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GG070-24_GA

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Geotechnical Assessment Report
46A York Terrace, Bilgola Plateau, NSW 2107

1. INTRODUCTION

At the request of Mr. Danny [redacted] on behalf of Structability Consulting Engineers (the Client), Groundzero Geo Pty Ltd (GG) carried out a Geotechnical Assessment (GA) at 46A York Terrace, Bilgola Plateau, NSW 2107. This geotechnical assessment was carried out to allow:

- Inspect and investigate soil and rock conditions exposed over a very steep, terraced slope after a localised landslide caused by the recent heavy rain events, which structurally damaged a raised timber deck and timber pathways along with a mortared stone retaining wall located adjacent to the east side of Lower Ground Floor (LGF) level over a very steep slope, and
- Provide recommendations for reinstatement/replacement of the completely damaged timber deck and retaining structures to ensure safety/stability of the slope face and the other building structures located over upper level of the very steep slope.

The geotechnical assessment has been carried out as requested by the Client.

The purpose of this assessment was to:

- Carry out a detailed geotechnical assessment to record the geological conditions of the in-situ soils and the underlying bedrock over a very steep, terraced slope (after the landslide) extending down to the eastern site boundary,

- Identify the root causes of the landslide causing failure of the existing raised, timber deck, timber pathways and a stone retaining walls and any/all contributing factors, such as storm, drainage issues and general ground movements,

- Identify if the upper-level of the raised timber deck and the existing building structures located over the upper section of this very steeply dipping slope, have suffered any damage and/or are at any immediate risk of damage due to collapse of the retaining walls,

- Provide a detailed scope of works and methodology to manage the failed fill/colluvial soils and the damaged timber deck and retaining wall which may slide down over the slope, and impact the neighbouring structures located over the lower section of the eastern slope, as an immediate course of action, ensuring the proposed scope of the stabilisation works can be performed by applicable contractors in a safe working manner, and

- Provide any risk management system required to be implemented to avoid any further damage to the existing building structures located over the eastern slope and address any other safety concerns.

Based on above mentioned assessment, prepare a geotechnical assessment report providing recommendations with regards to:

- The requirements for implementation of any suitable support measures in the form of reinstatement/replacement of the damaged/collapsed timber deck and the retaining wall and to ensure safety/stability of the slope face and hence stability of the existing site house.

- The relevant design parameters for implementation of support measures to ensure safety and stability of the eastern slope face and the existing building structures.

Following Scope of Work (SoW) and a design drawing provided by the client were used for preparation of this GA report:

> "Detailed instruction for the specialist to follow: Geo tech engineer – Confirm immediate make safe sow for the ground area at the front of the property. Confirm causation of soil slippage at the property. Confirm condition of ground that now remains at the affected soil area to front of property. Confirm depth of rock at the affected area of soil. Provide full remediation SOW for the soil affected area at the property. Confirm main dwelling is safe from collapse."

- Footing Plan and Details for Proposed Remedial Works, 46A York terrace, Bilgola Plateau, prepared and certified by Jack Hodgson Consultants Pty Ltd, Consulting Civil, Geotechnical and Structural Engineers, Job No.: 27599, Drawing No.: S1, Dated: 14 June 2011, as shown below in **Plate 1**:

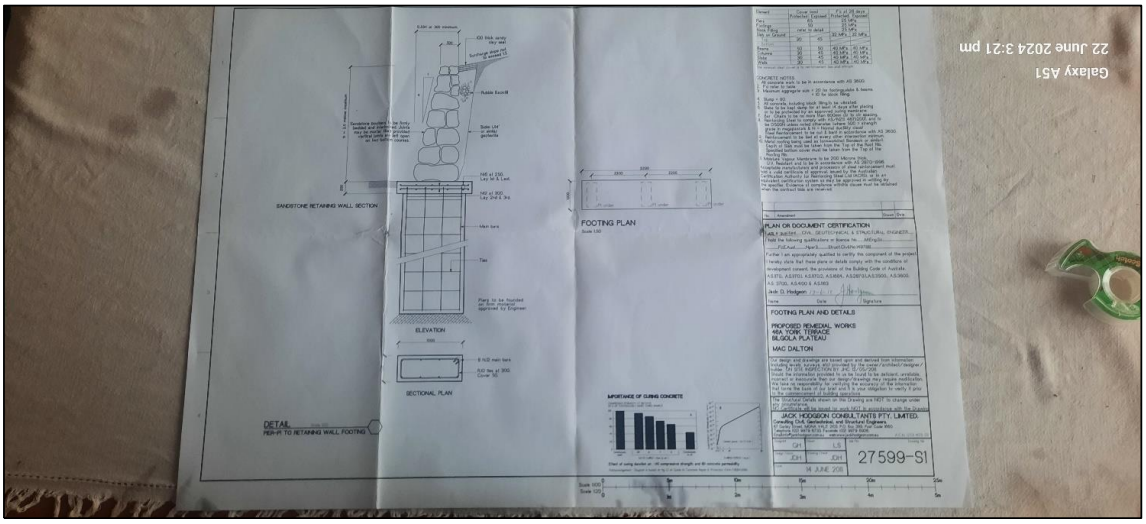


Plate 1: A snapshot of Footing Plan and Details, No. 27599-S1.

