FOUNDATION EARTH SCIENCES

HYDROGEOLOGICAL INVESTIGATION REPORT

Address

2-10 Berry Road, 14-16 Marshall Avenue & 5-9 Holdsworth Avenue, St Leonards NSW

Prepared for

Holdsworth Land Pty Ltd

Reference No. E2670-4

September 2023

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1.0 INTRODUCTION

Foundation Earth Sciences Pty Ltd was appointed by Holdsworth Land Pty Ltd to prepare a hydro-geological investigation report for the property located at 2-10 Berry Road, 14-16 Marshall Avenue & 5-9 Holdsworth Avenue, St Leonards NSW (hereafter known as the "site"). The purpose of this assessment includes:

- to achieve compliance with Council and Water NSW requirements in relation to the proposed future dewatering activities within the site.
- Assess the site surface and subsurface conditions and provide geotechnical recommendations for the design and construction of the proposed development.

Table 1: Summary of Details of the Site

Site	Details
Location	2-10 Berry Road, 14-16 Marshall Avenue and 5-9 Holdsworth Avenue, St Leonards NSW 2065
Lot/DP	Lots 38, 37, 36, 35, 34, 2, 1, 7, 8 and 9 Section 2 in DP7259
Local Council	Lane Cove
Area	Approximately 5,910m^2
Shape & Slope	Irregular shape and gently sloping towards south east
Existing Structures	Residential dwellings with associated structures
Closest Watercourse	Berrys Creek is located approximately 350m west to the site
Special Features	Holdsworth Avenue is located at least 3.0m below the all of the properties and there is a retaining wall along the road
Neighbouring Properties	North Marshall Avenue's road reserve and carriageway East Holdsworth Avenue's road reserve and carriageway South Residential Type Properties West Berry Road's road reserve and carriageway
Geology Map	Sydney 1: 1:100,000 Geological Series Sheet 9029-9130 Edition 1, 1983, from the Geological Survey of New South Wales
Primary Geology	Rwa – Ashfield Shale, Wianamatta Group, Triassic age, described as "Black to dark-grey shale and laminite"

Secondary Geology	Rh – Hawkesbury Sandstone, Wianamatta Group, Triassic age, described as "Medium to coarse-grained quartz sandstone, very minor shale, and laminite lenses" is located approximately 60m south west to the site
Proposed Development	Multi-storey building with five basement levels. Maximum excavation depth is inferred to be 17.0m

2.0 FIELDWORK AND LABORATORY TESTING

Following scope of work were carried out during the FES geotechnical investigation:

- Review of Dial-Before-You-Dig ("DBYD") plans and service locating.
- Mechanical drilling of four (4) boreholes, identified as BH1 to BH4 inclusive.
- Standard Penetration Testing ("SPT") within the augering of some of the boreholes.
- Installation of three (3) groundwater wells identified as GW1, GW2 and GW3 within the borehole BH1, BH2 and BH3 respectively.
- Subsequent visit to the site to measure the standing groundwater level.
- Laboratory testing of Point Load Index ("PLI") on the recovered rock samples.
- Laboratory testing of Aggressivity and Salinity on the soil and groundwater samples.

The approximate locations of the boreholes and groundwater wells are shown in a "Site Plan" and attached as Appendix A.

3.0 PROPOSED DEVELOPMENT

The site is currently occupied with residential dwellings including grassed areas, driveways, sheds and garages. The site is proposed to be redeveloped into a multi-storey residential building with multiple levels of residential units, three level basement car park, deep soil zone and landscape area. Maximum excavation depth is inferred to be approximately 17m BGL with an area of 1ha.

Refer to **Appendix G** – Proposed Development Plans.

4.0 GROUND CONDITION

4.1 Ground Profile

Ground profiles encountered within the boreholes are summarised in Table 2. However, reference should be made to borehole logs.

Table 2: Summary of Ground Profile

Unit	Details	Depth (m)			
		BH1	BH2	BH3	BH4
	Existing Ground Level (RL m AHD)	77.9	75.2	73.1	72.1
Fill	Gravelly Silt, low plasticity, fine to medium gravel, moist, firm Includes brick pavement	0.0 – 0.1	0.0 – 0.1	0.0 – 0.4	0.0 – 0.4
Residual Soils	Silty/Sandy CLAY, medium to high plasticity, moist, stiff-very stiff, interbedded of sandstone, shale	0.1 – 4.0	0.1 – 2.5	0.4 – 4.4	0.14 – 2.9
Class V [1] Sandstone	SANDSTONE, interbedded with some clay and shale, extremely to highly weathered	4.0 – 5.7	2.5 – 4.9	4.4 – 7.0	2.9 – 6.2
Class IV [1] Sandstone	SANDSTONE, with some shale bands, moderately weathered	5.7 – 11.4	4.9 – 8.2	7.0 – 11.27	6.2 – 10.57
Class III [1] Sandstone	SANDSTONE, with some shale bands, slightly weathered	11.4 – 17.75	8.2 – 17.98	–	–

Note: [1] Bedrock was classified in accordance with the research paper of Pells P.J.N, Mostyn G. & Walker B.F. Foundations on Sandstone and Shale in the Sydney Region, Australian Geomechanics Journal, December 1998.

4.2 Groundwater Investigation

Groundwater seepage was observed during the augering of the borehole BH2. Also standing groundwater levels were measured within the installed groundwater wells. Details of groundwater are summarised in Table 3.

Further groundwater recharge rate test was carried out within the installed groundwater wells.

Table 3: Summary of the Groundwater Details – FES GI

Details	Boreholes (Groundwater Wells)			
	BH1 (GW1)	BH2 (GW2)	BH3 (GW3)	BH4
Seepage	Not Observed until 5.65m	3.8m (RL 71.4m)	Not Observed until 1.31m	Not Observed until 1.34m
Standing groundwater level on 7/09/2021	6.9m (RL 71.0m)	5.8m (RL 69.4m)	4.0m (RL 69.1m)	–
Groundwater Recharge Rate (L/s/m^2)	1.16×10^{-3}	5.94×10^{-4}	3.23×10^{-4}	–
Hydraulic Conductivity K (m/s)	9.68×10^{-5}	1.17×10^{-7}	5.15×10^{-8}	–

Standing groundwater levels are also subject to a piezometric head at the drilled locations. Therefore, levels may not be representative of natural groundwater conditions of the site.

Further, it should be noted groundwater levels within the site may be subject to seasonal fluctuations, rainfall, prevailing weather conditions and also future developments of the areas and landforms.

4.3 Aggressivity and Salinity Tests

Aggressivity and Salinity tests were carried out on recovered soils and groundwater samples in accordance with Australian and NSW standards, guidelines, and regulations. Results of the Aggressivity tests and Salinity tests carried out are summarised in Table 4 and Table 5 respectively.

Table 4: Summary of Aggressivity Tests

Sample ID	Depth (m)	Soil Type	pH	Chloride (mg/kg)	Sulphate As SO_4 (mg/kg)
BH1	2.0	Silty CLAY	5.7	28	81
BH2	3.0	Sandstone	5.2	< 10	55
BH3	1.0	Sandy CLAY	5.6	< 10	55
Piling - Design and Installation - AS2159-2009					
	Clayey Soil	Sandy Soil			
	Non	Mild	> 5.5		< 5,000
Reinforced	Mild	Moderate	4.5 – 5.5		5,000-10,000
Concrete Piles	Moderate	Severe	4.0 – 4.5		10,000-20,000
	Severe	Very Severe	< 4.0		> 20,000
	Non	Non	> 5.0	< 5,000	
	Non	Mild	4.0 – 5.0	5,000-20,000	
Steel Piles	Mild	Moderate	3.0 – 4.0	20,000-50,000	
	Moderate	Severe	< 3.0	> 50,000	

Table 5: Summary of Groundwater Aggressivity Tests

Sample ID	Depth (m)	Soil Type	pH	Chloride (mg/L)	Sulphate As SO_4 (mg/L)
GW1	–	–	6.9	30	32
Piling - Design and Installation - AS2159-2009					
	Clayey Soil	Sandy Soil			
	Non	Mild	> 5.5	< 6,000	< 1,000
Reinforced	Mild	Moderate	4.5 – 5.5	6,000-12,000	1,000-3,000
Concrete Piles	Moderate	Severe	4.0 – 4.5	12,000-30,000	3,000-10,000
	Severe	Very Severe	< 4.0	> 30,000	> 10,000
	Non	Non	> 5.0	< 1,000	
	Non	Mild	4.0 – 5.0	1,000-10,000	
Steel Piles	Mild	Moderate	3.0 – 4.0	10,000-20,000	
	Moderate	Severe	< 3.0	> 20,000	

Table 6: Summary of Soil Salinity Tests

Sample ID	Depth (m)	Soil Type	Electrical Conductivity EC (µS/cm)	Factor	Saturated Extracted EC EC_e (dS/m)
BH1	2.0	Silty CLAY	74	7	0.52
BH2	3.0	Sandstone	39	14	0.55
BH3	1.0	Sandy CLAY	42	9	0.38
GW1	–	–	300	1	0.3
Environmental Planning & Assessment Regulation 1994			Saline		> 4
Dryland Salinity (1993)			Non-Saline Slightly Moderately Very Highly		< 2 2 – 4 4 – 8 8 – 16 > 16

5.0 GROUNDWATER MONITORING

Groundwater was monitored over a period from February 2021 to September 2023 to identify the fluctuations of the natural groundwater table. The table identified in **Appendix C** identifies the monitoring that was undertaken over this period.

