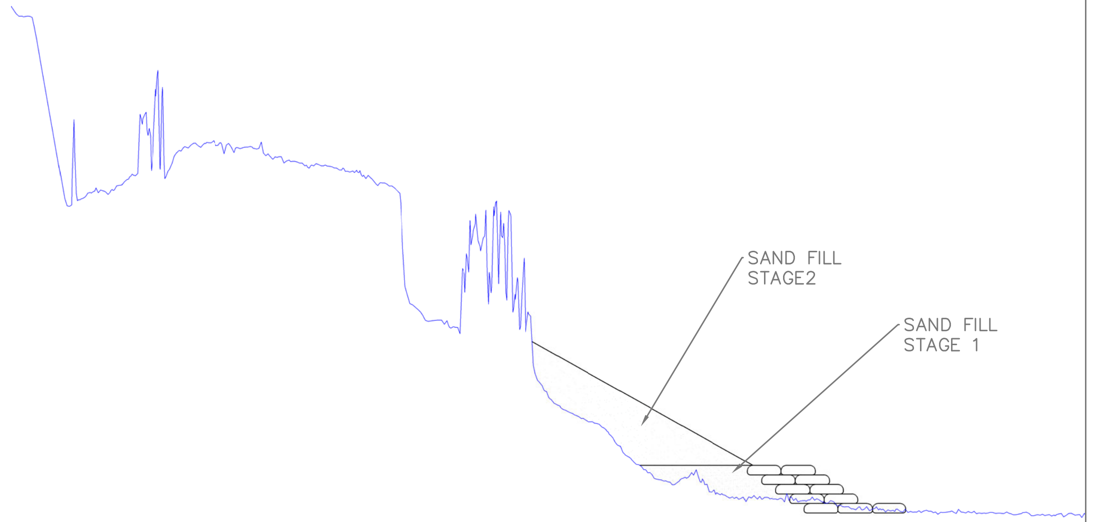
Date Created: 14/10/2020
Drawing Number:
Sheet 1 of 2
Revision: 1



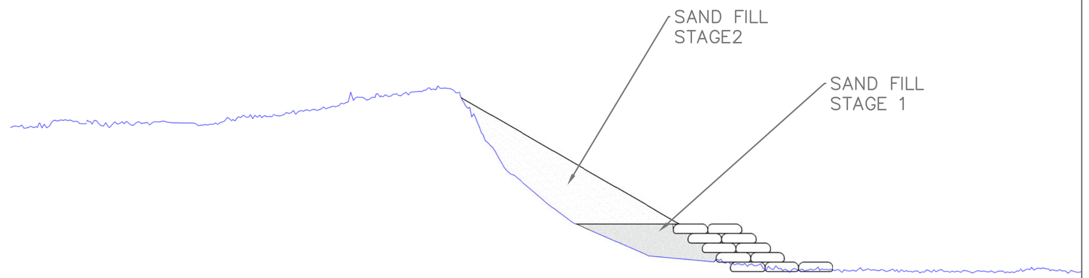
DETAIL B
WESTERN END AND PATH DETAIL



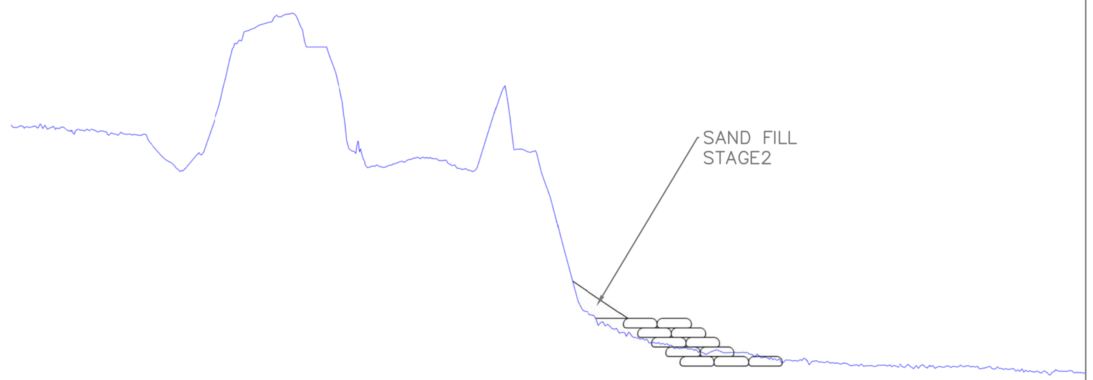
SECTION 1
WESTERN END DETAIL



SECTION AT Ch-20



SECTION AT Ch-40



SECTION AT Ch-60

Rev.	Date	Description	Approval
r1	14/10/2020	PRELIMINARY GEOMETRY	JTC
r0	09/10/2020	PRELIMINARY GEOMETRY	JTC

JTC

UNSW SYDNEY
WATER RESEARCH LABORATORY

CLARKES BEACH
INTERIM GEOBAGS

Scale

Drawn:	BDM
Surveyed:	Bluecoast
Coordinate System:	GDA2020/MGA Z56
Origin of Levels:	N/A
File Path/Name:	

CLARKES BEACH INTERIM GEOBAGS
DETAIL
0.75m3 GEOBAG OPTION

Date Created:	14/10/2020	Drawing Number:	
		Sheet 2 of 2	Revision: 1