- A review of the above-mentioned footing plan revealed that the following recommendation was provided for piers supporting the sandstone retaining wall:

  "**Piers to be founded on firm material approved by Engineer**".

  - <u>It is to be noted that the piers meant to support a retaining wall, constructed over a very steep slope, were not recommended to be founded and embedded into bedrock of at least Low to Medium strength, to provide sufficient lateral support against sliding over a very steeply dipping slope face</u>.

  - <u>Also, no allowable bearing capacity was recommended for "**Firm**" material</u>.

1.1 BACKGROUND

The client requested GG via an email to carry out a geotechnical assessment after a localised landslide failure which completely damaged a raised timber deck and the associated timber pathways along with a mortared stone retaining wall located adjacent to the east side of LGF level over a very steep slope.

Based on communications with the client, the landslide failure occurred due to the recent heavy rains, causing structural damages to a raised timber deck, timber pathways and a stone retaining wall constructed over the lower half of a terraced, very steep slope, adjacent to the eastern side of LGF level, while the sliding fill/colluvial soils were resting over the slope, potentially in an unstable condition. It appeared that the fill/colluvial soils retained by an inadequately designed retaining wall had slid down due to the uncontrolled surface water ingress into the fill/colluvial soils resting over a densely vegetated, very steep, terraced slope with no proper drainage measures to dissipate pore pressure build up within colluvial/fill soils.

A geotechnical assessment of the existing ground conditions is required:

- To recommend a suitable methodology for removal of the completely damaged timber deck, timber pathways and a collapsed retaining wall, and for the reinstatement/replacement of the damaged/collapsed structures to ensure safety/stability of the slope face and of the other building structures located over the upper levels of the slope.
- To design slope stabilization measures to ensure safety/stability of the slope face and the other building structures located over a very steep slope.

Reference to Pittwater Council's PLEP 2014 Geotechnical Risk Management Map (GTH_016), the site has been classified as being within the H1 (highest category) landslip hazard zone, as shown below in **Plate 2**. Therefore, the site requires a Geotechnical Landslip Risk Assessment to be conducted.

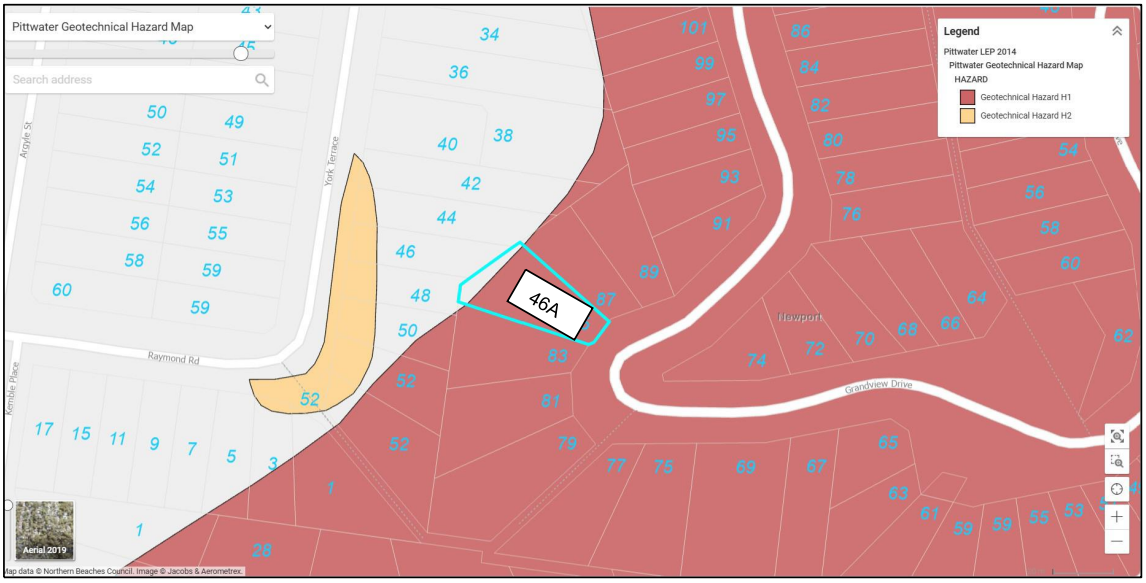


Plate 2: Geotechnical Risk Management Map (PLEP 2014) showing the site location.

1.2 Scope of Works

The scope of works for the GA included:

- Preparation of a Work Health and Safety Plan,
- Review of the relevant planning maps on NSW ePlanning and Northern Beaches Council Portals along with geological and topographical maps for the project area,
- A detailed Site walkover inspection and geological mapping by GG's Principal Engineering Geologist accompanied by the Client, to record the geological conditions of the in-situ soils and any exposed bedrock outcrops within the site area,
- Geotechnical assessment of the slope where landslide occurred causing structural damages to a raised timber deck, timber pathways and a stone retaining wall located at the front eastern side of the LGF level of the existing site house and design of the temporary and the permanent slope stabilisation measures required to mitigate the immediate and the long-term slope instability issues,
- Dynamic Cone Penetrometer (DCP) testing carried out at one location, adjacent to the damaged timber deck and the retaining wall located over the slope, to estimate the near surface soil conditions and confirm depth to top of the bedrock. Please note that further DCP testing could not be done due to over saturated slippery ground conditions over a very steep slope face. The termination depth encountered at DCP test location is tabulated below in **Table 1-1**:

- **Table 1 1 Summary of Termination/Refusal Depths in DCP Test**

Test No.	Location	Termination Depth (m, BEGL)	Comments
DCP1	East of LGF level at mid-slope level	2.92	Refusal on interpreted VLS bedrock

- Preparation of this letter report.