An analysis of the results indicated that the average groundwater fluctuation across the wells over the period was approximately 2.0m in BH2/GW2 and the minimum standing water level at RL 69.2 and maximum standing water level at RL 71.9, however this was noted to be over a two year period between installation and monitoring.

However, the groundwater seepage was detected within one of the boreholes at the highest point of 3.8m BGL in BH2/GW2 during the FES Geotechnical Investigation.

It is understood that the groundwater is within a semi-confined to confined aquifer based on the geology and that the subsequent drilling and installation has caused the groundwater to measure a significant piezometric head.

6.0 ENVIRONMENTAL SETTINGS

Table 7: Site Conditions and Surrounding Environmental Review

Site Information	Descriptions					
Sensitive Receivers	The nearest sensitive human receptors are the current and future users of the site, construction workers during the site redevelopment and the public. The nearest watercourse is Berry's Creek located 341m south of the site.					
Soil Landscape *Review of NSW Soil and Land Information website ESPADE.*	The Soil Landscape Map viewed on NSW ESPADE indicates that the site is located within the Glenorie landscape area: Undulating to rolling low hills on Wianamatta Group shales. Local relief 50-80m, slopes 5-20%. Narrow ridges, hillcrests and valleys. Extensively cleared tall open forest (wet sclerophyll forests).					
Topography *Review of NSW Soil and Land Information website ESPADE.*	The topography viewed on NSW ESPADE indicated the following for the Glenorie landscapes: Low rolling and steep hills. Local relief 50-120m, slopes 5-20%. Convex narrow (20-300m) ridges and hillcrests grade in moderately inclined sideslopes with narrow concave drainage lines. Moderately inclined slopes of 10-15% are the dominant landform elements.					
Geological Profile	The Geological Map of Sydney (Geological Series Sheet 9130, Scale 1:100,000, 1983), published by the Department of Mineral Resources indicates the residual soils within the site to be underlain by Triassic Age Shale of the Wianamatta Group, comprising black to dark grey shale and laminate.					
Presence of Acid Sulphate Soils *Review of NSW Department of Land & Water Conservation (DLWC) Acid Sulphate Soil Risk Maps (Edition Two, December 1997, Scale 1:250,000.*	A review of the "Prospect_Parramatta" map indicated that the site is in an area of "No known occurrences" of acid sulphate soil material within the soil profile.					
Localised Hydrogeology Review of DPI (Office of Water) Database.	**Number**	**Location from Site**	**Depth (m BGL)**	**SWL (m BGL)**	**Use**	**Water Bearing Zones**
	GW072478	972m NW	180.50	48.00	Domestic Bore	Unknown

Site Information	Descriptions					
	GW108224	900m NE	132.40	35.00	Domestic Bore	Unknown
Nearest Surface Water Body	The nearest watercourse is Berry's Creek located 341m south of the site					
Nearest Active Service Station & Dry Cleaner Shop (Google Maps Search)	Service Station: 1.3km east of the site. Dry Cleaner Shop: 400m north-east of the site					
Local Meteorology (Bureau of Meteorology BOM website)	The monthly rainfall of the local surrounding area is represented by the data collected from the BOM rainfall gauge located at the Chatswood Bowling Club, which is located approximately 2.3km from St Leonards. The records indicate that the mean monthly rainfall in August (date of fieldwork) was 77.5mm.					
Regulated Groundwater Resources	The Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources divides the east coast if NSW into 13 groundwater sources, of which the planned development is within the Sydney Central Basin Groundwater Source (SCBGS). FES classifies the SCBGS as a porous rock groundwater source					
Regional Hydrogeology	The most extensive aquifer at the site is the Hawkesbury Sandstone aquifer. The horizontal hydraulic conductivity of the Hawkesbury Sandstone is typically in the order of $5x10^{-7}$ m/sec to $5x10^{-8}$m/sec.					

7.0 GROUNDWATER ASSESSMENT

7.1 Groundwater – Adopted Discharge Criteria

The NSW EPA has endorsed the use of the Groundwater Investigation Levels (GILs) given in the 1999 NEPM '*Schedule B(1) Guideline on the Investigation Levels for Soil and Groundwater*' (Amendment 2013) and the water quality trigger levels given in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018). These Guidelines provide criteria for:

- Aquatic ecosystems – both marine and fresh waters

The NEPM advises that 'when assessing groundwater contamination, the GILs are to be applied at the point of extraction and as response levels at the point of use, or where there is a likelihood of an adverse environmental effect at the point of discharge'.

For assessing groundwater quality, it is first necessary to assess the potential uses of groundwater downgradient of the site being assessed.

Potential uses of groundwater downgradient of the site include:

- Discharge to water bodies sustaining aquatic ecosystems particularly Fresh Water.
- Extraction of groundwater by local users.

The threshold concentrations presented in the ANZECC (2000) Fresh and Marine Waters Quality Guidelines are considered applicable for the protection of aquatic ecosystems of the receiving waters. As these guidelines apply to receiving waters, it is generally conservative to apply these to groundwater discharging to receiving waters. It is important to note that these are not threshold values at which an environmental problem is likely to occur if exceeded,

rather, if the trigger values are exceeded, then further action is required which may include either further site-specific investigations to assess whether or not there is an actual problem or management / remedial action should be undertaken.

It is considered that ***Marine water trigger*** values are applicable for investigating chemical concentrations in groundwater at the site. The nearest watercourse is Berry's Creek located 341m south of the site. It is understood that the NSW EPA policy is that the trigger values for the protection of 95% of aquatic ecosystems should be used as groundwater assessment criteria when considering moderately or highly disturbed receiving environments. The receiving waters for groundwater at the site are moderately disturbed ecosystems and the ANZG (2018) 95% protection values are therefore considered appropriate groundwater assessment criteria for the site.

Guidelines from the Australian Drinking Water Criteria 2018 have also been included.

Refer to **Appendix E** – Adopted Discharge Criteria.

7.2 Groundwater Installation Methodology

The FES Geotechnical wells were constructed from the 30$^{TH\ of}$ August 2021 by adopting the following methodology:

- 50mm diameter, Class 18PVC threaded and flush joined casing and 0.45 machine-slotted screens were used.
- Coarse, washed sand and gravel was placed in the annulus surrounding the piping to a height of the screen.
- Bentonite pellets were placed in the annulus to form an impermeable plug near the top of the well to prevent surface runoff from entering directly into the well.
- Bentonite pellets were placed in the annulus to form an impermeable plug near the top encountered bedrock.
- A PVC cap was placed on the casing.

- 100mm diameter stainless steel flushed covers were used for all well finishes and concreted onto the ground surface.

Table 8: Summary of Well Construction Details

Well ID	Total Depth	Screening (m)	Surface Level (RL)	Water Bearing	Comment
BH1/GW1-GI	7.75	3.0-8.95	77.9	-	Dry
BH2/GW2	8.65	3.0-8.95	75.2	-	Current
BH3/GW3	7.6	3.0-8.95	73.2	-	Current

Table 9: Groundwater Field Results – 2023

Well ID	Date	pH	Electrical Conductivity (EC us/cm)	Redox Potential (ORP mV)	Dissolved Oxygen (mg/L)	Temperature (*C)
BH2/GW2	30/08/2023	3.15	243.5	139	22.7	18.3
BH3/GW3	30/08/2023	3.24	194.1	98.5	10.4	17.7

The results of the field parameters measured are summarised as follows:

- pH reading indicated the groundwater is generally acid.
- The EC reading indicated generally fresh water; and
- The redox potential indicated increasing conditions.

