Attachment AV

Assessment of the Stability of the Batter Faces of the Former Quarry

ACT Geotechnical Engineers Pty Ltd
ACN 063 673 530

5/9 Beaconsfield St, Fyshwick, ACT, 2609
PO Box 9225, Deakin, ACT, 2600
Ph: (02) 6285 1547 or 0404 064 858
E: jeremy.murray@actgeoeng.com.au

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Doma Group
via email: alex@domagroup.com.au

Attention: Mr Alex Moulis

CANBERRA BRICKWORKS REDEVELOPMENT - BLOCKS 1, 7, & 20, SECTION 102, YARRALUMLA
PROPOSED DWELLINGS - LOTS a to q

ASSESSMENT OF THE STABILITY OF THE BATTER FACES OF THE FORMER QUARRY

1 INTRODUCTION

At the request of Doma Group, ACT Geotechnical Engineers Pty Ltd carried out a assessment in the old quarry area of the Canberra Brickworks, in Yarralumla, ACT.

It is understood that the old Canberra Brickworks are being redeveloped into a residential development. As part of this redevelopment, some new dwellings will be constructed near the top edges of the batter faces of the former quarry. The aim of the assessment was to:

i) Inspect the quarry batter faces and areas near the top edges of the batters.
ii) Review existing geological information.
iii) Provide an assessment of the general stability of the batters.
iv) Provide an assessment of the impact on the stability of the batters due to surcharge loads of the proposed dwellings.
v) Provide advice on remediation to reduce the impact of the surcharge loads of the proposed dwellings.

2 SITE DESCRIPTION

The old Canberra Brickworks site is located on Block 1, Section 102, in Yarralumla, ACT. The eastern portion of the site was used as the quarry, where shale rock was excavated to make bricks, while the western portion of the site included the buildings and kilns used to make the bricks. A site plan showing the existing contours in the former quarry area, as well as the locations of the proposed dwellings are shown in Figure 1.

The natural topography of the eastern side of the site comprised a knoll, that was excavated down by up to 10m depth to source rock to make the bricks. The quarry is an irregular shape, as they chased seams of better brick-making rock. The quarry faces are generally near vertical, but appear to have weathered over time, with some soil and rock wedges that have fallen from the face and are now at the toe of the batters faces. There are trees along the top edges of the quarry faces, and some of the rock faces have become over-grown with vegetation. It is understood that rock was excavated from the quarry between 1913 and the mid-1930's.

3 GEOLOGY

The 1:100,000 Canberra Geology Map indicates the area to be underlain by Silurian age Yarralumla Formation bedrock, which includes siltstone, sandstone, mudstone, limestone, and tuffaceous sediments. A description of the Yarralumla Formation from "BMR Bulletin 233 - Geology of the Canberra 1:100,00 Sheet Area" is provided in the following section.

The Yarralumla Formation formation consists of an elastic sequence of calcareous and tuffaceous mudstone and siltstone with minor interbeds of limestone and quartz sandstone. Airfall tuff and a few rhyodacitic units were also deposited coevally with the marine sequence.

Exposed at the Canberra Brickworks locality are well-bedded, olive-green calcareous mudstone and siltstone with minor tuffaceous sandstone and dark-grey cherty limestone. The bedding is denoted by major partings, sometimes accentuated by fossiliferous horizons, spaced up to a few metres apart or on a smaller scale as laminations and graded tuffaceous units up to 2 cm thick. The sequence is folded into open symmetrical anticlines with a shallow plunge southwards.

A spaced, almost vertical cleavage is axial planar to the folds and also forms a well defined lineation where it intersects the bedding.

4 INVESTIGATION METHODS

The field investigation was carried out on 23 November 2022, by Mr Dennis Dyer, a senior engineering geologist with over 50 years experience, with assistance from Mr Jeremy Murray, a Chartered senior geotechnical engineer with over 20 years experience.

The fieldwork comprised a walk-over of the site to assess the general geological conditions, as well as a close inspection and geological mapping of the exposed quarry faces in the areas of proposed infilling.

The geological mapping included logging of the defect sets (bedding, cleavage/foliation, and jointing), logging of the rock type and weathering, and a close visual inspection of any signs of instability of the batters faces of the former quarry.

Detailed geological mapping of the exposed quarry faces was conducted at selected locations along the quarry faces, in areas where the new dwellings are proposed. A site plan showing the existing contours in the former quarry area, as well as the locations of the proposed dwellings are shown in Figure 1.

Photos 1 to 12 are presented in Figures 2 to 7, which show some of the quarry faces that were mapped, at the time of inspection.

A desk-top study of available geology maps and literature was also conducted, with geological information relevant to this site reviewed. These sources included the "1:100,000 Canberra Geology Map", "BMR Bulletin 233 - Geology of the Canberra 1:100,00 Sheet Area".

5 GEOLOGICAL MAPPING RESULTS

5.1 General Geological Assessment

The majority of the exposed quarry faces comprise weak to medium strong, highly weathered (HW) and moderately weathered (MW) phyllite bedrock. There were some sections of extremely weak, extremely weathered (EW) rock, as well as some sections of stronger, moderately to slightly weathered (MW/SW) rock. The phyllite is occasionally inter-bedded with sandstone, mudstone, siltstone, and tuff.

Phyllite is a type of foliated metamorphic rock created from slate (which itself has been metamorphosed from siltstone/mudstone) that is further metamorphosed so that very fine grained white mica achieves a preferred orientation (called a foliation or cleavage). It is primarily composed of quartz, sericite mica, and chlorite. The metamorphism has been caused by strong geological folding of the original sedimentary siltstone/mudstone bedrock.

The strong folding has resulted in the foliation/cleavage being a more prominent feature of the rock than the original bedding, and the stability of the batter faces is generally determined by the dip and dip direction of the foliation compared to the orientation of the cut quarry face.

5.2 Results of Geological Mapping

Results of the geological mapping of the exposed quarry faces are summarised in Table 1 below.

