Landslide Risk Assessment

Beleura Cliff Path, Caraar Creek Road to Mills Beach, Mornington

PREPARED FOR:
Mornington Peninsula Shire

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Abbreviations

1H:2V	Slope Ratio of 1 Horizontal to 2 Vertical
AADT	Average Annual Daily Traffic
AHD	Australian Height Datum
AGPT02-17	Austroads Guide to Pavement Technology Part 2 Pavement Structural Design
AGPT05-19	Austroads Guide to Pavement Technology Part 5 Pavement Evaluation
Base Course	Upper granular layer of the pavement
Capping Layer	Lower structural layer of pavement comprising Type A fill designed to minimise moisture movement between the upper pavement and underlying subgrade
CBR	California Bearing Ratio (%)
Construction Layer	Lower structural layer of pavement comprising Type A fill used to facilitate trafficking of the subgrade during construction
CTCR	Cement Treated Crushed Rock
DCP	Dynamic Cone Penetrometer
DF	Direction Factor
DoT	Department of Transport (formerly VicRoads)
DTL	Daily Traffic Loading
EC	Electrical Conductivity
EDCM	Victorian Planning Authority Engineering Design and Construction Manual for Design in Subdivision Growth Areas
ESA	Equivalent Standard Axles
FCR	Fine Crushed Rock
FoS	Factor of Safety
GPS	Global Positioning System
HVAG	Heavy Vehicle Axle Group
HV	Heavy Vehicles (Usually a %)
IDM	Local Government Infrastructure Design Association Infrastructure Design Manual
LF	Loading Factor
MGA	Map Grid of Australia
NATA	National Association of Testing Authorities
NDCR	Non-Descript Crushed Rock
Nominal Diameter	The sieve size in mm in which nearly all of the crushed rock sample will pass through
OMC	Optimum Moisture Content
PMB	Polymer Modified Binder
Prime	Application of a primer to a prepared base

RC500.22	DoT Code of Practice RC500.22 Selection and Design of Pavement and Surfacings
SAMI	Strain Alleviating Membrane Interlayer
Sub-Base Course	Lower granular layer of the pavement
Subgrade	Foundation material for the pavement
TDS	Total Dissolved Solids (salinity of water)
TLD	Traffic Load Distribution
Type A Fill	An engineered fill material defined in accordance with DoT Standard Specification 204
VPD	Vehicles Per Day

1.0 INTRODUCTION

Stantec was engaged by Gerard Cook on behalf of Mornington Peninsula Shire on 21 April 2023 with regard to carrying out a detailed site inspection and a land slide risk assessment for the full length of the Beleura Cliff Path, from Caraar Creek Lane to Mills Beach in Mornington. Additionally, a meeting was held with members of the Friends of Beleura Cliff Path community group on 16 June 2023 and a council led community engagement meeting was held on 04 July 2023 to collect anecdotal information relating to the landslide activity along the path. Both meetings were attended by Stantec representatives.

Two experienced geotechnical engineers from Stantec attended site to carry out a detailed inspection of the path, to gather information to form the basis of a landslide risk assessment for the full length of the path. Subsequently, recommendations for possible remediation measures intended to minimise the risk to life are presented in this report.

The works included:

- Gathering anecdotal evidence from local residents, including Friends of the Beleura Cliff Path Group and from attendees at a community engagement meeting;
- Light Detection and Ranging (LiDAR) survey;
- Detailed site inspection;
- Landslide risk assessment for full length of the path; and
- Options for remediation such that public access can restored with a tolerable societal risk to path users.

Location of the site, the Beleura Cliff Path, outlined in yellow is shown in Figure 1-1.

Figure 1-1 – Site Location – Beleura Cliff Path

The report will cover the following issues:

- A summary of the findings of the desktop study carried out prior to the site inspection, including historical reports and anecdotal information provided by local residents and the Friends of Beleura Cliff Path community group;
- The findings of the LiDAR survey of the site;
- Observations made during the detailed site investigation;
- The detailed landslide risk assessment considering risk to life for people using the path and risk to property for the path itself, for all of the different areas identified along the length of the cliff. The risk to walkers on the beach, the risk to the beach itself and the risk to nearby properties are excluded from this scope of works;
- Consideration of the effectiveness and extent of current risk mitigation measures;
- Site maps identifying key features, including high risk zones, accessible areas, historic works, past land movement and possible erosion sources (such as water sources);
- Options for remediation of the path (concept stage) with consideration of the Marine and Coastal Policy 2020, including advantages and disadvantages of each option, an assessment of their individual construction feasibility and relative overall costs for the proposed options;

- Summary of potential issues resulting from a detailed consideration of predicted sea level rise, with an aim to focus on path remediation;
- Recommendations for future monitoring measures;
- Recommendations for future maintenance requirements; and
- Recommendations for ongoing engagement with private property owners regarding erosion management, including water management.

2.0 LIMITATIONS OF THE REPORT

This report is limited to the scope of work presented in Section 1.0 and includes a discussion of the risk to life for people using the Beleura Cliff Path as a result of landslide activity, where the path location is as shown in Figure 1-1. This work does not consider risks to life for beach users, or risk to property or infrastructure located at the cliff crest or further inland from the crest.

The Australian GeoGuides for Slope Management and Maintenance that form part of the Australian Geomechanics Society Guidelines and Landslide Risk Management (AGS 2007) provides detailed guidance on appropriate practices for areas with steep slopes.

The limitations of the geotechnical report are contained in Appendix J.

3.0 DESKTOP STUDY

3.1 GENERAL

A desktop study was undertaken prior to the site inspection and was based on historical reports, anecdotal information and community feedback as well as information obtained from the LiDAR survey and aerial photography. Historical reports and documents provided and used in the preparation of this report include:

- Caraar Creek Foreshore Walkway Risk Assessment, prepared by Leigh Hale Consulting Services Pty Ltd issue 3, dated 14 November 2003
- Path upgrade & considerations for improving safety, Caraar Creek Foreshore / Cliff Top Path Mornington Geotechnical Investigation & slope Stability Assessment, prepared by SITE Geotechnical, dated 21 September 2009.
- The Planning File relating to 23 Kalimna Drive, Permit Number P12/0408, dated completed 20 November 2012

Historical documents have been used primarily to determine factors such as the frequency of landslides, the size of landslides and possible triggering factors.

The desktop study indicated that the area immediately surrounding the Beleura Cliff Path has been subject to significant landslide activity over a prolonged period.

The path itself was built approximately 100 years ago. In recent history, the path has been closed four times as a result of landslides. Closures occurred in 2003, 2010 – 2011, 2013 – 2016 and 2022 – 2023. A map showing past land movement is provided in Appendix A. Details relating to the landslide activity in the area have been well documented in recent years, with multiple reports written by geotechnical engineers relating to property development and landslide risk assessment and a wealth of anecdotal evidence collected by local residents. Despite this notable landslide activity, the path's alignment has generally remained unchanged since it was constructed.

While the alignment of the path has remained predominantly unchanged over its life, some significant changes have occurred, such as the upgrade of the surface of the path from gravel to asphalt within the last 20 years. Minor cracks in the surface of the asphalt surface are sealed periodically by the Council. Elsewhere, the construction of sections of boardwalk in the southern half of the path has been carried out following damage to the path from landslides. In recent years, the Friends of Beleura Cliff Path community group have implemented a significant revegetation program, propagating and planting out native vegetation on the cliff up and downslope of the path, over its full length, with the intent of providing stabilisation to the cliff. The locations of the sections where significant changes have occurred are noted in Figure 3-1

Figure 3-1 – Locations of sections of the path where boardwalks have been constructed.

Evidence of the significant landslide activity was extracted from the LiDAR survey carried out. The survey enabled a contour map and hill shade map to be created for the cliff along the full length of the path. The combination of shading and contour spacing provides a visual indication of specific areas where landslide activity has possibly occurred. This provided a basis for features to be examined more closely during the detailed site inspection.

3.2 GEOLOGY

The geological map of the area indicates that the superficial deposits along the site location are a combination of Devonian aged Granodiorite and Tertiary aged Baxter Formation, also known as Brighton Group, as presented in Figure 3-2.

Anecdotally the surface geology of the cliffs has been reported to change over the length of the path from Brighton Group in the north to granite in the south. This was confirmed during the detailed site inspection. Colluvium is present in multiple locations, indicating historic landslide activity within the area. Along its length, the path has been constructed on whichever material is present in each location.

Ironstone boulders can be observed on Mills Beach towards the southern end of the path. These boulders on the beach are likely to have originated from a layer that was originally located within the Brighton Group at the top of the cliff. As the underlying Brighton Group has been eroded, the ironstone becomes unsupported and eventually falls down to the beach at the base of the cliff.

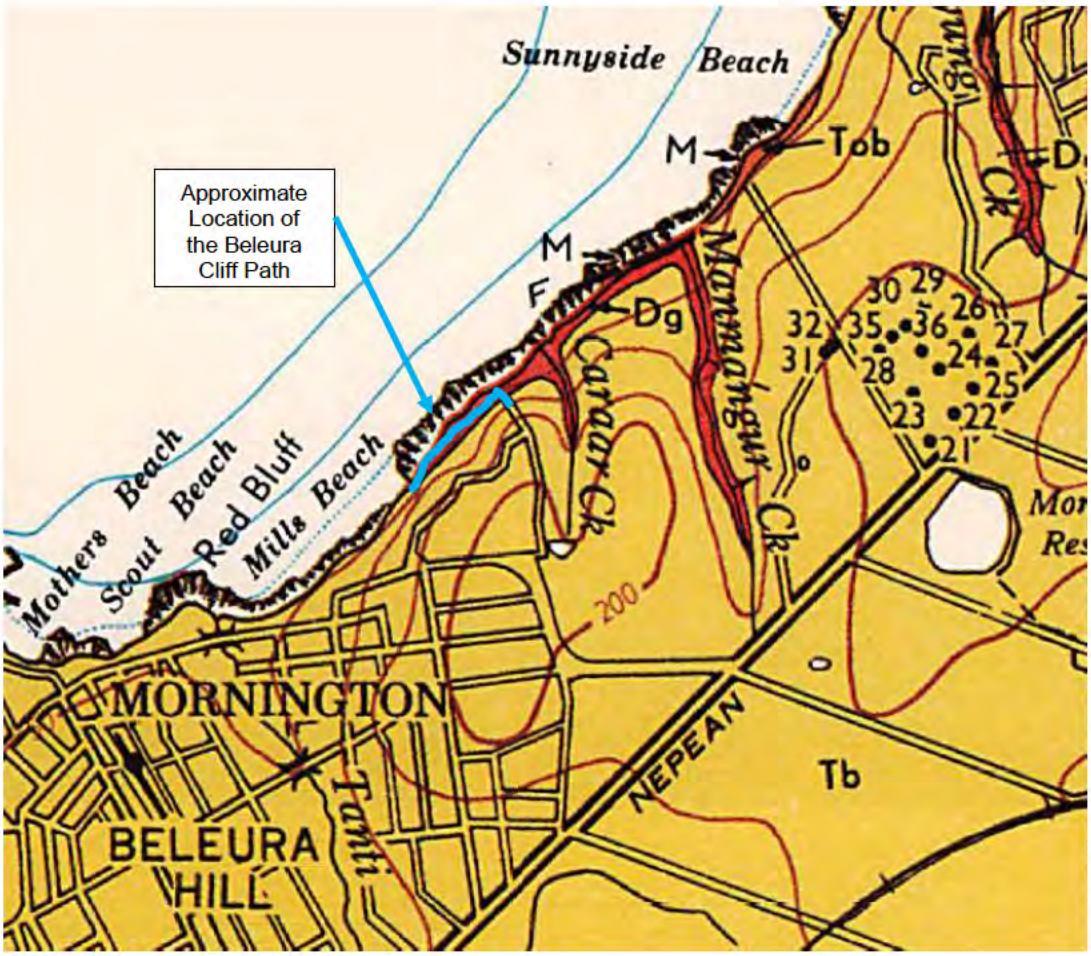

Figure 3-2 – Extract from the Cranbourne 1:63,360 geological map

3.3 WATER

3.3.1 Natural Groundwater

A number of naturally formed gullies exist along the cliff within the study area. These gullies would have been formed long before human habitation started within the area and provide natural drainage pathways for groundwater collected further inland from the cliff. Locations where natural gullies were identified are presented in Figure 3-3, Figure 3-4 and Figure 3-5.

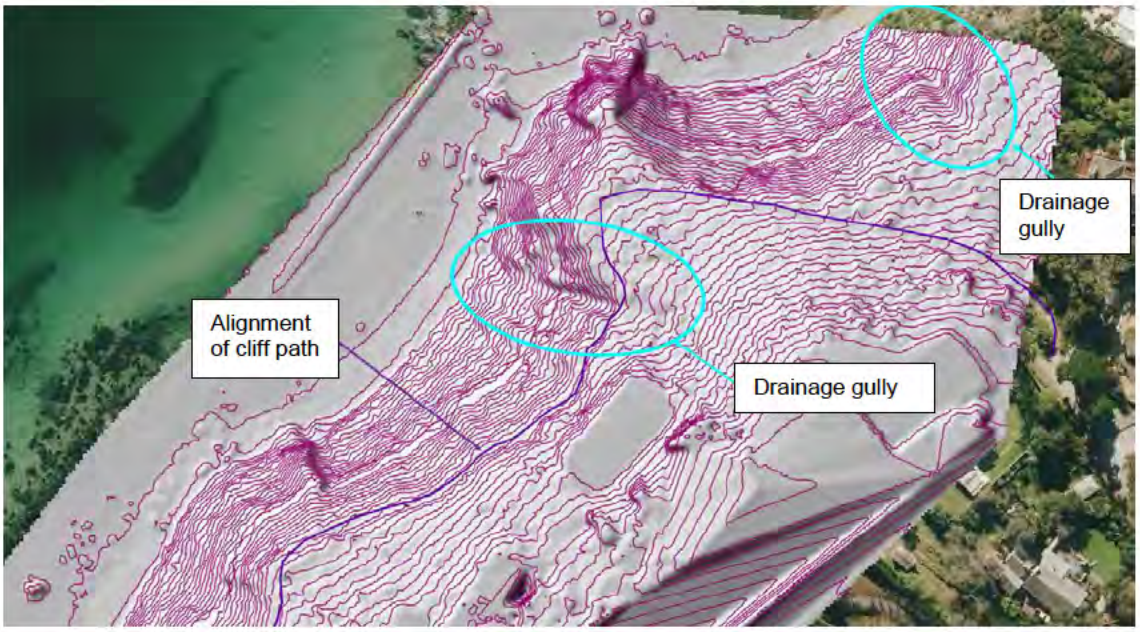

Figure 3-3 – Extract from LiDAR and contour map – northern section of the path

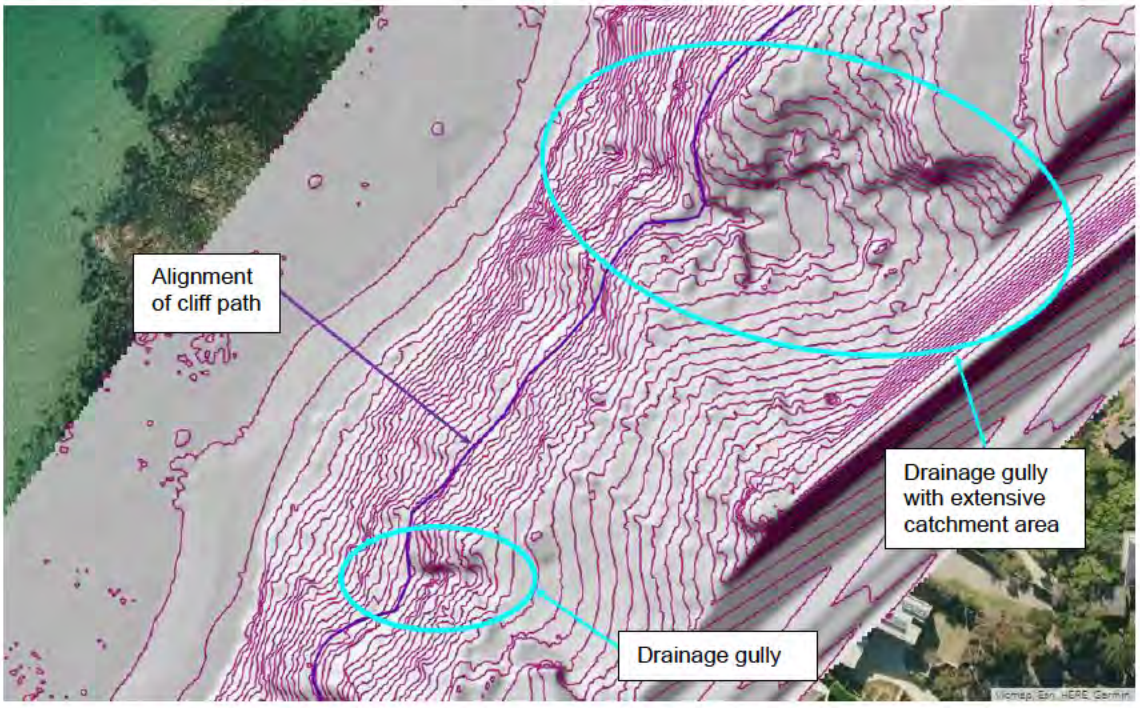

Figure 3-4 – Extract from LiDAR and contour map – central section of the path

Figure 3-5 – Extract from LiDAR and contour map – southern section of the path

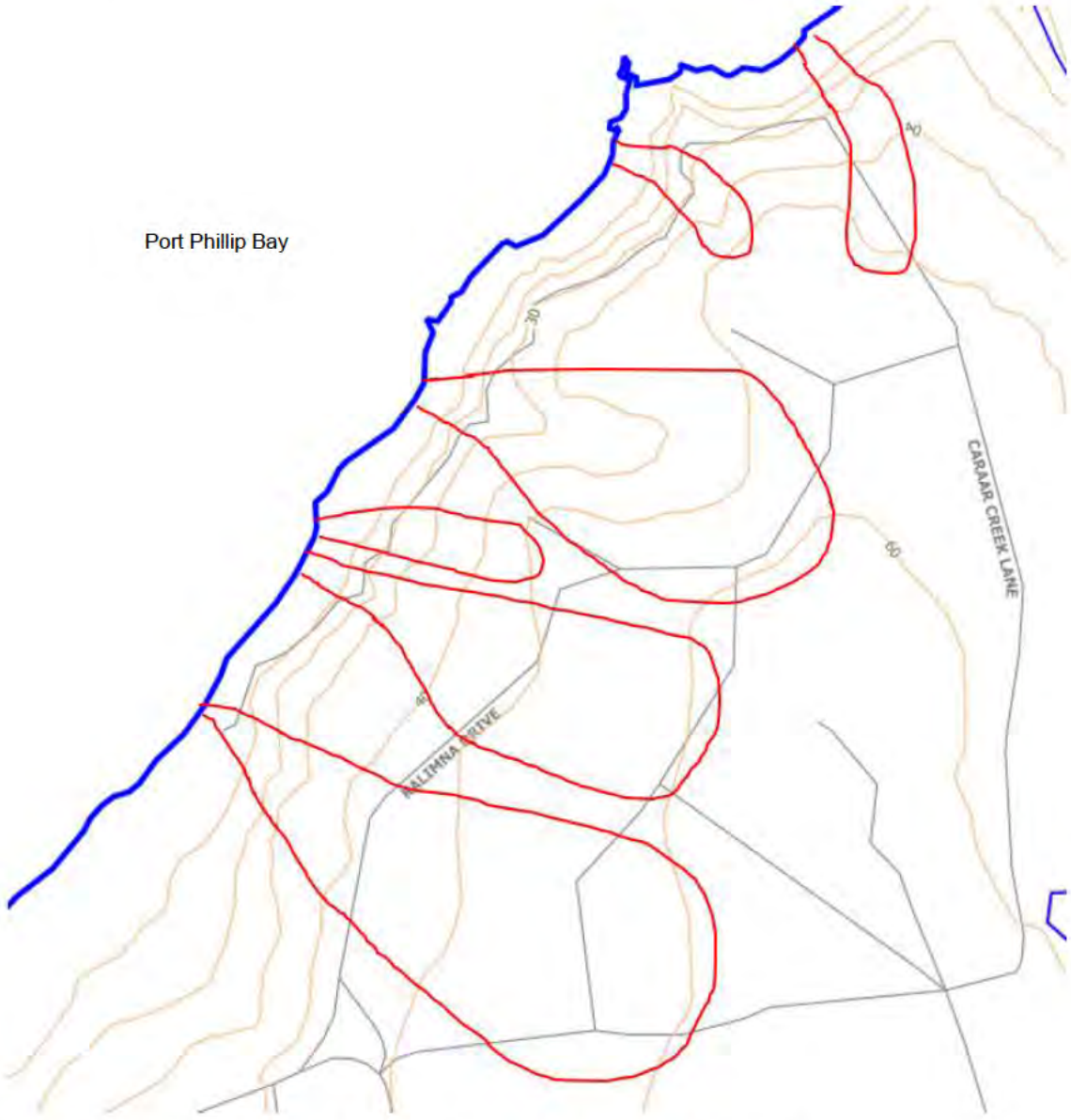

Figure 3-6 – Approximate catchment areas relating to each gully (map base from Earth Resources)

The gullies identified on the LiDAR and contour maps indicate that the catchment areas of these historic gullies typically extend some distance upslope of the path, as indicated in Figure 3-6.

As these gullies have been in this area for a geologically significant period of time (these were areas of instability prior to human development), they are also likely to represent zones where landslide activity is particularly pronounced. Surface run off channelled down the gullies will carry sediment downslope and prolonged exposure to water will result in a softening of the in-situ soils. Consequently, there is likely to be a cycle of steepening of the gully until it becomes over-steep, resulting in landslide activity until the gradient of the ground in the gully is shallow enough for the activity to slow down significantly, then a gradual re-steepening occurs as the cycle restarts.

The aerial imagery also provides an Indication of the level of saturation of the ground in the gully locations. The type and distribution of vegetation is a reflection of the moisture condition of the soils in which they are growing. Figure 3-7 presents an extract from the aerial imagery of one of the gullies located in the mid-section of the path. This shows that dense, lush, green vegetation that is indicative of high soil moisture levels is growing within the identified gully.

