23 October 2020 Document Ref: ADL2020-0176AB Rev2

City of Onkaparinga
Lot 10 Railway Road
Seaford Meadows, SA, 5169

Attention: Salvador Jurado

Dear Salvador

RE: Geotechnical Stability Assessment

Witton Bluff Base Trial

1 INTRODUCTION AND SCOPE OF WORK

The City of Onkaparinga (Council) have engaged CMW Geosciences Pty Ltd (CMW) to undertake a cliff stability assessment along the Witton Bluff Base Trail (WBBT) from Christies Beach to Port Noarlunga, SA.

This report has been prepared to summarize the results of the works performed by CMW.

2 PROJECT SETTING AND BACKGROUND

CMW understand City of Onkaparinga (Council) have received state government funding to construct a 3m wide shared use path around the base of Witton Bluff as per our site visit (05/06/2020). The shared use path is referred to this report as the WBBT.

The coastal WBBT will extend around the base of the cliffs from Beach Road Christies Beach to the Esplanade/Saltfleet Street intersection at Port Noarlunga (opposite the jetty). The proposed WBBT will be a combination of a concrete or bitumen paths and an elevated boardwalk and bridge. The proposed construction of the WBBT will require upgrade of the existing seawall (designs attached) to provide long term protection of the cliffs and the new WBBT. Construction of the WBBT and upgrade of protection works shall be designed to account for coastal conditions, including significant wave action/impacts and predicted sea level rise.

Previous assessments have determined the cliff faces are actively eroding and there are potential public safety risks when using the existing pathway due to cliff failures.

3 SUPPLIED INFORMATION

The following cliff stability reference files have been provided by City of Onkaparinga to CMW;

- Final Report Witton Bluff Base Trail 250705_Connel Wagner
- WBBT Concept Design_v2 pdf
- WittonNrth_Seawall_Upgrade_Design_Report_11-0669saa-pobrp-Rev A
- Cliff Top Erosion Audit_42655715 dated 2007
- Witton Bluff_42657366_R001b 30-10-09 dated 2009
- Witton_Bluff_Port_Noarlunga_rock_armour_revetment_BU_8706_2012-105_For_Construction_Rev_0_Drawings[1]

- Detailed_Cliff_Stability_Investigations_Stage_2_Final_ReportA

4 CLIFF STABILITY RISK ASSESSMENT OBJECTIVES

Council have requested the geotechnical risk assessment shall include;

- A risk analysis to WBBT users using the proposed shared use WBBT due to soil / rock fall or landside
- Propose an alignment / elevation of the WBBT or proposed remediation works to reduce the associated risks to an acceptable level

5 SCOPE OF WORKS

Given the above objectives the following scope of works was derived by Council and undertaken by CMW. Works undertaken by CMW have included;

- Review the available information and documents provided by Council;
- Conduct an assessment of the site to identify/verify the main geotechnical risk features of Witton Bluff cliffs;
- Conduct a risk analysis to users of the proposed WBBT and discuss proposed high-level design for mitigation measures with Council's project officers to reduce the risk (if required) which may include;
    - WBBT alignment
    - WBBT elevation
    - structures to catch material (catch drain)
    - mechanical intervention on the cliffs.
- Provide recommendations for the location of the WBBT in accordance with the above.

6 DOCUMENTS OF REFERENCE

The proposed WBBT concepts are presented in Figure 1 and Figure 2 and provide an outline of the project. These figures are included within the figures section of this report, where:

- Figure 1 covers the current plan and sections for the proposed Christies Beach Seawall.
- Figure 2 covers the current concept plans, images, illustrations, and sections for the WBBT.

7 PREVIOUS ASSESSMENTS

7.1 Work by the Author

The author of this report has been involved in this site since 2006 to the present day. During this period the author has noted only minor changes to the cliff's geometry. This familiarity with the project setting has been used in the assessment of slope instabilities impacting upon the existing WBBT. A key report prepared by the author is:

- Witton Bluff_42657366_R001b 30-10-09 dated 2009. This assessment undertaken by the author, is a key reference to this assessment. The drawings are therefore reproduced within this report (see Drawing Site Observations Sheet 1 of 2 and 2 of 2 in Appendix A). The geotechnical Zones delineated in this report are also of relevance to this project report.

7.2 Work by Others

Significant portions of the coastline within the Onkaparinga Council area have had cliff stability investigations and assessments since 2001. Assessments have been collated according to suburbs located along the coastline. Key reports for the stability assessments covered by this report include:

- Detailed_Cliff_Stability_Investigations_Stage_2_Final_Report A: This 2007 assessment highlighted the risk of soil slumping from the crest would reach the base of the cliff. Refer to

Appendix A for extracts (plans, risk assessments and property maintenance considerations and assessments) from this report regarding this site. These extracts provide zones that have been referenced and are considered relevant to this study.

- 235717 Rev 0 - Final Report Cliff Stability Review dated April 2016. This is a recent GHD report encompassing the greater area of the City of Onkaparinga's coastline. It is a specific slope stability report and is the most recent and detailed report for the area. The outcomes from this report are attached in Appendix B. The area of study has been assigned as Zone A in this report.
- Also, of note, the GHD 2016 assessment has assessed part of the area as a high risk of major landslide but a medium risk to minor landslide. Refer to Appendix B for the location and extents of this separate risk assessment to this report.

In addition to the geotechnical aspect of stability discussed above a series of reports have been prepared regarding coastal erosion studies that have been performed. These studies have been undertaken by others for Council. Other relevant studies prepared by others for Council include reports detailing future impact of sea level rise and wave action upon the cliff.

These studies are highly relevant to this project and the assessment of the longevity of the infrastructure. The details of these reports are covered in the seawall design works performed by others for this project and are not detailed in this report.

8 ASSESSMENT

It is highlighted that this slope stability risk assessment is based on the existing slope slumping, sliding or unravelling and falling/bouncing down the current cliff slope onto the WBBT. Subject to the geometry of the slope, the volume of material that reports to the bottom of the slope is dependent on the type of soils or rock that unravels, the height and lateral distances the materials travels.

This assessment does not provide details on the risk of instability and associated damage to the Esplanade or to civil structures above the cliff top (pavements, drainage, lookouts carparks etc).

This assessment aims to provide advice for the placement of the coastal WBBT out of future potential instabilities from above and below the WBBT. While it is hard to define a time frame of slope instabilities, the stability assessment has considered that sea level rise will be addressed by the seawall and therefore the resultant erosive forces on select soil units are predominantly water runoff, desiccation and gravity.

It is understood that an assessment of the rate of cliff recession has been estimated by others in recent commissions by Council. These assessments are based on photographic records and are there indicative only but they have allowed for some objective comment based on the Council's historical records of changes to the cliff slope at the site over time.

8.1 Mechanisms of Cliff Instability

The main instability mechanisms and geotechnical hazards identified in this and previous assessments are summarized from the top to the bottom of the slope as noted below. The Abbreviations of the mechanism of failure are described below in detail and referenced in Table 2 for each specific Zone of the project:

1. A lack of vegetation at the crest leading to surface erosion at the upper zone (EU);
2. Erosion Gullies (EG): caused by water flowing down soil slopes;
3. Circular Failures (CF): caused by gravity induced failure of soil and weak rock. This typically results in the shallow angle formation of the middle and upper parts of the slope;

4. Erosion of the slope between crest and base (EM): general shrink swell of the soil mass and erosive forces (wind, water, and animals) led to the transport/removal of material from the slope to the sea. This is a gradual but ongoing process slowly retreating the slope.
5. Erosion at base (EB): caused by wave action, leading to the undercutting of the slope, cave formation and then tensile failure of the low strength rock in the bottom half of the cliff. This typically results in subvertical slope formation in the lower parts of the slope; and
6. Combined erosional forces acting upon the full height of the slope, leading to large scale slope instability (EB + CF + EG + EU + EM).

As noted above the volume of material that may reach the WBBT is dependent on the above mechanism of soil or rock failure active upon a slope. With the geometry of the slope changing along the cliff slope and vegetation providing restoring forces limiting the failure, the assessments are interrelated along with the typical erosive forces of rainfall and animal activity.

The main long-term mechanisms of cliff instability for this project site are CF and EM failures. These failure types could lead to the oversteepening of the slope immediately above the public accessways (paths, bench seats, lookouts etc). They are also the mechanisms more likely to provide larger volume of material down the slope during failure. These modes of failure are typical to most soil materials and has precursor signs of bulging of the lower slope and tension cracks at the upper surface.

While EB failure mechanisms impact on the global slope, areas with these mechanisms are also very dangerous to people. We note in the undercut cave areas a potential consequence if there was a rock fall whilst people were present is a fatality.

Audits along the cliffs have recommended various forms of treatment. Treatments could include infilling of a local gully with granular material to fencing and signage along cliff top and cliff base. We note in Zone I on the attached Drawings and Figures, areas where Council have successfully back filled wave undercut areas to limit erosion and human access to these high-risk areas. For the bulk of this project area the area affected by EB mechanism of failure has been reduced by the sea wall and backfilling of areas.

8.2 Geotechnical Zones

To assist in the assessment of the risk of slope instabilities impacting upon the coastal WBBT, Zones of similar geotechnical characteristics have been defined. The attributes of these zones are briefly listed in Table 1.

The distribution and boundaries to these geotechnical zones with reference to the current coastal WBBT are denoted / illustrated on aerial images within Figures 3a to 3g. Also included in Figures 3a to 3g are suggested deviations to the coastal WBBT.

The 2009 URS Drawings are included in Appendix A below to provide illustration of these zones and other slope instability site notes relevant to this study.

8.3 Risk Assessment

Our risk assessment has been undertaken with consideration of the AGS qualitative risk assessment to property and as per City of Onkaparinga Risk Assessment process.

This process, as documented in GHD 2016 report, is included in Appendix B for reference. Appendix B also contains the assessment of the site with respect to the AGS qualitative risk assessment given minor and major landslide event probabilities.

This study has assessed each geotechnical zone listed in Table 1. The results of the risk assessment are listed in Table 2 and are also mapped on Figure 3a to Figure 3g.

Table 1: Geotechnical Zone geometry and slope hazards related to mechanism of slope failure

Cliff Zone	Height (m)	Slope	Hazards
A	5 to 10	1V:1H*	none
B	10 to 15	1.7V:1H^	CF, EM
C	15	1V:1.5H#	none
D1	15	1.2V:1H^	CF, EM, EG
D2	15	1.2V:1H^	CF, EM, EG
E	20	1V:1H*	EG
F1	20	1V:1H^	CF, EM, EG
F2	20	1V:1H^	CF, EM, EG
G	25 to 30	1V:1H*	EG
H1	25 to 30	1V:1H^	CF, EM, EG
H2	25 to 30	1V:1H^	CF, EM, EG
H3	25 to 30	1V:1H^	CF, EM, EG
I	25 to 30	1V:1H~	CF, EM, EG, EB
J	20 to 25	1V:1.7H~	CF, EM, EG, EB
K	20 to 25	1V:1H*	CF, EM, EG, EB
L	<15	1V:1H*	EB, EM, EG
M	<10	irreg.	EB, EM, EG
Slope Geometry			
*	Cliff - uniform grade from crest to toe		
#	Cliff - upper shallow slope, steep mid slope and shallower lower slope		
^	Cliff - upper steep slope and a lower shallow slope		
~	Cliff - shallow upper slope and a steep lower slope		
Hazard Notes / Slope Failure Mechanisms			
CF	circular failure in mid slope	EB	erosion at base
EM	erosion within slope	EG	erosion gullies

The following is noted regarding the assignment of consequence for this project which are over and above the description in AGS slope stability assessments and Council risk assessment.

A property consequence of 3 - assumes damage to the WBBT being able to be easily repaired by excavators or replacement of fences, minor retention walls where required.

With respect to human risk a consequence of 3 – is based on the soil mass being expected to unravel whilst tumbling down the slope to the toe/WBBT resulting in less potential harm to a human. This compares to a consequence of 4 where the slumped mass containing rock is not expected to unravel to the same extent as a soil mass at the toe of the slope. In the case, the material/boulder is expected to be larger and potentially result in greater harm to a human. It is also expected that the slumping failure would occur during (or shortly after) a storm event when the exposure time of the risk to humans is expected to be significantly reduced.

Area H1 and H2 has evidence of several rocks at the base of this slope, some beyond the current fence onto the WBBT. In area H2 the rocks are small at the WBBT but at Area H1 where the WBBT is close to the toe of the slope, the rocks are predicted to be larger and therefore generate a higher risk.

Further details of remedial actions to mitigate slope instabilities impacting upon the WBBT are provided in Section 9.

Table 2: City of Onkaparinga Risk assessment for Property based on AGS assessment methods

	Assessment of risk to property and people given current coastal WBBT			
Cliff Zone	**Likelihood**	**Consequences**	**Risk**	**Remedial Action^**
A	1	2	Low	none
B	3	3	High	modify WBBT
C	1	2	Low	none
D1	3	3	High	catch fence required
D2	3	2	Medium	none but fence
E	2	2	Low	none
F1	3	3	High	none but fence
F2	3	2	Med	none but fence
G	2	2	Low	none
H1	3	4	High	none but fence
H2	2	2	Low	none but fence
H3	3	2	Low	none but fence
I	2	2	Low	none
J	3	4	High	modify WBBT
K	2	2	Low	none
L	3	2	Medium	modify WBBT
M	1	2	Low	none

^remedial actions discussed in Section 9.

9 WBBT DESIGN CONSIDERATIONS

9.1 Discussion of risks and WBBT relocation options

A discussion on the risk assessments for the project site was undertaken with Council and CMW on the 28/7/20 during a site walk over. The aim of the discussions was understanding the interactions between Council's civil design with the CMW risk assessment for the various geotechnical zones and cliff slope geometries.

As a basis of design, the remediation options proposed by CMW would need to consider:

- An unstable volume of soil released/detached from the slope at a given height and lateral distance from the edge of the WBBT. On average a 1V:1H batter slope is considered to be representative of long-term stable conditions in the cliff slope. The assignment of unstable volumes of soil in the cliff slope to be determined by considering all material above a hypothetical 1V:1H batter slope projected from the edge of the WBBT to the height of the above pavement/kerb of the road.
- These static assessments required numerical modelling and ground models to be assigned and documented for the specific geometry of each geotechnical zone. The assessment should assess circular and non-circular failure modes of the soil/rock units and the velocity/energy of the final volume and block size to impact the toe of the slope.
- Catch fence to be designed based on the predicted impact energies from detached soil mass/landslide.
- The above advice should inform path alignment changes (distance and elevation) integrated with the catch fence design.

Given the outcomes of the above, the preferred engineering controls for the WBBT realignment discussed included:

1. Modifying the existing slope: This option included earthworks (either placement of material down the slope or removal of steep segments of the slope). The option presented safety risk for construction and the potential removal of vegetation. This option was not considered as suitable/viable for the project site and will not be discussed further.
2. Placement of a barrier at the base of the slope: given safety in design options, this would act as a catch fence, only considered required for areas where the lower portion of the cliff slope was at approximately 1V:1H. The catch fence aimed at only providing a barrier to a soil mass as it unravelled down the slope (consequence 3).
3. Moving the WBBT laterally seaward or vertically: This option was only considered required for Zone B where the cliff posed the highest risk to the public as any failure would immediately impact a person on the WBBT with the volume of material significant enough to potentially bury a person. Elevating the structure would provide additional storage volume from any potential material from a collapse to reduce the potential impact on the path. Also a cantilevered WBBT may pose as a suitable alternative for this area. Ramping up-onto and off-of the wooden/metal decking is expected to be required.

Considerate of the above discussion on site, the following Table 3 provides a breakdown of potential remediation options for each geotechnical zone.

Table 3: Current Path Remediation Recommendations

Cliff Zone	Assessment of risk to property and people given current coastal path		
	Risk	**Remedial Action**	**Recommended Action**
A	Low	none	WBBT remains in current location
B	High	Modify path and install catch fence	WBBT to be moved, Raise WBBT upward/move seaward + Install catch fence in the ramp areas
C	Low	none	WBBT remains in current location
D1	High	install catch fence	WBBT remains in current location, install catch fence, noting drainage issues to be considered
D2	Medium	install catch fence	WBBT remains in current location. Water related erosion, drainage to be considered, install catch fence,
E	Low	none	WBBT remains in current location
F1	High	install catch fence	WBBT remains in current location, install catch fence
F2	Med	install catch fence	WBBT remains in current location but develop the WBBT on the seaward side of the WBBT, upgrade existing fence to a catch fence
G	Low	install catch fence	WBBT remains in current location, upgrade existing fence to a catch fence only where existing.
H1	High	install catch fence	WBBT remains in current location, upgrade existing fence to a catch fence
H2	Low	install catch fence	WBBT remains in current location, upgrade existing fence to a catch fence
H3	Low	install catch fence	WBBT remains in current location, upgrade existing fence to a catch fence
I	Low	none	WBBT remains in current location
J	High	modify path	Current slope should be offset by the walkway by a height equal to the lateral offset to the crest and the walkway deck.

Cliff Zone	Assessment of risk to property and people given current coastal path		
	Risk	Remedial Action	Recommended Action
K	Low	modify path	Move WBBT away from edge of shelf
L	Medium	modify path	Cut new access, variable risk in this zone.
M	Low	none	WBBT remains in current location

With respect to the civil drainage design, it was agreed that a WBBT would not be able to sustain a working horizontal subsoil drainage layer as it would be prone to being blocked by materials eroding from the cliff slope. Alternative drainage under the WBBT must be considered and integrated in the design to ensure drainage does not erode the toe of the slope.

9.2 Recommendations

It is important to note that our recommendations in Table 3 are geotechnically focused and do not consider other civil engineering aspects required for the shared user WBBT development (e.g. drainage, fencing etc..). CMW have not been provided with the geometry of all the batter slopes over the length of this project area, however Figures 3a, 3b, 3c, 3d, 3e, 3f, and 3g indicate stability risk assessments for the WBBT and note where the WBBT should be realigned as per Table 3.

Based on our assessment and prior site assessments, the area of greatest concern to the increased risk of slope instability are areas where there is a steep cliff segment immediately adjacent to the WBBT (Area B). In this area moving the WBBT seaward or raising the WBBT (or a boardwalk) is recommended.

Cliff Zone H1 present a great risk to humans if the proposed breakout area is located close to the toe of the cliff. Engineered control will be required to be constructed including a barrier design to withstand impact from rock falls. Current examples of fences used within Council are provided within Appendix C.

Cliff Zone J present further risk but can be managed by placed the WBBT away from the fall zone and shaping the rock armour in the enclave to ensure any detached soil/rocks will not impact the proposed walkway structure.

Cliff Zone L presents a mix of risks as the WBBT intersects. This segment is unclear to CMW so the risk has been considered moderate, as instabilities could potentially impact the Esplanade.

10 LIMITATIONS

This report has been derived on the basis that the toe of the batter slope and the crest of the batter slope retreat at an even slow rate (as under current conditions). Thus, it is a current assessment of predicted long term stability. Incremental changes of sea level rise and ocean actions may induce changes to the rate of this erosion and cliff retreat. This could change the impact on the coastal cliffs thereby affecting the erosion and retreat of the cliff slope. This erosion will be uneven and biased in places. These predictions should also be revisited periodically.

The findings contained within this report are the result of the review information conducted in accordance with normal practices and standards by others over an extended period of time and supplied to CMW Geosciences Pty Ltd. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site and information provided.

This report has been prepared for use by City of Onkaparinga in relation to the Christies Beach and Port Noarlunga WBBT Project in accordance with generally accepted consulting practice and based on information supplied by City of Onkaparinga. No other warranty, expressed or implied, is made as to the professional advice included in this report. Use of this report by parties other than City of Onkaparinga and their respective consultants and contractors is at their risk as it may not contain sufficient information for any other purposes.

11 CLOSURE

We trust this is sufficient for your needs but do not hesitate to contact the undersigned with any queries.

For and on behalf of
CMW Geosciences Pty Ltd

John Slade

Principal Geotechnical Engineer

Attachments: Figure 1 – Seawall Plans and Sections

Figure 2 – WBBT concept plan

Figure 3 – CMW Slope Stability Risk Assessment and Path realignment suggestions

Appendix A: Detailed_Cliff_Stability_Investigations_Stage_2_Final_ReportA 2007

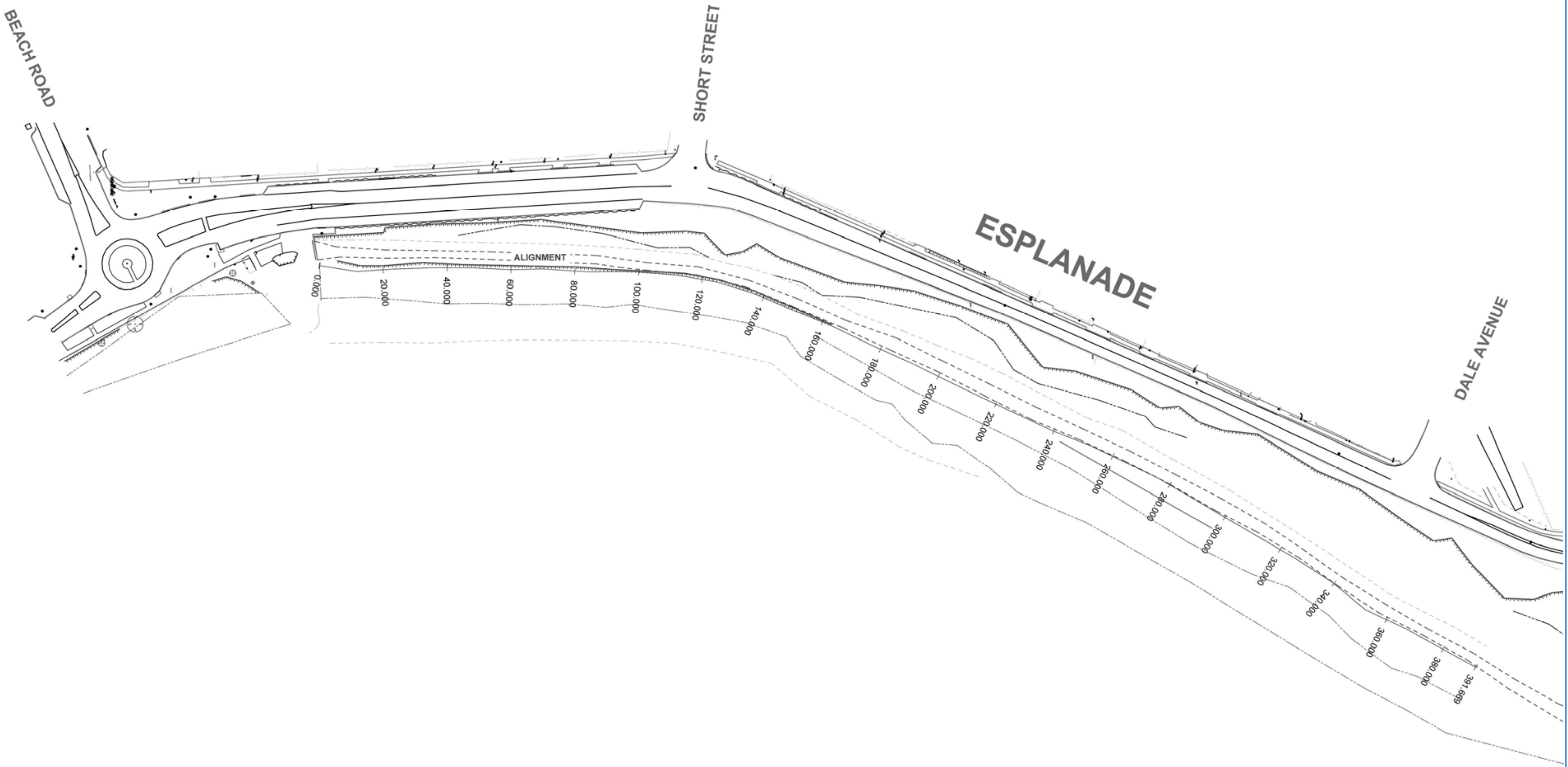
Appendix B: Extracts from GHD Cliff Stability Review Risk Assessment 2016

Appendix C: Current examples of fences installed by Council.

