



# OB Geotechnics

Consulting Geotechnical Engineering Services

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## **REPORT ON GEOTECHNICAL SITE INVESTIGATION**

**PREPARED FOR**

**Stephen Ring**

**Proposed Dual Occupancy**

**AT**

**Lot 4 DP 244699,  
23 Marine Parade, Byron Bay, NSW 2481**

**25 January 2025  
Project Ref: P599GI\_Rev1**

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## **1 INTRODUCTION**

This report presents the results of a geotechnical site investigation for the proposed dual occupancy at 23 Marine Parade, Byron Bay, NSW 2481, described as Lot 4 DP 244699. The investigation was commissioned by email from HGA Studio, dated 15 August 2024, to complete this investigation. The commission was based on our fee proposal (Ref. P599 Byron Bay), dated 15 August 2024. A Site Location Plan is presented as Figure 1.

The following plans have been provided to OB Geotechnics, and are attached in Appendix D:

- Architectural drawings, Drawing No. A0.01, A0.02, A1.01 to A1.04, A2.01.1 to A2.01.5, A4.01, A4.02, A5.01 and A5.02, Rev 02 – WIP, Job No. HGA 266, dated 7 August 2024, Prepared by HGA Studio.

Based on the provided information, we understand that a dual occupancy is proposed for the site mentioned above. The development includes a new dwelling, cut and fill earthworks with a maximum cut of approximately 3 metres, and retaining walls.

Structural loads have not been supplied, so we have assumed typical loading for this type of development. The purpose of the geotechnical investigation was to gather information regarding subsurface conditions, which will serve as a basis for site classification and recommendations. Additionally, the report provides recommendations, including footing design as well as batter and retaining wall recommendations, to assist with detailed design.

## **2 INVESTIGATION PROCEDURE**

The fieldwork for the investigation was carried out on 27 August 2024 and included the drilling of two boreholes (BH1 and BH2) to depths of 2.5 m and 1.3 m, respectively. Additionally, Dynamic Cone Penetrometer (DCP) tests, DCP1 and DCP2, were conducted adjacent to each borehole. The DCP tests were taken to refusal depths of 2.2 m (DCP1) and 1.4 m (DCP2).

The locations of the boreholes and DCP tests, as indicated on the attached Test Location Plan (Figure 2), were set out using tape measurements from existing surface features. The surface reduced levels (RLs) at the test locations were estimated by interpolation between contours shown on the existing survey plan, which is part of the drawing set. The existing site plan forms the basis of Figure 2.

The nature and composition of the subsoils were assessed by logging the materials recovered during drilling, using visual and tactile methods. The relative compaction/density of the subsoils was assessed by interpretation of the DCP tests results, completed adjacent to each one of the boreholes.

The refusal depth of DCP tests can provide an indicative depth to bedrock, although refusal can also occur on buried obstructions, 'floaters', other hard layers, etc, and not necessarily on bedrock. Groundwater observations were made during and on completion of drilling individual boreholes.

The investigation has been undertaken generally in accordance with AS 1726-2017<sup>1</sup> (Geotechnical Site Investigation). Our geotechnical engineer (Oded Ben-Nun) was on site full time during the fieldwork and set out the test locations, nominated the sampling and in-situ testing, and logged the encountered subsurface profile.

The borehole logs and DCP test result sheets are attached to this report along with our Report Explanation Notes, which describe the investigation techniques adopted and define the logging terms and symbols used.

### **3 RESULTS OF INVESTIGATION**

#### **3.1 Site Description**

Lot 4 on DP244699 is approximately 803 m<sup>2</sup>, irregular in shape, and about 15 m wide at the north end, 23 m at the south end, and approximately 43 m deep. The lot is bounded by residential properties to the south and west, with a council reserve, which comprises a gully waterway, to the east. The northern frontage of the lot is along Marine Parade.

The natural site slopes steeply between 25° and 30° from the southwest to the northeast. The existing residence is primarily located in the southern half of the lot. The proposed new dwelling is planned for the northern lot boundary, in the mid to downslope portion of the allotment.

#### **3.1 Subsurface Conditions**

Reference to geological mapping by the Geological Survey of New South Wales 1:250,000 series 'Tweed Heads' sheet indicates the site is underlain by formation from the Silurian aged of Palaeozoic Era and from the Neranleigh-Fernvale Group, which typically comprise "Greywacke, Slate Phyllite Quartzite".



The boreholes depict a subsurface profile comprising a layer of topsoil, which overly a silty clay profile underlaid by a weathered rock profile.

For a more detailed description of the subsurface profile encountered at test locations, reference should be made to the attached borehole logs and DCP sheet result. A summary of some of the more pertinent subsurface issues or considerations is outlined below:

**Topsoil:** Topsoil was encountered from the surface to a depth of at least 0.1 m. At the BH1 location, it was lightly covered by gravel, while at the BH2 location, it was covered by grasses and shrubs.

**Silty Clay:** A generally firm to stiff silty clay profile was encountered below the topsoil, extending to approximately 2.0 m at BH1 and approximately 0.5 m at BH2. The silty clay exhibited medium to high plasticity and contained gravel. The moisture content of the clay in both boreholes was observed to be about at the plastic limit.

**Weathered Rock:** Rock was encountered underlying the silty clay. The rock was assessed as being of very low strength in approximately the upper 0.5m, based on the DCP test results.

**Groundwater:** Groundwater seepage was not encountered during site investigation. However, it should be noted that groundwater levels can be expected to vary with seasonal and climatic conditions.

#### 4 **ACID SULFATE SOIL (ASS) ASSESSMENT**

As shown in Figure A, the NSW Planning Maps indicate that acid sulfate soils are not present in this area.

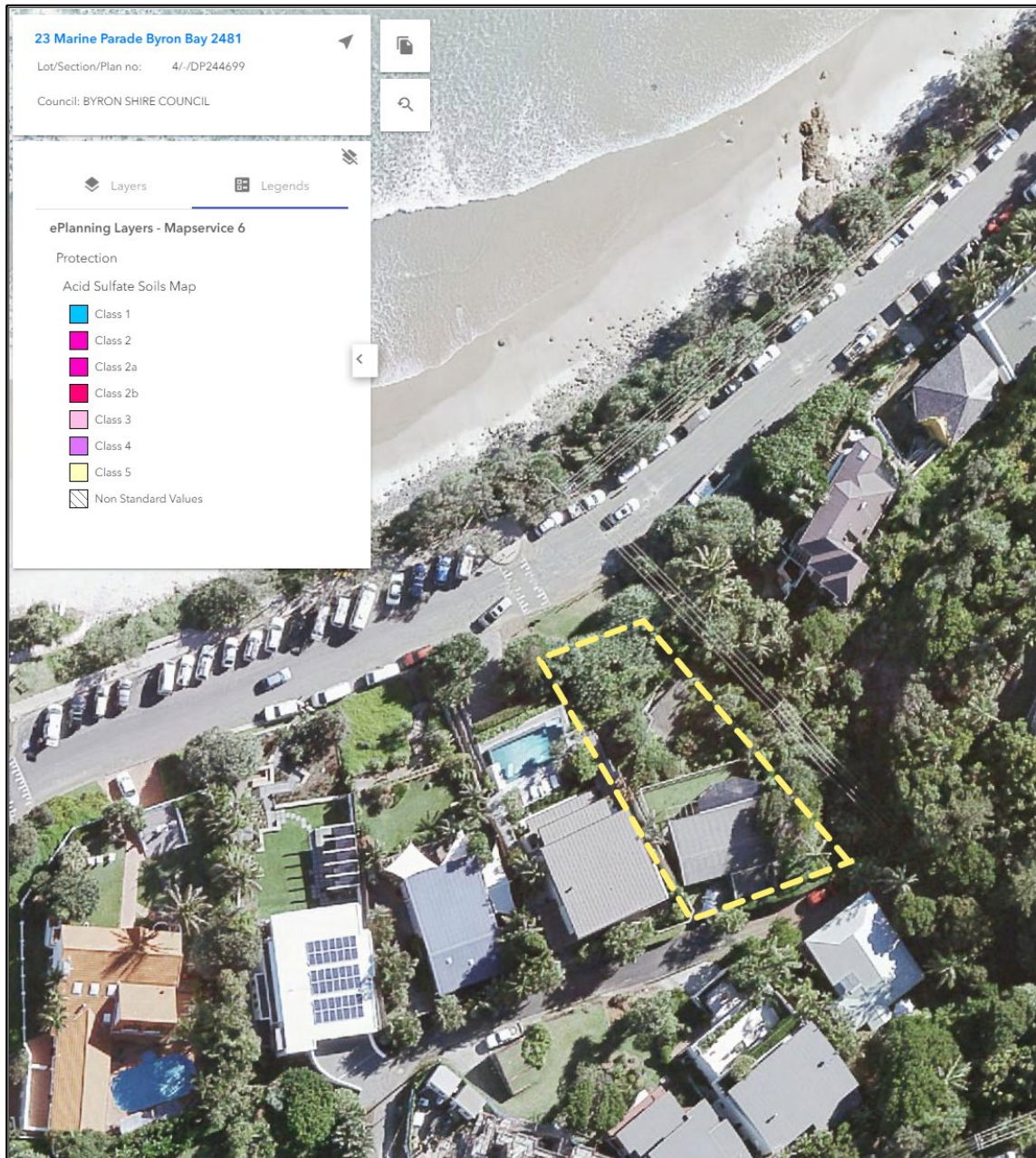


Figure A: Acid Sulfate Soils (ASS) as identified in NSW Planning mapping

As such, these soil materials are Non ASS (NASS: Non acid sulfate soils). These soils materials do not pose an environmental hazard.

## **5 COMMENTS AND RECOMMENDATIONS**

### **5.1 Earthworks**

Specific details regarding earthworks for the proposed development were not known at the time of preparing this report. Generally, all earthworks are to be carried out in accordance with AS 3798 – 2007<sup>2</sup> (Guidelines on Earthworks for Commercial and Residential Developments). Any excavations on site should be completed by reference to the Safe Work Australia Code of Practice ‘Excavation Work’, dated March 2015<sup>3</sup>.

### **5.2 Excavation Conditions and Support**

Conventional earthworks equipment may be suitable for excavation; however, consideration and allowances should be made for excavation through Low (L) strength or better rock.

Where shoring is not used, temporary excavation batters with a maximum slope of 1 Vertical (V) in 1 Horizontal (H) are considered feasible for the silty clay in the short term. For extremely weathered rock, temporary excavation batters with a maximum slope of 1 Vertical (V) in 0.5 Horizontal (H) are considered feasible.

These batter slopes are applicable where surcharge loadings (e.g., machinery loads) are well away from the crest of the batter. It is recommended that a geotechnical engineer be on site during cut operations to confirm safe batter slopes and assess the jointing and discontinuities of the rock.

If temporary batters or setbacks cannot be accommodated within the site geometry or are not preferred, further geotechnical advice should be sought. Temporary support or alternative solutions may be required.

### **5.3 Retaining Wall Design Parameters**

All retaining walls should be adequately designed in accordance with AS 4678-2002<sup>4</sup> (Earth-Retaining Structures).

Where some minor movements of retaining walls may be tolerated (these include landscape walls, cantilevered, single propped or anchored retaining walls) they may be designed using a triangular lateral earth pressure distribution and adopting the subsoil parameters and characteristic ‘active’ earth pressure coefficient ( $K_a$ ) provided in Table 1 below.

For walls that are rigid and unable to rotate or tilt (i.e. conventional walls that will be supported by the structure), it is recommended the use of a triangular lateral earth pressure distribution with an 'at-rest' earth pressure coefficient ( $K_o$ ), provided in Table 1 below.

The lateral earth pressure coefficients provided in Table 1 assume a horizontal backfill surface and have not made allowances for surcharge loadings. Any surcharge affecting the walls (e.g. nearby footings, compaction stresses, sloping retained surfaces, soil creep loads, construction loads etc) should be allowed for in the design using the appropriate earth pressure coefficient from above. In addition, the values provided below are ultimate values and appropriate safety factors or strength reduction factor should be involved.

Material	Unit Weight (KN/m <sup>3</sup> )	Cohesion C' (kPa)	$\phi$ (degrees)	Active $K_a$	At Rest $K_o$
Clay – Stiff or better	19	3	27	0.38	0.55
Extremely Weathered Rock	21	8	27	0.38	0.55
Weathered Rock (Low Strength or Better)	22	50	35	0.27	0.43

**Table 1: Earth pressure design parameters (assuming a horizontal backfill surface)**

Conventional retaining walls should be designed for full height water pressure and provision made for permanent and effective drainage of the ground behind the walls. Subsurface drains should incorporate a non-woven geotextile fabric, such as Bidim A34, to act as a filter against subsoil erosion. The subsoil drains should discharge into the stormwater system. Any backfill placed behind the wall should be loose granular material.

