GEOTECHNICAL ASSESSMENT REPORT

No. 43 Old Pittwater Road
Brookvale, NSW

Prepared for

Enhance Group Project Pty Ltd

Reference No. ESWN-PR-2018-280

21st August 2018

Geotechnical Engineering Services

- Geotechnical investigation
- Lot classification
- Geotechnical design
- Footing inspections
- Excavation methodology and monitoring plans
- Slope stability and landslide risk assessment
- Permeability test
- Waste classification

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Date: 21/08/2018 ....

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REFERENCES

1. Australian Standard – AS 1726-2017 Geotechnical Site Investigation.
2. Australian Standard – AS 2870-2011 Residential Slabs and Footings.
3. Australian Standard – AS 2159-2009 Piling - Design and Installation.
4. Australian Standard – AS 3798-2007 Guidelines on Earthworks for Commercial and Residential Developments.
5. Australian Standard – AS 1170.4-2007 Structural Design Actions – Part 4: Earthquake actions in Australia.
6. Austroads – "Pavement Design – A Guide to the Structural Design of Road Pavements", 2004.
7. "NSW WorkCover: Code of Practice – Excavation" July 2015.
8. Pells, P.J.N, Mostyn, G. & Walker B.F., "Foundations on Sandstone and Shale in the Sydney Region", Australian Geomechanics Journal, 1998.
9. CSIRO, BTF 18 - "Foundation Maintenance and Footing Performance: A Homeowner's Guide".

1. INTRODUCTION

ESWNMAN Pty Ltd (ESWNMAN) was commissioned by Enhance Group Project Pty Ltd to undertake a geotechnical investigation at No. 43 Old Pittwater Road, Brookvale, NSW 2100 in a Professional Services Agreement referenced ESWN-PP-2018-358 and dated 27th July 2018. The fieldwork was completed on 10th August 2018.

The purpose of the geotechnical investigation was to assess the feasibility of the site in geotechnical prospective for the proposed development.

This report presents results of geotechnical investigation, interpretation, assessment, and provides comments on geotechnical related issues and recommendations.

1.1 Available Information

The following information was provided to ESWNMAN prior to the fieldwork:

- Architectural plan titled "43 Old Pittwater Road, Brookvale, NSW 2100" prepared by Enhance Group Project Pty Ltd, referenced Job No. HH01, including drawing nos. DA012, DA090, DA100, DA101, DA102, DA103, DA300 & DA301, Revision A and dated 7th August 2018;
- A Survey plan titled "Detail and Level Survey of Lot 18 in DP35184, No. 43 Old Pittwater Road, Brookvale" prepared by SDG, Referenced 7701, drawing No. A1, Issue A and dated 5th July 2018.

1.2 Proposed Development

Based on the information provided in Section 1.1, the proposed development will comprise the demolition of existing structures and construction of a two-storey dwelling, with one basement level for underground carparking areas.

The following approximate setbacks were proposed from basement wall to site boundaries:

- 5.5m from site northern boundary;
- 3.5m from site eastern boundary;
- 2.0m from site southern boundary; and
- 2.0m from site western boundary.

The Finished Floor Level(FFL) for Basement Floor Level is proposed at RL12.6m. Based on proposed FFL at basement floor level and existing ground levels shown on the survey plan, the approximate excavation depths between 2.9m and 3.8m are expected to be required for the proposed basement level.

Other earthworks and excavation during construction may include the following:

- Excavation for driveway ramp from street entry to basement level;
- Excavation within structural footing areas (shallow footings or piles);
- Installation of underground water/sewer/stormwater pipes; and
- Subgrade preparation for driveway, footpath and pavement areas.

1.3 Scope of Work

The geotechnical investigation was carried out by ESWNMAN staff supervised by an experienced Geotechnical Engineer, including the following:

- Collection and review of Dial-Before-You-Dig (DBYD) plans;
- A site walkover to assess the surface conditions, identify relevant site features and nominate borehole and testing locations;
- Augering of four(4) boreholes, identified as BHs 1 and BH4 inclusive, using a hand operated equipment;
- Undertaking Dynamic Cone Penetrometer (DCP) Tests at four(4) locations next to boreholes, identified as DCPs 1 to 4; and
- Reinstatement of site with soil cuttings from boreholes.

The approximate locations of boreholes and DCP tests completed during site investigation are shown on a site location plan as included in Appendix A of this report.

2. SITE DESCRIPTION

The site is located within Northern Beaches Council area, approximately 13.3km to the north of Sydney CBD, 520m to the west of Brookvale Public School, 510m to the east of Allenby Park, and 175m to the northeast of Brookvale Creek.

At time of site investigation, the site was occupied by a single storey weatherboard residence. The site is a semi rectangular-shaped land, with an approximate area of 613.4m^2 comprised Lot 18 in Deposited Plan (DP)35184, and is bounded by the following properties and infrastructure:

- North: Carriageway and road reserve of Old Pittwater Road;
- East: Carriageway and road reserve of Funda Place;
- South: Single storey brick house at No. 45-49 Old Pittwater Road; and
- West: Single and double storey brick houses at No. 45-49 Old Pittwater Road.

Based on the survey plan referenced in Section 1.1, the site is generally flat and slightly sloping towards south, with a slope angle of 4° on average. The surface elevations are between RL16.24m and RL16.61m along site northern boundary, and vary between RL15.32m and RL15.46m along site southern boundary.

Selected site photographs recorded during site investigation are provided in Appendix B.

3. LOCAL GEOLOGY

Reference to the Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1), dated 1983, by the Geological Survey of New South Wales, Department of Mineral Resources, indicates the site is located within an area underlain by Hawkesbury Sandstone (Rh). The Hawkesbury Sandstone is described as "Medium to coarse-grained quartz sandstone, very minor shale and laminite lenses".

The geological map also indicates the site is also very close to another geological unit, i.e. Quaternary Deposit (Qha), which consists of "Silty to peaty quartz sand, silt, and clay. Ferruginous and humic cementation in places. Common shell layers".