Distribution: 1 copy to City of Onkaparinga (electronic)
Original held by CMW Geosciences Pty Ltd

Distribution: 1 copy to Client (electronic) Original held by CMW Geosciences Pty Ltd

Figure 1: Seawall plan and sections



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Notes:

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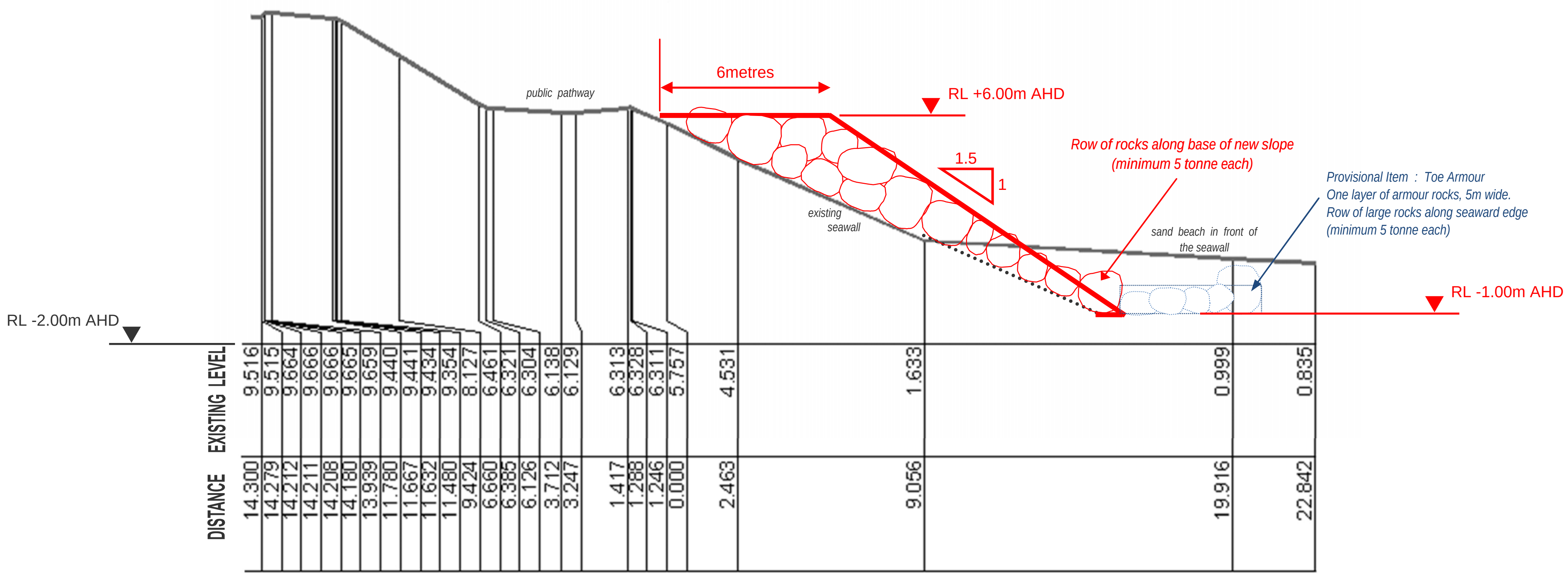
LAYOUT PLAN

Drawing Number:

11 - 669SAA - 001

Rev:

A



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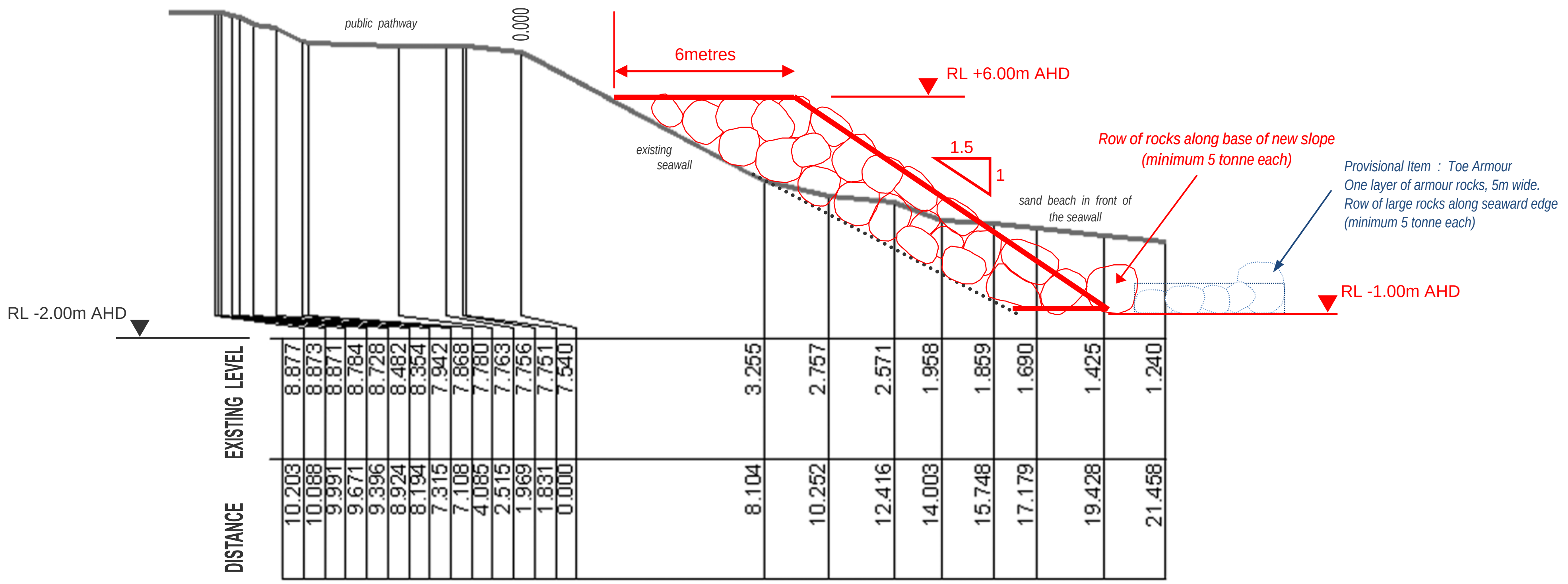

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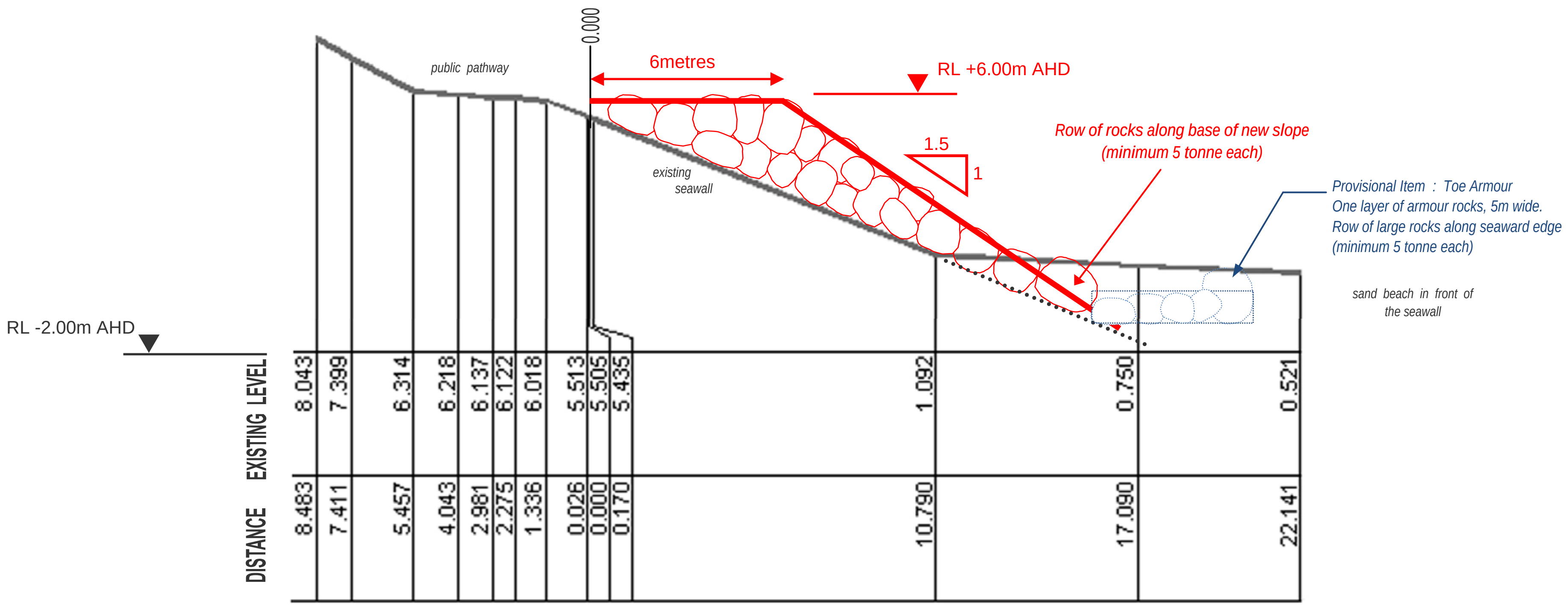
Drawing Number: **11 - 669SAA - 002**

Rev: **A**



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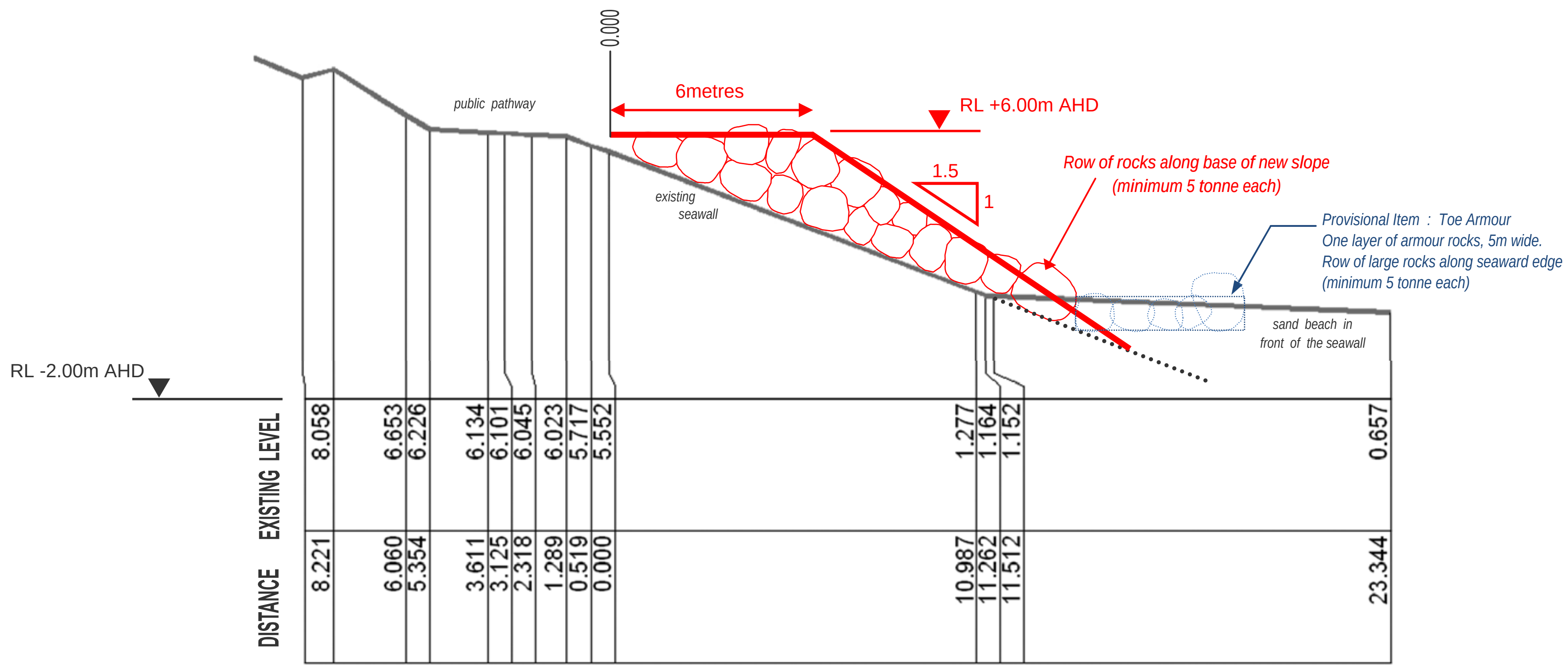

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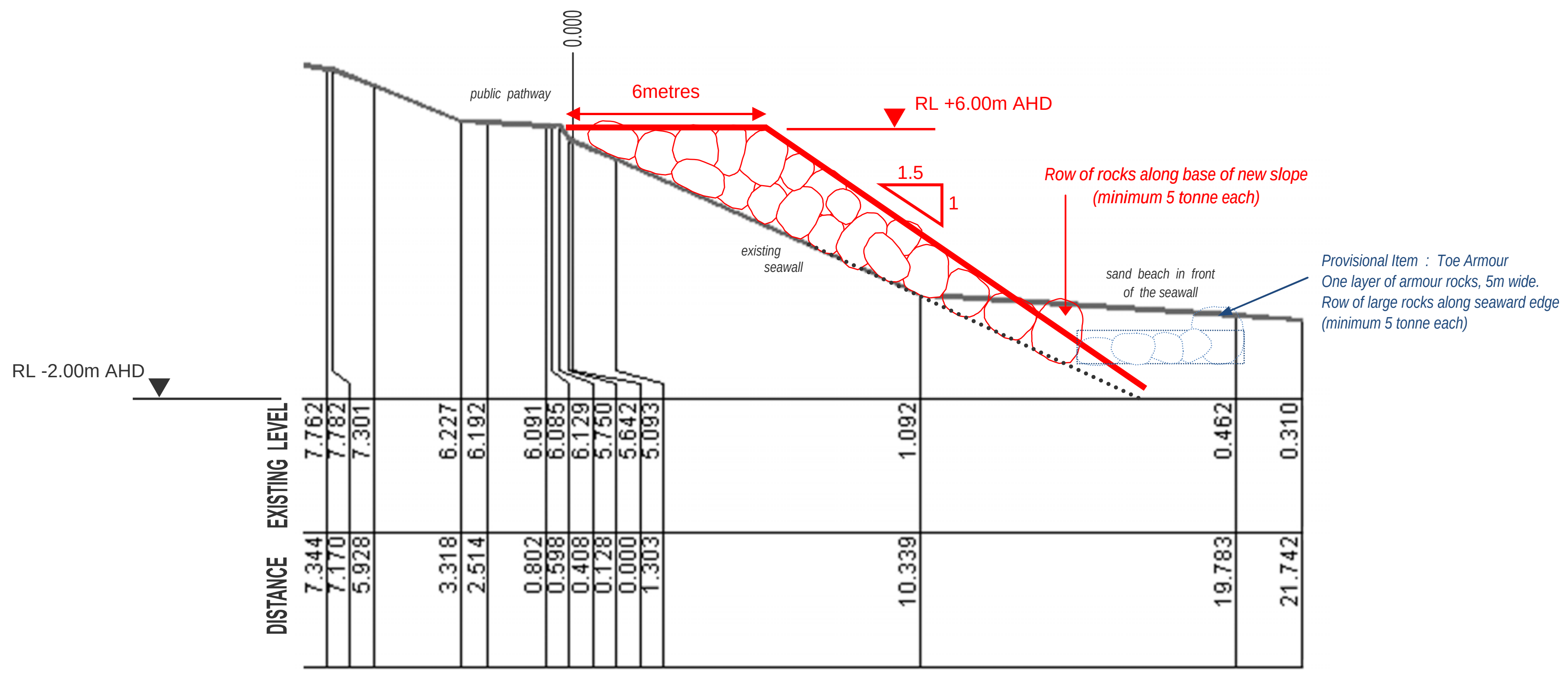
Drawing Number: **11 - 669SAA - 003**

Rev: **A**



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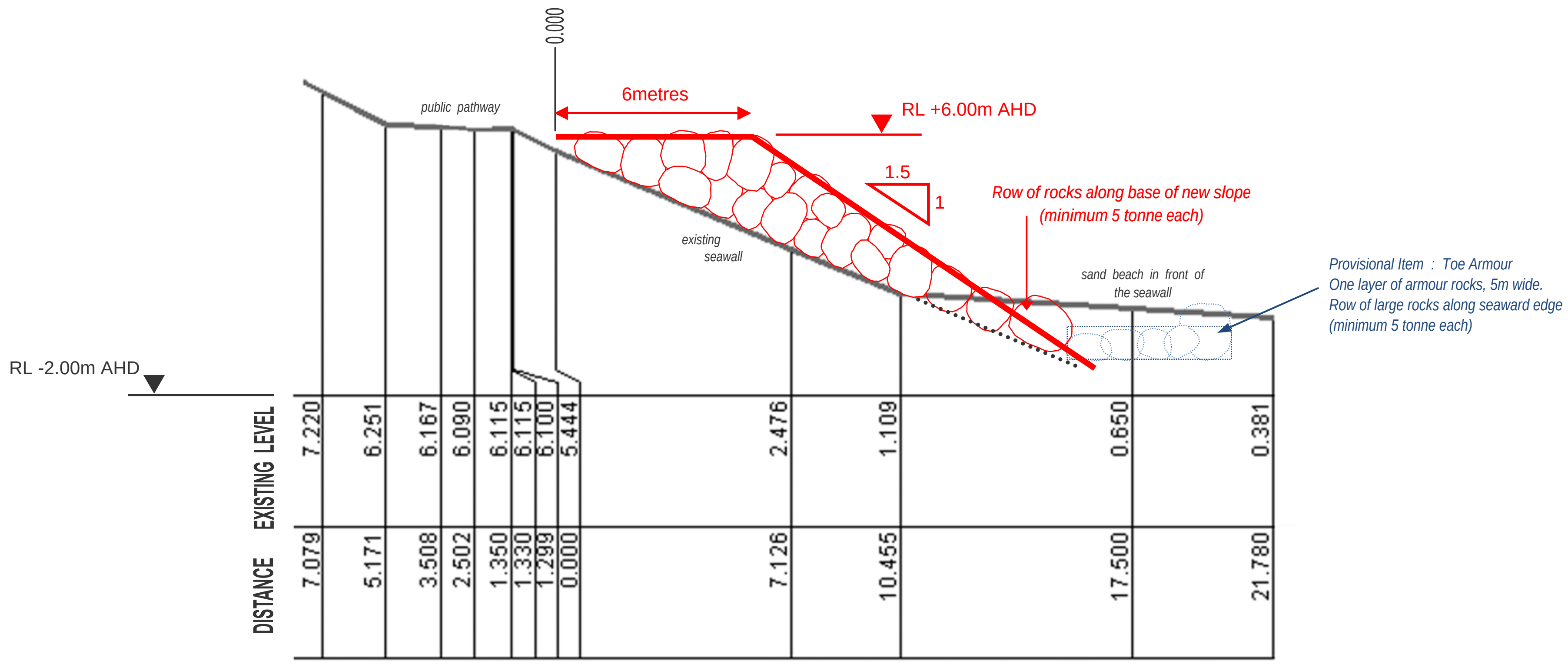