7.3 Groundwater Quality

Based on the groundwater sampling completed by FES as part of the FES DSI dated September 2023, the following parameters were outside (above and/or below) the adopted guideline criteria:

- ***Metals (copper & zinc)***

As per the water quality results further action is recommended to be undertaken to improve the quality of the extracted water before discharging into the council stormwater system. Further action includes treatment and retesting water prior to discharge. However, as the basement is not expected to intercept the underlying groundwater table significant amounts of dewatering is not expected.

7.4 Permeability Testing

Table 10: Summary of Pells Class Hydraulic Conductivity of Hawkesbury Sandstone

Pells Class	Bulk Hydraulic Conductivity m/sec
1	10^{-9} to 10^{-8}
2	10^{-8} to 10^{-7}
3	10^{-7} to $5x10^{-7}$
4	$5x10^{-8}$ to $2x10^{-7}$
5	10^{-8} to $5x10^{-8}$

The soil mass permeability was assessed using the results of pump-out tests carried out by Foundation Earth Sciences Pty in the FES GI boreholes. On this basis, we have adopted a permeability of 9.68 x 10^{-5} for the residual soils and $1x10^{-7}$ for the underlying sandstone geology.

The basement is likely to intercept the groundwater table, however significant amounts of dewatering is not expected.

7.5 Seepage Analysis and Results

Using the generalised excavation and shoring geometry together with an idealised subsurface profile and the above permeabilities, seepage analyses were carried out using the 2D finite element computer program which was used in this report. A sensitivity analysis was also undertaken and the effect of varying the permeability of the deeper strata on the inflow rates was examined.

The results of the analysis indicate that an inflow rate int the order of 1.39ML/180 days of constructions phase and 2.64ML/year during operational phase. Drawdown as a result of the dewatering is expected to be negligible if at all present. Based on this calculation and the parameters provided groundwater is unlikely to be identified within the basement.

A water access license is not expected to be required.

7.6 Impact of Dewatering

Based on the results of the dewatering analyses, a detailed assessment of the potential impacts that could arise has been completed. The potential impacts include reducing the groundwater availability to other users, effect on groundwater dependent eco systems and settlements resulting in damage of surrounding buildings, structures and infrastructure as a result of lowering the groundwater levels. The basement is likely to intercept the groundwater table, however significant amounts of dewatering is not expected.

7.7 Impacts on Existing Groundwater Users

Based on preliminary analysis the groundwater level external to the excavation should not be significantly lowered as the as the basement is not expected to intercept the underlying groundwater table. The proposed temporary dewatering will therefore not limit access to the groundwater resource with regards to the Surrounding Buildings, Structures and Infrastructure.

Installation of a shoring and internal lowering of the groundwater levels within the excavation could potentially result in some fluctuations of groundwater until the site groundwater flows return to natural equilibrium. This will be mitigated by continual monitoring during construction and further analysis of these areas will be undertaken prior and during construction in order to refine the current dewatering models.

8.0 LICENSING REQUIREMENTS

Dewatering during construction will not require a water licence to account for the groundwater inflow to the basement, since it is less than 3ML / year. T

The predicted maximum long term groundwater inflows to the planned drained basement during the operation phase are expected to be less than 3ML/year. Therefore, this development could be considered as a minor aquifer interference activity which may be exempt from the full extent of the Water Management Act.

9.0 GROUNDWATER IMPACT ASSESSMENT

Table 11: Minimal Impact Consideration under the Aquifer Interference Policy

AIP – Level 1	Assessment
Water Sharing Plan / Source	Greater Metro Region Groundwater Sources 2011 / Sydney Basin Central Groundwater Source
Aquifer	Porous Rock
Category	Less Productive
Water Table	The closest groundwater dependant ecosystem is located more than 1km from the subject site.
Water Quality	The proposed development is not expected to lower the beneficial use category of groundwater beyond 40m of the site.

10.0 DEWATERING MONITORING PLAN (CONTINGENCY ONLY)

10.1 General

Temporary groundwater pumping for dewatering within the subject site is predicted to have a minimal effect on groundwater levels in the area. Groundwater levels must, however, be monitored within and outside the excavation (using simple standpipes), and the pumping rate adjusted to maintain groundwater levels to not more than 1m below the base of the bulk excavation level within the excavation pit. External groundwater levels should vary by no more than natural variation from the measured levels.

Where the basement level is found to be within groundwater fluctuation zones then visual inspection of the underlying material is to be undertaken to confirm seepage rates. Based on the depth of the basement we do not envisage significant water flow through the stratum and therefore the dewatering requirements are not expected to be ongoing.

Disposal of pumped groundwater to the local stormwater system is proposed and water quality results available to date, suggest that pumped water should be suitable for discharge, although treatment may be required in some areas.

If water is identified approximately 10,000L – 13,000L of water is proposed to be removed during the dewatering of the basement over the as per the estimated modelling. The estimated duration of dewatering is to be 180 days during construction.

10.2 Groundwater Monitoring

A groundwater level, water quality and dewatering rate monitoring program must be implemented during constructions. The following program is tentatively proposed:

- Weekly monitoring of groundwater levels. The monitoring is to commence prior to dewatering commencing and to continue for a period of at least 2 months following cessation of dewatering.

- Monitoring of discharge water quality to be undertaken weekly, decreasing to monthly after the first four weeks, if groundwater quality is stable. The analytical suite should include as a minimum, Heavy Metals, BTEXN, TRH, PAH, VOC, turbidity, Ph, TDS /TSS, oil & grease and Electrical Conductivity (EC).
- The monitoring results must be provided weekly to the environmental engineer for review.

The final groundwater monitoring program should be developed following assessment of conditions by the authorities.

10.3 Survey Monitoring

A surveying monitoring program must also be implemented. The following program is proposed:

- Establish a benchmark on the site.
- Set up permanent monitoring points on the adjacent building.
- Take baseline level and orientation readings prior to dewatering commencing and thereafter at weekly intervals for a period of at least two months following cessation of dewatering.
- The survey monitoring results must be provided weekly to the geotechnical engineer for review.

10.4 Water Quality Treatment

During the construction process, water needs to be pumped into a holding Tank and a monitoring program needs to be applied. Direct discharge of untreated groundwater may potently cause unlawful environmental harm which is prohibited under the Environmental Protection Act 1994. To ensure that any potential environmental harm is managed correctly and to enable the proponent to demonstrate compliance, regular monitoring of water quality parameters must continue in a manner advised by professionals.

It is recommended that an appropriate filtration system is designed to allow the groundwater to pass through before entering the local system. In addition, the water quality should be sampled before the initial disposal occurs and at regular intervals during the disposal process. The samples should be analysed for Metals, TRH, BTEX, PAH, VOC, TSS, TDS, Turbidity, EC, Oil & Grease and pH as a minimum. Some examples of filtration systems include:

- Sediment Tanks;
- Sediment Tanks supplemented with chemical dosing units to enhance settling rates;
- Media Filtration Systems that can treat a range of recalcitrant contaminants.

It is our understanding that the water comes into the holding tank, the flocculant (eg aluminium sulphate) is added and left-over night to settle. The water quality is then tested and sent to NATA accredited laboratory to determine the suitability for disposal down stormwater. This process is repeated for the duration of the dewatering onsite. Any remaining sediment in the holding tank is to be collected & disposed offsite appropriately.

Foundation Earth Sciences recommends that 'tail' water from the dewatering operation be treated to the ***extent practicable*** prior to discharging, to meet the adopted discharge water quality criteria.

11.0 CONTINGENCY PLAN

Any exceedances recorded during groundwater or survey monitoring may be interrelated and should not be assessed in isolation.

11.1 Groundwater Level

Should the groundwater level monitoring indicate that the groundwater levels external to the basement are dropping or increasing more than those identified within the seasonal variations, the geotechnical engineer must be informed.

The cause is likely to be higher than estimated permeability of the sands or significant rainfall events. The above would be accompanied by a higher than estimated dewatering rate and the dewatering rate must be measured and provided to the geotechnical engineer.

The survey monitoring interval may need to be increased to assess whether the drawdown/surcharge is causing surrounding buildings and structures to settle.

With respect to pumping, a standby pump and hoses will be kept on site in the event that there is a failure with the installed pumps. If further extra hoses and adaptors to suit the systems are required on site, turnaround time will be within 24 hours of notice.