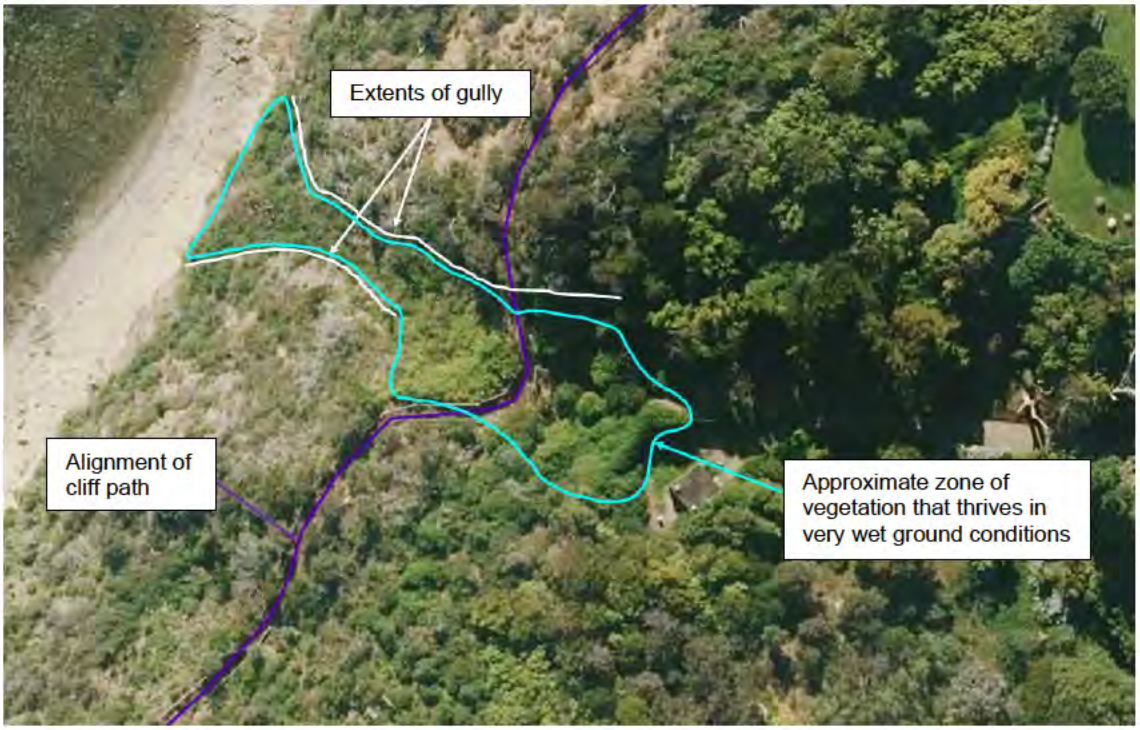

Figure 3-7 – Aerial image of a historic natural drainage gully in the mid-section of the path

3.3.2 Pipes and Irrigation

Drainage has been repeatedly highlighted as a significant concern along the length of the path. Anecdotal evidence provided indicates that multiple blocked pipes, broken pipes and drainage issues have been observed and linked to water flow over the face of the cliff in an uncontrolled manner.

The anecdotal evidence documentation provided indications of locations along the path where drainage was thought to be a contributing factor to landslide activity. This information provided a basis for features to be examined more closely during the site inspection.

It was observed that there are irrigation pipes for the length of the path, running on the slope, which were set up by the Friends Group. This irrigation pipe system is a controlled network from a point upslope and is understood to be only used for targeting watering. This system is switched on for when it is required to then once the work is completed, it is turned off and discharged. This process is acceptable.

Also, there are irrigation pipes observed downslope of the infinity pool at 23 Kalimna Drive, just above the head scarp of the landslide. These pipes are owned by the house with the infinity pool. This pipe

system seems to be uncontrolled and has been observed to be operating even where there is wet weather as well as having been observed to be leaking. This process is not acceptable.

3.3.3 Climate

Whilst natural groundwater flows and man-made drainage systems are considered likely to have an influence on landslide activity, climate conditions also play a part. During the wetter years, above average rainfall levels can be experienced, which result in a higher level of natural groundwater flow within gullies. In addition to this, the higher levels of rainfall will result in a higher volume of run off in the pipe network. Consequently, there is more potential for landslides in wetter years where above average rainfall conditions are experienced.

According to the Australian Government Bureau of Meteorology, the most recent La Niña events, where greater rainfalls are expected, occurred in 2020-2023, 2010-2012, 2008-2009 and 2007-2008, and the anecdotal evidence shows that six of the landslides reported occurred in these periods.

4.0 OBSERVATIONS FROM SITE INSPECTION

The detailed site inspection was conducted on 20 and 21 June 2023. The purpose of the inspection was to observe the current site conditions in order to identify the extents of any stability issues and gain additional information required for the completion of a landslide risk assessment, as well as to discuss any actions required to reduce the risk to life to the track users.

The site inspection involved walking the Beleura Cliff Path from Caraar Creek Lane to Mills Beach, shown in Figure 1-1, as well as walking along the beach at the base of the cliffs, from Mills Beach to the northern end of the path alignment.

During the site inspection, Stantec representatives walked all of the sections of the path deemed to be accessible. For the purposes of reporting observations from the site inspection the path has been split into sections based on the features observed along the length of the path, starting at Section 1 at the Caraar Creek Lane end of the path and finishing with Section 24 at the Mills Beach end of the path. The sections adopted are presented in Figure 4-1, Figure 4-2 and Figure 4-3. The overall site plan is shown in a larger scale in Appendix B.

A summary of the key types of features observed is presented in this section of the report, with a plan of observed features presented in Appendix C and a more detailed set of photos and observations presented in Appendix D. A plan of water observations presented in Appendix E and a more detailed set of photos and observations in Appendix F.

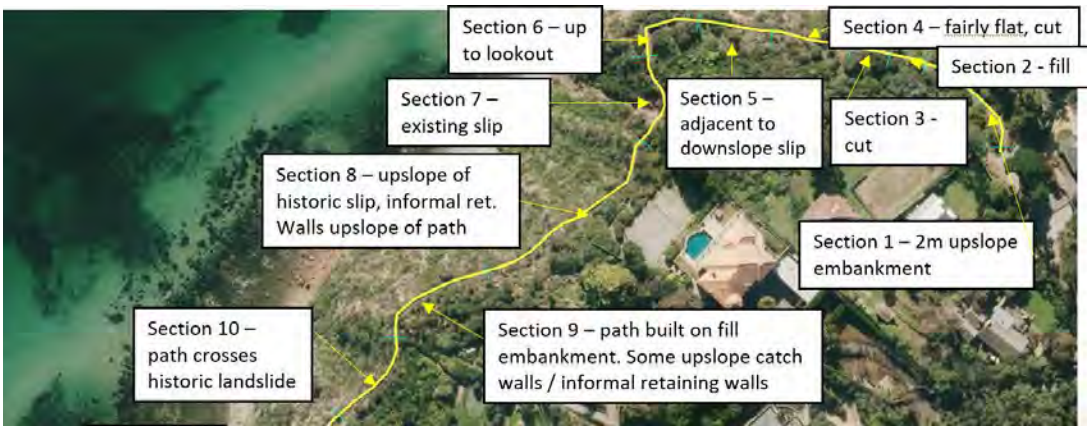

Figure 4-1 - Section Extents Part 1 of 3

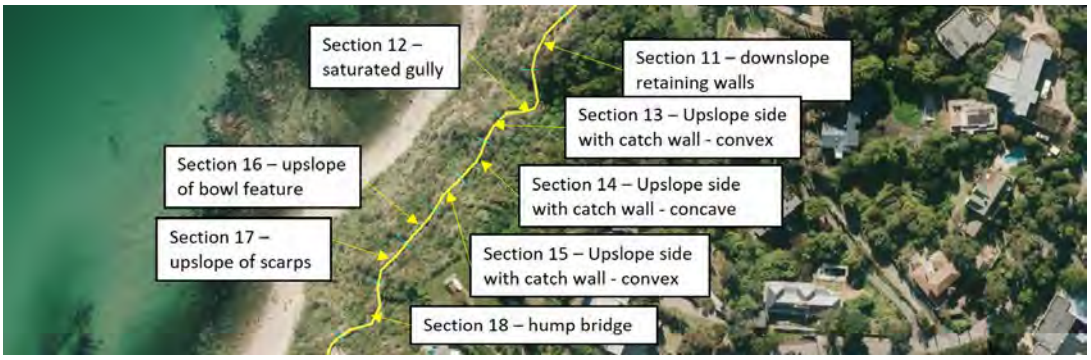

Figure 4-2 - Section Extents Part 2 of 3

Figure 4-3 - Section Extents Part 3 of 3

A summary of the site observations of the Beleura Cliff Path is provided below:

- The construction of the path has resulted on some sections of the path being built on a fill embankment, meaning material has been placed here, while other sections have been cut into the cliff. An example of the path built on a fill embankment is shown in Figure 4-4 and an example of the path cut into the cliff is shown in Figure 4-5.

Figure 4-4 – Example of path built on fill embankment (Section 9)

Figure 4-5 – Example of path cut into the cliff (Section 4)

- The path crosses areas of historic landslide activity in multiple locations. An example of this is shown in Figure 4-6.

Figure 4-6 – Example of path crossing a zone of historic landslide activity (Section 11)

- In multiple locations along the length of the path, cracking was observed in the asphalt surface of the path.

    a. Straight cracking was observed in sections of path constructed on fill, indicating a general, comparatively uniform settlement of the fill material downslope. An example is shown in Figure 4-7.

    b. Arcuate cracking was observed in sections of the path where landslide activity is occurring. An example is shown in Figure 4-8.

Figure 4-7 – Example of straight cracking (Section 22)

Figure 4-8 – Example of arcuate cracking (Section 16)

Generally, a large proportion of the cracking has been sealed with bitumen, although in some locations sealing or resealing needed to be carried out at the time of the site inspection.

- In multiple locations informal retaining walls were observed adjacent to the path. An example of these retaining walls is presented in Figure 4-9. In some instances, walls that were originally built to catch debris from minor upslope slips are full and have been planted. An example of overflowing catch walls is presented in Figure 4-10.

Figure 4-9 – Example of informal retaining walls (Section 11)

Figure 4-10 – Full and planted catch walls (Section 19)

- There are 2 active landslides that have impacted on the path in recent times:
    a. Section 7, where a debris flow has been reactivated. This is shown in Figure 4-11.
    b. Section 20, downslope of the property at 23 Kalimna Drive. This landslide is a smaller part of a larger historic landslide in this area. This is shown in Figure 4-12.

Figure 4-11 - Section 7: Recent Landslide, 2022

Figure 4-12 - Section 20: Recent Landslide

- In Section 18, following damage from a landslide the asphalt path has been replaced by a timber walkway, known as the ‘Hump Bridge”, as shown in Figure 4-13.

Figure 4-13 – The Hump Bridge (Section 18)

- In Section 21, following damage from a landslide, the asphalt path has been replaced by a section of boardwalk, as shown in Figure 4-14.

Figure 4-14 – Timber boardwalk (Section 21)

- Upslope of Section 19, informal remediation works have been implemented, in the form of timber boards nailed into the side of the cliff and a wire fence has been erected on the upslope side of the path to reduce future landslide material impacting/blocking the path, shown in Figure 4-15.

Figure 4-15 – Informal remedial works in Section 19

- In multiple locations, drainage pipes and systems were observed. Some drains appeared to be in poor condition. An example of a drain in a poor condition is presented in Figure 4-16.

Figure 4-16 – Section of open drain (Section 18).

- At the locations of the active landslides, water was observed seeping through the scarps. This is shown in Figure 4-17 and Figure 4-18.

Figure 4-17 – Water seepage observed on the scarp (Section 7).

Figure 4-18 – Water seepage observed on the scarp (Section 20).

- In some locations, it was observed surface water run off is washing soil material onto the path. An example of this is shown in Figure 4-19.

Figure 4-19 – Surface water run off has resulted in material deposited on the path (Section 8).

- In multiple locations along the beach, drainage pipes were observed with outfalls onto the beach. Although rainfall had occurred prior to the site inspection, water was discharging from some of the drainage pipes but not all of them, indicating the presence of breaks or blockages in the pipes. An example of this is shown in Figure 4-20.

Figure 4-20 – Not all pipes positioned to discharge on the beach had water coming out of them (Section 19).

- Where gullies were identified during the desktop study, their locations were confirmed during the site inspection. In Section 12, the change in vegetation type was observed and confirmed that it is indicative of prolonged wet ground conditions. This is shown in Figure 4-21 below.

Figure 4-21 – The gully observed in Section 12 contained dense, water-intense vegetation

Figure 4-22 – A view of the cliff from the beach

The site inspection also included observations of the cliff from the beach and extended the full length of the path. The view provided in Figure 4-22 is representative of a significant portion of the cliff downslope of the path with small, discrete zones of localised landslide activity observed towards the

base of the cliff. It is inferred that these small landslides result from erosion of the toe by wave action. The shape of the cliffs overall indicates that this erosion is occurring very slowly and is not currently contributing to the deterioration of the path. It is anticipated that a rise in sea levels has the potential to increase the rate of erosion at the toe of the cliff, but that it would remain unlikely to result in an immediate increase in risk to the stability of the path upslope.

5.0 LANDSLIDE RISK ASSESSMENT

The site inspection has identified multiple landslide hazards. These hazards have the potential to become active or to reactivate, especially during or following periods of wet weather or when water is introduced into the cliff from man-made sources. In order to determine whether it is appropriate for people to use the path a landslide risk assessment (LRA) has been conducted to assess the Risk to Life. The LRA has been conducted under the general guidance of the Australian Geomechanics Society *Practice Note Guidelines for Landslide Risk Management 2007* (AGS 2007).

5.1 LANDSLIDE HAZARDS

During the desktop study and detailed site inspection, multiple different potential landslide hazards have been identified for the site. The path has been divided into 24 sections, based on the hazard or hazards identified within each section, with sequential numbering starting from the northern end of the path at Caraar Creek Lane and heading south towards Mills Beach. The section extents are presented in Figure 4-1, Figure 4-2 and Figure 4-3 and in a larger scale in Appendix B.

Each of the sections and potential hazards as well as their likelihoods are presented below:

In order to determine the risk from the different landslides it is necessary to estimate the annual probability of them occurring. As there are a number of different landslides with different mechanisms each landslide will have a different probability. The estimates are made based on different factors such as whether the landslide is new or a reactivation and then how much rainfall may be required to trigger such a landslide, with the landslide risk assessment provided in Appendix G.

It is important to understand that these estimates are generally order of magnitude only.

1. The starting section of the path, located at the northern end accessed from Caraar Creek Lane: this section presents an embankment approximately 2m high to the south of the path. It is anticipated that if a landslide that were to occur in this section, it would be of comparatively small scale and material would likely slump across the full width of the path, with a shallow depth of material. A landslide in this section would likely be slow to moderate. As the path is 100 years old, an annual probability of 1.0E-02 is considered a conservative estimate.

2. The path located within Section 2 is built on fill material. A landslide occurring within the fill material could affect the full width of the path. A landslide in this section would most likely be moderate. As the path is 100 years old, an annual probability of 1.0E-02 is considered a conservative estimate.

3. Within Section 3 there is a small cut. Small slumps of material have previously fallen onto the path and have subsequently been cleared. Landslides in this area would not be expected to affect the

full width of the path. Landslides in this area would likely to be slow to moderate. As the path is 100 years old, an annual probability of 1.0E-02 is considered a conservative estimate.

4. Section 4 of the path is comparatively flat, with a very small steep cut immediately upslope of the path. It is anticipated that landslides in this area would comprise slumps of material falling on to the path, that could affect its full width. Landslides in this area would likely to be slow to moderate. As the path is 100 years old, an annual probability of 1.0E-02 is considered a conservative estimate.

5. Section 5 of the path is located immediately upslope of a significant existing head scarp. The scarp is currently located approximately 1.2m from the closest edge of the path. A landslide that occurred in this section would see the head scarp regressing beyond its current location which would likely affect the path over its full width. If the head scarp were to collapse, this would occur rapidly. The overall landslides in this area would most likely be slow. Based on the observed condition of the scarp, it is considered that an annual probability of 1.0E-01 is appropriate.

6. Section 6 of the path is located around the lookout. This area is relatively flat. A landslide that occurred in this area would likely involve a large volume of material being displaced downslope of the path. Should such a landslide occur it is anticipated that a person could move with the landslide as it moved downslope. Landslides in this area would likely to be moderate to rapid. An annual probability of 1.0E-03 is considered a conservative estimate.

7. Section 7 of the path considers the area where one of the currently activate landslides that affects the path is located. It has been assessed that the landslide occurring in this section is a reactivation of a historic debris flow. Material is falling downslope and undermining the path. Once activated, the debris flow would be rapid, but the regression affecting the path would be slow. It is considered that an annual probability of 1.0E00 is appropriate.

8. Section 8 of the path is positioned upslope of a large historic landslide that runs over nearly the whole length of the section. Within this section, two hazards are considered:

    a. The larger historic landslide: In the right conditions, the reactivation of this landslide would result in the movement of a significant volume of material and would result in the full width of the path being damaged over a significant length. Should a landslide occur in this area, it is anticipated a person could move with the landslide as it moved downslope. Landslides such as this one would likely to be slow to moderate. An annual probability of 1.0E-03 is considered estimate for the reactivation of the historic landslide.

    b. Smaller landslides within the area: cracking in the path indicates that smaller landslides, up to 5m in length, and affecting up to approximately 0.3m width of the downslope side of the path could be expected within this section. Landslides such as these would be expected to be slow. An annual probability of 1.0E-01 is considered appropriate.

9. Section 9 of the path has been constructed on a fill embankment. Cracking along the length of the path, towards the downslope side, has been observed. Landslides in this area would generally be small, downslope failures that would affect part of the width of the path. It is expected that these landslides would be slow. An annual probability of 1.0E-02 is considered appropriate.

10. Section 10 of the path crosses a historic landslide, with observations indicating that the path has been constructed on fill. Within this section, two hazards are considered:

    a. The larger historic landslide: In the right conditions, the reactivation of this landslide would result in the movement of a significant volume of material and would result in the full width of the path being damaged over a significant length. Should a landslide occur in this area, it is anticipated a person could move with the landslide as it moved downslope. Landslides such as this one would likely to be slow to moderate. An annual probability of 1.0E-03 is considered a conservative estimate for the reactivation of the historic landslide.

    b. Smaller landslides within the area: cracking in the path indicates that smaller landslides, up to 5m in length, and affecting up to approximately 0.3m width of the downslope side of the path could be expected within this section. Landslides such as these would be expected to be slow. An annual probability of 1.0E-01 is considered appropriate.

11. Section 11 of the path runs above a series of historic informal retaining walls and below an existing head scarp. Within this section, three hazards are considered:

    a. Failure of the head scarp that is located above the path. This would result in a significant volume of material falling onto the path which would affect the full width of the path. This landslide would most likely to be rapid and as such people would have difficulty avoiding the landslide if they were in the line of fall of the material. As the path is 100 years old, an annual probability of 1.0E-02 is considered appropriate for the failure of the head scarp onto the path.

    b. Failure of the slope upslope of the retaining walls. This would comprise smaller volumes of material falling onto shorter sections of the path but is expected that the full width of the path would be affected. This landslide would most likely to be moderate to rapid. As the path is 100 years old, an annual probability of 1.0E-02 is considered appropriate for the failure of the slope above the path.

    c. Overall failure of the slope, with a large volume of material being mobilised above and below the path. This would result in a significant length of the path being affected over its full width. This landslide would most likely to be slow to moderate. As the path is 100 years old, an annual probability of 1.0E-02 is considered a conservative estimate for the failure of the overall slope.

12. Section 12 of the path is located within a gully where the surrounding ground was noted to be saturated, with vegetation type and density indicating that the level of moisture is consistently high over long periods. It inferred that this gully contains a debris flow. Two hazards are considered within this section:

    a. Smaller landslides within the area: cracking in the path indicates that smaller landslides, up to 5m in length, and affecting up to approximately half the width of the path on the downslope side could be expected within this section. Landslides such as these would be expected to be slow. It is considered that an appropriate estimate of annual probability of a relatively small failure occurring is 1.0E-01.

    b. The historic debris flow: In the right conditions, the reactivation of a landslide within the debris flow would result in the movement of a significant volume of material and would result in the

full width of the path being damaged over a significant length. If a landslide were to occur in this area, it is anticipated a person could move with the landslide as it moved downslope. Landslides such as this one would likely to be slow to moderate. It is considered that an appropriate estimate of annual probability of the larger reactivation of the debris flow is 1.0E-03.

13. Section 13 of the path has been constructed on fill in this location. Cracks have been observed approximately two thirds of the way across the path (closer to the upslope side than the downslope side). A landslide occurring in this location would be expected to undermine the path and result in approximately 0.8m width of the path being affected. Landslides in this area would be expected to be slow to moderate. An annual probability of 1.0E-03 is considered a conservative estimate.

14. Section 14 of the path runs beneath an existing upslope head scarp. Catch walls run along the upslope side of the path. Two hazards are considered in this section:

    a. Smaller landslides within the area: cracking in the path indicates that smaller landslides, up to 5m in length, and affecting up to approximately half the width of the downslope side of the path could be expected within this section. Landslides such as these would be expected to be slow. It is considered that an appropriate estimate of annual probability of a relatively small failure occurring is 1.0E-01.

    b. The larger historic landslide: In the right conditions, the reactivation of this landslide would result in the movement of a significant volume of material and would result in the full width of the path being damaged over a significant length. If a landslide were to occur in this area, it is anticipated a person could move with the landslide as it moved downslope. Landslides such as this one would likely to be slow to moderate. It is considered that an appropriate estimate of annual probability of a larger scale reactivation of the landslide is 1.0E-02.

15. Section 15 of the path has been constructed on fill. Cracks have been observed approximately half of the way across the path. A landslide occurring in this location would be expected to undermine the path and result in approximately 0.8m width of the path being affected. Landslides in this area would be expected to be slow to moderate. An annual probability of 1.0E-03 is considered a conservative estimate.

16. Section 16 of the path is located upslope of an observed downslope bowl feature. Informal retaining walls were observed downslope of the path. A landslide occurring in this location would be expected to result in the movement of a significant volume of material, affecting the full width of the path over a significant proportion of this section. Landslides in this location would be expected to be slow to moderate. An annual probability of 1.0E-02 is considered appropriate.

17. Section 17 of the path is located upslope of two observed downslope scarps. Informal retaining walls were observed downslope of the path. A landslide occurring in this location would be expected to result in the movement of a significant volume of material, affecting the full width of the path over a significant proportion of this section. Landslides in this location would be expected to be slow to moderate. An annual probability of 1.0E-02 is considered appropriate.

18. Section 18 of the path is known as the “hump bridge”. Previous landslide activity in this area was recorded in 2003 and 2013. Further landslide activity in this area would be expected to result in

the movement of a significant volume of material, resulting in the full width of the path being impacted over a significant length of this section. Landslides in this location would be expected to be slow to moderate. An estimate of annual probability of 2.0E-02 is considered appropriate.

19. Section 19 of the path runs beneath zones of upslope overhanging material. Two hazards are considered in this section:

    a. Smaller blocks of material (typically <0.5m) falling onto the path. Falling material of this magnitude has previously been observed and it is considered likely that further falls of this size are likely. The falls would be rapid to very rapid and as such people would have difficulty avoiding the landslide if they were in the line of fall of the material. It is considered that an annual probability of 3.0E00 is appropriate.

    b. Larger blocks of material (1m-2m) falling onto the path without warning. It is considered that falls of this size are possible. The falls would be rapid to very rapid and as such people would have difficulty avoiding the landslide if they were in the line of fall of the material. It is considered that an annual probability of 1.0E-01 is appropriate.

20. Section 20 of the path runs across the area that is affected by the currently active landslide beneath 23 Kalimna Drive. Three hazards are considered in this section:

    a. 1 – Reactivation of the recent landslide, with the majority of the material coming from upslope of the path. This would result in the full width of the path being affected over approximately half the length of the section. Landslides such as this are expected to be slow to moderate. As this landslide has been active this year, it is considered that an annual probability of 1.0E00 is appropriate.

    a. 2 – Failure of the recent head scarp onto the path. Smaller falls of material would fall onto the path, affecting the full width of the path over a shorter proportion of the section. Landslides such as this would likely to be slow to moderate. As this landslide has been active this year, it is considered that an annual probability of 1.0E00 is appropriate.

    b. Reactivation of the big landslide at this location. Movement of a significant volume of material already on the slope, sliding downslope with the opportunity to move with the landslide downslope. This would affect the full width of the path over the majority of the length of this section. Landslides such as this would likely to be slow to moderate. An annual probability of 2.0E-02 is considered appropriate for this hazard.