2. SITE OBSERVATIONS

Following observations are made based on our site assessment on 22 June 2024:

- The project site is located on the lower east side of York Terrace, within very steep (<35°) east dipping topography. York Terrace is formed with a gently north dipping bitumen pavement, with low concrete gutter and kerb adjacent to the site. There were signs of excessive cracking or deformation within the road pavement that suggest creeping movement within the road base due to underlying geotechnical issues. The project site is a pentangular shaped block, located adjacent to the rear eastern boundary of property No. 46 York Terrace, occupied by a split level-level cladded residential dwelling, constructed over a terraced slope, located within the upper half of the block, with raised timber decks located adjacent to the east side of the upper and lower ground floor levels. An aerial view of the site is shown below in **Plate 3**.

Plate 3: Aerial view of the site (provided by the Owner).

- A steep, concrete paved driveway extending downslope along the southern site boundary of property No. 46 York Terrace, provides access from street level to a car parking area located adjacent to the eastern site boundary (of No. 46) and to a single lock-up garage located at the south-western corner of property No. 46, as shown below in **Plates 4 and 5**.

Plate 4: Driveway leading to properties Nos. 46 and 46A York terrace, Bilgola Plateau, looking east.

Plate 5: Lock-up garage for No. 46A, looking south.

- Through the rear eastern site boundary of No. 46, there is an access door leading to a timber pathway and stone paved stairway stepping down to a stone paved patio located at the upper south-western corner of the project site (No. 46A), as shown below in **Plates 6 and 7**.

Plate 6: Access door through rear eastern boundary of No. 46, leading to No. 46A, looking east.

Plate 7: Timber pathway leading down to stone paved patio of project site looking east.

- The stone paved patio located at the south-western corner of the upper floor level leads to a raised timber deck level located adjacent to the eastern side of the upper floor level where the main house entrance is located (upper floor level) located, as shown below in **Plates 8 and 9**.

Plate 8: Stone paved patio leading to raised timber deck at upper floor level, looking east.

Plate 9: Raised timber deck located to east of upper floor level, looking north.

- The upper floor level of the existing site house is built over a terraced area excavated into the hill slope and is bounded by stone paved pathways and mortared stone retaining walls along the north, west and south sides, as shown below in **Plates 10 to 12**. Those stone walls are generally in good condition with minor cracks along the mortared joints.

Plate 10: Stone paved pathway and stone wall along northern side of upper floor level, looking west.

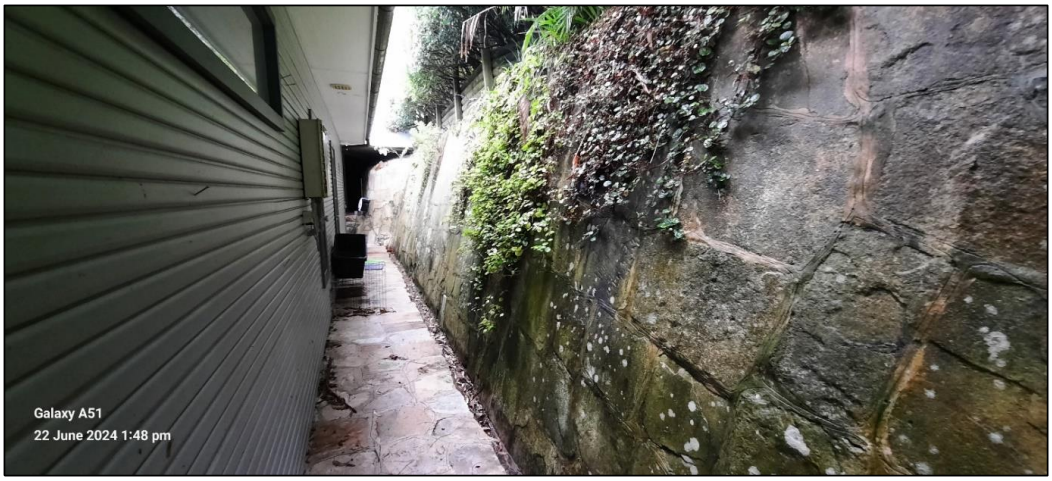


Plate 11: Stone paved pathway and stone wall along western side of upper floor level, looking south.

Plate 12: Stone paved pathway and stairway/stone wall along southern side of upper floor level, looking east.

- As observed within the subfloor cavity, the upper floor level is supported by mortared brick strip and column footings, as shown below in **Plate 13**. The founding conditions of those footing could not be observed during this inspection. Also, the subfloor area at the upper floor level did not appear to be well drained.

Plate 13: Strip and column footings supporting the upper floor level, looking south.

- As observed from inside of the LGF level, the timber deck and the timber pathways located within the densely vegetated, lower half of the site, have been completely damaged by the landslide, as shown below in **Plates 14 and 15**.