11.2 Surrounding Buildings and Structures

If the survey monitoring indicates that the adjacent buildings are settling, then we recommend as follows:

- **Settlement ≤ 5mm** – Inform geotechnical engineer and repeat the survey to confirm. Work should not stop but proceed with caution and increased vigilance in areas of movement.
- **Settlement 5mm to 8mm** – Inform the geotechnical engineer and repeat the survey to confirm. Work should not stop but proceed with caution and increased vigilance in

areas of movement. The geotechnical engineer, in conjunction with other parties, must analyse the results and attempt to identify the reason for the movement.

- **Settlement > 8mm** – All work must stop and not recommence until the methodology and monitoring procedures are reviewed and remedial measures or revisions approved by the geotechnical engineer.

Possible causes of movement include excessive groundwater drawdown, deflection of the shoring or subsoil erosion.

Possible remedial measures include groundwater recharge external to the shoring, additional shoring support or blocking leaks through the shoring.

11.3 Groundwater Quality

The monitoring results of the water quality will be regularly assessed by the environmental engineer and an indication of which properties exceed the guideline limits will become evident. Generally the pH can be controlled by dousing whilst turbidity can be controlled by the use of flocculants and settling tanks. Such treatment, if required, will take place prior to discharge into the stormwater pit.

12.0 RECOMMENDATION AND CONCLUSIONS

FES carried out pump tests in boreholes in June 2023. The results of the analysis indicate that an inflow rate int the order of 1.39ML/180 days of constructions phase and 2.64ML/year during operational phase. Drawdown as a result of the dewatering is expected to be negligible if at all present. Based on this calculation and the parameters provided groundwater is unlikely to be identified within the basement.

As the groundwater seepage inflow is less than 3ML/year, we expect that a water access licence will not be required subject to confirmation with WaterNSW. Therefore we recommend that a drained basement is proposed.

During the construction process, if water needs to be pumped into a holding Tank and a monitoring program needs to be applied. It is recommended that an appropriate filtration system is designed to allow the groundwater to pass through before entering the local system. It is our understanding that the water comes into the holding tank, the flocculant (eg aluminium sulphate) is added and left-over night to settle. The water quality is then tested and sent to NATA accredited laboratory to determine the suitability for disposal down stormwater. This process is repeated for the duration of the dewatering onsite. Any remaining sediment in the holding tank is to be collected & disposed offsite appropriately.

Recommendation

Based on the groundwater modelling results provided in this report including the seepage analysis limitations a drained basement is suitable for the development. This report should be read in conjunction with the FES geotechnical report titled “FES (2022) Geotechnical Report 2-10 Berry Road, 14-16 Marshall Avenue & 5-9 Holdsworth Avenue, St Leonards NSW - Ref G546-1 Revision 2.

Thank you for the opportunity of undertaking this work. We would be pleased to provide further information on any aspects of this report.

For and on behalf of Foundation Earth Sciences

Prepared by

Ben Buckley

Director

13.0 LIMITATIONS

The assessment of the sub-surface profile within the proposed development area and the recommendations presented in this report are based on limited information available to date.

The recommendations and advice presented in this report on soil and rock condition is considered to be indicative only as only very limited areas were assessed on site to date. Site inspection by a consulting Geotechnical Engineer or Engineering Geologist are to be undertake when further investigation works are to be carried out to confirm the condition of founding materials in which this geotechnical assessment recommends.

Anecdotal evidence and Information provided by client is assumed to be relevant and to the best of knowledge be appropriate for its interpretation.

There is a possibility that the actual geotechnical and groundwater conditions across the site could differ from the inferred geotechnical assumptions and derivations on which our recommendations are presented in this report. In that case, Foundation Earth Sciences should be contacted for further advise and review of the information provided in this report. Foundation Earth Sciences does not accept any liabilities for the conditions not provided and/or accessible during the preparation of this report. Any ensuring liability resulting from use of this report by third parties cannot be transferred to Foundation Earth Sciences.

14.0 REFERENCES

1. Australian Standard – AS1726-1993 “Geotechnical Site Investigation”.
2. Australian Standard – AS 1170.4-2007 “Structural Design Actions – Part 4: Earthquake actions in Australia”.
3. Australian Standard – AS 2870-2011 “Residential slabs and footings”.
4. Australian Standard – AS 2159-2009 “Piling - Design and installation”.
5. Pells, P.J.N, Mostyn, E and Walker, B F – Foundations on Sandstone and Shale in the Sydney Region, Australian Geomechanics Journal, Dec 1998.
6. Pells, P.J.N, Douglas D.J, Rodway, B, Thorne C, McManon B.K – Design Loadings for Foundations on Shale and Sandstone in the Sydney Region. Australian Geomechanics Journal, 1978.
7. Site Investigation for Urban Salinity, Department of Land and Water Conservation 2002.

Key

Approximate Test Locations

Not to scale

FOUNDATION EARTH SCIENCES

Ref #	Site Plan
E2670-4	Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust
MM	2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards

BOREHOLE : BH1

FOUNDATION EARTH SCIENCES

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 30/08/2021 **Completed :** 30/08/2021 **Logged By :** MM **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 77.9 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
ADT	Not encountered within the augering		77.8	0.10		CH	FILL, gravelly silt, low plasticity, fine to medium gravel, grey-brown-red	M	F		Fill	1
							Silty CLAY, medium to high plasticity, grey	M	St-VSt	SPT 2, 4, 13 N=17	Residual Soils	2
										SPT 9, 26, Bouncing N > 50		3
			73.9	4.00			SANDSTONE, fine to medium grained, interbedded with some clay and shale, extremely weathered, extremely low strength, yellow-grey	M			Bedrock	4
			72.3	5.65			Borehole BH1 continued as cored hole from 5.65m				TC bit refusal	5
												6
												7
												8
												9
												10

Comments:

D - Dry, M - Moist, W - Wet

VS - Very Soft, S - Soft, F - Firm, St - Stiff, VSt - Very Stiff, H - Hard

VL - Very Loose, L - Loose, MD - Medium Dense, D - Dense, VD - Very Dense

FOUNDATION EARTH SCIENCES

BOREHOLE : BH1

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 30/08/2021 **Completed :** 30/08/2021 **Logged By :** MM **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 77.9 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL VL L M H VH EH)	$Is_{(50)}$ (MPa)	RQD %	Defect Spacing (mm) (20 60 180 540 1620)	Defect Description	Depth (m)
				1									1
				2									2
				3									3
				4									4
				5		Continued from non-cored borehole							5
NMLC			72.3	5.65		SANDSTONE, fine to medium grained, with some shale bands, grey-brown-dark grey	MW		D A 0.43 0.82 D A 0.15 0.8 D A 0.53 0.51	68 74		5.72m, B, P, S, 0-5° 5.76m, B, P, S, 0-5° 5.85m, B, P, S, 0-5° 5.90m, B, P, S, 0-5°, Fe 5.92m, B, P, S, 0-5° 6.00m, HB 6.10m, B, P, S, 10-15° 6.30m, B, P, S, 5-10° 6.32m, B, P, S, 0-5° 6.39m, B, P, S, 0-5° 6.53m, B, P, S, 0-5° 6.70m, EW, 10mm 6.80m, B, P, S, 0-5° 6.88m, B, P, S, 0-5° 6.92m, J, P, S, 0-5°, Fe 7.00m, HB 7.15m, B, P, S, 0-5°, Fe 7.16m, B, P, S, 0-5°, Fe 7.30m, J, Ir, R, 0-5° 7.35m, J, Ir, R, 70-75°, Fe 7.46m, EW+CS, 50mm 7.52m, B, P, R, 0-5°, Fe 7.62m, B, P, R, 10-15°, Fe 7.69m, B, P, R, 10-15°, Fe 7.80m, B, P, R, 0-5°, Fe 8.00m, HB 8.10m, B, P, S, 0-5° 8.21m, J, P, R, 0-5° 8.31m, B, P, S, 0-5° 8.38m, B, P, S, 0-5° 8.45m, MB 8.51m, B, P, S, 5-10° 8.77m, B, P, S, 0-5° 8.82m, EW, 20mm 9.00m, HB 9.27m, B, P, R, 0-5° 9.28m, B, P, R, 0-5° 9.39m, J, P, S, 10-15° 9.63m, B, P, S, 0-5° 9.65m, B, P, S, 10-15° 9.93m, B, P, S, 0-5°	6 7 8 9 10

Comments:

Weathering
EW - Extremely
HW - Highly
MW - Moderately
SW - Slightly
Fr - Fresh

EL - Extremely Low
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High
EH - Extremely High

D - Diametral
A Axial

J - Joint
B - Bedding Plan
CS - Clay Seams
FZ - Fractured Zone
IS - Infill Seam
SS - Sheared Seam
CZ - Crushed Zone

MB - Mechanical Break
HB - Handling Break
Pl - Planar
Ir - Irregular
Cu - Curved
St - Stepped

S - Smooth
R - Rough
P - Polished
Qz - Quartz
Fe - Iron Stain

FOUNDATION EARTH SCIENCES

BOREHOLE : BH1

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 30/08/2021 **Completed :** 30/08/2021 **Logged By :** MM **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 77.9 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL VL L M H VH EH)	$Is_{(50)}$ (MPa)	RQD %	Defect Spacing (mm) (20 60 180 540 1620)	Defect Description	Depth (m)
NMLC				11		SANDSTONE, fine to medium grained, with some shale bands, grey-brown-dark grey *(continued)*	MW		D A 0.15 1.5	74		10.00m, HB 10.15m, B, P, S, 10-15° 10.17m, J, Ir, R, 85-90°, Fe 10.20m, J, Ir, R, 85-90°, Fe 10.22m, J, Ir, R, 85-90°, Fe 10.25m, J, Ir, R, 85-90°, Fe 10.28m, EW+CS, 50mm 10.40m, B, P, R, 0-5° 10.62m, B, P, R, 0-5° 10.70m, B, P, R, 0-5° 10.83m, B, P, R, 0-5° 11.00m, HB 11.08m, B, P, S, 0-5° 11.13m, B, P, S, 0-5° 11.22m, B, P, S, 0-5° 11.24m, B, P, S, 0-5° 11.35m, B, P, S, 0-5° 11.41m, B, P, S, 0-5°	11
				12			SW		D A 1.09 0.95			11.48m, MB 11.50m, B, P, S, 0-5° 11.72m, B, P, S, 0-5° 12.00m, B, P, S, 0-5° 12.03m, B, P, S, 0-5° 12.31m, B, P, R, 0-5°	12
				13						85		12.72m, B, P, S, 0-5° 13.00m, HB	13
				14					D A 1.1 0.87			13.25m, B, P, S, 0-5° 13.27m, B, P, S, 0-5° 13.37m, B, P, S, 0-5° 13.46m, B, P, S, 0-5° 13.54m, J, Ir, R, 0-5° 13.56m, B, P, R, 0-5° 13.60m, B, P, R, 0-5° 13.64m, B, P, R, 0-5° 13.72m, B, P, R, 0-5° 13.76m, B, P, R, 0-5° 14.00m, HB 14.30m, B, P, R, 0-5° 14.47m, MB	14
				15					D A 1.84 1.39			14.81m, B, P, S, 0-5° 14.90m, EW, 10mm 14.97m, B, P, S, 0-5° HB 15.05m, B, P, S, 0-5° 15.44m, B, P, S, 0-5°	15
				16						89		15.90m, B, P, S, 0-5° 15.93m, B, P, S, 0-5° 16.00m, HB 16.02m, B, P, S, 0-5°	16
				17					D A 1.17 1.1			16.90m, B, P, S, 0-5° 17.00m, HB	17
									D A 1.2 1.71				
			60.2	*17.75* 18		BH1 terminated at 17.75m						17.75m, MB	18
				19									19
				20									20

Comments:

Weathering: EW - Extremely; HW - Highly; MW - Moderately; SW - Slightly; Fr - Fresh

EL - Extremely Low; VL - Very Low; L - Low; M - Medium; H - High; VH - Very High; EH - Extremely High

D - Diametral; A Axial

J - Joint; B - Bedding Plan; CS - Clay Seams; FZ - Fractured Zone; IS - Infill Seam; SS - Sheared Seam; CZ - Crushed Zone

MB - Mechanical Break; HB - Handling Break; Pl - Planar; Ir - Irregular; Cu - Curved; St - Stepped

S - Smooth; R - Rough; P - Polished; Qz - Quartz; Fe - Iron Stain

BOREHOLE : BH2

FOUNDATION EARTH SCIENCES

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 31/08/2021 **Completed :** 31/08/2021 **Logged By :** RL/MM **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 75.2 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
ADT			75.2	0.05			Brick Pavement, approximate thickness of 50mm	M	F		Fill	
			75.0	0.20		CH	FILL, gravelly silt, low plasticity, fine gravel, dark brown-dark grey	M	St-VSt		Residual Soils	
							Silty CLAY, medium to high plasticity, grey with red mottling					1
			74.0	1.20		CS	Sandy CLAY, medium to high plasticity, fine to medium grained sand, grey-red-brown	M	St-VSt	SPT 3, 6, 9 N=15		2
			72.7	2.50			SANDSTONE, fine to medium grained, interbedded with some clay and shale, extremely weathered, extremely low strength, yellow-grey	M-W			Bedrock	3
	▶										Seepage from 3.8m to 4.0m	4
											TC bit refusal	5
			70.3	4.90			Borehole BH2 continued as cored hole from 4.90m					6
												7
												8
												9
												10

Comments:

D - Dry, M - Moist, W - Wet

VS - Very Soft, S - Soft, F - Firm, St - Stiff, VSt - Very Stiff, H - Hard

VL - Very Loose, L - Loose, MD - Medium Dense, D - Dense, VD - Very Dense

FOUNDATION EARTH SCIENCES

BOREHOLE : BH2

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 31/08/2021 **Completed :** 31/08/2021 **Logged By :** RL/MM **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 75.2 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength	$Is_{(50)}$ (MPa)	RQD %	Defect Spacing (mm)	Defect Description	Depth (m)
				1									1
				2									2
				3									3
				4									4
				5		Continued from non-cored borehole							5
NMLC			70.3	4.90 5		SANDSTONE, fine to medium grained, with some shale bands, light grey-grey-brown	MW		D A 0.45 0.62	52		4.95m, B, P, S, 0-5° 5.00m, B, P, S, 0-5° 5.11m, B, P, S, 10-15° 5.19m, J, Ir, R, 45-50° 5.27m, J, P, R, 10-15° 5.30m, J, P, R, 60-65°, Fe 5.34m, J, P, R, 60-65°, Fe 5.36m, J, P, R, 10-15° 5.46m, B, P, S, 0-5° 5.65m, B, P, R, 0-5° 5.73m, B, P, R, 0-5° 5.76m, CS, 10mm 5.83m, B, P, R, 0-5° 5.91m, EW, 20mm 6.00m, HB 6.05m, B, P, R, 0-5° 6.20m, MB 6.34m, B, P, S, 0-5° 6.68m, B, P, R, 5-10° 6.73m, B, P, S, 0-5° 6.91m, J, P, R, 5-10° 7.00m, B, P, S, 0-5° 7.10m, B, P, S, 0-5°	6
				7					D A 0.29 1.28	73		7.32m, J, Ir, R, 0-5° 7.36m, B, P, S, 0-5° 7.45m, B, P, S, 0-5° 7.54m, EW, 20mm 7.62m, B, P, S, 0-5° 7.72m, B, P, S, 0-5° 7.83m, B, P, R, 0-5° 7.86m, B, P, S, 0-5° 7.88m, B, P, S, 0-5° 7.97m, B, P, S, 0-5° 8.00m, B, P, S, 0-5° 8.08m, B, P, S, 0-5° 8.21m, B, P, S, 0-5° 8.23m, B, P, S, 0-5° 8.33m, B, P, S, 0-5° 8.41m, B, P, S, 0-5° 8.74m, J, P, R, 5-10° 9.00m, HB	7
				8			SW		D A 0.6 1.14			9.15m, MB 9.21m, B, P, S, 0-5°	8
				9									9
				10					D A 0.73 1.11	91		9.82m, B, P, S, 0-5°	10

Comments:

Weathering
EW - Extremely
HW - Highly
MW - Moderately
SW - Slightly
Fr - Fresh

EL - Extremely Low
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High
EH - Extremely High

D - Diametral
A Axial

J - Joint
B - Bedding Plan
CS - Clay Seams
FZ - Fractured Zone
IS - Infill Seam
SS - Sheared Seam
CZ - Crushed Zone

MB - Mechanical Break
HB - Handling Break
Pl - Planar
Ir - Irregular
Cu - Curved
St - Stepped