21. Section 21 of the path comprises a length of boardwalk that was built following landslide activity in 2010. Reactivation of the landslide activity in this area would be anticipated to affect the full width of the path over a length of approximately 25m. Landslides in this area would likely be slow to moderate. An estimate of the annual probability of 2.0E-02 is considered appropriate.

22. Section 22 of the path has been constructed on fill material. Straight cracks were observed running parallel to the length of the path. Landslides in this area would be anticipated to affect approximately half the width of the path over approximately 10m. Landslides in this section would be expected to be slow to moderate. As the path is 100 years old, an annual probability of 1.0E-02 is considered a conservative estimate.

23. Section 23 of the path is relatively flat and demonstrates little sign of movement. A landslide in this area would be expected to be small and to occur downslope of the path. It would affect approximately half the width of the path over approximately 5m. Landslides in this section would be expected to be slow to moderate. As the path is 100 years old, an annual probability of 1.0E-02 is considered a conservative estimate.

24. Section 24 of the path comprises the stairs between Mills Beach and the upslope path. The stairs were built following the erosion of the sand dune sand and cliff toe. Further erosion could result in further ground movement at this location. It is expected that this would affect the full width of the path over approximately half of the length of the section. A landslide in this section would be slow to moderate. As such, an annual probability of 5.0E-02 is considered a conservative estimate.

5.2 SPATIAL PROBABILITY

The spatial probability of a landslide involves the proportion of the area that may be impacted by a potential landslide. That is, if a landslide flowed onto a specific area to occupy 10% of that area, then the spatial probability would be 1.0E-01. If a landslide occupies the whole area, then the spatial probability is 1.0E00. However, if the landslide does not impact on the area, then the spatial probability is 0.0E00. For a rockfall, the spatial probability is based on the size of rock compared to the length and width of path.

The spatial probability needs to be estimated for each hazard along the length of the path.

The estimated spatial probability for each hazard is provided in Table 5-1.

Table 5-1 – Spatial probability for different hazards and properties

Hazard / Section	Spatial Probability
1	4.5E-0.2
2	1.4E-01
3	5.6E-02
4	1.1E-01
5	5.2E-01
6	1.3E-01
7	4.1E-01
8a	8.1E-01
8b	1.4E-01
9	5.9E-02
10a	7.5E-01
10b	7.5E-02
11a	3.3E-01
11b	1.7E-01
11c	8.3E-01
12a	1.8E-01
12b	5.5E-01
13	4.8E-01

Hazard / Section	Spatial Probability
14a	1.1E-01
14b	8.4E-01
15	3.1E-01
16	6.9E-01
17	9.4E-01
18	6.0E-01
19a	2.3E-03
19b	2.8E-02
20a1	4.5E-01
20a2	1.9E-01
20b	1.0E00
21	5.3E-01
22	2.0E-01
23	1.7E-01
24	3.9E-01

5.3 TEMPORAL PROBABILITY

The temporal probability is the likelihood of a person being on site at the location of the landslide at the time that it occurs compared to the period of a year. As the people who will access the area are most likely to be transiting through the area the temporal probability is based on the speed of a person walking the length of the affected area. The person most at risk is likely to be a person walking casually through the area at say 1km/hr. The person most at risk is based on a single transit through the site. Multiple transits by the same person or transits by multiple people over time are considered in the societal risk calculations.

The temporal probabilities for each section are summarised in Table 5-2.

Table 5-2 – Temporal probabilities for each section

Hazard / Section	Temporal Probability
1	5.1E-06
2	1.7E-06
3	1.7E-06
4	3.2E-06
5	3.3E-06
6	2.6E-06
7	4.2E-06
8a	9.9E-06
8b	9.9E-06
9	4.9E-06
10a	3.8E-06
10b	3.8E-06
11a	3.4E-06
11b	3.4E-06
11c	3.4E-06
12a	3.1E-06
12b	3.1E-06
13	1.6E-06
14a	2.7E-06
14b	2.7E-06
15	9.1E-07
16	2.0E-06
17	1.3E-06
18	3.6E-06
19a	4.1E-06
19b	4.1E-06
20a1	3.0E-06
20a2	3.0E-06
20b	3.0E-06
21	5.4E-06
22	2.9E-06
23	1.7E-06
24	1.5E-06

5.4 VULNERABILITY

The vulnerability is the likelihood that a person would be killed or seriously injured if impacted by the landslide. The vulnerability is dependent on a number of factors such as the speed of a landslide, whether the person is upslope or downslope of the landslide. A low vulnerability (i.e. very minor injury)

tends towards 0, a high vulnerability (i.e. serious injury) tends towards 1, with death being assigned a vulnerability of 1.

The vulnerabilities adopted for each section are summarised in Table 5-3.

Table 5-3 – Vulnerabilities adopted for each section

Hazard / Section	Vulnerabilities
1	0.2
2	0.2
3	0.2
4	0.2
5	0.2
6	0.2
7	0.2
8a	0.2
8b	0.1
9	0.1
10a	0.2
10b	0.1
11a	0.5
11b	0.2
11c	0.2
12a	0.1
12b	0.2
13	0.1
14a	0.1
14b	0.2
15	0.1
16	0.2
17	0.2
18	0.2
19a	1.0
19b	1.0
20a1	0.5
20a2	0.5
20b	0.2
21	0.2
22	0.1
23	0.1
24	0.2

5.5 ACCEPTANCE CRITERIA

AGS (2007) indicates that different levels of risk are appropriate when considering existing slopes or developments and new developments.

For existing slopes, AGS (2007) suggests that 'tolerable' risk should be less than or equal to $1x10^{-4}$. For newly engineered slops or new developments AGS (2007) suggests that 'tolerable' risk should be less than or equal to $1x10^{-5}$. For the purposes of this risk assessment, a 'tolerable' risk of $1x10^{-4}$ of less has been adopted.

It is important to understand that a risk assessment does not state that a death or serious injury will or will not occur. It is a statistical likelihood based on a number of factors that is then compared against a pre-defined level of tolerability.

The risk to life does not consider the potential risk of a person tripping or falling due to the hazard having previously occurred, such as at the existing landslides at Sections 7 and 20. It assumes the path has been reinstated in those areas to a trafficable width.

5.6 RISK TO LIFE ASSESSMENT – PERSON MOST AT RISK

The risk to life from the different hazards for the individual most at risk using the Beleura Cliff Path has been conducted. The results of the quantitative risk for the person most at risk is provided in Table 5-4.

Table 5-4 - Risk to Life for different hazards (Person Most at Risk)

Hazard / Section	Risk to Life (Person Most at Risk)
1	4.6E-10
2	4.6E-10
3	1.9E-10
4	6.8E-10
5	3.4E-08
6	6.8E-11
7	3.4E-07
8a	1.6E-09
8b	1.4E-09
9	2.9E-10
10a	5.7E-10
10b	2.9E-09
11a	5.7E-09
11b	1.1E-09
11c	5.7E-09
12a	5.7E-09
12b	3.4E-10
13	7.6E-11
14a	2.9E-09

Hazard / Section	Risk to Life (Person Most at Risk)
14b	4.6E-09
15	2.9E-11
16	2.7E-09
17	2.5E-09
18	8.7E-09
19a	2.9E-08
19b	1.1E-08
20a1	6.8E-07
20a2	2.9E-07
20b	1.2E-08
21	1.1E-08
22	5.7E-10
23	2.9E-10
24	5.7E-09
Risk to Life is Acceptable	
Risk to Life is Tolerable	
Risk to Life is Not Tolerable	

As can be seen from the table above, the risk to the individual most at risk from the landslides is currently 'Acceptable' from the individual hazards. This is primarily due to the relatively short transit time for each hazard compared to the length of a year. However, considering that the path is used by a number of people and also individual people may use the path multiple times in a year it is also important to consider the societal risk. This is discussed in the following section.

5.7 SOCIETAL RISK

Whilst the risk to the person most at risk has been identified as tolerable for this site, it is also important to consider the societal risk from a landslide. In simplified terms, the societal risk is the cumulative risk that builds up over time as each person uses the path. For paths which are regularly used, it is often the societal risk which dominates whether the risk is tolerable.

The societal risk takes into account the number of people using the path in its calculation. The societal risk considers people walking at average speed which is typically faster than the person most at risk.

The societal risk has been determined based on approximately 100 people using the path per day, noting that this is an estimate as no traffic count has been carried out to obtain actual user numbers for the path. This number is based on anecdotal information provided by the Shire and Friends groups.

The results for the societal risk is provided in Table 5-5.

Table 5-5 - Risk to Life for different Hazards (Societal Risk)

Hazard / Section	Risk to Life (Societal Risk)
1	5.6E-06
2	5.6E-06
3	2.3E-06
4	8.3E-06
5	4.2E-04
6	8.3E-07
7	4.2E-03
8a	1.9E-05
8b	1.7E-05
9	3.5E-06
10a	6.9E-06
10b	3.5E-05
11a	6.9E-05
11b	1.4E-05
11c	6.9E-05
12a	6.9E-05
12b	4.2E-06
13	9.3E-07
14a	3.5E-05
14b	5.6E-05
15	3.5E-07
16	3.3E-05
17	3.1E-05
18	1.1E-04
19a	3.5E-04
19b	1.4E-04
20a1	8.3E-03
20a2	3.5E-03
20b	1.5E-04
21	1.4E-04
22	6.9E-06
23	3.5E-06
24	6.9E-05
Risk to Life is Acceptable	
Risk to Life is Tolerable	
Risk to Life is Not Tolerable	

The analysis has shown that for individual hazards / sections, the Societal Risk is 'Not Tolerable' for Sections 7, 20a1 and 20a2. Elsewhere the Societal Risk is assessed as 'Tolerable' or 'Acceptable'. A

summary societal risk map is provided in Appendix H, with the Societal Risk to Life calculations provided in Appendix I.

As the hazards are aligned one after the other, meaning that a person using the path will walk through all of the different sections identified instead of accessing discrete sections, the Societal Risk of all of the sections combined needs to be considered as well. Based on the societal risk for individual hazards, the combined risk for the full length of the path is **1.42E-02**. This indicates that the Societal Risk to Life is not tolerable for people walking from one end of the path to the other.

It has been identified that the critical sections of the path include Sections 5, 7, 19 and 20. If the Societal Risk to Life in all these sections can be brought up to a 'Tolerable' level, then the combined Societal Risk to Life for the full length of the path would also become 'Tolerable'.

6.0 RISK MITIGATION MEASURES

6.1 CURRENT

The current risk mitigation approach centres around preventing people from accessing the path. To achieve this, there are significant fences positioned at both the northern and southern extremities of the path. The fencing on the southern end of the path is shown in Figure 6-1.

Figure 6-1 – Fencing at the Southern end of the path

In addition to this, fencing has been put in place on both sides of each of the active landslides. An example of this is presented in Figure 6-2 on the south side of the debris flow landslide (Section 7).

Figure 6-2 – Fencing on the southern side of the active failure in Section 7

It is noted that whilst the fences are in place, some members of the public choose to enter the area by avoiding the fences. It was observed that some fencing that had been positioned on either side of the active landslides had previously been removed and thrown down the cliff. The replacement fencing that was in place at the time of the site inspection showed signs of having had holes cut in it. The holes had been re-covered with a layer of chain link fencing fixed in place. The presence of tracks around the fencing were observed where people have circumnavigated the fencing to continue using the path. All of these observations indicate that within the path itself, the fences either side of the active landslide have limited effectiveness in preventing people from accessing the high-risk areas.

6.2 PROPOSED SOLUTIONS / REMEDIATION MEASURES

6.2.1 General

The Societal Risk to Life obtained from the LRA has been assessed to identify the most critical locations along the path to be targeted for remedial measures, such that the combined Societal Risk to Life for the full path can be reduced to a ‘Tolerable’ level. This assessment indicated that there are two areas along the path that, if both remediated, would improve the Societal Risk to Life of using the full length of the path to a ‘Tolerable’ level.

These two areas include one length along the north of the path including Sections 5, 6 and 7 (Area A). While the Societal Risk for Section 6 is ‘Tolerable’ the remediation required for Sections 5 and 7 would impact on use of the lookout in Section 6.

The other length is along the south of the path and includes Sections 19 and 20 (Area B).

6.2.2 The Marine and Coastal Policy (2020)

The Marine and Coastal Policy (2020) guides all planning and decision-making under the Marine and Coastal Act 2018 with the overall aim of having marine and coastal planning management in Victoria contribute to a more sustainable world. One of the intents of the policy that is particularly relevant to this work, is to guide the development of the coastal zone such that built assets are as resilient as possible in the face of future changes or are able tolerate change without losing their original function. Future changes include events such as rising sea levels and climate change induced increases in frequency and extremity of weather events, resulting in an increase in erosion.

6.2.3 The solutions proposed in this section are assessed for suitability in Section 6.3 and include consideration of the Marine and Coastal Policy. Area A

Towards the Caraar Creek Lane end of the path, the hazards within Sections 5 and 7 could be addressed by re-routing the path inland and further away from the hazards presented by Section 5 (downslope scarp) and Section 7 (active landslide).

The area inland from these sections is comparatively flat and there is space available in which the rerouting could be achieved. A spur track could be built from the new path alignment down to the lookout, to retain the functionality of the current lookout which lies within Section 6.

A possible approximate alignment for this solution is presented in Figure 6-3. The sections of path that the new alignment would be replacing will need to be permanently closed and made inaccessible as part of the re-routing works. Revegetating of these areas should then be conducted to further discourage access.

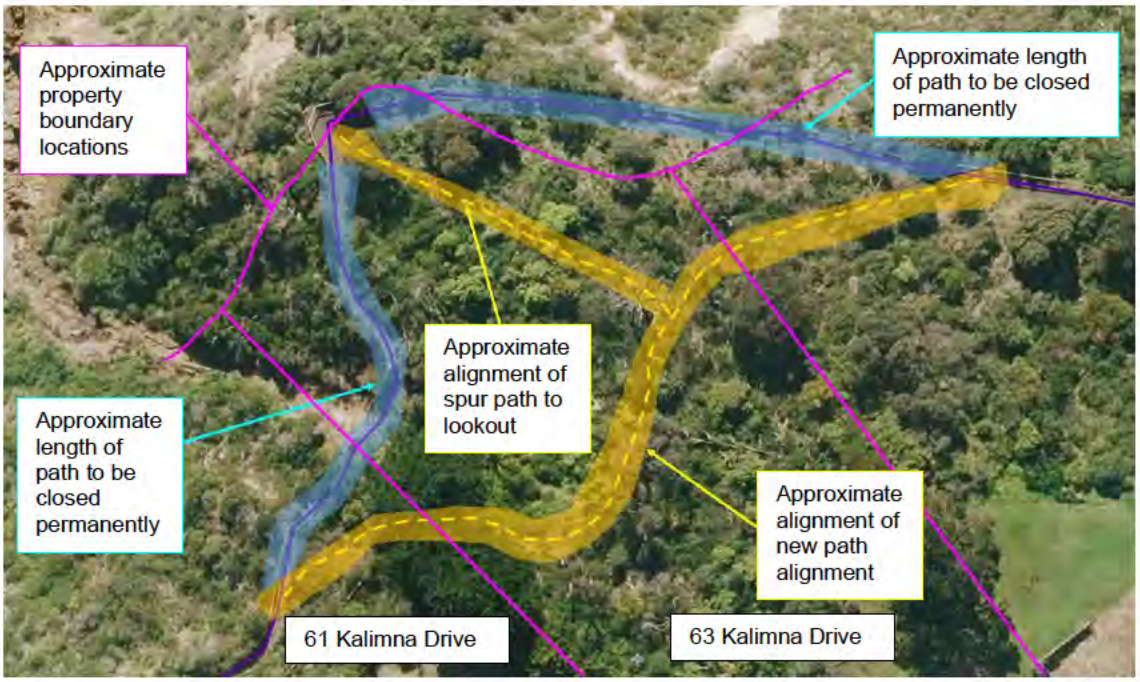

Figure 6-3 – Approximate alignment of new path alignment to avoid Sections 5,6 and 7

No further options were considered for this area as this solution is considered relatively low cost and achievable.

6.2.4 Area B

The second area where remedial works are recommended comprises Sections 19 and 20 towards the Mills Beach end of the path, located downslope of 23 Kalimna Drive. Four possible remedial options have been identified for these sections of the path. These options are presented in the sections below and an options assessment is presented in Section 6.3.

All of the options presented below will require cleaning out some of the loose material within the area of the landslide and will require drainage improvements in the area, both to deal with the natural groundwater and drainage from the upslope properties.

6.2.4.1 Option 1 – Bridge

A bridge solution could be implemented to cross the area of active landslide. This type of solution would effectively address risk in both Section 19 and Section 20. An illustration of a possible bridge alignment is presented in Figure 6-4.

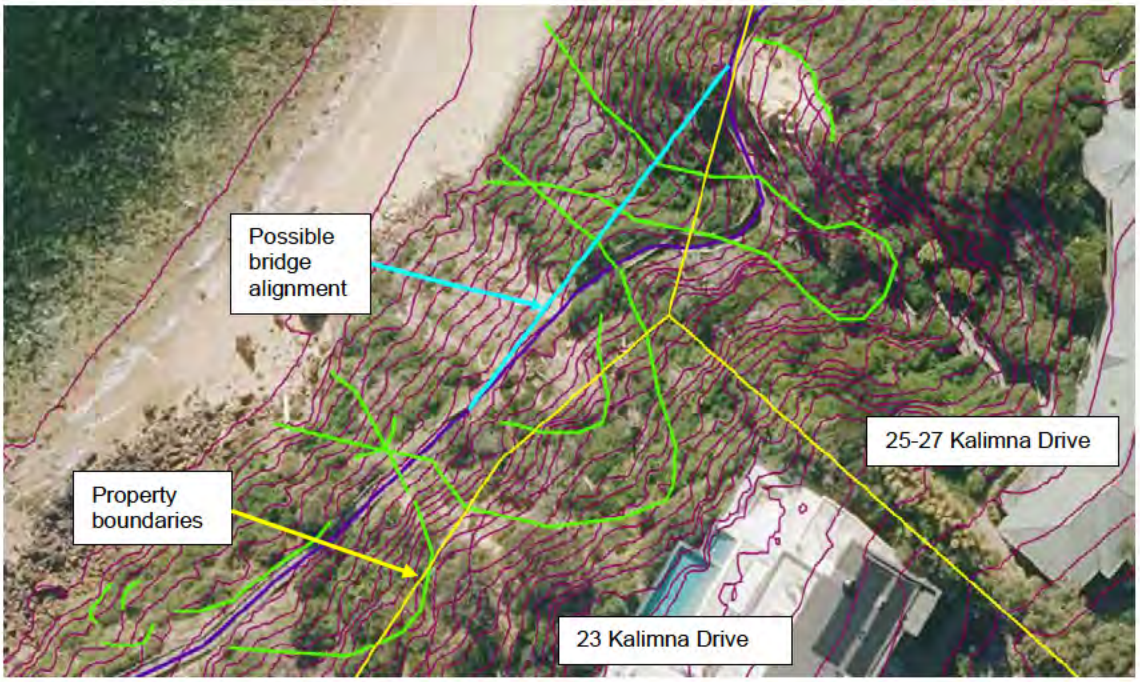

Figure 6-4 – Section 19/20: possible bridge alignment

6.2.4.2 Option 2 – Path to Beach

This option comprises the construction of an engineering solution, such as steps/path down to the beach. This would address the active landslides in both Sections 19 and 20. Refer to Figure 6-5.

Figure 6-5 – Section 19/20: possible 'soft' path/steps alignment

6.2.4.3 Option 3 – Gabion Supported Path and Grading

This option includes a combination of approaches to address the risks in Section19 and Section 20 separately.

Section 19 includes the areas where overhanging material was observed. It is recommended that the overhanging material is removed via mechanical means, and the section of the cliff upslope of the path be battered back to a shallower angle. The current catch wall needs to be emptied of material, such that any future soil material transported by surface run off is prevented from being deposited onto the path. This is illustrated in Figure 6-6 and Figure 6-7 below.

Section 20 includes the zone of active landslide downslope of 23 Kalimna Drive. This option comprises the construction of an engineering solution based on the use of gabion baskets to stabilise the path alignment. A sketch of this solution is presented in Figure 6-8.

Figure 6-6 – Section 19: zone of overhanging material to be mechanically removed

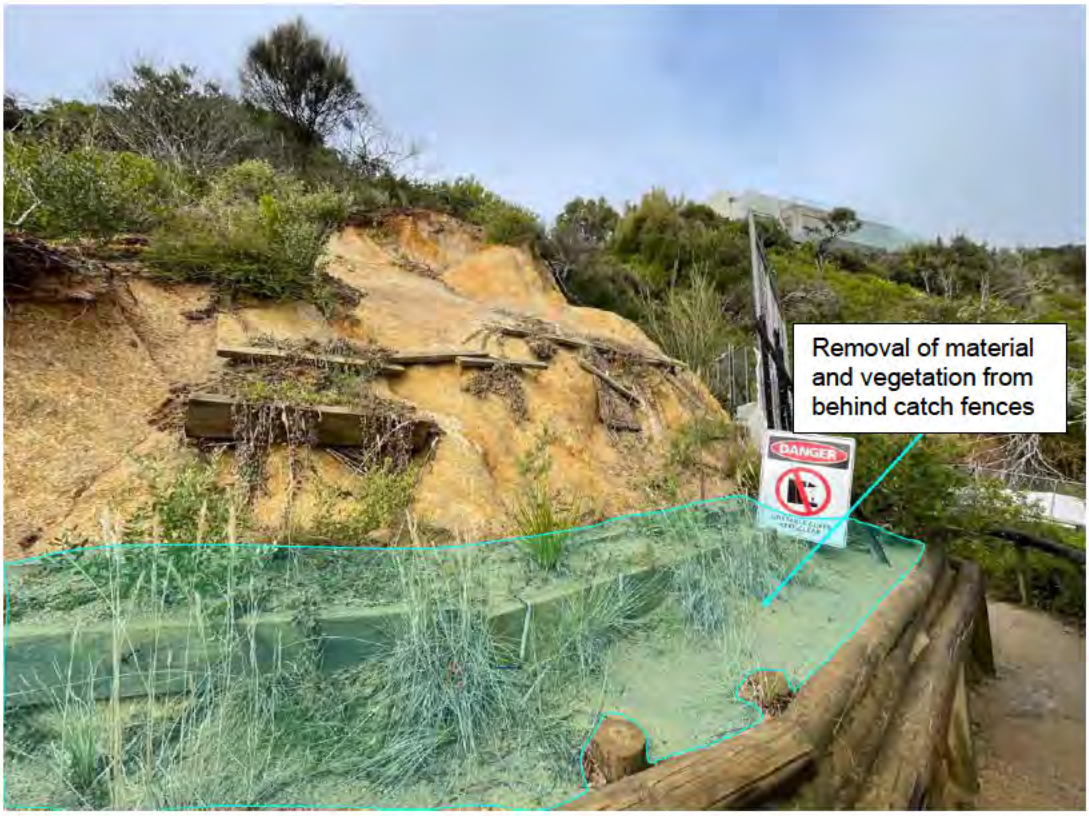

Figure 6-7 – Section 19: material and vegetation to be removed from behind catch wall

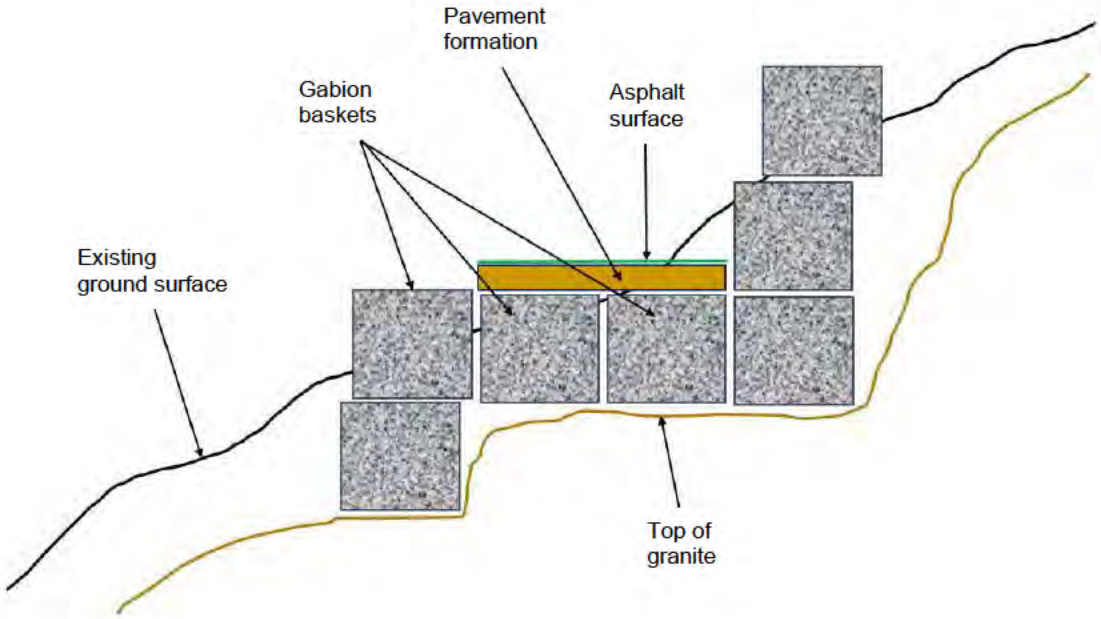

Figure 6-8 – Section 20: schematic of possible gabion based path reconstruction

6.2.4.4 Option 4 – Drainage and Grading

As in Option 3, this option includes a combination of approaches to address the risks in Section19 and Section 20 separately.