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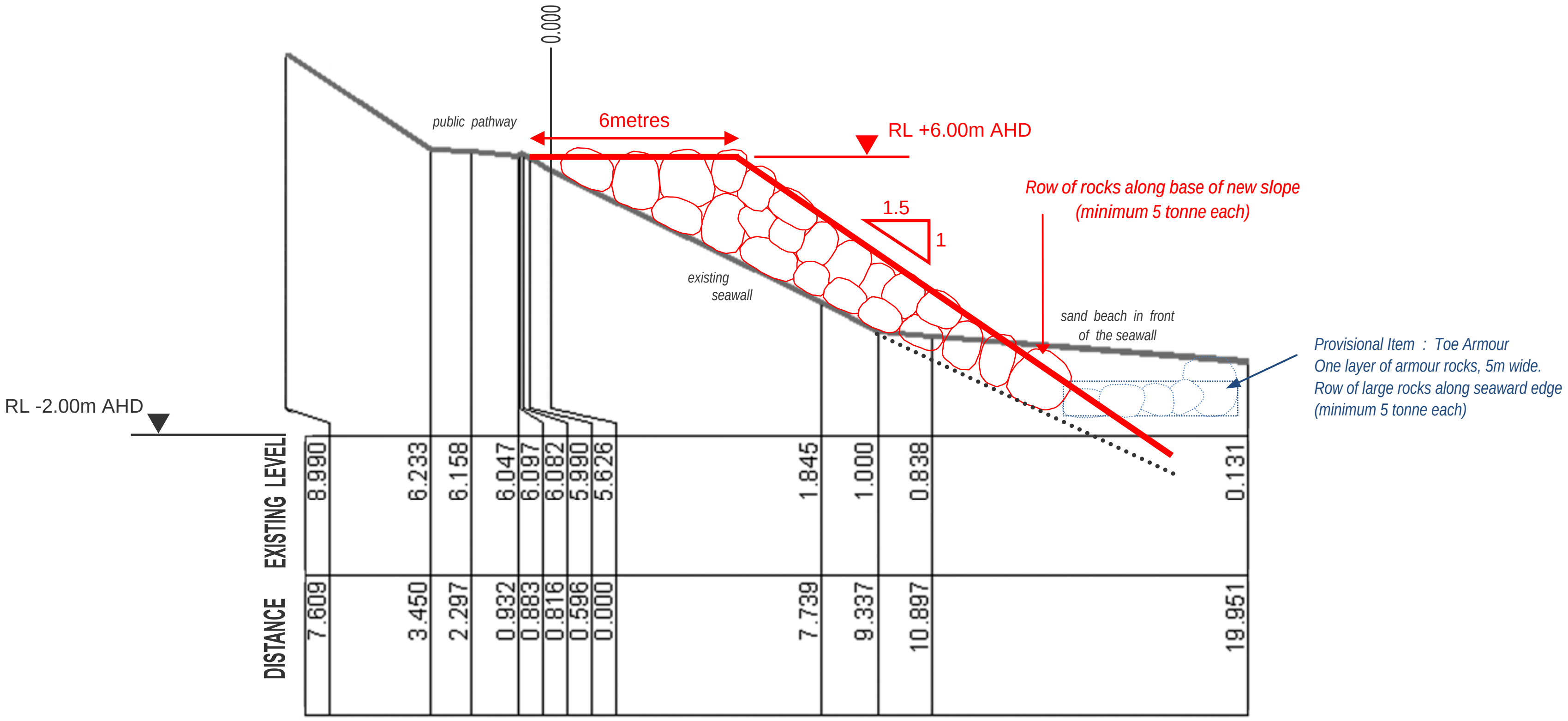
Rev: **A**



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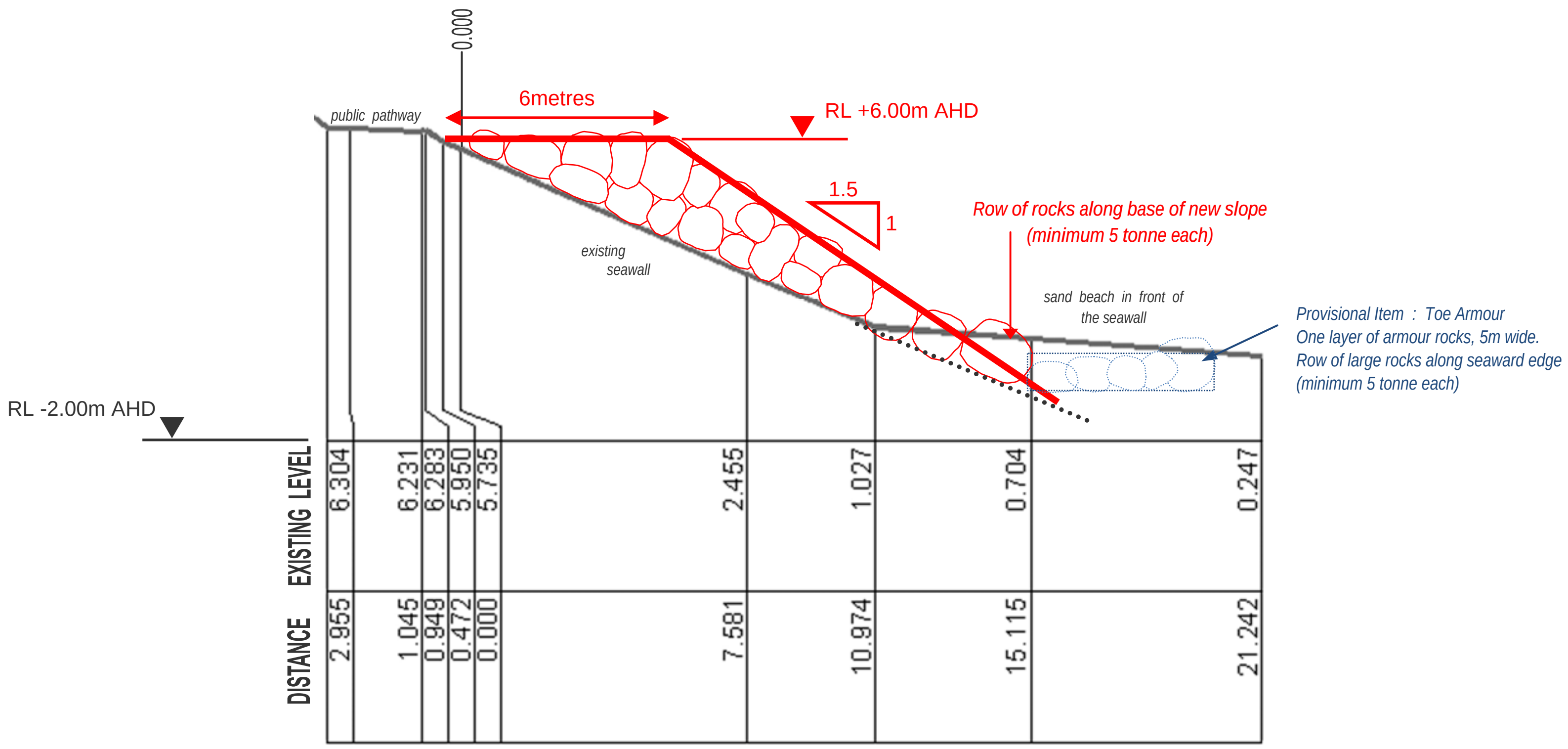

CH 120.000

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A	12Aug11	Original Issue	POB	HPR
No.	**Date**	**Description**	**By**	**Chk**
REVISIONS				

Notes:
1. All survey information provided by City of Onkaparinga (Corporate and Community) in AutoCad file 2011-101(PA).dwg

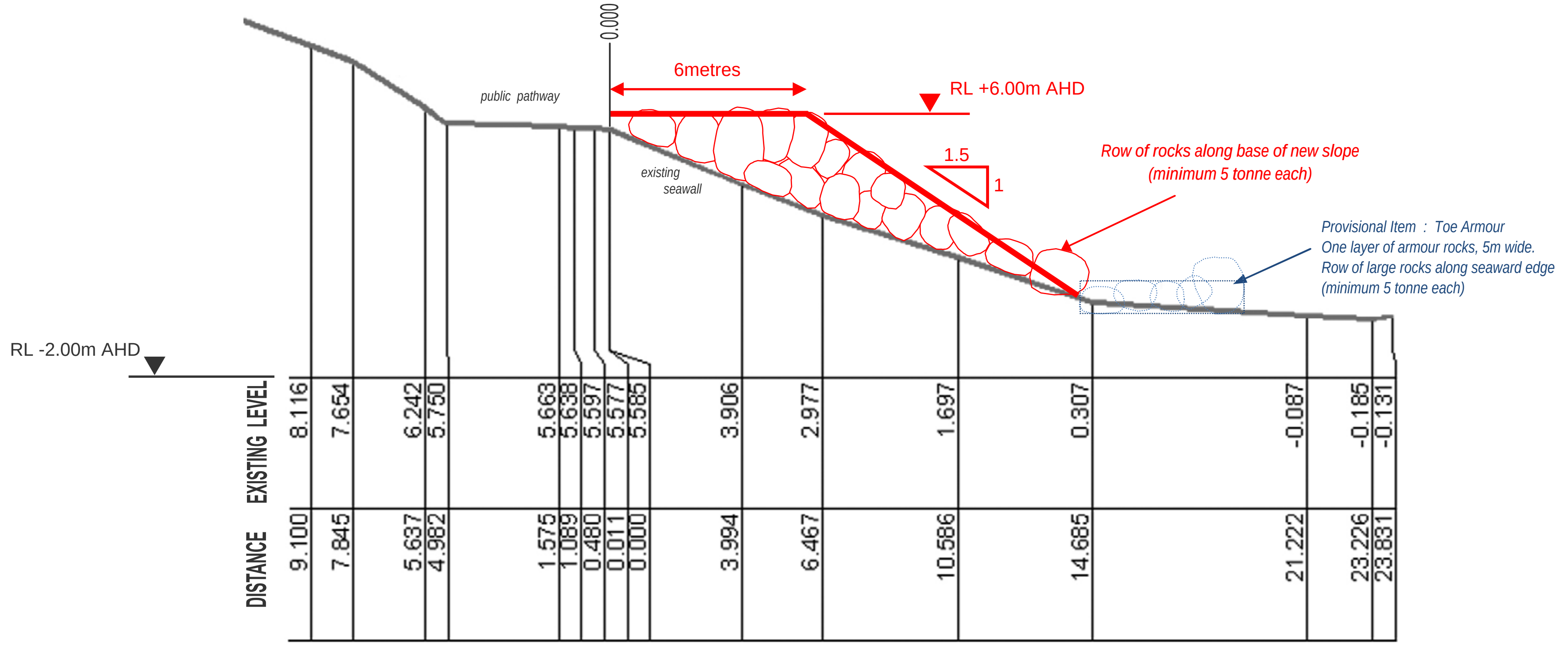
Datums:
Vertical : AHD

Scale at A3:
HORIZONTAL 1 : 200
VERTICAL 1 : 200

Project:
CHRISTIES BEACH SEAWALL STRUCTURAL UPGRADE

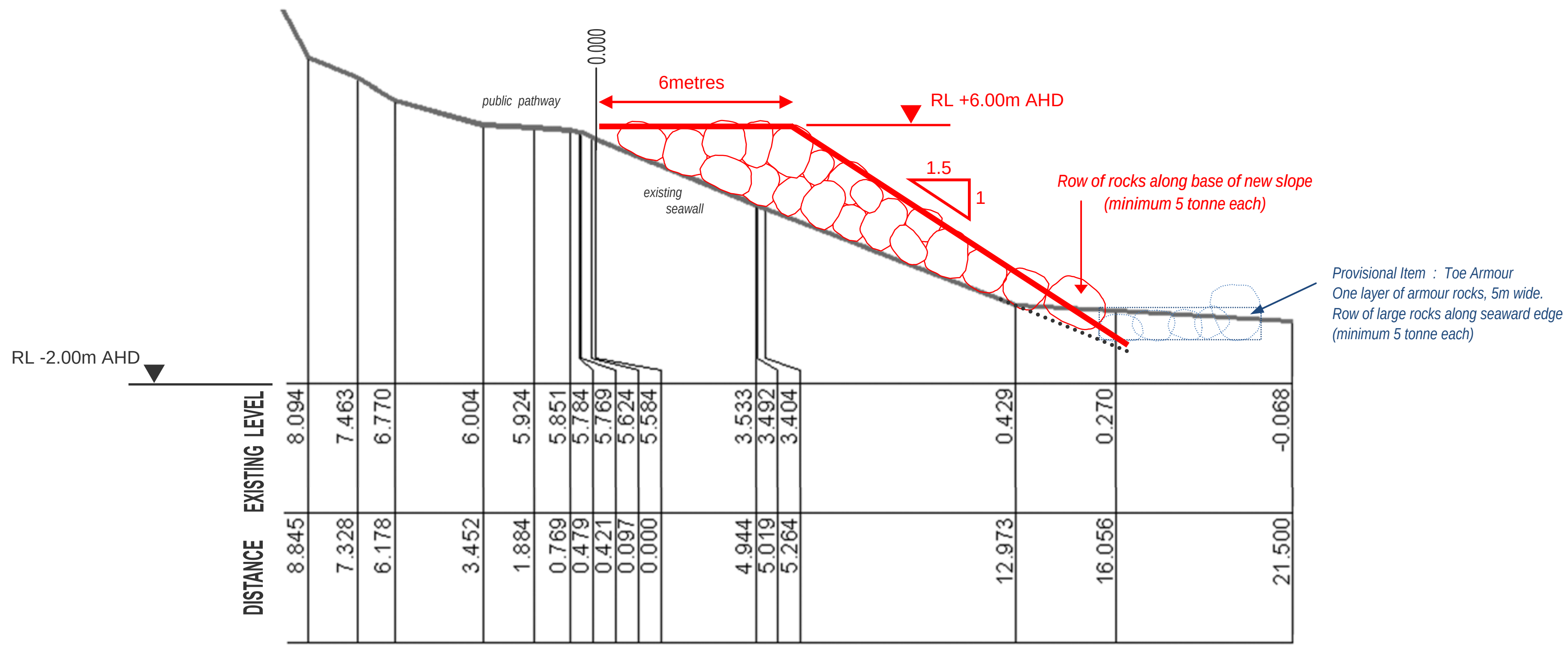
Drawing Title:
CROSS SECTIONS - Sheet 4

Drawing Number: **11 - 669SAA - 005**
Rev: **A**



CH 180.000

BEARING 114° 17’ 04”



CH 160.000

BEARING 111° 37’ 21”

COASTAL ENGINEERING SOLUTIONS

59 Hulcombe Road
PO Box 677
Samford
QLD 4520
Australia
tel: (+61 7) 3289 7011
fax: (+61 7) 3289 7022

25 Wirilda Way
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Australia
tel: (+61 3) 5683 2495

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No.	Date	Description	By	Chk
A	12Aug11	Original Issue	POB	HPR

REVISIONS

Notes:

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Datums:

Vertical : AHD

Scale at A3:

HORIZONTAL 1 : 200
VERTICAL 1 : 200

Project:

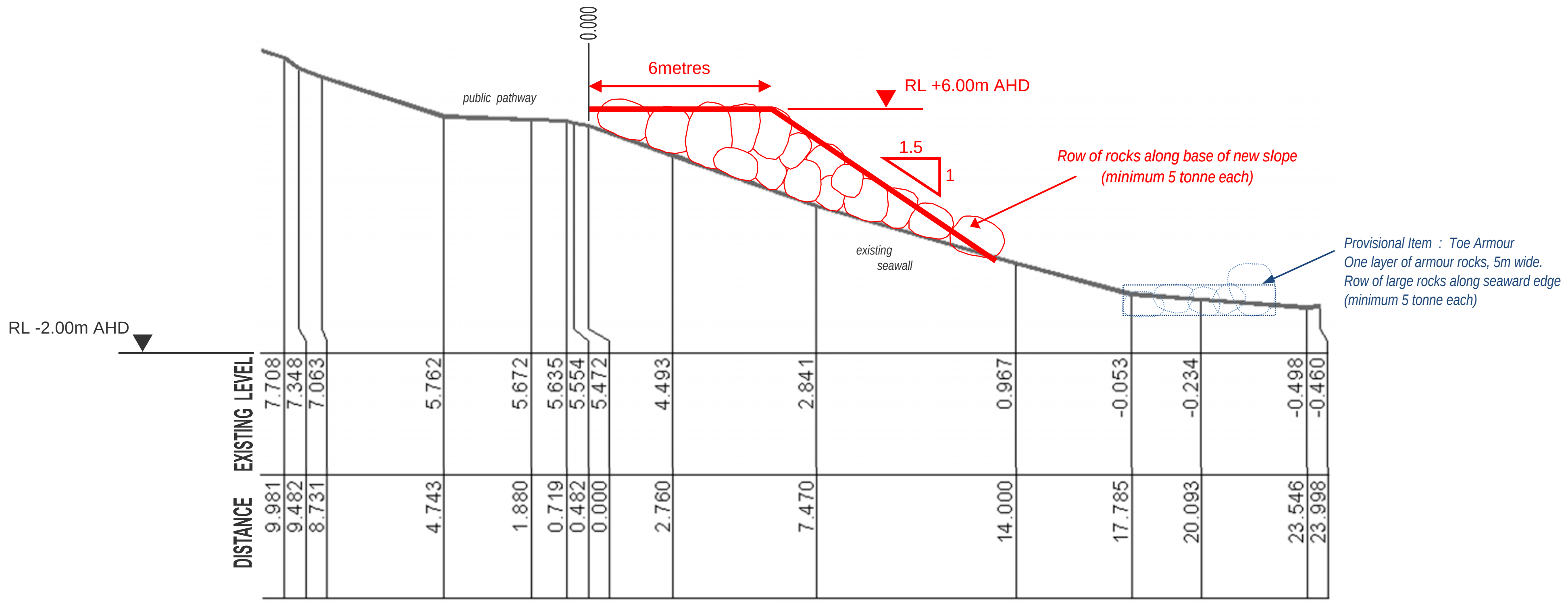
CHRISTIES BEACH SEAWALL STRUCTURAL UPGRADE

Drawing Title:

CROSS SECTIONS - Sheet 5

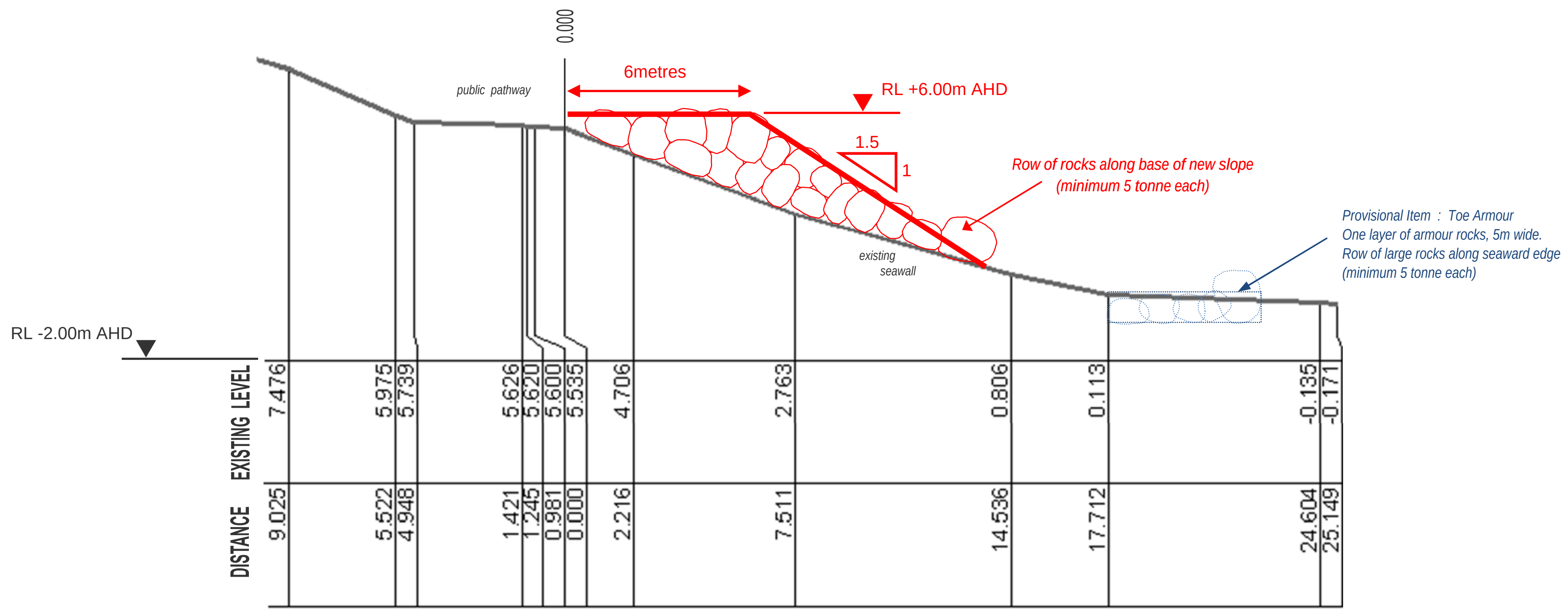
Drawing Number: **11 - 669SAA - 006**

Rev: **A**



CH 220.000

BEARING 115° 23' 29"



CH 200.000

BEARING 116° 31' 41"

COASTAL ENGINEERING SOLUTIONS

59 Hulcombe Road
PO Box 677
Samford
QLD 4520
Australia
tel: (+61 7) 3289 7011
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No.	Date	Description	By	Chk
A	12Aug11	Original Issue	POB	HPR

REVISIONS

Notes:
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Datums:
Vertical : AHD

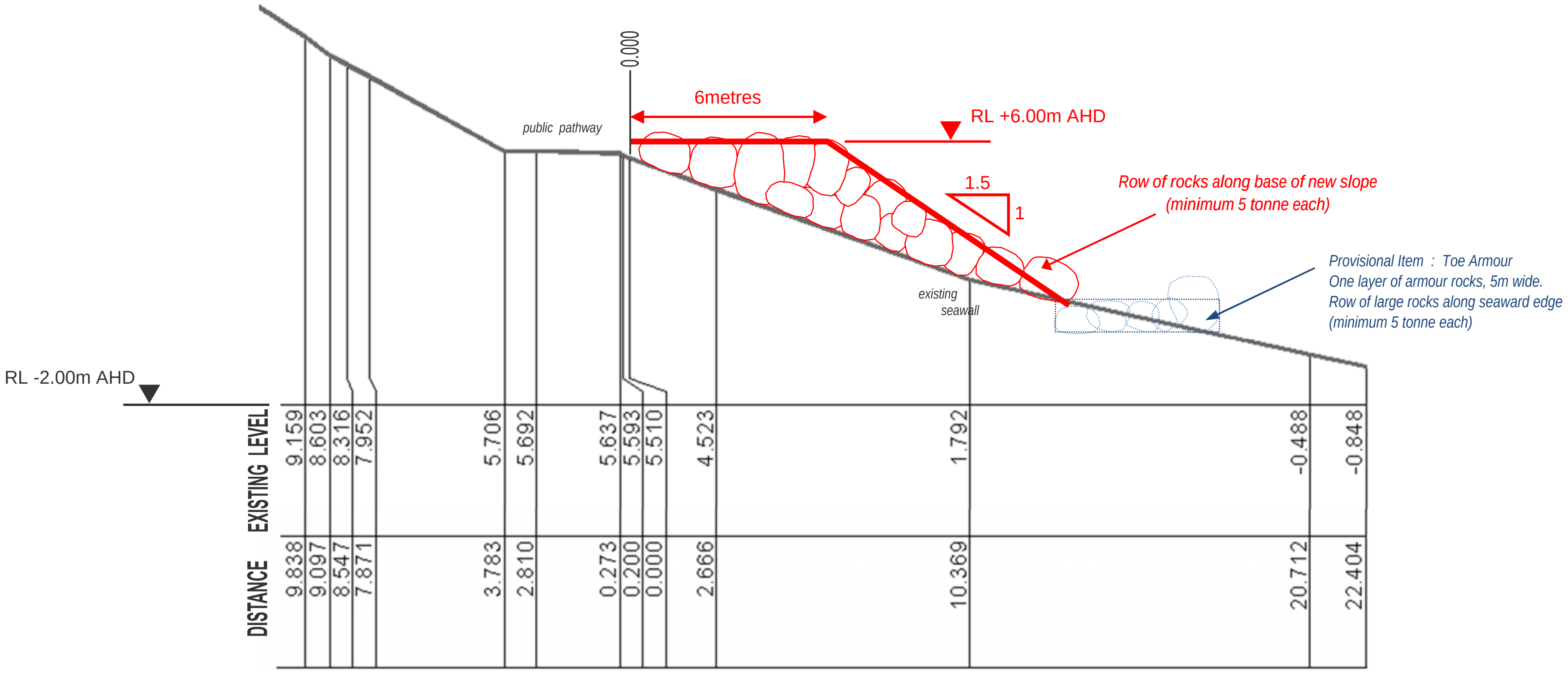
Scale at A3:
HORIZONTAL 1 : 200
VERTICAL 1 : 200