#### 5.4 **Footings**

Based on the geotechnical site investigation results, the subsurface conditions in the proposed structure will typically comprise topsoil underlain silty clay and weathered rock. Constructions loads are not to be supported in any topsoil, loose sand, soft or firm silty clay or any proposed builder's fill.

To lower the risk of instability and ensure uniform support while limiting potential differential settlement, we recommend that footings be embedded a minimum of 300 mm into the silty clay or rock profile.

High-level footings, such as stiffened rafts, pads, or strips, can be designed for an allowable bearing pressure of 150 kPa in the very stiff or better silty clay. Where footings are founded in the weathered rock profile, they can be designed for an allowable bearing pressure of 300 kPa.

Bored piers founded in the stiff or better silty clay profile may be designed for an allowable end bearing pressure of 200 kPa. Where bored piers are founded in the rock profile, they may be designed for an allowable end bearing pressure of 400 kPa. The upper 1.5 m of pile shaft adhesion should be ignored in capacity estimates to account for load development effects. An allowable shaft adhesion of 20 kPa can be adopted for each case where pile depths exceed 1.5 m.

Bored piers should be designed in accordance with the recommendations of AS 2159-2009<sup>5</sup> (Piling – Design and Installation). The presence of floating boulders is probable and should be considered in machinery selection.

All footings should be excavated, cleaned out, kept 'dry,' and poured with minimal delay. Inspection by a geotechnical engineer to confirm the above bearing capacities is recommended.

### 5.5 Site Classification

Based on the results of the geotechnical site investigation, the proposed development site is classified as a “**Class P**” site in accordance with the provisions of AS 2870-2011<sup>6</sup> (Residential Slab and Footings). This is due to the presence of 'reactive soil' found throughout the site, which is subjected to abnormal moisture conditions caused by mature trees on the building site.

In our calculations to determine the characteristic surface movement ( $y_s$ ), based on the location of the subjected site, we adopted a value for the change in soil suction at the surface ( $\Delta u$ ) of 1.2 picofarads (pF) and a design depth soil suction change (HS) value of 1.5m. In addition, based on laboratory testing from nearby sites on similar soils in the area, and employing the visual tactile method, a shrink-swell Index ( $I_{ss}$ ) of 3.5% / pF has been adopted in the  $y_s$  calculations.

Based on the subsurface profile encountered in the borehole and additional contribution for trees the assessed characteristic surface movement, under normal soil moisture variations, a reactivity similar to ‘**Class M**’ in accordance with AS 2870-2011<sup>6</sup> (Residential Slab and Footings) may be considered.

## 5.6 **Drainage**

The control of surface and subsurface water is critical to the overall performance of the site. All surface and subsurface water must be captured and directed off site via suitable outflow. Upslope surficial water flows must be directed away from both the building envelope and any sloping batters. Adequate subsoil and surface drainage should be incorporated in retaining wall design. Any stormwater discharge points should be suitably protected against scour and erosion.

## 5.7 **General Recommendations**

Good hillside engineering construction practice is considered mandatory during development of the site. 'Guidelines to Good and Bad Hillside Practices' and 'AGS Australian Geoguide LR7 (Landslide Risk)' are attached in Appendix E, provides some guidance material and additional information, which should be adopted during construction.

When all the above recommendations are fulfilled, maintained, and supervised by a qualified geotechnical engineer, OB Geotechnics is confident that the site and existing dwelling will remain stable and will not be affected by landslip or subsidence at, above, or below the site during excavation and construction of the buildings.

## 6 **REFERENCES**

1. AS 1726-2017 'Geotechnical Site Investigation', Australian Standard
2. AS 3798-2007 'Guidelines on Earthworks for Commercial and Residential Developments', Australian Standard
3. 'Excavation Work' Code of Practice, March 2015, Safe Work Australia.
4. AS 4678-2002 'Earth-Retaining Structures', Australian Standard
5. AS 2159-2009 'Piling – Design and Installation', Australian Standard
6. AS 2870-2011 'Residential Slabs and Footings', Australian Standard

## 7 **LIMITATIONS**

This report has been prepared for the geotechnical site investigation for the proposed dual occupancy at 23 Marine Parade, Byron Bay, NSW 2481. The recommendations given in this report are based on both the information provided regarding the proposed development and the findings of the investigation. Any change in the proposed development or building location may require additional testing and a review of all recommendations.

Occasionally, during construction the subsurface conditions are found to be different. This can be due to soil changes in different locations to those tested. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact the team at OB Geotechnics.

This report has been prepared for the proposed development described above and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose.

Regards,  
For and on behalf of OB Geotechnics Pty Ltd

**Dr. Oded Ben-Nun**

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## **APPENDIX A:**

**FIGURE 1: SITE LOCATION PLAN**  
**FIGURE 2: TEST LOCATION PLAN**



23 Marine Parade Byron Bay 2481

Lot/Section/Plan no: 4/-/DP244699

Council: BYRON SHIRE COUNCIL



Source: <https://www.planningportal.nsw.gov.au>

Title:

**SITE LOCATION PLAN**

Location:

23 Marine Parade, Byron Bay, NSW 2481

Report No:

P599GI

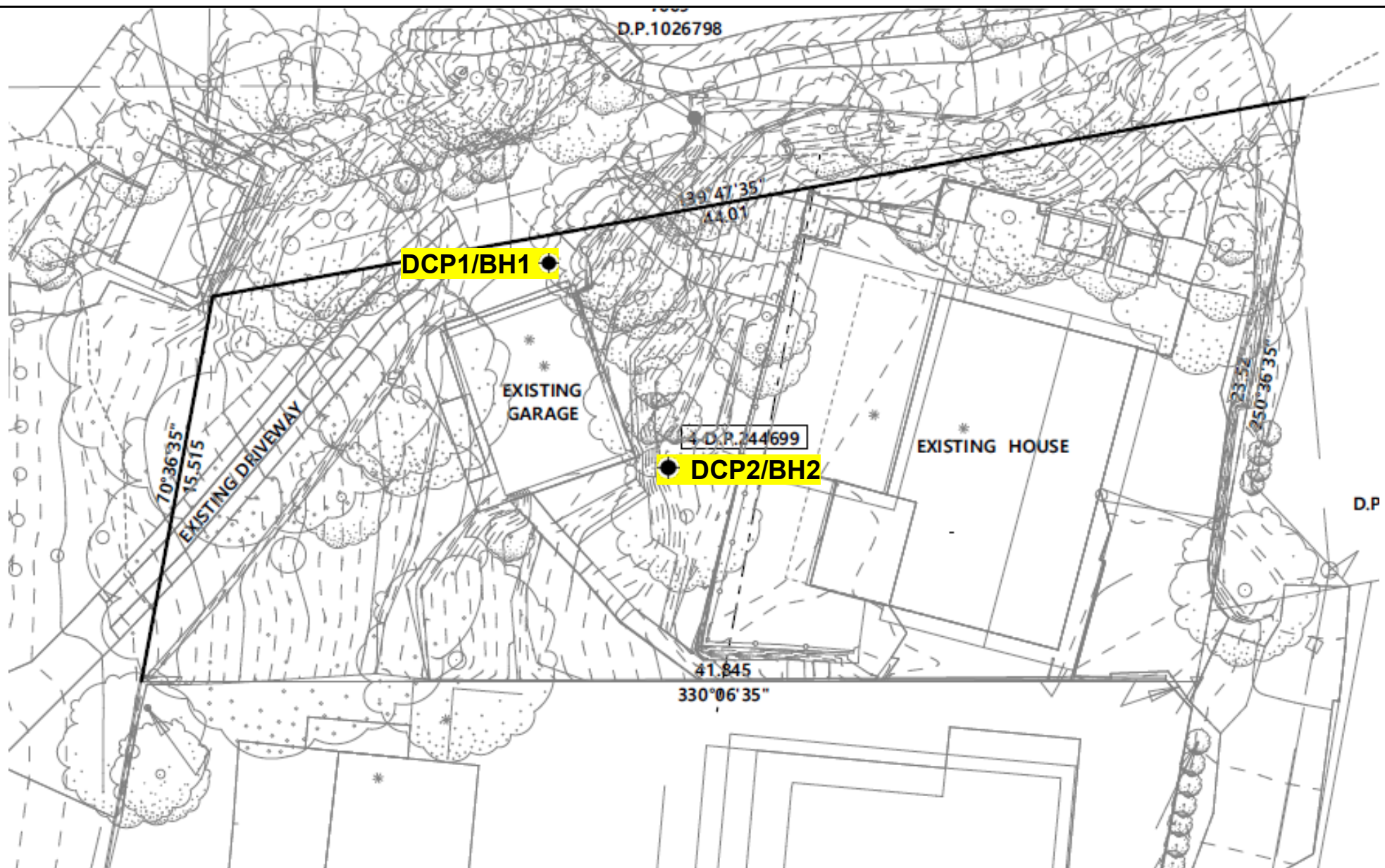
Figure No:

1

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## LEGEND

● LOCATION OF BOREHOLES AND DCP TESTS

Title:

## TEST LOCATION PLAN

Location: 23 Marine Parade, Byron Bay, NSW 2481

Report No: P599GI

Figure No: 2

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**APPENDIX B:**

**BOREHOLE LOGS AND DYNAMIC CONE PENETRATION  
TEST RESULTS**

# BOREHOLE LOG

Borehole No.

BH1

Client: Stephen Ring

Project: Geotechnical Site Investigation

Location: 23 Marine Parade, Byron Bay, NSW 2481

Job No. P599GI







Method: Hand Auger

R.L. Surface:  $\approx$  11m

Date: 27/08/2022

Logged/Checked By: OBN

Datum: AHD

Groundwater Record	Samples	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition / Weathering	Strength / Rel. Density	Hand Penetrometer Readings kPa.	Remarks
		REFER TO DCP TEST RESULTS				TOPSOIL: GRAVEL				
						Fill: Silty CLAY, medium to high plasticity, brown mottled yellow traces of roots and gravels				
			0.5		CL-CH	Silty CLAY, medium to high plasticity, brown mottled red	MC=PL	F-St		
			1.0		CL-CH	Silty CLAY, medium to high plasticity, brown mottled yellow	MC=PL	St-VSt		
			1.5		CL-CH	Silty CLAY, medium to high plasticity, yellow mottled grey	MC=PL	VSt		
			2.0		XW	Extremely weathered ROCK, yellow mottled grey		VL		
			2.5			END OF BOREHOLE AT 2.5m				
			3.0							

# BOREHOLE LOG

Borehole No.

BH2

Client: Stephen Ring

Project: Geotechnical Site Investigation

Location: 23 Marine Parade, Byron Bay, NSW 2481

Job No. P599GI


Method: Hand Auger

R.L. Surface:  $\approx$  15.5m

Date: 27/08/2022

Logged/Checked By: OBN

Datum: AHD

Groundwater Record	Samples	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition / Weathering	Strength / Rel. Density	Hand Penetrometer Readings kPa.	Remarks
		REFER TO DCP TEST RESULTS				TOPSOIL				
			0.5		CL-CH	Fill: Silty CLAY, medium to high plasticity, brown mottled yellow traces of roots and gravels	MC<PL	F-St		
			1.0		XW	Extremely weathered ROCK, yellow mottled grey		VL		
			1.5			END OF BOREHOLE AT 1.3m				
			2.0							
			2.5							
			3.0							




































# DYNAMIC CONE PENETRATION TEST RESULTS

Client:	Stephen Ring						
Project:	Geotechnical Site Investigation						
Location:	23 Marine Parade, Byron Bay						
Job No.	P599GI			Hammer Weight & Drop: 9kg/510mm			
Date:	27-08-2024			Rod Diameter: 16mm			
Tested By:	O.B.N.			Point Diameter: 20mm			
Number of Blows per 100mm Penetration							
Test Location	DCP1	DCP2					
Depth (mm)	RL≈ 11m	RL≈ 15.5m					
0 - 100	5	1					
100 - 200	5	1					
200 - 300	10	2					
300 - 400	15	5					
400 - 500	7	4					
500 - 600	6	4					
600 - 700	6	4					
700 - 800	4	4					
800 - 900	4	6					
900 - 1000	5	8					
1000 - 1100	5	10					
1100 - 1200	5	10					
1200 - 1300	5	17					
1300 - 1400	5	20					
1400 - 1500	5	Refusal					
1500 - 1600	5						
1600 - 1700	5						
1700 - 1800	7						
1800 - 1900	8						
1900 - 2000	9						
2000 - 2100	9						
2100 - 2200	20						
2200 - 2300	Refusal						
2300 - 2400							
2400 - 2500							
2500 - 2600							
2600 - 2700							
2700 - 2800							
2800 - 2900							
2900 - 3000							
Remarks:	1. The procedure used for this test is similar to that described in AS1289.6.3.2-1997, Method 6.3.2. 2. Usually 8 blows per 20mm is taken as refusal						