S - Smooth
R - Rough
P - Polished
Qz - Quartz
Fe - Iron Stain

FOUNDATION EARTH SCIENCES

BOREHOLE : BH2

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 31/08/2021 **Completed :** 31/08/2021 **Logged By :** RL/MM **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 75.2 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL VL L M H VH EH)	$Is_{(50)}$ (MPa)	RQD %	Defect Spacing (mm) (20 60 180 540 1620)	Defect Description	Depth (m)
NMLC				11		SANDSTONE, fine to medium grained, with some shale bands, light grey-grey-brown *(continued)*	SW		D 0.71 A 1.78	91		10.00m, HB 10.12m, HB 10.59m, B, P, S, 0-5° 10.96m, B, P, S, 0-10° 11.00m, HB 11.10m, B, P, S, 0-5° 11.12m, B, P, S, 0-5° 11.15m, B, P, S, 0-5° 11.17m, B, P, S, 0-5° 11.34m, B, P, S, 0-5° 11.36m, EW, 30mm 11.47m, B, P, S, 0-5° 11.67m, B, P, S, 0-5°	11
				12								12.00m, HB 12.09m,MB 12.41m, B, P, S, 0-5° 12.61m, B, P, S, 0-5° 12.66m, EW, 20mm	12
				13					D 0.71 A 0.98	98		12.93m, B, P, S, 0-5° 13.00m, HB 13.12m, B, P, S, 0-5° 13.23m, J, P, S, 20-30°	13
				14					D 1.37 A 1.57			14.00m, HB 14.18m, B, P, S, 0-5°	14
				15								15.00m, HB 15.02m, HB 15.05m, MB	15
				16					D 1.86 A 2.09			15.77m, B, P, S, 0-5° 16.00m, HB 16.07m, HB 16.46m, B, P, S, 0-5°	16
				17					D 1.51 A 1.66	98		17.00m, HB 17.63m, B, Ir, R, 0-10°	17
				18					D 1.47 A 1.66			17.98m, MB	18
			57.2	*17.98*		BH2 terminated at 17.98m							
				19									19
				20									20

EL VL L M H VH EH | 20 60 180 540 1620 4860

Comments:

Weathering
EW - Extremely
HW - Highly
MW - Moderately
SW - Slightly
Fr - Fresh

EL - Extremely Low
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High
EH - Extremely High

D - Diametral
A Axial

J - Joint
B - Bedding Plan
CS - Clay Seams
FZ - Fractured Zone
IS - Infill Seam
SS - Sheared Seam
CZ - Crushed Zone

MB - Mechanical Break
HB - Handling Break
Pl - Planar
Ir - Irregular
Cu - Curved
St - Stepped

S - Smooth
R - Rough
P - Polished
Qz - Quartz
Fe - Iron Stain

BOREHOLE : BH3

FOUNDATION EARTH SCIENCES

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 1/09/2021 **Completed :** 2/09/2021 **Logged By :** RL **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 73.2 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
							FILL, silty clay, low to medium plasticity, brown-dark brown	M	F		Fill	
HA	Not encountered within the augering		72.8	0.40		CH	Sandy CLAY, medium to high plasticity, light brown-orange	M	St		Residual Soils	
											Hand Auger refusal	
			71.9	1.31			Borehole BH3 continued as cored hole from 1.31m					

Comments:

D - Dry, M - Moist, W - Wet

VS - Very Soft, S - Soft, F - Firm, St - Stiff, VSt - Very Stiff, H - Hard

VL - Very Loose, L - Loose, MD - Medium Dense, D - Dense, VD - Very Dense

FOUNDATION EARTH SCIENCES

BOREHOLE : BH3

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 1/09/2021 **Completed :** 2/09/2021 **Logged By :** RL **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 73.2 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL VL L M H VH EH)	$Is_{(50)}$ (MPa)	RQD %	Defect Spacing (mm) (20 60 180 540 1620)	Defect Description	Depth (m)
				1		Continued from non-cored borehole							1
NMLC			71.9	1.31		SHALE, interbedded with clay and sandstone, fine to medium grained, brown-red-grey	EW		D 1.54 A 2.26 D 0.01 A 0	0 0			2 3 4
			68.8	4.37		SHALE, interbedded with sandstone, fine to medium grained, dark grey-brown	HW		D 0.38 A 0.66 D 0.4 A 1.41	50 63		4.43m, B, P, S, 0-5° 4.46m, B, P, S, 0-5° 4.71m, J, Ir, R, 0-5° 4.86m, B, P, S, 0-5° 4.95m, B, P, S, 0-5° 5.00m, B, P, R, 0-5° 5.06m, B, P, S, 0-5° 5.11m, B, P, S, 0-10° 5.26m, B, Ir, S, 0-10° 5.29m, B, P, S, 0-5° 5.35m, B, P, S, 0-5° 5.43m, B, P, S, 0-5° 5.46m, B, P, S, 0-10° 5.51m, B, P, S, 0-5° 5.56m, B, P, S, 0-5° 5.70m, B, P, S, 0-5° 5.76m, B, P, S, 0-5° 5.84m, B, P, S, 0-5° 5.94m, MB 6.00m, B, P, S, 0-10° 6.02m, J, Ir, R, 0-10° 6.06m, J, Cu, R, 10-20° 6.09m, B, P, R, 5-10° 6.10m, B, P, R, 5-10° 6.17m, B, Ir, S, 0-10° 6.31m, B, P, S, 0-5° 6.32m, B, P, S, 0-5° 6.38m, EW, 10mm 6.55m, J, Cu, S, 10-30° 6.67m, B, P, S, 0-5° 6.69m, B, P, S, 0-5° 6.70m, EW, 10mm 6.80m, B, P, S, 0-5° 6.84m, B, Ir, S, 0-10° 6.86m, B, P, S, 0-5° 6.95m, EW, 10mm 7.00m, HB 7.14m, B, P, S, 0-5° 7.20m, HB 7.54m, MB 7.59m, B, P, S, 0-5° 7.75m, B, P, S, 0-10° 7.93m, J, Ir, S, 0-15° 7.98m, HB 8.00m, HB 8.11m, B, P, S, 0-5° 8.21m, B, P, S, 0-5° 8.26m, B, P, S, 0-5° 8.35m, B, P, S, 0-5° 8.42m, B, P, S, 0-5° 8.63m, B, P, S, 5-10° 8.69m, B, P, S, 5-10° 8.90m, B, P, S, 0-5° 8.95m, B, P, S, 0-5° 9.00m, HB	5 6 7
			66.2	7.00		SANDSTONE, fine to medium grained, with some shale bands, light grey-grey	MW-SW		D 0.41 A 0.33 D 0.57 A 0.52	69 75			8 9 10

Comments:

Weathering: EW - Extremely; HW - Highly; MW - Moderately; SW - Slightly; Fr - Fresh

EL - Extremely Low; VL - Very Low; L - Low; M - Medium; H - High; VH - Very High; EH - Extremely High

D - Diametral; A - Axial

J - Joint; B - Bedding Plan; CS - Clay Seams; FZ - Fractured Zone; IS - Infill Seam; SS - Sheared Seam; CZ - Crushed Zone

MB - Mechanical Break; HB - Handling Break; Pl - Planar; Ir - Irregular; Cu - Curved; St - Stepped

S - Smooth; R - Rough; P - Polished; Qz - Quartz; Fe - Iron Stain

FOUNDATION EARTH SCIENCES

BOREHOLE : BH3

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 1/09/2021 **Completed :** 2/09/2021 **Logged By :** RL **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 73.2 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL VL L M H VH EH)	$Is_{(50)}$ (MPa)	RQD %	Defect Spacing (mm) (20 60 180 540 1620)	Defect Description	Depth (m)
NMLC				11		SANDSTONE, fine to medium grained, with some shale bands, light grey-grey *(continued)*	MW-SW		D 1.4 A 1.75 D 1.71 A 1.89	75 89		9.04m, MB 9.54m, CS, 10mm 9.62m, CS, 10mm 9.66m, B, P, S, 0-10° 9.71m, B, P, S, 0-5° 9.78m, B, P, S, 0-5° 9.90m, B, P, S, 5-10° 10.00m, HB 10.09m, EW, 10mm 10.18m, B, P, S, 0-5° 10.22m, B, P, S, 0-5° 10.37m, B, P, S, 0-5° 10.55m, MB 10.86m, B, P, S, 0-5° 11.00m, HB 11.09m, B, P, S, 0-5° 11.19m, B, P, S, 0-5° 11.22m, B, P, S, 0-5° 11.27m, MB	11
			61.9	*11.27*		BH3 terminated at 11.27m							
				12									12
				13									13
				14									14
				15									15
				16									16
				17									17
				18									18
				19									19
				20									20