Project:
CHRISTIES BEACH SEAWALL STRUCTURAL UPGRADE

Drawing Title:
CROSS SECTIONS - Sheet 6

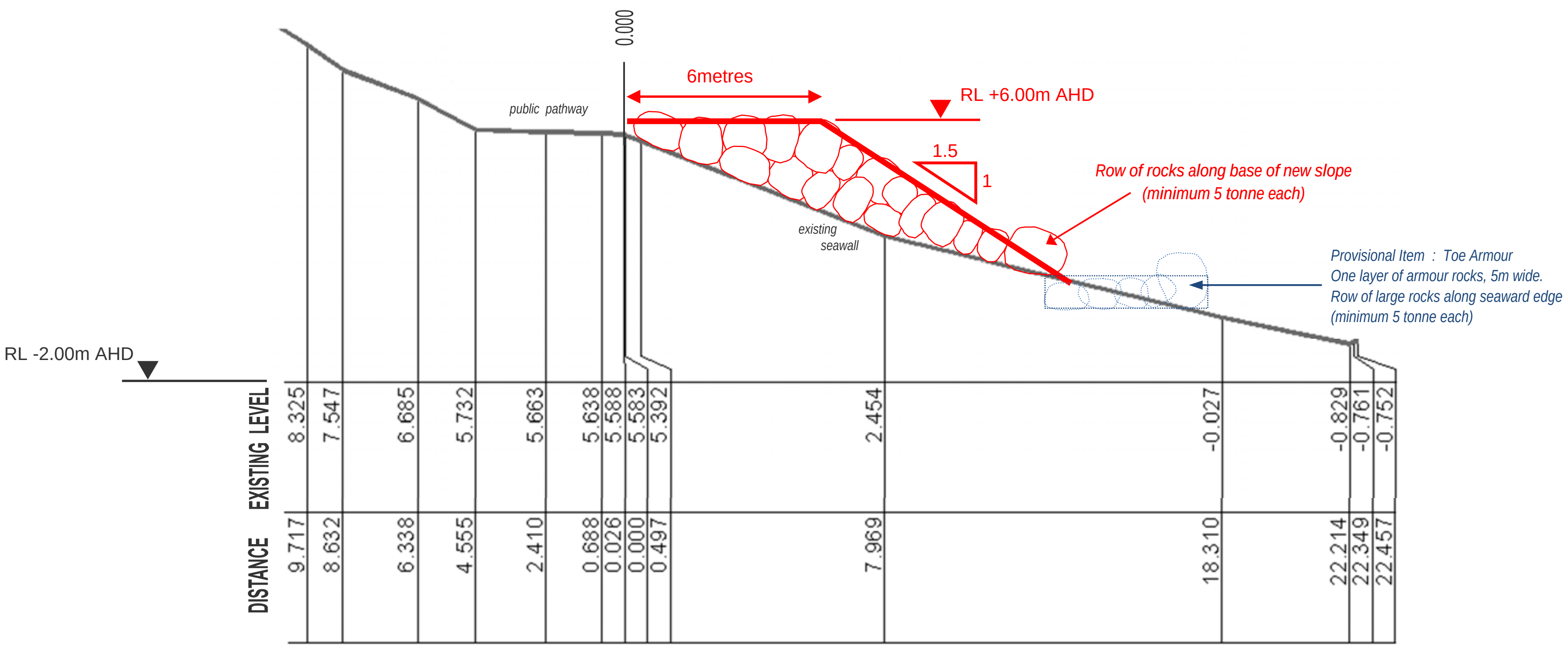
Drawing Number: **11 - 669SAA - 007**

Rev: **A**



CH 260.000

BEARING 115° 43’ 40”



CH 240.000

BEARING 111° 22’ 17”

COASTAL ENGINEERING SOLUTIONS
59 Hulcombe Road
PO Box 677
Samford
QLD 4520
Australia
tel: (+61 7) 3289 7011
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A	12Aug11	Original Issue	POB	HPR
No.	Date	Description	By	Chk
REVISIONS				

Notes:
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Datums:
Vertical : AHD

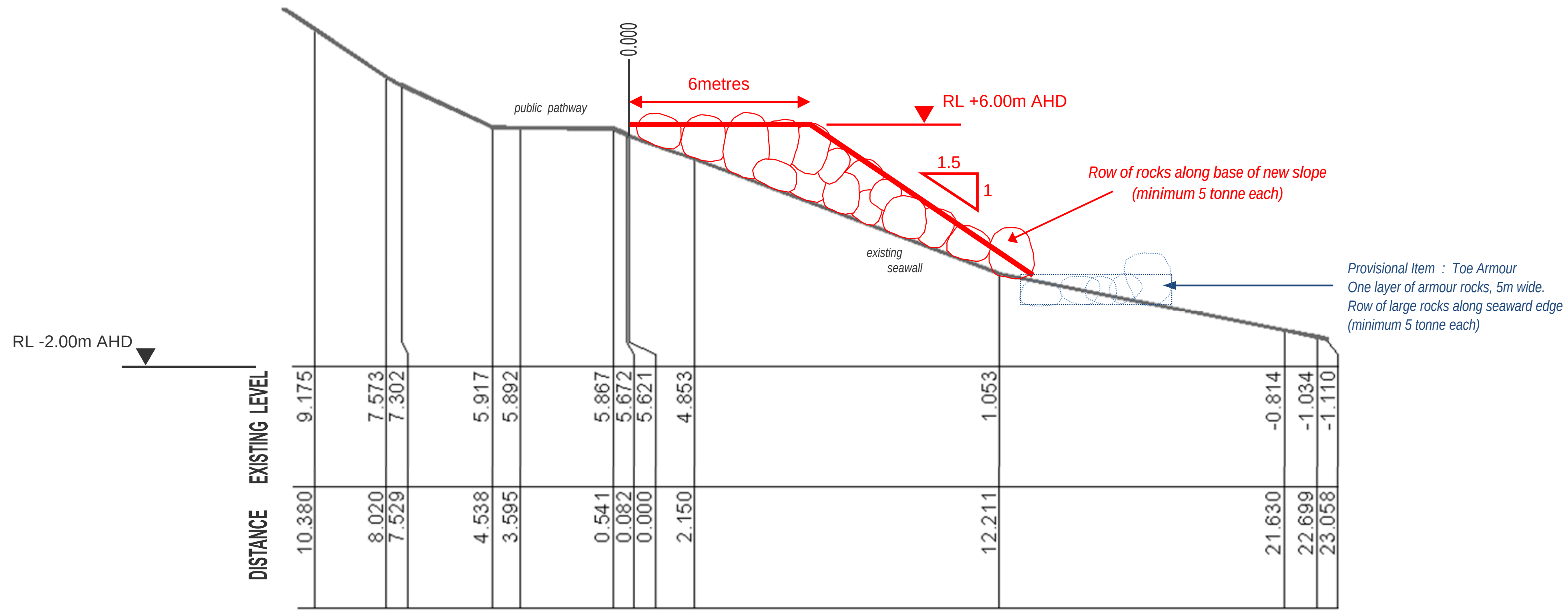
Scale at A3:
HORIZONTAL 1 : 200
VERTICAL 1 : 200

Project:
CHRISTIES BEACH SEAWALL STRUCTURAL UPGRADE

Drawing Title:
CROSS SECTIONS - Sheet 7

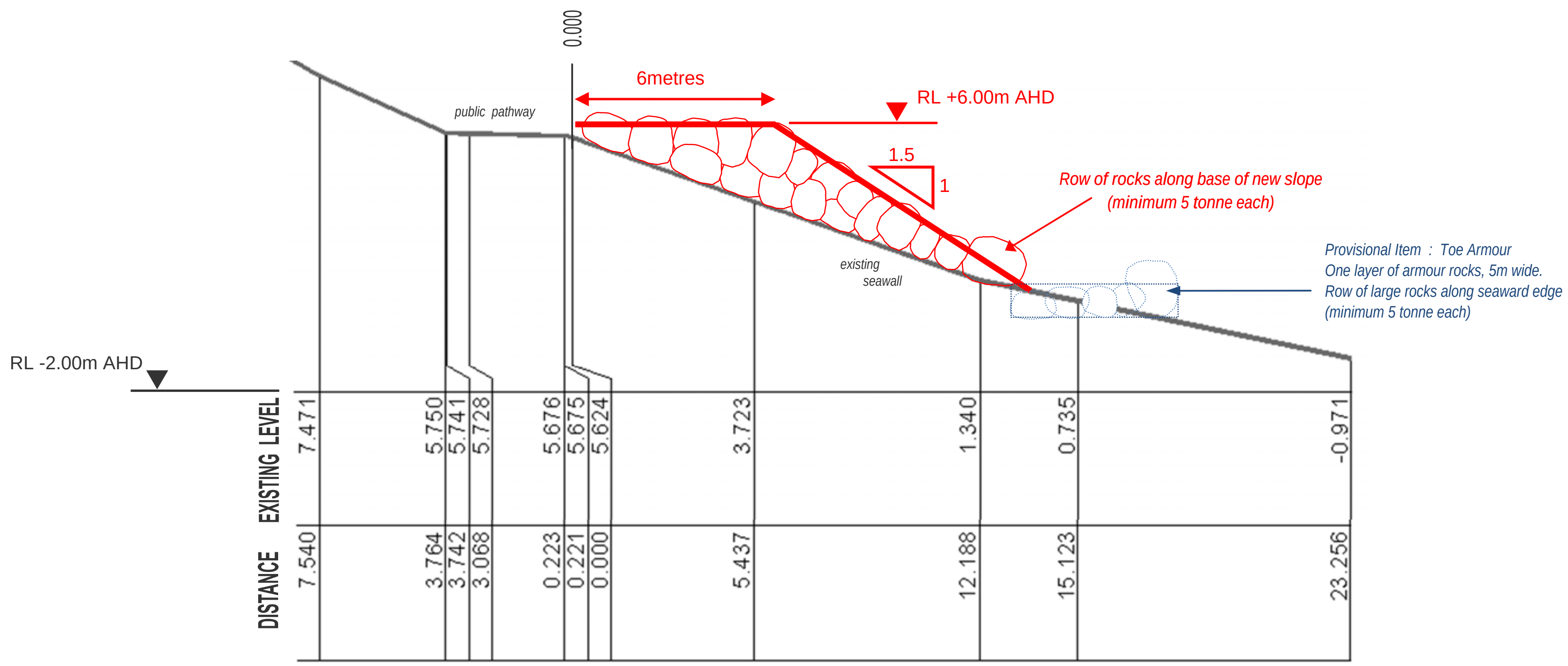
Drawing Number: **11 - 669SAA - 008**

Rev: **A**



CH 300.000

BEARING 120° 47’ 39”



CH 280.000

BEARING 119° 56’ 03”

COASTAL ENGINEERING SOLUTIONS
59 Hulcombe Road
PO Box 677
Samford
QLD 4520
Australia
tel: (+61 7) 3289 7011
fax: (+61 7) 3289 7022

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No.	Date	Description	By	Chk
A	12Aug11	Original Issue	POB	HPR

REVISIONS

Notes:
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Datums:
Vertical : AHD

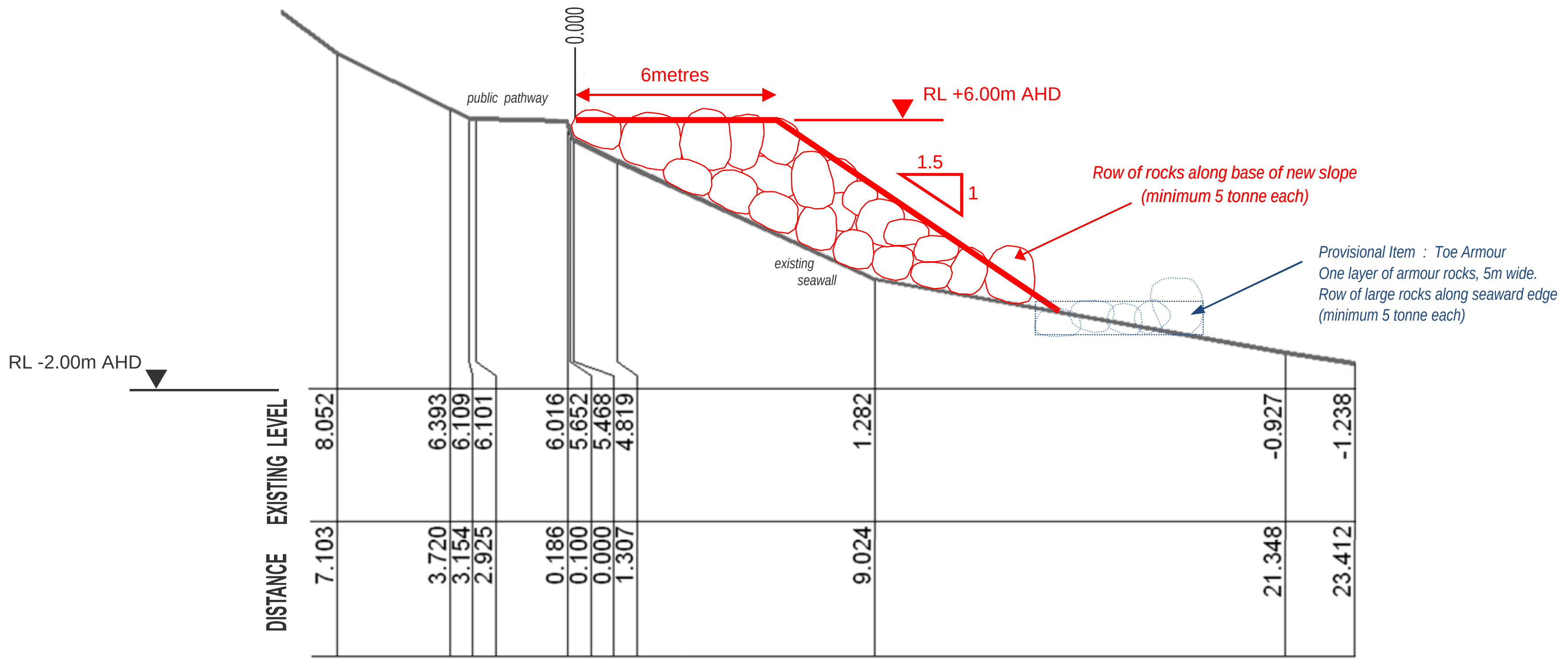
Scale at A3:
HORIZONTAL 1 : 200
VERTICAL 1 : 200

Project:
CHRISTIES BEACH SEAWALL STRUCTURAL UPGRADE

Drawing Title:
CROSS SECTIONS - Sheet 8

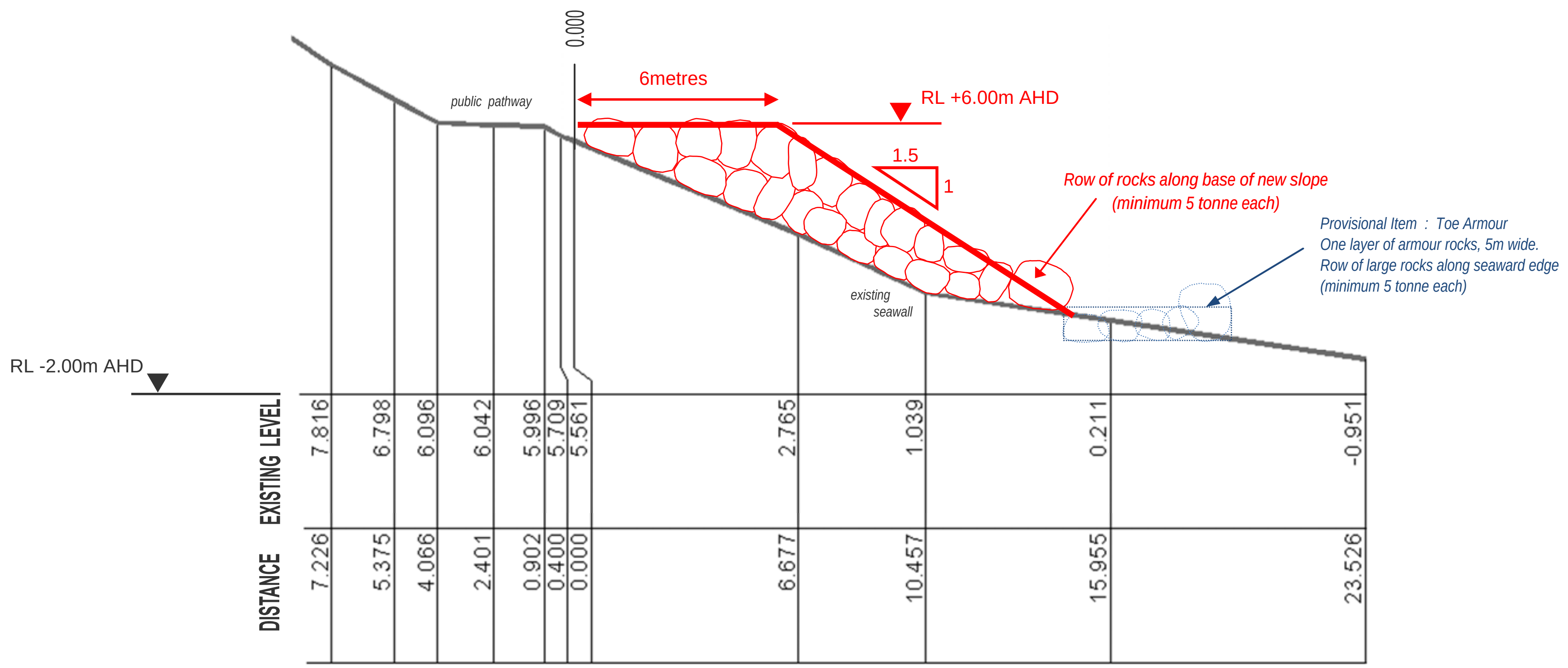
Drawing Number: **11 - 669SAA - 009**

Rev: **A**



CH 340.000

BEARING 129° 32’ 52”



CH 320.000

BEARING 120° 18’ 03”

COASTAL ENGINEERING SOLUTIONS

59 Hulcombe Road
PO Box 677
Samford
QLD 4520
Australia
tel: (+61 7) 3289 7011
fax: (+61 7) 3289 7022

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Fish Creek
VIC 3959
Australia
tel: (+61 3) 5683 2495

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No.	Date	Description	By	Chk
A	12Aug11	Original Issue	POB	HPR

REVISIONS

Notes:

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Datums:

Vertical : AHD

Scale at A3:

HORIZONTAL 1 : 200
VERTICAL 1 : 200

Project:

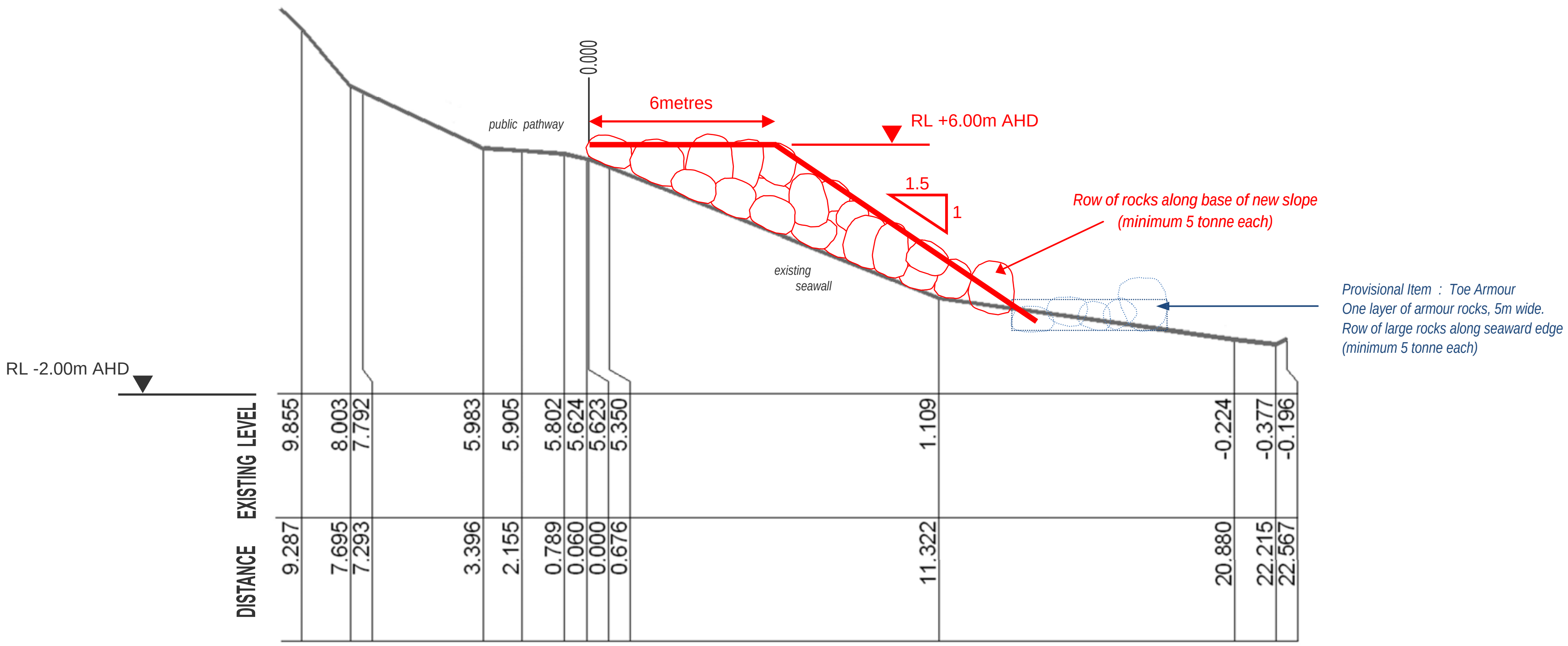
CHRISTIES BEACH SEAWALL STRUCTURAL UPGRADE

Drawing Title:

CROSS SECTIONS - Sheet 9

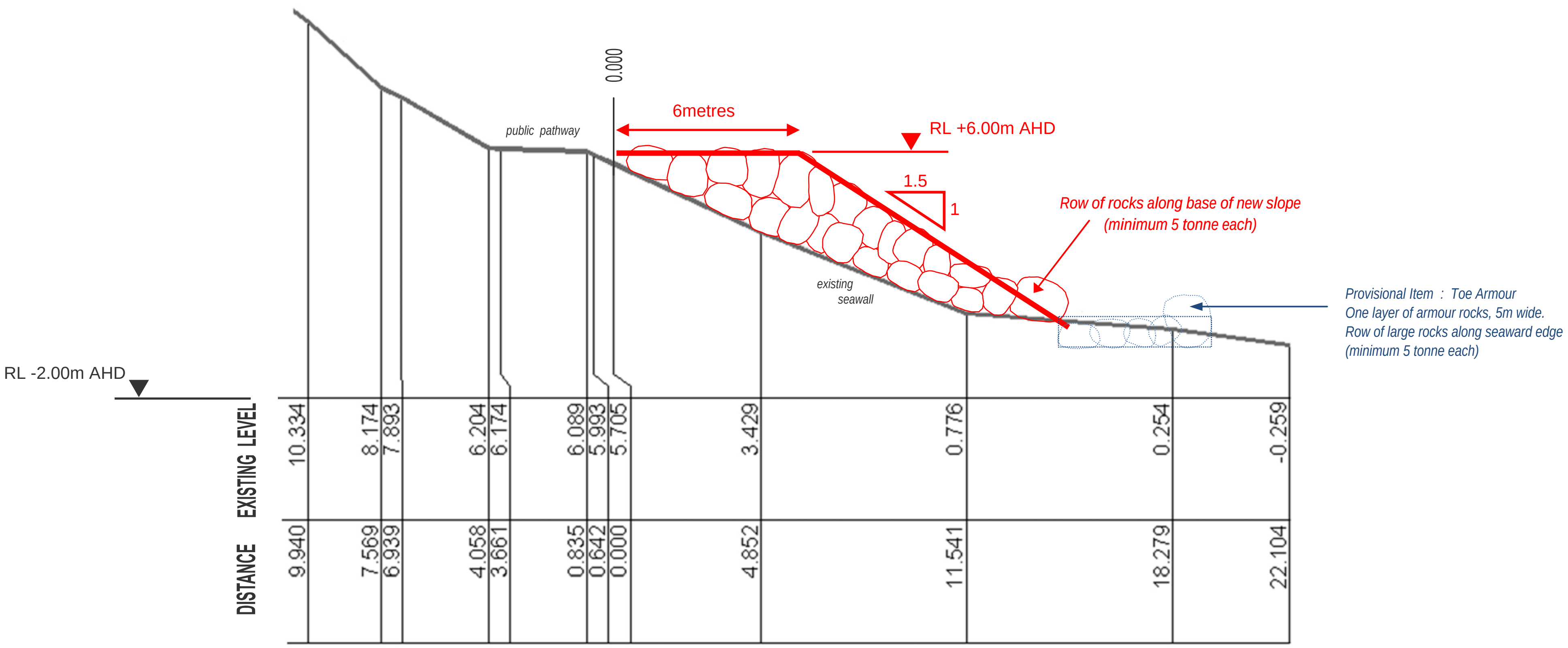
Drawing Number: **11 - 669SAA - 010**

Rev: **A**



CH 380.000

BEARING 118° 52' 05"



CH 360.000

BEARING 115° 24' 56"

COASTAL ENGINEERING SOLUTIONS

59 Hulcombe Road
PO Box 677
Samford
QLD 4520
Australia
tel: (+61 7) 3289 7011
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No.	Date	Description	By	Chk
A	12Aug11	Original Issue	POB	HPR

REVISIONS

Notes:

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Datums:

Vertical : AHD

Scale at A3:

HORIZONTAL 1 : 200
VERTICAL 1 : 200

Project:

CHRISTIES BEACH SEAWALL STRUCTURAL UPGRADE

Drawing Title:

CROSS SECTIONS - Sheet 10

Drawing Number: **11 - 669SAA - 011**

Rev: **A**

Figure 2: WBBT concept design and plans

City of Onkaparinga

swanbury penglase
architects *of human space*

NOT TO SCALE

N

WITTON BLUFF BASE TRAIL
SITE ANALYSIS

10.10.08

08146SK01B

 244 GILBERT ST ADELAIDE SA 5000 TEL (08) 8212 2679 FAX (08) 8212 3162 mail@swanburypenglase.com www.swanburypenglase.com

LEGEND

- PROPOSED PATH ALIGNMENT
- POTENTIAL AREAS FOR BREAKOUT SPACE INCORPORATING SEATING, ART WORKS AND SIGNAGE
- VISUALLY SENSITIVE AREAS
  LIMIT THE NUMBER OF COLUMNS WITHIN THESE ZONES TO ACCENTUATE THE EMBAYMENT AND SMALL DEPRESSION IN THE ROCK PLATFORM. THIS WILL ACCENTUATE THE NOTION OF FLIGHT AND THE STRUCTURE AS TREADING LIGHTLY ON THE LANDSCAPE.
- POSSIBLE AREAS OF COASTAL VEGETATION

City of Onkaparinga

swanbury penglase architects *of human space*

NOT TO SCALE

N

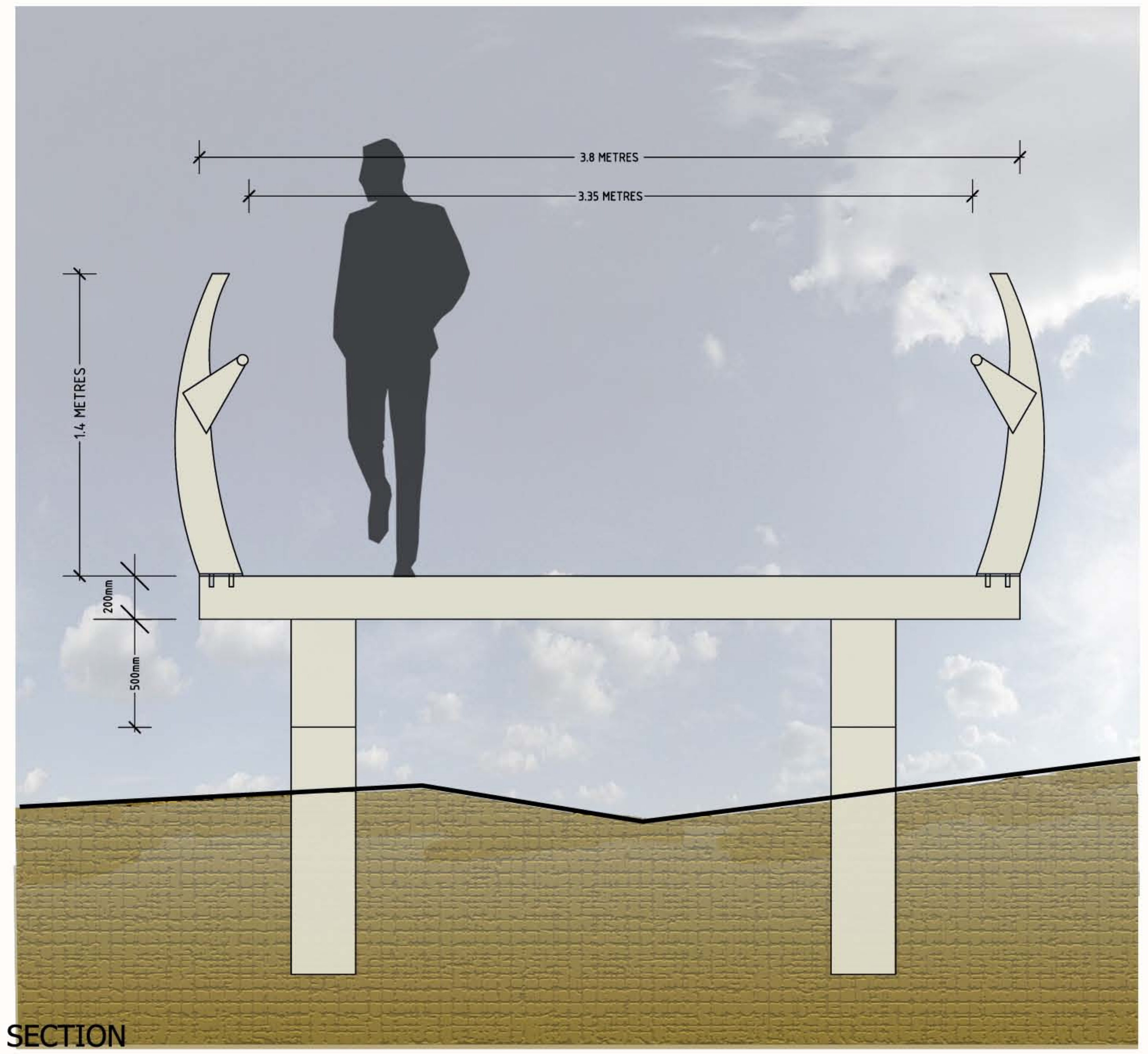
WITTON BLUFF BASE TRAIL
LANDSCAPE CONCEPT

10.10.08

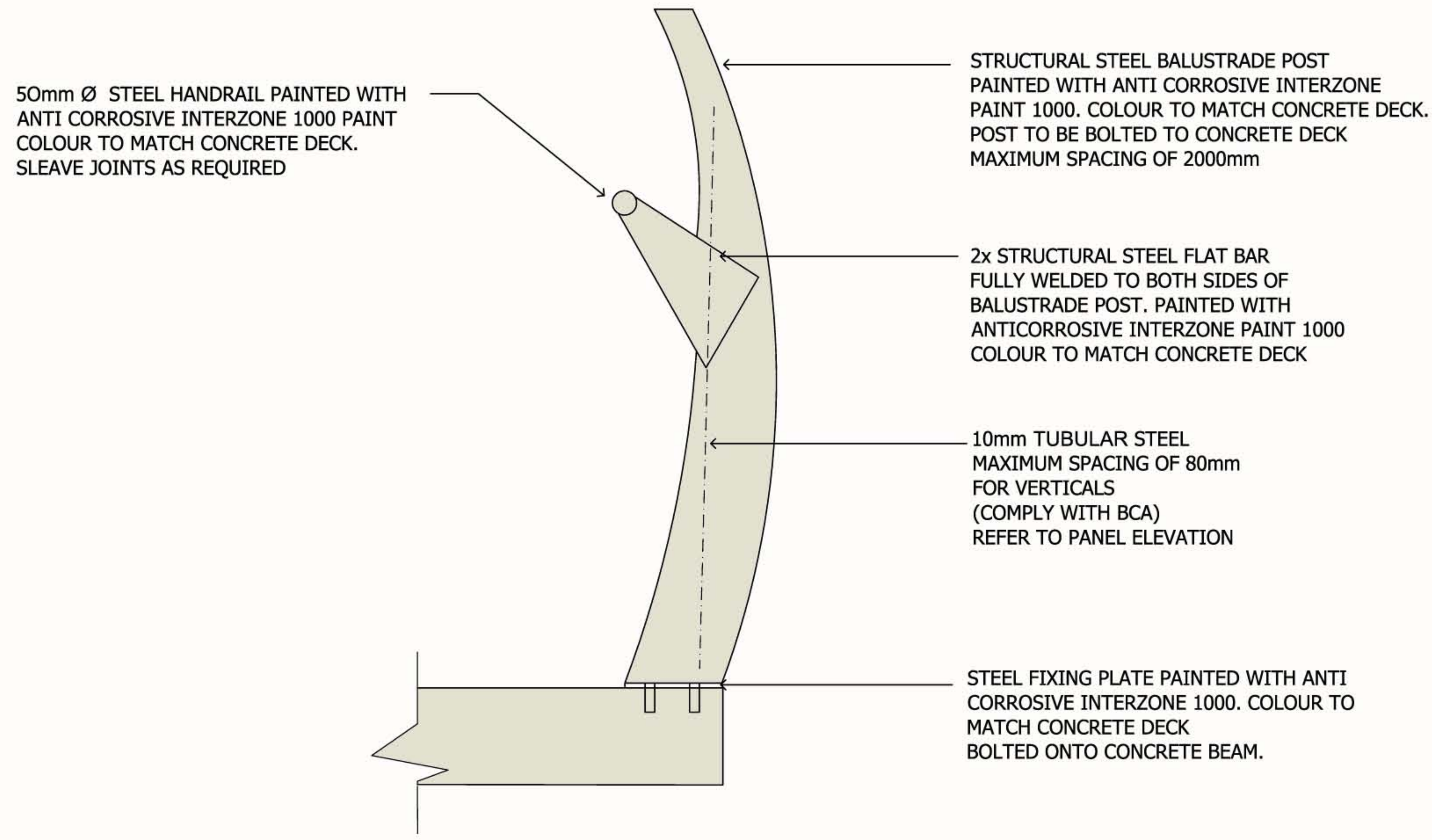
08146SK02B

244 GILBERT ST ADELAIDE SA 5000 TEL (08) 8212 2679 FAX (08) 8212 3162 mail@swanburypenglase.com www.swanburypenglase.com

ELEVATION
CONCRETE DECK
SCALE 1:20@A1



SECTION
CONCRETE DECK
SCALE 1:20@A1



SECTION
BALUSTRADE DETAIL
SCALE 1:10@A1

City of Onkaparinga

swanbury penglase
architects *of human space*

WITTON BLUFF BASE TRAIL
CONCRETE DECK

10.10.08
08146 SK05C

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PHOTOMONTAGE- ARTISTS IMPRESSION NOT TO SCALE

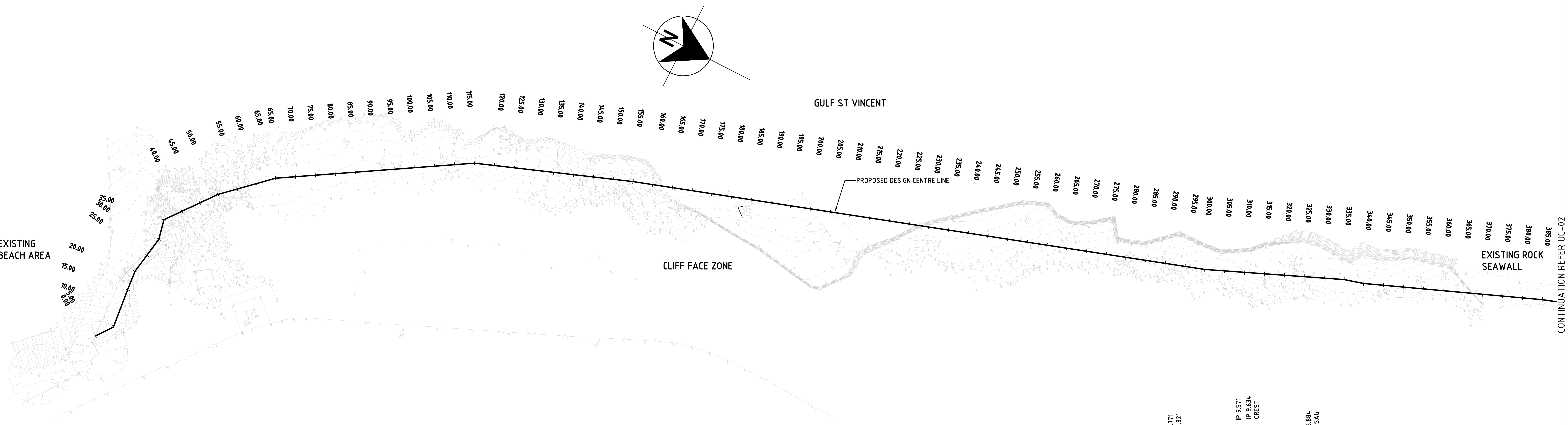
City of Onkaparinga

swanbury penglase
architects *of human space*

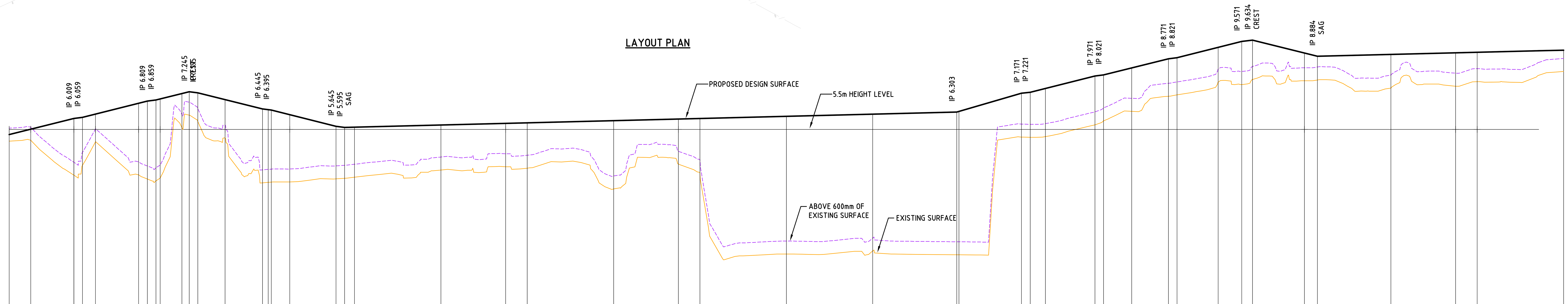
WITTON BLUFF BASE TRAIL
PHOTOMONTAGE

11.11.08

08146 SK10



LAYOUT PLAN



HORIZONTAL CURVE

VERTICAL CURVE

GRADE %: 5% | 2.5% | 5% | 2.5% | 5% | 2.5% | -5% | -2.5% | -5% | -2.5% | 0.5% | 5.787% | 2.5% | 5% | 2.5% | 5% | 2.5% | 5% | 2.5% | -5% | 0.5%

Datum RL. -6.00

CENTRELINE CHAINAGE	CUT/FILL DEPTH	NATURAL SURFACE LEVEL	EXISTING SURFACE PLUS 600	DESIGN CENTRELINE LEVEL
0.00	-0.300	4.959	5.559	5.259
5.00	-0.512	4.997	5.597	5.509
15.00	-2.629	3.381	3.981	6.009
15.01	-2.630	3.379	3.979	6.009
17.00	-2.223	3.836	4.436	6.059
20.00	-1.287	4.922	5.522	6.209
30.00	-3.307	3.402	4.002	6.709
32.00	-3.601	3.208	3.808	6.809
34.00	-3.737	3.122	3.722	6.859
35.00	-3.661	3.248	3.848	6.909
40.00	-1.574	5.585	6.185	7.159
41.71	-1.089	6.156	6.756	7.245
43.71	-1.334	5.861	6.461	7.195
50.00	-1.780	5.100	5.700	6.880
58.71	-3.417	3.028	3.628	6.445
60.00	-3.363	3.049	3.649	6.412
60.71	-3.333	3.061	3.661	6.395
65.00	-3.116	3.064	3.664	6.180
75.71	-2.435	3.210	3.810	5.645
77.71	-2.354	3.240	3.840	5.595
80.00	-2.317	3.289	3.889	5.606
100.00	-2.084	3.622	4.222	5.706
115.00	-2.013	3.768	4.368	5.781
120.00	-2.098	3.707	4.307	5.806
140.00	-3.160	2.746	3.346	5.906
155.00	-2.085	3.895	4.495	5.981
160.00	-2.553	3.453	4.053	6.006
180.00	-6.376	-0.270	0.330	6.106
200.00	-6.334	-0.128	0.472	6.206
219.47	-6.603	-0.300	0.300	6.303
220.00	-6.634	-0.301	0.299	6.333
234.47	-2.026	5.145	5.745	7.171
236.47	-2.083	5.138	5.738	7.221
240.00	-2.232	5.165	5.765	7.397
251.47	-2.258	5.713	6.313	7.971
253.47	-2.126	5.895	6.495	8.021
260.00	-2.009	6.338	6.938	8.347
268.47	-1.737	7.034	7.634	8.771
270.47	-1.724	7.097	7.697	8.821
280.00	-1.612	7.685	8.285	9.297
285.47	-1.995	7.576	8.176	9.571
287.98	-1.824	7.810	8.410	9.634
300.00	-1.279	7.754	8.354	9.033
302.98	-1.096	7.788	8.388	8.884
320.00	-1.553	7.416	8.016	8.969
335.00	-1.544	7.500	8.100	9.044
340.00	-1.358	7.711	8.311	9.069
360.00	-0.804	8.365	8.965	9.169

LONGITUDINAL SECTION OP 6 DES BWALK STR CL

H. 1:500
V. 1:100

PRELIMINARY - FOR REVIEW
NOT FOR CONSTRUCTION

Rev.	Date	Revision Details	Drn	Ver.	App.
01	28.10.08	FOR REVIEW	SY		

Connell Wagner
Connell Wagner Pty Ltd ABN 54 005 139 873
55 Grenfell Street Adelaide
South Australia 5000 Australia
Telephone: +61 8 8237 9777
Facsimile: +61 8 8237 9778
Email: cwadl@conwag.com

Client: CITY OF ONKAPARINGA

Project: WITTON BLUFF
PORT NOARLUNGA

Drawn	Signed	Date
SY		28.10.08
Designed SY	Signed	28.10.08
Verified	Signed	Date
Approved	Signed	Date

Drawing Title: LAYOUT PLAN AND LONGITUDINAL SECTION - 1

Project No. 35149.001

Scale 1:100 V 1:500 H

Sheet Size A1

Drawing No. UC-01

Rev. 01

PLOT DATE=11/7/2008 11:28 AM SCALE=1:1 USER=SOPHIA YAN FILENAME=W:\35149-001\UC 01.DWG
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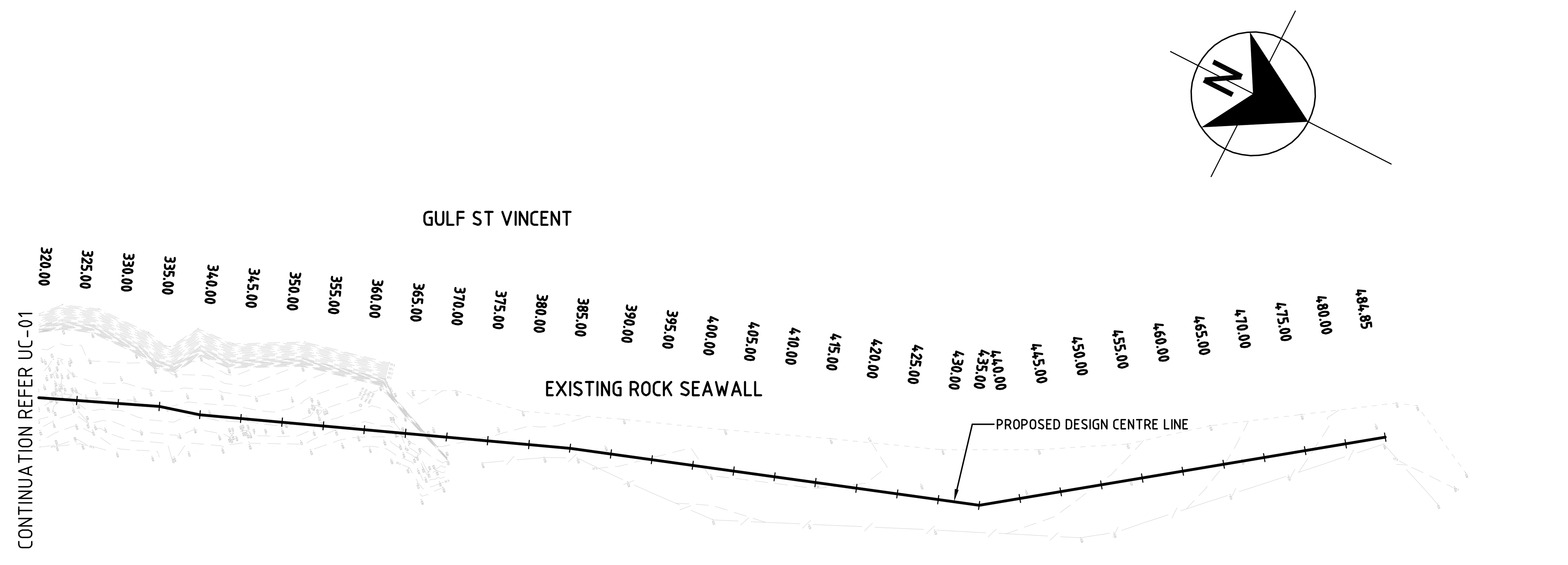
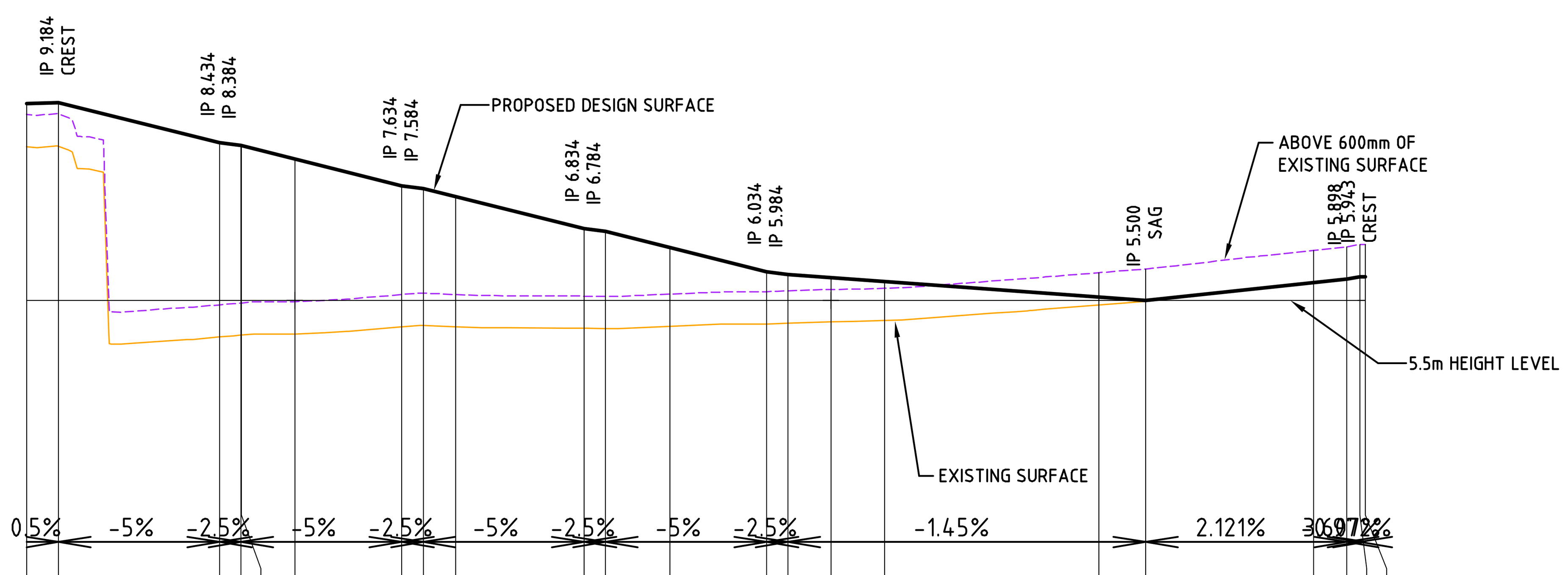
STYLE= ----



LAYOU PLAN



CENTRELINE CHAINAGE	CUT/FILL DEPTH	NATURAL SURFACE LEVEL	EXISTING SURFACE PLUS 600	DESIGN CENTRELINE LEVEL
360.00	-0.804	8.365	8.965	9.169
362.98	-0.815	8.369	8.969	9.184
377.98	-3.615	4.818	5.418	8.434
379.98	-3.531	4.852	5.452	8.384
380.00	-3.530	4.853	5.453	8.383
385.00	-3.258	4.875	5.475	8.133
394.98	-2.624	5.009	5.609	7.634
396.98	-2.548	5.035	5.635	7.584
400.00	-2.422	5.011	5.611	7.433
411.98	-1.854	4.980	5.580	6.834
413.98	-1.806	4.977	5.577	6.784
420.00	-1.466	5.017	5.617	6.483
428.98	-0.971	5.062	5.662	6.034
430.98	-0.907	5.076	5.676	5.984
435.00	-0.821	5.104	5.704	5.925
440.00	-0.728	5.125	5.725	5.853
460.00	-0.147	5.416	6.016	5.563
464.34	-0.014	5.486	6.086	5.500
480.00	0.000	5.832	6.432	5.832
483.09	0.000	5.898	6.498	5.898
484.34	-0.000	5.943	6.543	5.943
484.85	0.000	5.938	6.538	5.938

LONGITUDINAL SECTION OP 6 DES BWALK STR CL

H. 1:500
V. 1:100

PRELIMINARY - FOR REVIEW
NOT FOR CONSTRUCTION

Rev.	Date	Revision Details	Drn	Ver.	App.
01	28.10.08	FOR REVIEW	SY		

Connell Wagner

Connell Wagner Pty Ltd ABN 54 005 139 873
55 Grenfell Street Adelaide
South Australia 5000 Australia
Telephone: +61 8 8237 9777
Facsimile: +61 8 8237 9778
Email: cwadl@conwag.com

Client: CITY OF ONKAPARINGA

Project: WITTON BLUFF
PORT NOARLUNGA

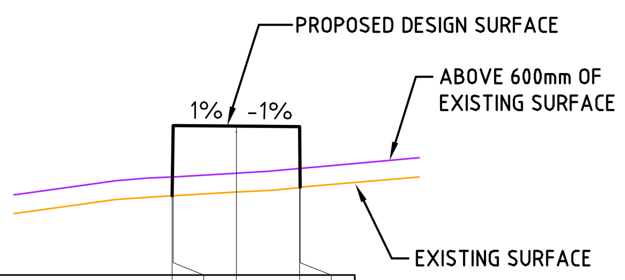
Drawn	Signed	Date
SY		28.10.08
Designed SY	Signed	Date 28.10.08
Verified	Signed	Date
Approved	Signed	Date

Drawing Title: LAYOUT PLAN AND
LONGITUDINAL SECTION - 2

Project No. 35149.001
Scale 1:100 V
1:500 H
Sheet Size A1
Drawing No. UC-02
Rev. 01

20 10 0 10 20 30 40 50 100mm

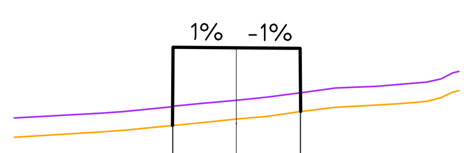
CROSS SECTIONS



Centreline Data
X = 4719.962
Y = 2974.113
Z = 5.706
Datum 1

DESIGN HEIGHT	3.505	5.726	5.706	5.686	3.771
EXISTING SURFACE PLUS 600	4.105	4.106	4.222	4.370	4.371
DEPTH	0.000	-2.220	-2.084	-1.916	-0.000
EXISTING SURFACE	3.505	3.506	3.622	3.770	3.771
DESIGN OFFSET	-2.022	-2.000	0.000	2.000	2.019

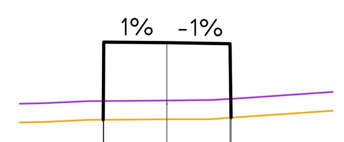
CHAINAGE 100.000



Centreline Data
X = 4668.435
Y = 3114.628
Z = 7.897
Datum 4

DESIGN HEIGHT	5.441	7.917	7.897	7.877	5.876
EXISTING SURFACE PLUS 600	6.041	6.044	6.242	6.474	6.476
DEPTH	-0.000	-2.474	-2.256	-2.004	-0.000
EXISTING SURFACE	5.441	5.444	5.642	5.874	5.876
DESIGN OFFSET	-2.025	-2.000	0.000	2.000	2.020

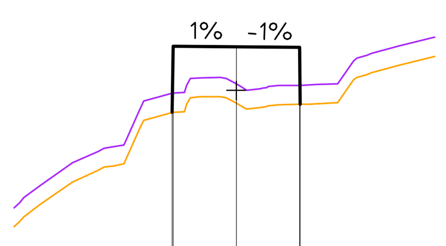
CHAINAGE 250.000



Centreline Data
X = 4616.208
Y = 3255.134
Z = 7.433
Datum 3

DESIGN HEIGHT	4.996	7.453	7.433	7.413	5.065
EXISTING SURFACE PLUS 600	5.596	5.596	5.611	5.663	5.665
DEPTH	0.000	-2.456	-2.422	-2.349	0.000
EXISTING SURFACE	4.996	4.996	5.011	5.063	5.065
DESIGN OFFSET	-2.025	-2.000	0.000	2.000	2.023

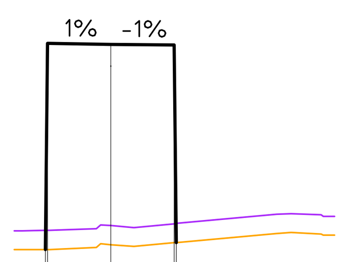
CHAINAGE 400.000



Centreline Data
X = 4748.314
Y = 2933.177
Z = 6.88
Datum 0

DESIGN HEIGHT	4.806	6.900	6.880	6.860	5.065
EXISTING SURFACE PLUS 600	5.406	5.410	5.700	5.665	5.665
DEPTH	0.000	-2.090	-1.780	-1.795	-0.000
EXISTING SURFACE	4.806	4.810	5.100	5.065	5.065
DESIGN OFFSET	-2.021	-2.000	0.000	2.000	2.018

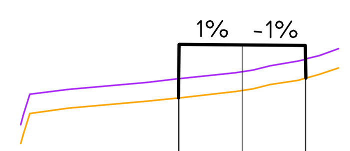
CHAINAGE 50.000



Centreline Data
X = 4684.115
Y = 3067.151
Z = 6.206
Datum -2

DESIGN HEIGHT	-0.285	6.226	6.206	6.186	-0.064
EXISTING SURFACE PLUS 600	0.315	0.316	0.472	0.530	0.536
DEPTH	-0.000	-6.510	-6.334	-6.256	0.000
EXISTING SURFACE	-0.285	-0.284	-0.128	-0.070	-0.064
DESIGN OFFSET	-2.065	-2.000	0.000	2.000	2.063

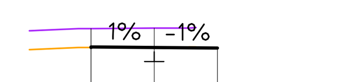
CHAINAGE 200.000



Centreline Data
X = 4634.111
Y = 3208.462
Z = 9.119
Datum 4

DESIGN HEIGHT	7.442	9.139	9.119	9.099	8.067
EXISTING SURFACE PLUS 600	8.042	8.044	8.271	8.664	8.667
DEPTH	-0.000	-1.695	-1.448	-1.035	-0.000
EXISTING SURFACE	7.442	7.444	7.671	8.064	8.067
DESIGN OFFSET	-2.017	-2.000	0.000	2.000	2.010

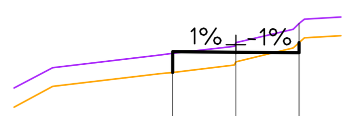
CHAINAGE 350.000



Centreline Data
X = 4575.109
Y = 3328.269
Z = 5.938
Datum 4

DESIGN HEIGHT	5.931	5.958	5.938	
EXISTING SURFACE PLUS 600	6.531	6.531	6.538	5.918
DEPTH	-0.000	-0.027	0.000	
EXISTING SURFACE	5.931	5.931	5.938	
DESIGN OFFSET	-2.000	-2.000	0.000	2.000

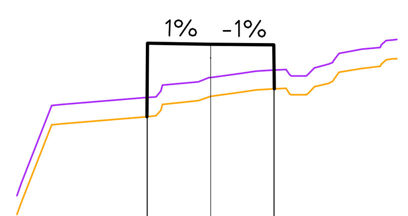
CHAINAGE 484.851



Centreline Data
X = 4793.845
Y = 2921.909
Z = 5.259
Datum 2

DESIGN HEIGHT	4.620	5.279	5.259	5.239	5.566
EXISTING SURFACE PLUS 600	5.220	5.221	5.559	6.163	6.166
DEPTH	-0.000	-0.658	-0.300	0.324	-0.000
EXISTING SURFACE	4.620	4.621	4.959	5.563	5.566
DESIGN OFFSET	-2.007	-2.000	0.000	2.000	2.003

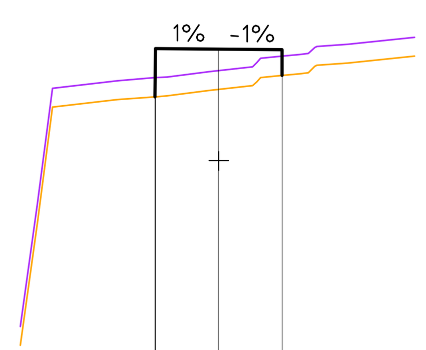
CHAINAGE 0.000



Centreline Data
X = 4699.97
Y = 3019.734
Z = 5.956
Datum -1

DESIGN HEIGHT	3.667	5.976	5.956	5.936	4.537
EXISTING SURFACE PLUS 600	4.267	4.269	4.904	5.136	5.137
DEPTH	0.000	-2.306	-1.652	-1.400	0.000
EXISTING SURFACE	3.667	3.669	4.304	4.536	4.537
DESIGN OFFSET	-2.023	-2.000	0.000	2.000	2.014

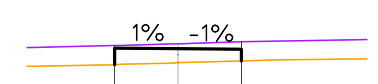
CHAINAGE 150.000



Centreline Data
X = 4652.754
Y = 3162.106
Z = 9.033
Datum -2

DESIGN HEIGHT	7.526	9.053	9.033	9.013	8.204
EXISTING SURFACE PLUS 600	8.126	8.127	8.354	8.803	8.804
DEPTH	-0.000	-1.526	-1.279	-0.809	-0.000
EXISTING SURFACE	7.526	7.527	7.754	8.203	8.204
DESIGN OFFSET	-2.015	-2.000	0.000	2.000	2.008

CHAINAGE 300.000



Centreline Data
X = 4595.862
Y = 3300.271
Z = 5.708
Datum 4

DESIGN HEIGHT	5.203	5.728	5.708	5.688	5.316
EXISTING SURFACE PLUS 600	5.803	5.803	5.859	5.916	5.916
DEPTH	-0.000	-0.525	-0.449	-0.372	-0.000
EXISTING SURFACE	5.203	5.203	5.259	5.316	5.316
DESIGN OFFSET	-2.005	-2.000	0.000	2.000	2.004

CHAINAGE 450.000

Rev.	Date	Revision Details	Drn	Ver.	App.
01	28.10.08	FOR REVIEW	SY		

Connell Wagner
Connell Wagner Pty Ltd ABN 54 005 139 873
55 Grenfell Street Adelaide
South Australia 5000 Australia
Telephone: +61 8 8237 9777
Facsimile: +61 8 8237 9778
Email: cwadl@conwag.com

Client: CITY OF ONKAPARINGA

Project: WITTON BLUFF PORT NOARLUNGA

			Signed	Date
Drawn	SY			28.10.08
Designed	SY			28.10.08
Verified				
Approved				

Drawing Title: CROSS SECTIONS

PRELIMINARY - FOR REVIEW
NOT FOR CONSTRUCTION

Project No. 35149.001

Scale 1:200 V 1:200 H

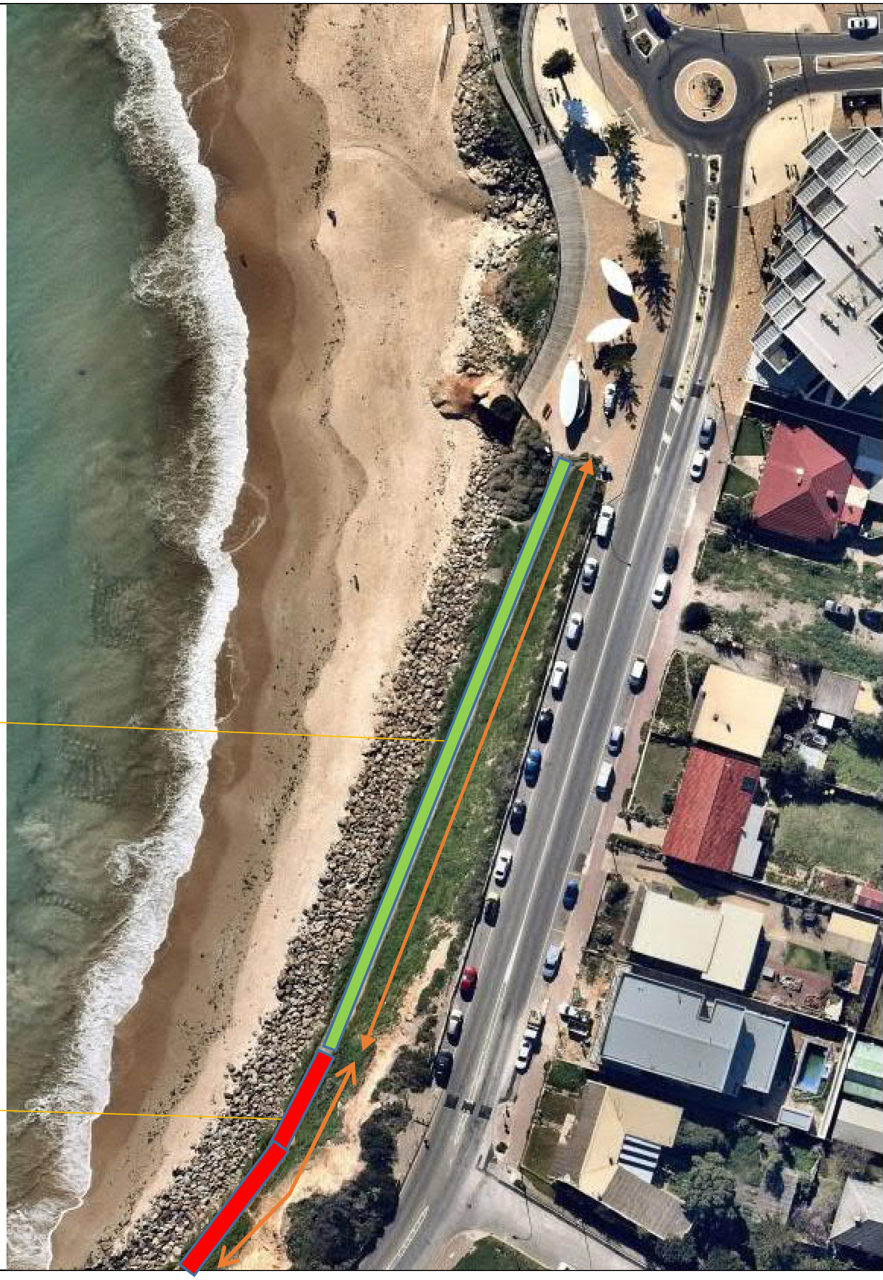
Sheet Size A1

Drawing No. UC-03

Rev. 01

PLOT DATE=11/7/2008 11:31 AM SCALE=1:1 USER=SOPHIA YAN FILENAME=W:\35149-001\UC 01.DWG
DEVICE= \\SYD2K_SERVER05\LEXMARK OPTRA N LEVEL 2 NORTH
STYLE= ----

Figure 3: CMW Slope Stability Risk Assessment and Path realignment suggestions



LEGEND

- High Instability Risk
- Med. Instability Risk
- Low Instability Risk

Client:	City of Onkaparinga
Project:	Christies Beach and Port Noarlunga Slope Stability - Path Relocation
Description:	Figure 3a: Path Realignment
Project No:	ADL2020-0176
Date:	23/07/20 J. Slade

CMW Geosciences

LEGEND

- High Instability Risk
- Med. Instability Risk
- Low Instability Risk

Client:	City of Onkaparinga
Project:	Christies Beach and Port Noarlunga Slope Stability - Path Relocation
Description:	Figure 3b: Path Realignment
Project No:	ADL2020-0176
Date:	23/07/20 J. Slade

CMW Geosciences

LEGEND

- High Instability Risk
- Med. Instability Risk
- Low Instability Risk

Client:	City of Onkaparinga
Project:	Christies Beach and Port Noarlunga Slope Stability - Path Relocation
Description:	Figure 3c: Path Realignment
Project No:	ADL2020-0176
Date:	23/07/20 J. Slade

CMW Geosciences

Zone of similar geotechnical characteristics

LEGEND

- High Instability Risk
- Med. Instability Risk
- Low Instability Risk

Client:	City of Onkaparinga
Project:	Christies Beach and Port Noarlunga Slope Stability - Path Relocation
Description:	Figure 3d: Path Realignment
Project No:	ADL2020-0176
Date:	23/07/20 J. Slade

CMW Geosciences

Zone of similar geotechnical characteristics

It is recommended to place the footings for the elevated walkway away from the edge of the current upper platform. This is too avoid cliff retreat but also strong vertical joints that persist in the rock mass and when loaded may result in lateral movement of the rock.

