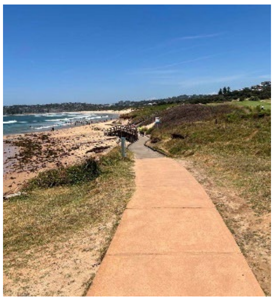
northern beaches council

Options and Feasibility Report Long Reef Boardwalk & Bridge Replacement



Prepared for Northern Beaches Council by:
Thompson Berrill Landscape Design Pty Ltd

Revision No:	Date:	Prepared by:	Reviewed by:
V1	22 Dec 2022	Andrew Zouroudis & Ashley Yan	Glenn Berrill
V2	14 Feb 2023	Andrew Zouroudis & Ashley Yan	Glenn Berrill
V3	18 April 2023	Andrew Zouroudis & Ashley Yan	Glenn Berrill

EXECUTIVE SUMMARY

Thompson Berrill Landscape Design Pty Ltd (TBLD) was engaged by Northern Beaches Council (NBC) in September 2022 to undertake an Options and Feasibility Report to assess the feasibility of the Long Reef Boardwalk and Bridge replacement, adjacent to the Long Reef Golf Club.

The Long Reef Boardwalk and Bridge is a part of Long Reef Headland loop track. The proposed boardwalk and bridge will replace the old boardwalk and bridge, which is near the end of its useful life.

The primary objectives of this Feasibility Report are to:

1. Outline issues and opportunities (environment, recreational experience, public safety, materials, constructability, etc.) of the proposed Long Reef boardwalk & bridge; and
2. Determine a feasible trail alignment, concept and construction methodology to guide Concept Design.

The Options and Feasibility Report investigations involved consideration of alignment alternatives, background information, and information from technical consultants including terrestrial ecologists, coastal engineers, Aboriginal Heritage Office (AHO) officers and geotechnical engineers.

In summary, this report recommends Option 2 ‘Reposition Boardwalk Further North’ is the most feasible and viable option for the replacement of the Long Reef boardwalk and bridge.

It is considered to be the preferred option as it is situated higher, further from the wave impact zone, and presents less public risk as it may assist in protecting people from golf ball strikes, as outlined in section 3.2 of this report.

Option 2 is also the preferred option as public walkers are able to utilise the existing boardwalk during the construction period (reducing impacts on the golf club), delivers improved long term separation from the golf course (continuous planted dunes provide visual and physical separation), provides reduced structure swell damage risk (less potential of walkway being overtopped by waves), and is considered to be the best solution for the proposed Long Reef boardwalk and bridge.

TABLE OF CONTENTS

APPENDICES

A Concept Design Plan and Typical Section (by TBLD Pty Ltd)

B Wave Runup on Long Reef Walkway Report (by NSW Water Research Laboratory)

C Long Reef Foreshore Boardwalk & Bridge Options Report (by Northern Beaches Council)

D Geotechnical Investigations Report (by Alliance Geotechnical Pty Ltd)

E Aboriginal Heritage Site Re-recording Form (by Aboriginal Heritage Office)

F Structural Engineer Advice Memo (by Woolacotts Consulting Engineers)

G Opinion of Probable Costs for Option 1 and Option 2 (by MDA Australia)

1. INTRODUCTION

1.1 Introduction

Long Reef is located within the Northern Beaches Council Local Government Area on the Northern Beaches of Sydney. The site is located in Griffith Park, Collaroy and is bounded by Long Reef Golf Club to the north, Long Reef Headland to the east and Long Reef Beach and the ocean to the south. The Long Reef Headland loop track is a 3km coastal loop and is subjected to a high volume of use by the community. This boardwalk and bridge section is situated between Long Reef Golf Club and Long Reef Beach. In August 2021, unusually large ocean swells caused significant structural damage to the lower section of the foreshore boardwalk at Long Reef headland. The boardwalk was repaired by council in late August 2021 to ensure that it was serviceable for the short term (9 -12 months). The structure is now reaching the end of its useful life.

The approximately 120m long existing boardwalk and timber bridge are directly impacted by coastal influences (including extreme southerly wind and wave processes), affecting the structural integrity of the existing and future replacement boardwalk and bridge. Due to the recent damage to the boardwalk, council determined it was worthwhile to consider alternate renewal responses besides replacing like-for-like (including alternative alignments and materials), to better future proof the asset and service provision.

Landscape Architectural consultants Thompson Berrill Landscape Design Pty Ltd (TBLD), and a team of specialist technical consultants were engaged in September 2022 to undertake initial site investigations and options assessment, to assist Council in determining a preferred preliminary concept design for replacement of the Long Reef Boardwalk and Bridge. TBLD were selected due to their previous experience successfully delivering a range of boardwalks in extreme environment conditions and significant sites.

1.2 Key Users of the Boardwalk

The boardwalk and bridge are frequently used by the local community as they walk around the Long Reef Headland loop track. In addition, key users of Griffith Park for water and land based activities are as follows.

Key water-based user groups identified include:

- Long Reef Surf Life Saving Club
- Surfers / kite-borders / swimmers
- Recreational anglers
- Coastal Education Centre and Community Centre activities (Reefcare Long Reef)

Key land-based key user groups identified include:

- Golf (Long Reef Golf Club)
- Walking / strolling / jogging
- Dog training / dog walking
- Organised sport such as Rugby Union and Cricket

It is Northern Beaches Council's intention that all users of the walkway will benefit from an improved asset design.

2. METHODOLOGY

2.1 Background Information

In 2022, Northern Beaches Council identified the requirement to replace the Long Reef Boardwalk and Bridge given the repaired boardwalk is reaching the end of its useful life. Council prepared the Long Reef Foreshore Boardwalk Bridge Options Report (refer Appendix C), with five potential boardwalk alignment and options identified. Following engagement of TBLD, the five potential options were discussed between Northern Beaches Council and TBLD, and two preferred options were short-listed and determined to be viable and worthy of further exploration in this Options and Feasibility report.

2.2 Process

In April 2022, UNSW Water Research Laboratory were engaged by Northern Beaches Council to provide coastal engineering advice on the site. The Wave Runup Report (following a site visit and using desktop assessment techniques) identified that the existing walkway is at risk of being impacted by wave runup for a number of design average recurrence interval (ARI) events. The design life of a replacement walkway for Long Reef Beach if it was to be retained in the same location as the existing structure, will likely be approximately 20 years.

In June 2022, Alliance Geotechnical Pty Ltd were engaged by Council to undertake a site investigation and provide recommendations on the geotechnical requirements for the replacement of the existing boardwalk and footbridge at Long Reef Beach.

Council has received preliminary advice from the Aboriginal Heritage Office that remnants of Aboriginal middens are located in the vicinity of the existing boardwalk. The advice also noted that the recent storms events has significantly diminished the middens. Council is in the process of undertaking additional heritage investigations (Aboriginal Cultural Heritage Assessment and AHIP), which is expected to be finalised in late 2023. The presence of these middens, and findings from the additional heritage investigations, may impact on the design and construction methodology of the preferred option.

Landscape Architectural consultants (Thompson Berrill Landscape Design) were engaged in September 2022 to undertake a site investigation and options and feasibility report to assist council determine an appropriate design response to the site conditions. This process involved site investigations and discussions with council officers on site, followed by detailed assessment by TBLD of site conditions, review of background information and development of a Preliminary Concept Design Options report in consultation with technical subconsultants and internal Council departments. The outcomes of the processes contained in this Report will be used to determine the preferred Long Reef Boardwalk alignment.

Initial site assessment by TBLD’s subconsultant ecologists GIS Ecological, and subsequent discussions between TBLD and GIS provided a greater understanding of the environmental and heritage issues and values to be considered in determining the two options to be explored and assessed in this report.

3. CONCEPT DESIGN DEVELOPMENT

3.1 Existing Site Conditions

The layout of the existing boardwalk and bridge through this 120m section of the highly-used Long Reef Headland loop track presents a risk to the public sustainability of the asset. The risks are summarised below.

3.1.1 Golf Ball Strike Risk

The boardwalk is located next to Long Reef Golf Club. Two golf tees are located approx. 8 - 10m northwards of the boardwalk (refer Figure 1). There is no fence or barrier between the golf tees and existing boardwalk, with a resultant potential risk of walkers being hit by stray golf balls. While council confirmed they do not have a record of a golf ball strike on this site, a mis-hit golf ball strike could occur. Golf ball strike risk is currently managed by council with advisory measures only (i.e. limited advisory warning signage for walkers to be aware of golf ball activity) which offer some level of protection to coastal walkers in proximity to golfers using the Long Reef Golf Club course. Council's intention is to consider opportunities as part of the boardwalk replacement to reduce golf ball strike risk if possible.

Figure 1: Golf tees close to trail

3.1.2 Coastal Erosion

Long Reef beach is subject to significant instability and coastal erosion. Natural coastal processes have recently resulted in significant weathering and erosion of soft rocks, soils and sand dunes on Long Reef headland. Many of the steeper areas are actively eroding with the subsequent loss of remnant vegetation (refer Figure 2).

Figure 2: Sand track in dune

3.1.3 Wave Impact

According to the wave runup report, Long Reef Beach is characterised by a moderate to high energy wave climate (typically, offshore generated swell) with some protection offered from swell waves from a number of shallow rocky reefs located directly offshore from the northern end of Long Reef Beach.

The boardwalk was damaged during a storm on 24 - 25 August 2021. The boardwalk deck level was assessed to be an elevation of approximately 3.6m AHD along the damaged area. On 1 - 2 April 2022, a large storm event caused wave runup to again impact the Long Reef walkway. In its current cross-shore location and current vertical elevation, the Long Reef walkway deck is at risk of being impacted by wave runup for storm events of 1 year ARI and larger when the beach is in an eroded state.

3.1.4 Falls from Height

There is potential risk of people falling from the boardwalk and bridge. Balustrades have been installed at areas where the deck level to natural surface is over 1m. On the bridge, from deck level to natural surface is about 2.5m. On the boardwalk the maximum northern side height of boardwalk from deck level to natural surface is about 1.6m. Pedestrians have the potential of get through the gaps between rails and may fall from height.

3.2 Consideration of Options

TBLD, in conjunction with Northern Beaches Council officers, undertook a detailed site investigation and analysis to discuss and assess the physical, functional, environmental, and visual qualities of the site. Careful consideration of the Wave Runup report by UNSW Water Research Laboratory, the Geotechnical report by Alliance Geotechnical Pty Ltd, and the feature survey by Byrne & Associates, informed the feasibility and concept design process. Council and TBLD agreed to explore two feasible options.

3.2.1 Option 1: Renew in Current Location

The existing boardwalk does not provide the required capacity to cater for the volume of use that this popular loop track is subjected to, due to its constrained width. The new boardwalk would need to be widened to 2m, which allows for two wheelchairs/strollers to pass by one another comfortably. For Option 1, the existing boardwalk would need to be demolished and removed, then re-built in the current location, which does not provide an alternative pedestrian access route during the construction period (likely leading to impacts on the golf course as walkers seek an alternative coastal walking route, and increased risk to the public from ball strike).

Renewing the boardwalk in its current location would require barriers along the entire beach side of the structure, as the boardwalk is positioned at an increased height above the adjacent ground levels (due to erosion of the adjacent sand).

Renewing the bridge and boardwalk in the current location would require extensive and deep footings, and very strong subfloor structure and decking in order for the structure to be protected against coastal erosion, wave impact and wave uplift. The structure would continue to be at risk of ongoing swell damage.

In its current location and current vertical elevation, the walkway deck is at risk of being impacted by wave runup for storm events of 1 year ARI and larger when the beach is in an eroded state. The lowest point of boardwalk and bridge would be 3.58m AHD.

The preferred material for new boardwalk design is mini-mesh FRP, with hardwood timber posts (driven piles), subfloor, balustrades and kickrails to visually soften the structure. The mini-mesh deck, by virtue of the smaller 13mm grid openings, whilst less susceptible than solid decking, would present significant resistance to wave runup uplift forces and would therefore be subject to storm and wave damage.

The existing boardwalk access to the beach would be removed, and a new pedestrian beach access would be provided to the western side of the boardwalk in the location of an existing access track. Construction of new pedestrian beach access would require a new ramp at top and installation of a board and chain walkway to the sand level, and large sandstone log stairs at base. The adjacent dune face would be retained with driven WPC piles and boards. This would be a low-cost access solution which could be easily repaired and adjusted to suit the shifting nature of the dune and foreshore environment.

In conjunction with the boardwalk replacement, a heavy sandstone rock revetment along the beach side of boardwalk would be constructed to protect the dune, the clay bench and assets from future wave damage. This would apply to both option 1 and 2.

Figure 3: Option 1 renew in current location

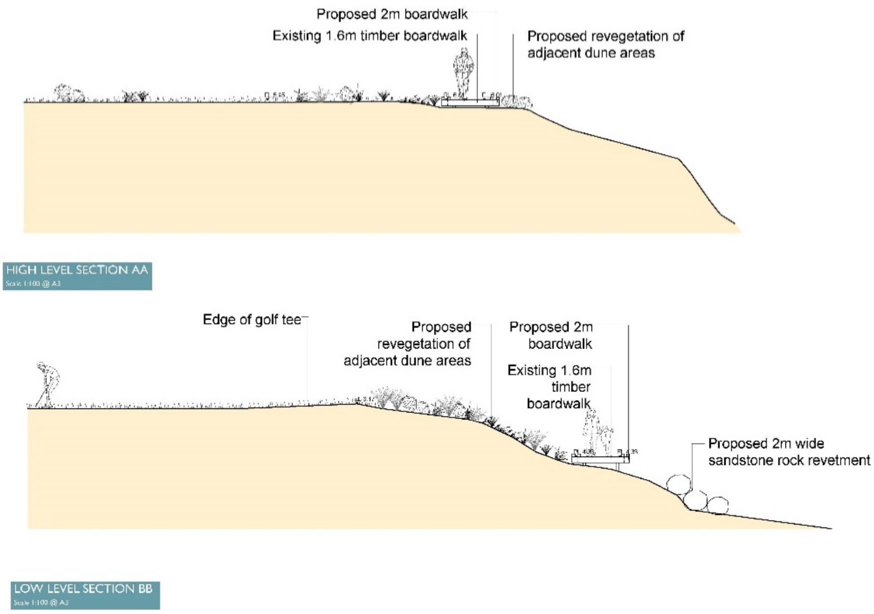


Figure 4: Option 1 renew in current location section AA and BB

Option 1 Advantages

1. New boardwalk and bridge built on established route, i.e. minimal impact on existing ecological and heritage fabric.
2. Minimal impact on surrounding coastal vegetation.
3. Alignment within council managed reserve.
4. Retains similar level of pedestrian protection from errant golf balls.
5. Retains access to/from beach.

Option 1 Disadvantages

1. Susceptible to swell damage – the deck is at risk of being impacted by wave runup for storm events of 1 year ARI and larger when the beach is in an eroded state.
2. Renewal will require major coastal engineering review and design (additional expense).
3. Rebuild cost would be high due to the requirement to resist wave runup impacts.
4. No pedestrian access along coastal walk during construction, which would likely impact golf course from informal public pedestrian use.

3.2.2 Option 2: Reposition Boardwalk Further North

The existing boardwalk does not provide the required capacity to cater for the volume of use that this popular loop track is subjected to, due to its constrained width. The new boardwalk would need to be widened to 2m, which allows for two wheelchairs/strollers to pass by one another comfortably.

The Option 2 boardwalk would be repositioned further north up the dune face and located further away and above wave impacts. The previously damaged boardwalk area is at approximately 3.6m AHD, whilst this proposed alignment would be at 5.5m AHD. The eastern end of the new boardwalk would end at 6.3m AHD. This would reduce the potential of boardwalk being overtopped by waves. In the wave runup report for 20 ARI, the calculated Rmax is 6.3m AHD and, the calculated R2% wave runup levels is 5.5m AHD. The 20 ARI has been adopted as the commencement level where the boardwalk deviates from the existing path. The lowest point of the Option 2 boardwalk and bridge would be 5.5m AHD.

The new bridge would be a free-span, aluminium off-shelf type pedestrian access only bridge, repositioned 1m further north of the existing bridge footprint. This allows public walkers to walk on the existing boardwalk and bridge during the construction period, lessening the impact on the community and on the golf course from people walking on the course. The deck level of the new bridge would be 5.5m AHD (raised from the existing deck level of 4.56m AHD), which reduces the potential of the bridge being overtopped by waves.

A new continuous and planted sand mound would be constructed north of the new boardwalk and up to edge of golf course. The difference in height from the top of the new dune to new boardwalk deck level would be a minimum of 2m, which would assist to reduce golf ball strike by virtue of the solid dune acting as a barrier to ball movements. Increasing the dune crest to 1.5m - 2.0m high may also reduce the potential of waves overtopping of the dune. In the wave runup report, for 100 ARI, the estimated Rmax is 6.5m AHD.

For Option 2 the two existing adjacent golf tees would need to move approximately 2m north to create sufficient space for construction of the dune which will facilitate construction of the dune shape and may reduce the potential for golf ball strike. In addition, the footpath in the golf course would need to be realigned to match the new tee location. There is little impediment to moving the tees 2m to the north as the current adjacent area is grass, and the proposed shift of 2m does not appear to impact on the course alignment.

The preferred material for the new boardwalk design is mini-mesh FRP, with hardwood timber posts (driven piles), subfloor, balustrades and kickrails. The materials are selected for maximum durability, and to visually soften the structure in the dune environs.

New pedestrian beach access is same as Option 1. It would be reconstructed on the alignment of the existing beach side access ramp at the start of boardwalk.

In conjunction with the boardwalk replacement, a heavy sandstone rock revetment along the beach side of boardwalk would be constructed to protect the dune, the clay bench and assets from future wave damage. This would apply to both option 1 and 2.

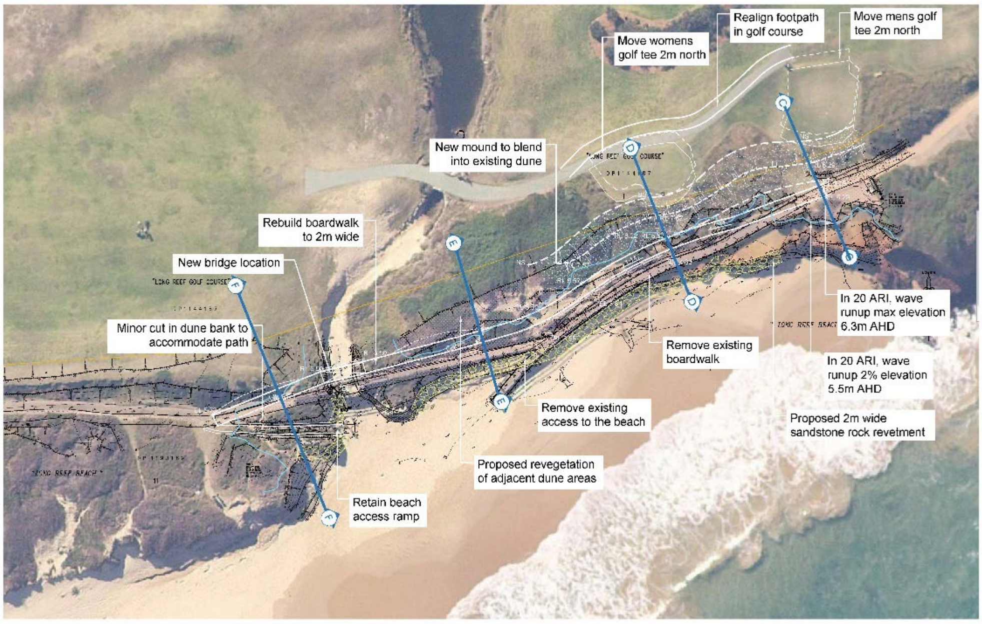


Figure 5: Option 2 reposition boardwalk further north

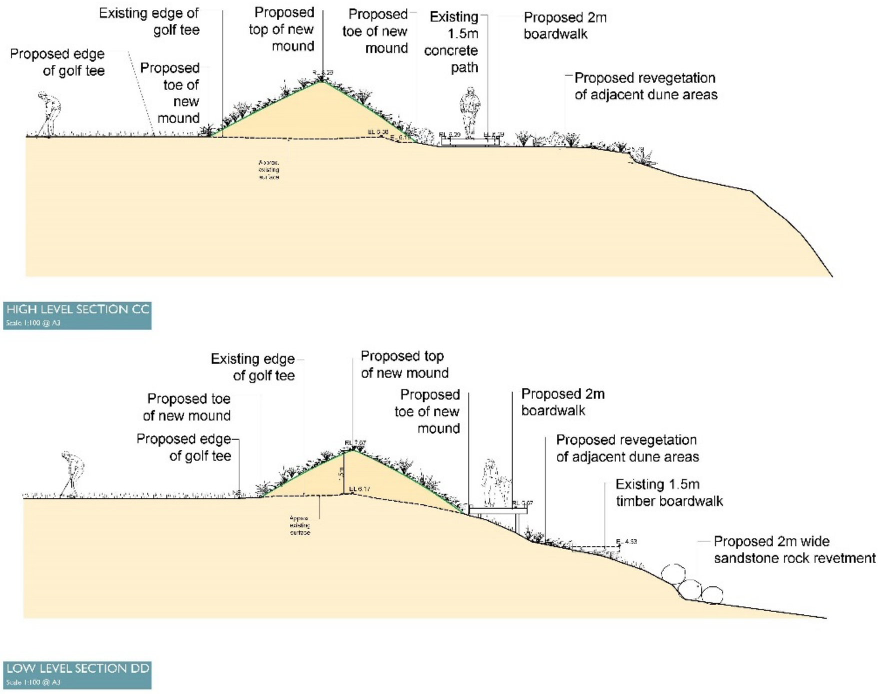
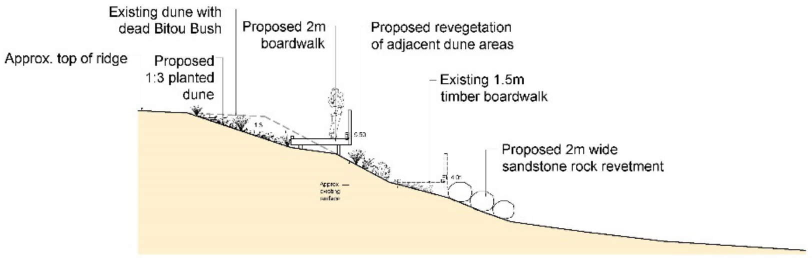
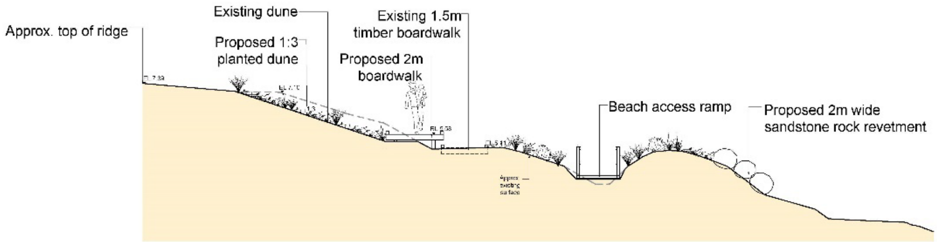


Figure 6: Option 2 reposition boardwalk further north sections CC and DD



SECTION EE



SECTION FF

Figure 7: Option 2 reposition boardwalk further north sections EE and FF

Option 2 Advantages

1. New boardwalk moved north, to the edge of the wave runup impact zone.
2. New boardwalk to be raised, reducing the potential of overtopping by waves.
3. Provides improved level of protection from errant golf balls.
4. Continuous planted dunes provide visual and physical separation between golf course and public user groups.
5. Retains access to/from beach.
6. Pedestrians can utilise the existing bridge and boardwalk during the construction period without disruption to the golf course.