TABLE 1
Results of Geological Mapping

Dwelling No.	Description	Rock Profile	Defect Mapping	Photo No.
Lot q	~4m high cut	~3m of overburden fill, then MW/SW PHYLLITE	Foliation - 73°/260° 80mm to 500mm spacing Bedding- 38°/235° - 30mm to 300mm spacing	Photo 7.
Lot p	~2.5m high cut	MW/SW PHYLLITE	Foliation - 88°/260° 80mm to 500mm spacing Bedding- 39°/247° - 30mm to 300mm spacing	Photo 8.
Lot o	NA	NA	Dwelling set well back from the top edge of the existing quarry faces	
Lot n	~6m high cut	HW to HW/MW PHYLLITE	Foliation - 88°/062° 5mm to 70mm spacing Bedding- 42°/260° - 30mm to 70mm spacing Signs of rock wedge failures and erosion on both sides of the 'peninsula'.	Photos 9, 10, 11, and 12
Lot m	~3m high cut	Covered in vegetation	Covered in vegetation	Photo 6
Lot l	~4m high cut	HW/MW PHYLLITE	Foliation - 81°/102° 5mm to 70mm spacing Bedding- 42°/213° - 30mm to 70mm spacing Joints - 68°/146° - 10mm to 20mm spacing	
Lot k	~3m high cut	HW/MW PHYLLITE	Foliation of the bedrock is dipping into the excavation.	
Lot j	~4m high cut	Residual soil & EW, underlain by HW/MW PHYLLITE	Disturbed and weathered face. Several large boulders on face (from quarrying or wedge failures) and signs or erosion.	Photo 4 & 5
Lot i	~4m high cut	Residual soil & EW, underlain by HW/MW PHYLLITE	Disturbed and weathered face. Several large boulders on face (from quarrying or wedge failures) and signs or erosion.	Photo 3 & 5
Lot h	~4m high cut	Residual soil & EW, underlain by HW/MW PHYLLITE	Disturbed and weathered face. Several large boulders on face (from quarrying or wedge failures) and signs or erosion.	Photo 5
Lot g	NA	NA	Dwelling set well back from the top edge of the existing quarry faces	
Lot f	NA	NA	Dwelling set well back from the top edge of the existing quarry faces	
Lot e	~4m high cut	HW/MW PHYLLITE	Foliation - 50°/185° ~500mm spacing	Photo 2
Lot d	~4m high cut	HW/MW PHYLLITE	Foliation - 50°/180° ~500mm spacing	Photo 2
Lot c	~4m high cut	HW/MW PHYLLITE	Foliation - 50°/190° ~500mm spacing	Photo 1

It should be noted that the proposed Lots a and b (and part of c) will be formed by placing fill (possibly supported by a gabion wall), and there will be no exposed quarry batter face in this area.

6 CONCLUSIONS

6.1 General Stability Assessment

The cut batters of the former quarry are typically 3m to 6m deep, and comprise weak to medium strong phyllite bedrock. The batters faces have been formed by excavation, and are quite steep (between 45° and vertical), and were formed during the quarrying operations between 1913 and the mid-1930's.

The batter faces have been exposed to the weather for a long time period (between 90 and 100 years), and show some signs of deterioration. This includes erosion of the batter faces in areas where the rock is more-weathered, and some isolated rock wedge failures. However, even given the long time exposure, the batters have remained in a stable condition.

Therefore, it is our assessment that the batter faces of the former quarry are stable at their present batter angles. However, erosion will continue to occur, and small rock wedges will fall from the batter faces from time to time. There is only minor erosion, as the batter faces have generally exposed bedrock, so future erosion is not expected to be a significant concern. Future rock wedge failures are only expected to occur where the orientation of the cut batter faces is unfavourable to the dip and dip direction of the foliation or jointing of the bedrock.

Where the proposed dwellings or swimming pools are in close proximity to the top edge of the cut batter faces, the additional surcharge will increase the risk of instability. It is assessed that any dwellings/pools that are less than 1(H):1(V) back from the top edge of the cut batter face is increasing the risk of instability (dwellings/pools that are not sect back from the top edge of the batter at least by the same distance as the depth of the cut batter at that location).

Therefore, it is assessed that dwellings and/or pools at Lots k to n, and Lots c to e are potentially surcharging the top edge of the batter faces and could increase the risk of instability.

5.2 Mitigation Measures

It is recommended that the set backs are increased for any pools or dwellings that are not set back from the top edge of the batter at least by the same distance as the depth of the cut batter at that location. This recommendation applies to Lots k to n, and Lots c to e.

Where pools or dwellings cannot be set back, then these structures must be founded on deep bored piers that are socketed into the weathered bedrock. The depth of pier socket into the bedrock will depend on the set back to the top edge of the cut batter and the depth of the cut at that location.

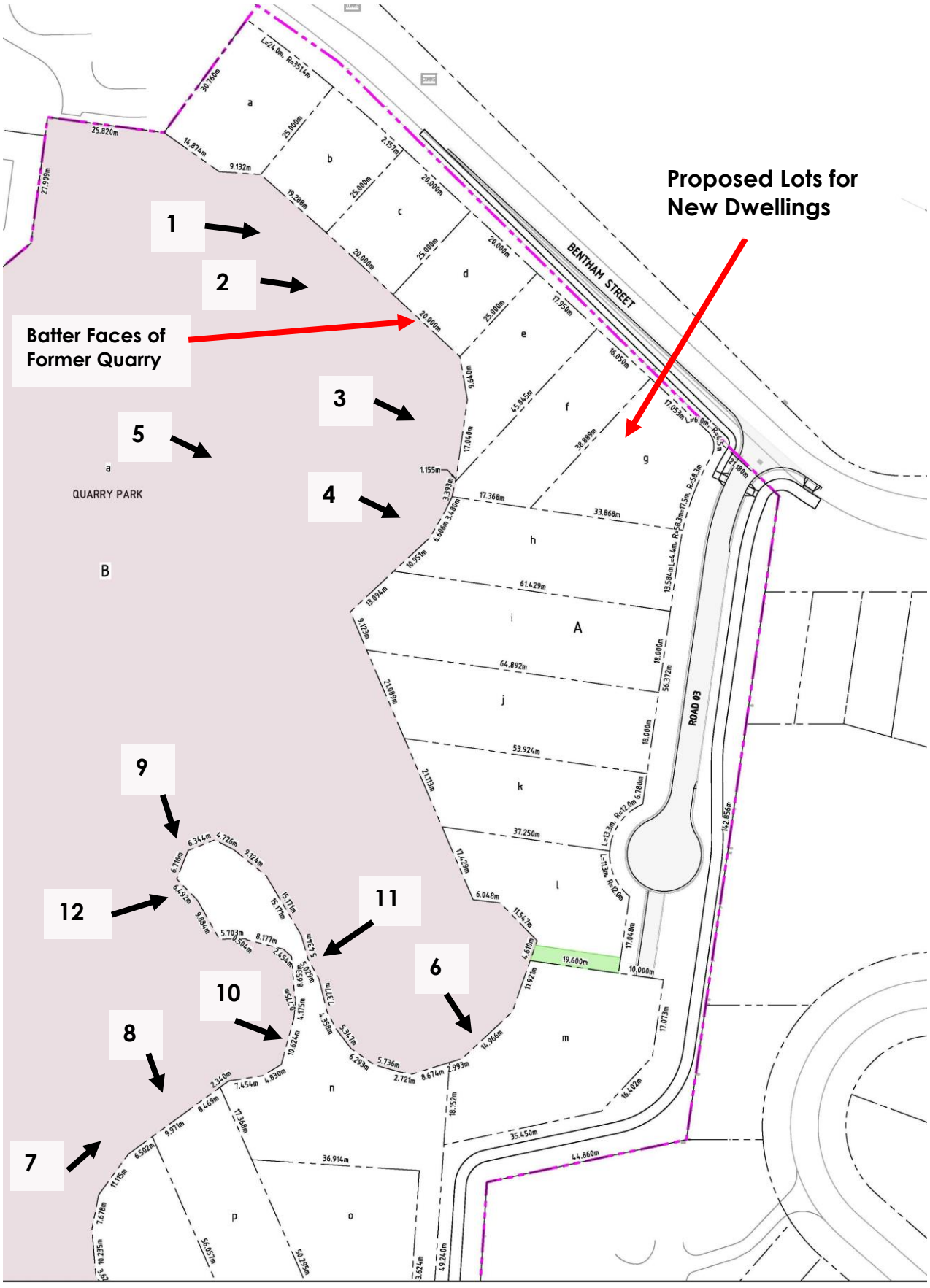
It has been indicated that the quarry faces are heritage listed, and stabilisation of the batters cannot be undertaken. Therefore, stabilisation measures to prevent future rock wedge failures such rock bolting and shotcreting are not possible.