For Section 19, this option is identical to that presented in Option 3.

For Section 20, this option comprises a solution based on the improvement in drainage in the area. This would include carrying out a drainage audit of the existing drainage in the section, and subsequent installation of new drainage. In addition to this, it is likely to require the installation of drainage bores into the cliff face to remove natural groundwater from the superficial soil layer and drain it into an appropriate drainage network to be disposed of away from the cliff face. Following completion of improved drainage, the path would be re-established along a similar alignment to the original path alignment.

6.3 OPTIONS ASSESSMENT

6.3.1 Assessment Criteria

The following nine criteria have been considered to assess the four options for Area B. Each criterion is categorised in a relative scale of high, medium and low with 'high' being the least acceptable and

'low' being the most acceptable. At this stage no weighting has been provided for each criterion as to which is considered more important.

1. **Safety During Works**: It is essential that during the works, the workers and the public are kept safe. Most options include the potential to dislodge loose or overhanging rocks such that they fall and roll towards the trail. It is anticipated that a significant exclusion zone will be required to keep the public from the area. However, some workers will still need to be in the vicinity of the site while the works are undertaken. A rating of 'high' identifies that the option has a greater potential for workers to be at risk during the works even with protections in place. A rating of 'medium' identifies either a medium level of risk without protections or that with protections the relative risk is reduced to medium. A rating of 'low' identifies a relatively low level of risk even without protections. However, as all methods are proposed to be conducted with appropriate safety measures and systems it is considered that all can be conducted safely. A rating of 'high' does not mean it has a high safety risk, just that the risk is higher than the other options.

2. **Medium Term Residual Risk**: The medium-term residual risk is the ability of the option to continue providing a reduced risk to the public for say the next 5 to 10 years (approximately). A high rating means that the solution is considered less likely to last through this period while a low rating means the solution is considered more likely to last through this period.

3. **Long Term Residual Risk**: The long-term residual risk is the ability of the option to continue to provide a reduced risk for an extended period (beyond say 10 years). A high rating means that the solution is unlikely to be suitable as a long-term protection while a low rating means there is a greater likelihood of long-term protection.

4. **Difficulty in Design**: Each of the different options will require geotechnical design with a different level of complexity, ranging from comparatively simple 2D modelling through to complex 3D models. A high rating means there is a significant degree of complexity in the design and a low rating means that the design process is relatively straightforward.

5. **Difficulty in Constructability**: Each of the different options involves different construction methods. Some involve bringing significant heavy equipment to the site while others require more effort to dispose of materials. A high rating identifies that significant equipment or effort is required to implement the work compared to the other options while a low rating identifies less effort.

6. **Relative Cost Ranking**: Each of the solutions determined is difficult to cost without formal quotations for the works. As such an order of magnitude comparison has been conducted to assess the different options with high being likely to be the most expensive and low being likely to be the least expensive.

7. **Environmental Impact**: Each of the solutions presented has a different degree of impact on the environment in the area. In the current scenario, environmental impact has been considered primarily as the impact of the proposed solution on the existing vegetation in the area, with a high rating indicating that a significant amount of vegetation clearance will be required and a low rating indicating a much lower impact on the vegetation in the area. A detailed environmental assessment has not been carried out at this stage.

8. **Will the option provide open pedestrian access to the path?** Each of the options presented is assessed for its ability to provide open pedestrian access to the path, with 'yes' indicating that open pedestrian access will be provided and 'no' indicating that it will not provide open pedestrian access.

9. **Will the option provide ongoing amenity of the path?** Each of the options has been assessed in terms of its ability to provide ongoing amenity of the path. A 'Low' risk rating indicates that there will be good ongoing amenity of the path and a 'High' rating indicates that there will be poor ongoing amenity of the path.

10. **Administrative Difficulty.** Each of the options has been assessed in terms of its perceived level of administrative difficulty. Difficulties considered include occupation of private land, cultural heritage implications and planning considerations.

The Marine and Coastal Policy (2020) has a particular focus on the sustainability, resilience and ongoing amenity of a built asset in light of changing conditions, such as increased erosion resulting from sea-level rise and increasingly frequent and extreme storm events. The assessment criteria presented above address these concerns, by including consideration of residual risks in the medium and long term, environmental impact, accessibility of the path and ongoing amenity of the path.

Based on the assessment criteria presented above, each of the suggested remediation options have been assessed below and summarised in Table 6-1.

6.3.2 Area B – Option 1 – Bridge

1. **Safety During Works:** This solution requires working with multiple different types of plant in restricted and difficult to access areas. There is a risk of vibrations from construction activities inducing further landslide activity in the areas, which could result in damage to plant and injury to construction personnel. The location of the bridge would be at a significant height above the beach, resulting in a significant fall hazard from the work area. Safe work methods would have to be established to reduce the risk to construction personnel as far as practicable. Based on the above, this solution has been assessed as 'High'.

2. **Medium and Long Term Residual Risk:** The bridge would span over the areas considered at high risk of further landslide activity such that it would not be affected by further landslide activity. As such the medium and long term residual risk have been assessed as 'Low'.

3. **Difficulty in Design**: A bridge requires significant design input from both geotechnical and structural engineering perspectives. As such this solution has been assessed as 'High'.

4. **Difficulty in Construction**: A bridge will require significant works on site, from foundations through to lifting the deck or deck components into position. Due to the location of a bridge structure in relation to the site access points and the size of the available working areas nearby, there will be significant challenges to get the appropriate machinery to site, as well as all of the materials required to construct the bridge. As such the difficulty in construction has been assessed as 'High'.

5. **Relative Cost:** This solution will incur significant design fees. It requires multiple types of plant to access the site and requires materials to be brought to site to build the bridge. Additionally, work is likely to be quite slow given the tight working areas. Any access from the beach below may also

be impacted by tidal constraints which would impact the construction program. As such it has been assessed that the relative cost of this solution is 'High'.

6. **Environmental Impact:** This solution requires significant temporary works to provide plant access to the working area. These temporary works would likely have a significant impact on the vegetation of the area around the landslide area. Additionally, if beach access is used for any part of the works, there may be environmental impacts of bringing construction vehicles along the beach to the required location. Furthermore, the construction works are likely to be comparatively lengthy and may be a source of noise pollution to the local residents. Based on the above, it has been assessed that the environmental impact of this solution is 'High'.

7. **Open Pedestrian Access:** This solution will provide open pedestrian access to the path.

8. **Ongoing Amenity of the Path:** This solution will provide good ongoing amenity to the path and therefore has been assessed as 'Low'.

9. **Administrative Difficulty:** This solution would be situated on exclusively Crown land and access to the area for construction purposes would be predominantly from Crown land. The solution itself requires significant disturbance of the surface in the vicinity of the site to facilitate construction. Therefore the cultural heritage implications could be significant. Consequently, this solution has been assessed as providing a 'Medium' administrative difficulty.

6.3.3 Area B – Option 2 – Path to Beach

1. **Safety During Works**: This solution involves the construction of a new 'soft' path and steps down from the existing path to the beach. While a small excavator may be required to do these sections of the works it is possible that a large amount of the works may be able to be conducted using human operated tools. If access to the area via the beach is used, there may also be risks associated with working adjacent to the sea and working within the tides' timetable. However, compared to the other options presented, it has been assessed that the relative construction risk is "Low'.

2. **Medium Term Residual Risk:** This solution involves the construction of 'soft' path and steps down the current cliff face beneath the Hump Bridge to access the beach and avoids the area of landslide activity in both Sections 19 and 20. It has been assessed that the medium term residual risk is 'Low'.

3. **Long Term Residual Risk**: The proposed route crosses the historic landslide that occurred prior to the construction of the Hump Bridge. This solution doesn't address the potential for reactivation of this landslide and as such the long term residual risk has been assessed as 'Medium'.

4. **Difficulty in Design:** The design input required for the construction of soft steps down to the beach is comparatively small and revolves around identifying a suitable alignment based on the terrain in the location and the geometry of steps required. As such the difficulty in design has been assessed as 'Low'.

5. **Difficulty in Construction:** It is likely that the new alignment can be constructed using a combination of hand tools and potentially a small excavator. The path could be started from the toe of the cliff and be constructed up to near the hump bridge using the constructed path as the working platform for further work. Initial work would need to be conducted during low tide.

However, compared to the other options presented, the relative difficulty in construction has been assessed as 'Low'.

6. **Relative Cost:** As this solution only requires minimal materials to be brought to site, the relative cost of this option has been assessed as 'Low'.

7. **Environmental Impact:** In this solution, the excavator will cut a pathway/steps down from the existing path locations to the beach. The path will be a 'soft' path and as such few materials will need to be brought to site for its construction. As such the environmental impact of this solution has been assessed as 'Low'.

8. **Open Pedestrian Access:** This solution will provide open pedestrian access to the path.

9. **Ongoing Amenity of the Path:** This solution takes pedestrians down to the beach where there are potential access issues. When the tide is low, there may only be a limited beach and when the tide is high, even scrambling across the rocks may not be possible. As such, it has been assessed that the ongoing amenity of the path is poor and has been rated as 'High'.

10. **Administrative Difficulty:** This solution would be situated on exclusively Crown land and access to the area for construction purposes would be predominantly from Crown land. The solution will require the construction of an at grade path from the existing path down to the beach. However, the areas has previously been disturbed by landslide activity. It is possible that these works may have an impact on cultural heritage. Based on this, this solution has been rated as having a 'Medium' administrative difficulty.

6.3.4 Area B – Gabion Supported Path and Grading

1. Safety During Works:

For Section 19 this solution involves the use of an excavator to remove the overhanging material. With the excavator positioned to the side of the area where material is being brought down, it will be outside of the zone where it might be hit by falling debris. Further grading back of the upslope section of the cliff is expected to be carried out with a small excavator. Suitable exclusion zones should be implemented during the works and if possible, consideration should be given to the use of remotely operated machinery.

For Section 20, this solution involves the recreation of a path along a similar alignment to the original path. An excavator will be required to clear landslide materials and excavate down to the weathered rock to form the alignment for the path. The access to that level of the cliff may be difficult and plant vibrations in the area risk reactivating landslide activity in the area. Gabion baskets will need to be brought to the path and filled in situ. There is a risk of injury from carrying rocks and filling the basket, as well as a risk of crushing injury.

Based on the above, the relative safety during works has been assessed as 'Medium'.

2. Medium Term Residual Risk:

For Section 19, the solution comprises the removal of the existing overhangs and battering back of the upslope cliff to reduce the risk of further overhangs forming.

For Section 20, this solution will re-create a path which follows approximately the same alignment as the original path, using gabion baskets to provide a surface on which to construct the path. It does not reduce the risk of further landslide activity upslope of the path. During the reconstruction of the path, a certain volume of landslide debris will be cleared and the cliff battered back to reduce the potential for rapid reactivation of the landslide.

Based on the above, the relative medium term residual risk has been assessed as 'Medium'.

3. Long Term Residual Risk:

For Section 19, this solution involves the removal of the existing overhangs and the battering back of the upslope cliff to reduce the risk of new overhangs forming rapidly. However, in the long term it is possible that new overhangs may form, resulting in more soil and rock material falling onto the path.

For Section 20, as in the medium term, this solution provides a path that is down slope of the current landslide and does not remove the potential for further landslide activity up slope of the path.

In the long term, the effects of weather and erosion mean that the relative long term residual risk has been assessed as 'High'.

4. Difficulty in Design:

For Section 19, the design input for this solution is relatively low for this solution and will be centred around assessing the appropriate batter gradients for the cliff.

For Section 20, the design input required for the construction of a path founded on gabion baskets is comparatively moderate and revolves around slope stability assessment to identify an appropriate position of the path and gabion basket configuration.

As such the relative difficulty in design for this solution has been assessed as 'Medium'.

5. Difficulty in Construction:

For Section 19, this solution involves mobilising an excavator to site under safe work methodology.

For Section 20, an excavator will be required to remove a volume of landslide debris and create the new pathway. Baskets and rocks will need to be brought to site and the gabion baskets constructed in situ. There may be challenges in mobilising the required plant and materials to the path location, given the possible access locations. Vibration resulting from construction equipment may also result in the reactivation of landslide activity in the area.

Based on the above the relative difficulty in construction has been assessed as 'Medium'.

6. **Relative Cost:**

   For Section 19, this solution requires a small excavator to be brought onto site. There will also be a requirement for spoil to be removed from site, which may be more challenging due to the access restrictions (in particular the path width and accesses to the path from the upslope roads).

   For Section 19, this solution requires plant to be brought to site, as well as materials to form the gabion baskets and to resurface the path. The tight access is also likely to impact on the construction program.

   The relative cost of this solution has been assessed as 'Medium'.

7. **Environmental Impact:**

   For Section 19, the excavator will remove the overhanging material and batter back the cliff above the path to a shallower gradient. This will result in the removal of vegetation upslope of the path.

   For Section 20, the excavator will remove some landslide debris to expose granite which will be used as a foundation for the gabions. This is likely to result in a significant volume of material to be removed from site. Once complete, it will be possible to revegetate the slopes above and below the path.

   The environmental impact of this solution has been assessed as 'Medium'.

8. **Open Pedestrian Access:** The proposed solution for Sections 19 and 20 will provide open pedestrian access to the path.

9. **Ongoing Amenity of the Path:** This solution will provide good ongoing amenity to the path and therefore has been assessed as 'Low'.

10. **Administrative Difficulty:** This solution will be located on both Crown land and private property. The solution will follow the alignment of the original path with some impact on the ground within the vicinity of the path and extend upslope within the area of the recent landslide. While it is thoughtto have limited further cultural heritage impact than that imposed by the original path, the planning requirements with regard to works on private land may be significant. On this basis, this solution has been assessed as of 'Medium' administrative difficulty.

6.3.5 Area B – Option 4 – Drainage and Grading

1. **Safety During Works:**

   For Section 19 this solution involves the use of an excavator to remove the overhanging material. With the excavator positioned to the side of the area where material is being brought down, it will be outside of the zone where it might be hit by falling debris. Further grading back of the upslope section of the cliff is expected to be carried out with a small excavator. Suitable exclusion zones should be implemented during the works and if possible, consideration should be given to the use of remotely operated machinery.

For Section 20 this solution requires sizeable equipment to be brought to site to install the required bores into the cliff and the construction of a suitable drainage system to collect all the natural groundwater and surface water run-off. It is anticipated that significant temporary works will be required to facilitate the access to site for the required plant, as well as the potential for rope work on steeper sections of the cliff.

Based on the above, the relative safety during works has been assessed as 'High'.

2. Medium Term Residual Risk:

For Section 19 this solution involves the removal of the existing overhangs and battering back of the cliff to prevent the rapid formation of new overhangs.

For Section 20, this solution involves the improvement of natural and surface water run-off drainage over the cliff. This would result in an improved stability of this section of the cliff.

As such, the medium term risk has been assessed as 'Low'.

3. Long Term Residual Risk:

For Section 19 this solution involves the removal of the existing overhangs and battering back of the cliff to prevent the rapid formation of new overhangs, however it is possible that in the long term new overhangs may form, resulting in small blocks of material falling onto the path.

For Section 20, the solution is primarily drainage based. As such it requires more ongoing maintenance than other solutions, including regular checks to ensure pipes have not become blocked and regular defouling.

Based on the above the long term risk for this solution has been assessed as 'Medium'

4. Difficulty in Design:

For Section 19, the design input for this solution is relatively low for this solution and will be centred around assessing the appropriate batter gradients for the cliff.

For Section 20, the design input required for the improved drainage system is significant.

As such, the difficulty in design has been assessed as 'High'.

5. Difficulty in Construction:

For Section 19, this solution involves mobilising an excavator to site under safe work methodology.

For Section 20, this solution involves the installation of bores into the cliff and the construction of a suitable drainage system to collect all the natural groundwater and surface water run-off. It is anticipated that significant temporary works will be required to facilitate the access to site for the required plant, as well as the potential for rope work on steeper sections of the cliff.

Based on the above it has been assessed that the difficulty in construction of this solution is 'High'.

6. **Relative Cost:**

   For Section 19, this solution requires a small excavator to be brought onto site. There will also be a requirement for spoil to be removed from site, which may be more challenging due to the access restrictions (in particular the path width and accesses to the path from the upslope roads).

   For Section 20, the high level of design input and high level of construction difficulty will result in this solution being relatively high cost.

   As such, it has been assessed that the overall relative cost of this option is 'High'.

7. **Environmental Impact:**

   For Section 19, the excavator will remove the overhanging material and batter back the cliff above the path to a shallower gradient. This will result in the removal of vegetation upslope of the path.

   For Section 20, this solution would require significant temporary works to enable access to site by the required plant. Drilling locations would likely be positioned over a significant portion of the cliff in this area and would therefore have a significant impact on the vegetation on the cliff face.

   As such the environmental impact of this option is considered 'High'.

8. **Open Pedestrian Access:** The proposed solution for Sections 19 and 20 will provide open pedestrian access to the path.

9. **Ongoing Amenity of the Path:** This solution will provide good ongoing amenity to the path and therefore has been assessed as 'Low'.

10. **Administrative Difficulty:** This solution requires significant intervention in both privately owned land and Crown land. It is a complex solution which is also anticipated to require a high level of planning complexity. On this basis, the administrative difficulty of this project has been assessed as 'High'.

6.3.6 Summary Matrix

The matrix presented in Table 6-1 summarises the outcome of the assessments discussed in Section 6.3.2, Section 6.3.3, Section 6.3.4 and Section 6.3.5.

Table 6-1 – Option Assessment Matrix

	Safety in construction	Medium Term Residual Risk	Long Term Residual Risk	Difficulty in Design	Difficulty in Construction	Relative Cost Ranking	Environmental Impact	Ongoing Amenity	Will the option provide open pedestrian access?	Administrative Difficulty
Option 1 - Bridge	High	Low	Low	High	High	High	High	Low	Yes	Medium
Option 2 - Steps to beach	Low	Low	Medium	Low	Low	Low	Low	High	Yes	Medium
Option 3 – Gabion supported path and grading	Medium	Medium	High	Medium	Medium	Medium	Medium	Low	Yes	Medium
Option 4 – Drainage and grading	High	Low	Medium	High	High	High	High	Low	Yes	High

In conclusion, all of the approaches presented would result in a tolerable combined Societal Risk to Life over the full length of the path and could therefore be considered suitable. The final decision regarding the solution adopted is at the discretion of the Mornington Peninsula Shire.

6.3.7 Area A

An options assessment was not completed for this area as it was discussed with MPSC representatives during the site inspection and was understood to be the most feasible remedial solution for this area.

It should be noted however, that this solution will pose some administrative difficulties as it is located exclusively on private property and may therefore pose difficulties in planning and finalising the solution.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Ongoing landslide activity has been observed along the cliffs on which the Beleura Cliff Path has been constructed. Evidence indicates that this has been occurring for thousands of years. The landslide activity is likely a result of multiple factors, including but not exclusively the geology of the cliffs, rainfall, and water (from natural and manmade sources).

Based on the assessment, it has been concluded that Area A and Area B identified in Section 6.3 have a 'Not Tolerable' risk to life and remediation of both of these areas are required to open the path.

7.1 RECOMMENDATIONS

Such that the path can be reopened with a tolerable level of Societal Risk to Life, remedial works are required in the area including Sections 5, 6 and 7 as well as the area including Sections 19 and 20. Options for remedial measures are presented in Section 6.2 of this report.

Along the full length of the path, it is recommended that an audit of all existing drainage is carried out. Although time consuming and difficult to complete, this would identify all functioning, blocked and broken drains that exist along the cliff face at present. It is recommended that irrigation systems are also included in the audit. Once the extent and condition of the drainage and irrigation network has been observed, drainage along the length of the cliff should be upgraded where necessary to prevent the uncontrolled discharge of water over the cliff face.

It is also recommended that community education programs relating to the correct use of irrigation systems are rolled out, with a specific focus on residents of the properties immediately adjacent to the cliff. Periodic audits of irrigation practices should be conducted by council staff to verify that recommended practices are being followed. Any irrigation systems need to be changed to be non-automated and such that they can be depressurised once manual watering is complete.

Ongoing engagement and liaison with property owners is encouraged. The local community groups provide valuable feedback relating to the condition of the path and any issues with drainage or irrigation within the area.

Following the remedial works in the areas identified, it is recommended that the path is inspected at regular intervals by a council officer (i.e. once every 3 months) to monitor areas of interest and identify if any significant changes are occurring. Should significant changes be identified then further geotechnical advice should be sought.

In addition to this, any cracks in the asphalt path must be sealed periodically (i.e. once every 6-12 months).