Plate 14: Timber deck (northern half) and pathway destroyed by landslide, looking north.

Plate 15: Timber pathway (southern half) destroyed by landslide, looking east.

- From the northern end of the upper-level timber deck, there is a flight of timber stairs and stone paved and timber stairways winding down over a very steep slope providing access to the completely damaged timber deck at the LGF level and to the densely vegetated, landscaped areas located at the lower levels of the eastern slope face, as shown below in **Plates 16 to 19**.

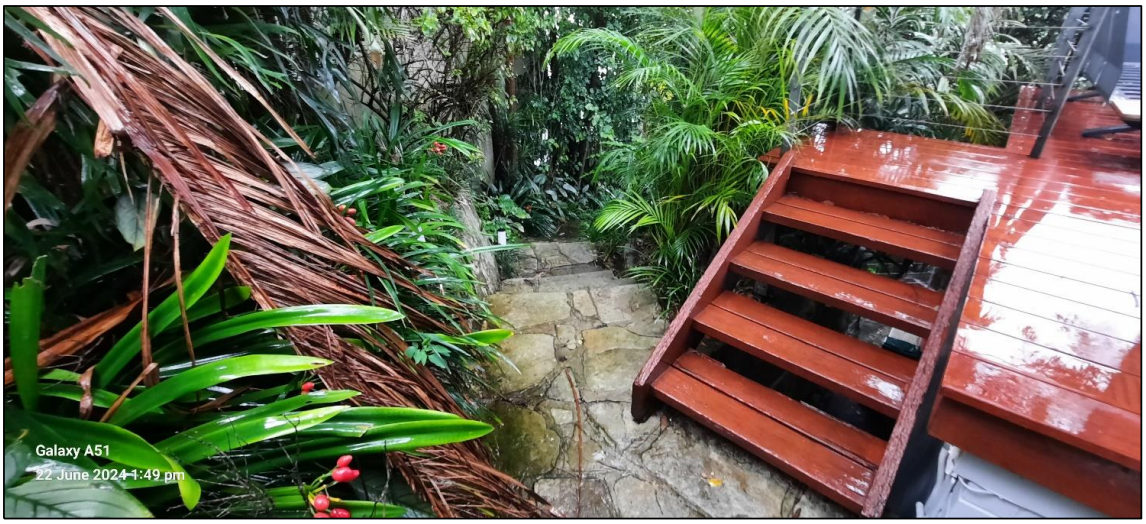


Plate 16: Timber pathway and stone stairs leading downslope over eastern slope, looking east.

Plate 17: Stone stairs providing access to northern end of timber deck at LGF level, looking south-west.

Plate 18: Stone paved pathway adjacent to northern end of timber deck at LGF level, looking south.

Plate 19: Displaced timber deck at LGF level, looking south.

- Further downslope to the east side, there are curved flights of stone and timber stairways leading downslope to the densely vegetated, landscaped, very steep eastern slope face, as shown below in **Plates 20 and 21**.

Plate 20: Stone stairs leading downslope over eastern slope, looking east.

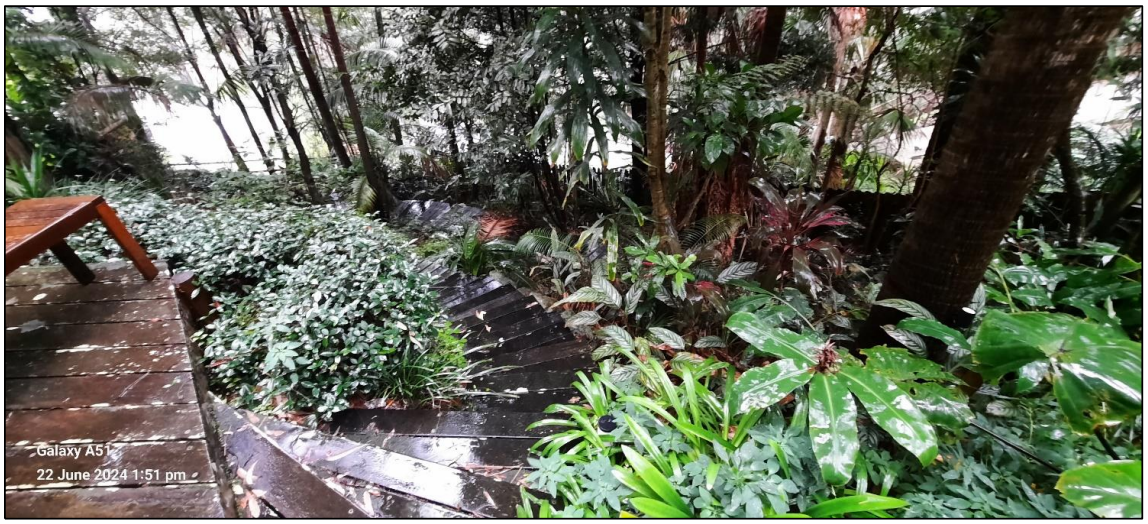


Plate 21: Timber stairs leading downslope to eastern site boundary, looking east.

- There are raised garden beds, retained by mortared stone walls, located over the steeply east dipping slope face adjacent to the eastern side of the timber deck at the LGF level, as shown below in **Plate 22**.