Erosion control mats and other erosion protection measures are also not permissable. However, it has been indicated that some earthworks will be carried out, including the removal of some trees from the top edges of the batters and from the batter faces themselves. It is recommened that during these works, all loose material is removed from the batter faces to reduce the risk of future rock wedge failure. Where possible, vegetation should be used to cover soil batter faces to reduce the risk of future erosion.

Surface drainage must be provided to ensure that rainfall run-off is diverted away from all exposed batter faces. All pools and retaining walls must also be positively drained.

Yours faithfully
ACT Geotechnical Engineers Pty Ltd

Jeremy Murray
Director - Senior Geotechnical Engineer
FIEAust CPEng EngExec RPEQ NER APEC Engineer IntPE (Aust)



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CANBERRA BRIOCKWORKS REDEVELOPMENT- QUARRY FACE STABILITY

SITE PLAN

ACT Geotechnical Engineers Pty Ltd	C11596.2	FIGURE 1

Photo 1 – 23/11/22 - View of the quarry faces looking towards Lots c and d.

Photo 2 – 23/11/22 - View of the batter faces looking towards Lots d and e. The exposed face is along foliation planes, with signs of past planar sliding failures along the foliation.

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CANBERRA BRIOCKWORKS REDEVELOPMENT- QUARRY FACE STABILITY
SITE PHOTOS

ACT Geotechnical Engineers Pty Ltd	**C11596.2**	**FIGURE 2**

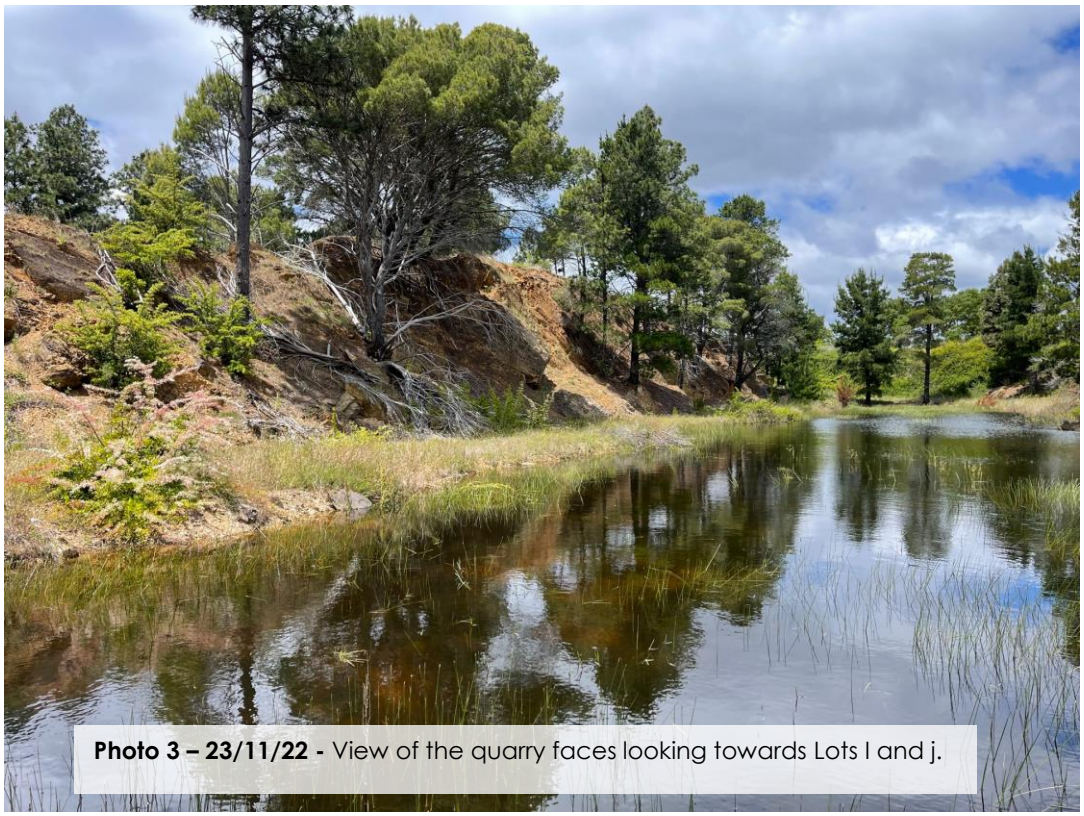

Photo 3 – 23/11/22 - View of the quarry faces looking towards Lots I and j.

