23 September 2020 Reference No. 19125312-005-L-Rev1

Emma Bernardi
Built Pty Ltd
Level 7/343 George St,
Sydney, NSW 2000

COVER LETTER FOR GEOTECHNICAL ASSESSMENT

Dear Emma,

The Geotechnical Assessment for Concept Design Report (ref., 19125312-002-L-Rev4 dated 8 September 2020) is submitted to Liverpool City Council (Council) on behalf of Built Development Group in support of a Stage 2 Development Application (DA) for Phase A of the Liverpool Civic Place development located at 52 Scott Street, Liverpool.

It follows the approval of a Concept Proposal / Stage 1 DA (DA-585/2019) for the broader Liverpool Civic Place master plan that has determined land uses, building envelopes, public domain and a multi-level common basement across the site. The full Liverpool Civic Place site, subject to the Concept Proposal / Stage 1 DA approval is illustrated at Figure 1, however the scope of this Stage 2 DA is limited to Phase A, as illustrated at Figure 2. Phase B and Phase C will be subject to future Stage 2 DA(s).

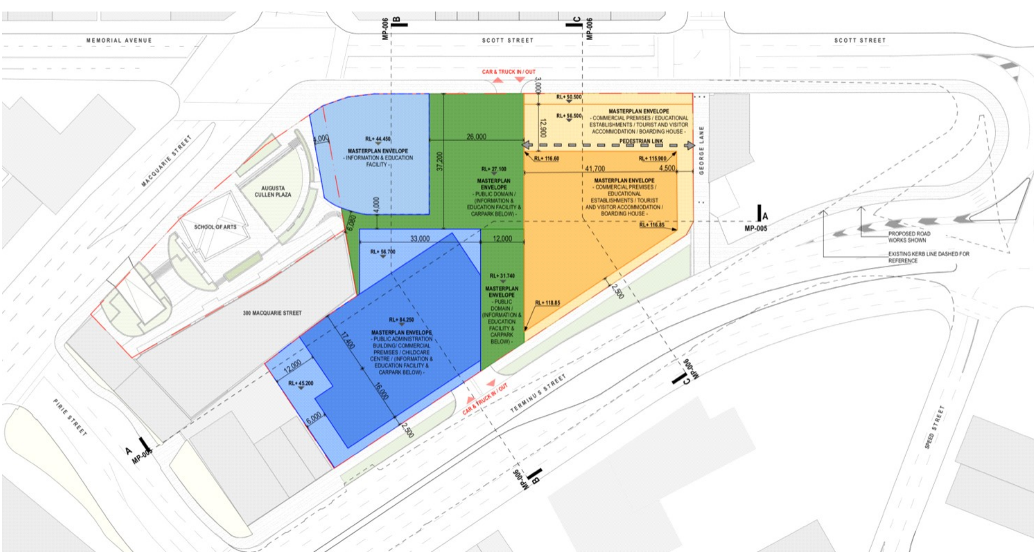

Figure 1: Liverpool Civic Place Master Plan Site

Source: FJMT

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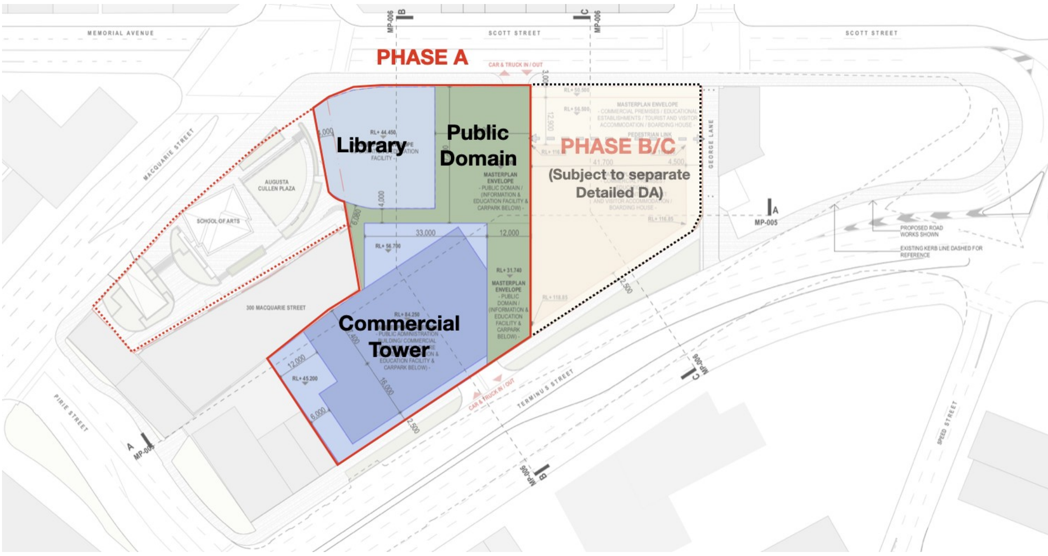


Figure 2: Liverpool Civic Place Phase A site (subject site)

Source: FJMT

This Stage 2 DA seeks approval for:

- Construction and use of a six (6) storey information and education facility (public library);
- Construction and use of a fourteen (14) storey mixed use building comprising:
  - Eight (8) storeys of public administration building floor space to be occupied by Liverpool City Council;
  - Four (4) storeys of commercial premises (office) floor space;
  - Single storey above ground child care centre on Level 8; and
  - Single storey of rooftop plant.
- Partial construction and use of the overall site's common basement;
- Landscaping and public domain works including:
  - an internal shared road connecting to Scott Street with basement access;
  - a public plaza fronting Scott Street; and
  - an elevated pocket park fronting Terminus Street.
- Extension and augmentation of services and infrastructure as required.

This DA reflects the staged planning approval pathway for the Liverpool Civic Place redevelopment which has included two previously approved DAs, as outlined below:

Concept DA DA-585/2019:

The planning approval pathway for the Liverpool Civic Place development commenced in in 2019, with the submission of a Concept Proposal / Stage 1 DA for the Liverpool Civic Place master plan. On 31 August 2020, the Concept Proposal / Stage 1 DA (DA-585/2019) was approved by the Sydney Western City Planning Panel. The Concept Proposal / Stage 1 DA consent sets out the future development concept of the site, including the approved land uses, building envelopes, an expanse of public domain and a common basement. The Concept Proposal / Stage 1 DA did not approve any physical works.