## **APPENDIX C:**

### **REPORT EXPLANATION NOTES**

## GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL		ROCK		DEFECTS AND INCLUSIONS	
	FILL		CONGLOMERATE		CLAY SEAM
	TOPSOIL		SANDSTONE		SHEARED OR CRUSHED SEAM
	CLAY (CL, CH)		SHALE		BRECCIATED OR SHATTERED SEAM/ZONE
	SILT (ML, MH)		SILTSTONE, MUDSTONE, CLAYSTONE		IRONSTONE GRAVEL
	SAND (SP, SW)		LIMESTONE		ORGANIC MATERIAL
	GRAVEL (GP, GW)		PHYLLITE, SCHIST		
	SANDY CLAY (CL, CH)		TUFF		CONCRETE
	SILTY CLAY (CL, CH)		GRANITE, GABBRO		BITUMINOUS CONCRETE, COAL
	CLAYEY SAND (SC)		DOLERITE, DIORITE		COLLUVIUM
	SILTY SAND (SM)		BASALT, ANDESITE		
	GRAVELLY CLAY (CL, CH)		QUARTZITE		
	CLAYEY GRAVEL (GC)				
	SANDY SILT (ML)				
	PEAT AND ORGANIC SOILS				







# UNIFIED SOIL CLASSIFICATION TABLE

Field Identification Procedures (Excluding particles larger than 75 µm and basing fractions on estimated weights)				Group Symbols	Typical Names	Information Required for Describing Soils	Use grain size curve in identifying the fractions as given under field identification	Laboratory Classification Criteria
Gravels More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW					
Coarse-grained soils More than half of material is larger than 75 µm sieve size (The 75 µm sieve size is about the smallest particle visible to naked eye)	Sands More than half of coarse fraction is smaller than 4 mm sieve size	Gravels with fines (appreciable amount of fines)	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics  Example: Silty sand, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand: (SM)	Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75 µm sieve size) Less than 5% 5% to 12% More than 12% Borderline cases requiring use of dual symbols GM, GC, SM, SC GW, GP, SW, SP	Use grain size curve in identifying the fractions as given under field identification	Laboratory Classification Criteria
		Clean sands (little or no fines)	SW	Well graded sands, gravelly sands, little or no fines				
Fine-grained soils More than half of material is smaller than 75 µm sieve size	Silt and clays Liquid limit less than 50	Sands with fines (appreciable amount of fines)	SP	Poorly graded sands, gravelly sands, little or no fines	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses  For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions  Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess: (ML)	Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75 µm sieve size) Less than 5% 5% to 12% More than 12% Borderline cases requiring use of dual symbols GM, GC, SM, SC GW, GP, SW, SP	Use grain size curve in identifying the fractions as given under field identification	Laboratory Classification Criteria
		Nonplastic fines (for identification procedures, see $ML$ below)	SM	Silty sands, poorly graded sand-silt mixtures				
		Plastic fines (for identification procedures, see $CL$ below)	SC	Clayey sands, poorly graded sand-clay mixtures				
		Identification Procedures on Fraction Smaller than 380 µm Sieve Size						
		Dry Strength (crushing characteristics)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity				
		None to slight	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays				
		Medium to high	OL	Organic silts and organic silts of low plasticity				
		Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts				
		Slight to medium	CH	Inorganic clays of high plasticity, fat clays				
		High to very high	OH	Organic clays of medium to high plasticity				
Medium to high	PT	Peat and other highly organic soils						
Highly Organic Soils	Silt and clays Liquid limit greater than 50	Readily identified by colour, odour, spongy feel and frequently by fibrous texture			Plasticity chart for laboratory classification of fine grained soils			

Note: 1 Soils possessing characteristics of two groups are designated by combinations of group symbols (eg. GW-GC, well graded gravel-sand mixture with clay fines).  
2 Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

## LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.
		Extent of borehole collapse shortly after drilling.
		Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N <sub>c</sub> = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)  (Cohesionless Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
	D	DRY – Runs freely through fingers.
	M	MOIST – Does not run freely but no free water visible on soil surface.
	W	WET – Free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT – Unconfined compressive strength less than 25kPa
	S	SOFT – Unconfined compressive strength 25-50kPa
	F	FIRM – Unconfined compressive strength 50-100kPa
	St	STIFF – Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF – Unconfined compressive strength 200-400kPa
	H	HARD – Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		<b>Density Index (I<sub>p</sub>) Range (%)</b> <b>SPT 'N' Value Range (Blows/300mm)</b>
	VL	Very Loose                      <15                      0-4
	L	Loose                      15-35                      4-10
	MD	Medium Dense                      35-65                      10-30
	D	Dense                      65-85                      30-50
	VD	Very Dense                      >85                      >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit 	Tungsten carbide wing bit. Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

## LOG SYMBOLS continued

### ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

### ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL	0.03	Easily remoulded by hand to a material with soil properties.
Very Low:	VL	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable.
Low:	L	0.3	A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
Medium Strength:	M	1	A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
High:	H	3	A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
Very High:	VH	10	A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

### ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	

## **APPENDIX D:**

## **DRAWINGS**



LANTERN HOUSE

23 MARINE PARADE, BYRON BAY

DRAWING SCALE

A0.01	COVER PAGE & DRAWING SCHEDULE
A0.02	DEVELOPMENT SUMMARY / LOCATION PLAN
A1.01	EXISTING SURVEY
A1.02	EXISTING SITE PLAN
A1.03	PROPOSED SITE STRATAPLAN
A1.04	PROPOSED SITE PLAN
A2.01.1	LOT A - DEMOLITION
A2.01.2	LOT B - DEMOLITION
A2.02.1	LOT A_GROUND LEVEL_PROPOSED
A2.02.2	LOT A_FIRST LEVEL_PROPOSED
A2.02.3	LOT A_ROOF_PROPOSED
A2.02.4	LOT B_PROPOSED
A2.02.5	LOT B_ROOF_PROPOSED
A4.01	LONG SECTION 01
A4.02	SHORT SECTIONS
A5.01	DOOR SCHEDULE
A5.02	WINDOW SCHEDULE

REV

02 - WIP
02 - WIP
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ISSUE DATE	REVISION ID	ISSUE NAME
5/10/2023	01	Consultant Review
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DRAWN	VN
CHECKED	HG
SCALE	1:4.22
PAPER	A3
PROJECT:	LANTERN HOUSE
JOB No#:	HGA 266
CLIENT:	STEPHEN RING
ADDRESS:	23 MARINE PARADE, BYRON BAY

DRAWING TITLE :	TITLE SHEETS
	COVER PAGE & DRAWING SCHEDULE
STATUS :	LANTERN HOUSE

DRAWING NO.	A0.01
REVISION NO.	02 - WIP
	7/08/2024



DEVELOPMENT SUMMARY  
23 MARINE PARADE, BYRON BAY

LOT 1 GFA

GROUND FLOOR: 30m2  
FIRST FLOOR: 137m2

LOT GFA: 167m2  
LOT AREA: 401.5m2

LOT 2 GFA

GROUND FLOOR: 86m2

LOT GFA: 86m2  
LOT AREA: 401.5m2

TOTAL GFA: 253m2  
SITE AREA: 803.25m2  
FSR: 0.3

COMPLIANCE

COMPLIANCE WITH BASIX REQUIREMENTS AS  
DETAILED IN THE **WIP** CERTIFICATE N#: XXXX &  
NATHERS N#: XXXX

COMPLIANCE WITH BUSHFIRE REPORT N# BY XXXXX



ISSUE DATE	REVISION ID	ISSUE NAME
5/10/2023	01	Consultant Review
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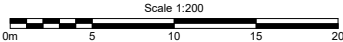
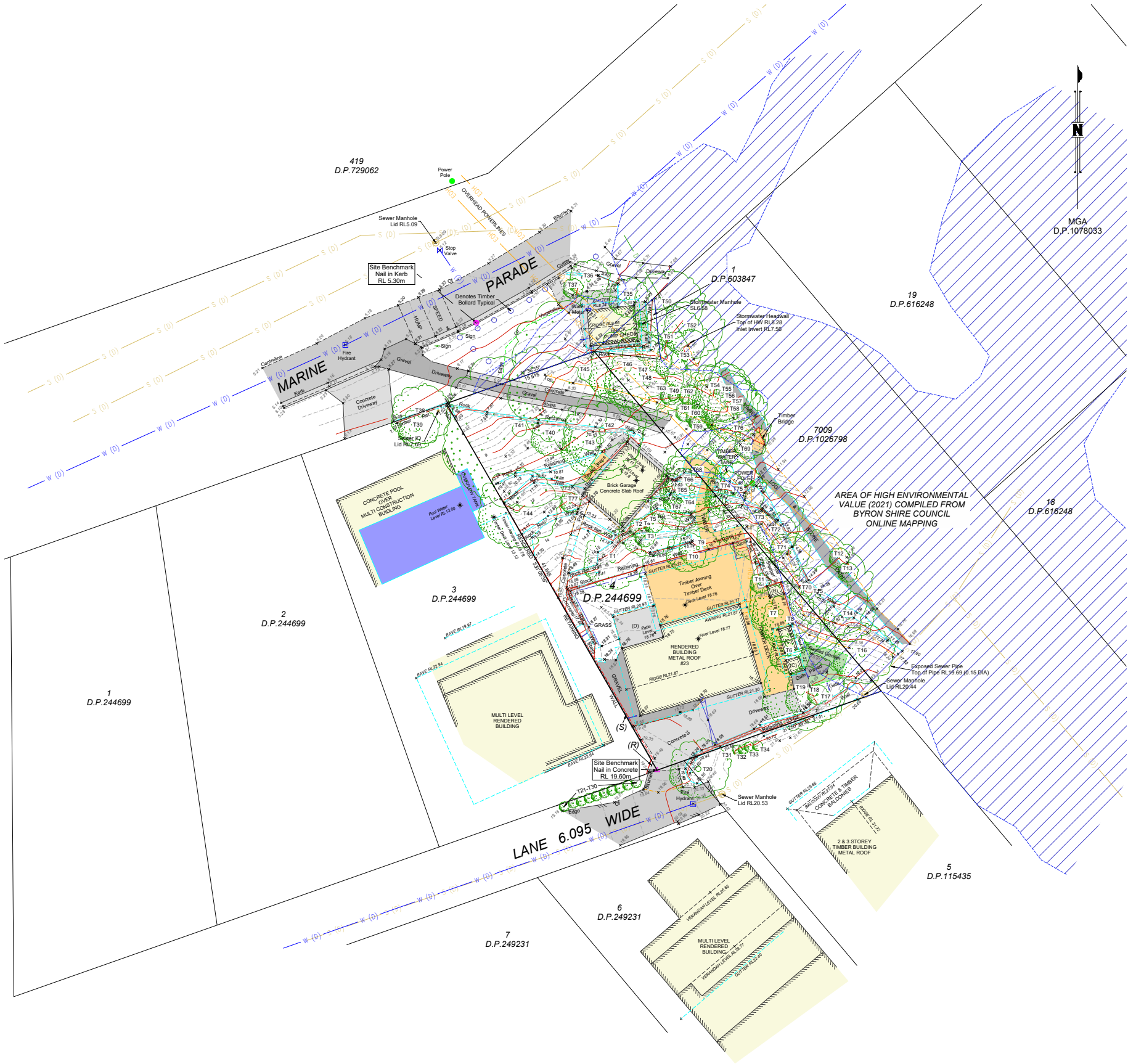
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CHECKED	HC
SCALE	1:285
PAPER	A3
PROJECT:	LANERN HOUSE
JOB No#:	HGA 266
CLIENT:	STEPHEN RING
ADDRESS:	23 MARINE PARADE, BYRON BAY