Appendix A – HISTORICAL LANDSLIDE MOVEMENTS

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Photo description	Historical Landslide Movements		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Appendix B – SECTION EXTENTS: OVERALL SITE PLAN

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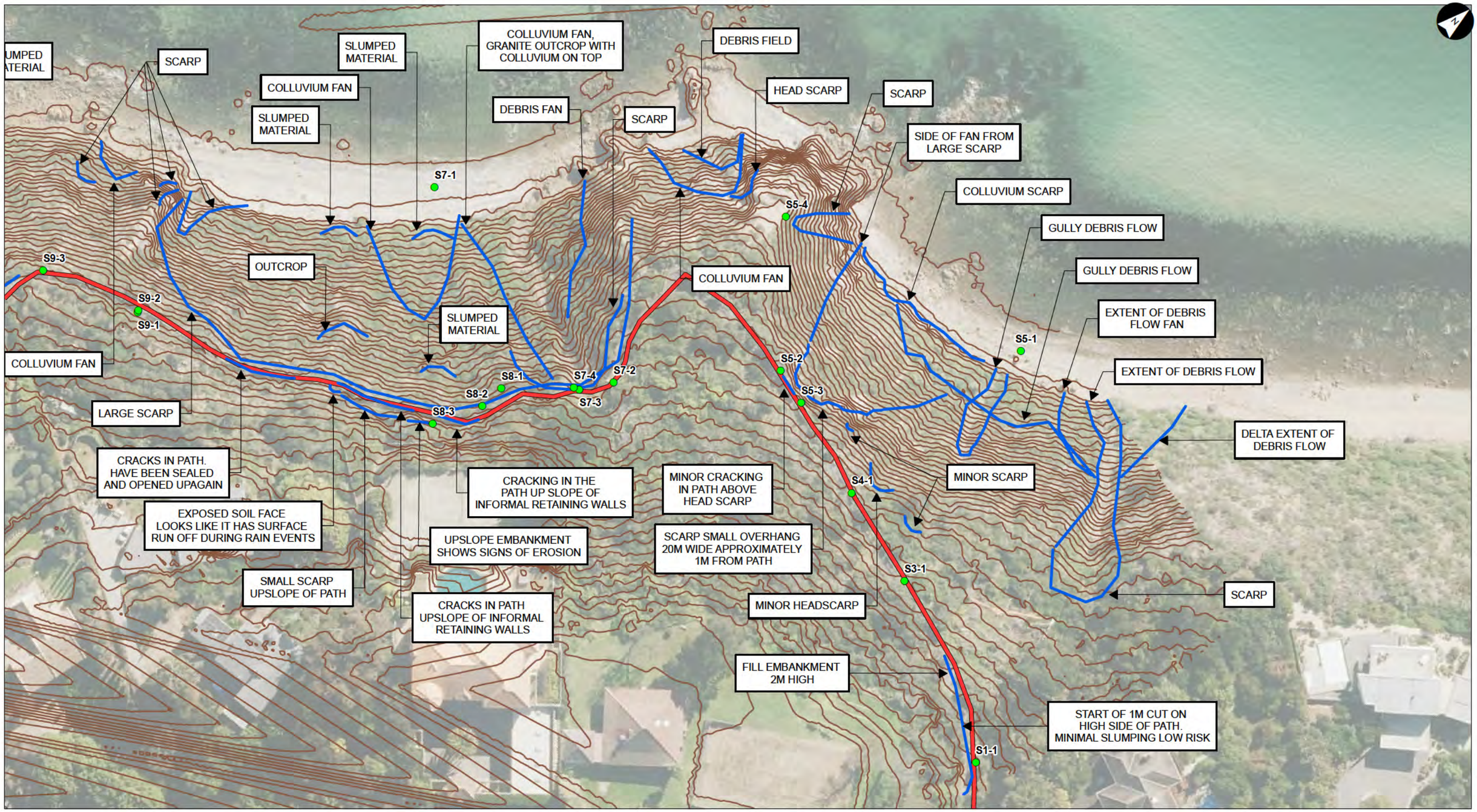
Photo description	Section Extents: Overall Site Plan		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Appendix C – SITE PLAN



Site Plan

Beleura Cliff Path, Mornington, VIC

Project Code: 304400705
Drawn By: [redacted]
Figure No: 1A | Rev: 1
Date: 2023-09-19

Legend

- Existing Path
- Contour - 1m
- Reported Features
- Reported Locations

Notes:
1. Coordinate System: GDA2020 MGA Zone 55

References:
1. Aerial Imagery Supplied by Metromap

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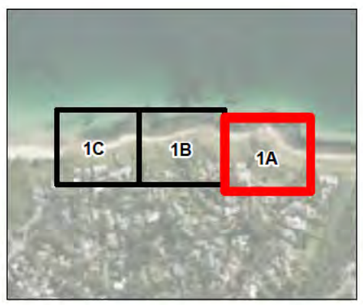
Scale at A3 1:800



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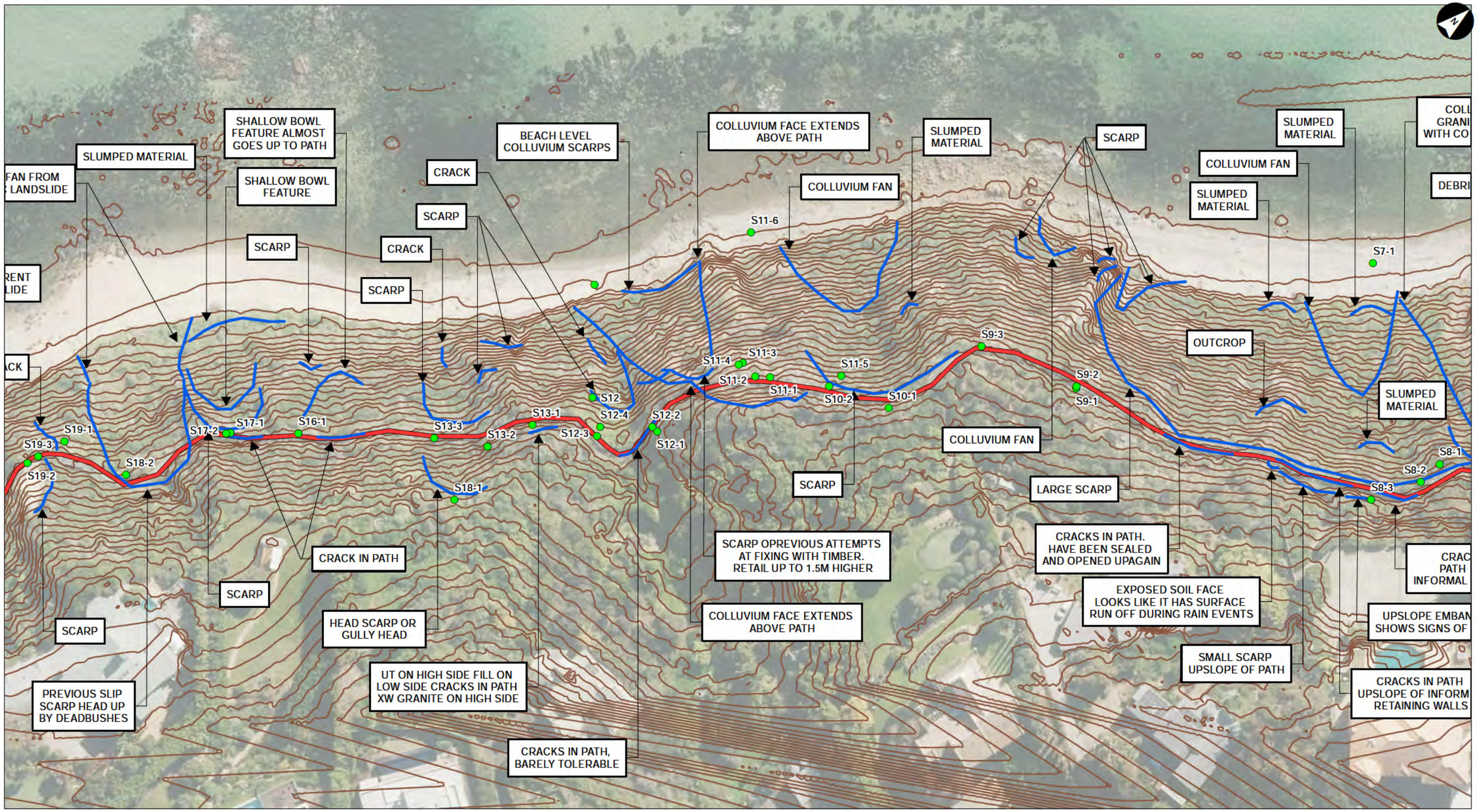

Site Plan

Beleura Cliff Path, Mornington, VIC

Project Code: 304400705
Drawn By: [redacted]
Figure No: 1B | Rev: 1
Date: 2023-09-19

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Legend

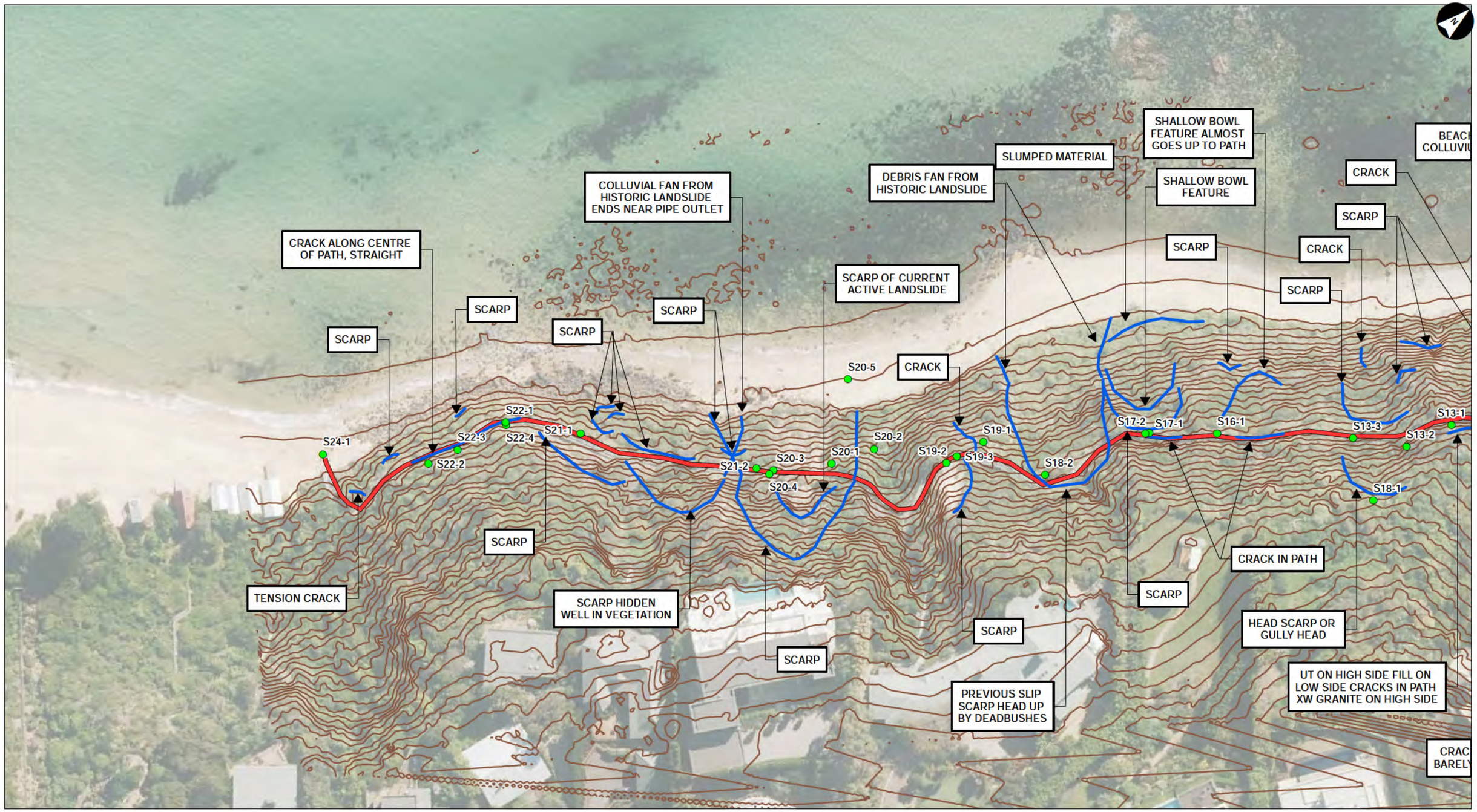
- Existing Path
- Contour - 1m
- Reported Features
- Reported Locations

Notes:
1. Coordinate System: GDA2020 MGA Zone 55

References:
1. Aerial Imagery Supplied by Metromap

0 20 40 Metres

Scale at A3 1:800



Site Plan

Beleura Cliff Path, Mornington, VIC

Project Code: 304400705
Drawn By: [redacted]
Figure No: 1C | Rev: 1
Date: 2023-09-19

Legend

- Existing Path
- Contour - 1m
- Reported Features
- Reported Locations

Notes:
1. Coordinate System: GDA2020 MGA Zone 55

References:
1. Aerial Imagery Supplied by Metromap

0 20 40 Metres

Scale at A3 1:800

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Appendix D – FEATURE PHOTOS

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Photo description	S1-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

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Photo description	S3-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

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Photo description	S4-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

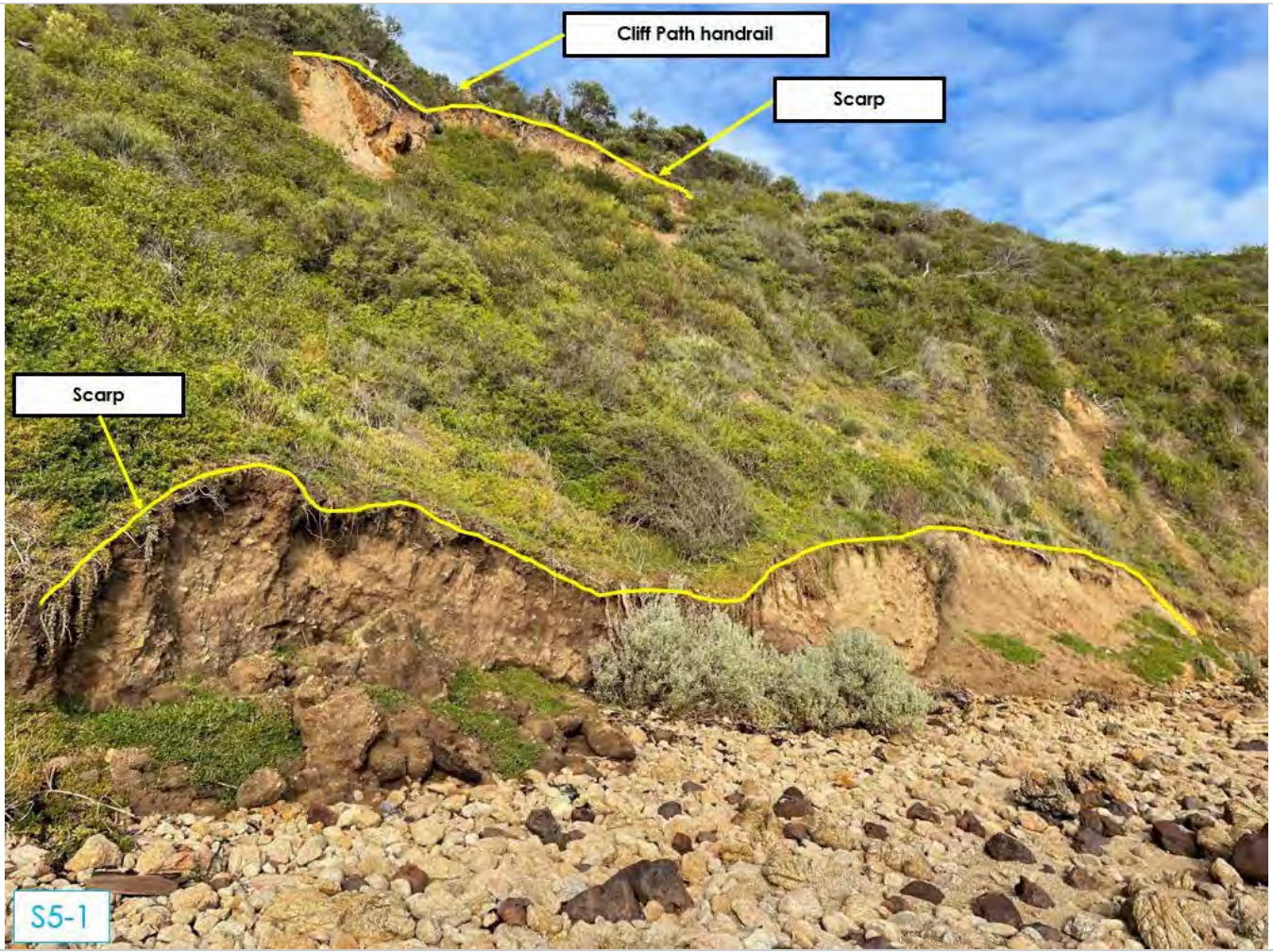

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Photo description	S5-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

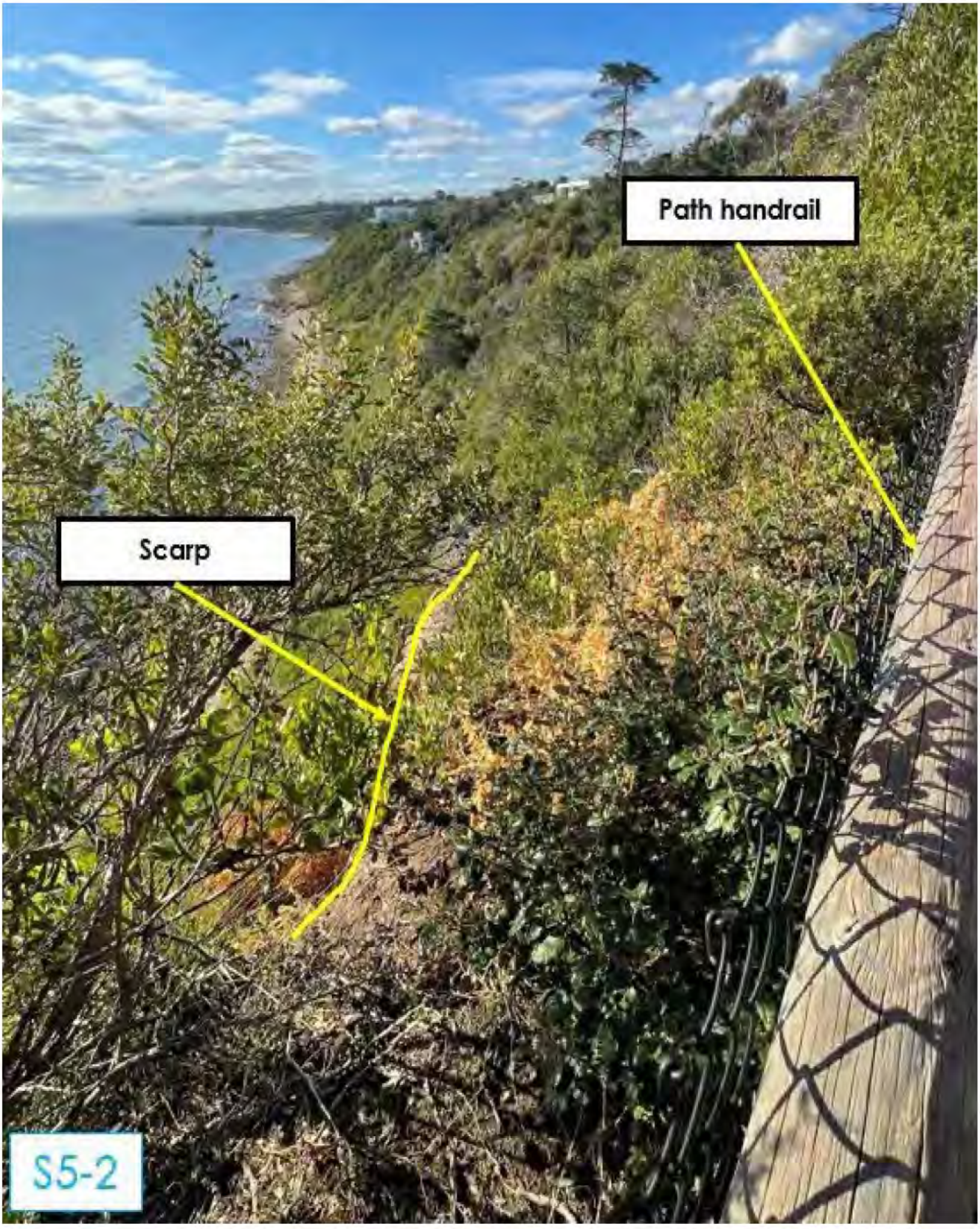

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Photo description	S5 2		
Client	Morn ngton Pen nsu a Sh re		
Location	Morn ngton V C		
Project name	Be eura C ff Path		
Project No	304400705	**Scale**	Not to Sca e

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Photo description	S5 3		
Client	Morn ngton Pen nsu a Sh re		
Location	Morn ngton V C		
Project name	Be eura C ff Path		
Project No	304400705	**Scale**	Not to Sca e

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Photo description	S5-4		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

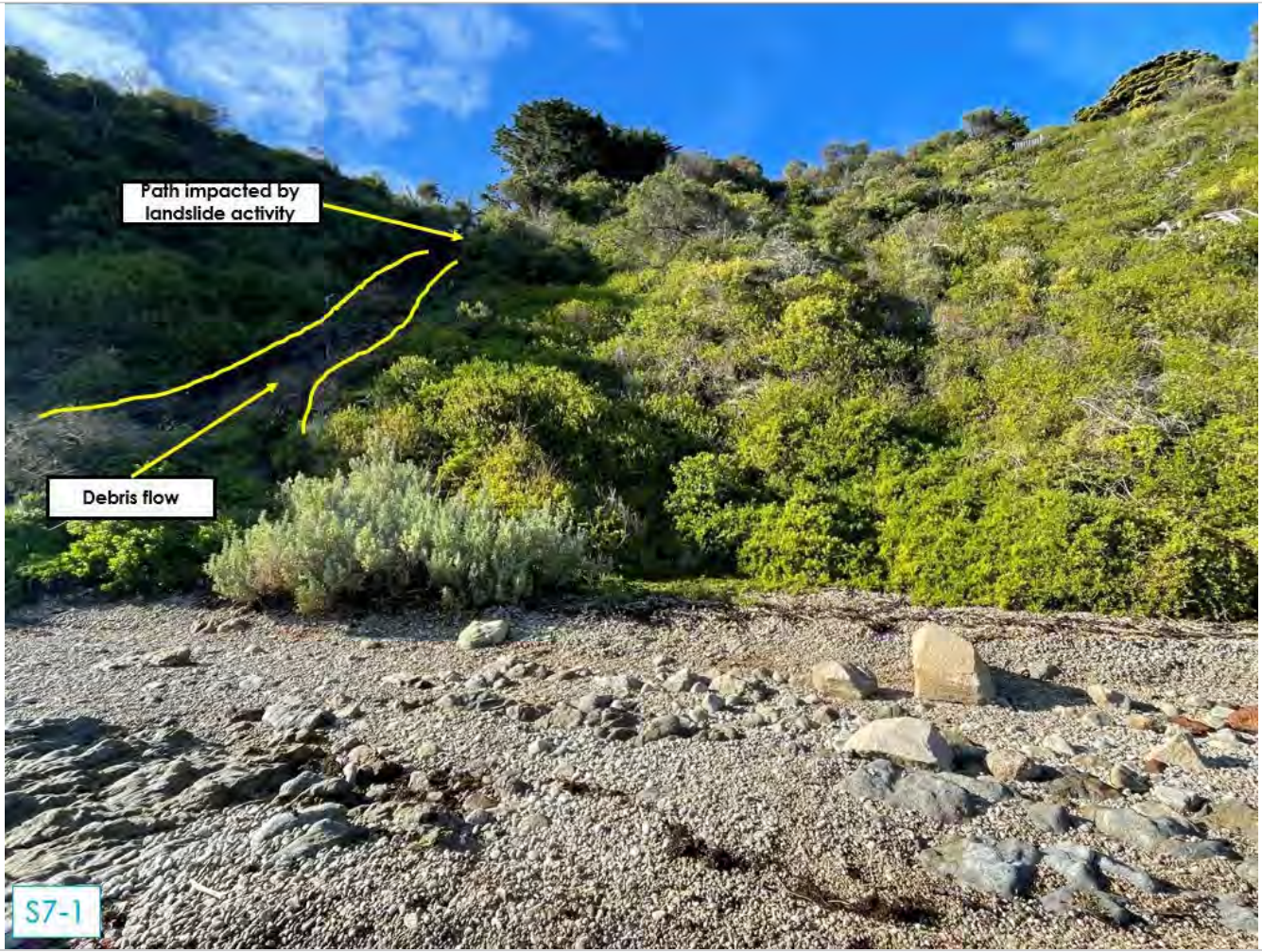

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Photo description	S7-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