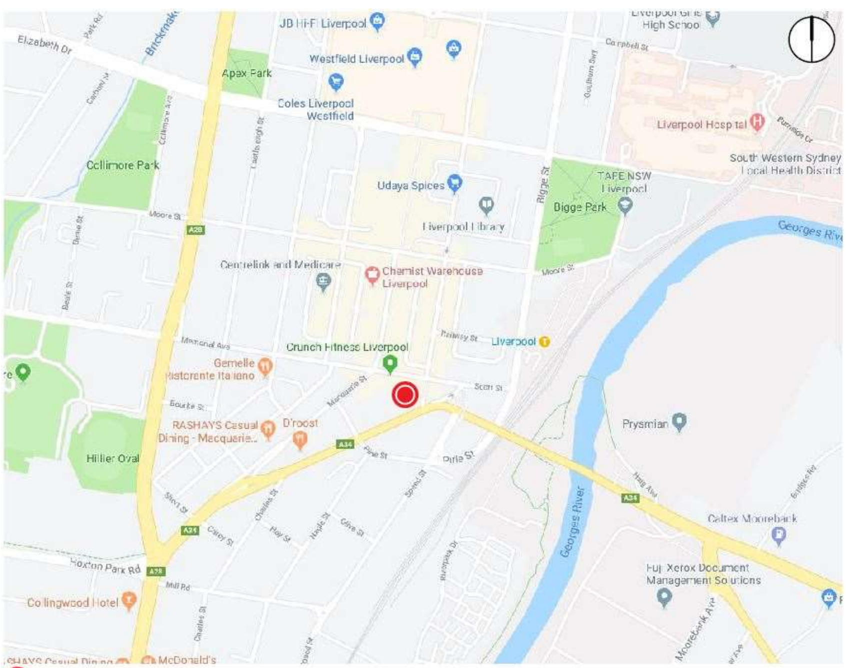
Early Works DA DA-906/2019:

Development Application DA-906/2019 was approved by the Sydney Western City Planning Panel on 29 June 2020. The development consent relates to demolition of all structures, select tree removal and bulk earthworks including shoring through the use of piles. Early works commenced on site in September 2020 and are scheduled for completion in August 2021.

Site Analysis

Site Location and Context

The site is located at 52 Scott Street, Liverpool within the Liverpool City Council Local Government Area (LGA) as illustrated at Figure 1. The site is located at the southern fringe of the Liverpool CBD. The site is approximately 300m south west of the Liverpool Railway Station and is also in the vicinity of a number of regionally significant land uses and features including Liverpool Hospital, Westfield Liverpool, Western Sydney University Liverpool Campus, the Georges River and Biggie Park public open space as illustrated at Figure 3.



The Site

Figure 3: Site Location

Source: Google Maps & Ethos Urban

Yours sincerely,

Golder Associates Pty Ltd

Attachments: Geotechnical Assessment for Concept Design

https://golderassociates.sharepoint.com/sites/112254/project files/6 deliverables/005-cover letter for geo assessment/19125312-005-l-rev1 cover letter for geotechnical assessment.docx

8 September 2020 Reference No. 19125312-002-L-Rev4

Emma Bernardi
Built Pty Ltd
Level 7/343 George St,
Sydney, NSW 2000

GEOTECHNICAL ASSESSMENT FOR CONCEPT DESIGN
LIVERPOOL CIVIC PLACE

Dear Emma,

1.0 INTRODUCTION

Built Pty Ltd (Built) has engaged Golder Associates Pty Ltd (Golder) to carry out a preliminary geotechnical assessment for the Liverpool Civic Place project (the site). We understand that this assessment, which involves two-dimensional finite element modelling, will be used to inform the structural design of retention for bulk excavation works for the site in an early works contract. The work is carried out in accordance with our proposal and your approval to proceed in an email dated 26 August 2020

In this revision, we have considered the permanent slab levels as provided in the revised Structural Drawings by RBG (as referenced in Section 2 below), and a bulk excavation level at RL +6.75 m AHD as instructed in your email dated 26 August 2020.

2.0 REFERENCES

The following documents were referred to in order to carry out the preliminary modelling presented in this report.

- Geotechnical and Environmental Investigation Report (ref.: 19125312-001-Rev4) by Golder dated17 April 2020
- Structural Drawings for adjacent buildings at 300 Macquarie St (ref.: 2012-176/C01-C04 and S01-S06) by Burgess, Arnott and Grava dated March 2013
- Early Works (Stage 1 Works only) Structural Drawings by Robert Bird Group dated 27 August 2020; and
- Architectural drawings (ref., BLCP SD-AR Rev E) by fmjt dated 28 August 2020.

3.0 PROPOSED BULK EXCAVATION

The proposed mixed-use development is understood to consist of a five basement-level car park. Built have informed us that the bulk excavation level (BEL) to be adopted is at RL +6.75 m AHD.

The existing ground level along the southern part of the site along the Terminus Street is approximately at RL +26 m AHD, about 3 m higher than the northern side along the Scott Street (i.e. RL +23 m AHD). The excavation depth for the site ranges between 16 m and 19 m below ground level (bgl).

The existing building in the vicinity with a basement is located to the north-west of the site. Based on the drawings provided, the bulk excavation for this building is to RL +17.8 m AHD, approximately 11 m higher than the proposed BEL.

The groundwater level measured in August 2019 is generally at about RL +17.5 m AHD, approximately 12 m higher than the proposed BEL. However, an exception was the water level measured in BH304 at RL +15 m AHD. Additional groundwater sampling was carried out on 27th March 2020 and observed groundwater levels as high as RL +18.7 m AHD and RL +19.6 m AHD in boreholes BH2 and BH306 respectively.

4.0 ANALYSIS METHODOLOGY

Two analysis sections (as shown in Figure 1) adopted in this preliminary analysis were nominated by the project structural engineer, Robert Bird Group (RBG).

We have adopted the information provided by RBG, received in emails on 11 November 2019 and 2 June 2020, as summarised in Table 1. RBG has informed Golder that the retention system will be designed as a permanent structure. We have not considered any loads from the superstructure imposed on the soldier pile wall.