DRAWING TITLE :	TITLE SHEETS
DEVELOPMENT SUMMARY / LOCATION PLAN	
STATUS :	LANERN HOUSE

DRAWING NO.	A0.02
REVISION NO.	02 - WIP
	7/08/2024



Tree Schedule				
Tree	Type	Diameter	Spread	Height
T1	EXOTIC	0.2	6	4
T2	EXOTIC	0.1	2	3
T3	EXOTIC	0.1	2	3
T4	EXOTIC	0.4	6	4
T5	EXOTIC	0.2	2	2
T6	PALM	0.3	4	8
T7	EXOTIC	0.3	6	8
T8	EXOTIC	0.3	6	8
T9	PALM	0.2	4	5
T10	PALM	0.2	4	5
T11	EXOTIC	0.2	2	4
T12	PALM	0.2	2	4
T13	PALM	0.2	2	4
T14	EXOTIC	0.5	5	5
T15	PALM	0.2	6	8
T16	EXOTIC	1.2	6	8
T17	PALM	0.2	2	4
T18	JACARANDA	0.2	6	8
T19	PALM	0.3	8	18
T20	PALM	0.5	6	6
T21	LILLI PILLI	0.1	1	2
T22	LILLI PILLI	0.1	1	2
T23	LILLI PILLI	0.1	1	2
T24	LILLI PILLI	0.1	1	2
T25	LILLI PILLI	0.1	1	2
T26	LILLI PILLI	0.1	1	2
T27	LILLI PILLI	0.1	1	2
T28	LILLI PILLI	0.1	1	2
T29	LILLI PILLI	0.1	1	2
T30	LILLI PILLI	0.1	1	2
T31	LILLI PILLI	0.1	1	2
T32	LILLI PILLI	0.1	1	2
T33	LILLI PILLI	0.1	1	2
T34	LILLI PILLI	0.1	1	2
T35	PALM	0.2	4	5
T36	PALM	0.2	4	5
T37	PALM	0.2	2	4
T38	PALM	0.2	6	4
T39	PINE	0.5	4	20
T40	PALM	0.3	4	4
T41	PALM	2.5	16	8
T42	PALM	0.4	8	10
T43	PALM	0.3	8	10
T44	EXOTIC	0.3	8	6
T45	EXOTIC	0.2	16	6
T46	EXOTIC	0.3	8	6
T47	EXOTIC	0.3	8	6
T48	EXOTIC	0.2	8	6
T49	EXOTIC	0.1	1	4
T50	PALM	0.4	7	4
T51	PALM	0.4	7	4
T52	PALM	0.3	6	8
T53	PALM	0.2	6	10
T54	PALM	0.2	6	8
T55	PALM	0.2	6	8
T56	PALM	0.2	6	10
T57	PALM	0.2	6	10
T58	PALM	0.2	6	10
T59	EXOTIC	0.05	2	6
T60	EXOTIC	0.01	2	6
T61	EXOTIC	0.1	2	6
T62	EXOTIC	0.2	2	6
T63	EXOTIC	0.2	2	6
T64	PALM	0.2	6	10
T65	PALM	0.2	6	10
T66	EXOTIC	0.1	6	6
T67	EXOTIC	0.2	6	6
T68	EXOTIC	0.1	6	10
T69	EXOTIC	0.15	3	8
T70	PALM	0.3	12	10
T71	EXOTIC	0.2	4	10
T72	EXOTIC	0.2	4	10
T73	PALM	0.2	8	8
T74	EXOTIC	0.2	4	10
T75	EXOTIC	0.1	6	6
T76	EXOTIC	0.15	6	8
T77	DEAD	0.2	2	2



LEGEND:	
<b>Road</b>	<b>Terrain</b>
Kerb Back	Driveway
Kerb Invert	Footpath
Edge of Blumem	Slab Edge
Edge of Gravel	Retaining Wall Base
Road Crown	Retaining Wall Top
Traffic Park Meter	Change of Grade
Traffic Light	Top of Bank
Traffic Pill	Toe of Bank
Traffic Sign	Waterline
Traffic Post Box	Garden Edge
<b>Structures</b>	Creek Top of Bank
Building Line	Creek Invert
Roof Ridgeline	Creek Waterline
Fence Line	Tree
Gate	Tree Canopy
Hand Rail	Control Point/PSM
Cattle Grid	
Bollard	
<b>Sewer</b>	<b>Drainage</b>
Sewer Line	Drainage line
Valve	Open Drain
Inspection Opening	Manhole
Manhole	Field Inlet
<b>Electrical</b>	Downpipe
Electricity Line	Communication Line
Overhead Line	Overhead Line
Pits/Manholes	Pits/Manholes
Pole	Pillar
Street Light In-Ground	<b>Gas</b>
Water	Gas Line
Water Line	Valve
Water Meter	Marker
Valve	Pot hole
Fire Hydrant	
Tap	
Sprinkler	
<b>Fuel</b>	<b>Subsurface Utility - QL</b>
Fuel Line	* QL-A (Hx50mm,Vx500mm)
Filling	* QL-B (Hx300mm,Vx500mm)
	* QL-C (Hx300mm,ZD)
	* QL-D (Exist Record)

- NOTES:
1. Drawn to scale on an A1 sheet.
  2. Contour Interval... 0.25m
  3. All levels are in metres on the Australian Height Datum referred to SSM90396 - RL 5.813 AHD situated in Marine Parade.
  4. All Boundaries are vide title and subject to confirmation by survey. CT distances shown only.
  5. The Location of Underground services are in accordance with AS5488:2019, the Australian Standard for classification of Subsurface Utility Information (SUI). The exact nature and location of these services should be confirmed prior to construction.
  6. Area vide Title : 796.7m<sup>2</sup>
  7. Field Survey Completed on 15.06.2023.
  8. This Detail Survey is not a 'Survey' as defined by the Surveying Act 2002. If any construction is planned it would be advisable to carry out further survey work to determine the boundary dimensions.
  9. Tree species should be verified by a suitably qualified professional. Tree spreads are diagrammatic only and may not be symmetrical. Heights and spreads are approximate only.

- (B) Rendered Pizza Oven  
(C) Metal Building Metal Roof  
(D) Timber Awning over Tiled Patio  
(S) Easement for Retaining Wall 0.2 Wide by D.P.1107057  
(R) Easement for Right of Carriageway variable width by D.P.1107057

Level datum: AHD Derived (SSM90396)  
Horiz datum: MGA Derived PLAN (D.P.1078033)  
Coord Origin: SSM (SCIMS) (SSM90396)  
GDA System: GDA2020 Coordinate System: Plane 1:1  
Meridian: +9°31'35" D.P.244699

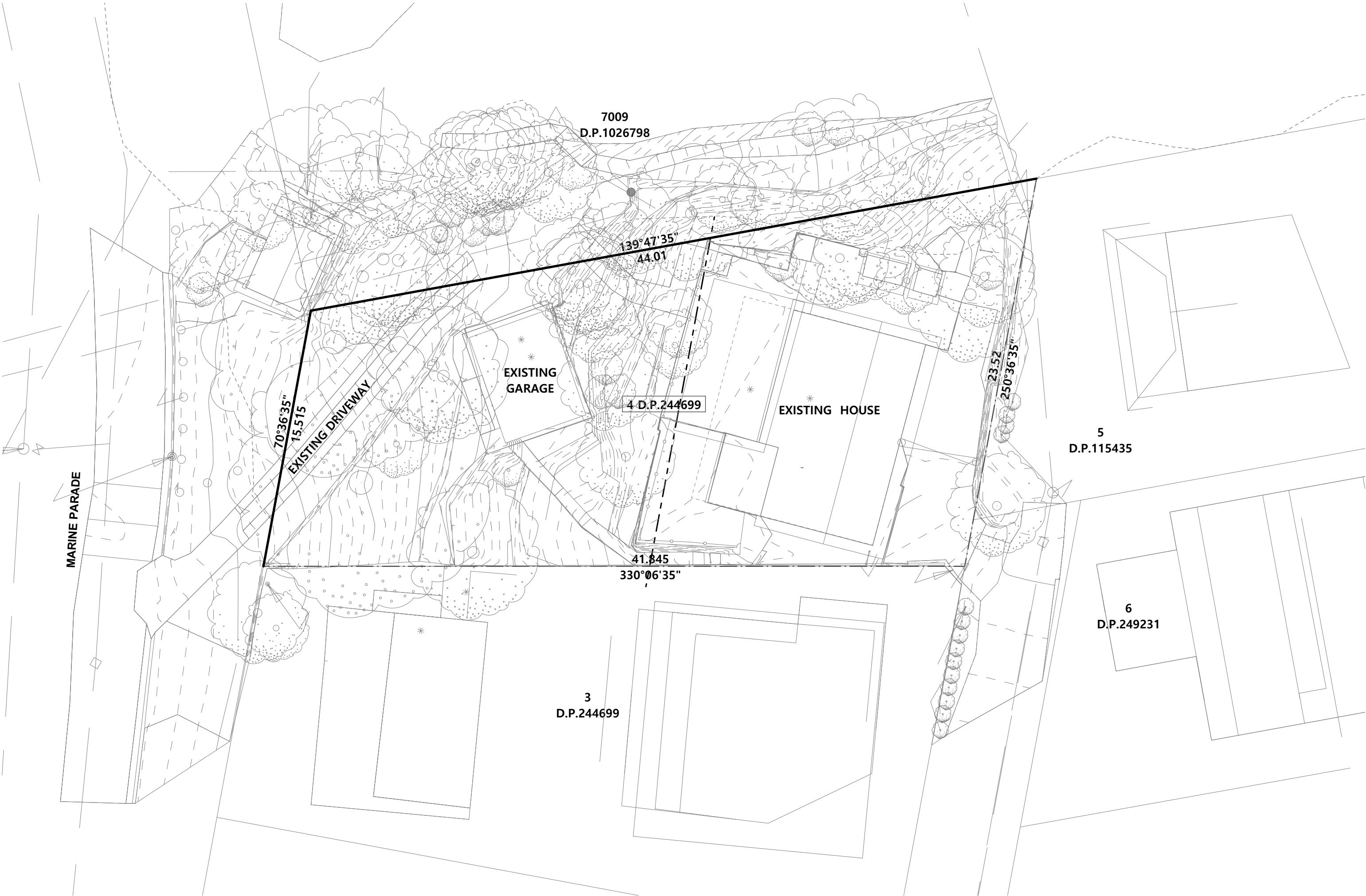
Title: **DETAIL SURVEY**  
**Lot 4 D.P.244699**  
**23 Marine Parade, Byron Bay**

Client:	Stephen Ring		
Locality:	Byron Bay		
Local Gov:	Byron Shire Council		
Surveyed By:	PB	Approved:	SAT
Date Created:	14/07/23	Scale:	1:200
File Ref:	230684		
Plan No:	230684_001_DET	Rev:	A

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<b>DRAWN BY:</b>	VN
<b>CHECKED BY:</b>	HC
<b>SCALE</b>	1:2.31
<b>PAPER</b>	A3
<b>PROJECT:</b>	LANTERN HOUSE
<b>JOB No#:</b>	HGA 266
<b>CLIENT:</b>	STEPHEN RING
<b>ADDRESS:</b>	23 MARINE PARADE, BYRON BAY

<b>DRAWING TITLE :</b>	<b>SITE</b>
	<b>EXISTING SURVEY</b>
<b>STATUS :</b>	<b>LANTERN HOUSE</b>



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NOMINATED ARCHITECT: HARLEY GRAHAM NSW REGISTRATION No#: 7892

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SCALE: A3  
PAPER: A3  
PROJECT: LANTERN HOUSE  
JOB No#: HGA 266  
CLIENT: STEPHEN RING  
ADDRESS: 23 MARINE PARADE, BYRON BAY

DRAWING TITLE :  
STATUS :

SITE  
**EXISTING SITE PLAN**  
**LANTERN HOUSE**

DRAWING NO.  
**A1.02**  
REVISION NO.  
**02 - WIP**  
7/08/2024





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**SCALE:** A3  
**PAPER:** A3  
**PROJECT:** LANTERN HOUSE  
**JOB No#:** HGA 266  
**CLIENT:** STEPHEN RING  
**ADDRESS:** 23 MARINE PARADE, BYRON BAY