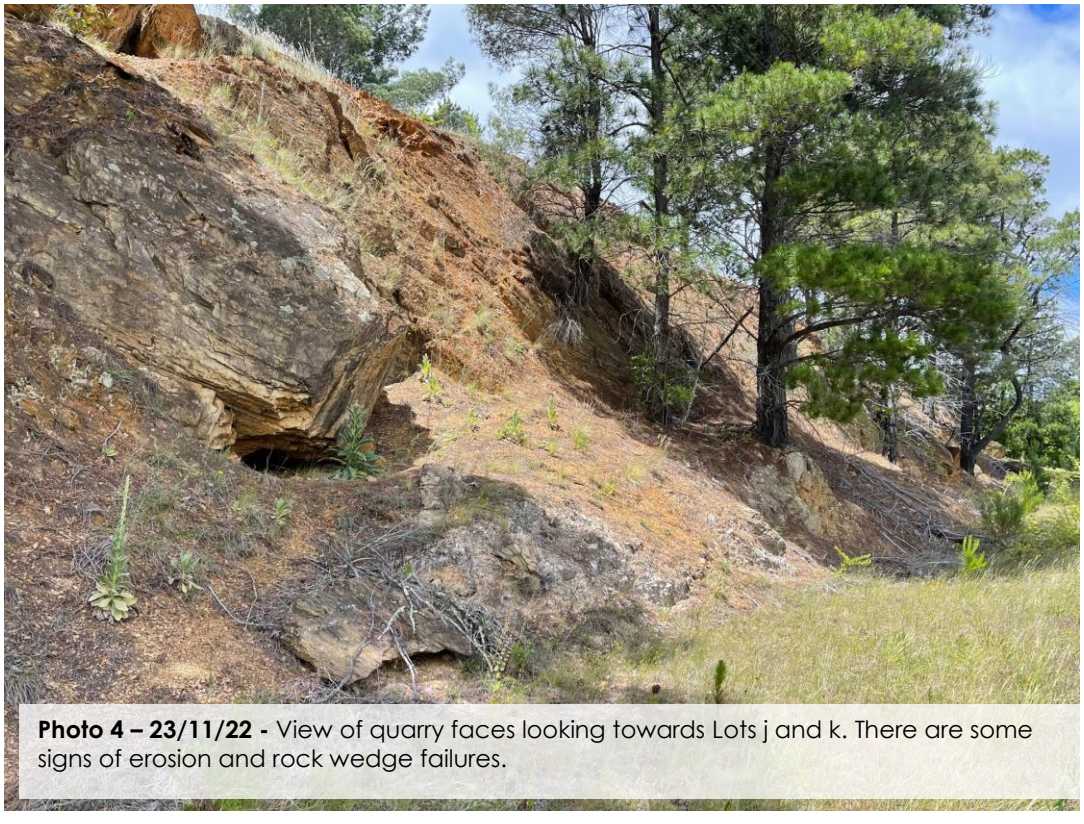

Photo 4 – 23/11/22 - View of quarry faces looking towards Lots j and k. There are some signs of erosion and rock wedge failures.

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CANBERRA BRIOCKWORKS REDEVELOPMENT- QUARRY FACE STABILITY
SITE PHOTOS

ACT Geotechnical Engineers Pty Ltd	**C11596.2**	**FIGURE 3**

Photo 5 – 23/11/22 - View of quarry faces looking towards Lots h to j.

Photo 6 – 23/11/22 - View of the quarry faces looking towards Lot m.

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CANBERRA BRIOCKWORKS REDEVELOPMENT- QUARRY FACE STABILITY
SITE PHOTOS

ACT Geotechnical Engineers Pty Ltd	**C11596.2**	**FIGURE 4**

Photo 7 – 23/11/22 - View of the quarry faces looking towards Lot q. There is some uncontrolled fill (dumped bricks) near the top edge of the batter.

Photo 8 – 23/11/22 - View of the quarry faces looking towards Lot p. There is some uncontrolled fill (dumped bricks) near the top edge of the batter.

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SITE PHOTOS

ACT Geotechnical Engineers Pty Ltd	**C11596.2**	**FIGURE 5**

Photo 9 – 23/11/22 - View of the quarry faces looking towards the tip of the peninsula of Lot n. There are some signs of rock wedge failures.

Photo 10 – 23/11/22 - View of the quarry faces looking towards the western side of Lot n.

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SITE PHOTOS

ACT Geotechnical Engineers Pty Ltd	**C11596.2**	**FIGURE 6**

Photo 11 – 23/11/22 - View of the quarry faces looking towards the eastern side of Lot n.

Photo 12 – 23/11/22 - View of western side of the peninsula of Lot n. There are some signs of erosion and rock wedge failures.

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CANBERRA BRIOCKWORKS REDEVELOPMENT- QUARRY FACE STABILITY
SITE PHOTOS

ACT Geotechnical Engineers Pty Ltd	**C11596.2**	**FIGURE 7**

Geotechnical Engineers ACT

ACT Geotechnical Engineers Pty Ltd
ACN 063 673 530

5/9 Beaconsfield St, Fyshwick, ACT, 2609
PO Box 9225, Deakin, ACT, 2600
Ph: (02) 6285 1547 or 0404 064 858
E: jeremy.murray@actgeoeng.com.au

12 June 2023
Our ref: JM/C11596.2

Doma Group
via email: alex@domagroup.com.au

Attention: Mr Alex Moulis

CANBERRA BRICKWORKS REDEVELOPMENT - BLOCKS 1, 7, & 20, SECTION 102, YARRALUMLA
PROPOSED DWELLINGS T6 to T20

STRUCTURE SET-BACKS FROM THE BATTER FACES OF THE FORMER QUARRY

1 INTRODUCTION

At the request of Doma Group, ACT Geotechnical Engineers Pty Ltd carried out a assessment in the old quarry area of the Canberra Brickworks, in Yarralumla, ACT.

It is understood that the old Canberra Brickworks are being redeveloped into a residential development. As part of this redevelopment, some new dwellings will be constructed near the top edges of the batter faces of the former quarry. ACT Geotech previously provided an assessment of the stability of the quarry batter faces in December 2022, and this report is an addendum the December 2022 assessment. The aim of the current assessment was to:

i) Provide advice for the required set back for structures from the top edge of the quarry faces.
ii) Provide footing advice where structures are inside the st back line.

2 PROPOSED SET BACKS FOR STRUCTURES

It is assessed that structures such as houses, pools, sheds, etc. cannot be constructed in close proximity to the top edges of the quarry batters. It is assessed that any dwellings/pools that are less than 1(H):1(V) back from the top edge of the cut batter face is increasing the risk of instability (dwellings/pools that are not sect back from the top edge of the batter at least by the same distance as the depth of the cut batter at that location). This does not apply to landscaping, hardscaping, fences, etc., which can be located in close proximity to the top edges of the quarry batters.

It has been indicated that there could be three different situations for the quarry batter faces, as follows:

1) Exposed bedrock - cut cliff batter faces of the old quarry. These are presnetly near-vertical, and comprise weathered bedrock.
2) Controlled fill batter - in areas where the quarry will be backfilled, the fill batters will be formed at 1(H):1(V), and be stabilised using a geofabric such as 'Geoweb' or 'Terramat'.
3) Gabion supported batter - to provide more land area at the top edge of the batters, the fill batters could be supported by gabions walls or other similar retaining structures. It is assumed that the gabion walls cannot withstand surcharge loading at the top edge of the batter.