Results of the investigation as provided in Section 5.2 confirmed the published geology.

4. METHODOLOGY OF INVESTIGATION

4.1 Pre-fieldwork

Prior to the commencement of the fieldwork, a site Safety Work Method Statement (SWMS) was prepared, which identifies potential hazards associated with the fieldwork and various control measures implemented to mitigate the hazards.

A 'Dial Before You Dig' (DBYD) services search, which forms a part of the SWMS, was also conducted and reviewed prior to the commencement of fieldwork.

4.2 Borehole Drilling

Four(4) boreholes were drilled on 10th August 2018 and extended to a final depth of 1.5m below existing ground level (BGL) and terminated to the refusal by hand augering.

The locations of boreholes are shown on the site location plan attached in Appendix A. Engineering logs of boreholes processed using Bentley gINT software along with an explanatory note are presented in Appendix C.

4.3 Dynamic Cone Penetrometer (DCP) Test

A total of four(4) DCP tests, identified as DCPs 1 to 4 located next to boreholes, were also completed during site investigation. The DCP tests reached refusal depth and bounce of hammer occurred at approximate depth between 2.1m and 3.5m BGL.

The locations of DCP tests are shown on the site location plan attached in Appendix A. The record of DCP test results is presented in Appendix D.

All fieldwork was supervised on a full time basis by an experienced Geotechnical Engineer who was responsible for nominating locations of boreholes and DCP tests, preparing field engineering logs of the subsurface strata encountered in accordance with AS 1726 for

Geotechnical Site Investigation, undertaking geological mapping of rock outcrops, taking site photographs and conducting SWMS procedures.

The approximate reduced levels of the boreholes, which were estimated based on the survey plan as referenced in Section 1.1, are presented in the attached Engineering logs.

5. INVESTIGATION RESULTS

5.1 Surface Conditions

During site investigation, apart from existing single storey weatherboard residence, a fibro cement shed, timber walkways and concrete path, the reminder of outdoor areas was covered grass and garden areas. One mature tree and several young trees were present within the front garden and along site northern or front boundary.

5.2 Subsurface Conditions

Based on borehole information and results of DCP test, the subsurface conditions encountered at testing locations consisted of the following:

- Fill (Unit 1): Clayey SAND, fine grained, grey, dry-moist, some gravel, some rootlets associated with topsoil, approximately 0.3m to 0.4m in thickness; overlying
- Alluvium (Unit 2): SAND, fine-medium grained, brown, moist, loose to medium dense, extending to a depth between 1.2m and 2.2m BGL; overlying
- Residual Soils (Unit 3): Clayey SAND, medium grained, brown, moist, dense to very dense, inferred to extend on top of rock; overlying
- Weathered Sandstone (Unit 4): extremely weathered, extremely low strength, inferred based on results of DCP test, which indicate the depth to top of rock is approximately at 3.1m, 3.5m, 2.2m and 2.6m BGL at location of DCPs 1 to 4 respectively.

The classification of rock was carried out in accordance with Pells et al (Reference 8). The geotechnical units and inferred depths to top of each unit are provided in Table 1 overleaf.

Table 1 – Subsurface Conditions at Testing Locations

Geotechnical Unit and Description		**Inferred Depth to Top of Unit** (m, BGL)			
		Rear garden		Front garden	
		BH1/ DCP1	BH2/ DCP2	BH3/ DCP3	BH4/ DCP4
Fill (Unit 1)	Clayey SAND, loose, topsoil	0	0	0	0
Alluvium (Unit 2)	SAND, loose to medium dense	0.4	0.3	0.3	0.3
Residual Soils (Unit 3)	Clayey SAND, dense to very dense	2.2	2.2	1.1	1.5
Weathered Sandstone (Unit 4)	Class V SANDSTONE, extremely weathered, extremely low strength	3.1	3.5	2.1	2.6
Approximate RL at ground surface (m, AHD)		15.5	15.5	16.4	16.1

5.3 Groundwater

No groundwater was encountered during drilling up to 1.5m BGL and no indication of water seepage/inflow during DCP testing up to 3.5m BGL when DCP rods were extracted onto ground surface upon completion of DCP test.

It is inferred that natural groundwater level may be deeper than depth of investigation at this site and likely in the form of minor seepage through natural defects within underlying sandstone, such as, joints, fractured zones, beddings, etc., subject to seasonal and daily fluctuations due to rainfalls.

Based on the local topography, it is inferred that natural groundwater (if any) may flow to the south and southwest towards Brookvale Creek.

6. GEOTECHNICAL ASSESSMENT

The main geotechnical aspects associated with the proposed development are assessed to include the following:

- Site classifications;
- Excavation conditions;
- Excavation stability/excavation support;
- Earth retaining structures;
- Foundations;
- Earthworks and material reuse; and
- Comments on pavement subgrade.

The assessment of the geotechnical aspects as listed on the above and recommendations for the proposed development are presented in the following sections.

6.1 Site Classifications

(a) Site reactive classification

Based on ground profile of the site and the criteria specified in AS 2870 (Reference 2), the site can be assessed as Class A - "Most sand and rock sites with little or no ground movement from moisture changes".

The above classification and footing recommendations are provided on the basis that the performance expectations set out in Appendix B of AS2870 are accepted.

Design, construction and maintenance of plumbing, ground drainage, protection of building perimeter, the garden, etc. should be carried out in accordance with CSIRO BTF18 (Reference 9) to avoid any water related problems or significant changes of moisture in building foundations, which may contribute to surface movement.

(b) Site earthquake classification

The results of the site investigation indicate the presence of fill, natural soils, underlain by Class V Sandstone or better rock. In accordance with Australian Standard AS 1170.4 (Reference 5), the site may be classified as a "Rock site" (Class B_e) for design of foundations and retaining walls embedded in the underlying Sandstone. The Hazard Factor (Z) for Sydney in accordance with AS 1170.4 is considered to be 0.08.

6.2 Excavation Conditions

Based on information provided in Section 1.2, excavation between 2.9m and 3.8m will likely be required during excavation of proposed basement level.

The observations and results of boreholes indicate the presence of fill, alluvium, residual soils and minor sandstone during excavation. Any fill and deleterious materials, including old footings/buried structures, plant/tree roots, redundant services, tiles, timber/brick material, and boulders, are expected to be stripped and removed from development area to spoils.

Based on information in Section 5.3, it is unlikely to encounter groundwater during excavation of proposed basement.

Excavation of the soils, low strength Class V Sandstone would be feasible using conventional earthmoving equipment. Heavy ripping and rock breaking equipment or vibratory rock breaking equipment is expected to be required for excavation in medium strength Class IV Sandstone or higher strength rock, which maybe encountered locally.

To ensure vibration levels remain within acceptable levels and minimise the potential effects of vibration, **excavation into Class IV Sandstone to Class III Sandstone should be carried out in a controlled & careful manner, and complemented with saw cutting or other appropriate methods prior to excavation. Rock saw cutting should be carried out using an excavator mounted rock saw, or the like, so as to minimise transmission of vibrations to any adjoining properties that may be affected.** Hammering is not recommended and should be avoided. However, if necessary, hammering should be carried out horizontally along bedding planes of (pre-cut) broken rock blocks or boulders where possible with noise levels restricted to acceptable to comfortable limits to adjacent residents.

6.3 Excavation Support / Stability of Basement Excavation

(a) ***Shallow Excavation*** (i.e. <1.0m in Depth)

The excavations should be carried out in accordance with the 'NSW WorkCover: Code of Practice – Excavation' July 2015.

Temporary excavations through the underlying soils to a maximum depth of 1.0m, may be excavated near vertical provided that:

- They are barricaded when not in use;
- They are not left open for more than 24 hours;
- No surcharge loading is applied within 1.5m of the edge of the excavation;
- No groundwater flows are encountered; and
- They are not used for access by a worker.

Where access is required for workers, the temporary excavation batters should be re-graded to no steeper than 2.5 Horizontal (H) to 1 Vertical (V) for the soils above the natural groundwater level, or supported by a suitable temporary shoring measure.

Any permanent excavation (or filling) greater than 0.5m in height should be retained by a permanent retaining wall to be designed based on the recommendation provided in Section 6.4 of this report.

(a) ***Deep Excavations*** (i.e. >1.0 m in Depth)

If required, any excavation batters in soils greater than 1.0 m in depth, the temporary safe batters for excavated slopes in Table 2 can be adopted under dry conditions:

Table 2 - Recommended Safe Excavation Batters[1]

Geotechnical Unit	Maximum Batter Angle	
	Temporary	**Permanent**
Fill (Unit 1)	2.5H:1V	3.0H:1V
Alluvium (Unit 2)	2.0H:1V	2.5H:1V
Residual Soils (Unit 3)	1.5H:1V	2.0H:1V
Weathered Sandstone (Unit 4)	Vertical, self-supporting, shotcrete if necessary[2]	Vertical, with reinforced shotcrete, localised rock bolts

Notes:
[1] - Typical temporary batters of excavated slopes (Hoerner, 1990).
[2] - The requirement for shotcrete to be assessed by a Geotechnical Engineer during excavation.

Based on proposed setbacks as mentioned in Section 1.2, we assessed that excavation using safe batters recommended in Table 2 are likely applicable for excavation along northern basement wall. Basement excavation along other site boundaries using safe batters on the above may not be practical. Therefore, we recommend the following shoring measures for basement excavation:

- Solider pile wall; or
- Contiguous piles.

Other alternative shoring options may be considered subject to assessment by the project Structural Engineer in consultation with the project Geotechnical Engineer.

Inspections of the excavation stability, safe batters adopted and shoring measures by a Geotechnical Engineer during construction will be required.

Earth retention structures can be designed using the recommended parameters provided in Section 6.4.

With the recommended safe excavation batters, shoring/support measures above, construction of the proposed basement in the short and long terms is expected to have no impacts on the adjoining buildings, roads and infrastructure.

6.4 Earth Retaining Structures

The earth retaining structure should be designed to withstand the applied lateral pressures of the subsurface layers, the existing surcharges in their zone of influence, including existing structures, construction machines, traffic and construction related activities. The design of retaining structures should also take into consideration hydrostatic pressures and lateral earthquake loads as appropriate.

The recommended preliminary parameters for the design of retaining structures are presented in Tables 3 and 4 below. The coefficients provided are based on drained conditions.

Table 3 - Preliminary Geotechnical Design Parameters for Retaining Walls

Geotechnical Unit	Unit Weight (kN/m^3)	Effective Cohesion c′ (kPa)	Angle of Effective Internal Friction ϕ'(°)	Modulus of Elasticity E_{sh} (MPa)	Poisson Ratio ν
Fill & Alluvium (Units 1 & 2)	17	0	30	8	0.35
Residual Soils (Unit 3)	18	2	28	15	0.35
Class V Sandstone (Unit 4)	24	150	35	200	0.30

Table 4 - Preliminary Coefficients of Lateral Earth Pressure

Geotechnical Unit	Coefficient of Active Lateral Earth Pressure (Ka)	Coefficient of Active Lateral Earth Pressure at Rest (Ko)	Coefficient of Passive Lateral Earth Pressure (Kp)
Fill & Alluvium (Units 1 & 2)	0.33	0.50	3.0
Residual Soils (Unit 3)	0.36	0.53	2.8
Class V Sandstone (Unit 4)	0.27	0.43	3.7

For design of soils nails or temporary ground anchors, the allowable bond stress of 25kPa for Alluvium/Residual Soils (Units 2 & 3), and 100kPa for Class V Sandstone (Unit 4) can be adopted. The following is recommended for the anchor design:

- Anchor bond length of at least 3m behind the “active” zone of the excavation;
- Overall stability of anchor system and interaction is satisfactory; and
- The anchors are proof loaded to at least 1.3 times the design working load before locking off at working load.

6.5 Foundations

Based on the information provided on the proposed development and subsurface conditions, we assessed that the majority of basement area at proposed FFL will be occupied by dense to very dense SAND (Unit 3) or Class V Sandstone (Unit 4).

Therefore, we assessed that a foundation system consisting of cast-in-situ reinforced concrete shallow foundations, such as raft slab/pad or strip footings under columns and walls, would be applicable for the proposed development at this site.

Piles are likely to be required for shoring wall system. Bored pile can be adopted for this site. However, the drilled holes should be protected and stabilised using a metal liner due to presence of loose sand materials.

The preliminary geotechnical parameters recommended for design of shallow footings and piers/piled foundations are provided in Table 5 below.

Table 5 - Preliminary Geotechnical Foundation Design Parameters

Geotechnical Unit	Allowable Bearing Capacity (kPa[1])	Allowable Shaft Adhesion (kPa)	Modulus of Elasticity Es,v MPa)
Fill (Unit 1)	N/A[2]	N/A[2]	5
Alluvium (Unit 2)	N/A[2]	N/A[2]	15
Residual Soils (Unit 3)	200 (Shallow footings /raft slab)	20	35
Class V Sandstone (Unit 4)	600 (shallow footings) 800 (piers/piles)	30	100

[1] With a minimum embedment depth of 0.3m into Class V Sandstone for shallow footings & 0.5m for piers/piles.
[2] N/A, being excavated, Not Applicable, not recommended for this development.

Design of shallow and piers/piled foundations should be carried out in accordance with Australian Standards AS2870 (Reference 2) and AS2159 (Reference 3).

To minimise the potential effects of differential settlement under the buildings loads, it is recommended all foundations of the proposed building should be founded on consistent materials of similar properties or rock of similar class.

Any loose materials/debris and wet material within footing areas should be removed prior to pouring of concrete.

An experienced Geotechnical Engineer should be engaged to inspect footing excavations to ensure foundation bases have suitable materials with adequate bearing capacity, and to check the adequacy of footing embedment depth. Verification of embedment depth, founding material and bearing capacity of foundation material by inspections would be required and inspections should constitute as "Hold Points".

6.7 Groundwater Assessment and Measures

The observations summarised in Section 5.3 indicate no groundwater during drilling up to 1.5m depth and DCP testing up to 3.5m BGL. During excavation and construction of the proposed basement, it is unlikely to encounter groundwater. Nevertheless, it would be prudent at this stage of the design to allow for precautionary drainage measures in the design and construction of the proposed basement level. As a guidance, such measures may include the following:

- Strip drains or drainage materials to be installed behind the retaining walls.
- Collection trenches or pipes and pits connected to the building stormwater system. A stormwater storage tank and pump system may be required.
- The basement walls and floor to be constructed with water-tight construction joints.
- The basement walls and slabs should be designed to withstand hydrostatic pressures taking into consideration the potential for seepage.

6.8 Comments on Earthworks and Material Reuse

The materials from excavation are assessed to be generally suitable for landscaping provided they are free of any contaminants. The suitability of the excavated materials for reuse should be subject to satisfying the following criteria:

- The materials should be clean (i.e. free of contaminants, deleterious or organic material), free of inclusions of >75mm in size, high plasticity material be removed and suitably conditioned to meet the design assumptions where fill material is proposed to be used.
- The materials should satisfy the Australian Standard AS 3798 Guidelines on Earthworks for Commercial and Residential Developments (Reference 4).

The final surface levels of all excavation and filling areas should be compacted in order to create achieve subgrades of adequate strength for the proposed building platforms, water/sewer/stormwater pipes, driveway and pavement area, and other infrastructure.

As a guidance for fill construction, the following compaction targets can be adopted:

- Moisture content of ±2% of OMC (Optimal Moisture Content);

- Minimum density ratio of 100% of the maximum dry density (MDD) for filling within building/structural footing areas;
- Minimum density ratio of 98% of MDD for backfilling surrounding the pipes within trenches;
- The loose thickness of layer should not exceed 250mm for cohesionless soils; and
- For the driveway/footpath/pavement areas (if any), minimum density ratio of 95% of MDD for general fill and 98% for the subgrade to 0.5m depth.

Design and construction of earthworks should be carried out in accordance with Australian Standard AS 3798 (Reference 4).

6.9 Preliminary Comments on Pavement Subgrade

It is recommended that pavement be designed on a CBR value of 5% on medium dense sand subgrade, based on the results of DCP tests.

Topsoil and any deleterious material should be removed prior to pavement construction. Loose fill materials as indicated by low DCP test results (DCP value <2) may present within the site, as confirmed by a site inspection and in-situ testing, should be either removed or improved by compaction in order to increase the strength of the material. The final levels of subgrade should be proof rolled and inspected by a Geotechnical Engineer.

If require, pavement design should be carried out in accordance with "Pavement Design – A Guide to the Structural Design of Road Pavements" (Reference 6) and should be complemented by the provision of adequate surface and subsurface drainage.

7. CONCLUSIONS AND RECOMMENDATIONS

The results of the geotechnical site investigation and assessment for this site indicate the ground conditions are suitable for the proposed development.

Based on ground profile of the site and the criteria specified in AS 2870, the site can be assessed as Class A. Cast-in-situ reinforced concrete shallow foundations, such as raft slab/pad or strip footings under columns and walls, would be applicable for the proposed development with basement.

The construction, including filling, excavation, safe batter, excavation support/shoring measures, retaining wall, and drainage works, should be implemented in accordance with the recommendations provided in Section 6.

To minimise the potential effects of differential settlement under the buildings loads, it is recommended all foundations of the proposed building should be founded on consistent materials of similar properties or rock of similar class. The final levels of subgrade should be tested/proof rolled and inspected by a Geotechnical Engineer.

It is recommended that an experienced Geotechnical Engineer should be engaged to inspect footing excavations to ensure the foundation base have been taken to suitable materials of appropriate bearing capacity and adequate embedment depth.

It is recommended the final civil and structural design drawings for the proposed development should be provided to us for further assessment and confirmation of suitable mitigation measures, foundation system and embedment depth, retaining walls and drainage systems.

8. LIMITATIONS

This report should be read in conjunction with the "Limitations of Geotechnical Investigation Statement" attached as Appendix E, which provides important information regarding geotechnical investigation, assessment and reporting. If the actual subsurface conditions exposed during construction vary significantly from those discussed in this report, this report should be reviewed, and the undersigned should be contacted for further advices.

For and on behalf of
ESWNMAN Pty Ltd

Yours sincerely,

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ESWNMAN
25 YEARS EXPERIENCE

APPENDIX A

SITE LOCATION PLAN

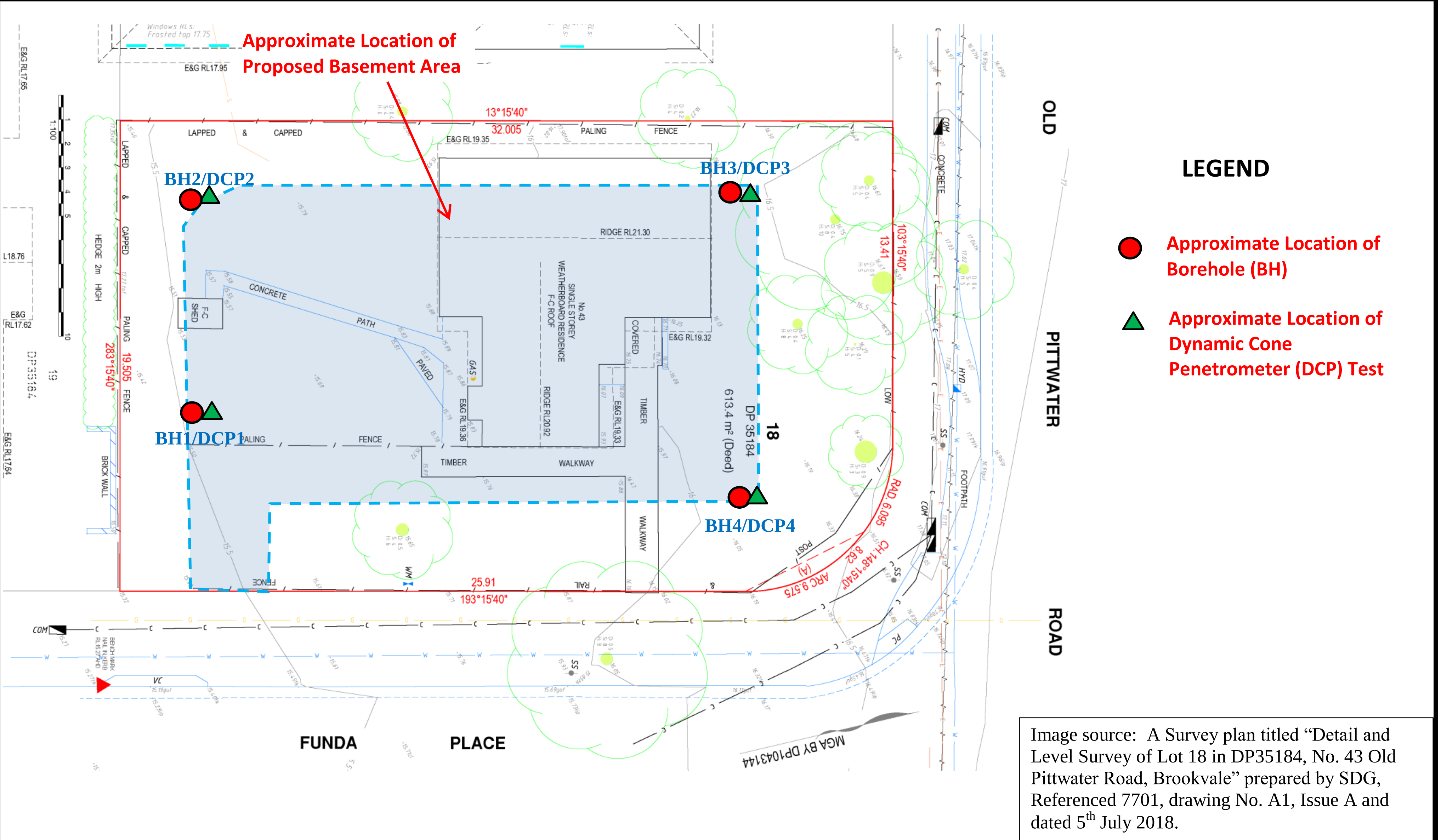

Image source: A Survey plan titled "Detail and Level Survey of Lot 18 in DP35184, No. 43 Old Pittwater Road, Brookvale" prepared by SDG, Referenced 7701, drawing No. A1, Issue A and dated 5th July 2018.

PROJECT: 43 Old Pittwater Road, Brookvale, NSW	**DRAWN BY:** J.L.	ESWNMAN 25 YEARS EXPERIENCE	**CLIENT:** Enhance Group Project Pty Ltd
PROJECT NO: ESWN-PR-2018-280	**DATE:** 14th August 2018		**TITLE:** Site Location Plan — Figure 1

APPENDIX B

SITE PHOTOGRAPHS

Photograph 1
View of rear garden and existing dwelling facing north

Photograph 2
Drilling in progress at location of BH1/DCP1 within rear garden

Photograph 3
Drilling at location of borehole BH2 within rear garden

Photograph 4
Dynamic Cone Penetrometer (DCP) Test and drilling at location of DCP2 within rear garden

Photograph 5
DCP test in progress at location of BH1/DCP1 within rear garden

Photograph 6
DCP test at location of BH3/DCP3 within front garden

Appendix B Site Photographs

APPENDIX C

ENGINGGERING BOREHOLE LOGS

AND EXPLANATORY NOTES

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BOREHOLE NUMBER BH1

CLIENT Enhance Group Project Pty Ltd
PROJECT NAME Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2018-280
PROJECT LOCATION 43 Old Pittwater Road, Brookvale, NSW

DATE STARTED 10/8/18 **COMPLETED** 10/8/18
R.L. SURFACE 15.5 **DATUM** m AHD
DRILLING CONTRACTOR ESWNMAN Pty Ltd
SLOPE 90° **BEARING** ---
EQUIPMENT Hand Auger & DCP
HOLE LOCATION Refer to Figure 1 Site Location Plan
HOLE SIZE 70mm
LOGGED BY Y.N. **CHECKED BY** J.L.
NOTES Rear garden

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered				SC	Clayey SAND, medium grained, grey, dry-moist, trace glass and gravel, very loose.		FILL
		15.0	0.5		SC	SAND, medium grained, grey-brown, moist, loose to medium dense.		ALLUVIUM
		14.5	1.0					
						- becoming medium dense at 1.1m depth		
		14.0	1.5					DCP test indicates top of rock at 3.1m depth
						Borehole BH1 terminated at 1.5m		
		13.5	2.0					

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BOREHOLE NUMBER BH2

CLIENT Enhance Group Project Pty Ltd
PROJECT NAME Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2018-280
PROJECT LOCATION 43 Old Pittwater Road, Brookvale, NSW

DATE STARTED 10/8/18 **COMPLETED** 10/8/18 **R.L. SURFACE** 15.5 **DATUM** m AHD
DRILLING CONTRACTOR ESWNMAN Pty Ltd **SLOPE** 90° **BEARING** ---
EQUIPMENT Hand Auger & DCP **HOLE LOCATION** Refer to Figure 1 Site Location Plan
HOLE SIZE 70mm **LOGGED BY** Y.N. **CHECKED BY** J.L.
NOTES Rear garden

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered				SC	Clayey SAND, medium grained, grey, dry-moist, trace glass and gravel, very loose.		FILL
		15.0	0.5		SC	SAND, medium grained, grey-brown, moist, loose.		ALLUVIUM
		14.5	1.0					
		14.0	1.5					DCP test indicates top of rock at 3.5m depth
						Borehole BH2 terminated at 1.5m		
		13.5	2.0					

ESWNMAN PTY LTD
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Ashfield NSW 1800
Telephone: 0279015582

BOREHOLE NUMBER BH3

CLIENT Enhance Group Project Pty Ltd
PROJECT NAME Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2018-280
PROJECT LOCATION 43 Old Pittwater Road, Brookvale, NSW

DATE STARTED 10/8/18 **COMPLETED** 10/8/18 **R.L. SURFACE** 16.4 **DATUM** m AHD
DRILLING CONTRACTOR ESWNMAN Pty Ltd **SLOPE** 90° **BEARING** ---
EQUIPMENT Hand Auger & DCP **HOLE LOCATION** Refer to Figure 1 Site Location Plan
HOLE SIZE 70mm **LOGGED BY** Y.N. **CHECKED BY** J.L.
NOTES Front garden

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered				SC	Clayey SAND, medium grained, grey, dry-moist, trace glass and gravel, very loose.		FILL
		16.0	0.5		SC	SAND, medium grained, grey-brown, moist, loose to medium dense.		ALLUVIUM
		15.5	1.0					
		15.0			SC	Clayey SAND, medium grained, brown, moist, dense.		RESIDUAL SOILS DCP test indicates top of rock at 2.1m depth
			1.5			Borehole BH3 terminated at 1.5m		
		14.5	2.0					

BOREHOLE NUMBER BH4

ESWNMAN 25 YEARS EXPERIENCE
ESWNMAN PTY LTD
PO Box 6
Ashfield NSW 1800
Telephone: 0279015582

CLIENT Enhance Group Project Pty Ltd
PROJECT NAME Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2018-280
PROJECT LOCATION 43 Old Pittwater Road, Brookvale, NSW

DATE STARTED 10/8/18 **COMPLETED** 10/8/18 **R.L. SURFACE** 16.1 **DATUM** m AHD
DRILLING CONTRACTOR ESWNMAN Pty Ltd **SLOPE** 90° **BEARING** ---
EQUIPMENT Hand Auger & DCP **HOLE LOCATION** Refer to Figure 1 Site Location Plan
HOLE SIZE 70mm **LOGGED BY** Y.N. **CHECKED BY** J.L.
NOTES Front garden

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered	16.0	0.0		SC	SAND, fine-medium grained, grey, dry-moist, some clay, very loose.		FILL
		15.5, 15.0	0.5, 1.0		SC	SAND, medium grained, grey-brown, moist, loose to medium dense.		ALLUVIUM DCP test indicates top of rock at 2.6m depth
		14.5	1.5, 2.0			Borehole BH4 terminated at 1.5m		

Explanatory Notes – Description for Soil

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer .

METHOD

Method	Description
AS	Auger Screwing
BH	Backhoe
CT	Cable Tool Rig
EE	Existing Excavation/Cutting
EX	Excavator
HA	Hand Auger
HQ	Diamond Core-63mm
JET	Jetting
NMLC	Diamond Core –52mm
NQ	Diamond Core –47mm
PT	Push Tube
RAB	Rotary Air Blast
RB	Rotary Blade
RT	Rotary Tricone Bit
TC	Auger TC Bit
V	Auger V Bit
WB	Washbore
DT	Diatube

WATER

Water level at date shown

Partial water loss

Water inflow

Complete water loss

NFGWO: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

NFGWE: The borehole/test pit was dry soon after excavation. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING

Sample	Description
B	Bulk Disturbed Sample
D	Disturbed Sample
Jar	Jar Sample
SPT	Standard Penetration Test
U50	Undisturbed Sample –50mm
U75	Undisturbed Sample –75mm

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty Soil

MOISTURE CONDITION

Dry - Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist - Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet - Cohesive soils usually weakened
Free water forms on hands when handling

For cohesive soils the following codes may also be used:

MC>PL Moisture Content greater than the Plastic Limit.
MC~PL Moisture Content near the Plastic Limit.
MC<PL Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

Description of Plasticity	LL (%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS - CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by hand penetrometer values and by resistance to deformation to hand moulding.

A Hand Penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. The undrained shear strength of cohesive soils is approximately half the UCS. The values are recorded in kPa as follows:

Strength	Symbol	Undrained Shear Strength, C_u (kPa)
Very Soft	VS	< 12
Soft	S	12 to 25
Firm	F	25 to 50
Stiff	St	50 to 100
Very Stiff	VSt	100 to 200
Hard	H	> 200

COHESIONLESS SOILS - RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

Term	Symbol	Density Index	N Value (blows/0.3 m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS PARTICLE SIZE DESCRIPTIVE TERMS

Name	Subdivision	Size
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

Description for Rock

The rock is described with strength and weathering symbols as shown below. Other features such as bedding and dip angle are given.

METHOD

Refer soil description sheet

WATER

Refer soil description sheet

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

$$TCR\ (\%) = \frac{\text{length of core recovered}}{\text{length of core run}}$$

$$RQD\ (\%) = \frac{\text{Sum of Axial lengths of core > 100mm long}}{\text{length of core run}}$$

ROCK MATERIAL WEATHERING

Rock weathering is described using the abbreviations and definitions used in AS1726. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between (but not including) XW and SW. For projects where it is not practical to delineate between HW and MW or it is deemed that there is no advantage in making such a distinction, DW may be used with the definition given in AS1726.

Symbol	Term	Definition
RS	Residual Soil	Soil definition on extremely weathered rock; the mass structure and substance are no longer evident; there is a large change in volume but the soil has not been significantly transported
XW	Extremely Weathered	Rock is weathered to such an extent that it has 'soil' properties, ie. It either disintegrates or can be remoulded in water
HW	Highly Weathered	The rock substance is affected by weathering to the extent that limonite staining or bleaching affects the whole rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength is usually decreased compared to the fresh rock. The colour and strength of the fresh rock is no longer recognisable.
DW (HW to MW)	*Distinctly Weathered (see AS1726 Definition below)*	
MW	Moderately Weathered	The whole of the rock substance is discoloured, usually by iron staining or bleaching, to the extent that the colour of the fresh rock is no longer recognisable
SW	Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength from fresh rock
FR	Fresh	Rock shows no sign of decomposition or staining

"Distinctly Weathered: Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to the deposition of weathering products in pores." (AS1726)

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM - Commission on Standardisation of Laboratory and Field Tests, "Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index", as follows:

Term	Symbol	Point Load Index $I_{s(50)}$ (MPa)
Extremely Low	EL	<0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	>10

● Diametral Point Load Index test

■ Axial Point Load Index test

DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly Laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very Thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2 m	Thick
Very widely spaced	>2 m	Very Thick

DEFECT DESCRIPTION

Type:	Definition:
B	Bedding
BP	Bedding Parting
F	Fault
C	Cleavage
J	Joint
SZ	Shear Zone
CZ	Crushed Zone
DB	Drill Break

Planarity:	Roughness:
P – Planar	R – Rough
Ir – Irregular	S – Smooth
St – Stepped	Sl – Slickensides
U – Undulating	Po – Polished

Coating or Infill:	Description
Clean	No visible coating or infilling
Stain	No visible coating or infilling but surfaces are discoloured by mineral staining
Veneer	A visible coating or infilling of soil or mineral substance but usually unable to be measured (<1mm). If discontinuous over the plane, patchy veneer
Coating	A visible coating or infilling of soil or mineral substance, >1mm thick. Describe composition and thickness

The inclinations of defects are measured from perpendicular to the core axis.

Graphic Symbols for Soil and Rock

Graphic symbols used on borehole and test pit reports for soil and rock are as follows. Combinations of these symbols may be used to indicate mixed materials such as clayey sand.

Soil Symbols

Main Components

- CLAY
- SILT
- SAND
- GRAVEL
- BOULDERS / COBBLES
- PEAT (Organic)

Minor Components

- Clayey
- Silty
- Sandy
- Gravelly

Other Symbols

- TOPSOIL
- FILL
- ASPHALT
- CONCRETE
- NO CORE

Rock Symbols

Sedimentary Rocks

- SANDSTONE
- SILTSTONE
- CLAYSTONE, MUDSTONE
- SHALE
- LAMINITE
- CONGLOMERATE
- BRECCIA
- TILL
- COAL
- LIMESTONE

Igneous Rocks

- PLUTONIC IGNEOUS (eg: Granite)
- VOLCANIC IGNEOUS (eg: Basalt)
- PYROCLASTIC IGNEOUS (eg: Ignimbrite)

Metamorphic Rocks

- SLATE, PHYLLITE, SCHIST
- GNEISS
- QUARTZITE

Engineering classification of shales and sandstones in the Sydney Region - A summary guide

The Sydney Rock Class classification system is based on rock strength, defect spacing and allowable seams as set out below. All three factors must be satisfied.

CLASSIFICATION FOR SANDSTONE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>24	>600	<1.5
II	>12	>600	<3
III	>7	>200	<5
IV	>2	>60	<10
V	>1	N.A.	N.A.

CLASSIFICATION FOR SHALE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>16	>600	<2
II	>7	>200	<4
III	>2	>60	<8
IV	>1	>20	<25
V	>1	N.A.	N.A.

1. ROCK STRENGTH

For expedience in field/construction situations the uniaxial (unconfined) compressive strength of the rock is often inferred, or assessed using the point load strength index (Is_{50}) test (AS 4133.4.1 - 1993). For Sydney Basin sedimentary rocks the uniaxial compressive strength is typically about 20 x (Is_{50}) but the multiplier may range from about 10 to 30 depending on the rock type and characteristics. In the absence of UCS tests, the assigned Sydney Rock Class classification may therefore include rock strengths outside the nominated UCS range.

2. DEFECT SPACING

The terms relate to spacing of natural fractures in NMLC, NQ and HQ diamond drill cores and have the following definitions:

Defect Spacing (mm)	Terms Used to Describe Defect Spacing[1]
>2000	Very widely spaced
600 – 2000	Widely spaced
200 – 600	Moderately spaced
60 – 200	Closely spaced
20 – 60	Very closely spaced
<20	Extremely closely spaced

[1]After ISO/CD14689 and ISRM.

3. ALLOWABLE SEAMS

Seams include clay, fragmented, highly weathered or similar zones, usually sub-parallel to the loaded surface. The limits suggested in the tables relate to a defined zone of influence. For pad footings, the zone of influence is defined as 1.5 times the least footing dimension. For socketed footings, the zone includes the length of the socket plus a further depth equal to the width of the footing. For tunnel or excavation assessment purposes the defects are assessed over a length of core of similar characteristics.

Source: Based on Pells, P.J.N, Mostyn, G. and Walker, B.F. (1998) – Foundations on sandstone and shale in the Sydney region. Australian Geomechanics Journal, No 33 Part 3

APPENDIX D

RESULTS OF DYNAMIC CONE PENETROMETER TESTS

RESULTS OF DYNAMIC CONE PENETROMETER TEST

ESWNMAN
25 YEARS EXPERIENCE

Client:	Enhance Group Project Pty Ltd	Ref No:	ESWN-PR-2018-280
Project:	Geotechnical Investigation	Date Tested:	10/08/2018
Location:	43 Old Pittwater Road, Brookvale, NSW 2100	Tested By:	Y.N/J.L.

Depth (mm)	DCP No.				Depth (mm)	DCP No.				
	1	2	3	4		5	6	7	8	9
0-100	0	0	1	1	0-100					
100-200	1	1			100-200					
200-300	1	1	4		200-300					
300-400		1	3	1	300-400					
400-500	1	1	3	1	400-500					
500-600		1	3	1	500-600					
600-700	2	6	2	2	600-700					
700-800	3	7	3	2	700-800					
800-900	3	3	4	3	800-900					
900-1000	2	3	5	2	900-1000					
1000-1100	2	2	4	4	1000-1100					
1100-1200	4	2	8	4	1100-1200					
1200-1300	5	2	14	4	1200-1300					
1300-1400	8	2	10	4	1300-1400					
1400-1500	7	3	5	6	1400-1500					
1500-1600	4	4	7	5	1500-1600					
1600-1700	4	5	6	6	1600-1700					
1700-1800	5	8	16	5	1700-1800					
1800-1900	4	6	17	8	1800-1900					
1900-2000	5	7	19	7	1900-2000					
2000-2100	6	5	24	7	2000-2100					
2100-2200	5	6	Terminated	6	2100-2200					
2200-2300	7	7		6	2200-2300					
2300-2400	8	8		9	2300-2400					
2400-2500	11	8		11	2400-2500					
2500-2600	12	7		23	2500-2600					
2600-2700	7	8		Terminated	2600-2700					
2700-2800	6	8			2700-2800					
2800-2900	5	7			2800-2900					
2900-3000	15	7			2900-3000					
3000-3100	20/80mm	13			3000-3100					
3100-3200	Bounce	15			3100-3200					
3200-3300		16			3200-3300					
3300-3400		19			3300-3400					
3400-3500		21			3400-3500					
3500-3600		Terminated			3500-3600					
3600-3700					3600-3700					
3700-3800					3700-3800					
3800-3900					3800-3900					
RL(m)	15.5	15.5	16.4	16.1	**RL(m)**					

Notes:

DCP testing equipment designed and conducted in accordance with AS1289.6.3.2

APPENDIX E

LIMITATIONS OF GEOTECHNICAL INVESTIGATION

General

In making an assessment of a site from a limited number of boreholes or test pits there is the possibility that variations may occur between testing locations. Site exploration identifies specific subsurface conditions only at those points from which samples have been taken. The risk that variations will not be detected can be reduced by increasing the frequency of testing locations. The investigation program undertaken is a professional estimate of the scope of investigation required to provide a general profile of the subsurface conditions. The data derived from the site investigation program 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 borehole/test pit logs are the subjective interpretation of subsurface conditions at a particular location, made by trained personnel. The interpretation may be limited by the method of investigation, and cannot always be definitive.

Subsurface conditions

Subsurface conditions may be modified by changing natural forces or man-made influences. A geotechnical report is based on conditions which existed at the time of subsurface exploration.

Construction operations at or adjacent to the site, and natural events such as rainfall events, floods, or groundwater fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept appraised of any such events, and should be consulted to determine if additional tests are necessary.

Assessment and interpretation

A geotechnical engineer should be retained to work with other appropriate design professionals explaining relevant geotechnical findings and in reviewing the adequacy of their drawings/plans and specifications relative to geotechnical issues.

Information and documentations

Final logs are developed by geotechnical engineers based upon their interpretation of field description and laboratory results of field samples. Customarily, only the final logs are included in geotechnical engineering reports. These logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings. To minimise the likelihood of bore/profile log misinterpretation, contractors should be given access to the complete geotechnical engineering report prepared or authorised for their use. Providing the best available information to contractors helps prevent costly construction problems.

Construction phase service (CPS)

During construction, excavation is frequently undertaken which exposes the actual subsurface conditions. For this reason geotechnical consultants should be retained through the construction stage, to identify variations if they are exposed and to conduct additional tests which may be required and to deal quickly with geotechnical problems if they arise.

Report

The report has been prepared for the benefit of the client and no other parties. ESWNMAN PTY LTD 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 ESWNMAN PTY LTD 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 enquiries and obtain independent advice in relation to such matters.

Other limitations

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