Select trimming of the local rock is recommended to ensure the northern elevated walkway abutment to Zone J is pushed east into the slope.

LEGEND

- High Instability Risk
- Med. Instability Risk
- Low Instability Risk

Client:	City of Onkaparinga
Project:	Christies Beach and Port Noarlunga Slope Stability - Path Relocation
Description:	Figure 3e: Path Realignment
Project No:	ADL2020-0176
Date:	23/07/20 J. Slade

CMW Geosciences

Zone of similar geotechnical characteristics

It is noted that this Zone J present the highest likelihood of instability but if the walkway is offset from the cliff the risk of interaction with falling soil and rocks can be separated.

Is it recommended to make this structure is made out of steel or wood and be a small diameter footing will be difficult and therefore gravity not bored pile footings are suggested.

LEGEND

- High Instability Risk
- Med. Instability Risk
- Low Instability Risk

Client:	City of Onkaparinga
Project:	Christies Beach and Port Noarlunga Slope Stability - Path Relocation
Description:	Figure 3f: Path Realignment
Project No:	ADL2020-0176
Date:	23/07/20 J. Slade

CMW Geosciences

Zone of similar geotechnical characteristics

LEGEND

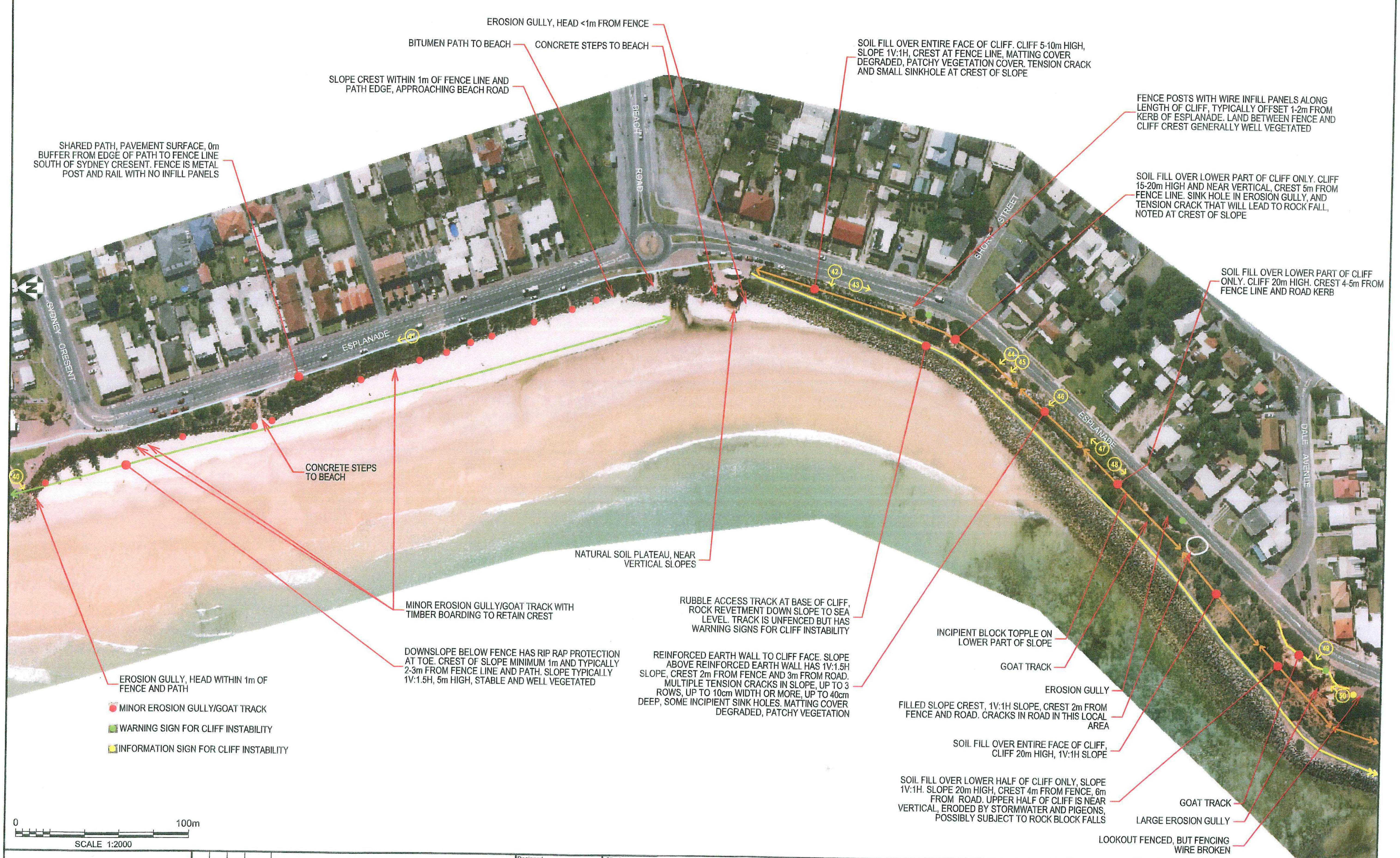
- High Instability Risk
- Med. Instability Risk
- Low Instability Risk

Client:	City of Onkaparinga
Project:	Christies Beach and Port Noarlunga Slope Stability - Path Relocation
Description:	Figure 3g: Path Realignment
Project No:	ADL2020-0176
Date:	23/07/20 J. Slade

CMW Geosciences

Appendix A: Detailed_Cliff_Stability_Investigations_ Stage_2_Final_ReportA 2007

A3



B	MLD	PWM	06/07	FINAL	
A	MLD	PWM	05/07	ISSUED FOR CLIENT REVIEW	
Rev	By	Appd	Date	REVISION RECORD	

URS

URS Australia Pty Ltd.
25 North Terrace
Hackney S.A. 5069
Tel. 08 8366 1000
Fax. 08 8366 1001

Designed	MLD
Drawn	SCS
Checked	MLD
Approved	PWM
Scales	1:2000

Client: City of Onkaparinga

Project Title: CLIFF TOP EROSION AUDIT

Drawing Title: CHRISTIES BEACH SHEET 2 OF 2

Status	REVIEW
Datum	
Date	JUNE 2007
CAD File Number:	42655715-013-04.dwg
Job Number:	42655715
Drawing Number:	08
Rev	B

A3

NOTE:
AREA COVERED BY DETAILED CLIFF STABILITY INVESTIGATION APRIL 2006, NOT INSPECTED AGAIN AS PART OF THIS CLIFF TOP EROSION AUDIT. COPY OF PREVIOUS DRAWING INCLUDED. REFER TO DRAWING 09A.

WARNING SIGN FOR CLIFF INSTABILITY

INFORMATION SIGN FOR CLIFF INSTABILITY

0 100m

SCALE 1:2000

URS

URS Australia Pty Ltd.
25 North Terrace
Hackney S.A. 5069
Tel. 08 8366 1000
Fax. 08 8366 1001

Rev	By	Appd	Date	REVISION RECORD
B	MLD	PWM	06/07	FINAL
A	MLD	PWM	05/07	ISSUED FOR CLIENT REVIEW

Designed	MLD
Drawn	SCS
Checked	MLD
Approved	PWM
Scales	1:2000

Client: City of Onkaparinga

Project Title: CLIFF TOP EROSION AUDIT

Drawing Title: PORT NOARLUNGA SHEET 1 OF 2

Status: REVIEW

Datum:

Date: JUNE 2007

CAD File Number: 42655715-014-01.dwg

Job Number: 42655715

09

Rev B

CLIFF TOP EROSION AUDIT

RISK ASSESSMENTS, RECOMMENDED RISK TREATMENTS AND COST ESTIMATES

REVISION 0 Jun-07

SUBURB: Christies Beach

Hazard	Drawing Nos	Plate Nos	Element at Risk	Score for Probability of Spatial Impact	Score for Temporal Probability	Score for Vulnerability	Risk Score for Element at Risk	Overall Risk Score for Hazard	Comment	Recommended Risk Treatment	Item	Quantity	Unit	Rate ($/unit)	Item Cost ($)	Remedial Works Cost ($)	Comment
Gully erosion of slope crest	07, 08	39, 40, 41	Persons walking or bicycling along path behind slope crest	1	1	1	1		Fencing present	Infill gullies	Supply and place rubble below slope crest at approximately 25 small gullies below path.	125	m^3	80	10000	10000	Address drainage lines and goat tracks down slope crest.
			Path and fence behind crest	2	2	1	4	4	Fencing close to slope crest								
Soil slump of slope crest	08	42, 43, 46, 47	Persons walking or bicycling along access path at cliff base	2	2	2	8	8	Slump material will reach the base of the cliff	Infill sinkholes and tension cracks	Clean out eroded/softened material from sinkholes and tension cracks, then supply and place bentonite granules to fill voids	2	days	1000	2000		Slope above reinforced earth wall and slope north of Short Street. Assume hand cleaning out and filling using 2 man crew .
			Road pavement and fence behind crest	1	2	1	2		Fencing set back several metres from crest	Revegetation along cliff top	Box out existing soil where required and supply and place 0.3 m thickness of plant growing medium	300	m^3	40	12000		Slope and crest above reinforced earth wall and crest behind slope north of Short Street.
			Base access path pavement	1	2	1	2		Slump unlikely to damage path		Supply and place erosion control matting	1000	m^2	8	8000		
											Supply and place vegetation and maintain during Year 1	1000	m^2	10	10000		
											Maintain vegetation over Years 2 to 5	1000	m^3	15	15000	47000	
Block falls/slides and topples from cliff	08	45, 48, 50, 51	Persons walking or bicycling along access path at cliff base	2	2	2	8	8	Generally not a cliff top erosion hazard but a cliff face hazard.	Recommend additional risk specific warning signage on base path and further assessment of potential failure blocks to determine if knocking them down is warranted.							
			Base access path pavement	2	2	1	4										

Notes

1) Costs are engineers estimates only and are based on the available information. A quantity surveyor should be consulted should more accurate costings be required.
2) Costs assume that all remedial works at all sites are undertaken as part of a single contract involving a single mobilisation to site.
3) All Council costs (consents, insurance, legals, community consultation, Aboriginal monitoring, etc) have been excluded from the above costs.
4) Costs based on 2007 prices and are exclusive of GST.
5) It is suggested that 15 % be added to the above costs for project management and supervision, and a further 20 % be added for contingency

CLIFF TOP EROSION AUDIT

RISK ASSESSMENTS, RECOMMENDED RISK TREATMENTS AND COST ESTIMATES

REVISION 0 Jun-07

SUBURB: Port Noarlunga

Hazard	Drawing Nos	Plate Nos	Element at Risk	Score for Probability of Spatial Impact	Score for Temporal Probability	Score for Vulnerability	Risk Score for Element at Risk	Overall Risk Score for Hazard	Comment	Recommended Risk Treatment	Item	Quantity	Unit	Rate ($/unit)	Item Cost ($)	Remedial Works Cost ($)	Comment
Gully erosion of slope crest	09, 10	52-54	Persons walking on footpath behind slope crest	1	1	1	1		Armco barrier present	Infill gullies	Supply and place rubble below slope crest at approximately 10 small gullies below footpath.	50	m^3	40	2000	2000	Address drainage lines and goat tracks down slope crest.
			Road, footpath and fence behind crest	2	2	1	4	4	Fence, footpath and road close to slope crest								

Notes

1) Costs are engineers estimates only and are based on the available information. A quantity surveyor should be consulted should more accurate costings be required.
2) Costs assume that all remedial works at all sites are undertaken as part of a single contract involving a single mobilisation to site.
3) All Council costs (consents, insurance, legals, community consultation, Aboriginal monitoring, etc) have been excluded from the above costs.
4) Costs based on 2007 prices and are exclusive of GST.
5) It is suggested that 15 % be added to the above costs for project management and supervision, and a further 20 % be added for contingency

Appendix B: Extracts from GHD Cliff Stability Review Risk Assessment 2016

4.5 Semi-Quantitative Risk Assessment - Risk to Property

4.5.1 Methodology

The assessment of risk to property has considered only council assets at cliff top level.

AGS (2007) descriptions for qualitative measures of likelihood for assessing risk to property appear to align with the broad description for likelihood given in the COO Risk Management Framework (2010-2013). AGS include a sixth division, 'barely credible' (refer **Error! Reference source not found.**).

The AGS descriptions for qualitative measures of consequence to property could also be considered to align with those given by COO. The consequences are separated into 5 divisions in both documents (refer Table 6 - AGS and COO qualitative consequence terms compared).

Table 5 - AGS and COO qualitative likelihood terms compared

AGS qualitative measures of likelihood			COO likelihood rating	
Approximate annual probability	Descriptor	Level	Rating	Level
10^{-1}	Almost certain	A	Almost certain	5
10^{-2}	Likely	B	Likely	4
10^{-3}	Possible	C	Possible	3
10^{-4}	Unlikely	D	Unlikely	2
10^{-5}	Rare	E	Rare	1
10^{-6}	Barely credible	F		

Table 6 - AGS and COO qualitative consequence terms compared

AGS qualitative measures of consequence			COO consequence rating	
Approximate Cost of Damage – Indicative value	Descriptor	Level	Rating	Level
200%	Catastrophic	1	Critical	5
60%	Major	2	Serious	4
20%	Medium	3	Moderate	3
5%	Minor	4	Minor	2
0.5%	Insignificant	5	Negligible	1

The COO risk assessment matrix contains four risk ratings, while the AGS risk analysis matrix contains 5, the additional risk level being 'very low risk'. Both AGS and COO risk implications broadly agree that very high and high risk ratings would require further treatment (risk control), moderate ratings may require additional treatment, and low risk ratings are usually acceptable. Except in the instance of very high ratings, the COO risk matrix tends to be more conservative than that suggested by the AGS. It is noted that the COO implications between risk ratings high and very high are a different level of management review, but that both require evaluation of control measures (refer **Error! Reference source not found.** and Table 8 - COO risk assessment matrix (axes reversed to match AGS matrix)).

In order to generally apply AGS guidance, while adopting COO risk management guidelines the following approach has been adopted. For assessment of risk to property, where assets are identified that may be at risk semi-quantitative techniques have been used whereby estimated landslide likelihood (derived during the assessment of risk to life) and assessment of likelihood of spatial impact (qualitatively assessed per zone) are combined to provide a qualitative measure of likelihood, using the approximate annual probabilities in the AGS guidelines. AGS levels E and F (rare and barely credible) have been combined to one level. Consequence has been assessed qualitatively using guideline descriptors in both AGS and COO guidelines.

These levels will be assessed against the COO risk assessment matrix to provide a risk rating for each hazard type identified at each site.

Table 7 – Qualitative risk analysis matrix – level of risk to property (AGS 2007)

		Consequences				
		Catastrophic	Major	Medium	Minor	Insignificant
Likelihood	Almost Certain	VH	VH	VH	H	M or L
	Likely	VH	VH	H	M	L
	Possible	VH	H	M	M	VL
	Unlikely	H	M	L	L	VL
	Rare	M	L	L	VL	VL
	Barely Credible	L	VL	VL	VL	VL

Table 8 - COO risk assessment matrix (axes reversed to match AGS matrix)

		Consequences				
		5	4	3	2	1
Likelihood	5	VH	VH	H	H	H
	4	VH	H	H	M	M
	3	H	H	H	M	L
	2	H	M	M	L	L
	1	M	M	L	L	L

4.5.2 Likelihood

The probability of landslides has been based directly on the probability of events occurring and impacting the crest as estimated for the risk to life (Section 4.4). No consideration has been given to individual small falls (danger class A) as they are considered unlikely to impact cliff top infrastructure.

The maximum depth of failure effect from the cliff crest has been estimated from the compiled inventory. The estimated probability of spatial impact has been estimated per zone based on a qualitative assessment of the proportion of the zone which has assets located within this distance of the crest.

Combining the two probabilities above results in an estimated likelihood value. Likelihoods have been derived using both the pessimistic and 'best estimate' values for probability of occurrence.

4.5.3 Consequence

The consequence for potentially impacted assets has been qualitatively estimated based on the asset type and estimated failure size. In this instance the landslides are always considered to be occurring below the asset rather than potentially impacting them from above. This distinction results in generally high consequences in all instances. Assessed consequence values varied from 3 to 5, with the lower end usually minor failures affecting fencing or paths and the higher end major failures affecting paths or roads. In some zones there is potential to relocate affected assets inland, while in many zones this may not be possible and if an affected asset was to be reinstated the affected land area would require stabilisation and reinstatement.

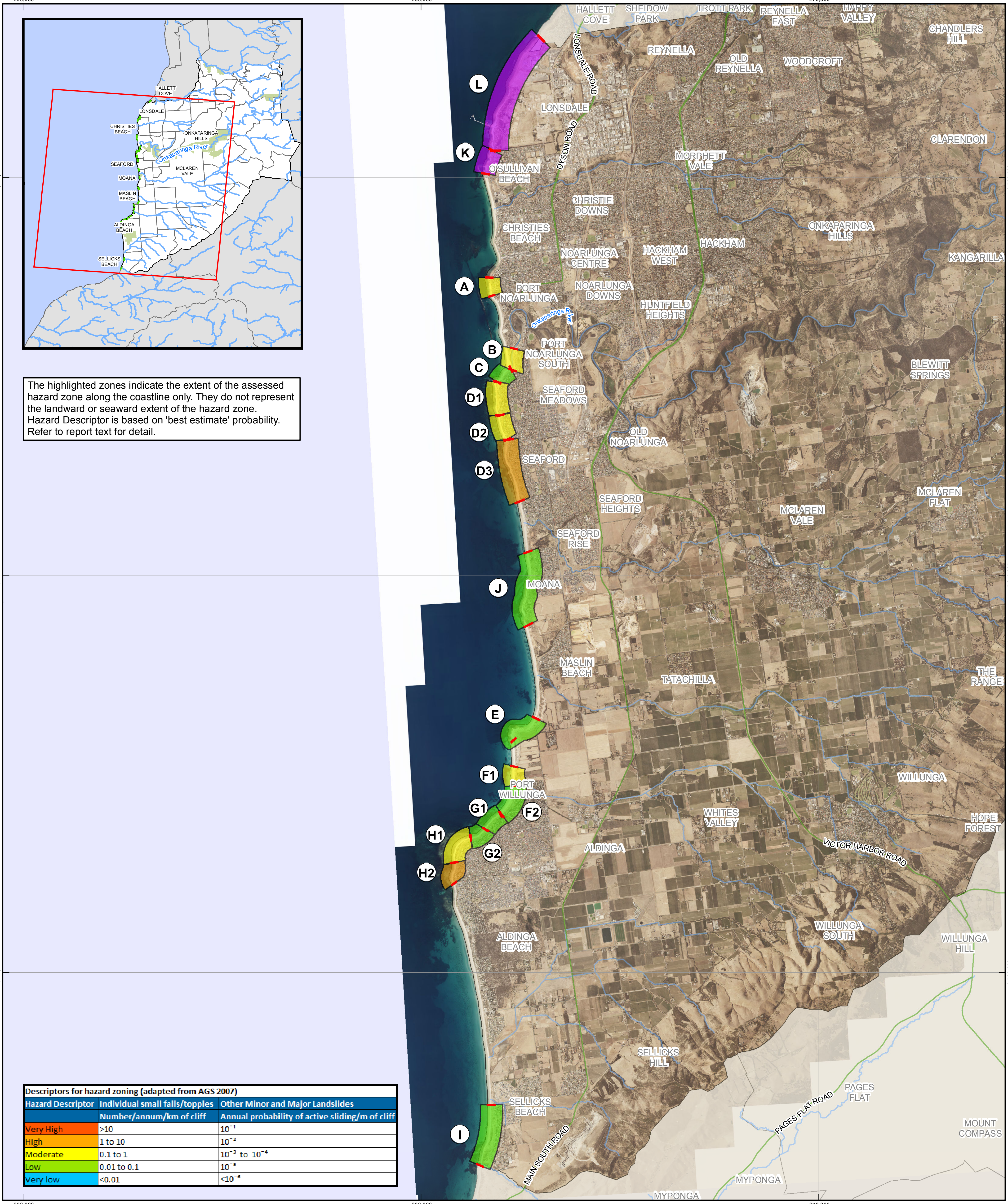
4.5.4 Risk estimation

The risk rating for minor and major landslides derived from the COO risk matrix is presented in Table 9 - Risk to property with calculations presented in Appendix E. Where the risk rating varied between the pessimistic and 'best estimate' values, the range has been presented. Estimated risk ratings were all Moderate or higher. Where a landslide type was identified as credible within a zone, but no impact on infrastructure was considered credible a rating of Low has been applied. Where a landslide type has not been identified as credible within a zone 'n/a' appears in the table.

Table 9 - Risk to property

Zone	Minor Landslides (Danger Class B)	Major Landslides (Danger Class C)
A	M	H
B	M	H
C	L	n/a
D1	M	n/a
D2	M	n/a
D3	H	H
E	L	L
F1	H or M	H
F2	L	n/a
G1	L	n/a
G2	L	M
H1	H or M	n/a
H2	H	H
I	L	H or M
J	L	n/a
K	n/a	n/a
L	n/a	n/a

The risk to property for Minor and Major landslides has been presented geographically in Figure 3 – Risk to Property, Minor Landslides and Figure 4 – Risk to property, Major Landslides respectively.



The highlighted zones indicate the extent of the assessed hazard zone along the coastline only. They do not represent the landward or seaward extent of the hazard zone.
Hazard Descriptor is based on 'best estimate' probability.
Refer to report text for detail.

Descriptors for hazard zoning (adapted from AGS 2007)

Hazard Descriptor	Individual small falls/topples	Other Minor and Major Landslides
	Number/annum/km of cliff	Annual probability of active sliding/m of cliff
Very High	>10	10^{-1}
High	1 to 10	10^{-2}
Moderate	0.1 to 1	10^{-3} to 10^{-4}
Low	0.01 to 0.1	10^{-5}
Very low	<0.01	$<10^{-6}$

LEGEND

Zone Boundaries

(A) Zone Identifier

Risk to Property from Minor Landslide

- High
- Moderate
- Low
- Hazard not identified during assessment

Paper Size A3

0 500 1,000 2,000 3,000 4,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

City of Onkaparinga
Cliff Stability Review

Risk to Property
Minor Landslides

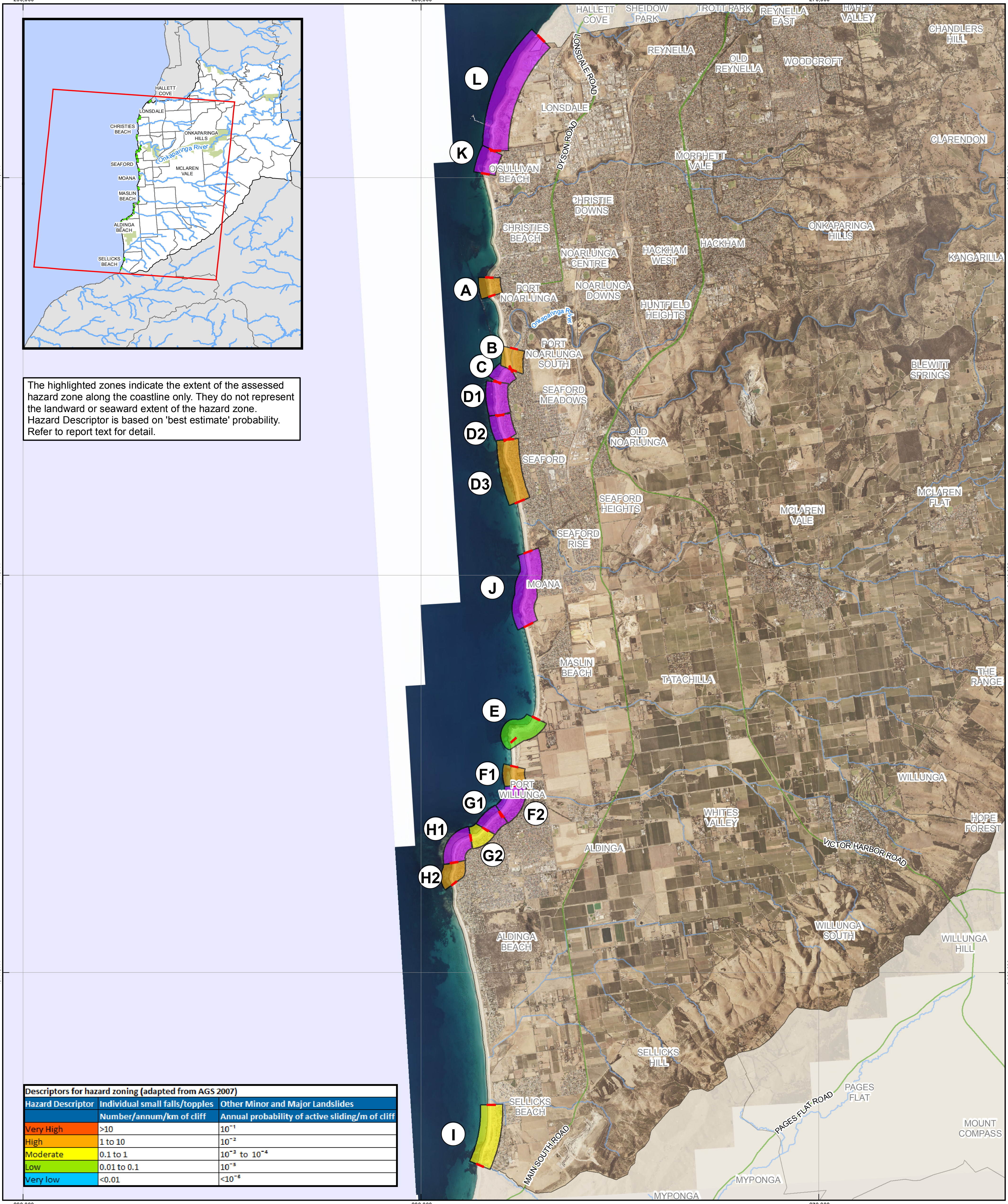
Job Number 31 - 30756
Revision A
Date 26 Apr 2016

Figure 3

G:\31\30756\GIS\Maps\Working\3130756_Figure3_RiskToProperty_MinorLandslide_A3P.mxd

5 Church St Traralgon VIC 3844 Australia T 61 3 5136 5800 F 61 3 5136 5888 E W www.ghd.com

Data source: dept of Planning, Transport and Infrastructure, Roads, 2014: GHD, Cliff Data 2014: City of Onkaparinga, Aerial Imagery, 2014. Created by:hcoles



The highlighted zones indicate the extent of the assessed hazard zone along the coastline only. They do not represent the landward or seaward extent of the hazard zone.
Hazard Descriptor is based on 'best estimate' probability.
Refer to report text for detail.

Descriptors for hazard zoning (adapted from AGS 2007)

Hazard Descriptor	Individual small falls/topples	Other Minor and Major Landslides
	Number/annum/km of cliff	Annual probability of active sliding/m of cliff
Very High	>10	10^{-1}
High	1 to 10	10^{-2}
Moderate	0.1 to 1	10^{-3} to 10^{-4}
Low	0.01 to 0.1	10^{-5}
Very low	<0.01	$<10^{-6}$

LEGEND

Zone Boundaries

(A) Zone Identifier

Risk to Property from Major Landslide

- High
- Moderate
- Low
- Hazard not identified during assessment

Paper Size A3

0 500 1,000 2,000 3,000 4,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

City of Onkaparinga
Cliff Stability Review

Job Number 31 - 30756
Revision A
Date 26 Apr 2016

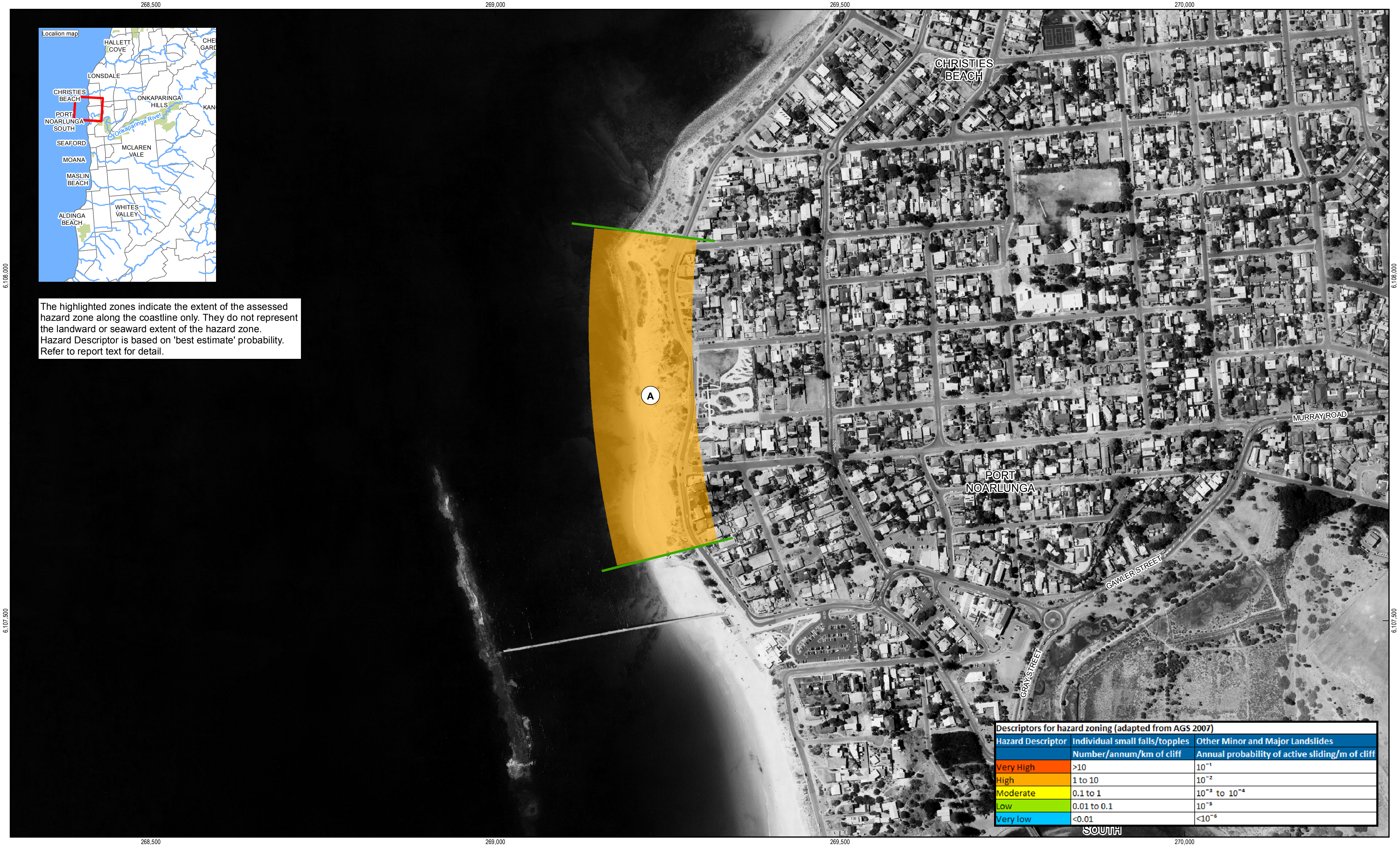
Risk to Property Major Landslides

Figure 4

G:\31\30756\GIS\Maps\Working\3130756_Figure4_RiskToProperty_MajorLandslide_A3P.mxd

5 Church St Traralgon VIC 3844 Australia **T** 61 3 5136 5800 **F** 61 3 5136 5888 **E** **W** www.ghd.com

Data source: dept of Planning, Transport and Infrastructure, Roads, 2014: GHD, Cliff Data 2014: City of Onkaparinga, Aerial Imagery, 2014. Created by:hcoles



The highlighted zones indicate the extent of the assessed hazard zone along the coastline only. They do not represent the landward or seaward extent of the hazard zone.
Hazard Descriptor is based on 'best estimate' probability.
Refer to report text for detail.

Descriptors for hazard zoning (adapted from AGS 2007)

Hazard Descriptor	Individual small falls/topples	Other Minor and Major Landslides
	Number/annum/km of cliff	Annual probability of active sliding/m of cliff
Very High	>10	10^{-1}
High	1 to 10	10^{-2}
Moderate	0.1 to 1	10^{-3} to 10^{-4}
Low	0.01 to 0.1	10^{-5}
Very low	<0.01	$<10^{-6}$

Paper Size A3

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

N

LEGEND

Zone Boundaries

(A) Zone Identifier

Hazard from Individual Falls

Very High

High

City of Onkaparinga
Cliff Stability Review

Job Number | 31-30756
Revision | 0
Date | 27 Apr 2016

Hazard from Individual Falls
Page 2 of 6 (Zone A)

Appendix G

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

G:\31\30756\GIS\Maps\Working\3130756_002_Hazard_IndivFalls_A3L_Rev0.mxd

Data source: Department of Planning, Transport and Infrastructure, Roads and Suburb information; City of Onkaparinga, Aerial Imagery, 2014. Created by:cagilbert

Area:	A	Port Noarlunga Witton Bluff

Group Weighting (%)		Assessment criteria	Criteria Weighting	Net weighting	Administrative				Minor works										Major works						Do Nothing	
					Signage		**Managed retreat**		**Access management**		**Drainage improvements**		**Revegetation**		**Slope reprofiling**		**Relocate infrastructure**		**Localised Rock Placement**		**Revetment**		**Wave attenuation**		**Do Nothing**	
					Install or upgrade signage		Allow erosion of vacant public land to continue, may require purchase of privately owned land or major infrastructure relocation		Provision/upgrade of fencing to control public access		Modification to stormwater management including cliff top earthworks		Slope revegetation		Flatten slopes to remove overhangs or unstable slopes		Minor realignments or relocation of infrastructure		Place rock in short segments at specific locations		Construct a rock revetment along the base of the cliff		Rock placement below the high water mark to trigger breaking of large waves prior to reaching the cliff base		No change to existing situation	
					Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score
40%	Effectiveness	Property risk - rockfall	0%	0%		0		0		0		0		0		0		0		0		0		0		0
		Public safety risk - rockfall	100%	40%	4	4	1	1	5	5	3	3	2	2	4	4	1	1	3	3	5	5	4	4	1	1
		Property risk - minor landslide	45%	18%	1	0.45	5	2.25	1	0.45	4	1.8	2	0.9	4	1.8	5	2.25	3	1.35	4	1.8	4	1.8	1	0.45
		Public safety risk - minor landslide	55%	22%	2	1.1	1	0.55	5	2.75	3	1.65	2	1.1	4	2.2	2	1.1	4	2.2	5	2.75	4	2.2	1	0.55
		Property risk - major landslide	45%	18%	1	0.45	5	2.25	1	0.45	4	1.8	2	0.9	4	1.8	5	2.25	3	1.35	4	1.8	4	1.8	1	0.45
		Public safety risk - major landslide	55%	22%	2	1.1	1	0.55	5	2.75	3	1.65	2	1.1	5	2.75	2	1.1	4	2.2	5	2.75	4	2.2	1	0.55
		Effectiveness Sub-total - Rockfall	**100%**		**1.6**		**0.4**		**2**		**1.2**		**0.8**		**1.6**		**0.4**		**1.2**		**2**		**1.6**		**0.4**	
		Effectiveness Sub-total - Minor Landslide	**100%**		**0.62**		**1.12**		**1.28**		**1.38**		**0.8**		**1.6**		**1.34**		**1.42**		**1.82**		**1.6**		**0.4**	
		Effectiveness Sub-total - Major Landslide	**100%**		**0.62**		**1.12**		**1.28**		**1.38**		**0.8**		**1.82**		**1.34**		**1.42**		**1.82**		**1.6**		**0.4**	
25%	Cost	Capital cost	70%	18%	5	3.5	3	2.1	5	3.5	4	2.8	3	2.1	2	1.4	3	2.1	3	2.1	2	1.4	2	1.4	2	1.4
		Maintenance cost	30%	8%	4	1.2	5	1.5	4	1.2	3	0.9	2	0.6	5	1.5	4	1.2	4	1.2	4	1.2	4	1.2	3	0.9
		Cost Sub-total	**100%**		**1.175**		**0.9**		**1.175**		**0.925**		**0.675**		**0.725**		**0.825**		**0.825**		**0.65**		**0.65**		**0.575**	
15%	Environmental	Construction impacts	15%	2%	5	0.75	2	0.3	5	0.75	3	0.45	4	0.6	2	0.3	3	0.45	1	0.15	1	0.15	1	0.15	2	0.3
		Ecological and coastal process impacts	50%	8%	1	0.5	5	2.5	3	1.5	3	1.5	4	2	5	2.5	2	1	3	1.5	1	0.5	2	1	5	2.5
		Visual amenity	35%	5%	2	0.7	5	1.75	1	0.35	3	1.05	5	1.75	4	1.4	2	0.7	3	1.05	2	0.7	1	0.35	5	1.75
		Environment Sub-total	**100%**		**0.2925**		**0.6825**		**0.39**		**0.45**		**0.6525**		**0.63**		**0.3225**		**0.405**		**0.2025**		**0.225**		**0.6825**	
15%	Operation	Implementation timeframe	30%	5%	5	1.5	1	0.3	5	1.5	4	1.2	4	1.2	2	0.6	3	0.9	3	0.9	2	0.6	2	0.6	5	1.5
		Monitoring and maintenance	35%	5%	4	1.4	5	1.75	4	1.4	3	1.05	3	1.05	4	1.4	4	1.4	4	1.4	4	1.4	4	1.4	1	0.35
		Expected life	35%	5%	3	1.05	5	1.75	5	1.75	2	0.7	3	1.05	4	1.4	3	1.05	3	1.05	4	1.4	4	1.4	1	0.35
		Operation Sub-total	**100%**		**0.5925**		**0.57**		**0.6975**		**0.4425**		**0.495**		**0.51**		**0.5025**		**0.5025**		**0.51**		**0.51**		**0.33**	
5%	Community	Public perception	100%	5%	2	2	2	2	1	1	4	4	5	5	4	4	2	2	3	3	3	3	2	2	1	1
		Community Sub-total	**100%**		**0.1**		**0.1**		**0.05**		**0.2**		**0.25**		**0.2**		**0.1**		**0.15**		**0.15**		**0.1**		**0.05**	
	--	**Weighted Total - Rockfall**		100%	**3.76**		**2.65**		**4.31**		**3.22**		**2.87**		**3.67**		**2.15**		**3.08**		**3.51**		**3.09**		**2.04**	
	M	**Weighted Total - Minor Landslide**		100%	**2.78**		**3.37**		**3.59**		**3.40**		**2.87**		**3.67**		**3.09**		**3.30**		**3.33**		**3.09**		**2.04**	
	H	**Weighted Total - Major Landslide**		100%	**2.78**		**3.37**		**3.59**		**3.40**		**2.87**		**3.89**		**3.09**		**3.30**		**3.33**		**3.09**		**2.04**	
					Signage not being obeyed		Managed retreat will prevent loss of private property and allow for works to restrict access at the top of the escarpment, but no change to risk profile at the base of the cliff Removal of affected infrastructure will be required				Multiple erosion gullies and drainage paths, may be difficult to manage		Slopes may be difficult to revegetate due to chemistry / nature of soil, and steepness of upper slopes.		Reprofiling slope may require greater setbacks and retreat in steep slopes. May disturb established vegetation and success fo revegetation may not be as efficient		Esplanade Road set back from cliff face. Any further retreat may require narrowing of road reserve or lanes.		Assessment for structures at sea level made on the basis of protecting against wave impacts. Area already protected by two sections of revetment. Revetment at base will move people away from base, attenuating structure may trap them within the fall zone.						Potential loss of roads and access to numerous properties over long term if erosion continues Residential development abutting and existing works in place so potential for concern about no action. Construction and maintenance impacts if erosion affects existing infrastructure.	

Notes

*Weighting for each group or criteria	
90%	This group or criterion is of critical importance
10%	This group or criterion is of minor importance

* How important is this group or criterion in determining the mitigation option.

**Raw score for each option	
5	This option is best for satisfying the criteria
4	This option is beter than others, but is not the best
3	This option is average for satisfying the criteria
2	This option is worse than others, but is not the poorest
1	This option is poorest for satisfying the criteria

** How this mitigation option satisfies the criteria. The options need not be ranked consecutively from 5 to 1 if several options are perceived as equal.

A zero weighted total indicates the option is not applicable in mitigating risk for the particualr identified hazard

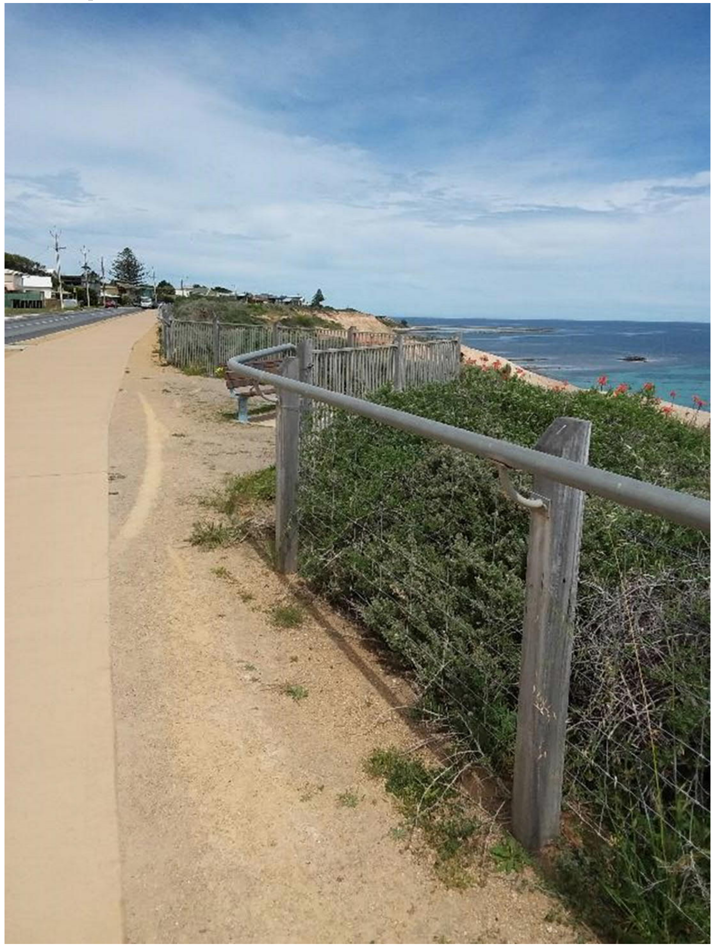
Appendix C: Current examples of fences installed by Council.

Soil and Rock Catch Fence

City Of Onkaparinga Port Willunga Examples 21/10/20

Modern fence systems installed as part of the footpath upgrade

Advantages:
Simple to build and fix
Durable
Allow vegetation to grow through
Unsightly
Large openings
Can have more than 1 high strength strand
Bicycle standard compliant



Soil and Rock Catch Fence

City Of Onkaparinga Port Willunga Examples 21/10/20

Modern barrier fence systems installed as part of the footpath upgrade at lookouts. Stops kids climbing.

Advantages:
Simple to build
Durable
Allow vegetation to grow through

Disadvantages as a soil and rock catch fence:
narrow openings will not allow soil or rock material through.
If hit by a soil mass will detach and the panels becomes a hazard.
Not flexible/elastic but rigid and therefore will not absorb energy but detach from post when struck

Soil and Rock Catch Fence

City Of Onkaparinga Port Willunga Examples 21/10/20

Old mesh fence systems installed as part of the original footpath

Advantages:
Simple to build and fix
Durable
Flexible when hit by rocks.
Used extensive by DPTI in their road throughout the Adelaide hills as a small scale rock catch fence.

Disadvantages
Visually not so pleasant
Narrow openings will not allow soil or rock material through.
Not to bicycle standard