**DRAWING TITLE :** SITE  
**PROPOSED SITE STRATA PLAN**  
**STATUS :** **LANTERN HOUSE**

**DRAWING NO.** **A1.03**  
**REVISION NO.** **02 - WIP**  
7/08/2024



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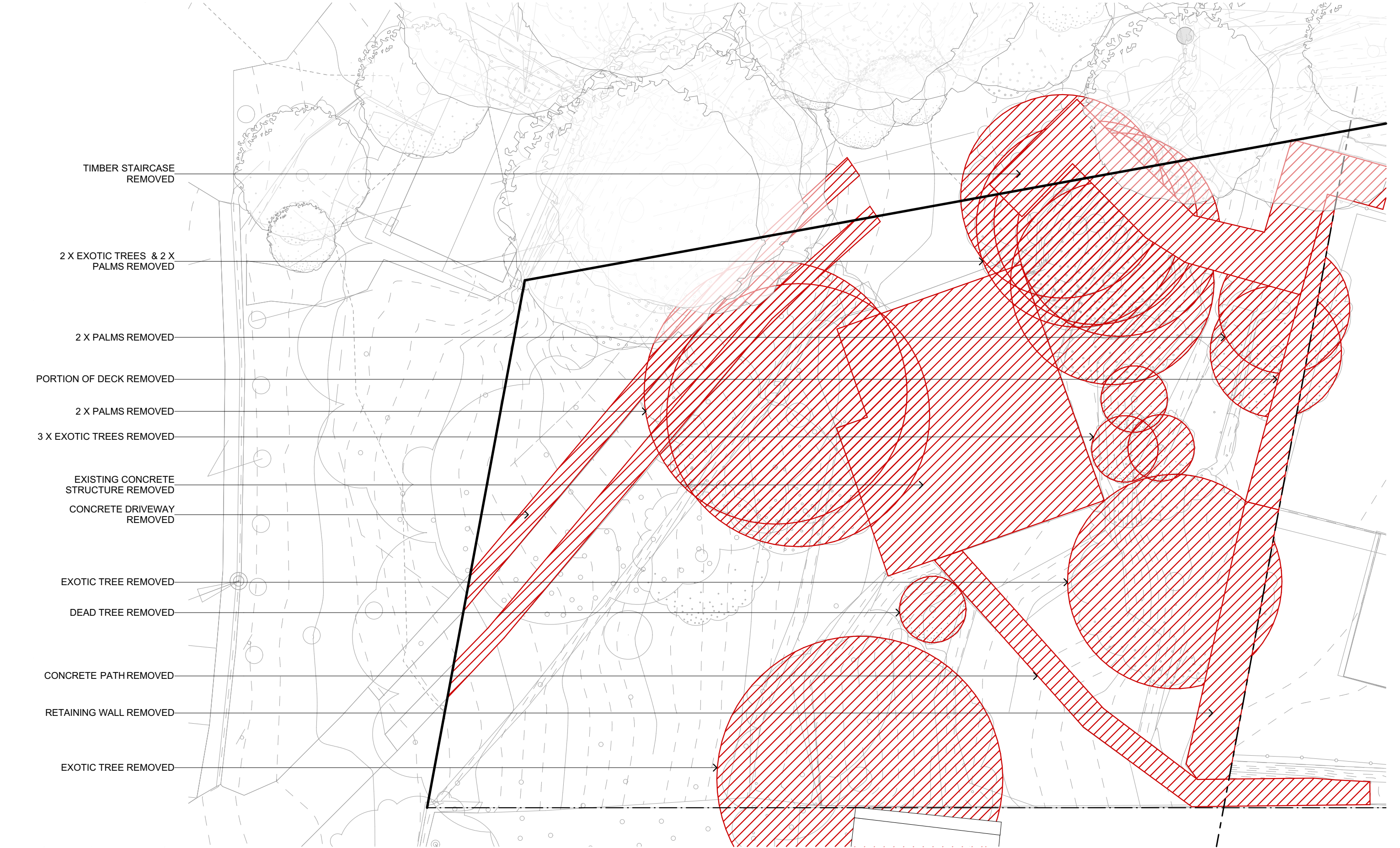


DRAWN BY: VN  
CHECKED BY: HG  
SCALE: A3  
PAPER: A3  
PROJECT: LANTERN HOUSE  
JOB No#: HGA 266  
CLIENT: STEPHEN RING  
ADDRESS: 23 MARINE PARADE, BYRON BAY

DRAWING TITLE :  
SITE  
**PROPOSED SITE PLAN**  
STATUS :  
**LANTERN HOUSE**

DRAWING NO.  
**A1.04**  
REVISION NO.  
**02 - WIP**  
7/08/2024





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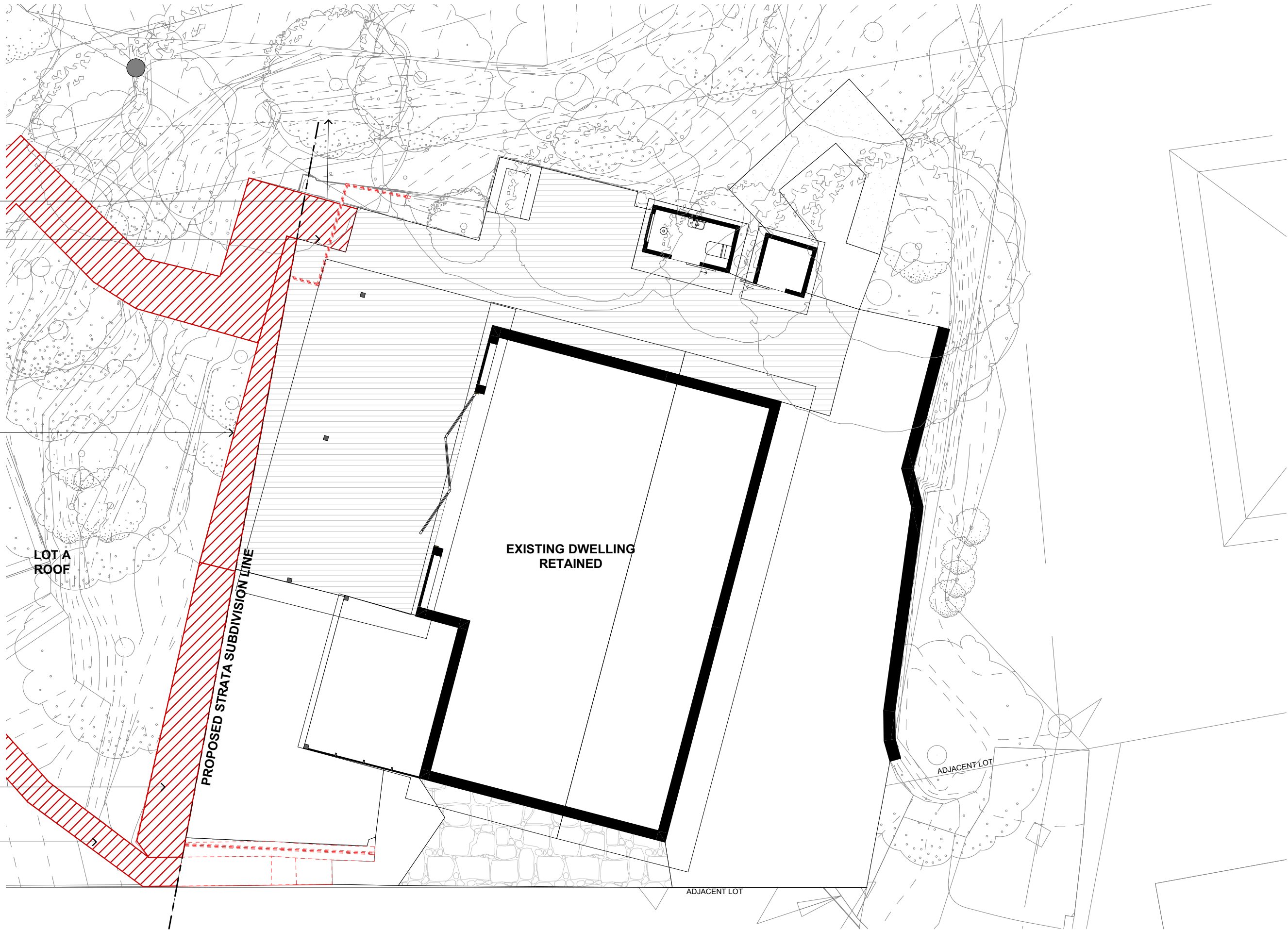
ISSUE DATE	REVISION ID	ISSUE NAME
5/10/2023	01	Consultant Review
Work in Progress	02 - WIP	Consultant Review



**DRAWN BY:** VN  
**CHECKED BY:** HG  
**SCALE:** A3  
**PAPER:** A3  
**PROJECT:** LANTERN HOUSE  
**JOB No#:** HGA 266  
**CLIENT:** STEPHEN RING  
**ADDRESS:** 23 MARINE PARADE, BYRON BAY

**DRAWING TITLE :**  
**DEMOLITION**  
**LOT A - DEMOLITION**  
**STATUS :**  
**LANTERN HOUSE**

**DRAWING NO.**  
**A2.01.1**  
**REVISION NO.**  
**02 - WIP**  
7/08/2024



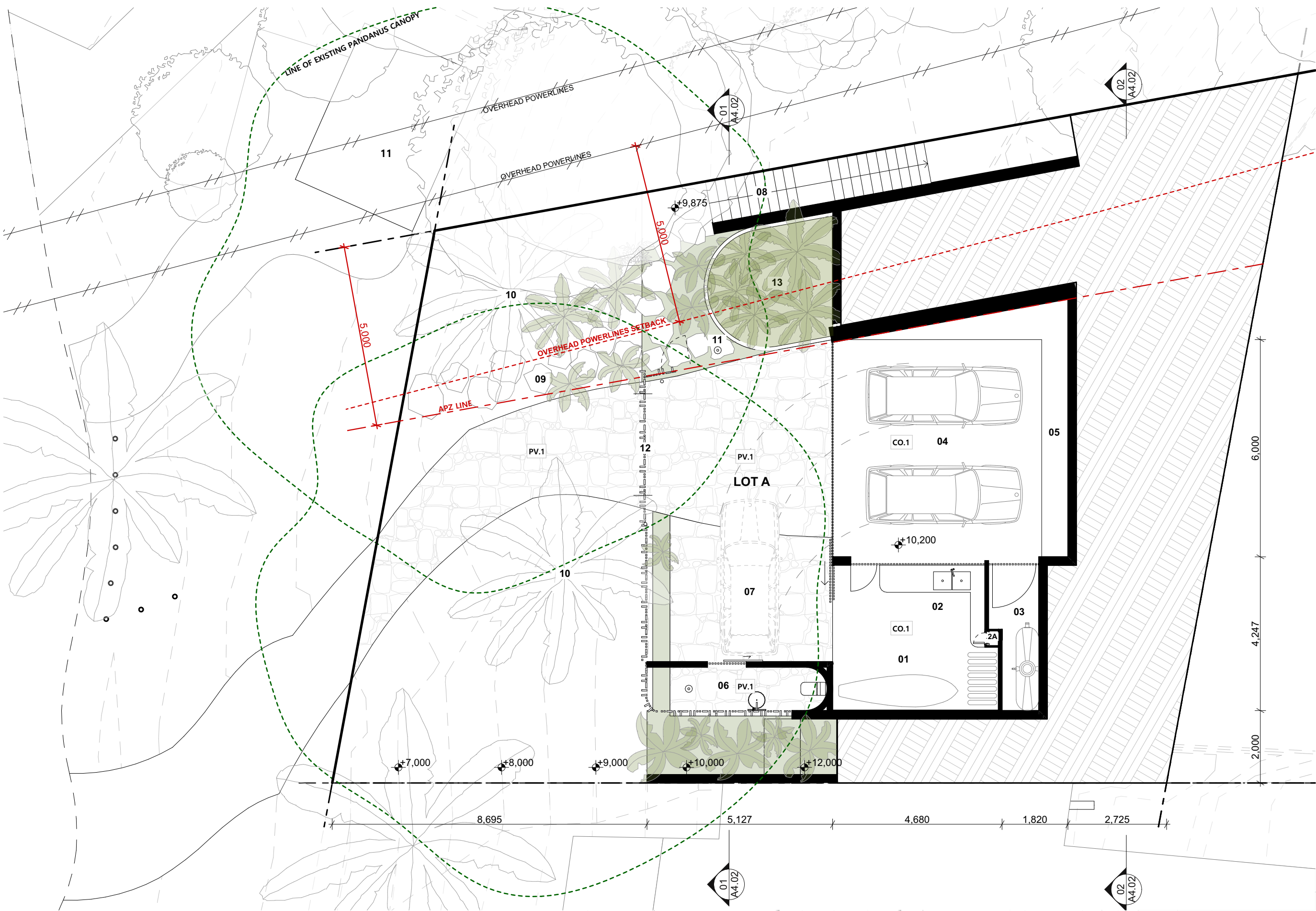
ISSUE DATE	REVISION ID	ISSUE NAME
5/10/2023	01	Consultant Review
Work in Progress	02 - WIP	Consultant Review



**DRAWN BY:** VN  
**CHECKED BY:** HG  
**SCALE:**  
**PAPER:** A3  
**PROJECT:** LANTERN HOUSE  
**JOB No#:** HGA 266  
**CLIENT:** STEPHEN RING  
**ADDRESS:** 23 MARINE PARADE, BYRON BAY

**DRAWING TITLE :**  
**DEMOLITION**  
**LOT B - DEMOLITION**  
**STATUS :**  
**LANTERN HOUSE**





- LAYOUT LEGEND
- 01 SURF STORE
  - 02 LAUNDRY
  - 2A LAUNDRY CHUTE
  - 03 RAINWATER TANK
  - 04 GARAGE
  - 05 STORAGE
  - 06 OUTDOOR SHOWER & WC
  - 07 REVERSING BAY
  - 08 STAIRS UP
  - 09 GARDEN PATH TO BEACH
  - 10 EXIST. PANDANUS
  - 11 OUTDOOR SHOWER
  - 12 SLIDING SCREEN
  - 13 PLANTER

- MATERIAL LEGEND
- AW.1 STEEL AWNING
  - CT.1 CERAMIC TILES
  - MRS.1 METAL ROOF SHEETING
  - PV.1 COBBLESTONE PAVING
  - TB.1 TIMBER BATTENS
  - TF.1 TIMBER FLOORING
  - CO.1 CONCRETE