Table 1: Instructions from RBG

Analysis Section 1	Analysis Section 2
■ Retention system consists of anchored soldier pile wall with shotcrete infill and vertical cuts in the underlying competent rock. ■ Spot bolting as required in Unit 3b and 4 depends on defects observed during site inspections. ■ The soldier pile wall consists of 600 mm diameter piles at the spacing of 1.5 m supported by three rows of anchors. ■ Unfactored loading from the existing building on the existing capping beam to be 335 kN/m. ■ Unfactored loading from the existing pad footing (i.e. 1.2 m x 1.6 m) right behind the capping beam to be 1,810 kN.	■ Retention system consists of anchored soldier pile wall with shotcrete infill and vertical cuts in the underlying competent rock. ■ Toe of soldier pile wall is 0.5 m into Unit 3b. ■ Spot bolting as required in Unit 3b and 4 depends on defects observed during site inspections. ■ The soldier pile wall consists of 600 mm diameter piles at the spacing of 2.4 m supported by two rows of anchors. ■ A surcharge of 20 kPa to be considered from 1 m behind the retaining wall. ■ Permanent floor slabs are 250 mm thick with a concrete strength of 40 MPa. ■ A reduction factor of 0.7 to be applied to the Young’s modulus of the concrete solider piles

Analysis Section 1	Analysis Section 2
■ Unfactored loading from the existing pad footing (i.e. 2.4 m x 2.4 m) along Gridline D to be 4,600 kN. ■ The allowable vertical and lateral displacement of the existing soldier pile wall and pad footing to be less than 10 mm. ■ Permanent floor slabs are 250 mm thick with a concrete strength of 40 MPa. ■ A reduction factor of 0.7 to be applied to the Young's modulus of the concrete solider piles and permanent floor slabs to account for the long-term condition.	and permanent floor slabs to account for the long-term condition.

The numerical modelling was carried out using the commercially available finite element analysis software, PLAXIS 2D 2020. The construction sequence is idealised and simulated with the staged construction, generally as follows:

- Generate in-situ stresses in the ground using K_o procedure.
- The surcharge and retaining wall are wished-in-place in the model, where installation effects are not considered.
- Excavation is modelled by deactivating layers of soil in each stage (e.g. 2 m) and the pore-water pressure distribution is calculated by steady-state analysis.
- Excavation is carried out to 0.5 m below the temporary ground anchors (if any), and the anchors are installed by wished-in-place in the subsequent stage.
- Permanent slabs are constructed by wished-in-place in stages. Temporary anchor is removed after the permanent slab above has been constructed.
- Long-term condition is simulated by a reduced modulus for concrete soldier piles and installation of permanent floor slabs.

The ground models and geotechnical parameters adopted for the analysis are based on our report (ref.:19125312-001-R Rev 5), which are presented in the following sections in this report.

We have assumed that all ground anchors provide temporary support only and the ground anchors will be de-stressed as the construction of basement floor slabs progress. The loads re-distributed to the constructed floor slabs after destressing of ground anchors are modelled and considered in the analysis. The soldier pile wall with shotcrete infill, base and floor slabs of the basement structure will provide lateral support to the retention system in the permanent condition.

Figure 1: Analysis section layout

5.0 GROUND MODEL

Table 2 presents the modelled ground profiles for each analysis section, which are inferred from the following boreholes:

- Analysis Section 1 – BH302 and BH303
- Analysis Section 2 – BH305 and BH306

Based on the available borehole investigations, we anticipate that bedding of the rock units present on site will be primarily horizontal. The defects in Unit 3a, 3b and 4 observed in the available boreholes has been considered in the design parameters proposed in our geotechnical investigation report (ref.: 19125312-001-Rev5).

The highly weathered material interbedded in Unit 3b is modelled with Unit 3a parameters. We have assumed that any possible adverse jointing encountered in Unit 3a, 3b and 4 will be supported (e.g. pattern bolting, spot bolting etc.) at each excavation stage. A 0.1 m thick horizontal joint (bedding plane) has been modelled in Unit 4, 0.3 m below the BEL, to investigate the possibility of excessive rock heave or fracturing of the floor rock from stress concentration.

Note that the current boreholes across the site do not extend beneath the proposed BEL. There is a possibility that the Unit 4 (H-VH Sandstone) encountered at the termination depth of the boreholes is underlain by bands of weaker shale or siltstone. The ground model adopted in this analysis may need to be revisited should more investigations be carried out or more information is available during bulk excavation. The outputs provided in this report assume that Unit 4 continues beyond the zone of influence of the basement excavation.

Table 2: Modelled ground profile

Ground Unit	Elevation of top of Unit (m AHD)	
	Analysis Section 1	Analysis Section 2
Unit 1 Filling	+22.3	+26.1
Unit 2 St-H Residual clay	+22.1	+24.0
Unit 3a L-M Laminite	+19.7	+21.7
Unit 3b M-H Laminite	+18.0	+15.4
Unit 4 H-VH Sandstone	+13.8	+12.8

Initial groundwater levels at RL +18 m AHD and RL +19.6 m AHD have been assumed in the analyses for Sections 1 and 2 respectively. In the temporary and permanent condition, no groundwater pressure has been considered to act on the rock face, suitably sized drainage will need to be provided behind the shotcrete panels to prevent water pressure build-up.

6.0 DESIGN PARAMETERS

The mechanical behaviour of the soils and rocks are modelled with Hardening Soil Model, which adopts the Mohr-Coulomb failure criterion. The geotechnical parameters adopted are extracted from our geotechnical investigation report (ref.: 19125312-001-Rev5) and summarised in Table 3.

Table 3: Design parameters for ground unit

Ground Unit	γ (kN/m^3)	C′ (kPa)	ϕ' (°)	E_{50} (MPa)	E_{ur} (MPa)	K_o (-)
Unit 1 Filling	17	0	30	10	20	0.5
Unit 2 St-H Residual clay	18	5	28	20	40	1
Unit 3a L-M Laminite	24	50	38	200	400	1
Unit 3b M-H Laminite	24	200	40	1,200	2,400	[1] 2
Unit 4	24	400	43	2,000	4,000	[1] 6

Ground Unit	γ (kN/m³)	C′ (kPa)	ϕ′ (°)	E_{50} (MPa)	E_{ur} (MPa)	K_o (-)
H-VH Sandstone						

Note:

1. K_o is elevated to generate the estimated locked-in horizontal stress.

The structural behaviour of the retaining wall is modelled as a plate element in the model, with normal stiffness (EA) and bending stiffness (EI) smeared in the plane-strain condition. The design parameters adopted for the soldier piles walls are summarised in Table 4 assuming a concrete grade of 40 MPa with a Young's modulus of 33 GPa.