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Photo description	S7-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

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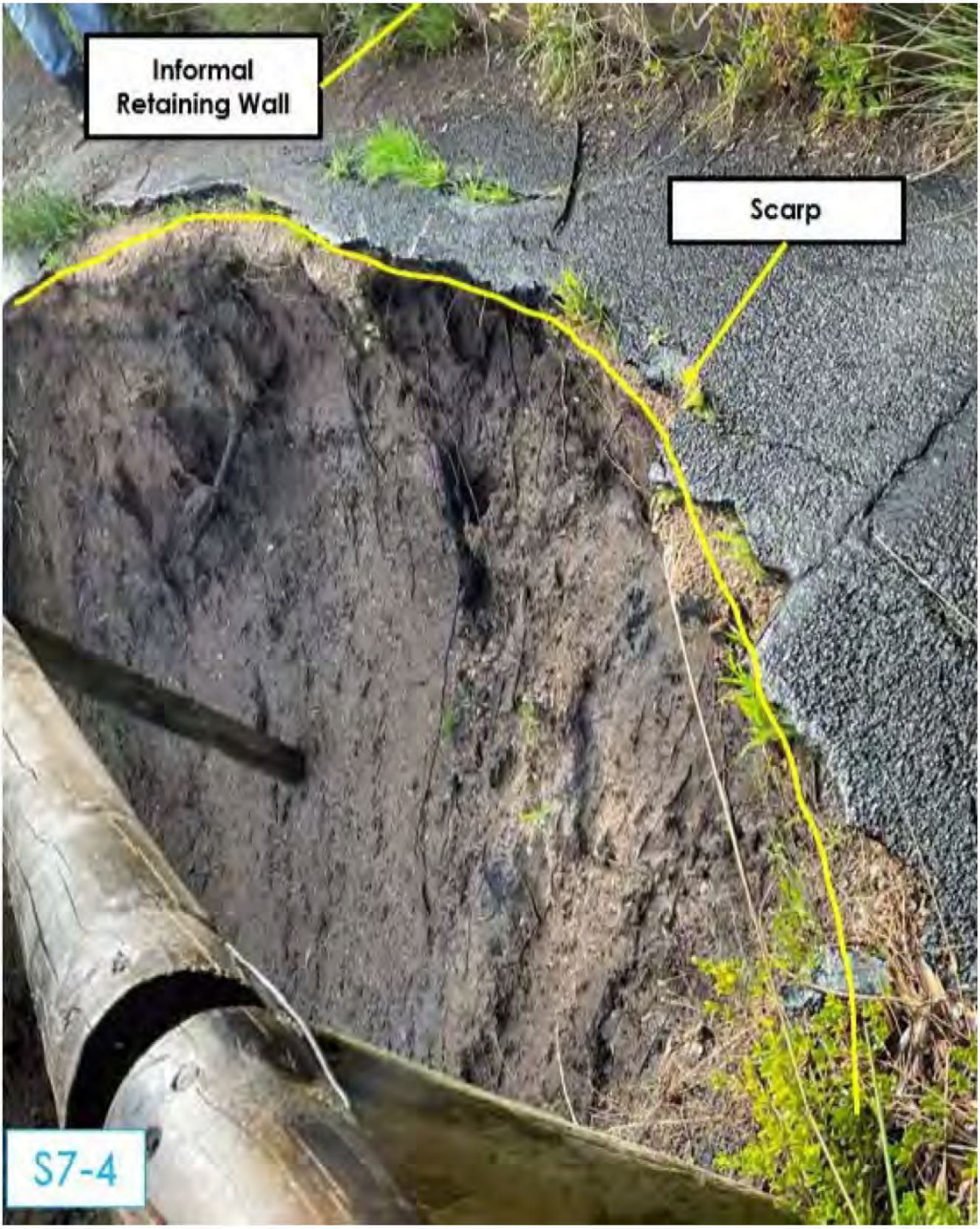
Photo description	S7-3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale



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Melbourne, Victoria 3000
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Photo description	S7 4		
Client	Morn ngton Pen nsu a Sh re		
Location	Morn ngton V C		
Project name	Be eura C ff Path		
Project No	304400705	**Scale**	Not to Sca e

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S8-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

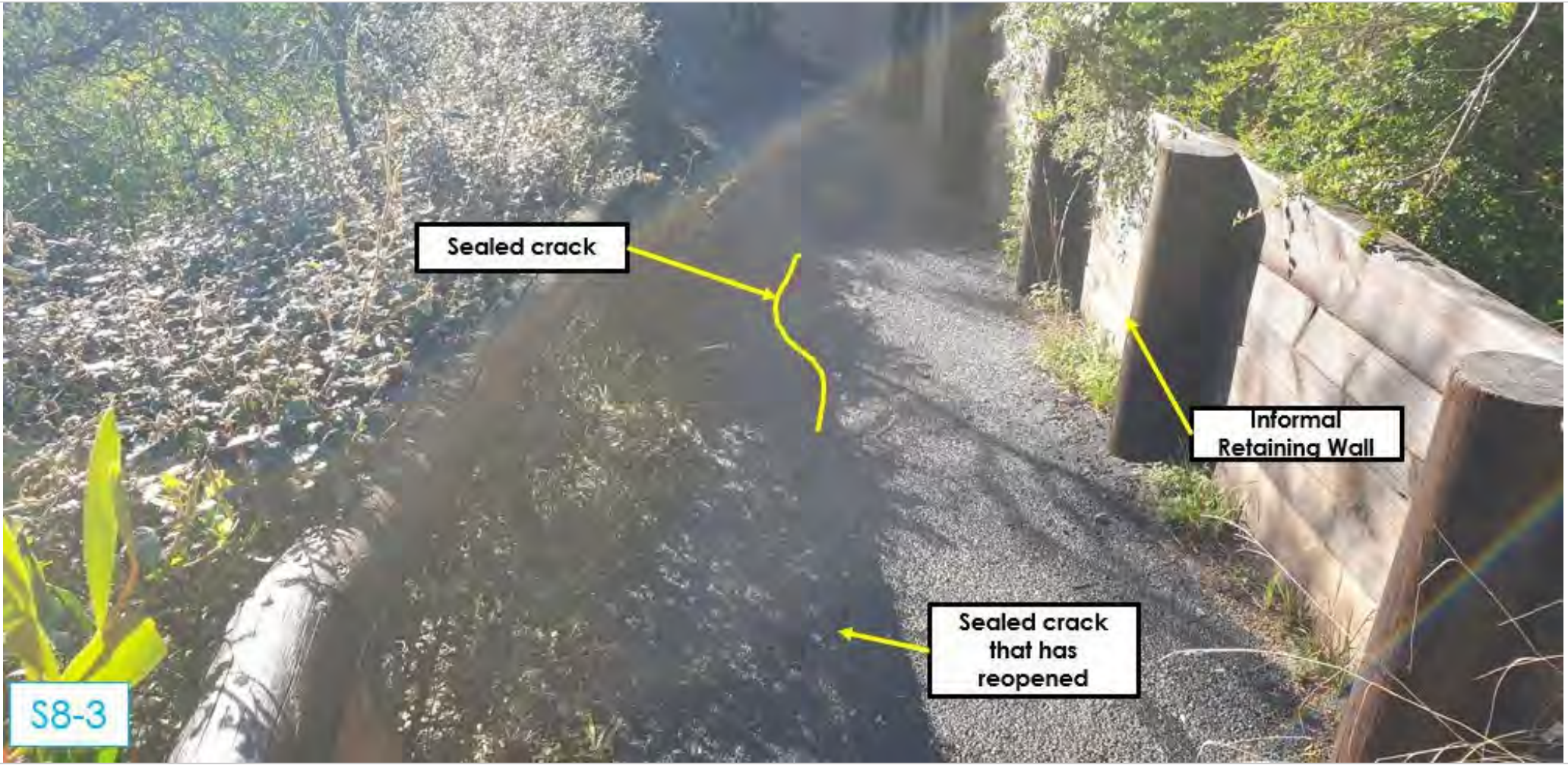
Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S8-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale



Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S8-3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S9-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S9-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

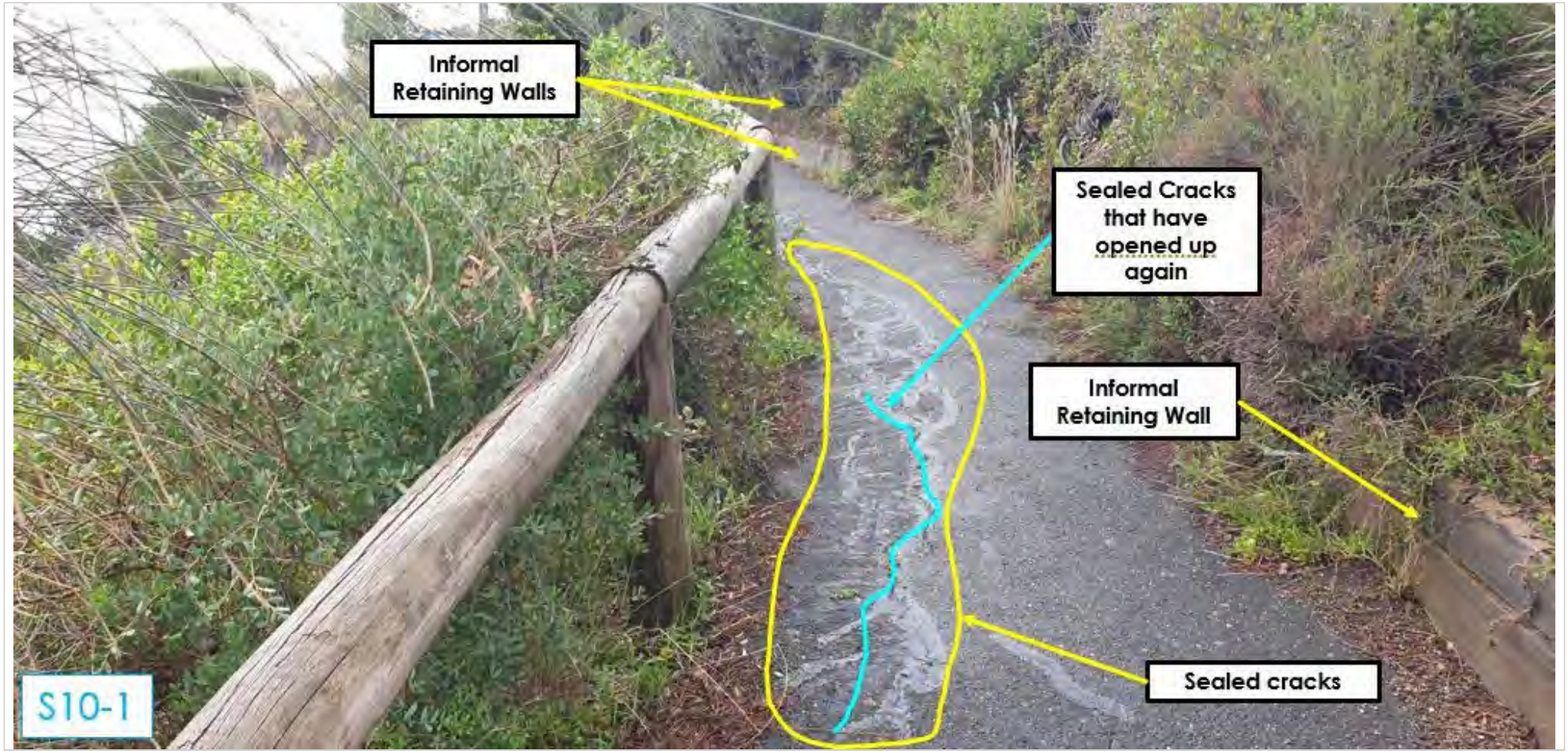
Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S9-3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale



Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S10-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S10-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S11-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

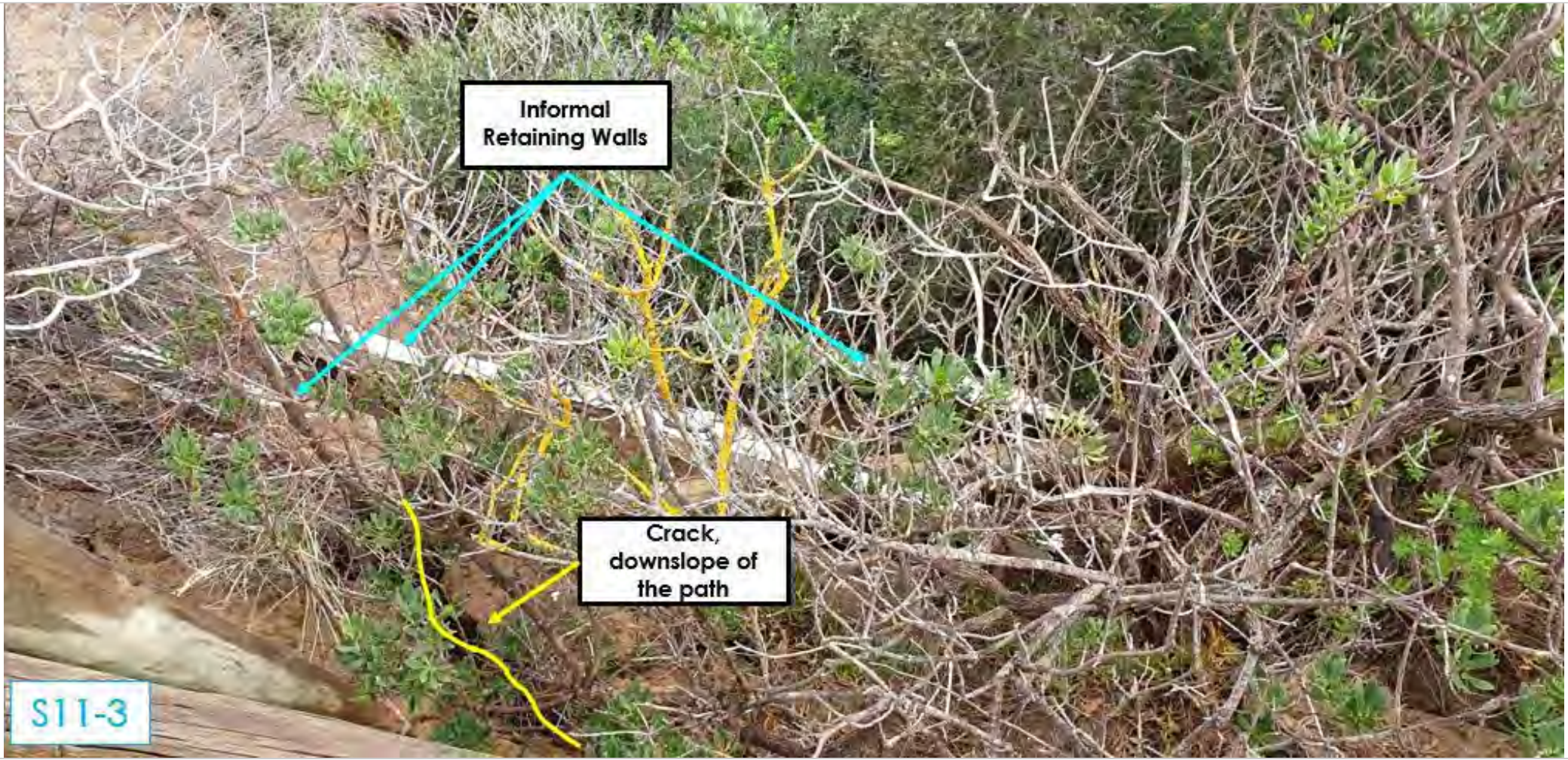
Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S11-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale



Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S11-3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S11-4		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S11-5		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S11-6		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S12-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S12-3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

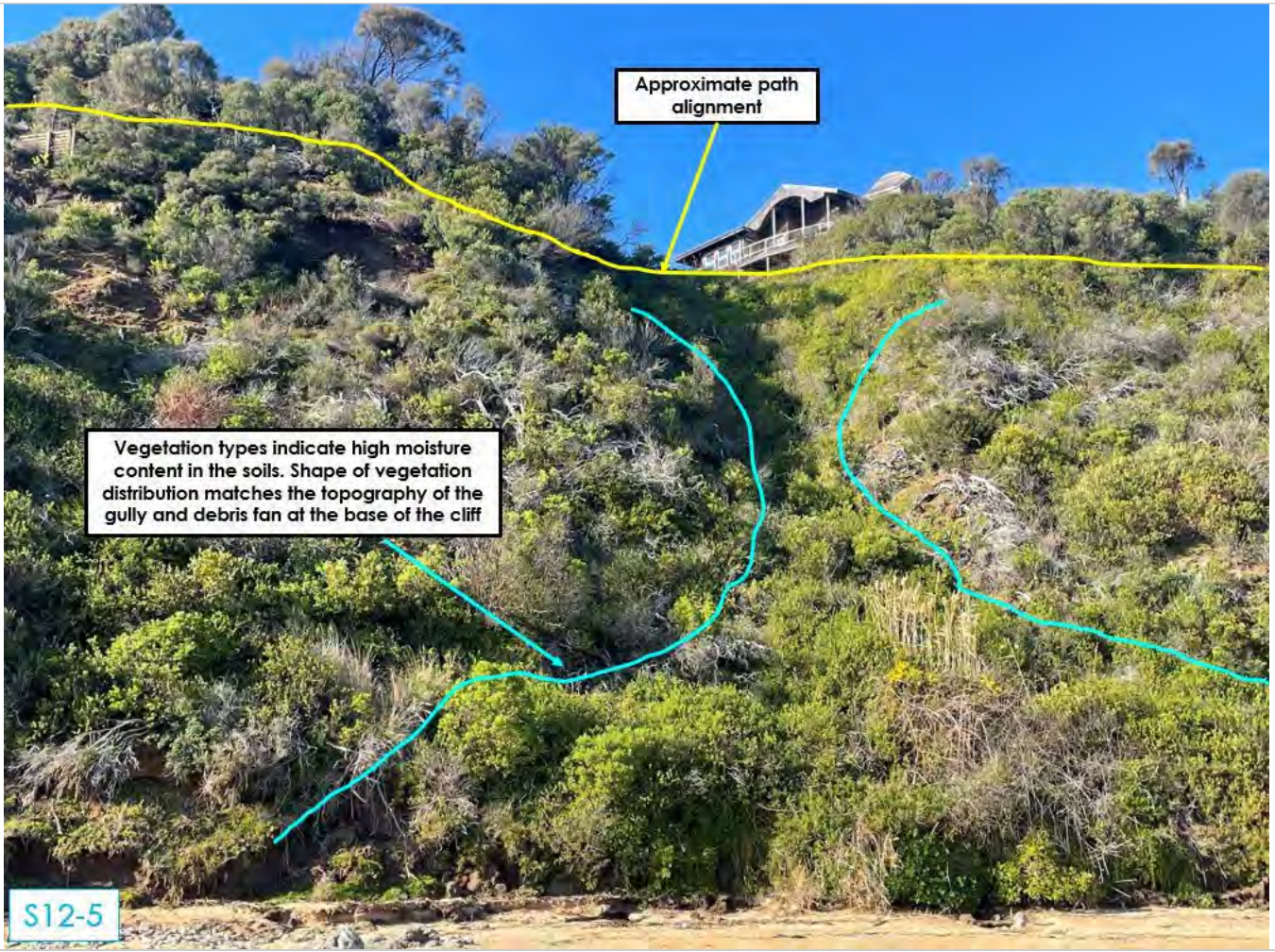
Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S12-4		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale



Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S12-5		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S13-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S14-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S14-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S16-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S17-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S17-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S18-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

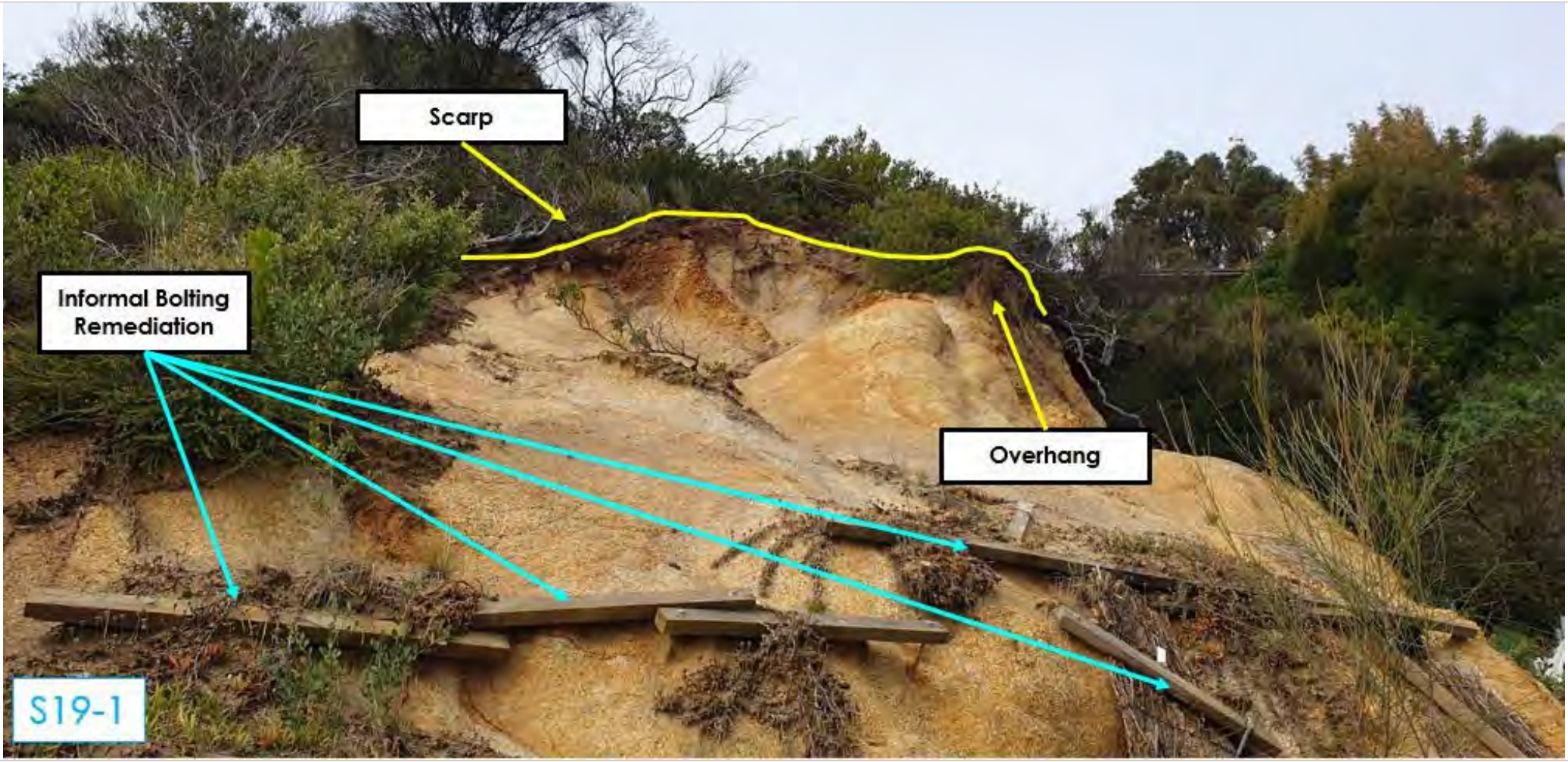
Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S18-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale



Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S19-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

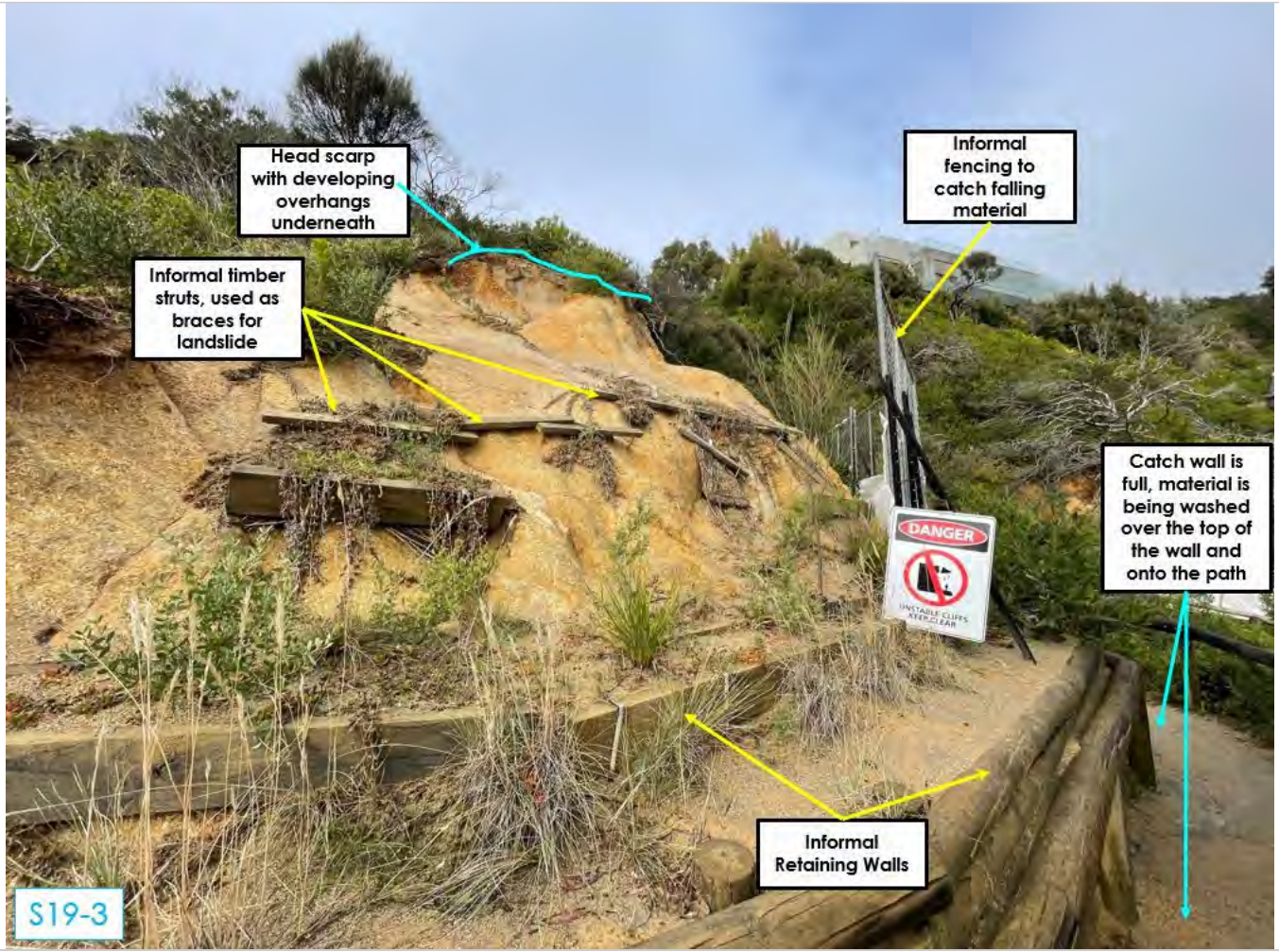
Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S19-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale



Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S19-3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

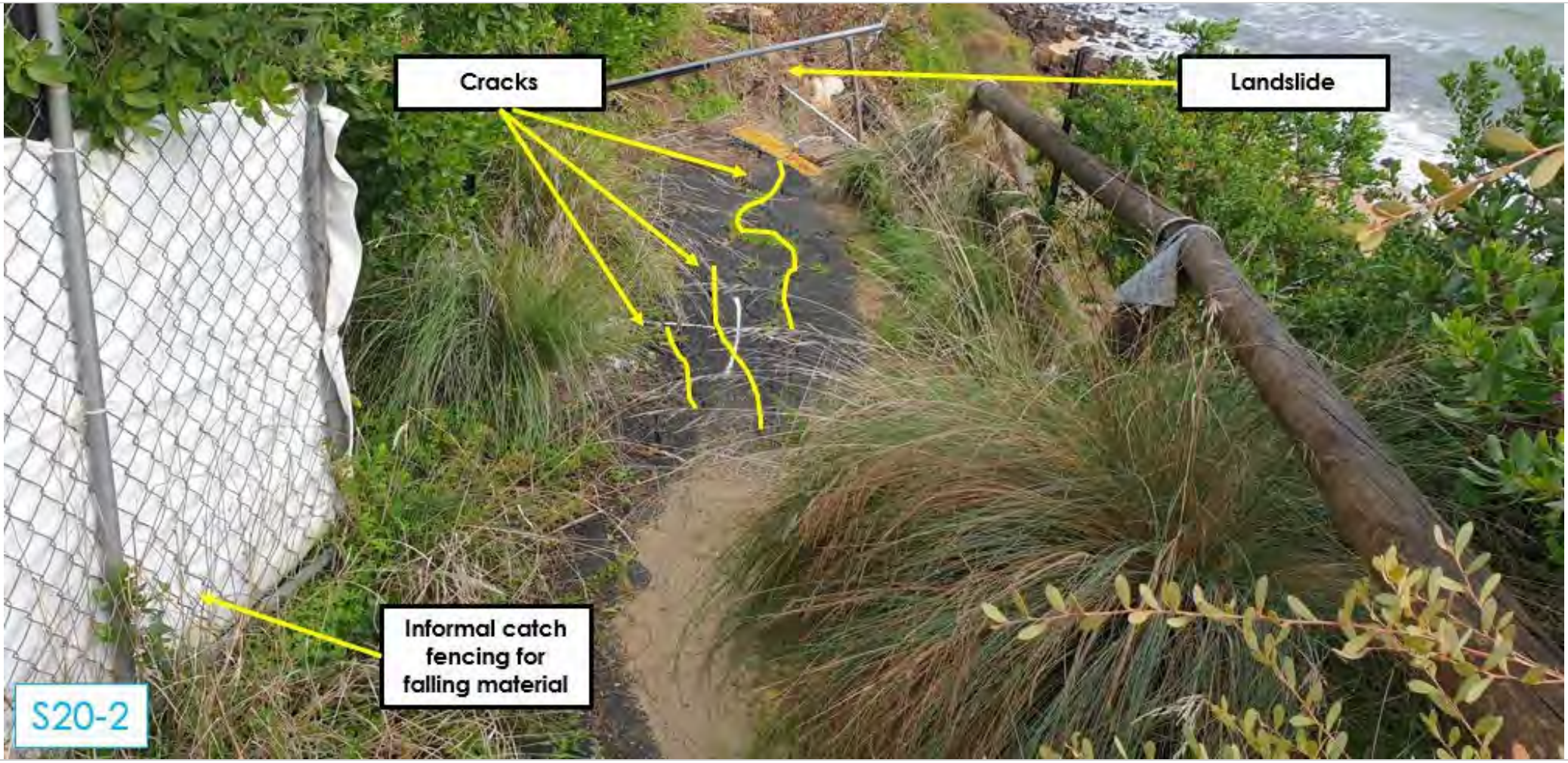
Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S20-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale



Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S20-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

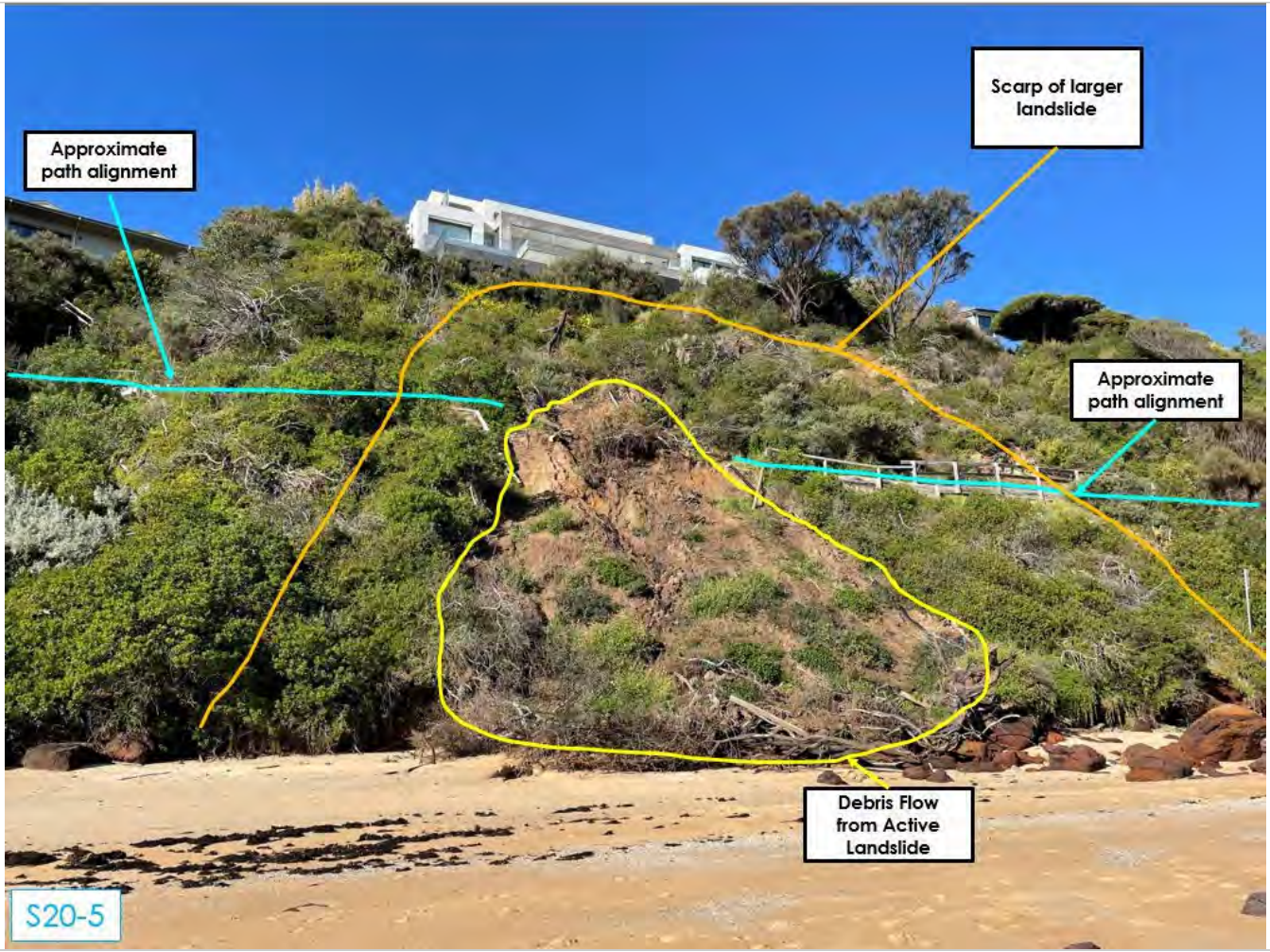
Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S20-3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec
(03) 8415 7777
Level 4, Swanston Street, Melbourne, Victoria 3000
BusinessServices.VIC@stantec.com

Photo description	S20 4		
Client	Morn ngton Pen nsu a Sh re		
Location	Morn ngton V C		
Project name	Be eura C ff Path		
Project No	304400705	**Scale**	Not to Sca e



Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S20-5		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S21-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S21-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S22-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S22-2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S22-3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S22-4		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S24-1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Appendix E – WATER OBSERVATIONS SITE PLAN

Site Plan
Water Observations

Beleura Cliff Path, Mornington, VIC

Project Code: 304400705-GS-015
Drawn By: [redacted] | Checked By: [redacted]
Figure No: 1A | Rev: 1
Date: 2023-10-17

Stantec

Legend

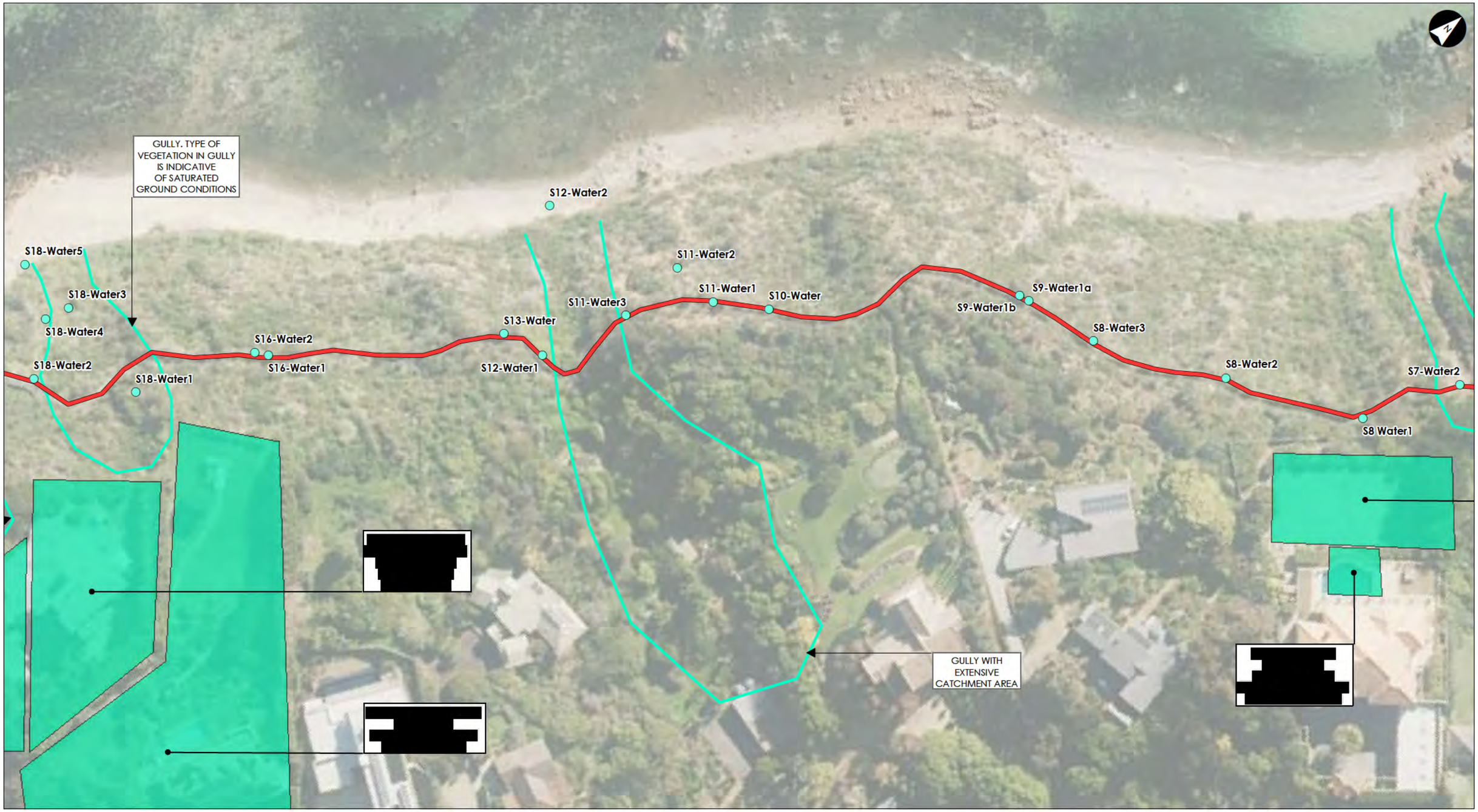
- Reported Water Observations
- Existing Path
- Water Observation (Line)
- Water Observation (Area)

Notes:
1. Coordinate System: GDA2020 MGA Zone 55

References:
1. Aerial Imagery Supplied by Metromap (July 2023)

0 20 40 Metres

Scale at A3 1 800



Site Plan
Water Observations

Beleura Cliff Path, Mornington, VIC

Project Code: 304400705-GS-015
Drawn By [redacted] | Checked [redacted]
Figure No: 1B | Rev: 1
Date: 2023-10-17

Stantec

Legend

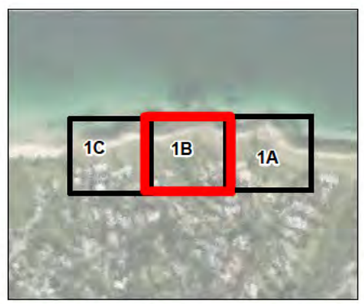
- Reported Water Observations
- Existing Path
- Water Observation (Line)
- Water Observation (Area)

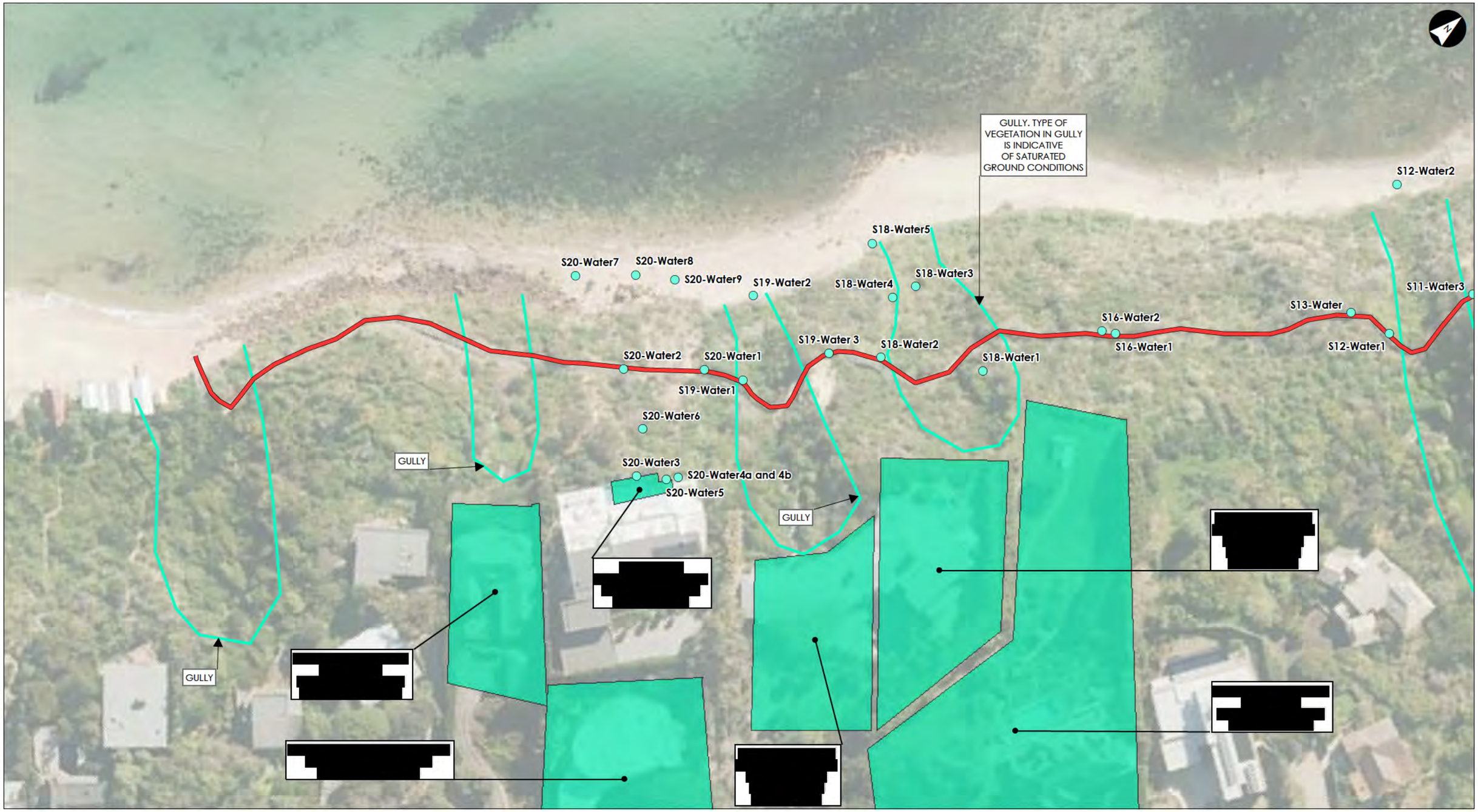
Notes:
1. Coordinate System: GDA2020 MGA Zone 55

References:
1. Aerial Imagery Supplied by Metromap (July 2023)

0 20 40 Metres

Scale at A3 1 800





Site Plan
Water Observations

Beleura Cliff Path, Mornington, VIC

Project Code: 304400705-GS-015
Drawn By: [redacted] | Checked By: [redacted]
Figure No: 1C | Rev: 1
Date: 2023-10-17

Legend

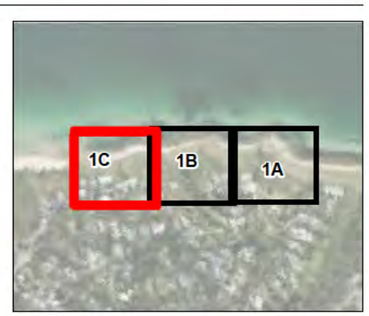
- Reported Water Observations
- Existing Path
- Water Observation (Line)
- Water Observation (Area)

Notes:
1. Coordinate System: GDA2020 MGA Zone 55

References:
1. Aerial Imagery Supplied by Metromap (July 2023)

0 20 40 Metres

Scale at A3 1 800



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Appendix F – WATER PHOTO OBSERVATIONS

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S7-Water 1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec
(03) 8415 7777
Level 4 Swanston Street
Melbourne Victoria 3000
BusinessServices.VIC@stantec.com