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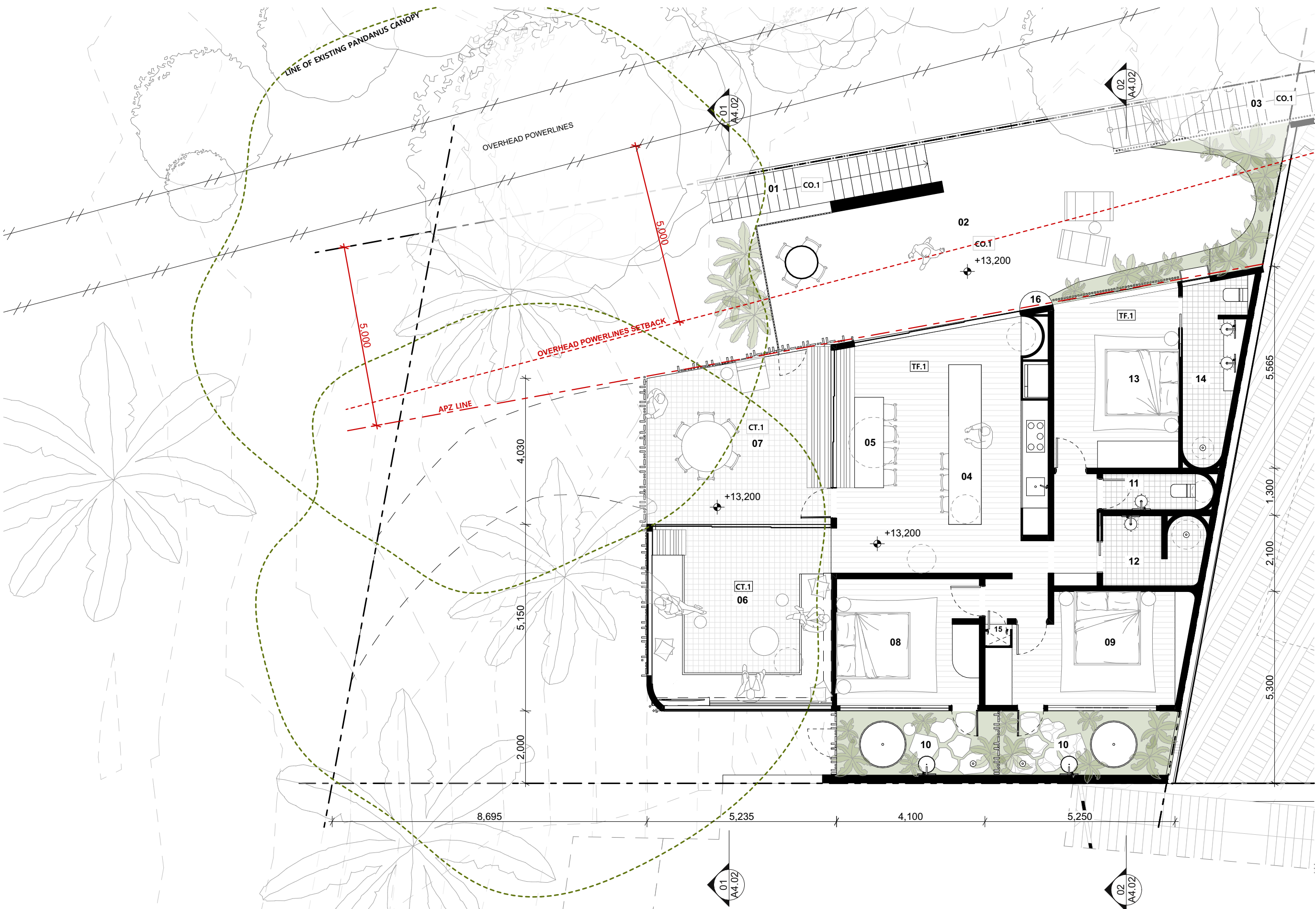
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Work in Progress	02 - WIP	Consultant Review



DRAWN BY: VN  
CHECKED BY: HG  
SCALE: A3  
PAPER: A3  
PROJECT: LANTERN HOUSE  
JOB No#: HGA 266  
CLIENT: STEPHEN RING  
ADDRESS: 23 MARINE PARADE, BYRON BAY

DRAWING TITLE : PROPOSED  
**LOT A GROUND LEVEL PROPOSED**  
STATUS : **LANTERN HOUSE**

DRAWING NO. **A2.02.1**  
REVISION NO. **02 - WIP**  
7/08/2024



LAYOUT LEGEND

- 01 STAIRS DOWN
- 02 ENTRY TERRACE
- 03 STAIRS UP
- 04 KITCHEN
- 05 DINING
- 06 LIVING
- 07 BALCONY
- 08 BED 2
- 09 BED 3
- 10 LANDSCAPED TERRACE
- 11 POWDER
- 12 BATHROOM
- 13 BED 1
- 14 ENSUITE
- 15 LAUNDRY CHUTE
- 16 BBQ BENCH

MATERIAL LEGEND

- AW.1 STEEL AWNING
- CT.1 CERAMIC TILES
- MRS.1 METAL ROOF SHEETING
- PV.1 COBBLESTONE PAVING
- TB.1 TIMBER BATTENS
- TF.1 TIMBER FLOORING
- CO.1 CONCRETE

HGA.STUDIO

LVL 1/144 JONSON STREET BYRON BAY | PO BOX 1285 NSW 2481  
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NOMINATED ARCHITECT: HARLEY GRAHAM NSW REGISTRATION No#: 7892

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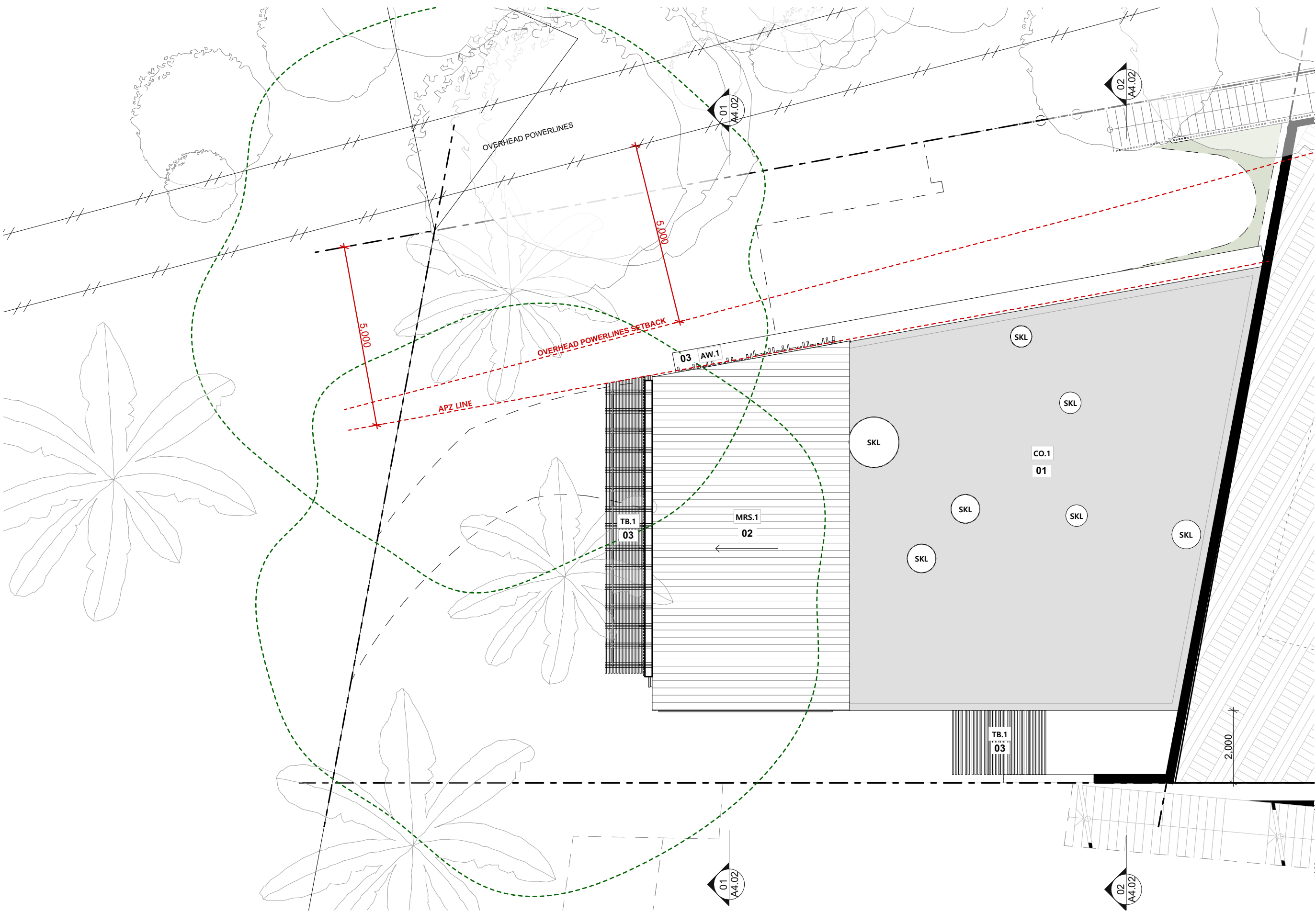


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CHECKED BY: HG  
SCALE: A3  
PAPER: A3  
PROJECT: LANTERN HOUSE  
JOB No#: HGA 266  
CLIENT: STEPHEN RING  
ADDRESS: 23 MARINE PARADE, BYRON BAY

DRAWING TITLE :  
PROPOSED  
**LOT A FIRST LEVEL PROPOSED**  
STATUS :  
**LANTERN HOUSE**

DRAWING NO.  
**A2.02.2**  
REVISION NO.  
**02 - WIP**  
7/08/2024





LAYOUT LEGEND

- 01 FLAT ROOF  
02 PITCHED ROOF  
03 AWNING

MATERIAL LEGEND

- AW.1 STEEL AWNING  
CT.1 CERAMIC TILES  
MRS.1 METAL ROOF SHEETING  
PV.1 COBBLESTONE PAVING  
TB.1 TIMBER BATTENS  
TF.1 TIMBER FLOORING  
CO.1 CONCRETE  
SKL SKYLIGHT

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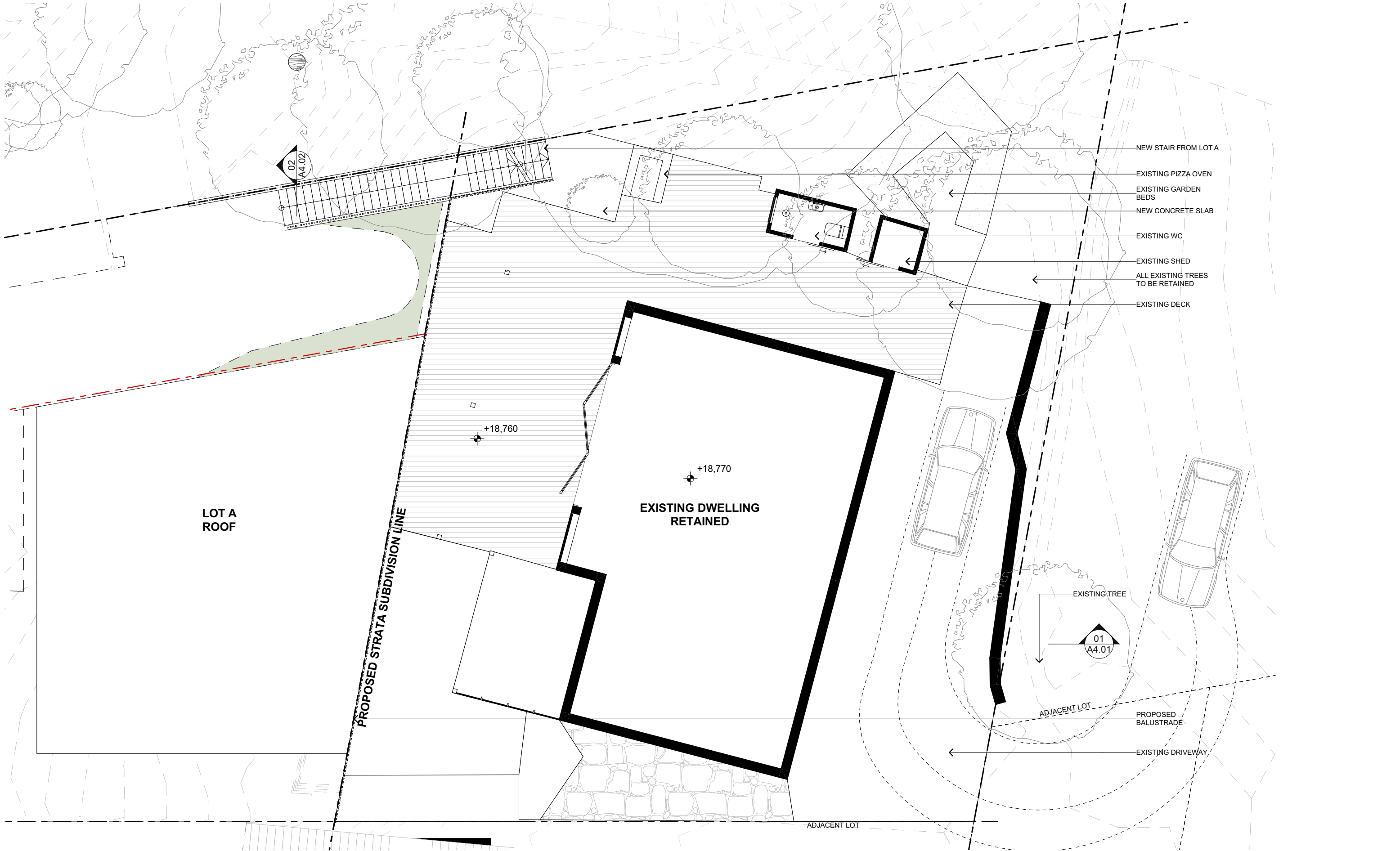
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CHECKED BY: HG  
SCALE: A3  
PAPER: A3  
PROJECT: LANTERN HOUSE  
JOB No#: HGA 266  
CLIENT: STEPHEN RING  
ADDRESS: 23 MARINE PARADE, BYRON BAY