Comments:

Weathering
EW - Extremely
HW - Highly
MW - Moderately
SW - Slightly
Fr - Fresh

EL - Extremely Low
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High
EH - Extremely High

D - Diametral
A Axial

J - Joint
B - Bedding Plan
CS - Clay Seams
FZ - Fractured Zone
IS - Infill Seam
SS - Sheared Seam
CZ - Crushed Zone

MB - Mechanical Break
HB - Handling Break
Pl - Planar
Ir - Irregular
Cu - Curved
St - Stepped

S - Smooth
R - Rough
P - Polished
Qz - Quartz
Fe - Iron Stain

FOUNDATION EARTH SCIENCES

BOREHOLE : BH4

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 7/09/2021 **Completed :** 7/09/2021 **Logged By :** RL **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 72.1 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
						FILL, silty clay, low to medium plasticity, brown-dark brown	M	F		Fill	
HA	Not encountered within the augering	71.7	0.40		CH	Sandy CLAY, medium to high plasticity, light brown-orange	M	St		Residual Soils	1
		70.8	1.34			Borehole BH4 continued as cored hole from 1.34m				Hand Auger refusal	2

Comments:

D - Dry, M - Moist, W - Wet

VS - Very Soft, S - Soft, F - Firm, St - Stiff, VSt - Very Stiff, H - Hard

VL - Very Loose, L - Loose, MD - Medium Dense, D - Dense, VD - Very Dense

FOUNDATION EARTH SCIENCES

BOREHOLE : BH4

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 7/09/2021 **Completed :** 7/09/2021 **Logged By :** RL **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 72.1 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL VL L M H VH EH)	$Is_{(50)}$ (MPa)	RQD %	Defect Spacing (mm) (20 60 180 540 1620)	Defect Description	Depth (m)
			1		Continued from non-cored borehole							1
NMLC		70.8	1.34		SANDSTONE, fine to medium grained, grey-brown, with some clay bands	EW		D 0.46 A 0.42	0			2
		69.2	2.90		SANDSTONE, interbedded with shale, fine to medium grained, grey-brown-red-light grey	HW		D 0.44 A 0.54	59		2.90m, B, P, S, 0-5° 2.97m, HB 3.00m, HB 3.14m, B, P, S, 0-5° 3.25m, B, Ir, S, 0-10° 3.33m, B, P, S, 0-5° 3.48m, EW, 10mm	3
			4					D 0.43 A 0.31	39		3.66m, J, P, R, 40-50° 3.71m, B, P, R, 0-5° 3.74m, B, P, R, 0-5° 3.82m, EW, 40mm 3.92m, B, P, R, 10-20° 3.96m, B, P, R, 0-5° 4.00m, MB 4.14m, B, P, S, 15-20° 4.37m, B, P, S, 15-20° 4.50m, B, P, S, 5-10° 4.60m, CS, 60mm 4.69m, CS, 20mm 4.80m, Core Loss, 90mm 4.91m, B, P, S, 0-5° 4.95m, B, P, S, 0-5° 4.99m, B, P, S, 0-5°	4
			5								5.00m, HB 5.04m, B, P, S, 0-5° 5.09m, B, P, S, 0-5° 5.13m, B, P, S, 0-5° 5.17m, B, P, S, 0-5° 5.21m, B, P, S, 0-5° 5.26m, B, P, S, 0-5° 5.30m, B, Ir, S, 0-10° 5.37m, B, P, S, 0-5°	5
			6					D 0.43 A 1.22	61		5.40m, J, Ir, S, 15-25° 5.43m, B, P, S, 0-5° 5.47m, B, Ir, S, 0-5° 5.49m, B, P, S, 0-5° 5.55m, MB 5.58m, B, Ir, S, 0-5° 5.64m, B, P, S, 0-5° 5.71m, B, P, S, 5-10°	6
		65.9	6.20		SANDSTONE, fine to medium grained, with some shale bands, light grey-grey	MW-SW						
			7								5.73m, B, P, S, 0-5° 5.92m, B, P, S, 0-5° 6.00m, B, P, S, 0-5° 6.03m, B, P, S, 0-5° 6.07m, B, Ir, S, 0-10° 6.08m, B, P, S, 0-5° 6.11m, B, P, S, 0-5° 6.13m, B, P, S, 0-5° 6.17m, B, P, S, 0-5° 6.33m, B, P, S, 0-5° 6.41m, B, P, S, 0-5°	7
			8					D 0.67 A 1.11	73		6.46m, B, P, S, 0-5° 6.56m, B, P, S, 0-5° 6.67m, B, P, S, 0-5° 6.77m, B, P, S, 0-5° 6.87m, B, P, S, 0-5° 7.00m, MB 7.08m, B, P, S, 0-5° 7.13m, B, P, S, 0-5° 7.27m, B, P, S, 0-5°	8
			9					D 0.39 A 0.47	30		7.32m, B, P, S, 0-5° 7.39m, B, P, S, 0-5° 7.44m, B, P, S, 0-5° 7.54m, B, P, S, 0-5° 7.59m, B, P, S, 0-5° 7.70m, B, P, S, 0-5° 7.76m, B, P, S, 0-5° 8.00m, HB 8.03m, HB 8.28m, B, P, S, 0-5° 8.54m, MB	9
			10					D 1.58 A 0.97	53			10

Comments:

Weathering: EW - Extremely; HW - Highly; MW - Moderately; SW - Slightly; Fr - Fresh

EL - Extremely Low; VL - Very Low; L - Low; M - Medium; H - High; VH - Very High; EH - Extremely High

D - Diametral; A - Axial

J - Joint; B - Bedding Plan; CS - Clay Seams; FZ - Fractured Zone; IS - Infill Seam; SS - Sheared Seam; CZ - Crushed Zone

MB - Mechanical Break; HB - Handling Break; Pl - Planar; Ir - Irregular; Cu - Curved; St - Stepped

S - Smooth; R - Rough; P - Polished; Qz - Quartz; Fe - Iron Stain

FOUNDATION EARTH SCIENCES

BOREHOLE : BH4

CLIENT NAME: Holdsworth Land Pty Ltd ATF Holdsworth Land Unit Trust **JOB NUMBER:** G511

SITE ADDRESS: 2-10 Berry Rd, 14-16 Marshall Ave & 5-9 Holdsworth Ave, St Leonards NSW **PROJECT:** Geotechnical Investigation

Date Started : 7/09/2021 **Completed :** 7/09/2021 **Logged By :** RL **Checked By :** MM

Borehole Location : Refer to Site Plan **Surface RL :** 72.1 **Datum :** m AHD

Equipment : Drilling Rig **Borehole Size :** 100mm **Slope :** -90°

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL VL L M H VH EH)	$Is_{(50)}$ (MPa)	RQD %	Defect Spacing (mm) (20 60 180 540 1620)	Defect Description	Depth (m)
NMLC					SANDSTONE, fine to medium grained, with some shale bands, light grey-grey *(continued)*	MW-SW		D 1.23 A 1.96	53		8.56m, B, Ir, S, 0-10° 8.68m, B, P, S, 0-5° 8.75m, B, P, S, 0-5° 8.77m, CS, 20mm 8.83m, B, P, S, 0-5° 8.88m, B, P, S, 0-5° 8.98m, EW, 20mm 9.02m, J, Ir, S, 80-90° 9.03m, B, Ir, S, 0-10° 9.09m, B, P, S, 0-5° 9.10m, CS, 60mm 9.19m, B, P, S, 0-5° 9.24m, B, P, S, 0-5° 9.27m, MB 9.32m, B, P, S, 0-5° 9.37m, B, P, S, 0-5° 9.40m, B, P, S, 0-5° 9.44m, B, P, S, 0-5° 9.62m, B, P, S, 0-5° 9.67m, B, P, S, 0-5° 9.70m, B, P, S, 0-5° 10.00m, HB 10.10m, B, P, S, 0-5° 10.15m, B, P, S, 0-5° 10.17m, B, P, S, 0-5° 10.20m, B, P, S, 0-5° 10.27m, B, P, S, 0-5° 10.32m, B, P, S, 0-5° 10.35m, B, P, S, 0-5° 10.37m, B, P, S, 0-5° 10.48m, B, P, R, 20-30° 10.57m, MB	
		61.5	*10.57*		BH4 terminated at 10.57m							