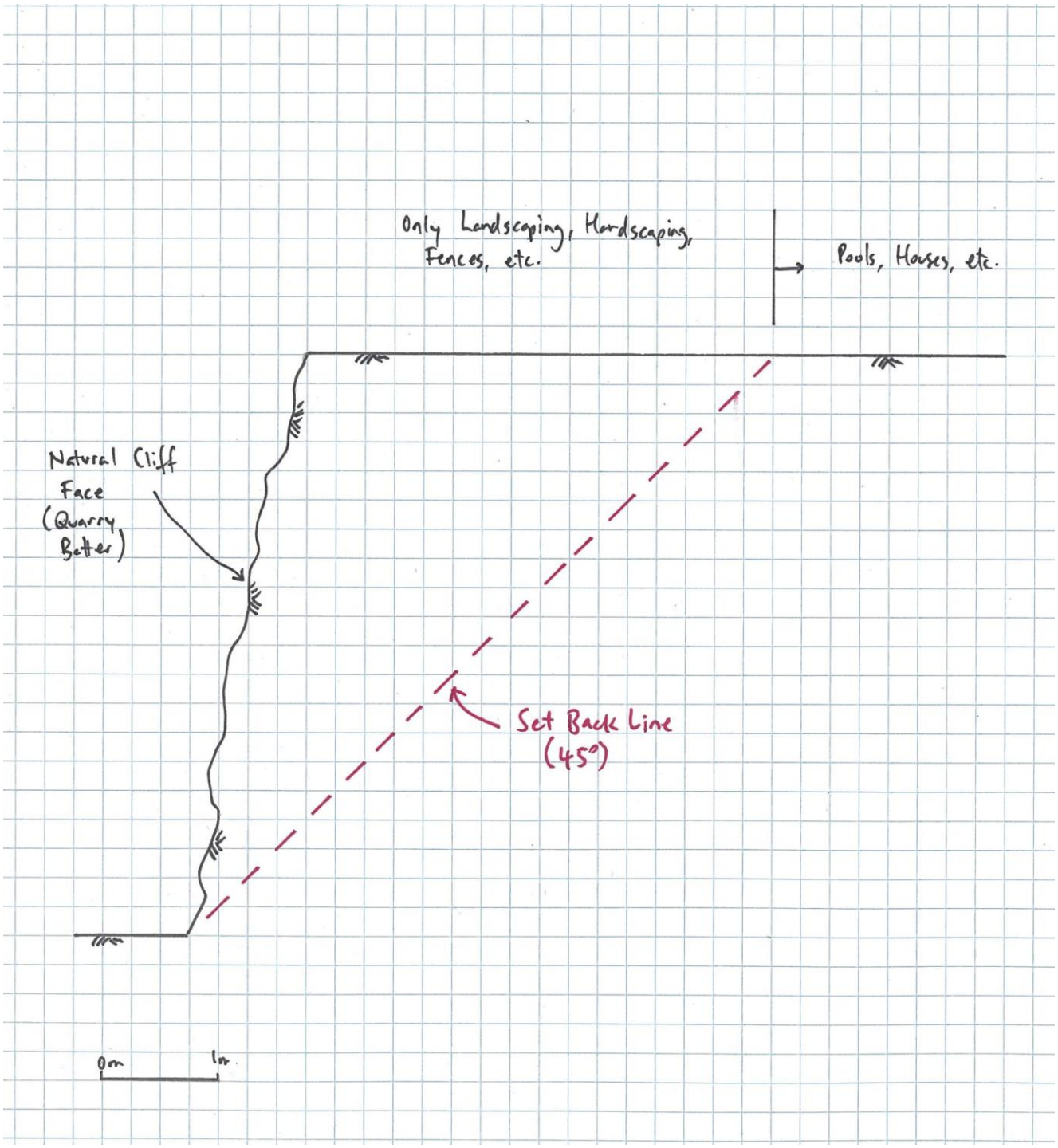
The set back lines showing the areas where house and pool structures can be constructed at the top edges of the quarry batters are shown in Figure 1 (quarry cliff batters), Figure 2 (fill batters), and Figure 3 (gabion supported batters).

3 ENCROACHMENT OF SET BACK LINES

Where pools or dwellings cannot be set back in accordance with the set back lines shown in Figures 1, 3, and 5, then these structures must be founded on deep bored piers so that the footing/structure loads are not surcharging onto the batter face. The bored piers must be founded below the set back lines by a depth of at least four pile diameters. For example, if the bored piers are 600mm diameter, then the piers must socket below the set back line by at least 4 x 600mm = 2400mm. The bored piers should preferably founded into weathered bedrock. This bored pier advice is shown in Figure 2 (quarry cliff batters), Figure 4 (fill batters), and Figure 6 (gabion supported batters).

Yours faithfully
ACT Geotechnical Engineers Pty Ltd

Jeremy Murray
Director
Senior Geotechnical Engineer
FIEAust CPEng EngExec RPEQ NER APEC Engineer IntPE (Aust)