Table 4: Design parameters for retaining wall

Retaining wall	Young's modulus, E (GPa)	EA (kN/m)	EI (kNm/m)	Poisson's ratio (-)
600 mm diameter Soldier Pile at 2.4 m spacing	33	3.8×10^6	86.9×10^3	0.2
600 mm diameter Soldier Pile at 1.5 m spacing	33	6.2×10^6	139.0×10^3	0.2

The temporary ground anchors are modelled with a fixed-end anchor with an input of EA and spacing (Table 5).

Table 5: Design parameters for anchor

Anchor	EA (kN)
40 mm solid steel bar	2.51×10^5

The 250 mm thick permanent slabs are modelled with a fixed-end anchor assuming a concrete grade of 40 MPa with a Young's modulus of 33 GPa.

Table 6: Design parameters for slab

Slab	Young's modulus, E (GPa)	EA (kN/m)
250 mm thick concrete slabs	33	8.20×10^6

7.0 RESULT OF ANALYSIS

7.1 Analysis Section 1 – adjacent to the existing building

Table 7 summarises the results computed in Analysis Section 1, for the proposed 600 mm diameter soldier pile wall at 1.5 m spacing for each construction stage. The foundation loads from the adjacent building (as provide by RBG) is considered as an equivalent infinite strip load in this plane strain analysis, using the method by Williams and Waite (1993)[1] as presented in CIRIA C760. The maximum wall displacement is computed to be 11 mm.

Table 7: Computed results of the proposed soldier pile wall in Analysis Section 1

Construction stage	Wall lateral displacement (mm)	[1] Maximum bending moment (kNm/pile)	[1] Maximum shear force (kN/pile)
Excavate to RL +16.3	3	125	225
Install Row 1 Anchor at RL +16.8	3	95	195
Excavate to RL +15.0	3	100	265
Install Row 2 Anchor at RL +15.5	3	80	175
Excavate to RL +13.5	3	100	285
Install Row 3 Anchor at RL +14.1	3	95	280
Excavate to RL +12.3	4	115	180
Excavate to RL +10.0	7	130	195
Excavate to RL +6.75	11	140	215
Construct B3 and B2 slabs and remove anchor R3 and R2	11	145	265
Construct B1 slab and remove anchor R1	11	120	235
[2] Long-term condition in the solider piles	11	120	240

Notes:
1. Value shown is unfactored. Values are rounded to the nearest multiple of 5 kNm for bending moment and 5 kN for shear force.
2. A reduction factor of 0.7 as described in Section 4.0 is applied to the Young's modulus of the proposed soldier pile and slabs to account for the long-term condition.

Experience with basement construction in shale and sandstone in Sydney has typically indicated lateral displacements of rock due to stress relief of horizontal stress is in the order of 1 mm/m towards the base of excavation. For excavation of and sandstone of 16 m below ground level, the lateral displacement due to stress relief of this competent rock is approximately 15 mm.

[1] Williams, B. P., & Waite, D. (1993). The design and construction of sheet-piled cofferdams (No. 95).

Figure 2 shows the lateral displacement and forces induced in the proposed soldier pile wall for each construction stage.

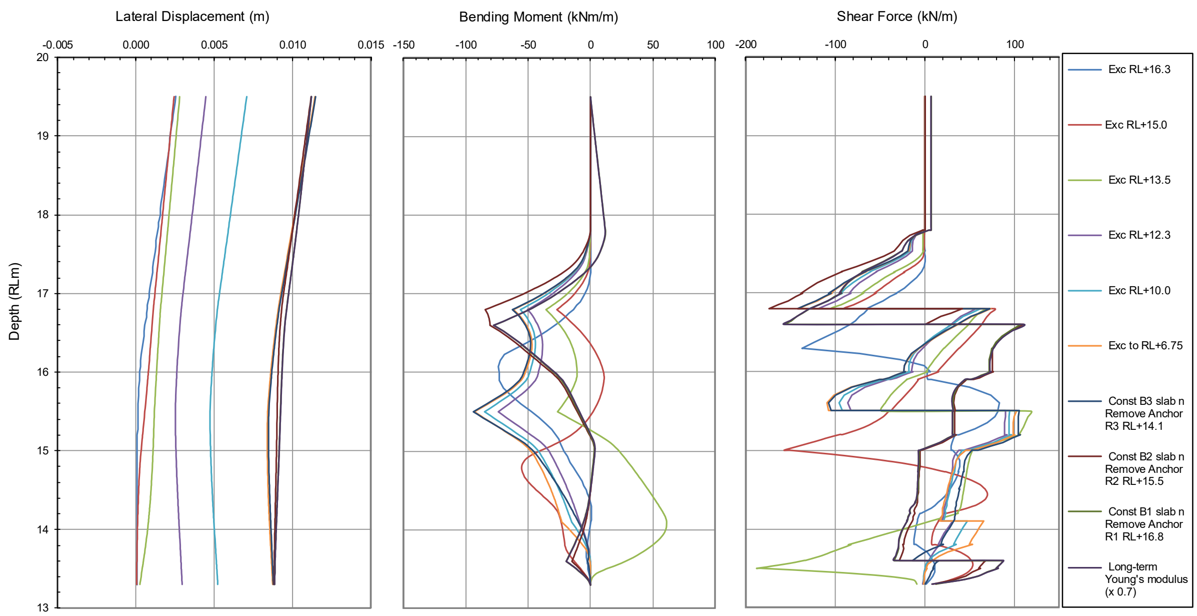


Figure 2: Lateral displacement and forces induced in the proposed soldier pile in Analysis Section 1

Table 8 summarises the anchor load considered in Analysis Section 1. A relatively high anchor prestress is required to limit the displacement of the existing soldier pile wall. We have assumed the project structural engineer will assess the potential impacts of excavation on the adjacent structure, such as the wall displacements and forces induced in the existing soldier piles. A maximum displacement of 11 mm, rounded up to the nearest mm as shown in Table 8, is computed for the existing soldier pile wall.

A planar wedge limit equilibrium analysis has been carried out, assuming a potential rock wedge formed from the nearest existing pad footing (i.e. 1.8 m behind the soldier pile wall) to the toe of the existing soldier pile (i.e. 2.6 m below the existing basement sofit). Based on the calculation, the proposed anchor loads satisfied the required load to stabilise the rock wedge.

We have assumed the anchors will be destressed after both floor slabs below and above the anchor is cast and gained sufficient strength. The design of the slabs should consider the redistribution of anchors loads into the slabs after the anchors have been distressed.

Considering the location of the existing pad footings and the associated stress imposed on the ground, a minimum anchor free-length of 4 m is suggested.