Comments:

Weathering: EW - Extremely; HW - Highly; MW - Moderately; SW - Slightly; Fr - Fresh

EL - Extremely Low; VL - Very Low; L - Low; M - Medium; H - High; VH - Very High; EH - Extremely High

D - Diametral; A Axial

J - Joint; B - Bedding Plan; CS - Clay Seams; FZ - Fractured Zone; IS - Infill Seam; SS - Sheared Seam; CZ - Crushed Zone

MB - Mechanical Break; HB - Handling Break; Pl - Planar; Ir - Irregular; Cu - Curved; St - Stepped

S - Smooth; R - Rough; P - Polished; Qz - Quartz; Fe - Iron Stain

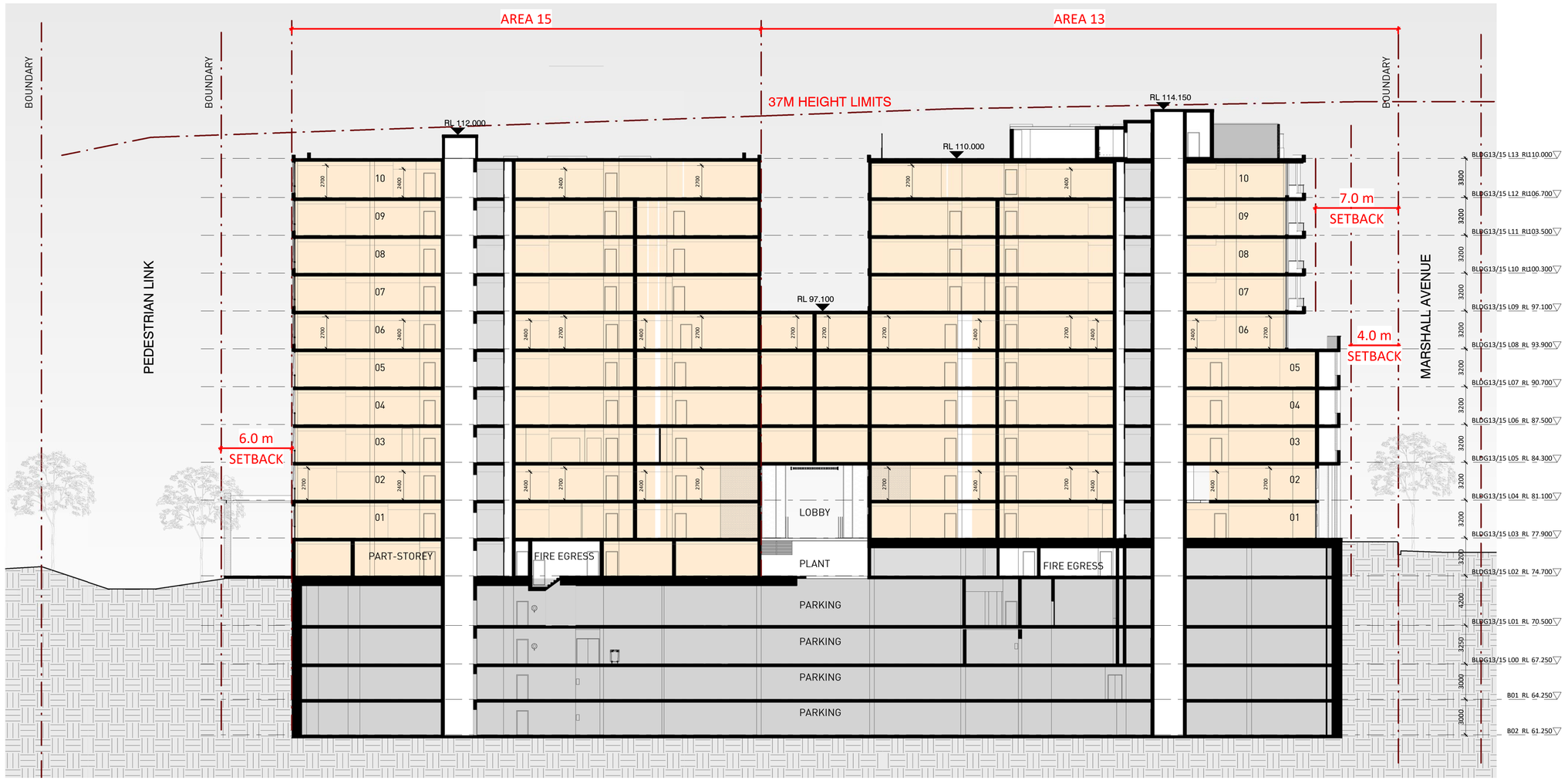
Table 1: Monitoring of Groundwater Levels at St Leonards

SAMPLE ID	RL for for location	DATE	SWL/m (BGL)	RL for Water Level	DATE	SWL/m (BGL)	RL for Water Level	DATE/TIME	SWL/m (BGL)	RL for Water Level
		Sep-21			*Jun-23*			*Jul-23*		
BH1/GW1	**77.9**	30/08/2021	6.9	71	13/06/2023	6.8	71.1	12/07/2023	6.9	71
BH2/GW2	**75.2**	30/08/2021	5.8	69.4	13/06/2023	3.3	71.9	12/07/2023	3.5	71.7
BH3/GW3	**73.2**	30/08/2021	4	69.2	13/06/2023	2.8	70.4	12/07/2023	3	70.2
		-	-	-						
SAMPLE ID	**RL for for location**	**DATE**	**SWL/m (BGL)**	**RL for Water Level**	**DATE**	**SWL/m (BGL)**	**RL for Water Level**	**DATE/TIME**	**SWL/m (BGL)**	**RL for Water Level**
		Aug-23			*Aug-23*			*Sep-23*		
BH1/GW1	**77.9**	3/08/2023	6.9	71	30/08/2023	6.8	71.1	8/09/2023	6.7	71.2
BH2/GW2	**75.2**	3/08/2023	3.4	71.8	30/08/2023	3.3	71.9	8/09/2023	3.6	71.6
BH3/GW3	**73.2**	3/08/2023	3.2	70	30/08/2023	2.8	70.4	8/09/2023	3.1	70.1
		-	-	-						

Table A1

	Heavy Metals (Dissolved)								TRH		BTEX							PAH					Physicochemical						
	ARSENIC	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	F1 (C_6-C_{10})	F2 (>C_{10}-C_{16})	BENZENE	TOLUENE	ETHYL BENZENE	M/P-XYLENE	O-XYLENE	NAPHTHALENE	TOTAL-XYLENE	BENZO(A)PYRENE	ANTHRACENE	PHENANTHRENE	FLUORANTHENE	NAPHTHALENE	pH	EC(us/cm)	Turbidity	Oil & Grease (mg/L)	Total Dissolved Solids mg/L	Faecal Coliforms	Total Suspensed Solid mg/L
Limit of Resolution (LOR)	1	0.1	1	1	1	0.05	1	1	10	50	1	1	1	2	1	1	-	1	1	1	1	1	-	1	0.1	5	5		5
Discharge Water Criteria																													
Based on ANZ (2018) + ANZECC 2000 + Drinking Water																													
Default Trigger Values South East Oz - Marine																							6.5-8.5	122-2200					
Fresh Water Trigger Values (95%)	24/13	0.2	1	1.4	3.4	0.06	11	8	-	-	950	-	-	200	350	-	-	-	-	-	-	16				ND			
Fresh Water Trigger Values (95%) -low reliability												180	80					0.1	0.01	0.6	1	-							
Marine Water		0.7	4.4	1.3	4.4	0.1	7	15			500											50							
NHMRC 2018 Drinking Water																										<600-900 (mg /L)		ND	
Default Trigger Values South East Oz - Marine																									6 to 50				

Notes All units are in ug/L unless otherwise stated



1 SECTION 13/15

1 : 200

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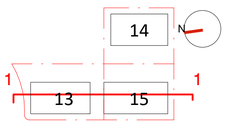
Key Plan:



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Rev	Amendment	By	Chk*	Date
B	ISSUE FOR DA SUBMISSION	JY	LG	24/03/23
A	ISSUE FOR COORDINATION	JY	LG	03/02/23

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1 : 200 @ A1

Project PA030465

14-16 Marshall Avenue, 5-9 Holdsworth Avenue & 2-10 Berry Road, ST Leonards

Status

Title
DA DRAWINGS
SECTION BLDG 13-15

Drawing Number DA-D120010

Revision B

01 May 23 5:52:26 PM

A1