Natural Quarry Cliff Batter Faces – Set Back Line

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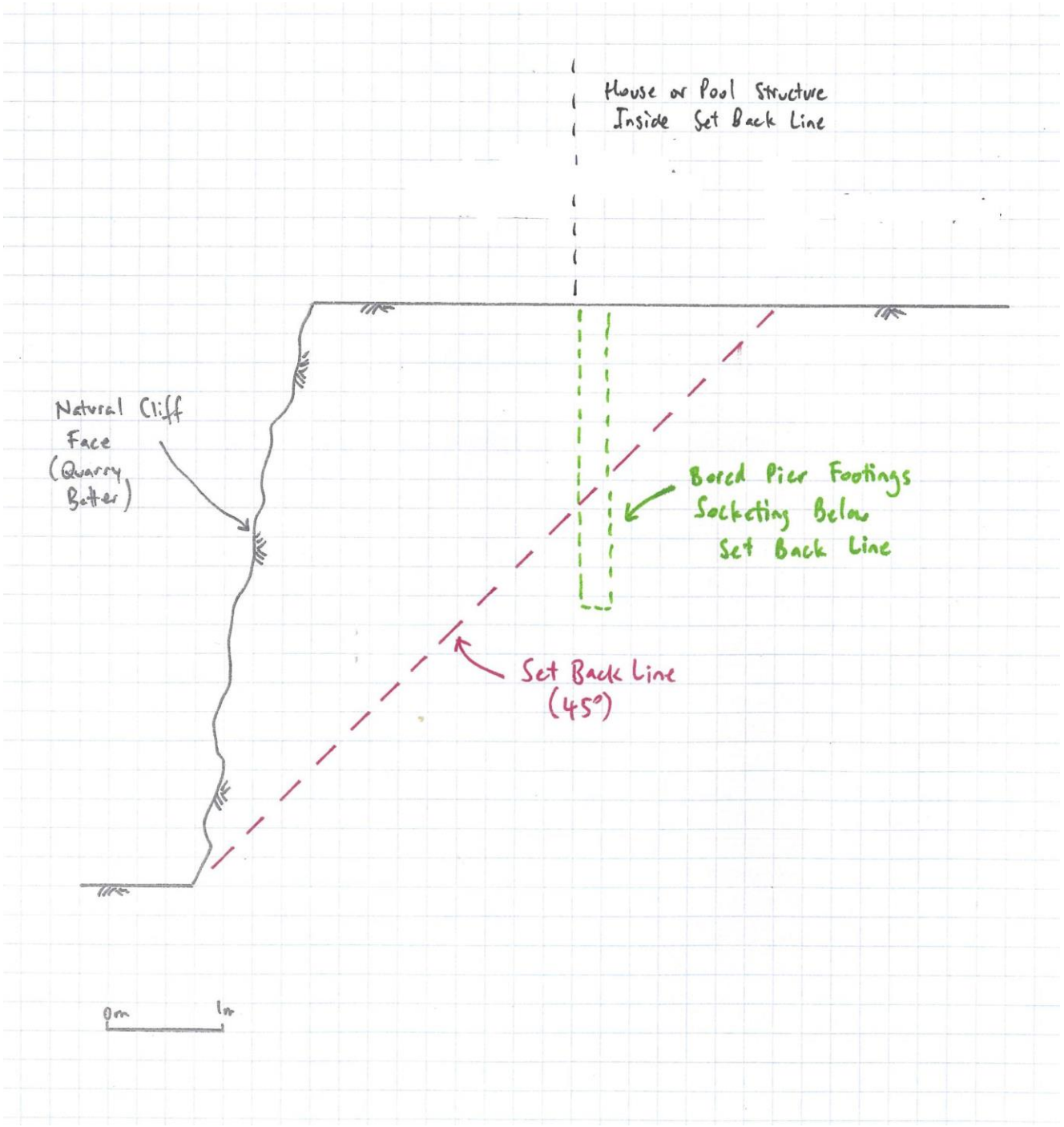
CANBERRA BRICKWORKS REDEVELOPMENT – STABILITY OF QUARRY FACES
QUARRY CLIFF BATTER – SET BACK LINE

ACT Geotechnical Engineers Pty Ltd	**FIGURE 1**



Natural Quarry Cliff Batter Faces
Bored Piers Required for Encroachment of Set Back Line

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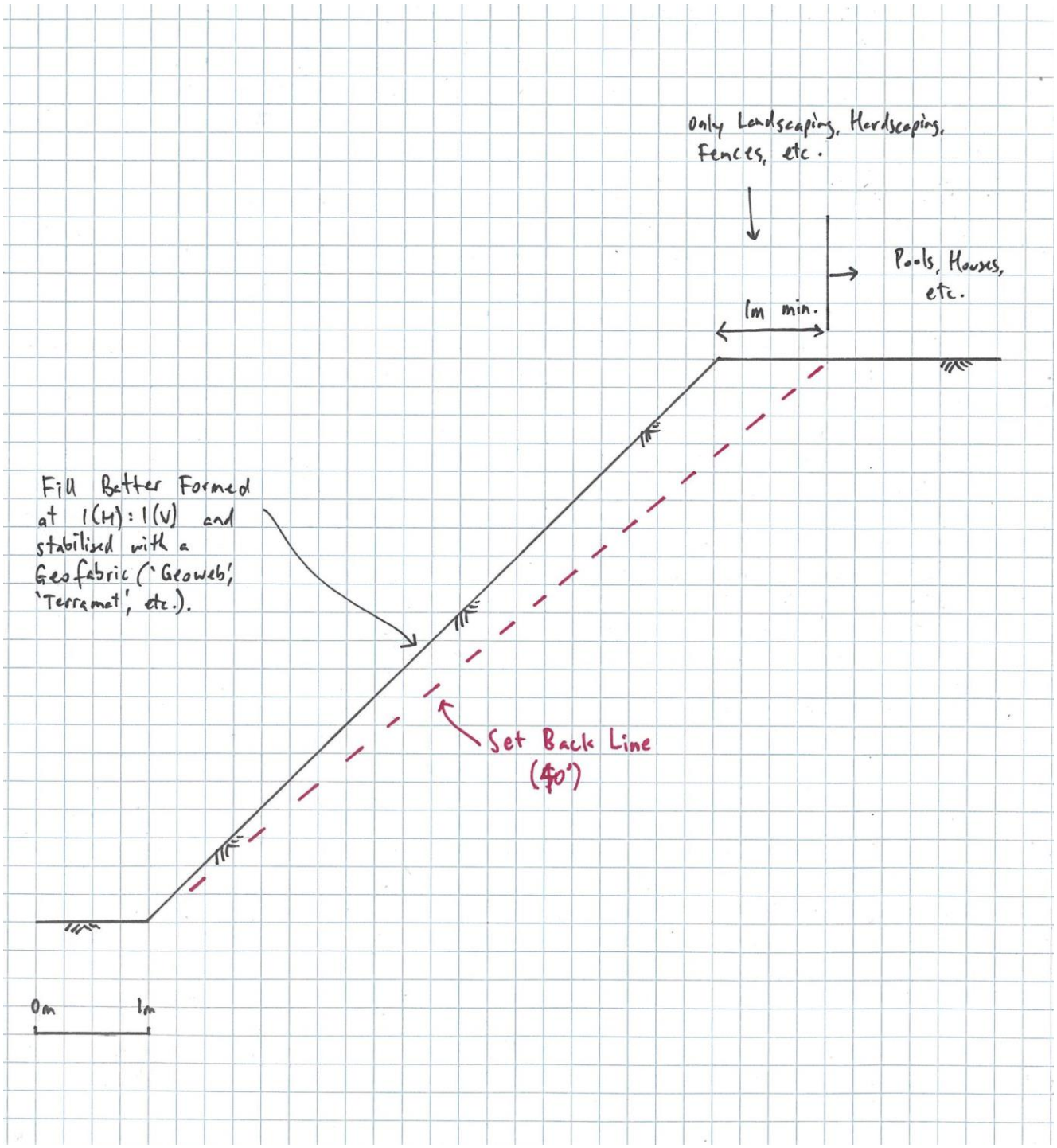
CANBERRA BRICKWORKS REDEVELOPMENT – STABILITY OF QUARRY FACES
QUARRY CLIFF BATTER – ENCROACHMENT OF SET BACK LINE

