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E25203.G12_Rev2

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# Groundwater Take Assessment
# Proposed Mixed Use Development
# 1112-1116 Barrenjoey Road, Palm Beach NSW

## 1. INTRODUCTION

### 1.1. BACKGROUND

At the request of Palmdev Pty Ltd (the Client), EI Australia (EI) has prepared this Groundwater Take Assessment for 1112-1116 Barrenjoey Road, Palm Beach NSW (the site).

EI has prepared the following reports for this site:

- Geotechnical Investigation (GI) report, referenced E25203.G03, dated 7 December 2021;
- Additional Geotechnical Investigation (AGI) report, referenced E25203.G04_Rev1, dated 8 August 2024;
- Groundwater Monitoring Report No. 1, referenced E25203.G11.01, dated 28 February 2024;
- Landslide Risk Assessment (LRA), referenced E25203.G14, dated 8 August 2024; and
- Construction Methodology Report, referenced E25203.G15, dated 8 August 2024.

### 1.2. PROPOSED DEVELOPMENT

The following documents were used to assist in the preparation of this analysis:

- Architectural drawings prepared by Koichi Takada Architects – Project at 1112-1118 Barrenjoey Road, Palm Beach, Drawing Nos. A0001, A0010 to A0013, A0019, A0022, A0050, A0051, A0099 to A0105, A0200 to A0203, A0300 to A0305, and A0320, latest revision I, dated 31 July 2024;
- Structural drawings prepared by M&G Consulting Engineers Pty Ltd – Job No. 5598, Drawing Nos. S010, S011, S015 and S020, Issue 1, dated 7 August 2024; and
- Site survey plan prepared by Beveridge Williams – Project No. 2101343, Drawing Ref. 2101343, Sheets 1 to 5 of 5, Version B, dated 6 September 2021. The datum in the survey plan is in Australian Height Datum (AHD), hence all Reduced Levels (RL) mentioned in this report are henceforth in AHD.

Based on the provided documents, EI understands that the proposed development involves the demolition of the existing site structures and the construction of a four-storey mixed-use building overlying a split single-level basement. The basement is proposed to have a Finished Floor Level (FFL) of between RL -1.22m and -2.4m Australian Height Datum (AHD). A Bulk Excavation Level (BEL) range between RL -1.5m and -2.7m AHD is assumed for the construction which includes allowance for a concrete basement slab. To achieve the BEL, an excavation depth varying from 4.3m (towards west of site) to 15.6m (towards east of site) Below Existing Ground Level (BEGL) is expected. Locally deeper excavations may be required for footings, service trenches, crane pads, and lift overrun pits.

EI has prepared a Groundwater Level Monitoring report, referenced E25203.G11.01, dated 28 February 2024, which should be read in conjunction with this report.

### 1.3. ASSESSMENT OBJECTIVES

The objective of this GTA is to provide an estimation of the groundwater take volumes that require pumping out during the construction and operational stage of the development, estimation of the groundwater drawdown as a result of the dewatering, and its associated ground settlements (if any).

# 2. SITE MODEL

## 2.1. SUBSURFACE CONDITIONS PERMEABILITY

Due to the sloping nature of the site EI has adopted the average subsurface conditions to the east and west of the site during the GI and AGI, which were linearly interpolated. A summary of the permeability values which were adopted for the assessment of groundwater take volumes are presented in **Table 3** below.

**Table 1 Summary of Subsurface Conditions and Adopted Design Parameters**

| Material [1] | Western Section | | Eastern Section | | Adopted Permeability (m/s) | Anisotropy (Ky/Kx) |
|---|---|---|---|---|---|---|
| | Depth to Top of Unit (m BEGL) [2] | Approximate RL of Top of Unit (m AHD) [2] | Depth to Top of Unit (m BEGL) [2] | Approximate RL of Top of Unit (m AHD) [2] | | |
| **Topsoil/Fill [3]** | 0 | 2.4 | 0 | 12.3 | $1 \times 10^{-4}$ | 1 |
| **Marine Soil [3]** | 0.4 | 1.8 | - | - | $1 \times 10^{-4}$ | 1 |
| **Residual Soil [4]** | 2.1 | 0 | - | - | $2.5 \times 10^{-6}$ | 1 |
| **Laminite Bedrock [4]** | 4.0 | -1.8 | 0.97 | 11.3 | $2 \times 10^{-7}$ | 0.3 |