Option 2 Disadvantages

1. Vegetation along the route will need to be cleared, and then replaced following removal of the existing boardwalk.
2. Aboriginal Heritage Impact considerations (additional investigations to inform).
3. Potential high cost of dune construction, and difficulty to source sand.
4. Will require financial contribution from council to reconfigure golf tees and footpath and have short term impact on gold course usability.

5. TECHNICAL REPORTS AND RESEARCH

5.1 Wave Runup on Long Reef Walkway Report

Council engaged the Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering at UNSW Sydney to undertake a wave runup report, finalised in April 2022 (Appendix B). This report included:

a) Coastal engineering advice in relation to a proposed upgrade of the Long Reef walkway which was damaged during a storm on 24-25 August 2021

b) Estimated the significant wave height at a water depth of 10 m immediately offshore of the Long Reef walkway for the 1, 10, 20, 50 and 100 year ARI events to then calculate the corresponding 2% exceedance (R2%) and maximum (Rmax) wave runup levels at the beach.

c) Identify whether the existing walkway is at risk of being impacted by wave runup for a number of design average recurrence interval (ARI) events using desktop techniques.

The conclusion from this report was that, in its current cross-shore location and current vertical elevation, the Long Reef walkway deck is at risk of being impacted by wave runup for storm events of 1 year ARI and larger when the beach is in an eroded state.

Event/ARI	WL (m AHD)	Hs nearshore (m) @ 10 m depth	Tp (s)	Runup 2% elevation (m AHD)	Runup max elevation (m AHD)
24-25/8/2021 Storm	1.15	3.18	12.9	4.8	5.5
1 ARI	0.52	3.14	11.0	3.4	3.9
10 ARI	1.35	3.59	12.1	5.4	6.2
20 ARI	1.37	3.64	12.3	5.5	6.3
50 ARI	1.41	3.73	12.7	5.6	6.4
100 ARI	1.44	3.77	13.0	5.7	6.5

Figure 7 : Wave runup levels at damaged walkway section for eroded Long Reef Beach condition (refer 2022 Wave Runup on Long Reef Walkway Report)

5.2 Geotechnical Investigation Report

Council engaged the Alliance Geotechnical Pty Ltd to undertake a geotechnical investigation, finalised in June 2022 (Appendix D). for the demolition and replacement of the existing board walk and footbridge at Long Reef Beach, Collaroy. This geotechnical report is prepared to provide the findings of the geotechnical investigation completed for this site along with design recommendations.

This report included:

a) Assess the subsurface conditions, six boreholes

b) Laboratory test soil samples results

c) Recommendations for demolition of Existing Footbridge and Boardwalk, Excavations and Batter Slopes, engineered Fill, suitable Footings and Geotechnical Parameters for Foundation Design, risk from Acid Sulfate and Saline Soils

5.3 Aboriginal Heritage Site Re-recording Form

The Aboriginal Heritage Site Re-recording Form (refer Appendix E) is from Aboriginal Heritage Office. This form recorded the officers' comments for Long Reef boardwalk. On 24/10/18 recorded evidence of splash impacts, and large scale erosion noted. One small artefact noted eroding from a midden area close to the track (refer photos within form). Probably quartz, broad flake, 14mm x 9mm x 4mm. On 24/10/18 recorded significant erosion on the north east end of site. Almost no shell remains.

5.4 Structural Engineer Advice

The Structural Engineer Advice Memo (refer Appendix F) has been prepared by Woolacotts Consulting Engineers (WCE). In the memo, Option 2 Reposition boardwalk further north is noted as the preferred option. WCE note Option 2 increases the height of the boardwalk and distance from the waterline and is therefore likely to be a longer-lasting solution as it will be better sheltered from significant storm events.

For the construction methodology, a similar construction methodology can be adopted for construction of the replacement boardwalk to that used circa 20 years ago. In order to construct the boardwalk as per the option 2 layout, it would be necessary to provide temporary benching at the lower side of the sand dunes, to allow backhoe access for pile installation. The dune and vegetation (which is currently weed-infested) would then need to reinstated upon completion.

For the construction materials, Woolacotts recommend:

- Boardwalk flooring: treated hardwood timber of Fibre Reinforced Polymer (FRP).
- Joists and Bearers: treated hardwood, FRP or Stainless Steel.
- Piles: treated hardwood or reinforced concrete.

Below is a record of two key council queries following their review of the draft Options and Feasibility report, and the responses from Woolacotts and TBLD:

Council Query 1:
Concern around proposal for timber substructure as previous timber structures have not fared well with the wetting/drying process at this location. Has FRP substructure been considered?

Woolacotts/TBLD response to Query 1:
20 years (approx.) design life was agreed as suitable in the design phase, and is achievable for the boardwalk with Class 1 timber subfloor and Class 1 timber piles (with appropriate detailing and specifications, which would be addressed in the Detailed Documentation phase). A stainless steel subfloor would be expected to have a far longer design life (50yrs) but would come at a cost premium.

There is not sufficient performance data available to comment on the long term design life of FRP framing, but Woolacotts note FRP beam products may be prone to delaminating over time given the highly exposed environment. Woolacotts note there is no current Australian Standards to undertake bespoke engineering FRP design, only European Standards, and if FRP was to be considered for the boardwalk beams, a proprietary system should be adopted.

As noted in the Woolacotts memo report (refer Appendix F), concrete piles could be adopted, and would likely provide a better long-term solution, but would have cost and program impacts for construction.

Council Query 2:
Please include some commentary around anticipated design life of the two options.

Woolacotts/TBLD response to Query 2:
Woolacotts note design life of around 20 years is anticipated for Option 1, with Option 2 (moving the boardwalk away from the wave impact zone) expected to increase the lifespan by at least 5 to 10 years. We note that timber construction will be the easiest to allow replacement of any specific members that deteriorate faster than anticipated or are damaged. The design life could be increased further, but this would have a significant impact on cost and visual amenity (i.e. larger piles and structural members would be required, or stainless steel).

6. CONCLUSION

The preferred option for the Long Reef boardwalk and bridge was derived from outcomes gained from detailed review of background information, extensive site assessments, Council and stakeholder consultation, technical subconsultant input and project objectives informed by Council.

There are a range of additional works and studies required to guide the preferred option development including:

- Heritage investigations (Aboriginal Cultural Heritage Assessment and AHIP)
- Ecological investigations and reporting
- Stakeholder consultation (Long Reef Golf Club and Aboriginal Heritage Officer)
- Detailed Documentation
- Engineering design and certification
- Geotechnical investigations and reporting
- Review of Environmental Factors for the preferred option

Subject to completion of the above tasks, the preferred Concept Design (Option 2) presented within this report would be deemed to be the most feasible option for the improvement of Long Reef boardwalk and bridge.

APPENDICES

APPENDIX A
Option Plans and Typical Sections
(by TBLD)

northern beaches council

THOMPSON BERRILL LANDSCAPE DESIGN

SURVEY KEY

- TOP OF BANK
- TOE OF BANK
- CONTOURS 0.5M INTERVAL
- BOUNDARY

NEW WORKS KEY

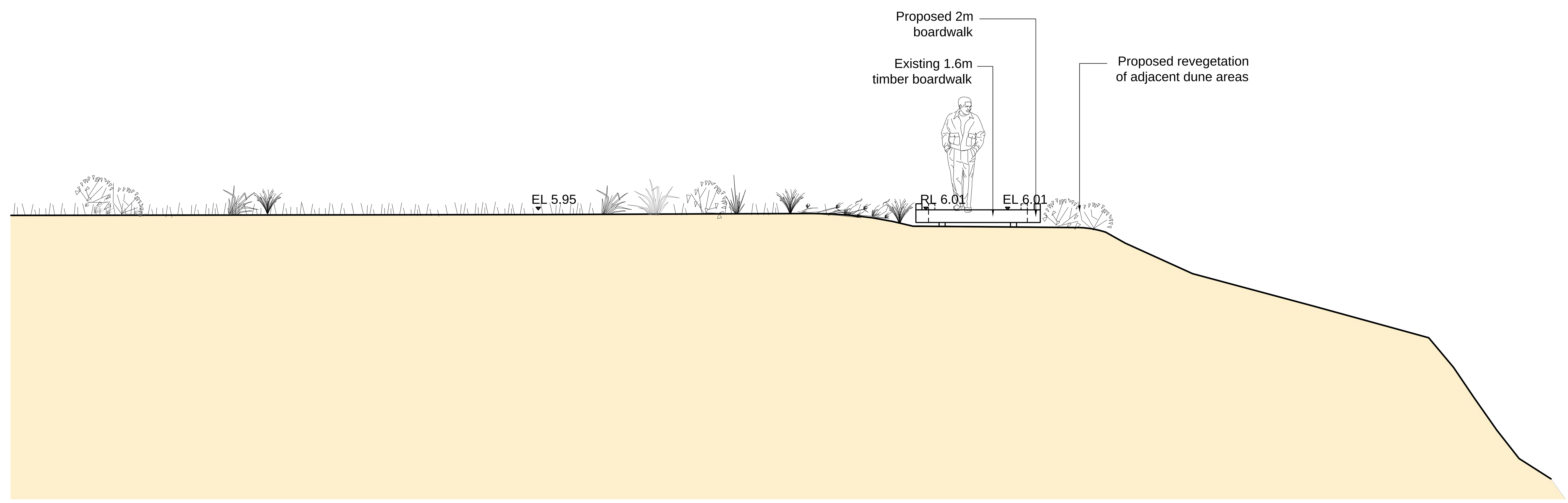
- NEW BEACH ACCESS RAMP WITH RETAINING WALL
- NEW 2M WIDE BOARDWALK
- NEW BARRIER
- NEW JUTE AND REVEGETATE DUNE
- EXTENT OF NEW ROCK REVETMENT

OPTION 1 RENEW IN CURRENT LOCATION PLAN

LONG REEF BOARDWALK 2022

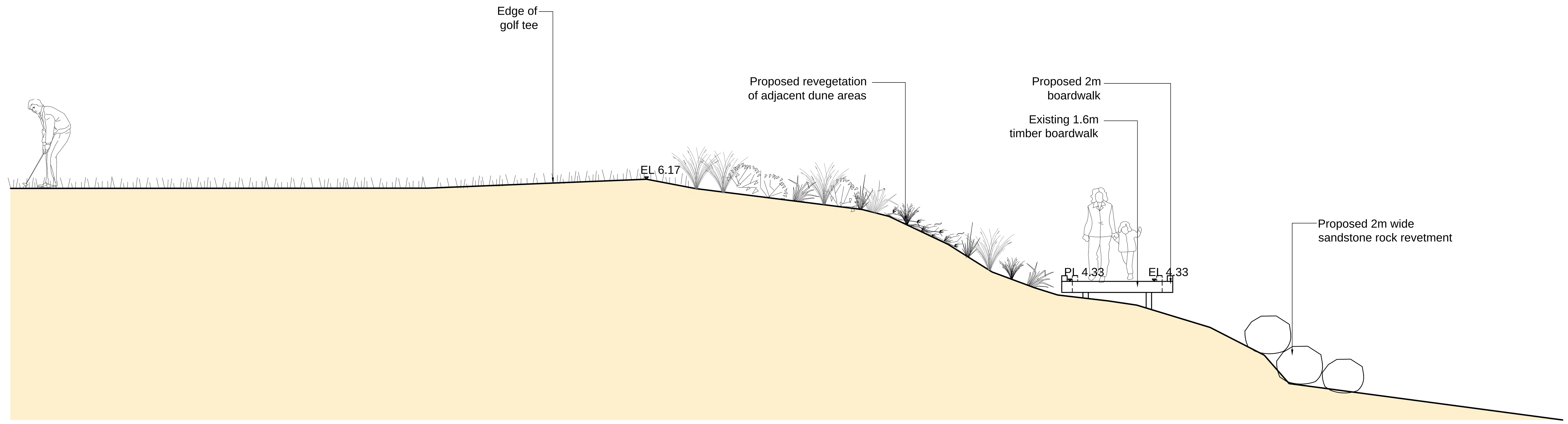
0 2 4 6 10

10th FEB 2023
1: 200 @ A1
1: 400 @ A3



HIGH LEVEL SECTION AA

Scale 1:100 @ A3



LOW LEVEL SECTION BB

Scale 1:100 @ A3

northern beaches council

THOMPSON BERRILL LANDSCAPE DESIGN

SURVEY KEY

TOP OF BANK
TOE OF BANK
CONTOURS 0.5M INTERVAL
BOUNDARY

NEW WORKS KEY

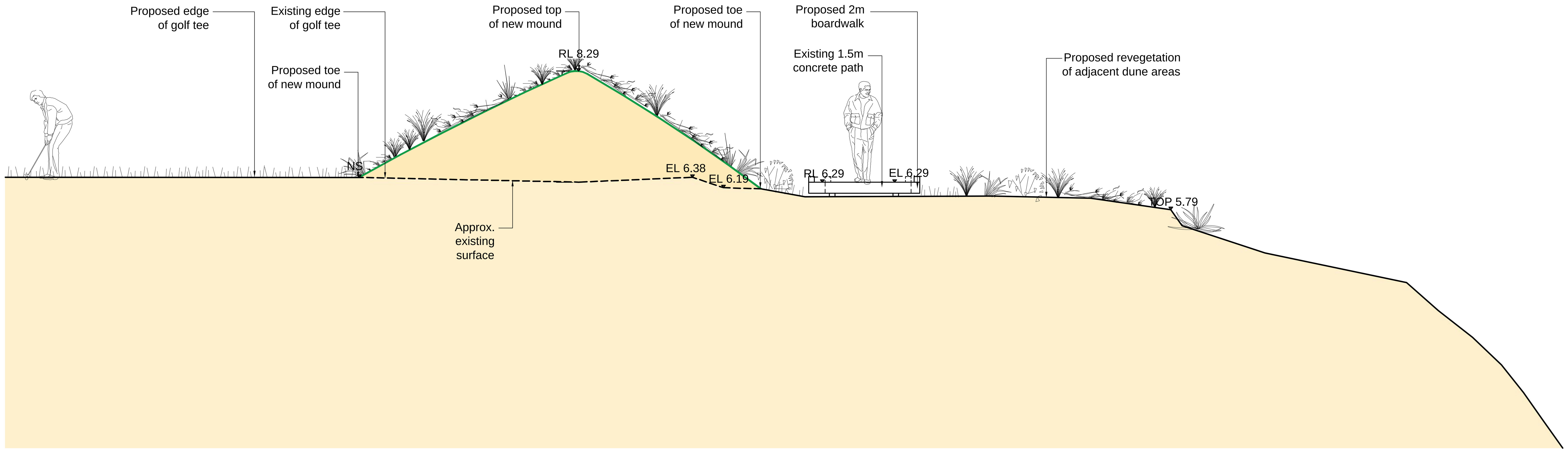
TOP OF NEW MOUND
TOE OF NEW MOUND
NEW MOUND
NEW BEACH ACCESS RAMP WITH RETAINING WALL
NEW 2M WIDE BOARDWALK
NEW BARRIER
NEW JUTE AND REVEGETATE DUNE
EXTENT OF NEW ROCK REVETMENT

OPTION 2 REPOSITION BOARDWALK FURTHER NORTH PLAN

LONG REEF BOARDWALK 2022

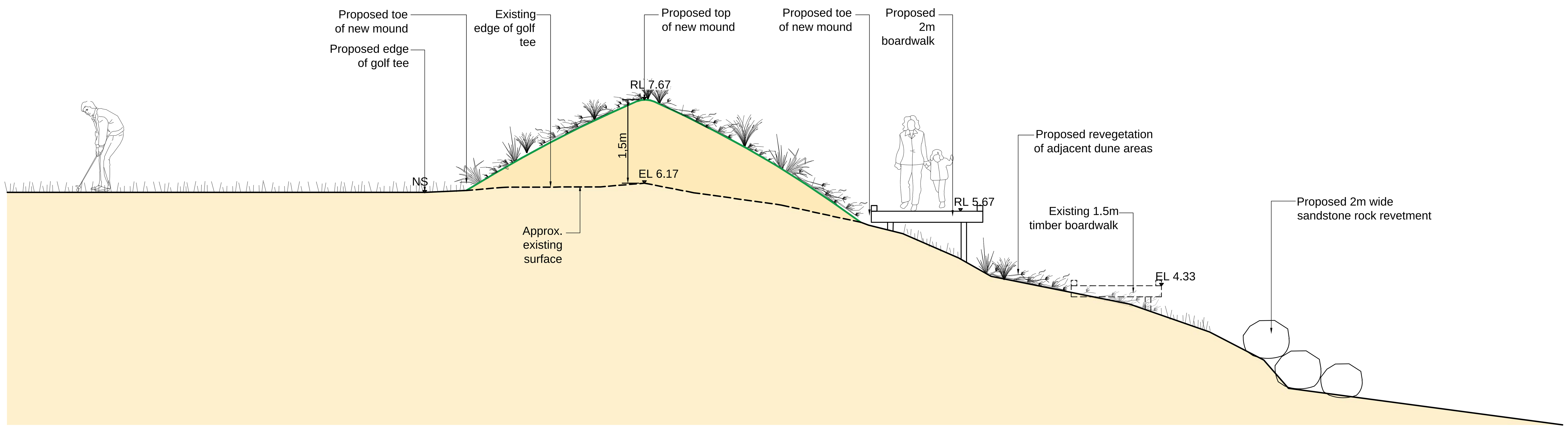
0 2 4 6 10

10th FEB 2023
1: 200 @ A1
1: 400 @ A3



HIGH LEVEL SECTION CC

Scale 1:100 @ A3



LOW LEVEL SECTION DD

Scale 1:100 @ A3

northern beaches council

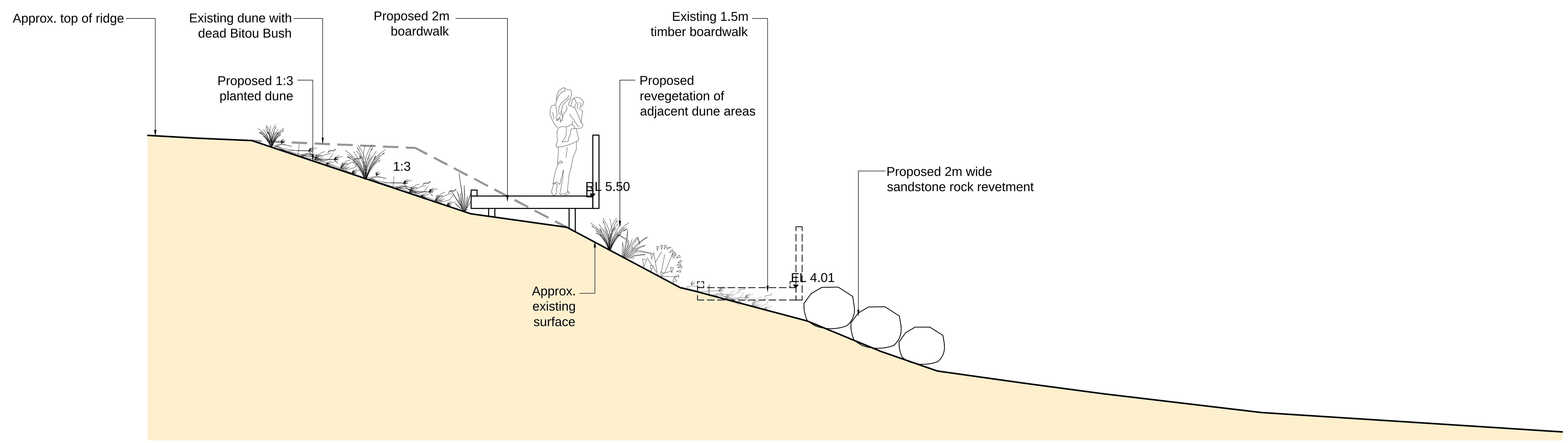
THOMPSON BERRILL LANDSCAPE DESIGN

OPTION 2 REPOSITION BOARDWALK FURTHER NORTH SECTIONS

LONG REEF BOARDWALK 2022

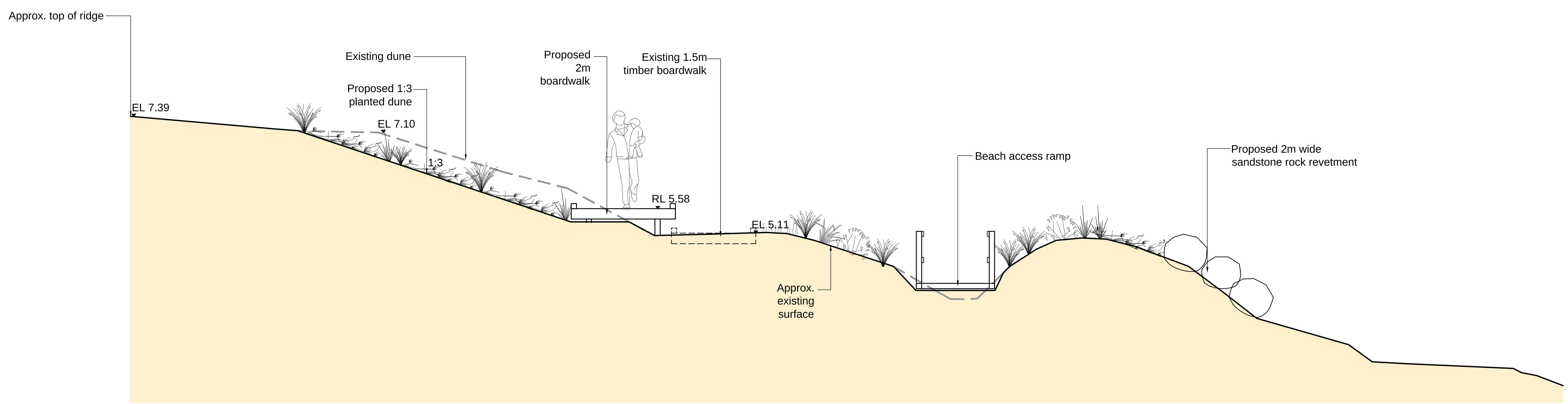
0 0.5 1 1.5 2.5

10th FEB 2023
1: 50 @ A1
1: 100 @ A3



SECTION EE

Scale 1:100 @ A3



SECTION FF

Scale 1:100 @ A3

northern beaches council

THOMPSON BERRILL LANDSCAPE DESIGN

OPTION 2 REPOSITION BOARDWALK FURTHER NORTH SECTIONS

LONG REEF BOARDWALK 2022

0 0.5 1 1.5 2.5

10th FEB 2023
1: 50 @ A1
1: 100 @ A3

APPENDIX B

Wave Runup on Long Reef Walkway Report
(by NSW Water Research Laboratory)