Plate 22: Garden beds retained by stone walls, adjacent to timber deck at LGF level, looking south-west.

- The mortared stone wall located immediately adjacent to the eastern edge of the timber deck at LGF, retaining the colluvial soils resting over the very steep slope, underneath the deck where timber post footings were supported by the concrete piles founded in colluvial soils, was completely damaged by the landslide, as shown below in **Plates 23 and 24**.

Plate 23: Completely failed stone wall, adjacent to eastern edge of timber deck at LGF level, looking north.

Plate 24: Timber post footings supported by concrete piles founded in colluvial soils, looking north.

- As per onsite discussion with owner of the property, a localised landslide failure from an unprotected colluvial slope (located immediately adjacent to the eastern edge of LGF level) occurred in the month of April 2024, during a heavy rain event which completely damaged the timber deck at the LGF level and the stone retaining wall, and the sliding debris, uprooted trees and cobbles got piled over the eastern slope face. As observed over the exposed sections of the scarred, very steeply dipping eastern slope face, the cover of colluvial soils appeared to be ≥3.00m thick which was overly saturated due to surface runoff ingress and fully penetrated by vegetation roots, underlain by weathered sandstone bedrock. Some loose boulders and pockets of colluvial soils can be seen perched precariously over the scarred slope which may slide down without any warning during wet weather conditions, as shown below in **Plates 25 and 26**.

Plate 25: Landslide extending to the eastern edge of LGF level, looking west.

Plate 26: Saturated colluvium and boulders exposed underneath timber deck at LGF level, looking north-east.

- Since the landslide extended to the eastern edge of the LGF level i.e. the existing building structure was located within the zone of influence of the landslide, therefore the conditions of the existing footings supporting the LGF level were inspected which were discovered to be undermined, founded on colluvium and contained significant cracks extending along mortared brick joint, as shown below in **Plates 27 to 29**.

Plate 27: Undermined concrete pad of brick strip footing supporting LGF level, looking north-west.

Plate 28: Concrete pad of brick strip footing founded on colluvium, looking west.

Plate 29: Cracks within brick strip footing, looking west

- Dynamic Cone Penetrometer (DCP) testing carried out at one location, adjacent to the damaged timber deck and the retaining wall located over the slope, to estimate the near surface soil conditions and confirm depth to top of the bedrock, in accordance with AS1289.6.3.2 – 1997, "Determination of the penetration resistance of a soil – 9kg Dynamic Cone Penetrometer" to estimate near surface soil conditions and confirm depths to bedrock. The refusal/termination depths encountered at DCP test locations are tabulated below in **Table 2-1**:

Table 2-1 Summary of Refusal/Termination Depth in DCP Tests

Test No.	Location	Termination Depth (m, BEGL)	Comments
DCP1	East of LGF level at mid-slope level	2.92	Refusal on interpreted VLS bedrock

The location of the DCP test is shown below on **Plate 30**, while the field test results are provided in **Appendix A**.

Plate 30: DCP1 test location, southern corner of concrete block, looking north-east.

3. REGIONAL GEOLOGY

Information on regional sub-surface conditions, referenced from the Sydney, Geological Series Sheet 1:100,000 9130 (1983), indicates the site is underlain by Hawkesbury Sandstone (Rh), typically comprised by medium to coarse grained quartz sandstone, very minor shale and laminite lenses. An extract for the site location is provided below in **Plate 31**:

Plate 31: Excerpt from regional geological map.

3.1 STRATIGRAPHY

Based on the inspection and assessment of the soil and bedrock outcrops over the site, the following stratigraphy was observed over the western slope face:

- **COLLUVIUM** – was observed over the western slope face exposed after sliding failure of colluvium. The colluvium is comprised of Clayey/Silty SAND with fine to coarse sandstone gravels, cobbles and boulders with rootlets; and
- **SANDSTONE BEDROCK** – Based on the inspection and visual assessment of the bedrock outcrops within the site area, it is characterised as slightly to moderately weathered, medium to thickly bedded sandstone of Low Strength (LS) to Medium Strength (MS).
- Based on DCP test results, sandstone bedrock of at least Very Low Strength (VLS) was inferred to be encountered at a depth of approximately 2.92m (DCP1) below the existing ground surface, adjacent to the eastern edge of the LGF level.

4. COMMENTS AND CONCLUSIONS

Based on the results of the geotechnical assessment of the ground conditions exposed over the eastern slope face located adjacent to the front eastern side of the LGF level of the existing site house (where landslide occurred), inspection of the footings supporting the existing building structures at the upper and lower ground floor levels and our site observations, it is concluded that:

- The saturated colluvium containing some loose boulders, lying over sections of the very steeply east dipping slope face after a localised landslide causing sliding of the colluvial soils triggered by heavy rain events (which completely damaged the timber deck and stone retaining wall at LGF level), is susceptible to erosion caused by uncontrolled stormwater water flows and at high risk of sliding as it is resting over a very steep slope face, further aided by root growth of vegetation over the slope.
- **Based on DCP testing adjacent to the damaged timber deck and the retaining wall located over the slope at LGF level, the depth to a minimum of Very Low Strength (VLS) sandstone bedrock is inferred to be encountered at a depth of approximately 2.92m (DCP1) below the existing ground surface, adjacent to the eastern edge of the LGF level.** This VLS bedrock is expected to grade quickly to Low Strength (LS) to Medium Strength (MS) bedrock which is outcropping within the site area.
- **Weathered Sandstone bedrock of very low strength is considered suitable for an Allowable Bearing Capacity of 800kPa.**
- It is interpreted that excessive surface water seepage due to uncontrolled surface water flows over and within the colluvium (of shallow thickness) has a major role in pore pressure build-up within the colluvial soils (and significant reduction in shear strength) due to the non-existent drainage measures which resulted in sliding of the colluvium along the very steeply dipping contact with the underlying sandstone bedrock of low to medium strength.
- The completely failed mortared stone wall located immediately adjacent to the eastern edge of the timber deck at LGF, that retained the colluvial soils resting over a very steep slope, underneath the deck where timber post footings were supported by the concrete piles founded in colluvium, appeared to be of non-engineered design and constructed without any drainage measures to prevent pore pressure build up within the colluvium being retained by this wall. **If the retaining wall had been designed adequately against sliding and overturning and designed as drained with measures provided for complete and permanent drainage to prevent pore pressure build up behind the wall then this wall would not have failed, therefore the principal cause of retaining wall failure is the defective retaining wall design**.
- It is interpreted that surface water ingress due to uncontrolled surface water flows within the colluvium resting over a very steep slope, caused a significant pore pressure build-up within the colluvial soils (and increase in lateral loads) due to the non-existent drainage measures behind/through the retaining wall which resulted in complete failure of the retaining wall and the raised timber deck at LGF level.
- Also, the presence of several shallow rooted trees and dense vegetation over the slope face is considered to be a significant factor to cause sliding of the cover of colluvial soils resting over a very steeply dipping slope, after saturation of the colluvium.
- The founding conditions of the mortared brick strip and column footings which support the existing building structure at the upper floor level, could not be inspected due to the access issue into the subfloor cavity. Also, the subfloor area at the upper floor level did not appear to be well drained. Although, the footings supporting the upper floor level were founded over a terraced/levelled area excavated into the hill slope (away from the crest of the slope), yet the in-situ ground conditions at the founding level of those footings need to be inspected to verify their bearing capacity and the in-situ nature of the founding strata.
- As the landslide extended right up to the eastern edge of the LGF level, meaning that the existing building structure was located within the Zone of Influence of the landslide. Also, the existing footings supporting the building structure at LGF level were found to be undermined, founded on colluvium and contained open cracks extending along mortared brick joints (as shown above in **Plates 27 to 29**). **Therefore, the existing site house is considered 'Unsafe" for occupancy, until the remedial measures recommended below in Section 5, are fully implemented**.

5. RECOMMENDATIONS

In view of the ground conditions exposed over the site area in general, particularly over the very steeply dipping eastern slope face located adjacent to the eastern edge of the LGF level, and due to the defective conditions of the existing footings supporting the LGF level building structure which was located within the Zone of Influence of the landslide, as explained above in **Section 4**, following slope stabilization/remedial measures are recommended for Client's consideration to ensure the stability of the eastern slope face and hence to ensure safety and stability of the existing site structures, on a "Short Term" and "Long Term" basis:

SHORT TERM STABILITY:

Following measures are recommended to be implemented immediately to prevent sliding of the colluvial soils and some boulders resting over sections of the very steeply dipping eastern slope face impacted by the recent landslide:

- **Temporary Underpinning of LGF Level** – Temporary steel props are recommended to be installed adjacent to all those brick column and strip wall footings supporting the LGF level building structure which appear to be undermined/founded on colluvium and contained open cracks. These steel props are meant to support the overlying building structures on a temporary basis, until the permanent support measures are installed.
- Removal of Colluvium from Eastern Slope – The damaged timber deck and the colluvial soils along with the damaged concrete pier footings resting over the eastern slope located adjacent to the eastern edge of the LGF level and underneath the damaged timber deck are being impacted by creeping movement within the colluvial soils, which is further aided by persistent surface runoff over the slope. The colluvium resting over the underlying sandstone bedrock could slide down due to uncontrolled stormwater flows over the slope face. Therefore, it needs to be removed as a first step to ensure safety of the workers and any plant and equipment to carry out ground preparation works to implement the required slope stabilisation measures over the eastern slope face.
- **Scaling/Cleaning Works** – After removal of the colluvium from the eastern slope face adjacent to and from underneath the timber deck, scaling/cleaning works over the entire slope face should be carried out as below scaling/cleaning works over the scarred section of the entire slope face should be carried out as below:
    - Removal of the topsoil, vegetation, colluvium and scaling of any loose boulders resting over the slope should be carried out to expose the underlying, in-situ sandstone bedrock.
    - **These scaling/cleaning works must be carried out by the experienced personnel, professionally trained, and certified for carrying out this type of activities over extremely difficult terrain**.