ACT Geotechnical Engineers Pty Ltd	**FIGURE 2**



Fill Batter Formed at 1(H):1(V) & Stabilised With a Geofabric such as "Geoweb' or 'Terramat' – Set Back Line

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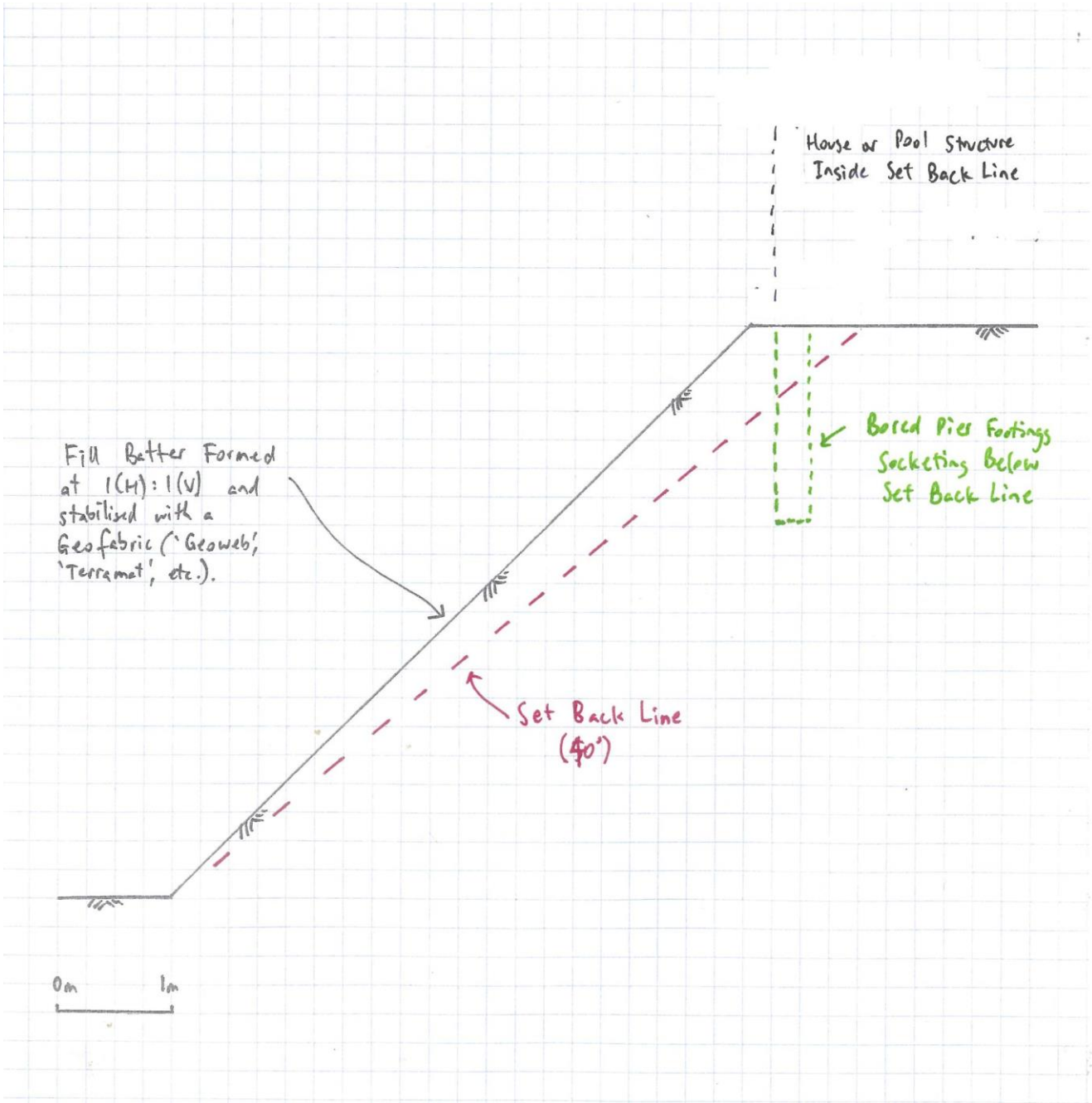
CANBERRA BRICKWORKS REDEVELOPMENT – STABILITY OF QUARRY FACES
1:1 FILL BATTER – SET BACK LINE

ACT Geotechnical Engineers Pty Ltd	**FIGURE 3**



Fill Batter Formed at 1(H):1(V) & Stabilised With a Geofabric such as "Geoweb' or 'Terramat'
Bored Piers Required for Encroachment of Set Back Line