11 April 2022

WRL Ref: WRL2021106 LR20220411

Craig Morrison
Team Leader – Coast
Northern Beaches Council

By email: craig.morrison@northernbeaches.nsw.gov.au

UNSW
Water Research
Laboratory

Dear Craig,

Wave runup on Long Reef walkway

This letter report is presented as a draft for review and comment by NBC. We would appreciate your feedback by 13 May 2022. If we have not received comment by this date we will assume that the report is acceptable to NBC in its present form and issue it as final.

1. Introduction

The Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering at UNSW Sydney was engaged by Northern Beaches Council (NBC) to provide coastal engineering advice in relation to a proposed upgrade of the Long Reef walkway which was damaged during a storm on 24-25 August 2021 (Figure 1-1 and Figure 1-2).

Figure 1-1 Photograph 1 of 2 of damage to Long Reef walkway: 25 August 2021 (Source: NBC)

UNSW SYDNEY
Water Research Laboratory | School of Civil & Environmental Engineering | UNSW Sydney
110 King St, Manly Vale NSW 2093 Australia | T +61 (2) 8071 9800
ABN 57 195 873 179 | wrl.unsw.edu.au | Quality system certified to AS/NZS ISO 9001

Figure 1-2 Photograph 2 of 2 of damage to Long Reef walkway: 25 August 2021 (Source: NSW SES)

2. Objective

While a series of three tasks had been proposed for consideration by NBC in WRL's proposal dated 25 November 2021 (ref: WRL2021106 P20211125), only Task 1 (wave runup) was commissioned, and is documented within this letter.

The objective of Task 1 was to identify whether the existing walkway is at risk of being impacted by wave runup for a number of design average recurrence interval (ARI) events using desktop techniques.

3. Site visit

A site inspection was conducted by two of WRL's coastal engineers (Ian Coghlan and Dr Francois Flocard) on Monday, 28 February 2022 at 15:30. At the time of the inspection, it was approximately 1.5 hours after low tide (14:04) and the average nearshore wave height was approximately 0.3 m. It was noted that repairs to the walkway had been completed since the 24-25 August 2021 storm event.

An RTK-GPS survey (of approximately 100 points) was conducted by WRL to record elevation data of the upper beach and the Long Reef walkway. Ground surface elevations were measured using a Trimble R10 RTK-GPS using the NSW CorsNET network to an accuracy of ±20 mm vertically and ±10 mm horizontally. A map of the survey is provided in Appendix A. Values of this RTK-GPS survey were cross-checked against the survey data provided by NBC dated 19 October 2021 (Byrne & Associates, 2021).

On the day of the site visit, the beach fronting the section of the Long Reef walkway, which was the focus of this study, was observed to be in a relatively eroded state (Figure 3-1 and Figure 3-2). This was further confirmed by conducting a review of historical aerial imagery back to 2012 (images not shown for brevity). The upper part of the beach located directly beneath and in front of the walkway was predominantly devoid of a sand veneer, with soft bedrock and rock shingles/pebbles exposed down to around approximately 0.5 m AHD.

Figure 3-1 Photograph of beach looking seaward taken from the top of the dune

Figure 3-2 Photograph of beach looking landward taken from the edge of the swash zone (approximately +0 m AHD). Note rocky outcrops which may focus wave runup.

The area of the recently repaired section of the walkway was observed to be undermined across around a 15 m long section with approximately 12 of the vertical wooden posts fully exposed due to the erosion of the dune face. Upon further inspection, the 12 vertical wooden posts were all found to still be embedded into the ground/beachface, providing some vertical support to the walkway, however, the efficacy of the embedment depth would need to be assessed by a structural and/or geotechnical engineer.

The walkway deck level was assessed to be at an elevation of approximately 3.6 m AHD along the previously damaged area. The crest of the dune directly leeward from the walkway had an elevation of approximately 6.0 m AHD.

The beach levels measured during the site visit were subsequently used for the wave runup calculations for this study. Publicly available bathymetric data (Marine LiDAR Topo-Bathy data; NSW Government, 2018) was used to extend the beach survey data to a bed elevation of approximately -10 m AHD to create an idealised two-dimensional (2D) bathymetric profile for the purposes of this study (Figure 3-3).

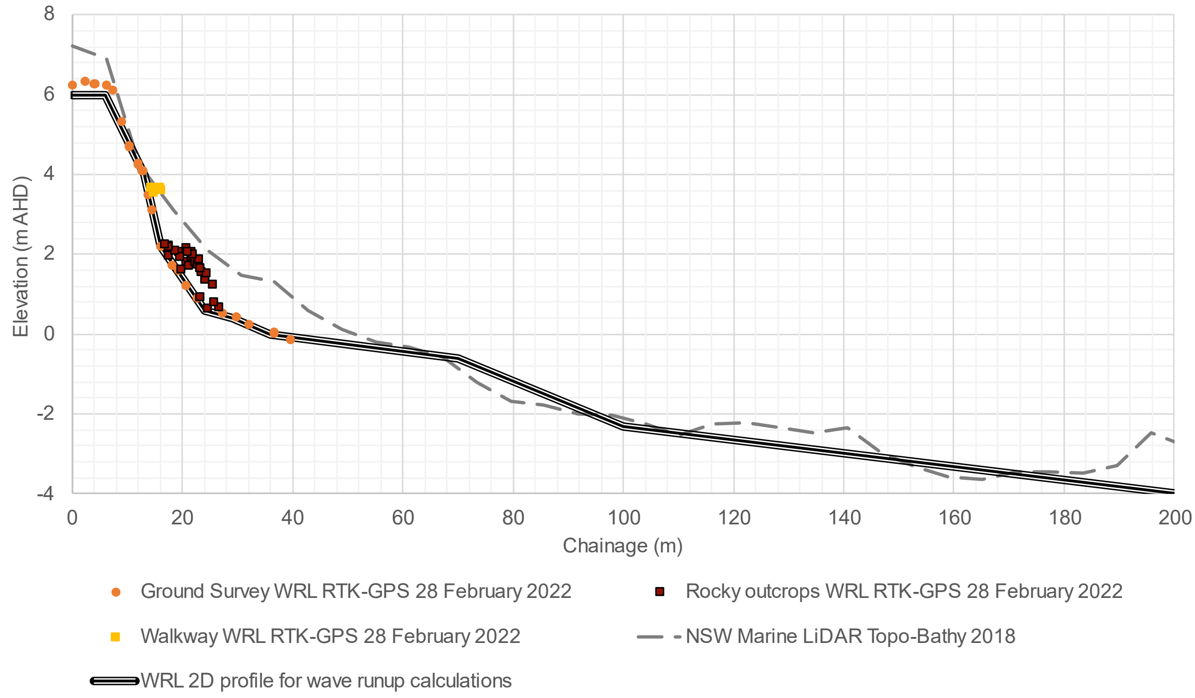


Figure 3-3 WRL 2D profile used for wave runup calculations with surveyed data overlays

The use of a relatively eroded upper beach profile is preferred for design calculations, compared with a less eroded profile (such as captured in the NSW Marine LiDAR Topo-Bathy data) as it will result in slightly higher nearshore wave conditions and therefore more conservative wave runup elevations. This eroded profile is also considered to be more representative of a beach state which may occur during a design event because of erosive processes.

Two rocky outcrops approximately 10 m long and 1 m high were found to be fully exposed on the upper beach face and flanking the area of the previously damaged walkway section (Figure 3-2). It is probable that the outcrops' position on the upper beach face and overall orientation, naturally focus the wave energy and associated runup towards the area where the walkway was damaged during the 24-25 August 2021 storm event. However, quantifying the effect of such complex topographic features on the upper beach face and their influence on wave runup processes is beyond the scope of this desktop study, and would likely require a physical model and/or extensive field investigation.

4. Design conditions

Long Reef Beach is characterised by a moderate to high energy wave climate (typically, offshore generated swell) with some protection offered from swell waves from a number of shallow rocky reefs located directly offshore from the northern end of Long Reef Beach.

Offshore conditions for both the 24-25 August 2021 event (Figure 4-1) and design events (1, 10, 20, 50 and 100 year ARI events) were all based on wave buoy measurements from the Sydney directional Waverider buoy installed approximately 5 km offshore of the project site in 100 m water depth. This directional wave buoy has been operating since 1992. The water level (WL) timeseries for 24-25 August 2021 was obtained from the HMAS Penguin station (Middle Head).

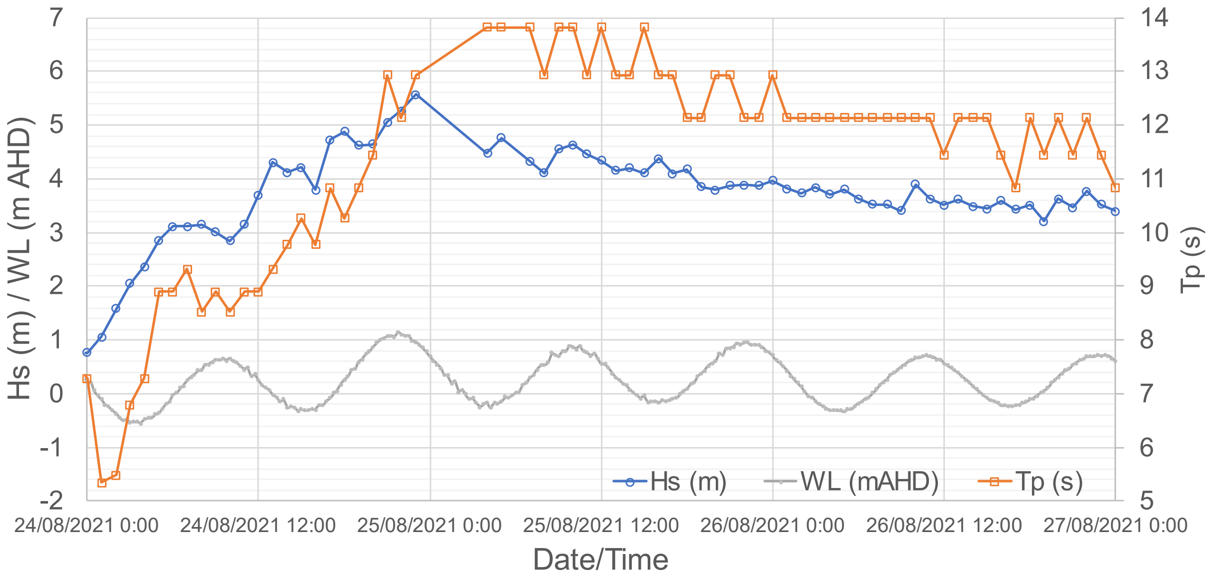


Figure 4-1 Measured wave and water level conditions during the 24-25 August 2021 storm

To simulate the transformation of waves from deeper water off the coast of Sydney (approximately 100 m deep), into the Long Reef foreshore (approximately 10 m deep), WRL used output from an existing MIKE21 Spectral Wave (SW) transformational model. This spectral wave model was established as part of an ARC linkage project that WRL partnered in (Mortlock, 2015).

The offshore-to-nearshore wave transformation was conducted using the idealised 2D bathymetric profile. As such, the desktop wave analysis conducted for this study was not able to fully capture three-dimensional (3D) wave processes in depths shallower than -10 m AHD (see blue hexagon in Figure 4-2), such as wave reflection or focusing from offshore reefs.

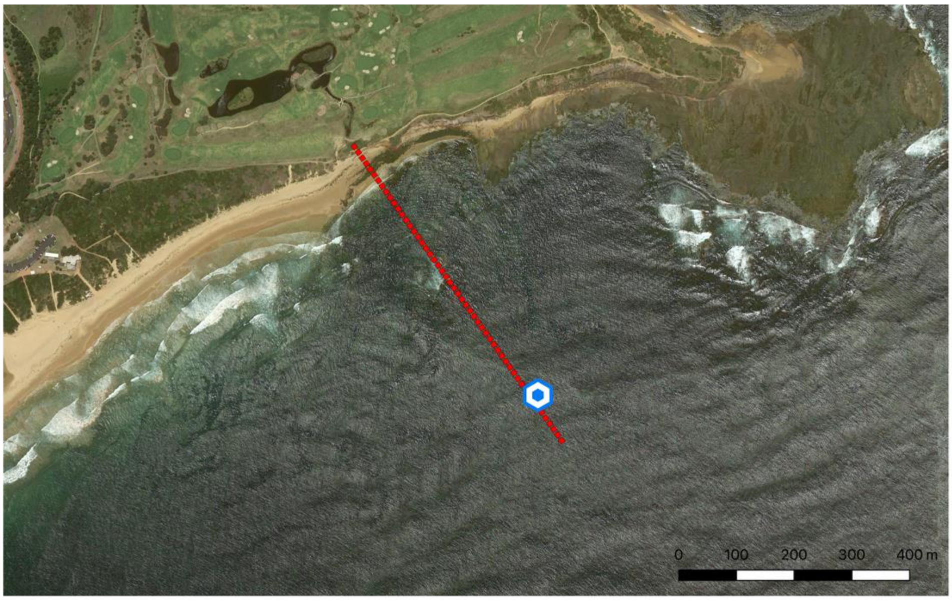


Figure 4-2 Location of the nearshore wave transformation output (blue hexagon) relative to WRL 2D idealised profile used for wave runup calculations (Aerial photo 03/12/2018; Source: Google Earth)

WRL estimated the nearshore significant wave height (Hs) at a water depth of 10 m immediately offshore of the Long Reef walkway for the 24-25 August 2021 storm event based on measurements at the Waverider buoy. The nearshore Hs was similarly estimated for five design events (1, 10, 20, 50 and 100 year ARI). Offshore waves with an approximate south-east direction (window between east-south-east and south-south-east) result in the largest nearshore design wave heights for the walkway.

Table 4-1 provides the offshore design conditions and resulting transformed nearshore wave heights for each event in addition to the associated water level and peak spectral wave period (Tp). Design storm tide water levels (astronomical + anomaly) in Table 4-1 were obtained from the Coastal Risk Management Guide (NSW DECCW, 2010 after Watson and Lord, 2008) except for the Mean High Water (MHW) elevation (used in conjunction with 1 year ARI waves) which was defined by MHL (2013). Offshore design wave conditions for Hs were sourced from Shand et al. (2011a) and the associated Tp values from Shand et al. (2011b).

Table 4-1: Offshore and nearshore design wave conditions

Event/ARI	WL (m AHD)	Hs offshore (m)	Tp (s)	Hs nearshore (m) @ 10 m depth
24-25/8/2021 Storm (1)	1.15	5.3	12.9	3.18
1 year ARI	0.52 (2)	5.9	11.0	3.14
10 year ARI	1.35	7.5	12.1	3.59
20 year ARI	1.37	7.9 (3)	12.3 (4)	3.64
50 year ARI	1.41	8.6	12.7	3.73
100 year ARI	1.44	9.0	13.0	3.77

Notes

(1) conditions for the 24/08/2021 were chosen at the maximum recorded water level (excluding wave setup) as this would result in the highest wave runup height

(2) water level for the 1 ARI is based on MHW due to joint-probability considerations as agreed with key DPE staff previously for coastal hazard assessments; see Coghlan et al. (2017)

(3) estimated 20 year ARI value for Hs offshore has been inferred by WRL for this study from Shand et al. (2011a)

(4) estimated 20 year ARI value for Tp has been inferred by WRL for this study from Shand et al. (2011b)

It should be noted that review of the 24-25 August 2021 offshore wave data indicates that offshore waves were predominantly from a southerly direction during the 48 hours of the storm. Review of the water level records from the HMAS Penguin station shows that the tidal anomaly was between +0.3 m and +0.4 m during the storm period.

The joint-occurrence of high energy wave conditions from a southerly direction with a relatively high tidal anomaly is uncommon. A high-level comparison of the recorded conditions with historical records indicates that the resulting wave runup during the 24-25 August 2021 storm was approximately a 5 year ARI event (see also later Table 5-1).

5. Wave runup heights

The 2% exceedance and maximum wave runup levels ($R_{2\%}$ and R_{max}) were calculated using the empirical method of Mase (1989). $R_{2\%}$ levels are typically used to describe wave runup in coastal engineering and represent the wave runup water level that is exceeded by 2% of incident waves.

The wave runup calculation methodology was verified against the wave and water levels conditions recorded during the 24-25 August 2021 storm event which we can infer resulted in severe overtopping of the walkway given the level of damage it sustained.

The following comparison was made between calculated runup elevations and the walkway deck and dune crest elevations for the peak (approximately 21:45 AEST on 24 August 2021) of the storm event:

- Walkway elevation damaged during storm: 3.6 m AHD
- Dune crest elevation behind walkway: 6.0 m AHD
- Calculated $R_{2\%}$ elevation using the method Mase (1989): 4.8 m AHD
- Calculated R_{max} elevation using the method Mase (1989): 5.5 m AHD

The calculated $R_{2\%}$ wave runup levels exceeded the walkway elevation by approximately 1 m which is considered reasonable given the level of damage sustained by the walkway while the calculated R_{max} value did not exceed the dune crest (i.e. no overtopping of the dune). These results verify that the method of Mase (1989) is appropriate to estimate wave runup at Long Reef Beach for a range of design events.

Calculated wave runup values for a range of conditions, including design events, on the eroded Long Reef Beach are shown in Table 5-1.

Table 5-1: Wave runup levels at damaged walkway section for eroded Long Reef Beach condition

Event/ARI	WL (m AHD)	Hs nearshore (m) @ 10 m depth	Tp (s)	Runup 2% elevation (m AHD)	Runup max elevation (m AHD)
24-25/8/2021 Storm	1.15	3.18	12.9	4.8	5.5
1 ARI	0.52	3.14	11.0	3.4	3.9
10 ARI	1.35	3.59	12.1	5.4	6.2
20 ARI	1.37	3.64	12.3	5.5	6.3
50 ARI	1.41	3.73	12.7	5.6	6.4
100 ARI	1.44	3.77	13.0	5.7	6.5

The calculated $R_{2\%}$ wave runup levels exceed the existing walkway deck elevation of 3.6 m AHD during storm events equal to or larger than 10 year ARI. However, the estimated $R_{2\%}$ wave runup levels are below the current dune crest of 6.0 m AHD for storm events up to (and including) 100 year ARI.

The calculated R_{max} values indicate that the walkway could be overtopped by waves for storm events of at least 1 year ARI. The estimated R_{max} wave runup levels exceed the current dune crest elevation of 6.0 m AHD for storm events equal to or larger than 10 year ARI, and therefore, would likely result in infrequent wave overtopping of the dune.

It should be noted that all wave runup calculations were performed for present day conditions only. These did not consider future increase in water levels due to sea level rise or additional recession of Long Reef Beach. These assumptions are considered reasonable given that the design life of a replacement walkway for Long Reef Beach will likely be approximately 20 years.