***Notes:***

1 For more detailed descriptions of subsurface conditions reference should be made to the Geotechnical Investigation Report.
2 Depths and levels presented in **Table 1** above are generalised using the most conservative levels from the Geotechnical Investigation across the excavation area for the purpose of groundwater seepage modelling.
3 Permeability values have been correlated for material encountered during the GTA using Look (2014).
4 Permeability value of the Residual Soil and Laminite Bedrock was calculated based on the pump out test carried out by EI.

The permeability the Residual Soil and laminite bedrock was calculated based on the pump-out test rests completed within monitoring wells. The monitoring wells and pump out test results are summarised in **Table 2** below.

**Table 2 Monitoring Well Details and Pump Out Test Results**

| Monitoring Well/ Test ID | Total Well Depth (m BEGL) | Screen Length (m) | Screened Section | Date of Test | Approximate RL of Groundwater Level (m AHD) | Adopted Permeability (m/s) [3] |
|---|---|---|---|---|---|---|
| **BH104** | 7.0 | 3 | Laminite | 24-Oct-23 | 2.81 | $2.1 \times 10^{-6}$ |
| **BH201M** | 4.7 | 3 | Residual/Laminite | 24-Oct-23 | -0.7 | $2.5 \times 10^{-6}$ |
| **BH202M** | 6.0 | 3 | Residual/Laminite | 24-Oct-23 | -0.82 | $2.5 \times 10^{-6}$ |
| **BH204M** | 15.1 | 2 | Laminite | 24-Oct-23 | -3.6 | $1.9 \times 10^{-7}$ |

## 2.2. GROUNDWATER OBSERVATIONS AND PUMP OUT TESTS

As part of the GI and AGI scope, EI had installed five monitoring wells (BH101M, BH104M, BH201M, BH202M, BH203M and BH204M) for groundwater monitoring. EI undertook a Groundwater Monitoring Event (GME) on 24 October 2023 and the 14 November 2023 and carried out the Pump Out test in all boreholes on the 24 October 2023 and BH104M and BH204M on the 14 November 2023. Groundwater measurements are presented in **Table 4** below. EI notes that BH101M was damaged during demolition of the site structures and no results were gathered from this location. Borehole and groundwater monitoring well locations are shown in **Figure 1** attached at the end of this report.

**Table 3 Summary of Groundwater Levels**

| Monitoring Well / Test ID | Date of Observation | Approximate Depth to Groundwater Level m BEGL) | Approximate RL of Groundwater Level (m AHD) |
|---|---|---|---|
| BH101M | 8 September 2023 | 1.15 | 1.16 |
| BH104M | 14 November 2023 | 8.79 | 3.71 |
| BH201M | 24 October 2023 | 1.06 | 0.18 |
| | 22 February 2024 | 0.75 | 0.45 |
| BH202M | 24 October 2023 | 1.58 | 0.82 |
| | 22 February 2024 | 0.56 | 1.84 |
| BH203M | 24 October 2023 | 0.79 | 1.71 |
| | 22 February 2024 | 0.87 | 1.63 |
| BH204M | 24 October 2023 | 5.63 | 7.27 |
| | 14 November 2023 | 5.20 | 7.70 |
| | 22 February 2024 | 5.30 | 7.60 |

EI completed long-term groundwater monitoring from 24 October 2023 to 22 February 2024 in BH201M to BH204M. A summary of the groundwater levels observed during the long term monitoring are summarised below in **Table 4**.

**Table 5 Summary of Long Term Groundwater Levels**

| Monitoring Well / Test ID | Average Groundwater RL (mAHD) | Highest Groundwater RL (mAHD) | Lowest Groundwater RL (mAHD) |
|---|---|---|---|
| BH201M | 0.4 | 0.78 | 0.12 |
| BH202M | 1.7 | 2.01 | 1.49 |
| BH203M | 1.7 | 1.88 | 1.52 |
| BH204M | 7.6 | 9.47 | 7.03 |

A design groundwater level of RL 2.0m to the west of the site and RL 8.1m to the east of the site has been adopted for assessment of groundwater seepage inflow rates and groundwater take volumes within the excavation. EI note the groundwater to the east of the site has been taken slightly above the average level to account for spikes in the groundwater level from adverse weather.

## 2.3. SHORING SYSTEM

Based on communication with the client and structural design, EI understands that the shoring system is comprised of the following:

- Construction phase: Secant pile walls on the northern, southern and western elevations founded at least 3.0m below BEL, with a freely draining solider pile wall to the east.
- Operational phase: Waterproof walls will be installed for the eastern basement wall creating a water-tight basement.

This assessment does not assess the overall stability and embedment depth of the shoring system. Once final designs are made available, this assessment should be revised accordingly.

For the purpose of this assessment the secant pile walls are assumed to be water tight and the solider pile wall is assumed to be free to drain.

# 3. GROUNDWATER TAKE ASSESSMENT

## 3.1. INITIAL VOLUME OF PORE WATER DEWATERED WITHIN EXCAVATED MATERIALS

For calculation of the volume of water to be removed from excavated sandy soil in the western half of the site, the following assumptions have been made:

- The sandy soil below the groundwater table is completely saturated;
- A design static groundwater level of RL 2.0m for western portion of the site based on groundwater monitoring data;
- The sandy soil layer is saturated from RL 2.0m to RL 0.0m; and
- Average Porosity (η) of 0.366 for the well graded sandy marine soil. Therefore, every 1m$^3$ of subsurface material removed from below the water table, contains approximately 0.366 m$^3$ of water.

The total volume of sandy marine soil below the water table estimated for dewatering is:

$$V_{sat} = A \times T, \text{ where}$$

$$A = \text{Area of the excavation (approxinmate calculation from the survey plan referenced above)}$$

$$= 664 \text{ m}^2$$

$$T = \text{Thickness of dewatered soil material} = 2.0 \text{ m}$$

$$\therefore V_{sat} = 664\text{m}^2 \times 2.0 \text{ m} = 1{,}328\text{m}^3$$

$$1{,}328\text{m}^3 \times 0.366 = 486.05 \text{ m}^3 \; = \; \mathbf{0.486ML}$$

Therefore, the estimated total volume of water to be removed from excavated marine soil in the western half of the site is expected to be about **0.486 ML**.

## 3.2. GROUNDWATER SEEPAGE VOLUMES DURING CONSTRUCTION PHASE

Groundwater seepage analysis for flow through and beneath the shoring wall during construction has been undertaken using SEEP/3D, a three-dimensional finite element groundwater seepage analysis software. SEEP/3D estimates the seepage rate of water entering the excavation through the soldier pile wall and from beneath the secant pile walls. This model estimates the volume of water which will be required to be dewatered during the construction of the basement and until the dewatering is turned off.

For the purpose of this modelling, it has been assumed that:

- The subsurface conditions were horizontal beyond the site boundaries and interpolated between the eastern and western boundary of the site. The permeability values presented in **Table 1** above were adopted for each unit.
- The secant pile shoring walls to the north, south and west are assumed to be impermeable and soldier pile wall to the east is assumed to be free to drain.
- For the simplicity of this model, temporary dewatering will be undertaken within the basement retaining wall perimeter to the lowest BEL, or about RL -2.7m.
- An external design groundwater level of RL 2.0m to the west assumed at a constant 80m away from the shoring wall and 8.1m to the east was assumed to be constant at 25 m away from the shoring wall.

The SEEP/3D model is presented in **Appendix A** attached at the end of this report. **Table 6** below provides the estimated groundwater inflow rate into the basement.

**Table 6 Summary of Analysis Results**

| Shoring System | Inflow into excavation ($m^3$/day) | Inflow into excavation (ML/Year) |
|---|---|---|
| Hybrid: Secant and Soldier Pile Wall | 7.14 | 2.61 |

## 3.3. ASSESSMENT OF GROUNDWATER TAKE DURING OPERATIONAL PHASE

When a fully water-tight tanked basement is adopted, the volume of groundwater inflow into the basement during the operational phase of the development is expected to be **zero**.

## 3.4. ESTIMATED DRAWDOWN SETTLEMENT

Elastic compression occurs for a soil or rock layer when a compressive stress is applied across the layer. The magnitude of the compression (d) is determined from the equation:

d = (stress change) x H/E

stress change = $10kN/m^3$ x 10.8m = 108kPa
H= layer thickness = 10.8m
E = elastic modulus = 300MPa

$d = 108 \times 10.8 / 300 \times 10^3 = 3.9mm$

There are two phases/models for groundwater assessment at this site location.

- Model 1: representing the soil and groundwater at the western boundary of the site, under influence of the nearby Pittwater tidal marine system.
- Model 2: representing the steep slope at the rear eastern boundary of the site, with a relatively thin residual soil layer overlying weathered siltstone bedrock, becoming less weathered with depth, and a sloping groundwater profile.

The assessed groundwater responses and ground settlement resulting from the basement excavation, and keeping it dry by sump and pumping during the building stage, are as follows:

| Models | Design GWL RL (m AHD) | Lowered GWL RL (m AHD) | Groundwater Drawdown Depth (m) | Stratum affected by GWL Lowering | Settlement (mm) |
|---|---|---|---|---|---|
| Model 1 | 2.0 | 1.98 | 0.02 | Sand alluvium | Practically nil |
| Model 2 | 8.1 | -2.7 | 10.8 | Residual soil and siltstone bedrock Class IV / III | 3.9 |

# 4. CONCLUSIONS AND COMMENTS

Based on the findings of this report and within the limitations of available data, EI concludes that:

- The groundwater take will be approximately:
  - Construction phase: **0.49 ML** from the initial pore water dewatering, plus **2.61 ML/year** during bulk excavation, or 3.1ML in the first year.
  - Operational phase: **Zero**.
- The above estimate is based on the following assumptions:
  - The shoring wall system during basement excavation is a mixture of a drained and impermeable retention system, comprised of secant and soldier pile walls.
  - Continuous dewatering in order to maintain the groundwater at a depth of the lowest BEL during construction.
  - The basement walls and slab will be designed as tanked for the development's lifetime.
  - This assessment does not take into consideration any excavation that may be required for footings, service trenches, lift pits, or crane pads. This additional excavation, if required, is not expected to affect the retention or the dewatering system.
  - Drawdown to the west is expected to be within the natural variation of the groundwater and as such no adverse settlements are expected due to drawdown.
  - Drawdown to the east is expected to occur within the rock profile with estimated settlement of about 3.9mm.

Should any design or construction conditions differ from that adopted in this report; this GTA should be reviewed and updated as required.

# 5. LIMITATIONS

This report has been prepared for the exclusive use of Palmdev Pty Ltd who is the only intended beneficiary of EI's work. The scope of the inspections carried out for the purpose of this report is limited to those agreed with Palmdev Pty Ltd.

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

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

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

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

# 6. CLOSURE

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

For and on behalf of
EI Australia

| Author | Technical Reviewer |
|---|---|
| | |
| Anthony Camillos<br>Geotechnical Engineer | Stephen Kim<br>Senior Geotechnical Engineer |

Attachments: **Figure 1**: Borehole and Groundwater Monitoring Well Location Plan
**Appendix A**: Seep/3D Output (Hybrid Secant and Soldier Pile Wall)
Important Information

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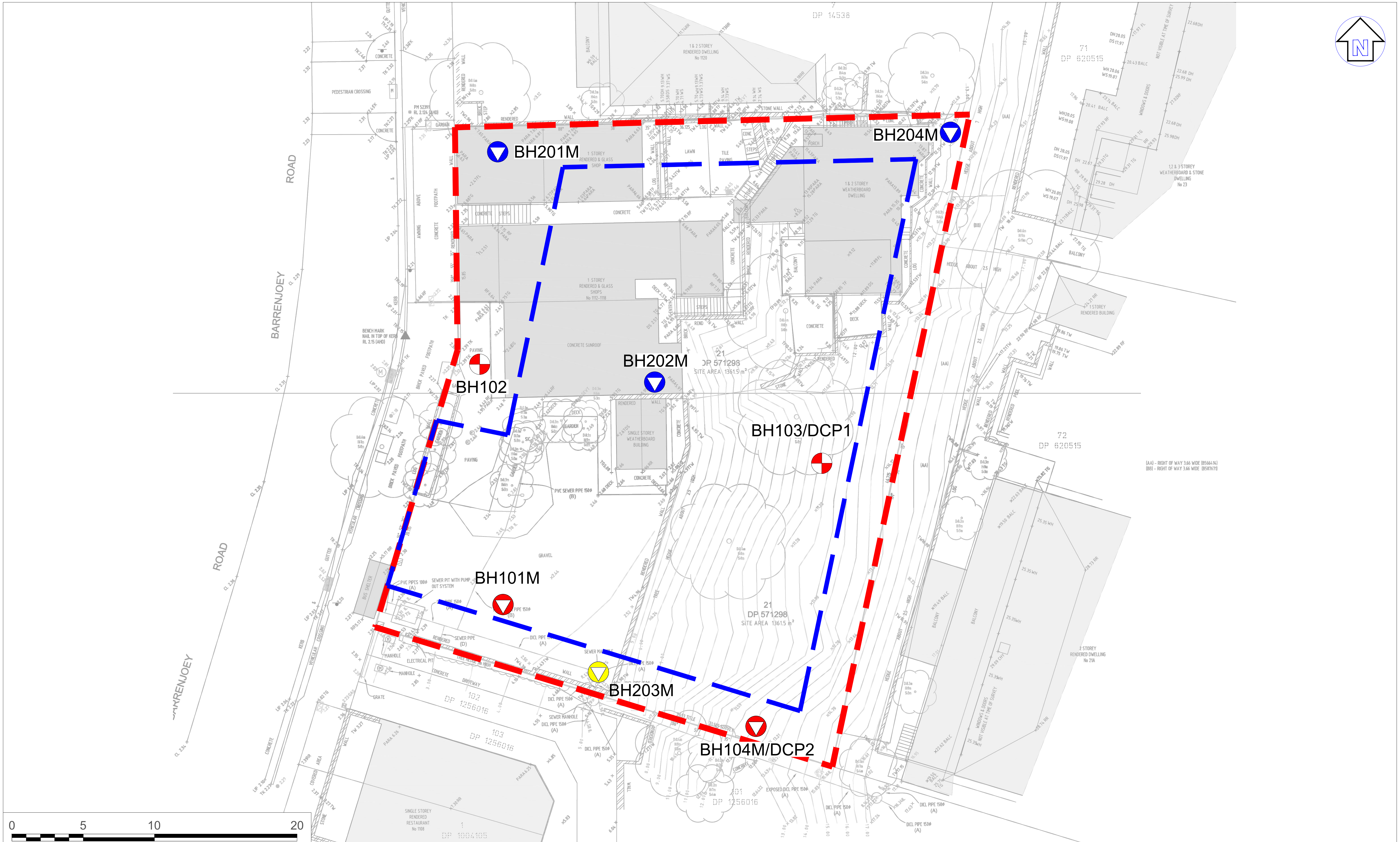


**Map Source:** Site Survey Plan prepared by Beveridge Williams - Project No. 2101343, Drawing Ref. 2101343, Sheet 1 of 5, Version B, dated 6 September 2021

**LEGEND** (Note: All locations are approximate)

- Site boundary
- Proposed basement boundary
- Location of Borehole (EI Australia, Geotechnical Investigation 2021)
- Location of Monitoring Well (EI Australia, Geotechnical Investigation 2021)
- Location of Borehole and Monitoring Well (EI Australia, Additional Geotechnical Investigation 2023)
- Location of Monitoring Well Only (EI Australia, Additional Geotechnical Investigation 2023)