Photo description	S7 Water 2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S8-Water 1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S8-Water 2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S8-Water 3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S9-Water 1a		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S9-Water 1b		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S10-Water		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S11-Water 1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S11-Water 2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S11-Water 3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S12-Water 1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S12-Water 2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S13-Water		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S16-Water 1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S16-Water 2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S18-Water 1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S18-Water 2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

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Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S19-Water 1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S19-Water 2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S19-Water 3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
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Photo description	S20-Water 1		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

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Photo description	S20-Water 2		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

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Photo description	S20-Water 3		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
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Photo description	S20-Water 4a		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

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(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S20-Water 4b		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S20-Water 5		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S20-Water 6		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S20-Water 7		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
Melbourne, Victoria 3000

BusinessServices.VIC@stantec.com

Photo description	S20-Water 8		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Stantec

(03) 8415 7777

Level 4, Swanston Street,
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BusinessServices.VIC@stantec.com

Photo description	S20-Water 9		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Appendix G – LANDSLIDE RISK ASSESSMENT

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\,H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	Start of path. 2m upslope cut	Fill	Cut
Hazard	Section 1	Section 2	Section 3
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	1.0E-02	1.0E-02	1.0E-02
Length of Area at Risk (m)	44.60	14.60	14.90
Width of Area (m)	1.20	1.20	1.20
Width of Landslide (along area) (m)	2	2	1
Width of Area Affected (m)	1.20	1.20	1.00
$P_{(S\,H)}$, Probability of Spatial Impact	4.5E-02	1.4E-01	5.6E-02
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	4.5E-02	1.5E-02	1.5E-02
$P_{(T\,S)}$, Temporal Spatial Probability	5.1E-06	1.7E-06	1.7E-06
Vulnerability $V_{(D\,T)}$	0.20000	0.20000	0.20000
$R_{(LOL)}$	4.6E-10	4.6E-10	1.9E-10
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	1.5E-10	1.5E-10	6.3E-11
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	5.6E-06	5.6E-06	2.3E-06
Number of People Per Group	1	1	1
F - N	5.6E-06	5.6E-06	2.3E-06
	Acceptable	Acceptable	Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\,H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	Fairly flat, cut	Adjacent to downslope slip. Current scarp approx 1.2m from downslope edge of path.	Around the lookout, fairly flat
Hazard	Section 4	Section 5	Section 6
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	1.0E-02	1.0E-01	1.0E-03
Length of Area at Risk (m)	28.00	29.00	23.20
Width of Area (m)	1.20	1.20	1.20
Width of Landslide (along area) (m)	3	15	3
Width of Area Affected (m)	1.20	1.20	1.20
$P_{(S\,H)}$, Probability of Spatial Impact	1.1E-01	5.2E-01	1.3E-01
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	2.8E-02	2.9E-02	2.3E-02
$P_{(T\,S)}$, Temporal Spatial Probability	3.2E-06	3.3E-06	2.6E-06
Vulnerability $V_{(D\,T)}$	0.20000	0.20000	0.20000
$R_{(LOL)}$	6.8E-10	3.4E-08	6.8E-11
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	2.3E-10	1.1E-08	2.3E-11
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	8.3E-06	4.2E-04	8.3E-07
Number of People Per Group	1	1	1
F - N	8.3E-06	4.2E-04	8.3E-07
	Acceptable	Tolerable	Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\ H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	Section affected by existing downslope slip	Path is upslope of a large historic landslide (pre PN records) scarp that runs nearly full length of section. Informal retaining walls upslope of path. Cracks in path observed A - reactivation of large landslide across most of this section.	Path is upslope of a large historic landslide (pre PN records) scarp that runs nearly full length of section. Informal retaining walls upslope of path. Cracks in path observed. B - Smaller sections within this length
Hazard	Section 7	Section 8a	Section 8b
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	1.0E+00	1.0E-03	1.0E-01
Length of Area at Risk (m)	36.60	86.30	86.30
Width of Area (m)	1.20	1.20	1.20
Width of Landslide (along area) (m)	15	70	5
Width of Area Affected (m)	1.20	1.20	0.30
$P_{(S\ H)}$, Probability of Spatial Impact	4.1E-01	8.1E-01	1.4E-02
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	3.7E-02	8.6E-02	8.6E-02
$P_{(T\ S)}$, Temporal Spatial Probability	4.2E-06	9.9E-06	9.9E-06
Vulnerability $V_{(D\ T)}$	0.20000	0.20000	0.10000
$R_{(LOL)}$	3.4E-07	1.6E-09	1.4E-09
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	1.1E-07	5.3E-10	4.8E-10
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	4.2E-03	1.9E-05	1.7E-05
Number of People Per Group	1	1	1
F - N	4.2E-03	1.9E-05	1.7E-05
	Not Tolerable	Tolerable	Tolerable

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\ H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	Fill embankment, cracking in path. Some upslope informal retaining walls	Section crossing historic landslide (pre PN records). Cracking in path that has been sealed. Path built on fill? A - Large landslide take out full path, triggered by extreme weather event, not seen in >100 years	Section crossing historic landslide (pre PN records). Cracking in path that has been sealed. Path built on fill? B - Small slide based on excess rainwater/drain water
Hazard	Section 9	Section 10a	Section 10b
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	1.0E-02	1.0E-03	1.0E-01
Length of Area at Risk (m)	42.70	33.40	33.40
Width of Area (m)	1.20	1.20	1.20
Width of Landslide (along area) (m)	5	25	5
Width of Area Affected (m)	0.60	1.20	0.60
$P_{(S\ H)}$, Probability of Spatial Impact	5.9E-02	7.5E-01	7.5E-02
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	4.3E-02	3.3E-02	3.3E-02
$P_{(T\ S)}$, Temporal Spatial Probability	4.9E-06	3.8E-06	3.8E-06
Vulnerability $V_{(D\ T)}$	0.10000	0.20000	0.10000
$R_{(LOL)}$	2.9E-10	5.7E-10	2.9E-09
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	9.5E-11	1.9E-10	9.5E-10
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	3.5E-06	6.9E-06	3.5E-05
Number of People Per Group	1	1	1
F - N	3.5E-06	6.9E-06	3.5E-05
	Acceptable	Acceptable	Tolerable

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\ H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	Multiple historic retaining walls downslope. Informal retaining wall upslope of path. Headscarp of landslide above path a - failure of headscarp onto path	Multiple historic retaining walls downslope. Informal retaining wall upslope of path. Headscarp of landslide above path b - failure of the slope upslope of retaining walls	Multiple historic retaining walls downslope. Informal retaining wall upslope of path. Headscarp of landslide above path c - Overall failure of the slope
Hazard	Section 11a	Section11b	Section 11c
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	1.0E-02	1.0E-02	1.0E-02
Length of Area at Risk (m)	30.00	30.00	30.00
Width of Area (m)	1.20	1.20	1.20
Width of Landslide (along area) (m)	10	5	25
Width of Area Affected (m)	1.20	1.20	1.20
$P_{(S\ H)}$, Probability of Spatial Impact	3.3E-01	1.7E-01	8.3E-01
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	3.0E-02	3.0E-02	3.0E-02
$P_{(T\ S)}$, Temporal Spatial Probability	3.4E-06	3.4E-06	3.4E-06
Vulnerability $V_{(D\ T)}$	0.50000	0.20000	0.20000
$R_{(LOL)}$	5.7E-09	1.1E-09	5.7E-09
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	1.9E-09	3.8E-10	1.9E-09
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	6.9E-05	1.4E-05	6.9E-05
Number of People Per Group	1	1	1
F - N	6.9E-05	1.4E-05	6.9E-05
	Tolerable	Tolerable	Tolerable

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\,H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	Section crossing saturated gully. Brighton Group ends at the border or sections 11 and 12 a - small failure around path	Section crossing saturated gully. Brighton Group ends at the border or sections 11 and 12 b - larger reactivation of debris flow/failure	Upslope catch wall next to path. Cracks in path. Convex section, built on fill, cracks approx 2/3rds of the way across the path (closer to upslope side than downslope side)
Hazard	Section 12a	Section 12b	Section 13
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	1.0E-01	1.0E-03	1.0E-03
Length of Area at Risk (m)	27.30	27.30	14.00
Width of Area (m)	0.60	1.20	1.20
Width of Landslide (along area) (m)	5	15	10
Width of Area Affected (m)	0.60	1.20	0.80
$P_{(S\,H)}$, Probability of Spatial Impact	1.8E-01	5.5E-01	4.8E-01
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	2.7E-02	2.7E-02	1.4E-02
$P_{(T\,S)}$, Temporal Spatial Probability	3.1E-06	3.1E-06	1.6E-06
Vulnerability $V_{(D\,T)}$	0.10000	0.20000	0.10000
$R_{(LOL)}$	5.7E-09	3.4E-10	7.6E-11
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	1.9E-09	1.1E-10	2.5E-11
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	6.9E-05	4.2E-06	9.3E-07
Number of People Per Group	1	1	1
F - N	6.9E-05	4.2E-06	9.3E-07
	Tolerable	Acceptable	Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\ H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	Upslope catch wall next to path. Cracks in path. Upslope head scarp identified. Section all in granite b1 - concave section - small failures	Upslope catch wall next to path. Cracks in path. Upslope head scarp identified. Section all in granite b2 - concave section - reactivation of larger scale landslide	Upslope catch wall next to path. Cracks in path. Upslope head scarp identified. Section all in granite c - convex section
Hazard	Section 14a	Section 14b	Section 15
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	1.0E-01	1.0E-02	1.0E-03
Length of Area at Risk (m)	23.70	23.70	8.00
Width of Area (m)	1.20	1.20	1.20
Width of Landslide (along area) (m)	5	20	5
Width of Area Affected (m)	0.60	1.20	0.60
$P_{(S\ H)}$, Probability of Spatial Impact	1.1E-01	8.4E-01	3.1E-01
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	2.4E-02	2.4E-02	8.0E-03
$P_{(T\ S)}$, Temporal Spatial Probability	2.7E-06	2.7E-06	9.1E-07
Vulnerability $V_{(D\ T)}$	0.10000	0.20000	0.10000
$R_{(LOL)}$	2.9E-09	4.6E-09	2.9E-11
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	9.5E-10	1.5E-09	9.5E-12
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	3.5E-05	5.6E-05	3.5E-07
Number of People Per Group	1	1	1
F - N	3.5E-05	5.6E-05	3.5E-07
	Tolerable	Tolerable	Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\,H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	Section upslope of a bowl feature. Informal downslope retaining walls	Section upslope of at least 2 scarps. Informal downslope retaining walls	Hump bridge. Crosses zone where previous slip has occurred (2003 and 2013)
Hazard	Section 16	Section 17	Section 18
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	1.0E-02	1.0E-02	2.0E-02
Length of Area at Risk (m)	17.40	11.70	31.90
Width of Area (m)	1.20	1.20	1.20
Width of Landslide (along area) (m)	12	11	19
Width of Area Affected (m)	1.20	1.20	1.20
$P_{(S\,H)}$, Probability of Spatial Impact	6.9E-01	9.4E-01	6.0E-01
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	1.7E-02	1.2E-02	3.2E-02
$P_{(T\,S)}$, Temporal Spatial Probability	2.0E-06	1.3E-06	3.6E-06
Vulnerability $V_{(D\,T)}$	0.20000	0.20000	0.20000
$R_{(LOL)}$	2.7E-09	2.5E-09	8.7E-09
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	9.1E-10	8.4E-10	2.9E-09
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	3.3E-05	3.1E-05	1.1E-04
Number of People Per Group	1	1	1
F - N	3.3E-05	3.1E-05	1.1E-04
	Tolerable	Tolerable	Tolerable

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\ H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	Section with upslope overhanging sections a - falls of smaller chunks	Section with upslope overhanging sections b - large chunk coming down without warning, 1m to 2m dia.	Landslide beneath infinity pool (23 Kalimna Drive) a1- reactivation of recent landslide - majority of material coming from upslope
Hazard	Section 19a	Section 19b	Section 20a1
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	3.0E+00	1.0E-01	1.0E+00
Length of Area at Risk (m)	35.60	35.60	26.40
Width of Area (m)	1.20	1.20	1.20
Width of Landslide (along area) (m)	0.5	1	12
Width of Area Affected (m)	0.20	1.20	1.20
$P_{(S\ H)}$, Probability of Spatial Impact	2.3E-03	2.8E-02	4.5E-01
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	3.6E-02	3.6E-02	2.6E-02
$P_{(T\ S)}$, Temporal Spatial Probability	4.1E-06	4.1E-06	3.0E-06
Vulnerability $V_{(D\ T)}$	1.00000	1.00000	0.50000
$R_{(LOL)}$	2.9E-08	1.1E-08	6.8E-07
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	9.5E-09	3.8E-09	2.3E-07
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	3.5E-04	1.4E-04	8.3E-03
Number of People Per Group	1	1	1
F - N	3.5E-04	1.4E-04	8.3E-03
	Tolerable	Tolerable	Not Tolerable

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\ H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	andslide beneath infinity pool (23 Kalimna Drive) a2 - Failure of recent headscarp onto the path	Landslide beneath infinity pool (23 Kalimna Drive) b - reactivation of big landslide - movement of material already on the slope, sliding, with the opportunity to 'ride' the material downslope	Historic scarp upslope of path / boardwalk. Slip in 2010
Hazard	Section 20a2	Section20b	Section 21
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	1.0E+00	2.0E-02	2.0E-02
Length of Area at Risk (m)	26.40	26.40	46.90
Width of Area (m)	1.20	1.20	1.20
Width of Landslide (along area) (m)	5	26.4	25
Width of Area Affected (m)	1.20	1.20	1.20
$P_{(S\ H)}$, Probability of Spatial Impact	1.9E-01	1.0E+00	5.3E-01
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	2.6E-02	2.6E-02	4.7E-02
$P_{(T\ S)}$, Temporal Spatial Probability	3.0E-06	3.0E-06	5.4E-06
Vulnerability $V_{(D\ T)}$	0.50000	0.20000	0.20000
$R_{(LOL)}$	2.9E-07	1.2E-08	1.1E-08
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	9.5E-08	4.0E-09	3.8E-09
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	3.5E-03	1.5E-04	1.4E-04
Number of People Per Group	1	1	1
F - N	3.5E-03	1.5E-04	1.4E-04
	Not Tolerable	Tolerable	Tolerable

Landslide Risk Assessment

Stantec Australia Pty Ltd

Beleura Cliff Path - Full Length

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S\,H)}.P_{(T:S)}.V_{(D:T)}$

Hazard Description	Section with straight cracks along centre of path - historic fill?	Relatively flat with little sign of distress / movement	Stairs to beach
Hazard	Section 22	Section 23	Section 24
Condition	Existing	Existing	Existing
Suggested Tolerable Limit[1]	1.0E-04	1.0E-04	1.0E-04
Annual Probability - $P_{(H)}$	1.0E-02	1.0E-02	5.0E-02
Length of Area at Risk (m)	25.10	14.80	12.90
Width of Area (m)	1.20	1.20	1.20
Width of Landslide (along area) (m)	10	5	5
Width of Area Affected (m)	0.60	0.60	1.20
$P_{(S\,H)}$, Probability of Spatial Impact	2.0E-01	1.7E-01	3.9E-01
Speed of Walker - s (km.hr)	1.00	1.00	1.00
Time in affected area - t (hr)	2.5E-02	1.5E-02	1.3E-02
$P_{(T\,S)}$, Temporal Spatial Probability	2.9E-06	1.7E-06	1.5E-06
Vulnerability $V_{(D\,T)}$	0.10000	0.10000	0.20000
$R_{(LOL)}$	5.7E-10	2.9E-10	5.7E-09
	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0
$AvR_{(LOL)}$	1.9E-10	9.5E-11	1.9E-09
Number of People/Groups per Day	100	100	100
Number of People/Groups per Year	36500	36500	36500
F - Annual Probability of Loss of Life	6.9E-06	3.5E-06	6.9E-05
Number of People Per Group	1	1	1
F - N	6.9E-06	3.5E-06	6.9E-05
	Acceptable	Acceptable	Tolerable

Appendix H – SOCIETAL RISK PLAN

Stantec

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Photo description	Societal Risk Plan		
Client	Mornington Peninsula Shire		
Location	Mornington VIC		
Project name	Beleura Cliff Path		
Project No	304400705	**Scale**	Not to Scale

Appendix I – SOCIETAL RISK TO LIFE CALCULATIONS

Societal Risk to Life – Combined over the Full Length of the Path (no remedial works)

Hazard / Section	Risk to Life (Societal Risk)	Risk to Life – Person NOT being Affected (Societal Risk)
1	5.6E-06	9.999944E-01
2	5.6E-06	9.999944E-01
3	2.3E-06	9.999977E-01
4	8.3E-06	9.999917E-01
5	4.2E-04	9.995834E-01
6	8.3E-07	9.999992E-01
7	4.2E-03	9.958420E-01
8a	1.9E-05	9.999806E-01
8b	1.7E-05	9.999826E-01
9	3.5E-06	9.999965E-01
10a	6.9E-06	9.999931E-01
10b	3.5E-05	9.999653E-01
11a	6.9E-05	9.999306E-01
11b	1.4E-05	9.999861E-01
11c	6.9E-05	9.999306E-01
12a	6.9E-05	9.999306E-01
12b	4.2E-06	9.999958E-01
13	9.3E-07	9.999991E-01
14a	3.5E-05	9.999653E-01
14b	5.6E-05	9.999444E-01
15	3.5E-07	9.999997E-01
16	3.3E-05	9.999667E-01
17	3.1E-05	9.999694E-01
18	1.1E-04	9.998945E-01
19a	3.5E-04	9.996528E-01
19b	1.4E-04	9.998611E-01
20a1	8.3E-03	9.917013E-01
20a2	3.5E-03	9.998533E-01
20b	1.5E-04	9.998533E-01
21	1.4E-04	9.998611E-01
22	6.9E-06	9.999931E-01
23	3.5E-06	9.999965E-01
24	6.9E-05	9.999306E-01
Combined probability of none of the hazards occurring		9.857425E-01
Combined probability of one of the hazards occurring		1.425750E-02
Risk to Life is Acceptable		
Risk to Life is Tolerable		
Risk to Life is Not Tolerable		

Societal Risk to Life – Combined over the Full Length of the Path (Rerouting around Area A and fully engineered solution for Area B)

Hazard / Section	Risk to Life (Societal Risk)	Comments
1	9.999944E-01	
2	9.999944E-01	
3	9.999977E-01	
4	9.999917E-01	
5	9.999900E-01	Rerouting of the path further from the cliff to avoid these sections.
6	9.999992E-01	
7	9.999900E-01	
8a	9.999806E-01	
8b	9.999826E-01	
9	9.999965E-01	
10a	9.999931E-01	
10b	9.999653E-01	
11a	9.999306E-01	
11b	9.999861E-01	
11c	9.999306E-01	
12a	9.999306E-01	
12b	9.999958E-01	
13	9.999991E-01	
14a	9.999653E-01	
14b	9.999444E-01	
15	9.999997E-01	
16	9.999667E-01	
17	9.999694E-01	
18	9.998945E-01	
19a	9.999900E-01	Implementation of an engineered solution that avoids this area.
19b	9.999900E-01	
20a1	9.999900E-01	
20a2	9.999900E-01	
20b	9.999900E-01	
21	9.998611E-01	
22	9.999931E-01	
23	9.999965E-01	
24	9.999861E-01	
Combined probability of none of the hazards occurring	9.999861E-01	
Combined probability of one of the hazards occurring	8.147839E-04	'Tolerable'
Risk to Life is Acceptable		
Risk to Life is Tolerable		
Risk to Life is Not Tolerable		

Societal Risk to Life – Combined over the Full Length of the Path (Rerouting around Area A and improved drainage (probability <1 in 50) solution for Area B)

Hazard / Section	Risk to Life (Societal Risk)	Comments
1	9.999944E-01	
2	9.999944E-01	
3	9.999977E-01	
4	9.999917E-01	
5	9.999900E-01	Rerouting of the path further from the cliff to avoid these sections.
6	9.999992E-01	
7	9.999900E-01	
8a	9.999806E-01	
8b	9.999826E-01	
9	9.999965E-01	
10a	9.999931E-01	
10b	9.999653E-01	
11a	9.999306E-01	
11b	9.999861E-01	
11c	9.999306E-01	
12a	9.999306E-01	
12b	9.999958E-01	
13	9.999991E-01	
14a	9.999653E-01	
14b	9.999444E-01	
15	9.999997E-01	
16	9.999667E-01	
17	9.999694E-01	
18	9.998945E-01	
19a	9.999900E-01	Implementation of an engineering solution to prevent falls from the current overhangs.
19b	9.999900E-01	
20a1	9.998340E-01	Implementation of an improved drainage scheme to reduce the probability of the hazard occurring to 1 in 50 years.
20a2	9.999307E-01	
20b	9.999927E-01	
21	9.998611E-01	
22	9.999931E-01	
23	9.999965E-01	
24	9.999861E-01	
Combined probability of none of the hazards occurring	9.990320E-01	
Combined probability of one of the hazards occurring	9.679679E-04	'Tolerable'

Risk to Life is Acceptable

Risk to Life is Tolerable

Risk to Life is Not Tolerable

Sections where Risk to Life (Societal Risk) has been reduced to 1.0E-05

Sections where Risk to Life (Societal Risk) has been reduced by decreasing the annual probability of the hazard occurring to 1 in 50 years through improved drainage.

Appendix J – LIMITATIONS OF REPORT

LIMITATIONS OF GEOTECHNICAL REPORTS

The purpose of this report is to provide a geotechnical assessment of the sites examined. The information provided herein will reduce the exposure to risks, but no geotechnical assessment can eliminate them. Nonetheless, even a rigorous assessment may fail to detect all of the geotechnical conditions on a site. Site variations may have occurred in areas not investigated or sampled.

This geotechnical report should not be used when the nature of the proposed site usage changes, when the size, layout, or location of the development is modified, when the site ownership changes nor should it be applied to a nearby area. No environmental assessment has been undertaken nor is implied.

This site geotechnical assessment identifies actual subsurface conditions where the samples were taken and at the time they were taken. Any soil tests completed, were carried out in Stantec's NATA accredited soil laboratory. Geotechnical engineers then interpreted the laboratory results and field data and rendered an opinion about the overall subsurface conditions, including the soil type, extent of the soil layers, and their likely impact on the proposed development, with a discussion of the implications considered likely. The actual conditions may differ from the inferred conditions, as no person (no matter how qualified) or even the most detailed subsurface investigation can predict with confidence what may be hidden by soil or water or may have altered with time. Often the interface between different geotechnical areas may be more abrupt or gradual than anticipated. The actual conditions in an area may differ from those predicted.

Site assessments are limited by time, and natural processes such as erosion, or mankind altering the ground conditions, including the site levels or filled areas, may affect a site assessment. This geotechnical assessment is prepared in response to a client's specific requirements. No person other than the client should apply the report without first conferring with Stantec.

Costly problems can occur if the report is misinterpreted. To avoid these problems, Stantec should be retained to work with the appropriate design professionals and to review the adequacy of their plans and specifications relative to the geotechnical matters.

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Finally, geotechnical reports are based extensively on opinion and judgment and are less exact than other sciences. The report may contain a number of explanatory clauses or limitations on the results to inform the client about the restrictions of the report. These clauses are not meant to be exculpatory clauses to foist liability onto another person, but to identify where Stantec's and the client's responsibilities start and finish. Their use is to clarify where individual responsibilities lie and to allow the individual to take appropriate actions.

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