A waler or capping beam is recommended to allow the load from the existing pad footings to be distributed over a greater extent of the wall.

Table 8: Temporary anchor forces for Analysis Section 1

Row	Spacing (m)	Inclination (º)	[1] Anchor prestress load (kN/anchor)	[1] Maximum axial force (kN/anchor)
R1	1.5	15	250	350
R2	1.5	15	250	350
R3	1.5	15	70	100

Note:

1. Value shown is unfactored and a waler is required to distribute the load equally between anchors.

The long-term earth pressure imposed on the soldier piles can be estimated from the Ko provided in Table 3. Considering soil arching effects where most of the lateral pressure will be distributed to the stiffer solider piles, a lateral earth pressure of 20 kPa is suggested to be applied for the design of the shotcrete wall between the soldier piles. The total pressure acting on the soldier pile wall should also consider the surcharges such as from footings.

Analysis Section 1 has considered the foundation load (provided by RBG) from the adjacent building behind the proposed soldier pile wall. Due to the relative high foundation load, the soldier pile is to be constructed through Unit 3b and terminated on top of Unit 4 or 2 m below Row 2 anchor, whichever is deeper.

Axial loads of up to 300 kN are expected to be induced in each of the soldier piles, therefore it is recommended a rock ledge should be formed by having the vertical cut face at least 0.2 m away from the closest edge of the piles. We recommend an allowance for rock bolts at 0.5 m below the pile toe to support any potential rock wedges that could become unstable during excavation. Note that this bearing assessment should be reviewed if there is additional external load applied on the piles or a change in the inclination of anchors.

Table 9 summarises the performance of the existing soldier pile wall, which consists of 600 mm diameter piles at 1.5 m spacing. The maximum vertical and lateral displacement computed is 10 mm and 6 mm respectively. Impact assessments due to excavation should consider these displacements and additional induced forces in the existing solder piles. The displacements (i.e. vertical and lateral) of the existing pad footings are similar to those experienced by the existing soldier piles wall.

Table 9: Computed results of the existing soldier pile wall in Analysis Section 1

Construction stage	[2] Wall vertical displacement (mm)	[2] Wall lateral displacement (mm)	[1] Additional induced bending moment (kNm/pile)	[1] Additional induced shear force (kN/pile)
Excavate to RL +16.3	0	1	30	70
Excavate to RL +15.0	1	1	35	60
Excavate to RL +13.5	2	2	30	50
Excavate to RL +12.3	3	2	15	30
Excavate to RL +10.0	6	3	10	25

Construction stage	[2] Wall vertical displacement (mm)	[2] Wall lateral displacement (mm)	[1] Additional induced bending moment (kNm/pile)	[1] Additional induced shear force (kN/pile)
Excavate to RL +6.75	10	6	10	25
Construct B3 and B2 slabs and remove anchor R3 and R2	10	6	10	25
Construct B1 slab and remove anchor R1	10	6	10	15
[3] Long-term condition in the solider piles	10	6	5	15

Notes:

1. Value shown is unfactored. Values are rounded to the nearest multiple of 5 kNm for bending moment and 5 kN for shear force.
2. The computed vertical and lateral displacements of the existing pad footings are similar to those experienced by the existing solder pile wall.
3. A reduction factor as described in Section 4.0 is applied to the Young's modulus of the proposed soldier pile (not existing) and slabs to account for the long-term condition.

Table 10 summarises the results computed in Analysis Section 1, for the 250mm thick slabs. Note that the computed slab forces are due to the loads re-distributed after the temporary ground anchors are removed.

Table 10: Computed results of the slabs in Analysis Section 1 after the temporary ground anchors are removed

Slab	RL (m AHD)	Thickness (mm)	[1] Maximum slab axial force (kN/m)
B1 slab	+19.5	250	15
B2 slab	+16.6	250	300
B3 slab	+13.6	250	125

Note:

1. Value shown is unfactored. Values are rounded to the nearest multiple of 5 kN/m.

Outputs for Analysis Section 1 is attached in APPENDIX A.

7.2 Analysis Section 2 – adjacent to road

Table 11 summarises the results computed in Analysis Section 2, for the proposed 600 mm diameter soldier pile wall at 2.4 m spacing for each construction stage.

Table 11: Computed results of the proposed soldier pile wall in Analysis Section 2

Construction stage	Wall lateral displacement (mm)	[1] Maximum bending moment (kNm/pile)	[1] Maximum shear force (kN/pile)
Excavate to RL +23.6	5	120	85
Install Row 1 Anchor at RL +24	5	85	100
Excavate to RL +22.2	4	105	105
Excavate to RL +19.7	5	105	125
Excavate to RL +16.5	5	105	240
Install Row 2 Anchor at RL +17.1	5	105	240
Excavate to RL +13.7	9	95	125
Excavate to RL +10.0	13	105	145
Excavate to RL +6.75	18	120	170
Construct B2 and B1 slabs and remove anchor R2	19	120	170
Construct LG and UG slabs and remove anchor R1	20	140	175
[2] Long-term condition in the solider piles	18	85	100

Notes:

1. Value shown is unfactored. Values are rounded to the nearest multiple of 5 kNm for bending moment and 5 kN for shear force.
2. A reduce factor of 0.7 as described in Section 4.0 is applied to the Young's modulus of the proposed solder pile and slabs to account for the long-term condition.

Experience with basement construction in shale and sandstone in Sydney has typically indicated lateral displacements of rock due to stress relief of horizontal stress is in the order of 1 mm/m towards the base of excavation. For excavation of sandstone 19 m below ground level, the lateral displacement due to stress relief of this competent rock is approximately 20 mm.

Figure 3 shows the lateral displacement and forces induced in the proposed soldier pile wall for each construction stage.