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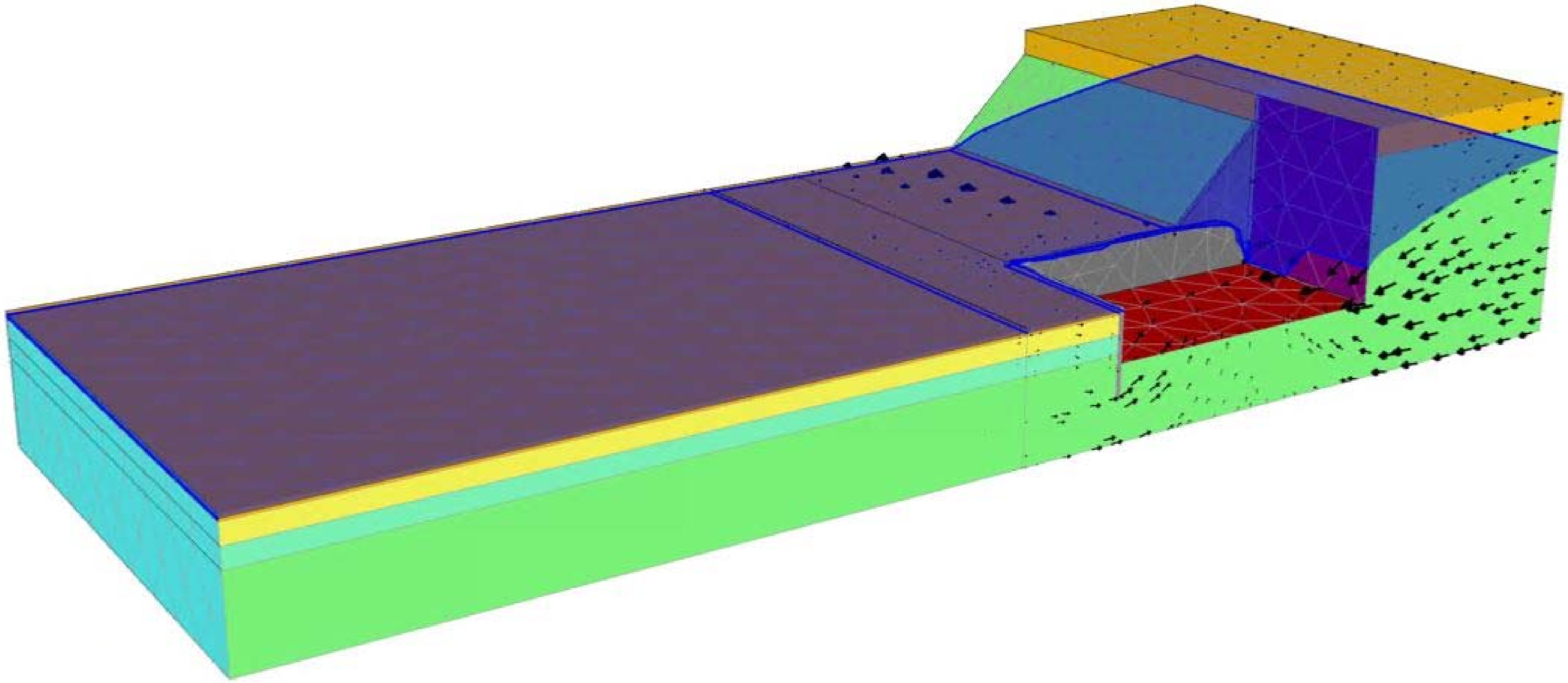
| Drawn: | J.O. |
| Approved: | S.K. |
| Date: | 7-8-2024 |

**Palmdev Pty Ltd**
Groudwater Take Assessment
1112-1116 Barrenjoey Road, Palm Beach NSW
Borehole Location Plan

Figure: 1

Project: E25203.G12



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| Drawn: | AC | |
| Approved: | SK | |
| Date: | 28/02/24 | |
| Approx Scale: | N/A | |

**Palmdev Pty Ltd**
Groundwater Take Assessment
1112-1116 Barrnjoey Road, Palm Beach NSW
SEEP/3D Model Output (Hybrid Secant and Soldier Pile Wall)

Appendix:
A

Project: E25203.G12

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# Important Information

## SCOPE OF SERVICES

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

## RELIANCE ON DATA

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

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## LIMITATIONS OF SITE INVESTIGATION

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

## SUBSURFACE CONDITIONS ARE TIME DEPENDENT

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

## VERIFICATION OF SITE CONDITIONS

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

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