LONG TERM STABILITY (PERMANENT SOLUTION):

To ensure the long-term stability and safety of the eastern slope face located to the east of the LGF level of the existing site house and hence stability of the existing building structures, following support measures are recommended to be implemented in the following sequence:

- **Removal of Damaged Timber Deck/Pathway** – Since the timber post footings and the concrete piers supporting the raised timber deck, along with the stone retaining wall are completely damaged and the raised timber deck and the associated timber pathways are significantly displaced over the slope, it is recommended that the existing timber deck and pathways should be dismantled and removed to prevent their further sliding downslope.
- **Inspection of Existing Footings** – In view of a recommendation for supporting the sandstone retaining wall stating, "**Piers to be founded on firm material approved by Engineer**", provided on the Footing Plan and Details for Proposed Remedial Works, 46A York terrace, Bilgola Plateau, prepared and certified by Jack Hodgson Consultants Pty Ltd, Consulting Civil, Geotechnical and Structural Engineers, Job No.: 27599, Drawing No.: S1, Dated: 14 June 2011, the pier/column/strip footings supporting the existing building structures on the site are suspected to be founded at shallow depths into colluvium/fill soils, and not into the underlying bedrock for their stability against sliding. Therefore, it is strongly recommended that all the existing pier/column footings supporting the intact raised timber deck (at the upper level) and the Upper and

Lower Ground Floor Levels , be inspected by the experienced geotechnical and structural engineers to confirm their founding conditions, before replacement/underpinning of any insufficiently designed /damaged footings.

- **Construction of New Pier Footings** – After confirmation of the founding conditions of all the existing footings, particularly at the LGF level, the new footings are recommended to be designed by an experienced Structural Engineer and constructed as per following recommendations:

    - It is recommended that all new/replaced pier footings to support the existing site house (Upper and Lower Ground Floor Levels), along with the intact raised timber deck at the upper floor level and the new raised timber deck (at LGF level) must be socketed at least 0.50m into Low Strength (LS) to Medium Strength (MS) sandstone bedrock to provide sufficient lateral support against sliding over a very steeply dipping slope face.
    - LS-MS sandstone bedrock is considered suitable for an allowable bearing pressure of 1200kPa.

- **Construction of New Retaining Walls** – The new retaining walls must be designed by a qualified Structural Engineer and are recommended to be steel reinforced concrete wall constructed in accordance with Australian Standard AS 4678-2002 Earth Retaining Structures. The new retaining walls must be founded/doweled into the underlying bedrock for their long-term stability against sliding and overturning and designed as drained and measures are to be taken to provide complete and permanent drainage to prevent pore pressure build up behind the walls.

  Parameters for calculating pressures acting on retaining walls for the materials likely to be retained are provided below:

Material	Unit Weight (kN/m^3)	Long Term (Drained)	Earth Pressure Coefficients		Passive Earth Pressure Coefficient *
			Active (Ka)	At Rest (K_0)	
Natural soils	20	$\phi' = 30°$	0.33	0.50	N/A
VLS bedrock	22	$\phi' = 38°$	0.26	0.38	200 kPa

  Remarks:

    - In suggesting these parameters, it is assumed that the retaining walls will be fully drained with suitable subsoil drains provided at the rear of the wall footings. If this is not done, then the walls should be designed to support full hydrostatic pressure in addition to pressures due to the soil backfill. It is suggested that the retaining walls should be back filled with free-draining granular material (preferably not recycled concrete) which is only lightly compacted in order to minimize horizontal stresses.
    - Retaining structures near site boundaries or supporting existing structures should be designed with the use of at rest (K_0) earth pressure coefficients to reduce the risk of movement in the excavation support and resulting surface movement in adjoining areas. Backfilled retaining walls within the site, away from site boundaries or existing structures, that may deflect can utilize active earth pressure coefficients (Ka).

- After completion of the above-mentioned construction works, any of the excavated areas within the subfloor areas, are recommended to be backfilled with structural fill up to the required levels. Earthworks recommendations provided in this report should be complemented by reference to AS3798. Materials preferred for use as engineered fill are well-graded granular materials, such as ripped or crushed sandstone, free of deleterious substances and having a maximum particle size not exceeding 75 mm. such fill should be compacted in layers not greater than 200 mm loose thickness, to a minimum density of 98% of Standard Modified Dry Density (SMDD).

RECOMMENDED GEOTECHNICAL INSPECTIONS

Following geotechnical inspections (**Hold Point Inspections**) are recommended to be carried out during construction works to verify that the recommended remedial works are suitable for the in-situ ground conditions and are carried out as per GG recommendations:

- An inspection will be required after scaling works are completed for further assessment of the in-situ rock conditions and any defects within the rock mass.
- Geotechnical inspections of all new footings by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata of new footings.

6. MAINTENANCE AND INSPECTION

After implementation of the recommended slope stabilization measures for ensuring long term stability of the eastern slope face located adjacent to the front eastern side of the LGF level and of the existing site house, a maintenance and inspection program given below in **Table 1** should be implemented to ensure long term and satisfactory performance of the installed support measures:

Table 1: Recommended Maintenance and Inspection Program

STRUCTURE	MAINTENANCE/INSPECTION ITEM	FREQUENCY
Stormwater drains	Owner to inspect to ensure that the open drains and pipes are free of debris and sediment build-up. Clear surface grates and litter. Owner to check and flush retaining wall drainage pipes/systems.	Every year or following each major rainfall event.
Retaining walls, or remedial measures	Owner to inspect walls for deviation from as constructed conditions and repair/replace.	Every two years or following major rainfall event.
Large trees on or adjacent to site	Arborist to check conditions of trees and remove as required. Where trees are within steep slopes (>18^{o}) or adjacent to structures, requires geotechnical inspection prior to removal of trees.	Every five years
Slope Stability	Geotechnical Engineering Consultant to check on site stability and maintenance.	Five years after construction is completed

7. LIMITATIONS

This report has been prepared for the exclusive use of Structability Consulting Engineers who is the only intended beneficiary of GG's work. The scope of the inspections carried out for the purpose of this report is limited to those agreed with Structability Consulting Engineers (Mr. Danny [redacted]).