DRAWING TITLE :  
PROPOSED  
LOT A ROOF PROPOSED  
STATUS :  
LANTERN HOUSE

DRAWING NO.  
A2.02.3  
REVISION NO.  
02 - WIP  
7/08/2024



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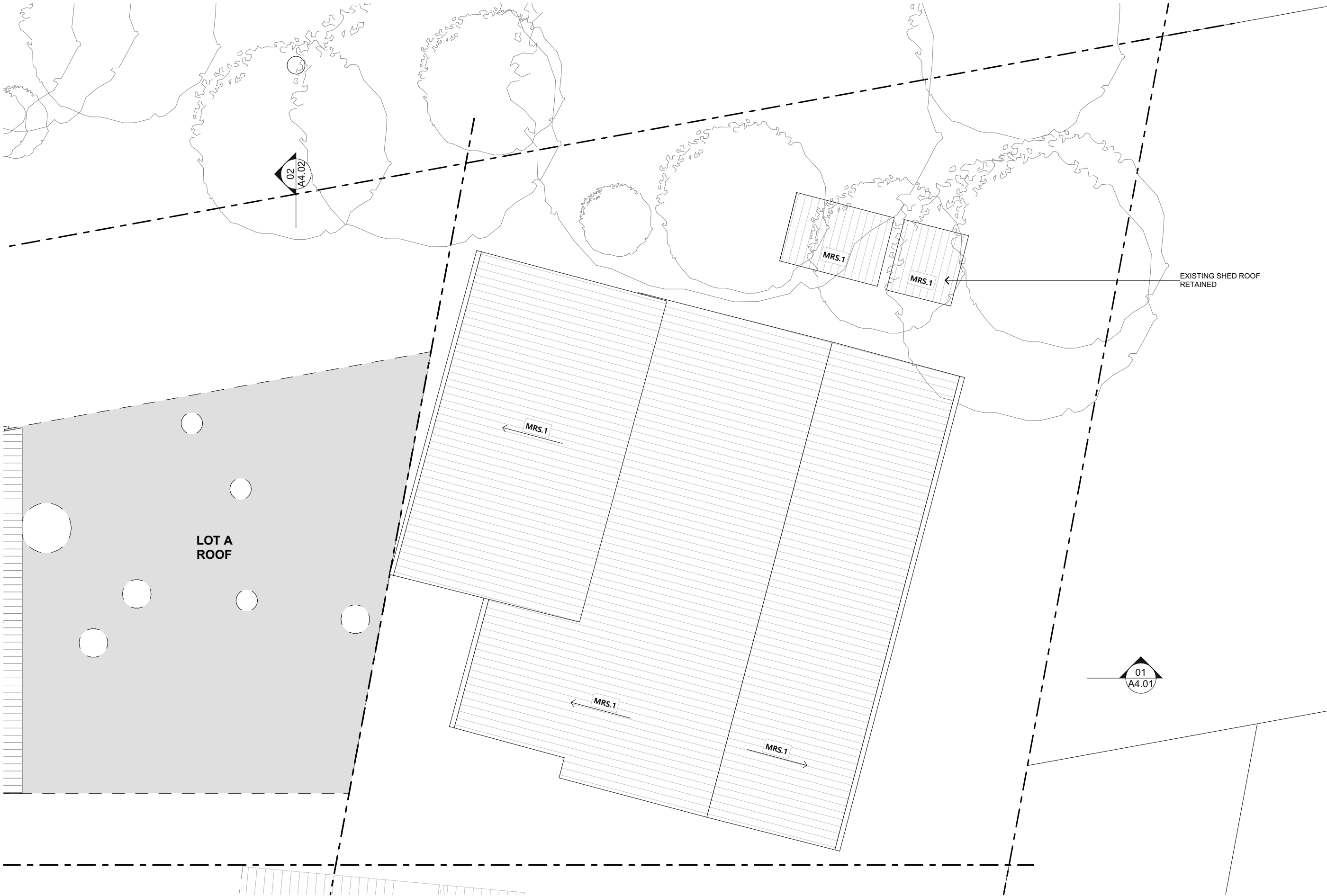


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**SCALE:** A3  
**PAPER:** A3  
**PROJECT:** LANTERN HOUSE  
**JOB No#:** HGA 266  
**CLIENT:** STEPHEN RING  
**ADDRESS:** 23 MARINE PARADE, BYRON BAY

**DRAWING TITLE :** PROPOSED  
**LOT B. PROPOSED**  
**STATUS :** LANTERN HOUSE

**DRAWING NO.** A2.02.4  
**REVISION NO.** 02 - WIP  
7/08/2024





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NOMINATED ARCHITECT: HARLEY GRAHAM NSW REGISTRATION No#: 7892

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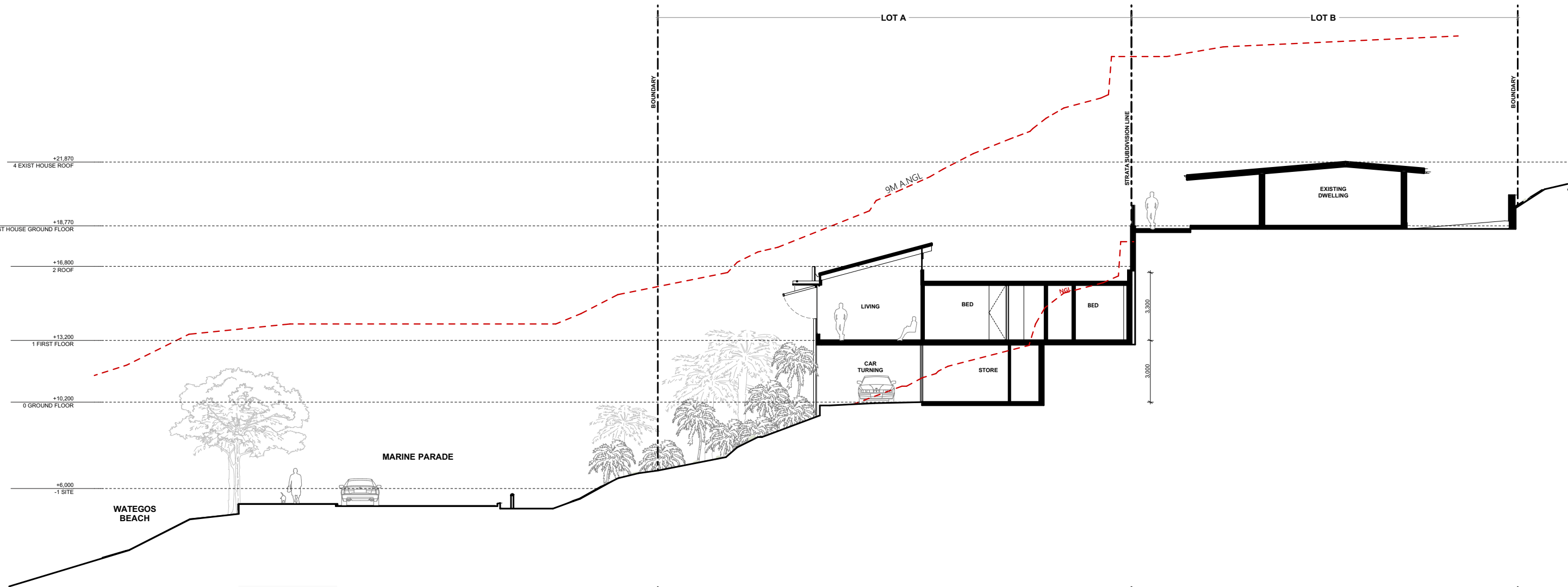
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Work in Progress	02 - WIP	Consultant Review



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**CHECKED BY:** HG  
**SCALE:** A3  
**PAPER:** A3  
**PROJECT:** LANTERN HOUSE  
**JOB No#:** HGA 266  
**CLIENT:** STEPHEN RING  
**ADDRESS:** 23 MARINE PARADE, BYRON BAY

**DRAWING TITLE :** PROPOSED  
**LOT B\_ROOF\_PROPOSED**  
**STATUS :** LANTERN HOUSE

**DRAWING NO.** A2.02.5  
**REVISION NO.** 02 - WIP  
7/08/2024



01. LONG SECTION 01

HGA.STUDIO

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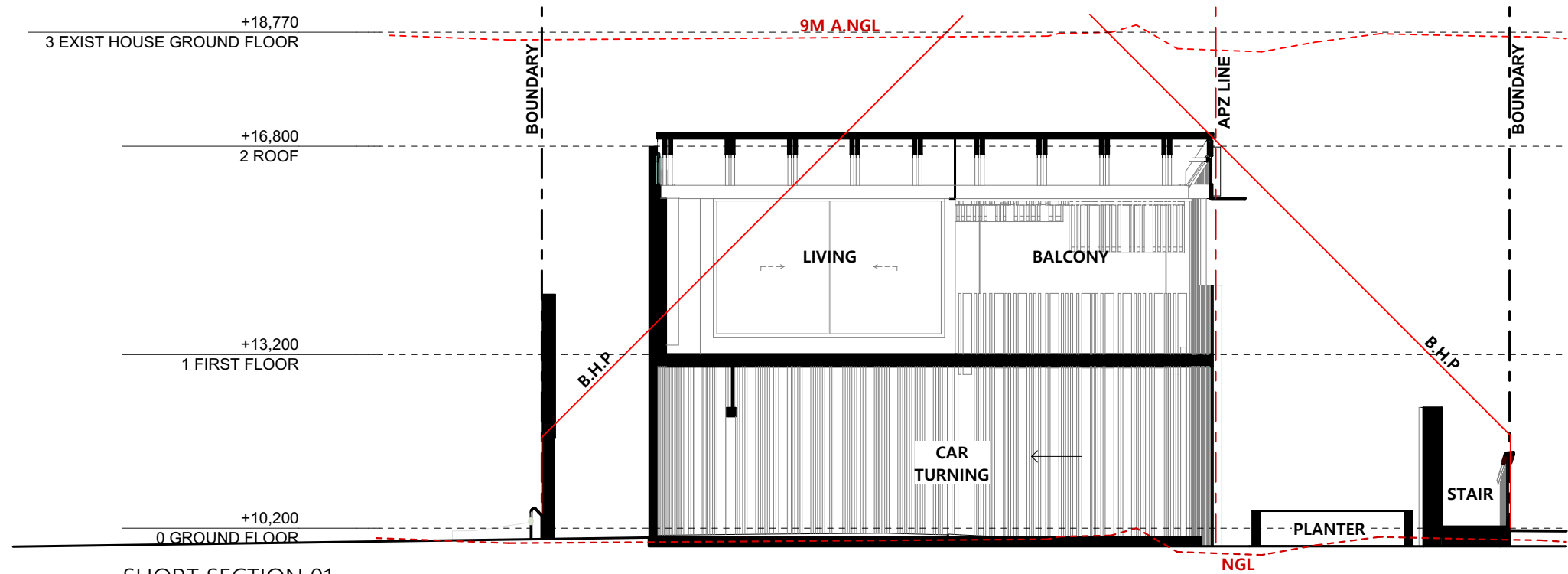
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**PROJECT:** LANTERN HOUSE  
**JOB No#:** HGA 266  
**CLIENT:** STEPHEN RING  
**ADDRESS:** 23 MARINE PARADE, BYRON BAY

**DRAWING TITLE :**  
**STATUS :**

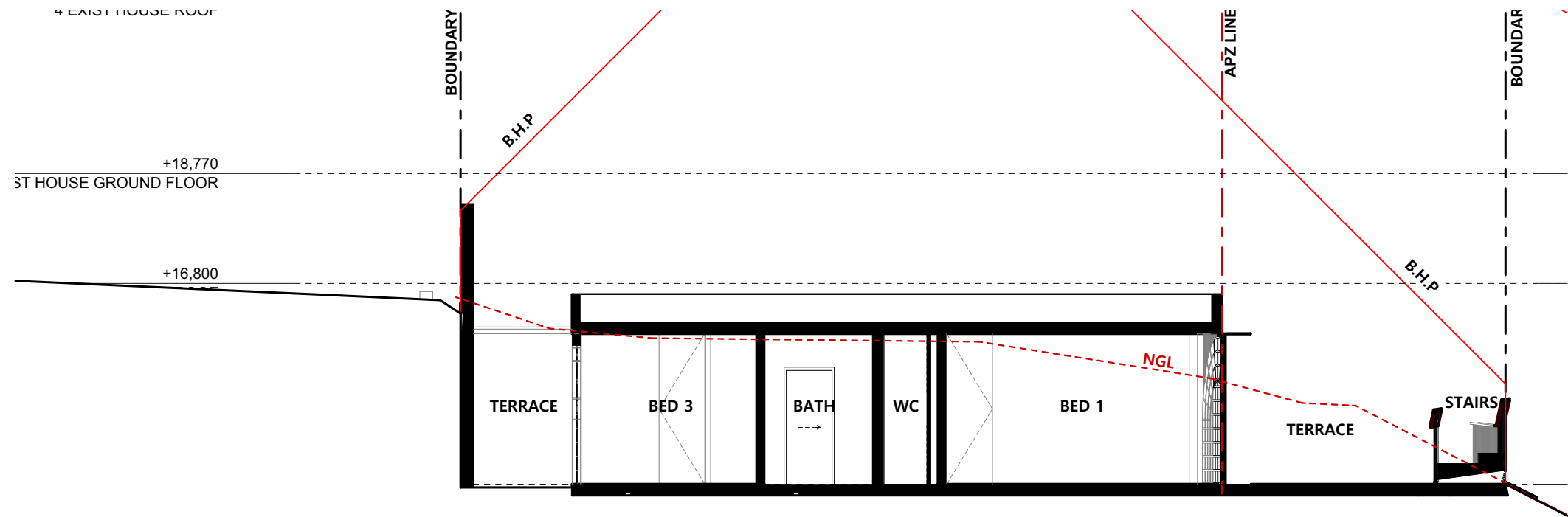
**SECTIONS**  
**LONG SECTION 01**  
**LANTERN HOUSE**

**DRAWING NO.**  
**A4.01**

**REVISION NO.**  
**02 - WIP**  
7/08/2024



01. SHORT SECTION 01



02. SHORT SECTION 02

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SCALE	
PAPER	A3
PROJECT:	LANTERN HOUSE
JOB No#:	HGA 266
CLIENT:	STEPHEN RING
ADDRESS:	23 MARINE PARADE, BYRON BAY

DRAWING TITLE :  
STATUS :

SECTIONS  
SHORT SECTIONS  
LANTERN HOUSE

DRAWING NO.  
**A4.02**  
REVISION NO.  
**02 - WIP**  
7/08/2024

## **APPENDIX E:**

## **GUIDANCE MATERIAL**

## AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

### LANDSLIDE RISK

#### Concept of Risk

Risk is a familiar term, but what does it really mean? It can be defined as *"a measure of the probability and severity of an adverse effect to health, property, or the environment."* This definition may seem a bit complicated. In relation to landslides, geotechnical practitioners (GeoGuide LR1) are required to assess risk in terms of the likelihood that a particular landslide will occur and the possible consequences. This is called landslide risk assessment. The consequences of a landslide are many and varied, but our concerns normally focus on loss of, or damage to, property and loss of life.

#### Landslide Risk Assessment

Some local councils in Australia are aware of the potential for landslides within their jurisdiction and have responded by designating specific "landslide hazard zones". Development in these areas is often covered by special regulations. If you are contemplating building, or buying an existing house, particularly in a hilly area, or near cliffs, go first for information to your local council.

**Landslide risk assessment must be undertaken by a geotechnical practitioner.** It may involve visual inspection, geological mapping, geotechnical investigation and monitoring to identify:

- potential landslides (there may be more than one that could impact on your site)
- the likelihood that they will occur
- the damage that could result
- the cost of disruption and repairs and
- the extent to which lives could be lost.

Risk assessment is a predictive exercise, but since the ground and the processes involved are complex, prediction tends to lack precision. If you commission a

landslide risk assessment for a particular site you should expect to receive a report prepared in accordance with current professional guidelines and in a form that is acceptable to your local council, or planning authority.

#### Risk to Property

Table 1 indicates the terms used to describe risk to property. Each risk level depends on an assessment of how likely a landslide is to occur and its consequences in dollar terms. "Likelihood" is the chance of it happening in any one year, as indicated in Table 2. "Consequences" are related to the cost of repairs and temporary loss of use if a landslide occurs. These two factors are combined by the geotechnical practitioner to determine the Qualitative Risk.

**TABLE 2: LIKELIHOOD**

Likelihood	Annual Probability
Almost Certain	1:10
Likely	1:100
Possible	1:1,000
Unlikely	1:10,000
Rare	1:100,000
Barely credible	1:1,000,000

The terms "unacceptable", "may be tolerated", etc. in Table 1 indicate how most people react to an assessed risk level. However, some people will always be more prepared, or better able, to tolerate a higher risk level than others.

Some local councils and planning authorities stipulate a maximum tolerable level of risk to property for developments within their jurisdictions. In these situations the risk must be assessed by a geotechnical practitioner. If stabilisation works are needed to meet the stipulated requirements these will normally have to be carried out as part of the development, or consent will be withheld.

**TABLE 1: RISK TO PROPERTY**

Qualitative Risk		Significance - Geotechnical engineering requirements
Very high	VH	<b>Unacceptable</b> without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low. May be too expensive and not practical. Work likely to cost more than the value of the property.
High	H	<b>Unacceptable</b> without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable level. Work would cost a substantial sum in relation to the value of the property.
Moderate	M	<b>May be tolerated</b> in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as possible.
Low	L	<b>Usually acceptable</b> to regulators. Where treatment has been needed to reduce the risk to this level, ongoing maintenance is required.
Very Low	VL	<b>Acceptable.</b> Manage by normal slope maintenance procedures.

## AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

### Risk to Life

Most of us have some difficulty grappling with the concept of risk and deciding whether, or not, we are prepared to accept it. However, without doing any sort of analysis, or commissioning a report from an "expert", we all take risks every day. One of them is the risk of being killed in an accident. This is worth thinking about, because it tells us a lot about ourselves and can help to put an assessed risk into a meaningful context. By identifying activities that we either are, or are not, prepared to engage in we can get some indication of the maximum level of risk that we are prepared to take. This knowledge can help us to decide whether we really are able to accept a particular risk, or to tolerate a particular likelihood of loss, or damage, to our property (Table 2).

In Table 3, data from NSW for the years 1998 to 2002, and other sources, is presented. A risk of 1 in 100,000 means that, in any one year, 1 person is killed for every 100,000 people undertaking that particular activity. The NSW data assumes that the whole population undertakes the activity. That is, we are all at risk of being killed in a fire, or of choking on our food, but it is reasonable to assume that only people who go deep sea fishing run a risk of being killed while doing it.

It can be seen that the risks of dying as a result of falling, using a motor vehicle, or engaging in water-related activities (including bathing) are all greater than 1:100,000 and yet few people actively avoid situations where these risks are present. Some people are averse to flying and yet it represents a lower risk than choking to death on food. Importantly, the data also indicate that, even when the risk of dying as a consequence of a particular event is very small, it could still happen to any one of us any day. If this were not so, no one would ever be struck by lightning.

Most local councils and planning authorities that stipulate a tolerable risk to property also stipulate a tolerable risk to life. The AGS Practice Note Guideline recommends that 1:100,000 is tolerable in newly

developed areas, where works can be carried out as part of the development to limit risk. The tolerable level is raised to 1:10,000 in established areas, where specific landslide hazards may have existed for many years. The distinction is deliberate and intended to prevent the concept of landslide risk management, for its own sake, becoming an unreasonable financial burden on existing communities. Acceptable risk is usually taken to be one tenth of the tolerable risk (1:1,000,000 for new developments and 1:100,000 for established areas) and efforts should be made to attain these where it is practicable and financially realistic to do so.

**TABLE 3: RISK TO LIFE**

<b>Risk (deaths per participant per year)</b>	<b>Activity/Event Leading to Death (NSW data unless noted)</b>
1:1,000	Deep sea fishing (UK)
1:1,000 to 1:10,000	Motor cycling, horse riding , ultra-light flying (Canada)
1:23,000	Motor vehicle use
1:30,000	Fall
1:70,000	Drowning
1:180,000	Fire/burn
1:660,000	Choking on food
1:1,000,000	Scheduled airlines (Canada)
1:2,300,000	Train travel
1:32,000,000	Lightning strike

**More information relevant to your particular situation may be found in other AUSTRALIAN GEOGUIDES:**

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR8 - Hillside Construction
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

# PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

## APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

### GOOD ENGINEERING PRACTICE

### POOR ENGINEERING PRACTICE

#### ADVICE

GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
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#### PLANNING

SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
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#### DESIGN AND CONSTRUCTION

HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.

#### DRAWINGS AND SITE VISITS DURING CONSTRUCTION

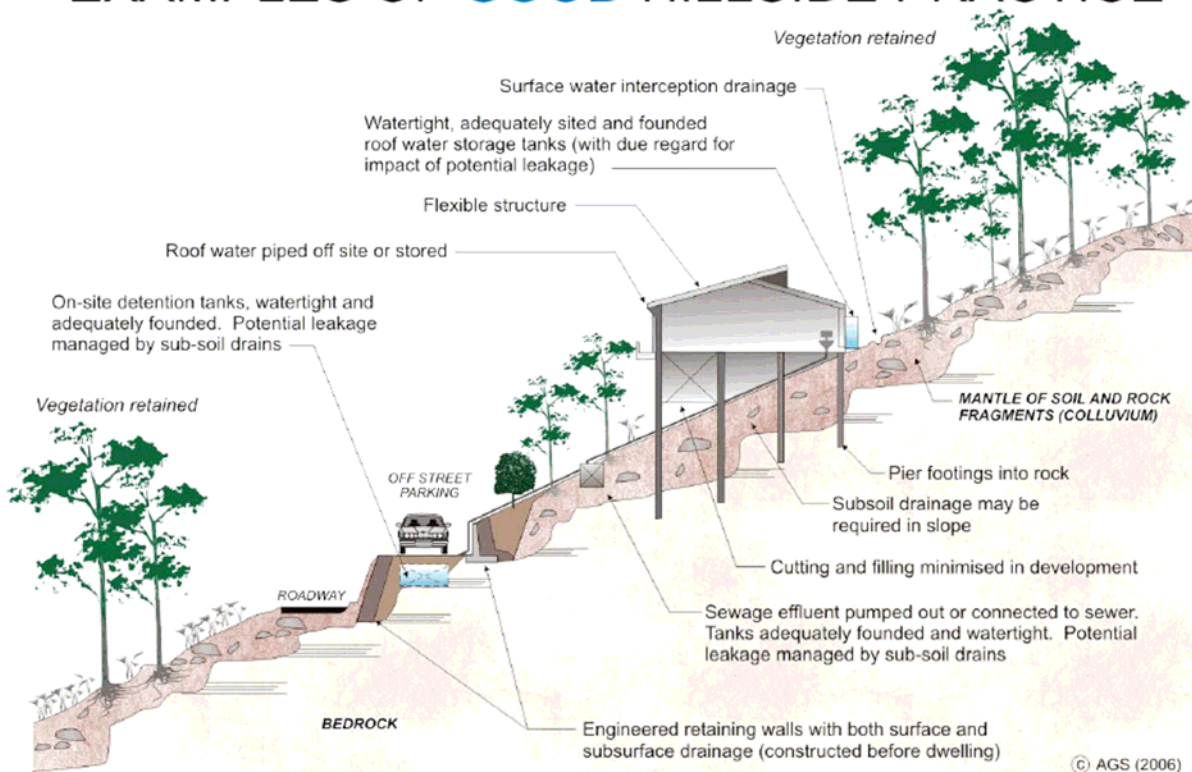
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	

#### INSPECTION AND MAINTENANCE BY OWNER

OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	
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## EXAMPLES OF **GOOD** HILLSIDE PRACTICE



## EXAMPLES OF **POOR** HILLSIDE PRACTICE