6. Additional Storm Event: 1-2 April 2022

Shortly prior to the time of writing this letter report, a large storm event on 1-2 April 2022 caused wave runup to again impact the Long Reef walkway. Unfortunately, at the time of writing, measured data is unavailable from the Sydney directional Waverider buoy for this event, but WRL understands that this data may be able to be retrieved when the buoy is next serviced. The measured water levels at HMAS Penguin for the two high tides that impacted the walkway were approximately 1.1 m AHD (22:00 AEDT on 1 April) and 1.0 m AHD (09:45 AEDT on 2 April). Some damage to the walkway had occurred during the storm when it was inspected by Ian Coghlan at 09:45 AEDT on 2 April. Photos from this inspection, including examples of wave runup and overtopping of the walkway, are provided in Appendix B. In the absence of detailed wave runup calculations, WRL considers that the wave runup during the 1-2 April 2022 event was similar in magnitude to that of 24-25 August 2021.

7. Acknowledgments

WRL acknowledges that the wave and water level data obtained for the 24-25 August 2021 storm event is owned by the Biodiversity and Conservation Division, NSW Department of Planning and Environment and collected by Manly Hydraulics Laboratory.

8. Summary

Thank you for the opportunity to provide coastal engineering advice in relation to the Long Reef walkway which was damaged during the 24-25 August 2021 storm event.

In this letter, WRL has estimated the significant wave height at a water depth of 10 m immediately offshore of the Long Reef walkway for the 1, 10, 20, 50 and 100 year ARI events to then calculate the corresponding 2% exceedance ($R_{2\%}$) and maximum (R_{max}) wave runup levels at the beach.

In its current cross-shore location and current vertical elevation, the Long Reef walkway deck is at risk of being impacted by wave runup for storm events of 1 year ARI and larger when the beach is in an eroded state.

Please contact Francois Flocard (0420-423-382), Ian Coghlan (0423-113-920) or James Carley (0414-385-053) in the first instance should you wish to discuss the details raised in this letter further.

Yours sincerely,

Duncan Rayner
Director, Industry Research (Acting)

9. References

Byrne & Associates 2021, "Level and Detail Survey Over Part of Lot 1 I DP1144187 & Lot 11 in DP1193189 "Long Reef Headland Walkway" Anzac Avenue, Long Reef", Drawing no. 11162D, Revision A, Date of Survey 19 October 2021, Date of Issue 29 October 2021.

Coghlan, IR, Carley JT, Harrison AJ, Howe D, Ruprecht JE, Short AD, Flocard FD, Rahman PF 2017, "Eurobodalla Coastal Hazard Assessment", WRL Technical Report 2017/09.

Manly Hydraulics Laboratory [MHL] 2013, OEH NSW Tidal Planes Analysis: 1990-2010 Harmonic Analysis, A report prepared for the NSW Office of Environment and Heritage, MHL Report 2053, October 2013.

Mase, H 1989, 'Random Wave Runup Height on Gentle Slopes', Journal of Waterway, Port, Coastal, and Ocean Engineering 115(5):649-661, American Society of Civil Engineers.

Mortlock, TRC 2015, Wave Climate and Coastal Change in Southeast Australia, PhD Thesis, Macquarie University, 20 November 2015, accessed 31 March 2022, http://hdl.handle.net/1959.14/1252045.

NSW Department of Environment and Climate Change and Water [DECCW] 2010, Coastal Risk Management Guide: Incorporating seal level rise benchmarks in coastal risk assessments.

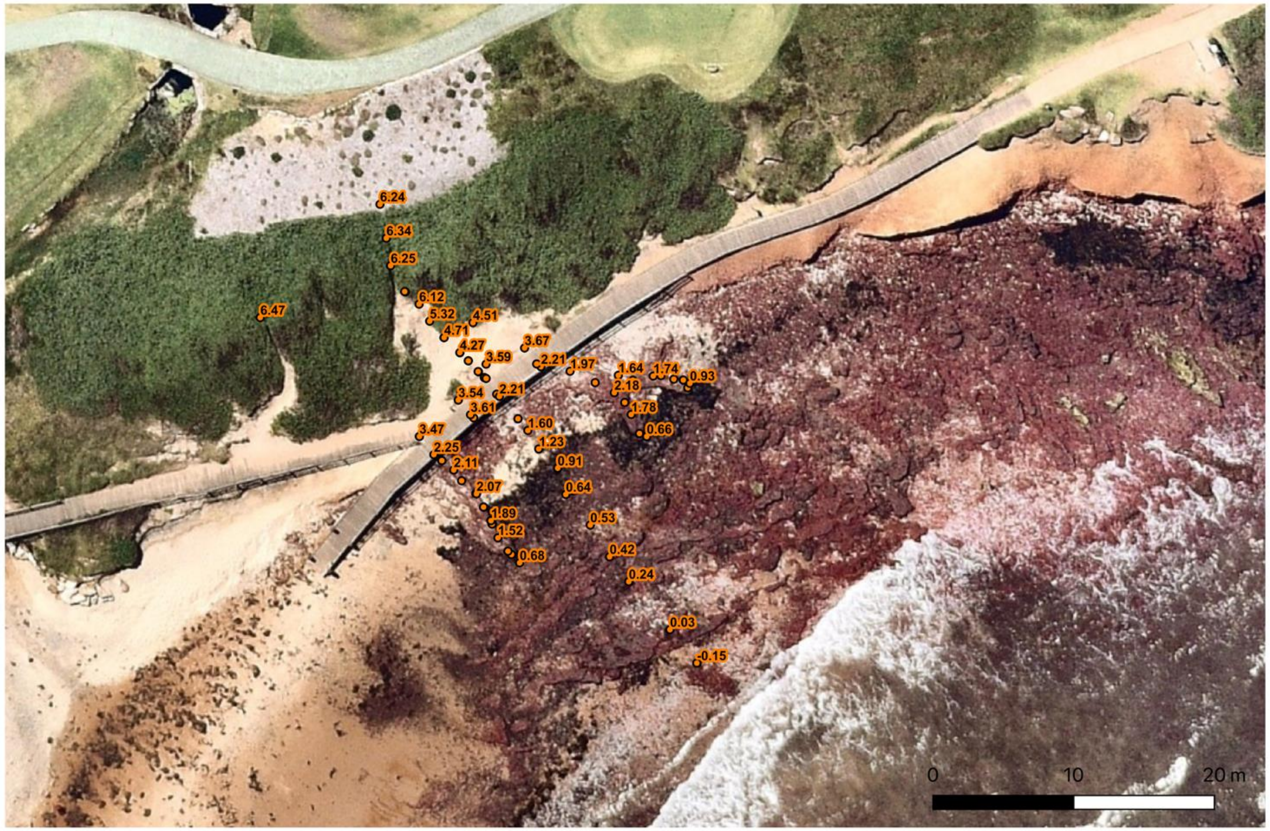
NSW Government 2018, NSW Marine LiDAR Topo-Bathy 2018 Geotif, Acquired for the NSW Office of Environment and Heritage, accessed 31 March 2022, https://data.gov.au/dataset/ds-nsw-d15daa7b-6f0b-4093-a7f5-cbd208627e66/details?q=marine%20LiDAR.

Shand, TD, Mole, MA, Carley, JT, Coghlan, IR, Harley, MD and Pierson, WL 2011a, "NSW Coastal Inundation Hazard Study: Coastal Storms and Extreme Waves", WRL Technical Report 2010/16.

Shand, TD, Mole, MA, Carley, JT, Peirson, WL and Cox, RJ 2011b, "Coastal Storm Data Analysis: Provision of Extreme Wave Data for Adaptation Planning", WRL Research Report 242.

Watson, PJ and Lord, DB 2008, "Fort Denison Sea Level Rise Vulnerability Study", A report prepared by the Coastal Unit, Department of Environment and Climate Change, October 2010.

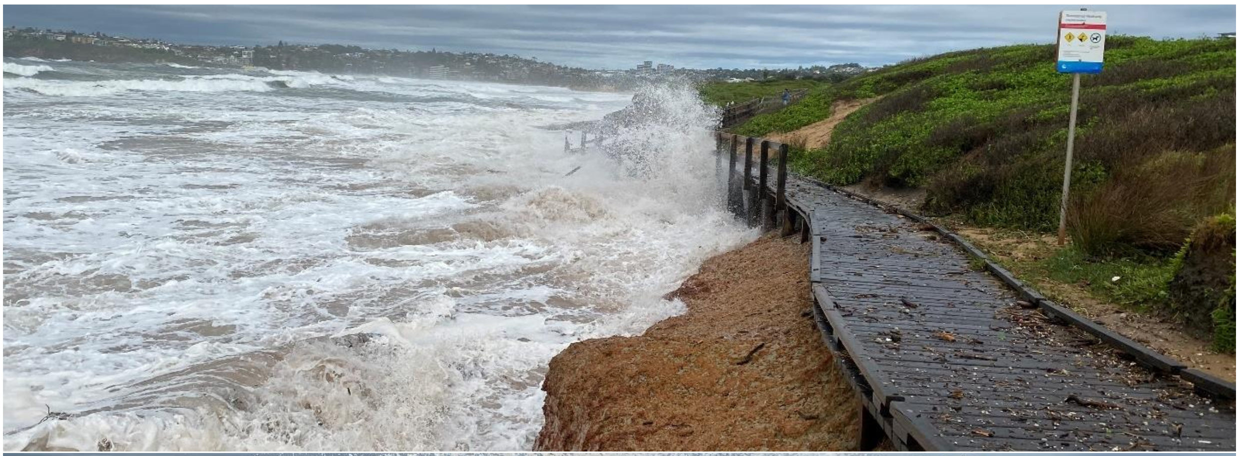
10. Appendix A: RTK-GPS survey conducted by WRL 28/02/2022

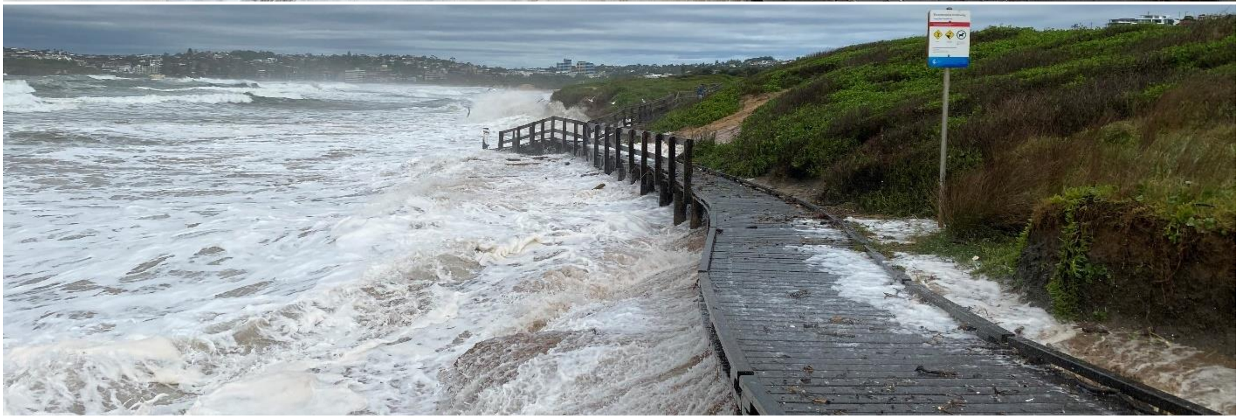


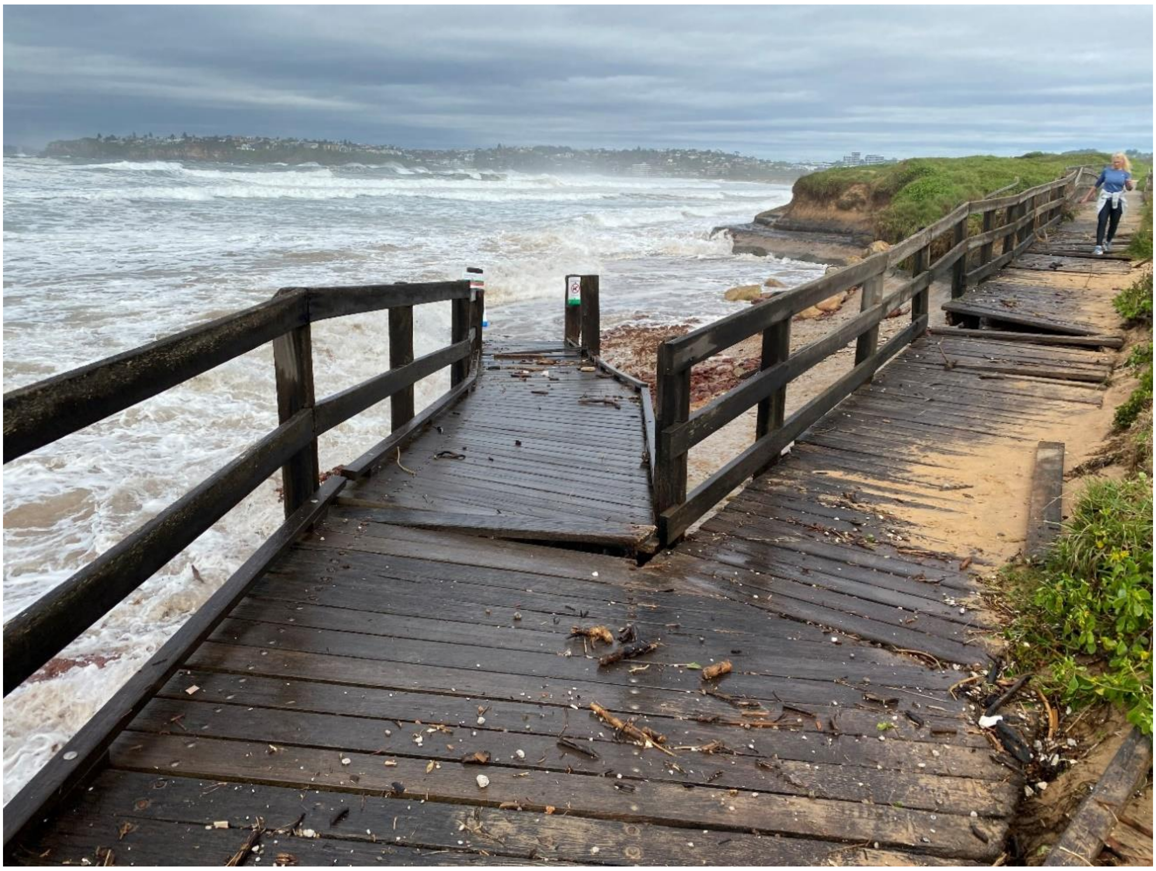
Note: The aerial imagery, on which the RTK-GPS points are plotted (elevation provided in m AHD), was taken on 29 January 2022 (Source: Nearmap). Comparison of this aerial photograph with observations from WRL site visit on the 28 February 2022 indicates that the beach was slightly less eroded on 28 February 2022, with the sand veneer extending up to around 0.5 m AHD contour and overall smaller area of exposed bedrock. This would indicate that the beach fronting the Long Reef walkway is currently experiencing sediment deposition, likely from cross-shore sediment transport.

11. Appendix B: Site visit conducted by WRL at high tide on 02/04/2022

The following photographs were taken by Ian Coghlan around high tide (09:45 AEDT) on 2 April 2022 during the 1-2 April storm event to document damage to the Long Reef walkway and wave runup and overtopping over it.







APPENDIX C

Long Reef Foreshore Boardwalk & Bridge Options Report (by Northern Beaches Council)

Long Reef Foreshore Boardwalk & Bridge Options Report

Background

In August 2021 large swells caused significant damage to the foreshore boardwalk at Long Reef headland. This boardwalk is part of the Long Reef Headland loop track and is subjected to a high volume of use by the community. The boardwalk is being repaired in late August to ensure that it is serviceable for the short term (9-12) months.

Figure 1 - Damaged decking August 2021

Figure 2 - Damaged substructure August 2021

The boardwalk and adjacent timber bridge are reaching the end of their useful life. Due to the recent damage to the boardwalk, it is worth considering alternate renewal responses besides replacing like for like, to better future proof the asset and service provision.

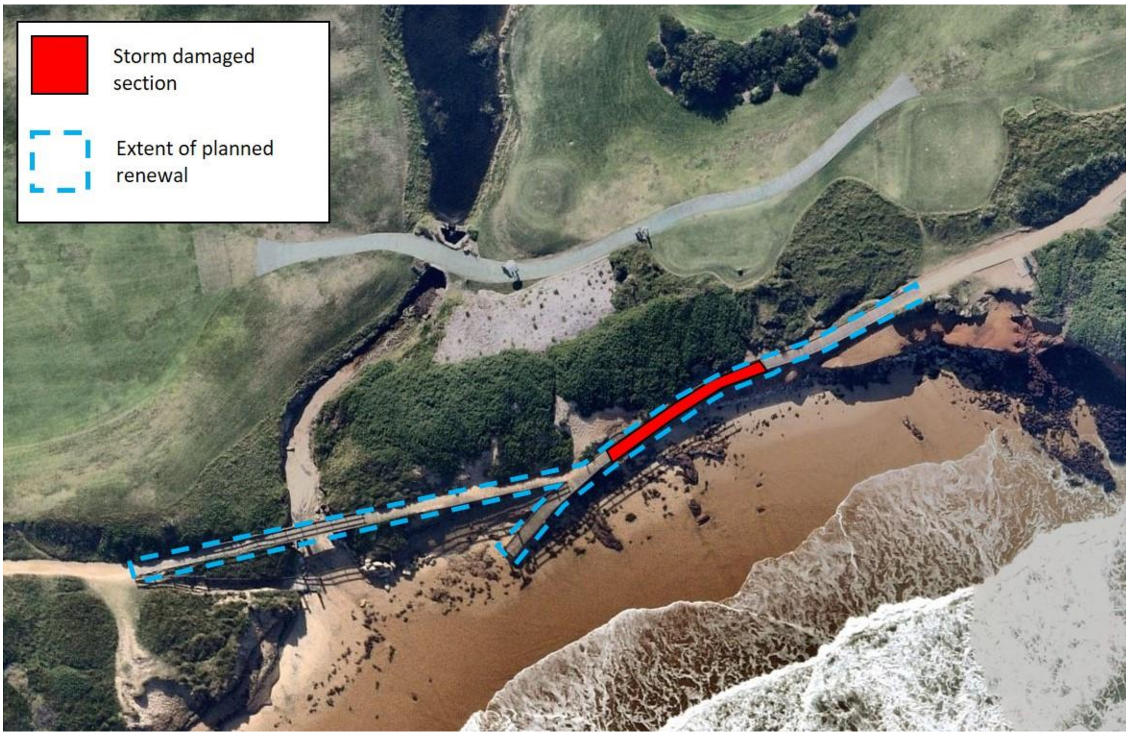


Figure 3 - Bridge & Boardwalk extent

Site Constraints

Council has received advice from the Aboriginal Heritage Office that Aboriginal middens are located in the vicinity of the existing boardwalk. The presence of these middens may impact on the design and construction methodology of the preferred option.

Access for machinery to the part of the site east of the golf course channel will be difficult with access via the beach (tidal impacts) or golf course (access negotiations) being the only viable options.

Design Aims

The existing boardwalk does not provide the required capacity to cater for the volume of use that this popular loop track is subjected to. The minimum width for any new bridge and boardwalk construction will be 2 metres, which allows for 2 wheelchairs/strollers to pass by one another comfortably.

Option 1 – Renew in the same location

Pros	Cons
• Established Route • Minimal impact on surrounding coastal vegetation • Alignment within Council managed reserve • Cover provided from errant golf balls	• Susceptible to swell damage • Renewal will require coastal engineering design review (additional expense)

Renewing the bridge and boardwalk in the same location will require further design work, and increased cost. Material choice will have to be carefully considered to achieve an appropriate design life, with extensive footings being required for the structure to protect against coastal erosion and wave impact. The structure will continue to be at risk of ongoing swell damage.

Option 2 – Position boardwalk further north

Pros	Cons
• Moves the most exposed section of boardwalk further up the dune and away from the tidal zone. • Alignment within Council managed reserve • Cover provided from errant golf balls	• Vegetation will need to be cleared • Removes boardwalk access to the beach. Access to be from western side of bridge only. • More susceptible to wave runup for storm events of 1 year ARI and larger when the beach is in an eroded state. • Aboriginal Heritage Impact considerations

Figure 4 - Option 2 alignment

Moving the boardwalk section slightly north addresses the risks presented by storm surge that caused the damage in August. Other impacts such as vegetation clearing and boardwalk grades will need to be addressed at the transition from the existing bridge alignment to the new boardwalk alignment.

Option 3 – Reposition Bridge and Boardwalk

Pros	Cons
• Revised alignment will improve grades for path users • Repositions boardwalk and bridge further from the tidal zone • Alignment within Council managed reserve • Alignment runs along relatively flat sections of the dune, which may allow for concrete path rather than boardwalk in places, reducing cost • Less susceptible to wave runup for storm events of 1 year ARI and larger when the beach is in an eroded state.	• Vegetation will need to be cleared • Removes boardwalk access to the beach. Access to be from western side of bridge only. • Some exposure to errant golf balls • Aboriginal Heritage Impact considerations

Figure 5 - Option 3 alignment

This option provides the biggest buffer between the tidal zone and the boardwalk, further reducing the risk of swell damage and improving any potential structure's longevity. This option may increase the risk of users of the path to errant golf balls from the adjacent course. This risk could be addressed by fencing, planting, or a combination of both.

Option 4 – Reroute path through golf course

Pros	Cons
• Removes swell damage and erosion risk completely • Concrete path construction only, far cheaper option • The estimated R2% wave runup levels are below the current dune crest of 6.0 m AHD for storm events up to (and including) 100 year ARI.	• Will require negotiation with the club to amend lease conditions • Will require contribution from Council to reconfigure golf hole and tees to minimise conflict with golf.