No other party should rely on the document without the prior written consent of GG, and GG undertakes no duty, or accepts any responsibility or liability, to any third party who purports to rely upon this document without GG's approval.

GG has used a degree of care and skill ordinarily exercised in similar investigations by reputable members of the geotechnical industry in Australia as at the date of this document. No other warranty, expressed or implied, is made or intended. Each section of this report must be read in conjunction with the whole of this report, including its appendices and attachments.

The conclusions presented in this report are based on a limited investigation of conditions, with specific sampling locations chosen to be as representative as possible under the given circumstances.

GG's professional opinions are reasonable and based on its professional judgment, experience, training and results from analytical data. GG may also have relied upon information provided by the Client and other third parties to prepare this document, some of which may not have been verified by GG.

GG's professional opinions contained in this document are subject to modification if additional information is obtained through further investigation, observations, or validation testing and analysis during remedial activities. In some cases, further testing and analysis may be required, which may result in a further report with different conclusions.

8. CLOSURE

Please do not hesitate to contact the undersigned should you have any questions.

For and on behalf of,

GROUNDZERO GEO PTY LTD

Author

[redacted]

Shahzada [redacted]
Principal Engineering Geologist
MAIG, Member AUSIMM

ATTACHMENTS: APPENDIX A – Filed Test Results

Important Information

Appendix A – Field Test Results

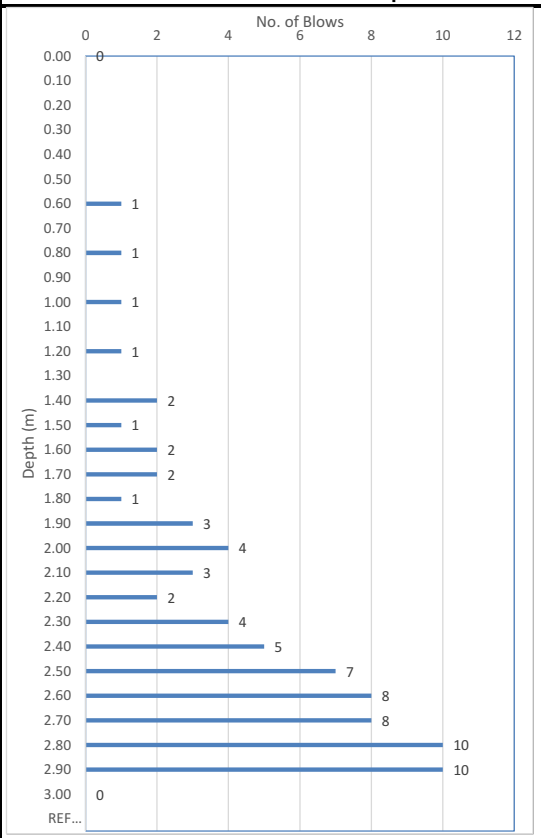
GroundzeroGeo

DYNAMIC PENETROMETER TEST SHEET

CLIENT:	Structability Consulting Engineers	**DATE:**	22/06/2024
PROJECT:	Geotchnical Site Investiagtion	**PROJECT No.:**	GG070-24
LOCATION:	46A York Terrace, Bilgola Plateau	**SHEET:**	1 of 1

Depth (m)	Test Location
	DCP1
0.00	HW
0.10	
0.20	
0.30	
0.40	
0.50	
0.60	1
0.70	
0.80	1
0.90	
1.00	1
1.10	
1.20	1
1.30	
1.40	2
1.50	1
1.60	2
1.70	2
1.80	1
1.90	3
2.00	4
2.10	3
2.20	2
2.30	4
2.40	5
2.50	7
2.60	8
2.70	8
2.80	10
2.90	10
3.00	20mm/8 (B)
REF @2.92m depth on VLS Bedrock	

Penetration vs Depth



TEST METHOD: AS 1289. F3.2, DYNAMIC CONE PENETROMETER

REMARKS:

HW	Hammer weight
(B)	Test hammer bouncing upon refusal on solid object
--	No test undertaken at this level due to prior excavation of soils

Important Information

SCOPE OF SERVICES

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client and Groundzero Geo Pty Ltd ("GG"). The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

RELIANCE ON DATA

GG has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. GG has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, GG will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented, or otherwise not fully disclosed to GG.

GEOTECHNICAL ENGINEERING

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g., a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

LIMITATIONS OF SITE INVESTIGATION

The investigation programme undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation programme and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies. The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. GG should be kept appraised of any such events and should be consulted to determine if any additional tests are necessary.

VERIFICATION OF SITE CONDITIONS

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that GG be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience, and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

REPORTS

This report is the property of Groundzero Geo Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal.

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The report has been prepared for the benefit of the Client and no other party. GG assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of GG or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

OTHER LIMITATIONS

GG will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.