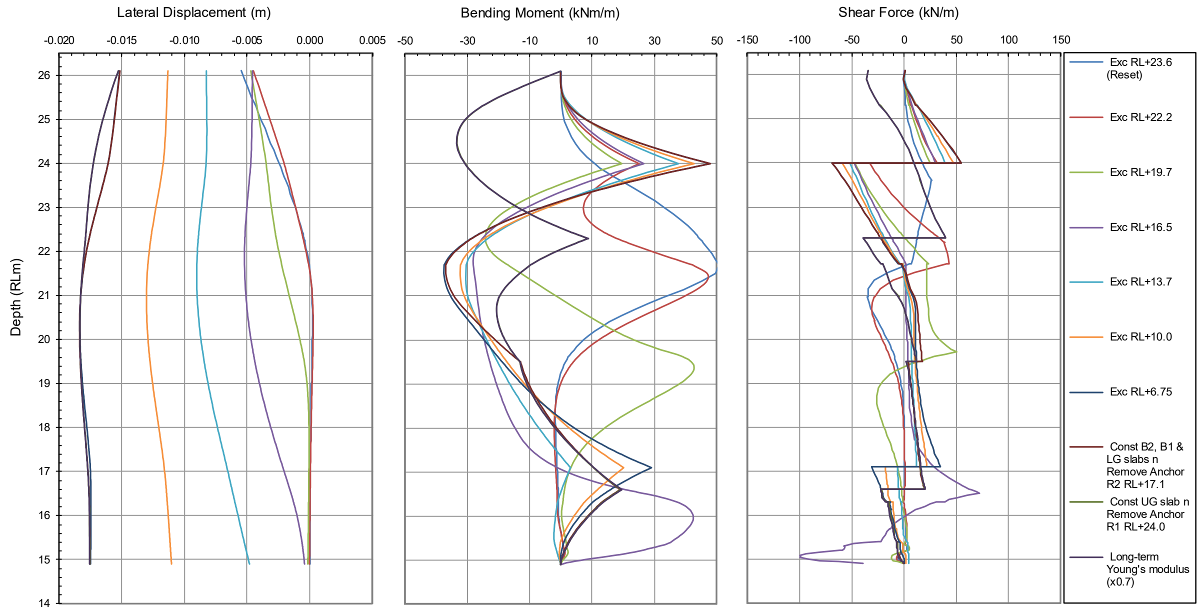


Figure 3: Lateral displacement and forces induced in the proposed soldier pile in Analysis Section 2

Table 12 summarises the proposed anchor load considered in Analysis Section 2.

The proposed depth of 2 m below ground level for the first row is based on the depth of encountered underground services (e.g. Optus cable) approximately 1 m below ground level. The actual alignment and depth of any underground services behind the soldier pile wall should be verified on-site before drilling and installation of the anchor are commenced.

For this analysis, the second row of anchors is proposed to be below the B2 Floor slab. The subsequent analysis is required to consider the top of slab level for LG, UG and B1 Floor slab as it varies across the site.

We have assumed the anchors will be destressed after both Floor slabs below and above the anchor is cast and gained sufficient strength. The design of the slabs should consider the redistribution of anchors loads into the slabs after the anchors have been distressed.

The anchor fixed-length should be located beyond a plane projected at an angle of 45^{o} from the horizontal from the base of Unit 3a. Should the anchor inclination be required to be steeper to avoid underground services or/and achieve a shorter anchor total length, additional analyses are required as the effectiveness of anchor supporting the wall decreases with an increase of anchor inclination from the horizontal and additional axial force will be imposed on the supporting rock ledge. Golder can carry out additional analysis sections upon request.

Table 12: Temporary anchor forces for Analysis Section 2

Row	Spacing (m)	Inclination (°)	[1] Anchor prestress load (kN/anchor)	[1] Maximum axial force (kN/anchor)
R1	2.4	15	200	300
R2	2.4	15	150	200

Note:
1. Value shown is unfactored and a waler is required to distribute the load equally in a row.

The long-term earth pressure imposed on the soldier piles can be estimated from the Ko provided in Table 3. Considering soil arching effects where most of the lateral pressure will be distributed to the stiffer soldier piles, a lateral earth pressure of 20 kPa is suggested to be applied for the design of the shotcrete wall between the soldier piles. The total pressure acting on the soldier pile wall should also consider the surcharges such as from roads.

The soldier piles are recommended to be socketed 0.5 m in Unit 3b. Axial loads up to 160 kN have been computed in each of the soldier piles due to the inclination of the anchors, therefore it is recommended that a rock ledge be formed by having the vertical cut face at least 0.2 m from the closest edge of the piles. Note that this bearing assessment should be reviewed if there is additional external load applied on the piles or a change in the inclination of anchors.

Table 13 summarises the results computed in Analysis, for the 250 mm thick slab. Note that the computed slab forces are due to the loads re-distributed after the temporary ground anchors removal.

Table 13: Computed results of the slabs in Analysis Section 2 after the temporary ground anchors are removed

Slab	RL (m AHD)	Thickness (mm)	[1] Maximum slab axial force (kN/m)
UG slab	+26.1	250	40
LG slab	+22.3	250	100
B1 slab	+19.5	250	20
B2 slab	+16.6	250	45

Note:

1. Value shown is unfactored. Values are rounded to the nearest multiple of 5 kN/m.

Outputs for Analysis Section 2 are attached in APPENDIX B.

8.0 DISCUSSION AND RECOMMENDATIONS

8.1 Proposed retention system

The proposed retention system consists of anchored soldier piles wall with shotcrete infill and vertical cuts in the underlying competent rock (i.e. Unit 3b and 4). In addition to the recommendations as listed in Section 9.3 in our geotechnical investigation report (ref.: 19125312-001-Rev5), it is worthwhile to note the following:

- We have not considered any long-term loadings. If required, the length of the soldier piles can be extended to achieve sufficient geotechnical resistance depending on the imposed loads.
- We have assumed that a temporary drainage system be designed to manage construction groundwater inflows, which could include strip drains behind the infill shotcrete wall between the anchored soldier piles.
- The installation and testing of the anchors should be in accordance to AS5100.3. Equivalent or better anchor type in term of axial stiffness can be adopted.
- The grouted length of the ground anchor is to be assessed by an anchor contractor and these anchors should be proof load tested to 1.25 times the Maximum Axial Force and locked off at the Anchor Prestress Load as set out in Table 8 and Table 12.
- The ground anchors in the detailed design stage (i.e. inclination, length and depth) should avoid all the underground services.
- In Analysis Section 1, we note that the existing pad footings are spaced approximately 7.5 m apart along with the existing soldier pile wall. Upon request from Built, we can carry out further in-depth analysis such as 3D modelling to refine the anchor and wall requirements.
- Excavations through shale and sandstone in Sydney may encounter adversely inclined joints that can result in significant blocks of rock becoming dislodged from the excavation face, which may apply additional loads to the adopted retention system as well as a potential safety risk during construction. We consider that there is a low risk of these blocks occurring and dislodging, assuming the excavation in rock will be carried out in 2 m depth intervals and the excavated rock face is inspected by a Geotechnical Engineer. If such inclined joints are identified on-site, it is likely that further analyses will be required.
- We recommend that all Laminites in Unit 3a and 3b are protected by shotcrete to prevent fretting from wetting and drying of the rock face over time.
- For Section 2, the top of Unit 3b is anticipated ranging between RL +15.4 m AHD and RL +18.5 m AHD (ref.: 19125312-001-Rev5). The RL of the permanent B1 and B2 slabs are +19.5 m AHD and +16.6 m AHD respectively. The proposed pile toe is 0.5 m into Unit 3b, i.e. ranges from RL +14.9 m AHD to RL +18 m AHD. The pile toe may be founded at the level either between B1 and B2 slabs or B2 and B3 slabs. For the case that the wall toe is not fixed/supported by floor slab, bending moment induced in the soldier pile wall at this free span length to be considered in structural design.
- We have not carried out any structural design and assessment of the retention system in both temporary and permanent condition.