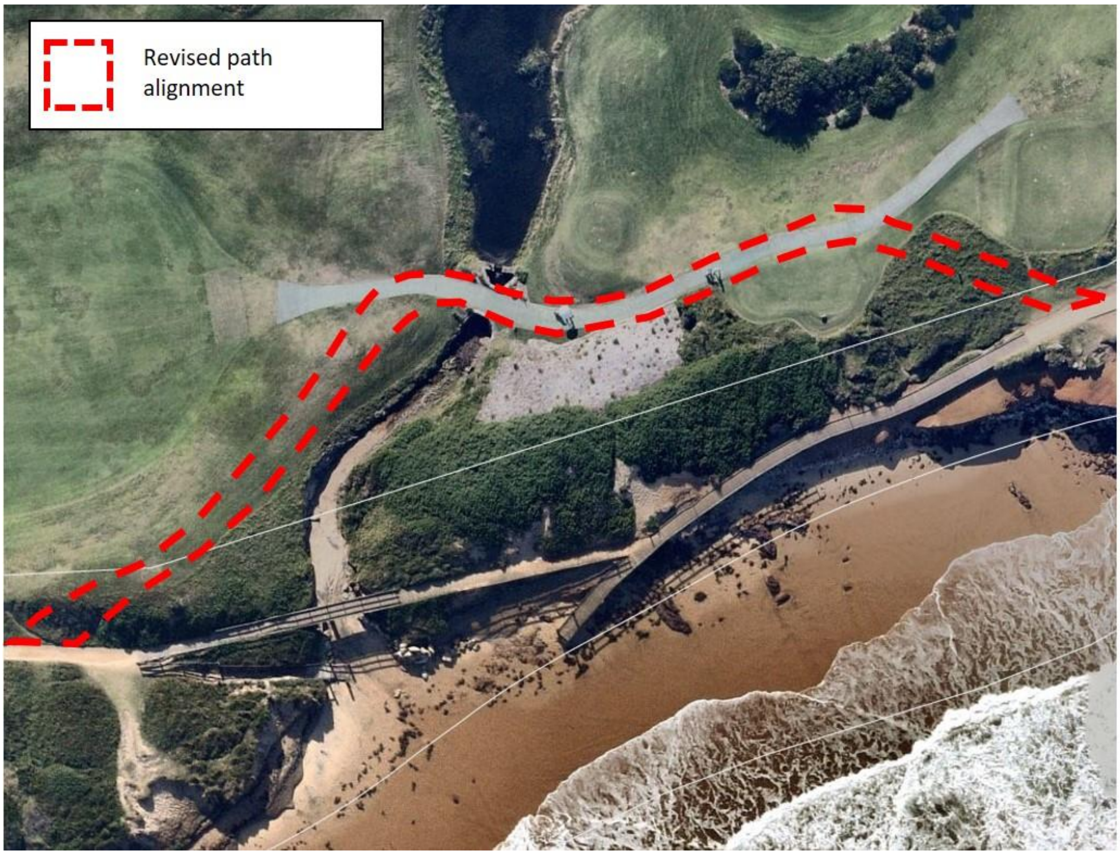


Figure 6 - Option 4 alignment

This option removes the risk of swell damaging the path connection. It would however require negotiation with Long Reef golf club, and likely a contribution to reconfigure the course to ensure minimal disruption to golf players and users of the path alike. This option is not realistic.

Option 5 – Remove boardwalk and bridge

Pros	Cons
• Relatively Cheap • Removes maintenance and operational burden	• Part of the loop would be on the beach and be inaccessible for prams and wheelchairs • Inaccessible during peak high tides or when the golf course creek has outflow. • Walkers likely to divert onto the golf course, leading to conflict with users

	• Likely to result in significant reputational damage to Council

This option is not a realistic course of action.

APPENDIX D

Geotechnical Investigations Report
(by Alliance Geotechnical Pty Ltd)

Geotechnical Investigation Report

Project

Proposed Replacement Footbridge & Boardwalk, Long Reef Beach, Collaroy

Prepared for

Northern Beaches Council

Date

8 June 2022

Report No

14801-GR-1-2

alliance

geotechnical & environmental solutions

Alliance Geotechnical Pty Ltd

Address: 8-10 Welder Road
Seven Hills, NSW

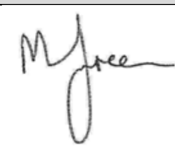
Phone: 1800 288 188

Office Email: info@allgeo.com.au

Web: www.allgeo.com.au

DOCUMENT CONTROL

Revision	Date	Description	Author	Reviewer
0	08/06/2022	Original issue	ZK	MAG

	Author	Reviewer
Signature		
Name	Zubair Khan	Mark Green
Title	Senior Geotechnical Engineer	Principal Geotechnical Engineer

Contents

Appendices`

1 INTRODUCTION

This report presents the findings of a geotechnical investigation undertaken by Alliance Geotechnical Pty Ltd (Alliance) for Northern Beaches Council (Client) for the demolition and replacement of the existing board walk and footbridge at Long Reef Beach, Collaroy (the site). The investigation was undertaken in accordance with the scope of works outlined in Alliance's fee proposal (Estimate No. 6311, dated 4 March 2022).

Alliance was provided with a project brief by the client, and it is understood that the existing footbridge and boardwalk will be demolished and replaced with a proposed Fibre Reinforced Polymer (FRP) Footbridge and boardwalk. It is understood based on the brief that the new bridge and boardwalk is to retain the same alignment as the bridge and boardwalk to be demolished.

This geotechnical report is prepared to provide the findings of the geotechnical investigation completed for this site along with design recommendations. The geotechnical investigation was undertaken generally in accordance with Australian Standard AS 1726 – 2017 for "Geotechnical Site Investigations".

The purpose of this preliminary geotechnical investigation was to assess the subsurface conditions and provide preliminary comments and recommendations relating to:

- Geotechnical subsurface conditions.
- Groundwater conditions.
- Suitable bridge footing types and construction considerations.
- geotechnical foundation design parameters.
- Soil aggressivity in relation to concrete and steel.
- Provide commentary on risk from acid sulfate soils and saline soils.

2 SITE DESCRIPTION AND REGIONAL GEOLOGY

The site covers approximately 100m in total including the existing footbridge and boardwalk that is to be replaced. The site is located on the eastern side of Long Reef beach and is bounded by Long Reef Golf Club to the north, Long Reef Headland to the east and Long Reef Beach and the ocean to the south.

The site is within a localised low point in relation to the walking track and is generally undulating. The site RL is approximately RL 4m to 6m based on Google Earth. The surrounding topography around the site generally slopes downwards in the southern direction towards the ocean.

Figure 1 below shows the site location in relation to the surrounding area.

Figure 1 – General Site Layout (Bridge in Yellow and Board Walk in Red)

The Sydney 1:100,000 Geological Map indicates that the site is underlain by three Quaternary marine geologies including ”medium to fine grained marine sand with podsols”, ‘’medium to fine marine sand’’ and ‘’course quartz sand, varying amounts of shell fragments. Bald Hill Claystone is also bordering the site on the east and is defined as ‘’dominantly red shale and fine to medium sandstone’’.

The investigation confirms the presence of marine sand overlaying residual sandy clay.

3 FIELDWORK

The geotechnical site investigation was carried out over one day on 3 May 2022. Selected site photographs taken during the fieldwork are presented above and in Appendix A.

The investigation comprised the initial marking out test locations along with the drilling of six boreholes (BH01-LR to BH02-LR). Borehole BH01-LR was drilled using a track-mounted drilling rig and was advanced through the soil profile using solid flight augers fitted with a tungsten carbide bit (TC-bit). Boreholes BH02-LR through to BH06-LR were drilled using a hand auger to a maximum refusal depth of 1.25m. Dynamic Cone Penetrometer (DCP) tests were taken up to 2.4m depth adjacent to the borehole locations and Standard Penetration Tests (SPT) were carried out (within BH01-LR only) at approximately 1.5m depth intervals with the deepest test being undertaken at 9.0m depth. The encountered soils were logged and sampled by an experienced geotechnical engineer from Alliance.

Borehole BH01-LR is located west of the existing bridge in order to determine the required bridge footing design. Due to access issues the track mounted drill rig could not cross the bridge to be able to determine the subsurface materials on the eastern side of the bridge and therefore hand augers were carried out for the remainder of the boreholes along the board walk heading east from the bridge.

3.1 Subsurface Conditions

Table 1 below summarises the subsurface conditions encountered within the boreholes. For further information reference should be made to the attached borehole logs.

Table 1 - Summary of Subsurface Profile

Borehole	BH01	BH02	BH03
Description	**Depth below the ground surface (m)**		
ALLUVIAL: Sand, fine to medium grained (Loose)	-	0.0-0.2	0-0.1
DUNE SAND: Sand, fine to medium grained (Loose)	0.0-1.5	-	-
DUNE SAND: Sand, fine to medium grained (Medium Dense)	1.5-2.5	-	-
ESTUARINE: Clay/Clayey Sand, fine to medium grained, medium to high plasticity (Very Loose or Very Soft)	2.5-4.5	-	-
ESTUARINE: Clayey Sand, (medium dense)	4.5-6.3	-	-
RESIDUAL: Clay, high plasticity (Stiff)	6.3-9.5	-	0.1-1.2
Groundwater	2.3	NE*	NE*
Target depth	9.5	3.0	3.0

Table 2 - Summary of Subsurface Profile

Borehole	BH04	BH05	BH06
Description	**Depth below the ground surface (m)**		
ALLUVIAL: Sand, fine to medium grained (Loose)	0-0.5	-	-
RESIDUAL: Sandy Clay, medium plasticity (Soft)	-	0.0-0.5	-
RESIDUAL: Clay, high plasticity (Firm)	0.5-0.9	0.5-1.0	0.2-0.6
RESIDUAL: Clay, high plasticity (Stiff)	0.9-1.25	-	0.6-1.2
Groundwater	NE*	NE*	NE*
Target depth	9.5	3.0	3.0

*Non-Encountered

Groundwater

Groundwater was encountered at 2.3m depth within BH01-LR at the time of the investigation. All other boreholes refused at a maximum depth of 1.25m. It should be noted that groundwater is subject to weather conditions and may fluctuate. No long-term monitoring has been undertaken.

4 LABORATORY TEST RESULTS

Laboratory tests were carried out on selected soil samples collected from the boreholes during the site investigation. Two particle size distribution and moisture content tests were carried out at our NATA accredited laboratory and two soil aggressivity tests were carried out on selected soil samples at our nominated accredited external laboratory.

The laboratory test certificates of the laboratory tests are presented in Appendix D and the results are summarised in Table 2 and 3 below:

Table 2 – Particle Size Distribution Test Results

Borehole	Depth (m)	Moisture (%)	Particle Size Distribution (% passing)		
			1.18mm	0.425mm	0.075mm
BH01-LR	0.5-1.5	5.3	100	94	3

Table 3 – Atterberg Limit & Linear Shrinkage Test Results

Borehole	Depth (m)	Moisture (%)	Atterberg Limits			Linear Shrinkage (%)
			Liquid Limit (%)	Plastic Limit (%)	Plasticity index (%)	
BH01-LR	7.5-8.0	26.3	62	17	45	23.5

Table 4 - Soil Aggressivity Test Results

Test	Unit	BH01-LR (3.0m –3.4m)	BH01-LR (7.1m – 7.5m)
Chloride	mg/kg	31	24
pH	--	8.4	6.2
Conductivity	µS/cm	77	15
Resistivity	Ohm.cm	13000	68000
Sulfate	Mg/kg	12	<10
Moisture	%	21	19
In respect to Concrete		Mild	Non-aggressive
In respect to Steel		Non-aggressive	Non-aggressive

5 RECOMMENDATIONS

5.1 Demolition of Existing Footbridge & Boardwalk: Excavations & Batter Slopes

The material on site was generally dune sand underlain by residual clayey sand/ sandy clay.

The existing bridge should be demolished along with any associated structures and removed from the site. The natural material may both be excavated and re-used as fill on site after drying out the material.

A cut to fill plan was not yet available at the time of writing this report but it is assumed that no significant ‘’cut and fill’’ will be required for the construction of the new footbridge and boardwalk. It is assessed that conventional earth moving equipment such as excavators will be sufficient to excavate the subsurface materials.

The maximum batter slopes or benching should be 1H:2V above the water table level. No excavated vertical cut should be greater than 1.0m depth without being benched or battered.

5.2 Engineered Fill

Any fill being placed on site in order to achieve design subgrade levels should be placed in near-horizontal layers with maximum 300mm thick compacted layers (noting the maximum particle size should not be larger than 2/3^{rds} the layer thickness). The layers should be compacted to at least 95% standard dry density ratio to within 0.6m of the finished subgrade level. The upper 0.6m thickness should be compacted to achieve at least 100% standard dry density ratio, with placement moisture contents being within 2% dry of Optimum Moisture Content (OMC). Any fill being placed more than 0.4m total thickness should be placed under Level 1 geotechnical supervision.

5.3 Suitable Footings & Geotechnical Parameters for Foundation Design

The proposed bridge and boardwalk can be founded on screw or driven pile footings. It is recommended to found the footings for the footbridge within medium dense or better estuarine sand/clayey sand encountered at an approximate depth of 4.5m below the ground surface in BH01-LR located on the western side of the bridge. The western side of the bridge is anticipated to encounter similar consistency material at similar depths. The Boardwalk can also be designed on screw or driven piles on medium dense sands or stiff clays found at approximately 1.0m depth within BH02-LR to BH06-LR. To avoid any differential foundation settlement, it is recommended to found the whole structure on a similar layer and on a similar footing system.

Preliminary design parameters considered appropriate for the pile footings are presented in Table 3.

Table 3 – Recommended Preliminary Geotechnical Design Parameters for Deep Foundation

Description	Approximate Depth * (m)	Allowable End Bearing Pressure (kPa)	Allowable Shaft Adhesion (kPa)
Medium Dense estuarine Clayey Sand/ Sand or Stiff residual Clay	Below 4.5m in BH01-LR or deeper Below 1.0m in BH02-LR to BH06-LR or deeper	250 150	20 15
* It should be noted that the depths are estimated based on the drilled borehole location			

If a deep foundation system is adopted for this project, a minimum socket depth of 500mm is recommended into minimum medium dense alluvial sand with a minimum total depth of 4.5m below the existing surface level for the bridge and 1.5m below the existing surface level for the boardwalk. Where the boardwalk does not have any lateral support, the footings should extend deeper to compensate for the unsupported depth. It is recommended that the pile foundations be designed in accordance with AS 2159-2009 Piling – Design and Installation.

Further advice should be undertaken from a specialist piling contractor to design and install screw piles, should that be the chosen solution. Our allowable bearing pressure is based on a minimum helix diameter.

Based on the drilling investigation, the geotechnical design parameters are recommended in Table 4 below.

Table 4 – Geotechnical Design Parameters

Description	γ (kN/m^3)	C_u (kPa)	c' (kPa)	$\emptyset'$ (degrees)	K_a	K_o	K_p	E (MPa)	ϑ
Estuarine: SAND/Clayey Sand (medium dense)	19	0	0	32	0.31	0.47	3.25	35	0.3
Residual: Clay/Sandy Clay (Stiff)	18	50	5	26	0.39	0.56	2.56	15	0.3

Legend:
$\emptyset'$: Effective Friction Angle
γ: Unit Weight
ϑ: Poisson's Ratio
c': Effective Cohesion, C_u: Undrained cohesion
K_o: Earth pressure at rest
K_a: Active earth pressure
K_p: Passive earth pressure
E: Elasticity Modulus

5.4 Risk from Acid Sulfate and Saline Soils

It is assessed based on the NSW Planning Industry and Environment eSPADE Soil and Land Information map that the site falls an area that has had no occurrence of Acid Sulfate Soils. This indicates that there is minimal risk of acid sulfate soils within the area.

It is assessed that it is unlikely to encounter Saline Soils within the area based on the DIPNR 'Salinity Potential in Western Sydney 2002', dated March 2003. Saline soils generally follow a pattern of being near the creeks and waterways of Western Sydney, typically over shale bedrock.

6 LIMITATIONS

This report has been prepared for Northern Beaches Council to provide geotechnical input and commentary regarding Long Reef Beach footbridge and boardwalk, Long Reef Beach, Collaroy NSW. The findings and recommendations provided here are specific to this site for the purposes outline in this report.

The borehole investigation and test results provided in this report are indicative of the subsurface conditions at the site only at the specific testing locations, and to the depths drilled and tested at the time.

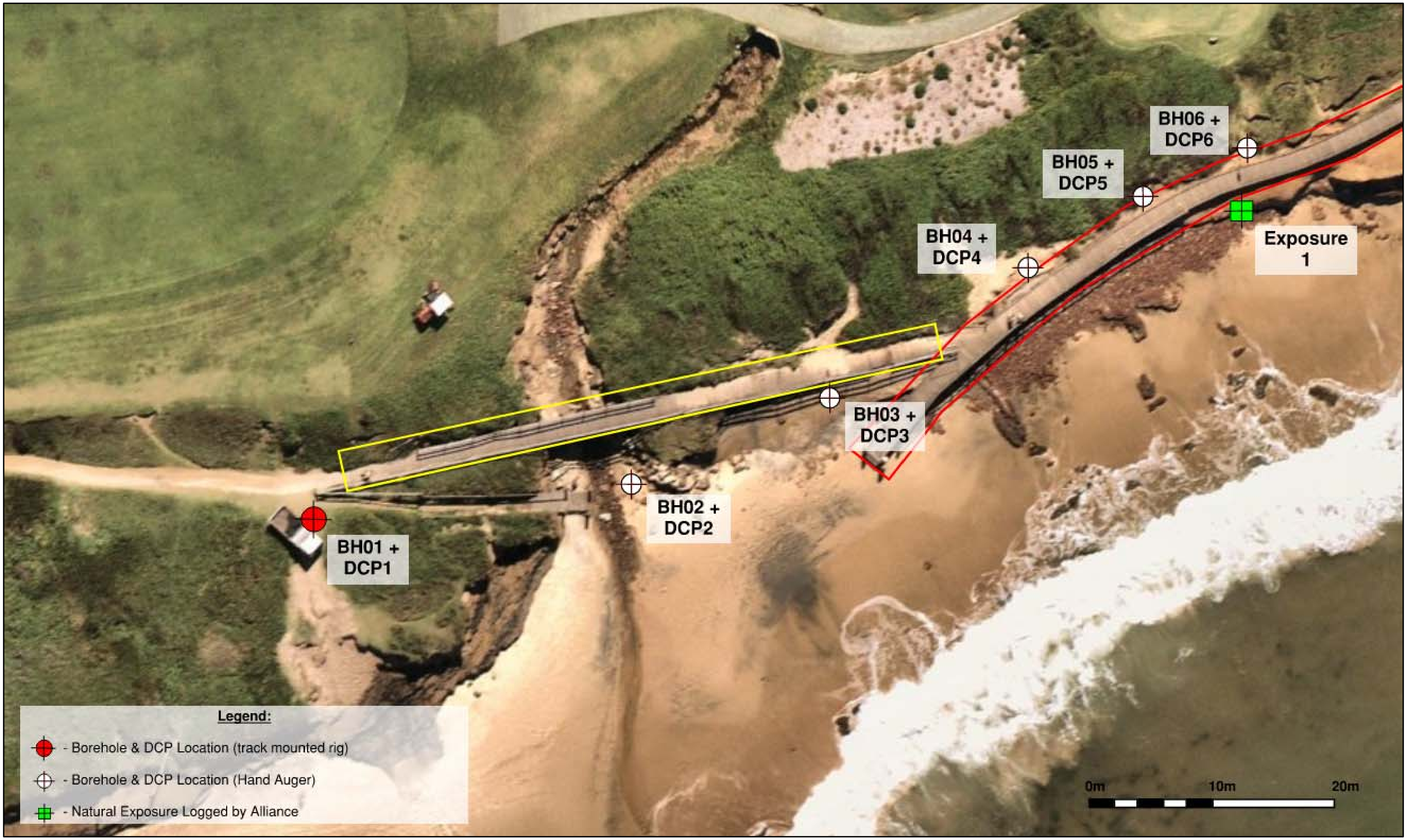
It is recommended that a qualified and experienced Geotechnical Engineer be engaged to provide further input and review during the design development; including site visits during construction to verify the site conditions and provide advice where conditions vary from those assumed in this report.

APPENDIX A – Site Photographs

Photo 1 – BH01-LR facing east towards the headland

Photo 2 – The existing boardwalk

APPENDIX B – Borehole Location Plan (Drawing 14801-GR-1-B)



Site Investigation Plan

alliance	Client Name:	Northern Beaches Council	Figure / Drawing Number:	14801-GR-2-A
	Project Name:	Proposed Footbridge and Boardwalk	Figure / Drawing Date:	02/06/2022
	Project Location:	Long Reef Beach, Collaroy NSW	Report Number:	14801-GR-1-2

N

APPENDIX C – Borehole Logs & Explanatory Notes

alliance
geotechnical & environmental solutions

Borehole Log

Alliance Geotechnical Pty Ltd
T: 1800 288 188
E: office@allgeo.com.au
W: www.allgeo.com.au

BH No: BH01-LR
Sheet: 1 of 2
Job No: 14801

Client: Northern Beaches Council
Project: Bridge Replacement
Location: Long Reef Beach
Started: 5/03/2022
Finished: 5/03/2022
Borehole Size 110 mm

Rig Type: Christie Rig | **Hole Location:** Refer Drawing: 14801-GR-1-B | **Driller:** DR | **Logged:** MS
RL Surface: 6m | **Contractor:** BG Drilling | **Bearing:** --- | **Checked:** ZK

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT				0.0–0.2			SAND, fine grained, yellow-brown, poorly graded.		D	L	DUNE SAND
			5.5	0.5			SAND, fine to medium grained, red-brown, poorly graded.		M	L - MD	
			5.0	1.0							
			4.5	1.5				SPT 4, 5, 6 N=11		MD	
			4.0	2.0							
	GW @ ~2.3m		3.5	2.5			Clayey SAND, fine to medium grained, poorly graded, dark grey/black, trace silt.		W	VL	ALLUVIUM/ESTUARINE
			3.0	3.0				SPT 0, 0, 0 N=0			
			2.5	3.5							
			2.0	4.0			CLAY, medium to high plasticity, grey-dark grey, trace silt and fine grained sand.		MC > PL		
			1.5	4.5			Clayey SAND, fine to medium grained, grey/pale grey, poorly graded, trace silt, with Sandy CLAY layers.	SPT 4, 6, 3 N=9	W	MD	
			1.0	5.0							

alliance
geotechnical & environmental solutions

Borehole Log

Alliance Geotechnical Pty Ltd
T: 1800 288 188
E: office@allgeo.com.au
W: www.allgeo.com.au

BH No: BH01-LR
Sheet: 2 of 2
Job No: 14801

Client: Northern Beaches Council
Project: Bridge Replacement
Location: Long Reef Beach
Started: 5/03/2022
Finished: 5/03/2022
Borehole Size 110 mm

Rig Type: Christie Rig
Hole Location: Refer Drawing: 14801-GR-1-B
Driller: DR
Logged: MS
RL Surface: 6m
Contractor: BG Drilling
Bearing: ---
Checked: ZK

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT			0.5, 0.0	5.5, 6.0			Clayey SAND, fine to medium grained, grey/pale grey, poorly graded, trace silt, with Sandy CLAY layers. *(continued)*	SPT 3, 6, 10 N=16	W	MD	
			-0.5, -1.0, -1.5, -2.0, -2.5, -3.0	6.5, 7.0, 7.5, 8.0, 8.5, 9.0			CLAY, high plasticity, pale grey, trace silt and fine grained sand.	SPT 4, 5, 6 N=11	MC ~ PL	St - VSt; St	RESIDUAL
			-3.5	9.5			CLAY, high plasticity, pale grey with red bands, trace fine grained sand and silt.	SPT 5, 5, 6 N=11			
			-4.0	10.0			Target Depth Borehole BH01-LR terminated at 9.5m				

alliance
geotechnical & environmental solutions

Borehole Log

Alliance Geotechnical Pty Ltd
T: 1800 288 188
E: office@allgeo.com.au
W: www.allgeo.com.au

BH No: BH02-LR
Sheet: 1 of 1
Job No: 14801

Client: Northern Beaches Council
Project: Bridge Replacement
Location: Long Reef Beach
Started: 5/03/2022
Finished: 5/03/2022
Borehole Size 60 mm

Rig Type: HA
RL Surface: 3m
Hole Location: Refer Drawing: 14801-GR-1-B
Contractor: BG Drilling
Driller: MY
Bearing: ---
Logged: MS
Checked: ZK

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
HA	NE						SAND, fine to medium grained, brown, poorly graded.		W	L	ALLUVIUM
							Refusal on Inferred boulder. Borehole BH02-LR terminated at 0.2m				
			2.5	0.5							
			2.0	1.0							
			1.5	1.5							
			1.0	2.0							
			0.5	2.5							
			0.0	3.0							
			-0.5	3.5							
			-1.0	4.0							
			-1.5	4.5							
			-2.0	5.0							

alliance
geotechnical & environmental solutions

Borehole Log

Alliance Geotechnical Pty Ltd
T: 1800 288 188
E: office@allgeo.com.au
W: www.allgeo.com.au

BH No: BH03-LR
Sheet: 1 of 1
Job No: 14801

Client: Northern Beaches Council
Project: Bridge Replacement
Location: Long Reef Beach

Started: 5/03/2022
Finished: 5/03/2022
Borehole Size 60 mm

Rig Type: HA
RL Surface: 4m
Hole Location: Refer Drawing: 14801-GR-1-B
Contractor: Alliance Geotechnical
Driller: MY
Bearing: ---
Logged: MS
Checked: ZK

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
HA	NE						SAND, fine grained, red-brown, poorly graded, trace clay, trace rootlets.		M	L	DUNE SAND
							Sandy CLAY, high plasticity, pale grey mottled red-brown, fine grained sand, trace silt.		MC > PL	F	RESIDUAL
										St	
			3.5	0.5							
										VSt	
			3.0	1.0							
							Sandy CLAY, high plasticity, brown and pale grey mottled red-brown, fine grained sand, trace silt with ironstone gravel.				
							Hand Auger Refusal Borehole BH03-LR terminated at 1.2m				
			2.5	1.5							
			2.0	2.0							
			1.5	2.5							
			1.0	3.0							
			0.5	3.5							
			0.0	4.0							
			-0.5	4.5							
			-1.0	5.0							

geotechnical & environmental solutions

Borehole Log

Alliance Geotechnical Pty Ltd
T: 1800 288 188
E: office@allgeo.com.au
W: www.allgeo.com.au

BH No: BH04-LR
Sheet: 1 of 1
Job No: 14801

Client: Northern Beaches Council
Project: Bridge Replacement
Location: Long Reef Beach

Started: 5/03/2022
Finished: 5/03/2022
Borehole Size 60 mm

Rig Type: HA
RL Surface: 4m
Hole Location: Refer Drawing: 14801-GR-1-B
Contractor: Alliance Geotechnical
Driller: MY
Bearing: ---
Logged: MS
Checked: ZK

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
HA	NE						SAND, fine grained, brown, poorly graded.		M	L	DUNE SAND
							Clayey SAND, fine to medium grained, grey and dark grey, poorly graded, trace silt and organics.		W	MD	RESIDUAL
			3.5	0.5			Clayey SAND, fine to medium grained, pale grey, low plasticity, trace silt.				
			3.0	1.0			Sandy CLAY, medium plasticity, pale grey mottled red, fine grained sand.		MC > PL	St	
							1.0m: with fine ironstone gravel.			VSt	
			2.5	1.5			Hand Auger refusal Borehole BH04-LR terminated at 1.25m				
			2.0	2.0							
			1.5	2.5							
			1.0	3.0							
			0.5	3.5							
			0.0	4.0							
			-0.5	4.5							
			-1.0	5.0							

2.2. NON CORED BOREHOLE (NO COORD) 14801.GPJ GINT STD AUSTRALIA.GDT 8/6/22

alliance
geotechnical & environmental solutions

Borehole Log

Alliance Geotechnical Pty Ltd
T: 1800 288 188
E: office@allgeo.com.au
W: www.allgeo.com.au

BH No: BH05-LR
Sheet: 1 of 1
Job No: 14801

Client: Northern Beaches Council
Project: Bridge Replacement
Location: Long Reef Beach
Started: 5/03/2022
Finished: 5/03/2022
Borehole Size 60 mm

Rig Type: HA | **Hole Location:** Refer Drawing: 14801-GR-1-B | **Driller:** MY | **Logged:** MS
RL Surface: 4m | **Contractor:** Alliance Geotechnical | **Bearing:** --- | **Checked:** ZK

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	NE		3.5	0.5			Sandy CLAY, medium plasticity, pale grey mottled orange and red, fine grained sand, trace fine gravel.		MC > PL	F	RESIDUAL
			3.0	1.0			Sandy CLAY, medium plasticity, pale grey mottled orange red, fine grained sand, trace with silt and ironstone gravel.			St VSt	
			2.5	1.5			Hand Auger refusal Borehole BH05-LR terminated at 1m				
			2.0	2.0							
			1.5	2.5							
			1.0	3.0							
			0.5	3.5							
			0.0	4.0							
			-0.5	4.5							
			-1.0	5.0							

alliance
geotechnical & environmental solutions

Borehole Log

Alliance Geotechnical Pty Ltd
T: 1800 288 188
E: office@allgeo.com.au
W: www.allgeo.com.au

BH No: BH06-LR
Sheet: 1 of 1
Job No: 14801

Client: Northern Beaches Council
Project: Bridge Replacement
Location: Long Reef Beach
Started: 5/03/2022
Finished: 5/03/2022
Borehole Size 60 mm

Rig Type: HA
RL Surface: 5m
Hole Location: Refer Drawing: 14801-GR-1-B
Contractor: Alliance Geotechnical
Driller: MY
Bearing: ---
Logged: MS
Checked: ZK

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
HA	NE						SAND, fine grained, brown, trace with silt.		M	D	DUNE SAND
			4.5	0.5			Sandy CLAY, medium plasticity, brown and dark grey mottled red, trace with silt.		MC > PL	F	RESIDUAL
			4.0	1.0			Sandy CLAY, medium plasticity, brown and grey mottled red, trace with silt and ironstone.			St VSt	
			3.5	1.5			Hand Auger refusal Borehole BH06-LR terminated at 1.2m				
			3.0	2.0							
			2.5	2.5							
			2.0	3.0							
			1.5	3.5							
			1.0	4.0							
			0.5	4.5							
			0.0	5.0							

alliance
geotechnical & environmental solutions

Exposure Log

Alliance Geotechnical Pty Ltd
T: 1800 288 188
E: office@allgeo.com.au
W: www.allgeo.com.au

TP No: E01-LR
Sheet: 1 of 1
Job No: 14801

Client: Northern Beaches Council
Project: Bridge Replacement
Location: Long Reef Beach

Started: 5/03/2022
Finished: 5/03/2022
Test Pit Size - m

Rig Type: Natural Exposure
RL Surface: 5m
Hole Location: Refer Drawing: 14801-GR-1-B
Contractor: -
Driller: -
Bearing: ---
Logged: MS
Checked: ZK

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
N					SC	Clayey SAND, fine to medium grained, poorly graded, pale grey and orange.		M	L	DUNE SAND
		4.5 / 4.0 / 3.5	0.5 / 1.0 / 1.5		CI-CH	Sandy CLAY, medium to high plasticity, pale grey mottled red, fine to medium grained sand, with fine ironstone gravel. % of gravel gradually increasing with depth.		MC ~ PL	St - VSt	RESIDUAL
		3.0 / 2.5	2.0 / 2.5		CG	IRONSTONE (40%) bands and nodules through CLAY matrix (60%). CLAY, high plasticity, pale grey. IRONSTONE, fine grained, red, highly weathered, medium strength.		MC ~ PL	VSt	
		2.0 / 1.5 / 1.0 / 0.5 / 0.0	3.0 / 3.5 / 4.0 / 4.5 / 5.0			Bottom of exposure Test Pit E01-LR terminated at 2.6m				

alliance geotechnical & environmental solutions	Your On-Site Geotechnical Specialists Phone Us Today – 1800 288 188

Dynamic Cone Penetrometer (DCP) Test Report

Client:	Northern Beaches Council	Report Number:	14801-GR-2-1
Project Name:	Proposed Footbridge and Boardwalk	Project Number:	14801
Project Location:	Long Reef Beach	Date Tested:	03/05/2022
Test Method:	AS 1289.6.3.2		

Test Number	DCP-2 (BH02)	DCP-3 (BH03)	DCP-4 (BH04)	DCP-5 (BH05)	DCP-6 (BH06)
Test Locations	Refer to Drawing No. 14805-GR-2-A				
Surface Material	SAND (Moist)				
Depth (metres)					
0.00 – 0.15	4	1	4	2	2
0.15 – 0.30	14	3	6	2	3
0.30 – 0.45	4	4	2	2	4
0.45 – 0.60	5	7	3	3	3
0.60 – 0.75	8	11	4	6	5
0.75 – 0.90	7	14	4	3	5
0.90 – 1.05	10 @50mm	13	6	5	10
1.05 – 1.20	DB Refusal	18	8	12	11
1.20 – 1.35		25+	11	9	13
1.35 – 1.50			13	10	16
1.50 – 1.65			18	16	16
1.65 – 1.80			17	24	12
1.80 – 1.95			22	20	16
1.95 – 2.10			25+	20	18
2.10 – 2.25				25+	25+
2.25 – 2.40					
2.40 – 2.55					
2.55 – 2.70					

Notes:

1. This penetrometer test report is intended to be read in conjunction with the geotechnical report by Alliance Geotechnical (ref: -GR-1-1).

alliance
geotechnical & environmental solutions

Explanatory Notes
Drill & Excavation Logs

GENERAL

Information obtained from site investigations is recorded on log sheets. Soils and very low strength rock are commonly drilled using a combination of solid-flight augers with a Tungsten-Carbide (TC) bit. Descriptions of these materials presented on the “Borehole Log” are based on a combination of regular sampling and in-situ testing. Rock coring techniques commences once material is encountered that cannot be penetrated using a combination of solid-flight augers and Tungsten-carbide bit. The "Cored Borehole Log" presents data from drilling where a core barrel has been used to recover material - commonly rock.

The "Excavation - Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits or trenches.

The heading of the log sheets contains information on Project Identification, Hole or Test Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material description and structure presented as a series of columns in relation to depth below the ground surface which is plotted on the left side of the log sheet. The scale is presented in the depth column as metres below ground level.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is included in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures, and geological unit. Material description and classifications are based on Australian Standard Geotechnical Site Investigations: AS 1726 - 2017 with some modifications as defined below.

These notes contain an explanation of the terms and abbreviations commonly used on the log sheets.

DRILLING

Drilling, Casing and Excavating

Drilling methods deployed are abbreviated as follows

AS	Auger Screwing
ADV	Auger Drilling with V-Bit
ADT	Auger Drilling with TC Bit
BH	Backhoe
E	Excavator
HA	Hand Auger
HQ	HQ core barrel (~63.5 mm diameter core) *
HMLC	HMLC core barrel (~63.5 mm diameter core) *
NMLC	NMLC core barrel (~51.9 mm diameter core) *
NQ	NQ core barrel (~47.6 mm diameter core) *
RR	Rock Roller
WB	Wash-bore drilling

* Core diameters are approximate and vary due to the strength of material being drilled.

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage. It is introduced to assist with the drill process, in particular, when core drilling. The introduction of drill fluid/water does not allow for accurate identification of water seepages.

Drilling Penetration/Drill Depth

Core lifts are identified by a line and depth with core loss per run as a percentage. Ease of penetration in non-core drilling is abbreviated as follows:

VE	Very Easy
E	Easy
F	Firm
H	Hard
VH	Very Hard

GROUNDWATER LEVELS

Date of measurement is shown.

Standing water level measured in completed borehole

Level taken during or immediately after drilling

Groundwater inflow water level

SAMPLES/TESTS

Samples collected and testing undertaken are abbreviated as follows

ES	Environmental Sample
DS	Disturbed Sample
BS	Bulk Sample
U50	Undisturbed (50 mm diameter)
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (*sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Device
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer Test
HB	Hammer Bouncing

EXCAVATION LOGS

Explanatory notes are provided at the bottom of drill log sheets. Information about the origin, geology and pedology may be entered in the "Structure and other Observations" column. The depth of the base of excavation (for the logged section) at the appropriate depth in the "Material Description" column. Refusal of excavation plant is noted should it occur. A sketch of the exposure may be added.

MATERIAL DESCRIPTION – SOIL

Material Description - In accordance with AS 1726-2017

Classification Symbol - In accordance with the Unified Classification System (AS 1726-2017).

Abbreviation	Typical Names
GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures.
SW	Well graded sands, gravelly sands, little or no fines.
SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands.
SM	Silty sand, sand-silt mixtures.
SC	Clayey sands, sand-clay mixtures.
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
OL	Organic silts and organic silty clays of low plasticity. *
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, clastic silts.
CH	Inorganic clays of high plasticity, fat clays
OH	Organic clays of medium to high plasticity, organic silts. *
Pt	Peat and other highly organic soils. *

* Additional details may be provided in accordance with the Von Post classification system (1922).

Organic Soils - Identification using laboratory testing:

Material	Organic Content - % of dry mass
Inorganic	<2
Organic Soil	<2 ≤ 25
Peat	> 25

Organic Soils - Descriptive terms for the degree of decomposition of peat:

Term	Decomposition	Remains	Squeeze
Fibrous	Little or none	Clearly recognizable	Only water No solid
Pseudo-fibrous	Moderate	Mixture of fibrous and amorphous	Turbid water < 50% solids
Amorphous	Full	Not recognizable	Paste > 50% solids

Particle Characteristics– Definitions are as follows:

Fraction	Component (& subdivision)		Size (mm)
Oversize	Boulders		> 200
	Cobbles		> 63 ≤ 200
Coarse grained soils	Gravel	Coarse	> 19 ≤ 63
		Medium	> 6.7 ≤ 19
		Fine	> 2.36 ≤ 6.7
	Sand	Coarse	> 0.6 ≤ 2.36
		Medium	> 0.2 ≤ 0.6
		Fine	> 0.075 ≤ 0.21
Fine grained soils	Silt		0.002 ≤ 0.075
	Clay		< 0.002

Secondary and minor soil components

In coarse grained soils – The proportions of secondary and minor components are generally estimated from a visual and tactile assessment of the soils. Descriptions for secondary and minor soil components in coarse grained soils are as follows.

Designation of components	Percentage fines	Terminology (as applicable)	Percentage accessory coarse fraction	Terminology (as applicable)
Minor	≤ 5	Trace clay / silt	≤ 5	Trace sand / gravel
	> 5 ≤12	With clay / silt	> 5 ≤12	With sand / gravel
Secondary	> 12	Silty or clayey	> 30	Sandy or gravelly

Descriptions for secondary and minor soil components in fine grained soils are as follows.

Designation of components	Percentage coarse grained soils	Terminology (as applicable)
Minor	≤ 5	Trace sand / gravel / silt / clay
	> 5 ≤12	With sand / gravel / silt / clay
Secondary	> 30	Sandy / gravelly / silty / clayey

Plasticity Terms – Definitions for fine grained soils are as follows:

Descriptive Term	Range of Liquid Limit for silt	Range of Liquid Limit for clay
Low Plasticity	≤ 50	≤ 35
Medium Plasticity	N/A	> 35 ≤50
High Plasticity	> 50%	> 50

Particle Characteristics

Particle shape and angularity are estimated from a visual assessment of coarse-grained soil particle characteristics. Terminology used includes the following:

Particle shape – spherical, platy, elongated,

Particle angularity –angular, sub-angular, sub-rounded, rounded.

Moisture Condition – Abbreviations are as follows:

D	Dry, looks and feels dry
M	Moist, No free water on remoulding
W	Wet, free water on remoulding

Moisture content of fine-grained soils is based on judgement of the soils moisture content relative to the plastic and liquid limit as follows:

MC < PL	Moist, dry of plastic limit
MC ≈ PL	Moist, near plastic limit
MC > PL	Moist, wet of plastic limit
MC ≈ LL	Wet, near liquid limit
MC > LL	Wet of liquid limit

Consistency - of cohesive soils in accordance with AS 1726-2017, Table 11 are abbreviated as follows:

Consistency Term	Abbreviation	Indicative Undrained Shear Strength Range (kPa)
Very Soft	**VS**	< 12
Soft	**S**	12 ≤ 25
Firm	**F**	25 ≤ 50
Stiff	**St**	50 ≤ 100
Very Stiff	**VSt**	100 ≤ 200
Hard	**H**	≥ 200
Friable	**Fr**	-

Density Index (%) of granular soils is estimated or is based on SPT results. Abbreviations are as follows:

Description	Abbreviation	Relative Density	SPT N
Very Loose	VL	< 15%	0 - 4
Loose	L	15 - 35%	4 - 10
Medium Dense	MD	35 - 65%	10 - 30
Dense	D	65 - 85%	30 - 50
Very Dense	VD	> 85%	> 50

Structures - Fissuring and other defects are described in accordance with AS 1726-2017 using the terminology for rock defects

Origin - Where practicable an assessment is provided of the probable origin of the soil, e.g. fill, topsoil, alluvium, colluvium, residual soil.

MATERIAL DESCRIPTION - ROCK

Material Description

Descriptions of rock for geotechnics and engineering geology in civil engineering

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-2017.

Rock Naming – Where possible conventional geological names are used within the logs. Engineering properties cannot be inferred directly from the rock names in the table, but the use of a particular name provides an indicative range of characteristics to the reader. Lithological identification of rock is provided to appreciate the geology of an area, to correlate geological profiles seen in boreholes or to distinguish boulders from bedrock.

Grain Size – Grain size is done in accordance with AS1726-2017 as follows:

Coarse grained	Mainly 0.6 to 2 mm
Medium grained	0.2 – 0.6 mm
Fine grained	0.06 – 0.2 mm

Colour – Rock colour is described in the moist condition.

Texture and Fabric - Frequently used terms include:

Sedimentary Rock	Metamorphic Rock	Igneous
Bedded	Cleaved	Massive
Interbedded	Foliated	Flow banded
Laminated	Schistose	Folded
Folded	Banded	Lineated
Massive	Lineated	Porphyritic
Graded	Gneissose	Crystalline
Cross-bedded	Folded	Amorphous

Bedding and Laminated – AS 1726 – 2017 bedding and laminated rock descriptions are provided below with additional detail from BS EN ISO 14689-1 as guidance.

Description	Spacing (mm)
Very Thickly Bedded	> 2000
Thickly Bedded	> 600 ≤ 2000
Medium Bedded	> 200 ≤ 600
Thinly Bedded	> 60 ≤ 200
Very Thinly Bedded	> 20 ≤ 60
Thickly Laminated	> 6 ≤ 20
Thinly Laminated	< 6

Features, inclusions and minor components – Features, inclusions and minor components within the rock material shall be described where those features could be significant such as gas bubbles, mineral veins, carbonaceous material, salts, swelling minerals, mineral inclusions, ironstone or carbonate bands, cross-stratification or minerals the readily oxidise upon atmospheric exposure.

Moisture content – Where possible descriptions are made by the feel and appearance of the rock using one according to following terms:

Dry	Looks and feels dry.
Moist	Feels cool, darkened in colour, but no water is visible on the surface
Wet	Feels cool, darkened in colour, water film or droplets visible on the surface

The moisture content of rock cored with water may not be representative of its in-situ condition.

Durability – Descriptions of the materials durability such as tendency to develop cracks, break into smaller pieces or disintegrate upon exposure to air or in contact with water are provided where observed.

Rock Material Strength – The strength of the rock material is based on uniaxial compressive strength (UCS). The following terms are used:

Rock Strength Class	Abbreviation	UCS (MPa)	Point Load Strength Index, $I_{s(50)}$ (MPa)
Very Low	VL	> 0.6 ≤ 2	> 0.03 ≤ 0.1
Low	L	> 2 ≤ 6	> 0.1 ≤ 0.3
Medium	M	> 6 ≤ 20	> 0.3 ≤ 1
High	H	> 20 ≤ 60	> 1 ≤ 3
Very High	VH	> 60 ≤ 200	> 3 ≤ 10
Extremely High	EH	> 200	> 10

Strengths are estimated and where possible supported by Point Load Index Testing of representative samples. Test results are plotted on the graphical logs as follows:

D	Diametral Point Load Test
A	Axial Point Load Test

Where the estimated strength log covers more than one range it indicates the rock strength varies between the limits shown. Point Load Strength Index test results are presented as $I_{s\,(50)}$ values in MPa.

Weathering - Weathering classification assists in identification but does not imply engineering properties. Descriptions are as follows:

Term (Abbreviation)	Description
Fresh (FR)	No signs of mineral decomposition or colour change.
Slightly Weathered (SW)	partly stained or discoloured. Not or little change to strength from fresh rock.
Moderately Weathered (MW)	material is completely discoloured, little or no change of strength from fresh rock.
Highly Weathered (HW)	material is completely discoloured, significant decrease in strength from fresh rock.
Extremely Weathered (EW)	Material has soil properties. Mass structure, material texture and fabric of original rock are still visible.
Residual Soil (RS)	Material has soil properties. Mass structure and material texture and fabric of original rock not visible, but the soil has not been significantly transported.

Alteration – Physical and chemical changes of the rock material due to geological processes by fluids at depth at pressures and temperatures above atmospheric conditions. Unlike weathering, alteration shows no relationship to topography and may occur at any depth. When altered materials are recognized, the following terms are used:

<table>
<tr><th colspan="2">Term</th><th colspan="2">Abbreviation</th><th>Definition</th></tr>
<tr><td colspan="2">Extremely Altered</td><td colspan="2">XA</td><td>Material has soil properties.
Structure, texture and fabric of original rock are still visible.
The rock name is replaced with the name of the parent material, e.g. Extremely Altered basalt.
Soil descriptive terms are used.</td></tr>
<tr><td>Highly Altered</td><td rowspan="2">Distinctly altered</td><td>HA</td><td rowspan="2">DA</td><td>The whole of the rock material is discoloured.
Rock strength is changed by alteration.
Some primary minerals are altered to clay minerals.
Porosity may be higher or lower due to loss of minerals or precipitation of secondary minerals in pores.</td></tr>
<tr><td>Moderately Altered</td><td>MA</td><td>The whole of the rock material is discoloured
Little or no change of strength from fresh rock.
The term ‘Distinctly Altered’ is used where it is not practicable to distinguish between ‘Highly Altered’ and ‘Moderately Altered’.
Distinctly Altered is defined as follows:
The rock may be highly discoloured;
Porosity may be higher due to mineral loss; or may be lower due to precipitation of secondary minerals in pores; and
Some change of rock strength.</td></tr>
<tr><td colspan="2">Slightly Altered</td><td colspan="2">SA</td><td>Rock is slightly discoloured
Little or no change of strength from fresh rock.</td></tr>
</table>

Alteration is only described in the context of the project where it has relevance to the civil and structural design.

Defect Descriptions

General and Detailed Descriptions – Defect descriptions are provided to suit project requirements. Generalized descriptions are used for some projects where it is unnecessary to describe each individual defect in a rock mass, or where multiple similar defects are present which are too numerous to log individually. The part of the rock mass to which this applies is delineated.

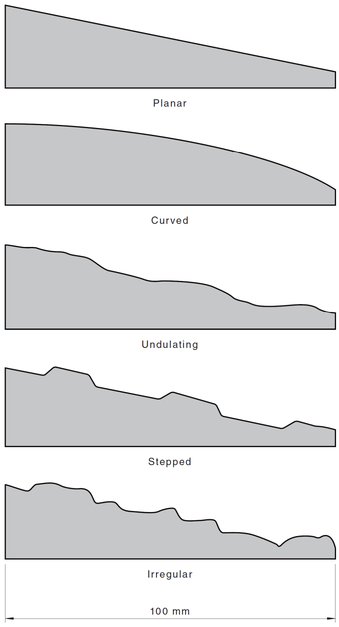
Detailed descriptions are given of defects judged to be particularly significant in the context of the project. For example, crushed seams in an apparently unstable slope. As a minimum, general descriptions outlining the number of defect sets within the rock mass and their broad characteristics are provided where it is possible to do so.

Defect Type – Defect abbreviations are as follows:

BP	Bedding Parting	FL	Foliation	SP	Shear Plane
CL	Cleavage	FZ	Fracture Zone	SZ	Shear Zone
CS	Crushed Seam	HB	Handling break	VN	Vein
DB	Drilling break	JT	Joint		
DL	Drill Lift	SM	Seam		

Defect Orientation – The dip and dip direction are recorded as a two-digit and three-digit number separated by a slash, e.g. 50/240 only when orientated core are collected and there is not core loss that could obscure core orientation. If alternative measurements are made, such as dip and strike or dip direction relative to magnetic north this shall be documented.

Surface Shape –At the medium scale of observation, description of the roughness of the surface shall be enhanced by description of the shape of the defect surface using the following terms, as illustrated below:



Defect Coatings and Seam Composition – Coatings are described using the following terms:

(a) *Clean* No visible coating.
(b) *Stained* No visible coating but surfaces are discoloured.
(c) *Veneer* A visible coating of soil or mineral, too thin to measure; may be patchy.
(d) *Coating* A visible coating up to 1 mm thick. Soil in-fill greater than 1 mm shall be described using defect terms (e.g. infilled seam). Defects greater than 1 mm aperture containing rock material great described as a vein.

Defect Spacing, Length, Openness and Thickness –described directly in millimetres and metres. In general descriptions, half order of magnitude categories are used, e.g. joint spacing typically 100 mm to 300 mm, sheared zones 1 m to 3 m thick.

Depending on project requirements and the scale of observation, spacing may be described as the mean spacing within a set of defects, or as the spacing between all defects within the rock mass. Where spacing is measured within a specific set of defects, measurements shall be made perpendicular to the defect set.

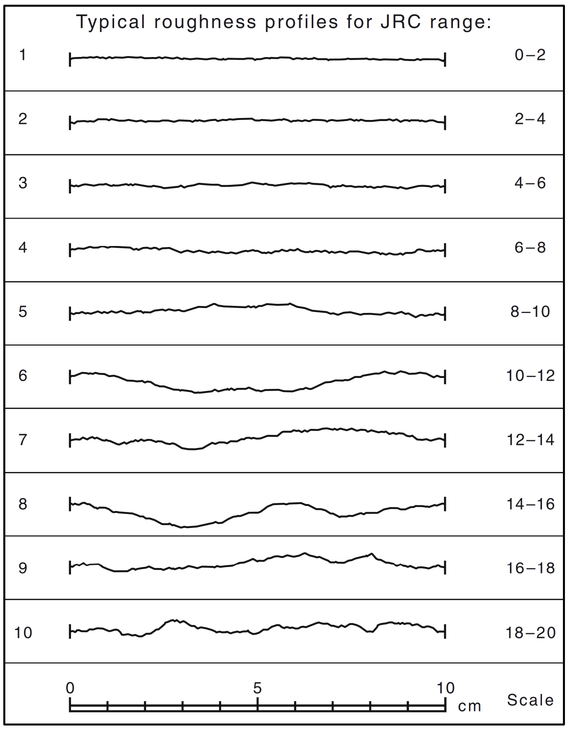
Defect spacing and length (sometimes called persistence), shall be described directly inmillimetres and metres.

Stratigraphic Unit - Geological maps related to the project are used for the designation of lithological formation name and, where possible geological unit name, e.g. Bringelly Shale, Potts Hill Sandstone Member.

Defect Roughness and Shape – Defect surface roughness is described as follows:

Very rough	Many large surface irregularities with amplitude generally more than 1 mm.
Rough	Many small surface irregularities with amplitude generally less than 1 mm.
Smooth	Smooth to touch. Few or no surface irregularities.
Polished	Shiny smooth surface
Slickensided	Grooved or striated surface, usually polished.

Where applicable Joint Roughness Range (JRC) is provided as follows:



Joint roughness profiles and corresponding JRC range based on Barton, N and Choubey, V. The Shear Strength of Rock Joints in Theory and Practice. *Rock Mechanics.* Vol. 10 (1977), pp. 1–54.

Where possible the mineralogy of the coating is identified.

Defect Infilling - abbreviated as follows:

CA	Calcite	KT	Chlorite
CN	Clean	MS	Secondary Mineral
Cy	Clay	MU	Unidentified Mineral
CS	Crushed Seam	Qz	Quartz
Fe	Iron Oxide	X	Carbonaceous

Parameters Related to Core Drilling

Total Core Recovery – T

Defect Spacing or Fracture Index – T

Rock Quality Designation – Y

Core Loss – Core loss occurs when material is lost during the drilling process It is shown at the bottom of the run unless otherwise indicated where core loss is known.

APPENDIX E – Laboratory Test Certificates

Material Test Report

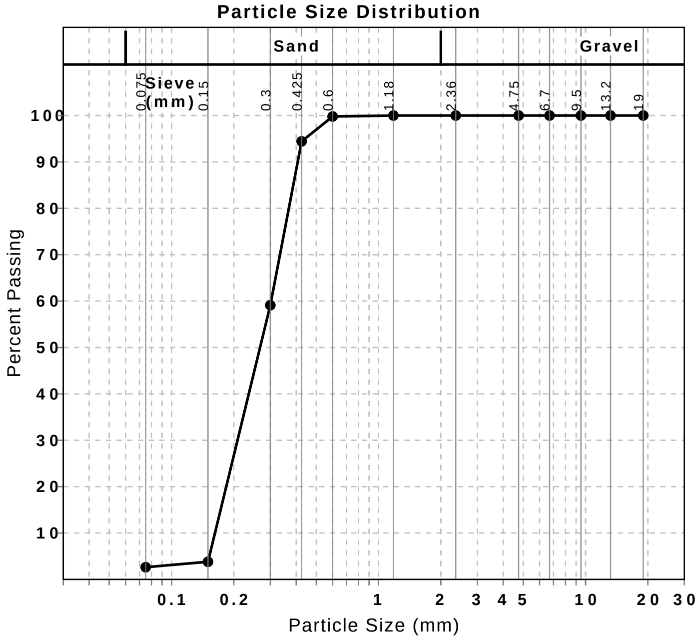
Report Number:	**14801-2**
Issue Number:	1
Date Issued:	10/05/2022
Client:	Alliance Geotechnical
	10 Welder Road, Seven Hills NSW 2147
Contact:	Matt Swinbourn
Project Number:	14801
Project Name:	Bridge Replacement - Tyagarah
Project Location:	Tyagarah Reserve
Work Request:	19000
Sample Number:	22-19000A
Date Sampled:	28/02/2022
Dates Tested:	04/05/2022 - 06/05/2022
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Sample Location:	**BH01 - LR, Depth: 0.5-1.5m**
Material:	SAND, fine to medium grained, trace clay/silt, red brown

alliance
geotechnical & environmental solutions
Alliance Geotechnical Pty Ltd
10 Welder Road Seven Hills NSW 2147
PO Box 275, Seven Hills NSW 1730
Phone: 1800 288 188
Email: brett@allgeo.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Brett Bellingham
Conformance Testing Manager
NATA Accredited Laboratory Number: 15100

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
19 mm	**100**		
13.2 mm	**100**		
9.5 mm	**100**		
6.7 mm	**100**		
4.75 mm	**100**		
2.36 mm	**100**		
1.18 mm	**100**		
0.6 mm	**100**		
0.425 mm	**94**		
0.3 mm	**59**		
0.15 mm	**4**		
0.075 mm	**3**		



Material Test Report

Report Number:	**14801-2**
Issue Number:	1
Date Issued:	10/05/2022
Client:	Alliance Geotechnical 10 Welder Road, Seven Hills NSW 2147
Contact:	Matt Swinbourn
Project Number:	14801
Project Name:	Bridge Replacement - Tyagarah
Project Location:	Tyagarah Reserve
Work Request:	19000
Sample Number:	22-19000B
Date Sampled:	28/02/2022
Dates Tested:	04/05/2022 - 09/05/2022
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Sample Location:	**BH01 - LR, Depth: 7.5-8.0m**
Material:	CLAY, high plasticity, pale grey, trace silt and trace fine sand

alliance
geotechnical & environmental solutions
Alliance Geotechnical Pty Ltd
10 Welder Road Seven Hills NSW 2147
PO Box 275, Seven Hills NSW 1730
Phone: 1800 288 188
Email: brett@allgeo.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Brett Bellingham
Conformance Testing Manager
NATA Accredited Laboratory Number: 15100

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	62		
Plastic Limit (%)	17		
Plasticity Index (%)	**45**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.1		
Linear Shrinkage (%)	23.5		
Cracking Crumbling Curling	Curling		

Material Test Report

Report Number:	**14801-2**
Issue Number:	1
Date Issued:	10/05/2022
Client:	Alliance Geotechnical 10 Welder Road, Seven Hills NSW 2147
Contact:	Matt Swinbourn
Project Number:	14801
Project Name:	Bridge Replacement - Tyagarah
Project Location:	Tyagarah Reserve
Work Request:	19000
Date Sampled:	28/02/2022
Dates Tested:	04/05/2022 - 05/05/2022
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Location:	Tyagarah Reserve

alliance
geotechnical & environmental solutions
Alliance Geotechnical Pty Ltd
10 Welder Road Seven Hills NSW 2147
PO Box 275, Seven Hills NSW 1730
Phone: 1800 288 188
Email: brett@allgeo.com.au

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Brett Bellingham
Conformance Testing Manager
NATA Accredited Laboratory Number: 15100

Moisture Content AS 1289 2.1.1			
Sample Number	Sample Location	Moisture Content (%)	Material
22-19000A	BH01 - LR, Depth: 0.5-1.5m	5.3 %	SAND, fine to medium grained, trace clay/silt, red brown
22-19000B	BH01 - LR, Depth: 7.5-8.0m	26.8 %	CLAY, high plasticity, pale grey, trace silt and trace fine sand

eurofins | Environment Testing

Certificate of Analysis

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates.

Alliance Geotechnical
10 Welder Road
Seven Hills
NSW 2147

Attention: **Zubair Khan**

Report **886101-S**
Project name LONG REEF
Project ID 14801
Received Date May 04, 2022

Client Sample ID			**BH01-LR 3.0-3.4**	**BH01-LR 7.1-7.5**
Sample Matrix			**Soil**	**Soil**
Eurofins Sample No.			**S22-My0015727**	**S22-My0015728**
Date Sampled			**May 03, 2022**	**May 03, 2022**
Test/Reference	LOR	Unit		
Chloride	10	mg/kg	31	24
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	77	15
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	8.4	6.2
Resistivity*	0.5	ohm.m	130	680
Sulphate (as SO4)	10	mg/kg	12	< 10
% Moisture	1	%	21	19

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Chloride	Sydney	May 11, 2022	28 Days
- Method: LTM-INO-4270 Anions by Ion Chromatography			
Conductivity (1:5 aqueous extract at 25°C as rec.)	Sydney	May 11, 2022	7 Days
- Method: LTM-INO-4030 Conductivity			
pH (1:5 Aqueous extract at 25°C as rec.)	Sydney	May 11, 2022	7 Days
- Method: LTM-GEN-7090 pH by ISE			
Sulphate (as SO4)	Sydney	May 11, 2022	28 Days
- Method: In-house method LTM-INO-4270 Sulphate by Ion Chromatograph			
% Moisture	Sydney	May 06, 2022	14 Days
- Method: LTM-GEN-7080 Moisture			

Company Name:	Alliance Geotechnical	**Order No.:**		**Received:**	May 4, 2022 5:44 PM
Address:	10 Welder Road Seven Hills NSW 2147	**Report #:**	886101	**Due:**	May 12, 2022
		Phone:	1800 288 188	**Priority:**	5 Day
		Fax:	02 9675 1888	**Contact Name:**	Zubair Khan
Project Name:	LONG REEF				
Project ID:	14801				

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Aggressivity Soil Set	Moisture Set
Melbourne Laboratory - NATA # 1261 Site # 1254							
Sydney Laboratory - NATA # 1261 Site # 18217						X	X
Brisbane Laboratory - NATA # 1261 Site # 20794							
Mayfield Laboratory - NATA # 1261 Site # 25079							
Perth Laboratory - NATA # 2377 Site # 2370							
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	BH01-LR 3.0-3.4	May 03, 2022		Soil	S22-My0015727	X	X
2	BH01-LR 7.1-7.5	May 03, 2022		Soil	S22-My0015728	X	X
Test Counts						2	2

eurofins | Environment Testing

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**μg/L:** micrograms per litre
ppm: parts per million	**ppb:** parts per billion	**%:** Percentage
org/100 mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100 mL:** Most Probable Number of organisms per 100 millilitres

Terms

APHA	American Public Health Association
COC	Chain of Custody
CP	Client Parent - QC was performed on samples pertaining to this report
CRM	Certified Reference Material (ISO17034) - reported as percent recovery.
Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
LOR	Limit of Reporting.
LCS	Laboratory Control Sample - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
SRA	Sample Receipt Advice
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
TBTO	Tributyltin oxide (*bis*-tributyltin oxide) - individual tributyltin compounds cannot be identified separately in the environment however free tributyltin was measured and its values were converted stoichiometrically into tributyltin oxide for comparison with regulatory limits.
TCLP	Toxicity Characteristic Leaching Procedure
TEQ	Toxic Equivalency Quotient or Total Equivalence
QSM	US Department of Defense Quality Systems Manual Version 5.4
US EPA	United States Environmental Protection Agency
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

The acceptance criteria should be used as a guide only and may be different when site specific Sampling Analysis and Quality Plan (SAQP) have been implemented

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR: No Limit

Results between 10-20 times the LOR: RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% for Speciated Phenols & 50-150% for PFAS

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.4 where no positive PFAS results have been reported have been reviewed and no data was affected.

.

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

eurofins | Environment Testing

Quality Control Results

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank									
Chloride			mg/kg	< 10			10	Pass	
Conductivity (1:5 aqueous extract at 25°C as rec.)			uS/cm	< 10			10	Pass	
Sulphate (as SO4)			mg/kg	< 10			10	Pass	
LCS - % Recovery									
Chloride			%	98			70-130	Pass	
Conductivity (1:5 aqueous extract at 25°C as rec.)			%	93			70-130	Pass	
Resistivity*			%	93			70-130	Pass	
Sulphate (as SO4)			%	95			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
				Result 1					
Chloride	S22-My0019061	NCP	%	106			70-130	Pass	
Sulphate (as SO4)	S22-My0019061	NCP	%	102			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
				Result 1	Result 2	RPD			
Chloride	S22-Ma17668	NCP	mg/kg	120	120	<1	30%	Pass	
Conductivity (1:5 aqueous extract at 25°C as rec.)	S22-My0023942	NCP	uS/cm	230	190	17	30%	Pass	
pH (1:5 Aqueous extract at 25°C as rec.)	S22-My0023942	NCP	pH Units	5.3	5.3	<1	30%	Pass	
Resistivity*	S22-My0023942	NCP	ohm.m	44	53	17	30%	Pass	
Sulphate (as SO4)	S22-Ma17668	NCP	mg/kg	72	72	1.0	30%	Pass	
% Moisture	S22-My0015692	NCP	%	12	14	15	30%	Pass	

eurofins | Environment Testing

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	No
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised by:

Robert Biviano	Analytical Services Manager
Harsha Kothalawala	Senior Analyst-Inorganic

Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Eurofins shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall Eurofins be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

APPENDIX E
Aboriginal Heritage Site Re-recording Form
(by Aboriginal Heritage Office)

Northern Beaches Council - Central

ABORIGINAL HERITAGE SITE RE-RECORDING FORM
SITE: NBCC#190

NPWS SITE NO: 45-6-0741
SITE NAME: QP3 [Long Reef Aquatic Reserve]
SITE TYPE: MIDDEN

Grid Reference (GPS):
GPS 2001&2006 and GIS. Accuracy = 1 (good)

AMG 66

	3	**4**	**3**	3	6	6	mE
6	2	**6**	**4**	8	5	0	mN

GDA 94

	3	**4**	**3**	4	7	0	mE
6	2	**6**	**5**	0	4	0	mN

Previous AMG
As recorded on original NPWS site card. Accuracy of NPWS AMG is moderate. 343470 mE 6264880 mN
AHIMS 2013 figures are slightly NNE of AHO but within site boundary. Accuracy is good. GDA 343480 6265043

LOCATION

At northern end of Long Reef Beach, at signs for Long Reef Beach Aquatic Reserve. South of Golf Course. On deflating area.
(NPWS site card) [at boardwalk, a few metres from where rocky headland starts].

UBD Map showing location of site

DESCRIPTION

Poor, eroding badly

Dashed red line shows rough area where shell has been seen.

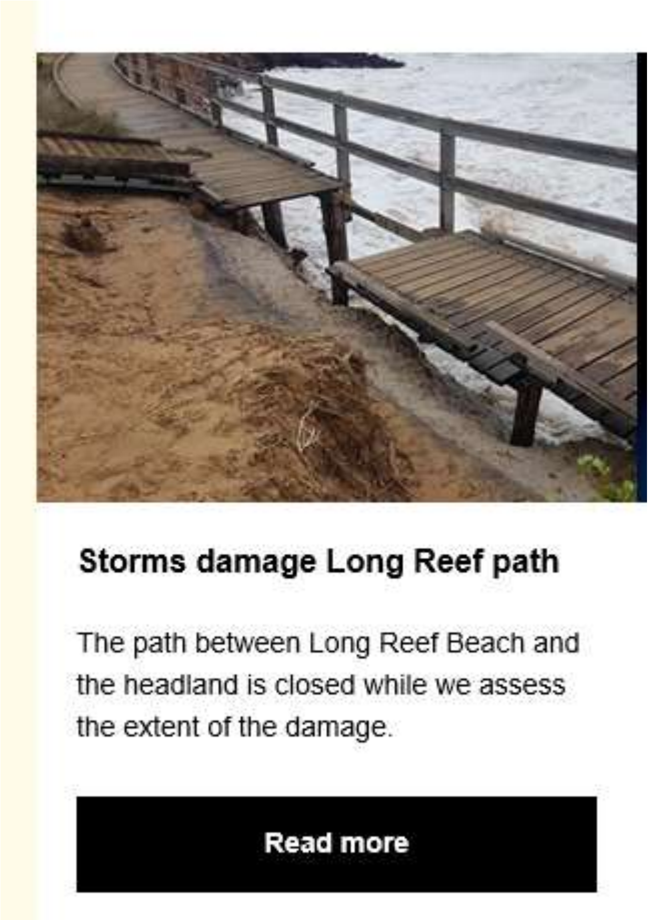
CONDITION:

Aboriginal Heritage Office

Aboriginal Site Monitor
AHO Site # NBCC#190 AHIMS Site # 45-6-0741

DATE	REASON	OFFICER/VOL	COMMENTS
	Eg track work, reg monitor etc	AHO officer, Council or volunteer	Brief comment, eg no change; new graffiti; etc
22/11/01	Monitor		Very badly eroded area (in storm impact area).
		Very few shells located half way down the eroded bank. There is a boardwalk and from a brief observation people kept to the boardwalk. Damage to area appears largely natural.	
17/03/06	Monitor		Very low density shell layer in eroded bank profile. High seas are eroding bank. Similar to previous.
28/1/2010	Review	Phil Hunt	Revise location on AHIMS to reflect position GDA 343470 6265040
14/04/2014	Monitor	Phil Hunt, Gareth Birch, Athena Mumbulla	Monitoring with photos. Edge erosion evident. Possible artefact found (DSC 0453-454). Plan and aerial added. AHIMS 2013 have GDAs about 12m to the NNE of AHO but is within midden boundary. No need to update either entry.
7/6/16	Monitor	Phil Hunt	Monitor after big 5th June 2.05m tide and storm.
	Evidence of splash impacts but largescale erosion noted. One small artefact noted eroding from a midden area close to the track (see photos). Probably quartz, broad flake, 14mm x 9mm x 4mm. Possible usewear at narrow end.		
24/10/18	Coastal Erosion Project	Dani Mitchell, Taylar Reid	Significant erosion on the north east end of site. Almost no shell remains
25/8/21	Update	Phil Hunt, Susan Whitby	Northern Beaches Council news update showing damage to boardwalk.

PHOTOS TAKEN:
2021



Storms damage Long Reef path

The path between Long Reef Beach and the headland is closed while we assess the extent of the damage.

Read more

2018

P1060680 NE end of site, looking SW

P1060681 Replicating 2014 photo 0465

2016

DSC-3237 area of midden

3238 shell and artefact (circled)


DSC-3241 flake found eroding from deposit


3242


DSC-3235

2014 DSC-0453-0468


0462 looking north


0463


DSC-0453 possible split pebble


DSC-0457 location of split pebble


DSC-0460


0461


0464 - Shell


0465 - Shell


0466 - Shell


0467


0468

2006 [3380-3386]


3380 3381 Shell exposed by sea.

3386 Location, looking north – note beginning of rocky headland on right.


3382 low density shell in profile. 3383 Fragments by boardwalk.

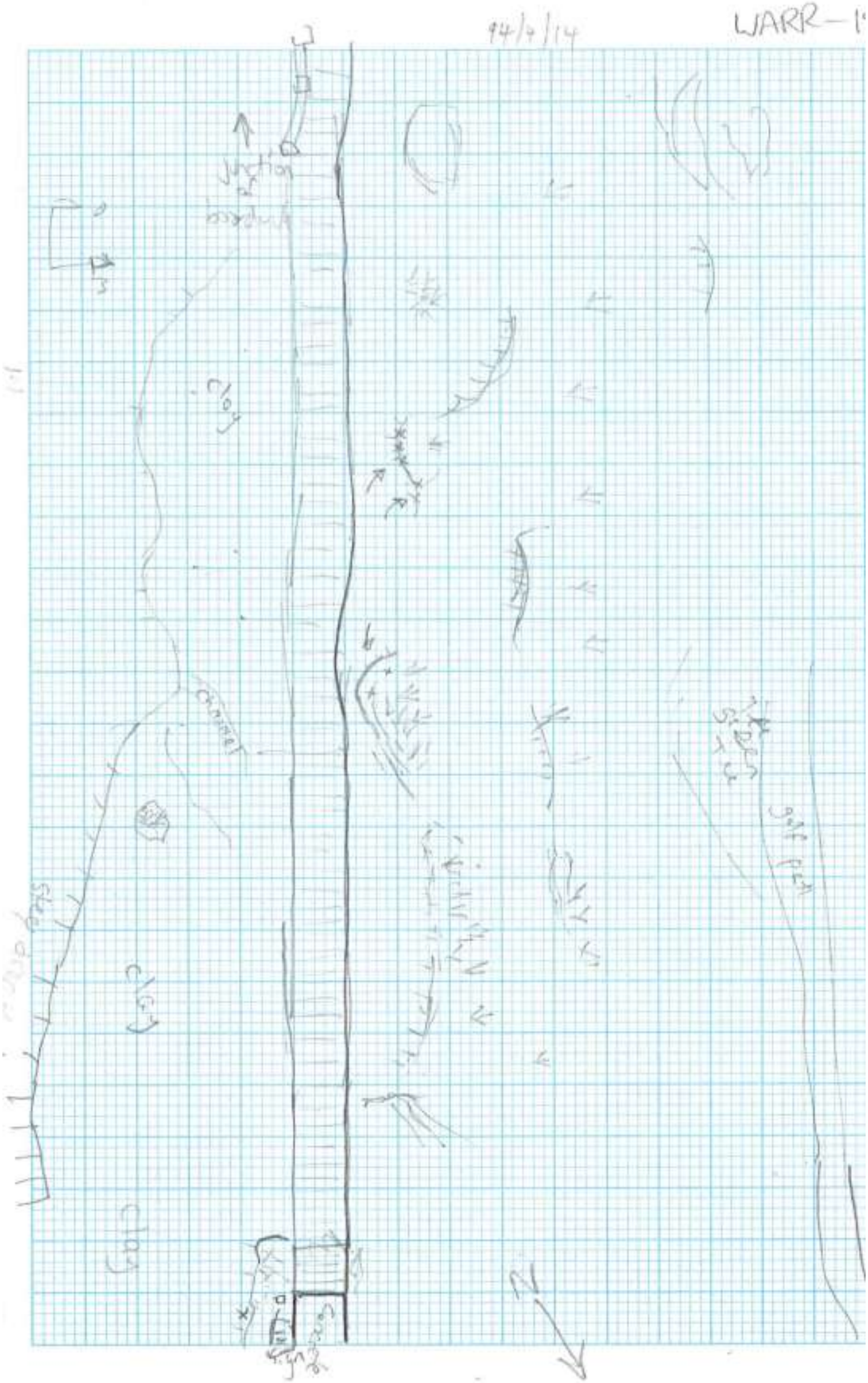
2001 [1629-1635]


1629 Boardwalk, looking north. 1631 Boardwalk, looking south.

1632 Eroding bank. 1635

1633 1634

PLAN:



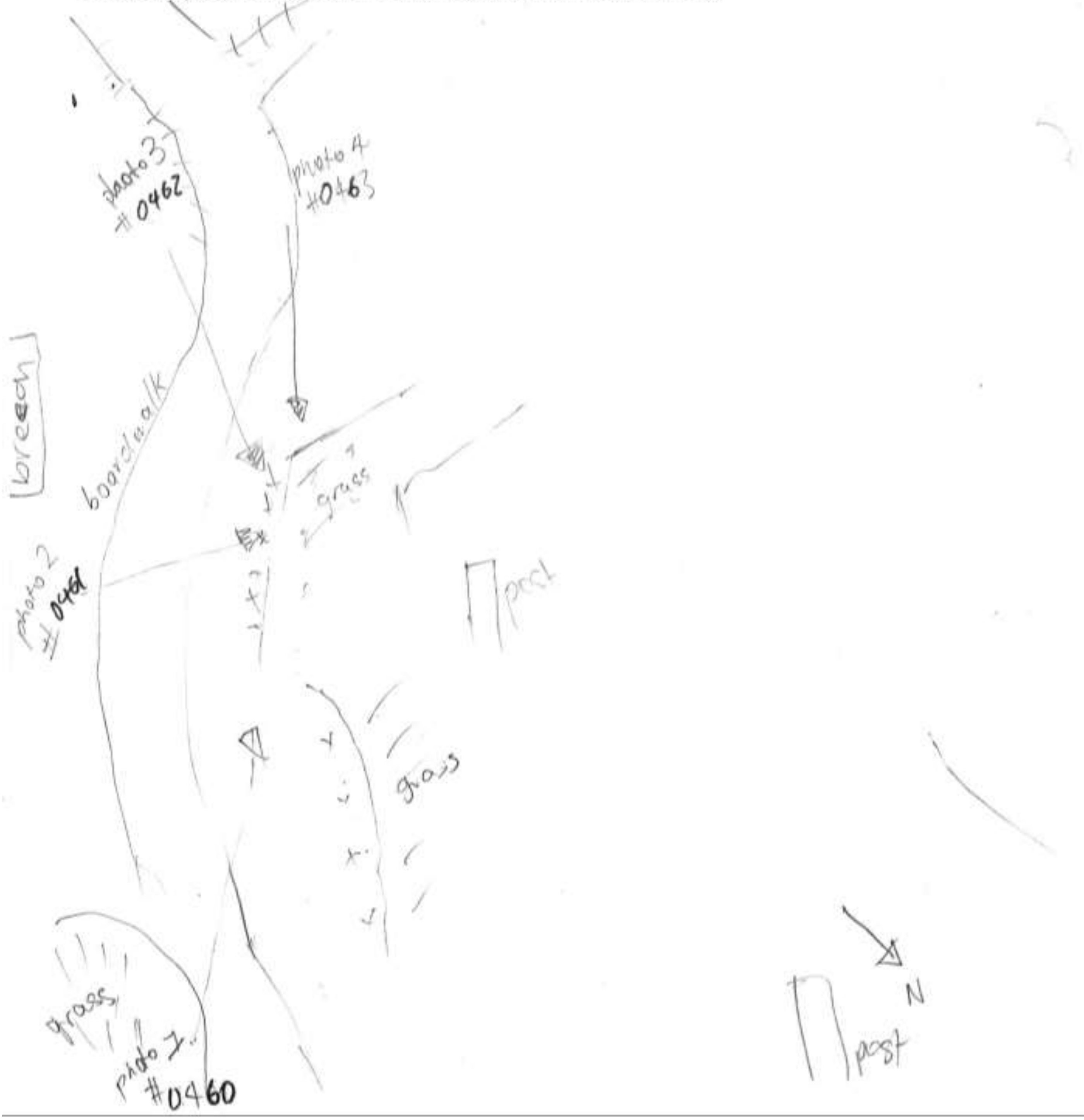
CAMERA & VIDEO MONITORING

AHO Site # Jarr-190 **NPWS Site #** **Date:** 14/4/14 **Time:**

Location: **Recorders:**

Wide shot (Left, Middle, Right)
Sections: Left Profile, Front (perpendicular to cross-section location), Right Profile
Close Ups: diagonally L, R and front

SKETCH: (take distance measurements from main cross-section area).




midden face
photo 7
0467
photo 8
0468
grass
midden face
photo 6
0466


photo
0464-0465
post
headland
clay

45-6-741

SITE POSITION & ENVIRONMENT | OFFICE USE ONLY: NPWS site no: REGISTER COPY

1. Land form a. beach/hill slope ~~/ridge top, etc~~: b. site aspect: open c. slope:

d. mark on diagram provided or on your own sketch the position of the site: e. Describe briefly:

f. Local rock type: g. Land use/effect: golf course / beach

2. Distance from drinking water: Source:

3. Resource Zone associated with site (estuarine, riverine, forest etc):

4. Vegetation:

5. Edible plants noted:

6. Faunal resources (include shellfish):

7. Other exploitable resources (river pebbles, ochre, etc):

Site type: open midden

DESCRIPTION OF SITE & CONTENTS.
Note state of preservation of site & contents. Do NOT dig, disturb, damage site or contents.

Site QP 3 Open midden and artefact scatter
Mona Vale 1:25,000 4347 6488

A sparse, scattered midden possibly a "dinnertime camp" (Meehan 1982). The shells were found in an eroded section at the interface of a darker soil layer with a lighter horizon some 30-40 cm below the present ground level. The lighter horizon is presumed to be post contact because of an in situ. house brick 20 cm below the surface. Existing walking tracks in this area have accelerated erosion in several points across the site (see Photos 3 and 4).

Shell was observed along only 22 m of the eroded bank, which is over 50 m long in toto. A maximum of 20 individual shells were seen, most of these being large triton (over 80%). Cockle, oyster (Saccostrea commercialis) and sand snail (probably Polinices aulacoglossa) shells were also observed. Fragmented shell and an indurated mudstone artefact were observed below the bank, along the gullied and sheet washed erosion area. Another stone artefact was located 25 metres east of the erosion bank on a gravel lag. This was also of indurated mudstone, and consisted of an unmodified flake < 3 cm long.

The site is situated at the location where access onto the beach was proposed. Discussions with Mr Stutchbury indicated that this proposal is flexible and that access can be positioned to avoid the site.

WARR 190-91

THURSDAY 22nd NOV. 2001

45-6-741 / QR3 - Long Reef Aquatic Reserve.

Location: Park at Long Reef Beach S.L.C. and walk North to the end of Long Reef Beach & Start of Golf Course & Aquatic Reserve area.

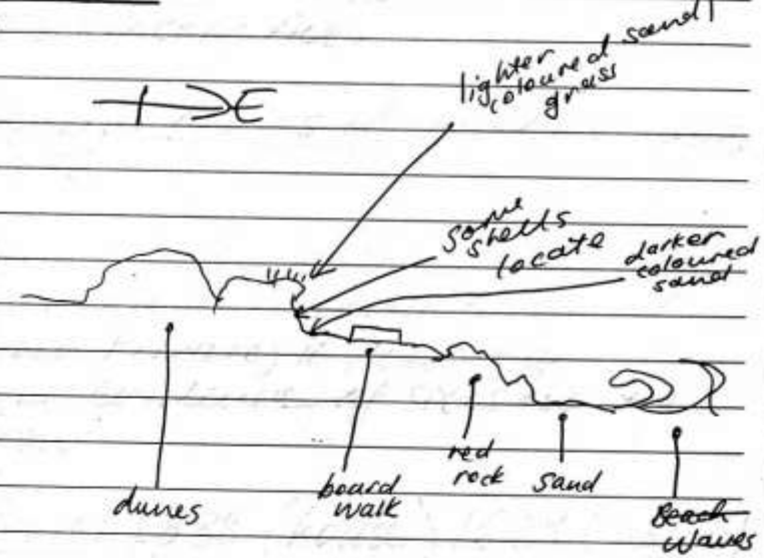
PHOTOS: 1631 (from area looking South) 1630/1629 (from area looking North 1632/1633/1634/1635 (Along eroded bank with some exposed shells)

Description: Very badly eroded area (Storms last few days contributing to this) very few shells located half way down eroded bank (if it had not been previously recorded by NPWS & artefacts located I would have not assumed it to be a midden (so few shells, may be regarded as normal on beach)

GPS: 0363366E
6264850N / 22m error

There is a boardwalk platform for walkers to stay on (& from observation of walkers going past when recording they stick to boardwalk). Damage to midden site appears <u>largely</u> natural.

Sketch:



APPENDIX F

Structural Engineer Advice Memo
(by Woolacotts Consulting Engineers)

Woolacotts.
CONSULTING ENGINEERS

Our reference: 23-01

10 February 2023

Thompson Berrill Landscape Design Pty Ltd
PO Box 665
Manly NSW 2095

Attn: Glenn Berrill
sent by email to: gberrill@tbld.com.au

Dear Glenn,

RE: LONGREEF BOARDWALK & BRIDGE REPLACEMENT

As requested, with reference to our site inspection on 18 January 2023 and the subsequent advice received by Thompson Berrill Landscape Design (TBLD) from Northern Beaches Council (Council) regarding construction of the existing boardwalk and bridge, we comment on the structural implications and feasibility of the proposed new works as follows:

A. EXISTING CONDITIONS

The following description of existing conditions is based on our visual inspection and information provided to us by TBLD and Council only. No opening up nor testing of materials was undertaken.

The existing boardwalk consists of hardwood timber members. Timber boards are screw fixed down to joists, which are in turn supported by bearers bolted between piles. For parts of the boardwalk length, a timber framed guardrail system provides fall protection on the beach side of the boardwalk and at both sides over the bridge section.

We understand that the timber piles used are Class 1 hardwood (turpentine: syncarpia glomulifera), triple treated with suitable marine protection. 300mm diameter piles were used for support of the bridge section and 200mm diameter for the remainder of the boardwalk.

We understand that some parts of the boardwalk have been recently replaced following storm damage and at the time of our inspection, the hardwood timber framing appeared in fair to good condition throughout. We understand however that scouring of the beach/dunes has occurred adjacent and underneath sections of the boardwalk, exposing sections of the piles which were once fully embedded in ground and increasing the height of a potential fall from the boardwalk.

At the bridge area, we observed that some rocks have been placed around the base of the timber piles to provide protection.

Refer to Photographs 1 to 6 for the condition of the boardwalk at the time of our inspection.

Photograph 1: Northern end of boardwalk, looking south

Photograph 2: Northern end of boardwalk

Photograph 3: Bridge at southern end of boardwalk

Photograph 4: Rock armoring at northern end of bridge

Photograph 5: Scouring of sand dune below southern end of bridge approach

Photograph 6: Scouring of sand adjacent to boardwalk, exposing reddish clay material

B. PROPOSED BOARDWALK OPTIONS

We understand that there are two options being considered for replacement of the boardwalk as follows:

1. Reconstruct boardwalk in similar configuration
2. Relocate boardwalk further back into the sand dunes wo provide better protection from storm events

With regard to option 1, we observed that due to the extent of sand that has been washed away, the boardwalk is located at an increased height above the adjacent ground levels at beach side and therefore the length of guard railing would need to be extended to provide adequate fall protection to the boardwalk.

Option 2, which we understand to be the preferred option, will require the modification of the sand dunes for construction and at the northern end in order to provide permanent protection to persons using the boardwalk from possible golf ball strike. This option increases the height of the boardwalk and distance from the waterline and is therefore likely to be a longer lasting solution as it will be better sheltered from significant storm events.

For both options, we recommend that a revetment wall is constructed along the beach side to prevent future loss of ground material adjacent to and beneath the boardwalk. This revetment wall should be extended around the bridge embankments to prevent a similar loss of material to that observed currently at the southern end of the bridge.

C. BOARDWALK CONSTRUCTABILITY

<u>Methodology</u>

Constructing the boardwalk will require heavy vehicles for installation of the pile foundations. We note that the use of a heavy tracked crane to construct the piles is not considered practical as the tracks would cause significant damage to the golf course (and require temporary golf course closure) or if the crane was located beachside, it would be limited by tidal action and be at rick of becoming bogged and/or damaged by high tides.

We understand that the piles for construction of the existing boardwalk were installed using a backhoe with a machine mounted auger, to drill into the rocky clay base material for socketing of the timber piles. In our opinion this procedure can be adopted for the construction of the replacement boardwalk.

We further understand that for the construction of the existing boardwalk (circa 20 years ago), an existing vehicle access route through the golf course was used to transport materials and machinery for pile installation to the site. We were informed that this vehicle access route, consisting of a sandstone rock base material, still exists but has been grassed over. Refer to Figure 1 for a marked up aerial photograph indicating the understood location of the route.

Figure 1: Annotated aerial photograph indicating heavy vehicle access route across golf course

Based on the above, a similar construction methodology can be adopted for construction of the replacement boardwalk to that used circa 20 years ago.

In order to construct the boardwalk as per the option 2 layout, it would be necessary to provide temporary benching at the lower side of the sand dunes, to allow backhoe access for pile installation. The dune and vegetation would then need to reinstated upon completion.

We note that option 2 alignment could be constructed whilst leaving the existing boardwalk in active use, with construction site fencing separating the works from the boardwalk.

<u>Materials</u>

Given the location of the boardwalk in an aggressive coastal environment, we would recommend that the following construction materials are considered:

Boardwalk flooring: Treated hardwood timber of Fibre Reinforced Plastic (FRP)
Joists and Bearers: Treated hardwood, FRP or Stainless Steel
Piles: Treated hardwood or reinforced concrete

The environment is not suitable for mild steel sections which, even with the best protective coating systems will likely corrode quickly and require extensive ongoing maintenance and replacement.

FRP materials are likely to be longer lasting than treated hardwood and should be considered for the flooring but we would recommend that treated timber is adopted for bearers and joists due to constructability and simplicity of connections. Stainless steel would result in smaller member sizes but likely be the most costly of the 3 options.

Reinforced concrete piles could be considered in lieu of timber piles and would provide a longer lasting solution but would have increased costs and program impacts.

We trust the above information is sufficient for your needs, however should you require further assistance with this matter, please contact the undersigned.

Yours faithfully,

Woolacotts Consulting Engineers

Scott Clemmett