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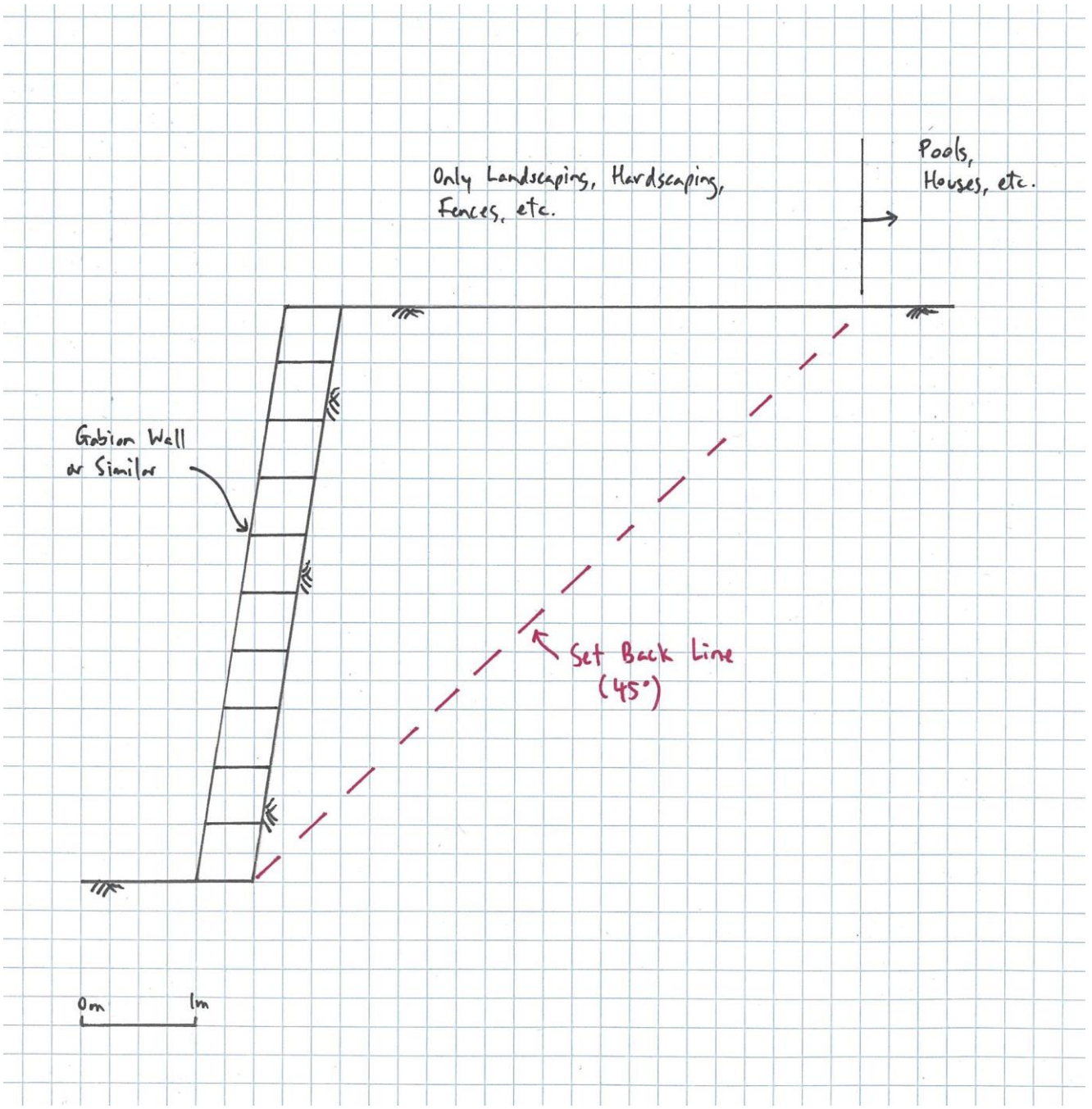
CANBERRA BRICKWORKS REDEVELOPMENT – STABILITY OF QUARRY FACES
1:1 FILL BATTER– ENCROACHMENT OF SET BACK LINE

ACT Geotechnical Engineers Pty Ltd	FIGURE 4



Gabion Spported Batter Faces – Set Back Line

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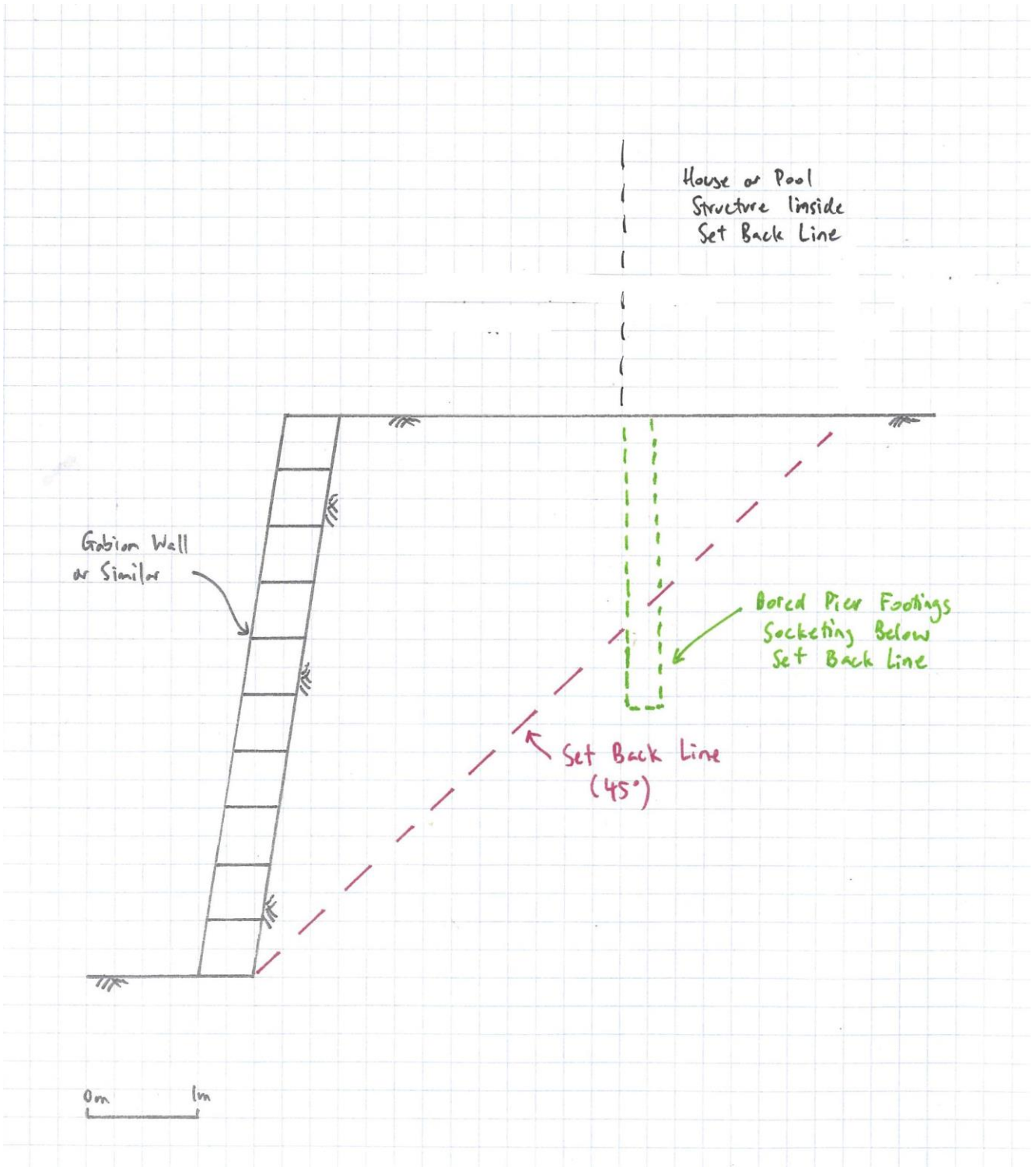
CANBERRA BRICKWORKS REDEVELOPMENT – STABILITY OF QUARRY FACES
GABION SUPPORTED BATTER – SET BACK LINE

ACT Geotechnical Engineers Pty Ltd	FIGURE 5



Gabion Supported Batter Faces
Bored Piers Required for Encroachment of Set Back Line

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CANBERRA BRICKWORKS REDEVELOPMENT – STABILITY OF QUARRY FACES
GABION SUPPORTED BATTER – ENCROACHMENT OF SET BACK LINE

ACT Geotechnical Engineers Pty Ltd	FIGURE 6