The information contained in this report is sensitive to the suitability of the assumptions made and discussed throughout. If any of these assumptions are found to be inappropriate, it may be necessary to carry out further analyses and to revise this report.

8.2 The adjacent building north-west of the Site

An analysis section, Analysis Section 1, has been carried out considering the foundation load (provided by RBG) from the adjacent building behind the proposed soldier pile wall. This report has included an estimated displacement of the footings and forces induced in the soldier pile wall due to the proposed excavation. We have not assessed the impact of the construction works and excavation on this building.

Due to the relatively high foundation load from this building, the proposed soldier pile is to be constructed through Unit 3b (medium to high strength Laminite) and terminated on the top of Unit 4 (high to very high strength Sandstone) or below B4 slab, whichever is deeper.

Based on the drawings provided, the excavation is expected to expose the buried ground anchors of the adjacent building. Prior to commencement of the proposed excavation, an agreed method of excavating and removal of the existing anchors should be developed with the involvement of the relevant stakeholders and structural engineers.

The proposed soldier piles are designed at 1.5 m spacing, identical to the spacing of the existing soldier piles for this adjacent building. The proposed soldier piles should be installed between the span of the existing soldier piles, allowing the proposed ground anchors to be installed without interfering with the existing soldier piles.

The proposed ground anchors are below the groundwater table and within the zone providing geotechnical resistance to the foundation of the existing building. The construction and installation of ground anchors should consider any potential disturbance that could result in a reduction of the available geotechnical resistance for the existing foundations.

The temporary ground anchors will be destressed/removed after construction of the permanent floor slabs. The soldier pile wall with shotcrete infill and floor slabs are to form the permanent retention system.

8.3 Indicative monitoring requirements

We recommend that monitoring of deformations of the walls of the excavation be undertaken at regular intervals during construction. The performance of the retaining wall and response of the adjacent building during excavation should be monitored with suitable monitoring regime and systems, which can consist of three-dimensional survey targets/monitoring points, settlement monitoring points, and/or inclinometers.

Groundwater monitoring well(s) might be required depending on the requirements by council for a drained basement to monitor the groundwater drawdown.

The settlement monitoring points and groundwater wells should be installed and monitored prior to the commencement of excavation works. The survey targets should be attached to the shotcrete, between anchor heads as soon as practical after the construction of the wall to the level at which the targets will be located.

Due to the proximity of the excavation to the building adjacent to the north-west of the site, the building is expected to be susceptible to damage from vibrations when rock excavations are made in the immediate vicinity. We anticipate vibration monitoring would be required to verify allowable limits is achieved on site.

If requested, we can develop a Geotechnical Monitoring Programme presenting:

- Monitoring and instrumentation requirements.
- Recommended hold points and trigger levels of all monitoring systems; and

- Details of action plan and contingency for the principal building contractor in the event trigger levels are exceeded.

9.0 IMPORTANT INFORMATION

Your attention is drawn to the document “Important Information”, which is attached to APPENDIX C of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be and to present you with recommendations on how to minimise the risks associated with the services provided for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

Yours sincerely,

Golder Associates Pty Ltd

Eric Woon
Senior Geotechnical Engineer

Bernie Francis
Principal Geotechnical Engineer

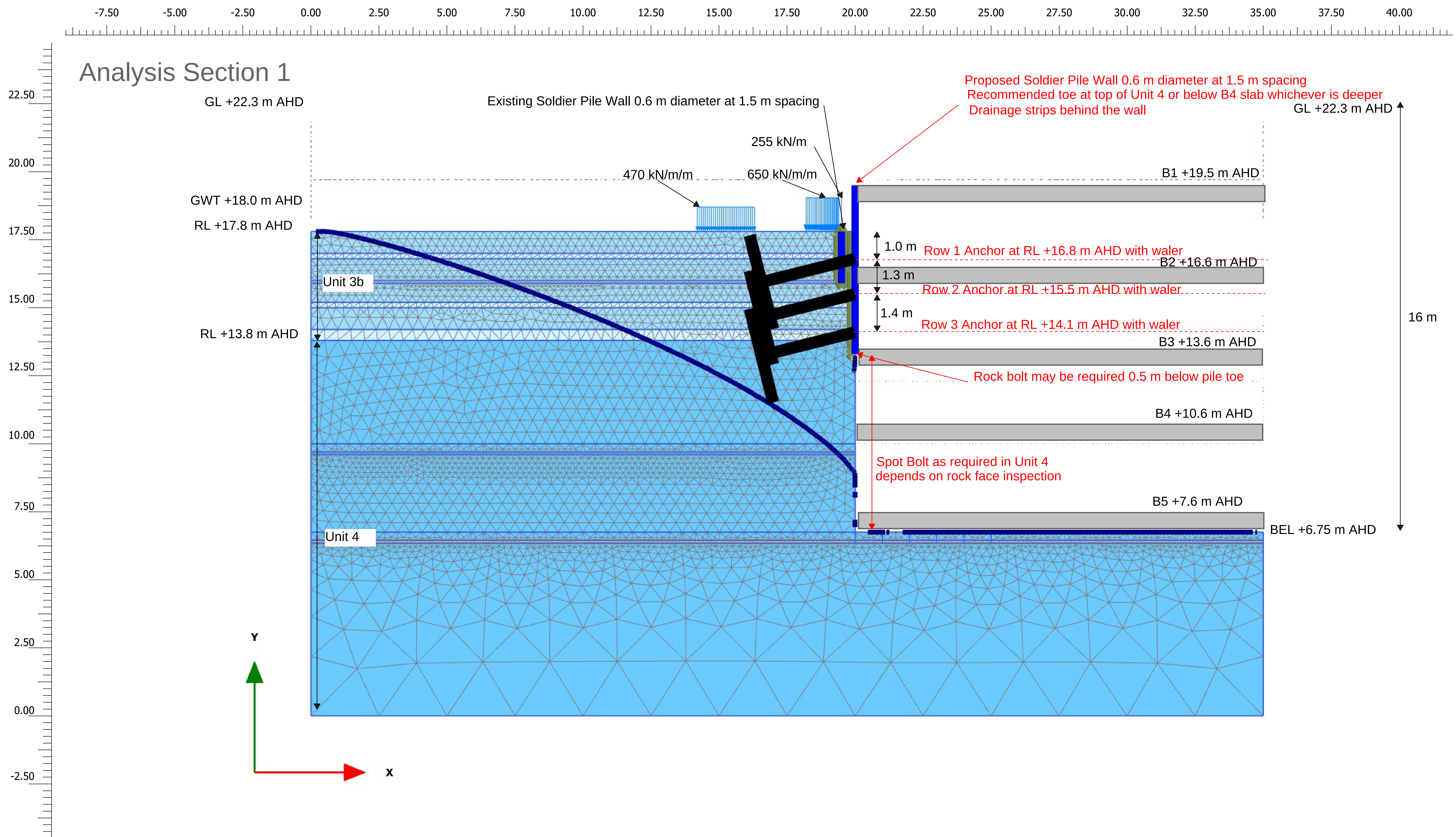
EW/BJF/it:ew

https://golderassociates.sharepoint.com/sites/112254/project files/6 deliverables/002-r-additional geo assessment/19125312-002-l-rev1 additional geo assessment.docx

APPENDIX A

Analysis Outputs for Section 1

Output Version 20.3.0.60



Notes:
1. The reduced levels and length shown are indicatively only.

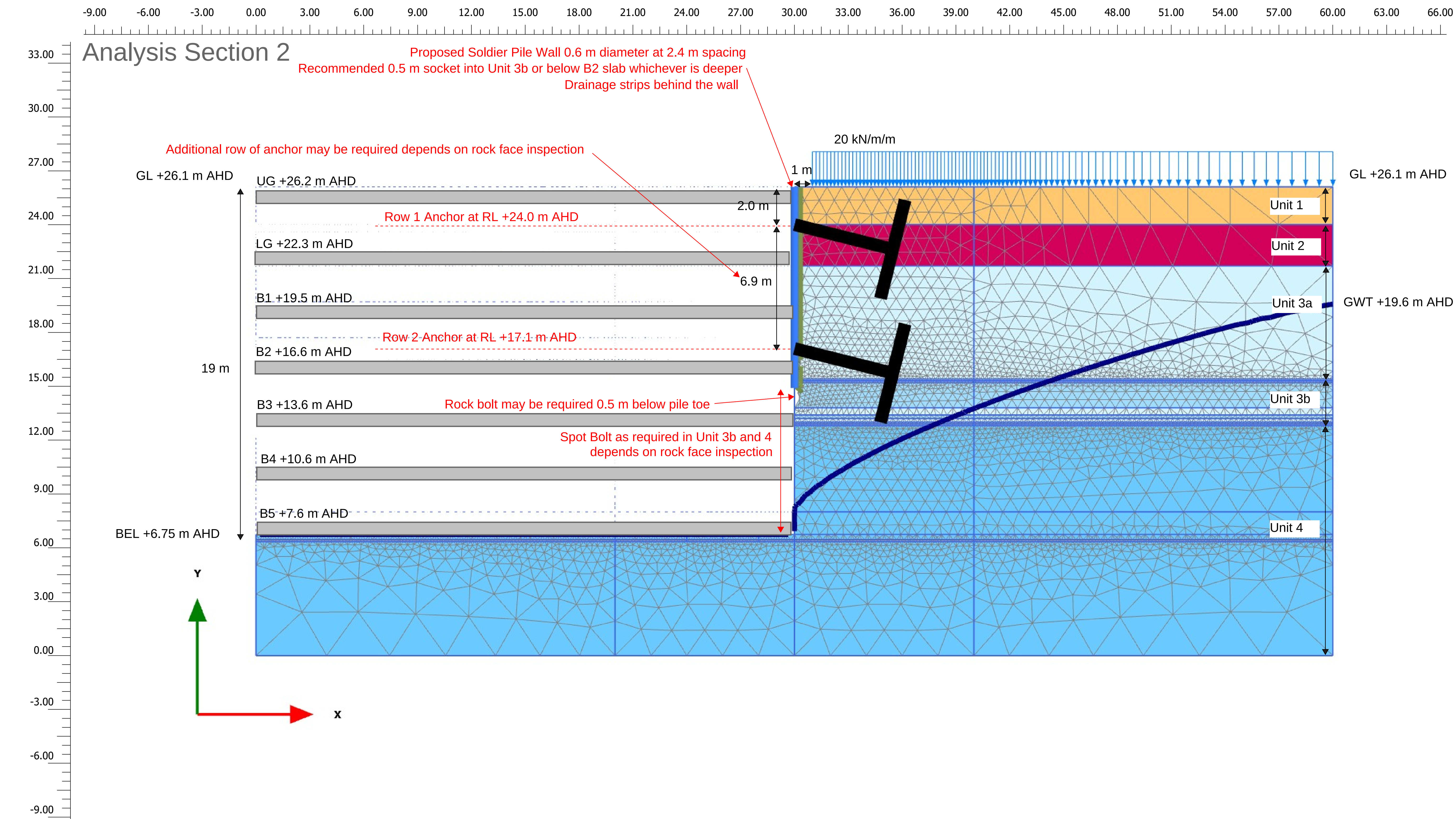
Project description		Date
Liverpool Civic Place - Analysis Section 1		8/31/2020

Project filename	Step	Company
LCP - Sec 1 -Permanent_Rev4a	179	Golder Associates Pty Ltd

GOLDER

APPENDIX B

Analysis Outputs for Section 2



Notes:
1. The reduced levels and length shown are indicatively only.

GOLDER	*Project description* Liverpool Civic Place - Analysis Section 2		*Date* 8/31/2020
	Project filename LCP - Sec 2 - Permanent_Rev4a	*Step* 89	*Company* Golder Associates Pty Ltd

APPENDIX C

Important Information

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification