Nepean Geotechnics

ABN 45 626 934 389
15 Henry Place, Narellan Vale, NSW 2567
Email: info@nepeangeotechnics.com.au
PH: 0447 280 042

Geotechnical Investigation and Slope Stability Risk Assessment

Proposed New Residence

Lot 03, 10 Fern Creek Road, Warriewood NSW

Report No. R22009.03.Rev0

Prepared for:

Skycorp Australia

2 February 2022

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Appendices

1. Introduction

This report presents the results of a geotechnical investigation and slope stability risk assessment undertaken for proposed residential development to be constructed at Lot 03, 10 Fern Creek Road, Warriewood. The investigation was undertaken in accordance with Nepean Geotechnics general terms of engagement.

We've been advised that the development comprises the construction of a double storey residential dwelling at the site. According to the provided conceptual design drawings of the project, the finished floor elevation of lower ground level will be at RL 26.4 m and excavations up to approximate depth of 2.3 m will be required for the lower ground level. A copy of design drawings can be found in Appendix A.

The objective of investigation was to assess the surface and subsurface soil conditions across the site in order to provide comments on:

- Slope stability risk assessment in general accordance with Australian Geomechanics Society (AGS) Guidelines.
- Indicative site classification in accordance with AS2870,
- Bearing capacity of near surface material, and
- Safe batter slopes and retaining wall design parameters.

Reference to the Pittwater Local Environmental Plan (2014), Geotechnical Hazard Map, indicates that the proposed new lot (Lot 03) is located outside the boundary of Geotechnical Hazard H1. A copy of the overlay map is provided in Appendix E.

The investigation included a site walkover inspection by an experienced geotechnical engineer and the drilling of boreholes. The borehole locations are shown on a marked up aerial photograph in Appendix A.

2. Site Description

The allotment is located within a newly developed residential subdivision. The proposed allotment (Lot 03) has frontage to Fern Creek Road and is located on the low side of the roadway on the side of a hill. The allotment is bordered by undeveloped residential lots to the remaining sides.

Topographically, the allotment is situated along the lower slope of a hill. The ground surface across the site moderately slopes downward to the north-east and had a fall approximately 6 – 7 m. However, the construction area of the allotment had a difference in elevation of approximately 4 – 5 m. At the time of field works, there were no existing structures within the allotment.

Site vegetation comprised grasses, weeds and scattered native trees. The trees were in upright position. The following site photographs show the general site conditions at the time of field work:

Photograph 1 – General site conditions, looking south

3. Geology

According to the Sydney 1:100 000 Geological Series Sheet the site is underlain by undifferentiated rocs belong to the Narrabeen Group (Rnn) of Middle Triassic age. According to the mapping, he rocks within this formation typically consist of laminate, shale, lithic-quartz sandstone and claystone.

4. Field Work

The field work comprised drilling of two boreholes within the allotment using a Landcruiser-mounted drilling rig equipped with solid flight augers. Borehole logging and mapping exercise were carried out by an experienced geotechnical engineer. Dynamic cone penetrometer (DCP) tests were carried out adjacent to each borehole location to provide an indication of the penetration resistance and strength of the near-surface soils.

A site walkover was also carried out to observe the site surface and drainage conditions, ground slopes and vegetation covers across the site.

5. Subsurface Conditions

Surface material in the boreholes comprised minor topsoils and colluvium to approximate depths of 0.5 – 0.7 m. The surface material in BH101 were underlain by silty sandy clays and gravelly clays of stiff to very stiff consistency to approximate depth of 1.8 m. Extremely to highly weathered rock consisting of interbedded shale and lithic sandstone were encountered below a depth of 1.7 m in BH101 and continued to the termination depth of 3.0 m.

The near surface colluvium in BH102 were underlain by clayey sands in dry conditions to a depth of 0.8 m overlying silty sandy clays and silty clays of stiff to very stiff consistency to approximate depth of 1.9 m. Extremely to highly weathered rock consisting of interbedded shale and lithic sandstone were encountered below this depth and continued to the termination depth of 3.0 m.

The borehole logs in Appendix B should be referred to for the details of material encountered at each investigation location.

No free groundwater was observed during drilling at the borehole locations.

6. Site Classification

Due to presence of trees and sloping ground, the site will be classified Class P in accordance with AS2870 'Residential Slabs & Footings'. Provided the recommendations of the report are adopted and all footings are founded in the stiff residual material or bedrock, a ground surface movement equivalent to 'Class M – Moderately Reactive', may be considered for the existing soils for design purposes. The site classification will be subject to the site inspection at the completion of bulk earthworks.

7. Earthworks

According to the conceptual drawings, cutting up to approximate depths of 1.3 - 2.3 m will be required at the south-western portion of the building footprint to achieve the design elevations of propose lower ground level. Due to the sloping ground, the excavation depths would be gradually decreasing towards the north and east of the building footprint. Minor filling up to 0.5 m would likely be required at the north-eastern portion of the allotment for leveling the site and landscaping purposes. During the excavation and footing construction, the soils and any extremely to highly weathered rock are expected to be removed using a medium size excavator equipped with toothed bucket or auger attachment with no difficulty. Some light to medium ripping may be required for the excavation of highly weathered rock similar to the material encountered below the auger refusal depths of boreholes.

8. Safe Batters & Retaining Walls

Temporary cut batters in medium dense sands and clayey sands in dry conditions may be constructed at a grade of 2(H): 1(V). Temporary cut battered at a grade of 1:1 may be constructed in stiff to very stiff clayey material. As a general approach any general fill embankments with no surcharge loads should be constructed at a grade of 1V:3H. However, placing excessive fill material on sloping ground should be minimized as it may lead to instability and creep movement.

Due to sloping ground and presence of existing residential lots at the lower slope of the allotment, fill embankments along the north-eastern portion of building envelope shall be supported by engineer designed retaining walls which are founded into the underlying residual clays or bedrock. Retaining walls shall be constructed to support the cut battered with surcharge loads from proposed structures or existing roadway. The final surface shall be protected from erosion by promoting vegetation cover.

Where required, retaining walls may be designed based on 'at rest earth pressure coefficient' of 0.55 and 0.7 for medium dense sandy material and stiff clays, respectively. These values are for horizontal ground surface behind the retaining walls. Where the ground surface behind the walls is sloping, depending on the ground slope and material type, there will be significant increase of the earth pressure coefficient values. Granular material shall be placed directly behind the retaining walls. Efficient drainage shall be provided by placing perforated drainage pipes along the bottom of the wall. The effect of water pressure needs to be considered in the design of retaining walls where there is a potential for the saturation of backfill material and residual soil.

9. Footings

Due to sloping ground, the development shall be undertaken in accordance with the recommendations given in the AGS Appendix G – 'Some Guidelines for Hillside Construction', a copy of which can be found in Appendix D.

All the footings and piers will need to be founded on the underlying stiff gravelly clays or weathered rock. As a guide, high level pad or strip footings founded in the stiff clays below the near surface colluvium, medium dense sandy material may be designed based on an allowable bearing capacity of 150 kPa. At the bulk excavation level, extremely to highly weathered rock would likely be exposed within parts of the lower ground level footprint. Shallow footings or piers founded in the extremely weathered rock may be propertied based on an allowable bearing capacity of 450 kPa. It is noted that all footings will need to be extended into the similar foundation material to avoid the risk of premature cracking in the slabs.

All the footings and piers shall be founded on material of similar stiffness and will need to be keyed into the suitable foundation material to a minimum depth of 300 mm.

10. Drainage and Maintenance

In order to minimise the effects of erosion on the site, surface soil will need to be protected by directing surface runoff away from the construction areas, access roads and behind any retaining walls. Any stormwater flow shall be collected from the construction areas, cut faces and any fill embankments using drainage swales.

Surface drainage should be maintained at all times during the earthworks and the entire life of the development. The drainage should be provided as soon as possible in order to control surface flows and prevent saturation and erosion of the surficial soils across sloping areas of the site. To maintain the long term stability of the site, the stripped areas will need to be revegetated.

The developed site should be maintained in accordance with the CSIRO publication 'Foundation Maintenance and Footing Performance' (Appendix C). The guide suggests site maintenance practices to assist in minimising the foundation movements and keeping the cracking within acceptable limits. It is stressed that some minor cracking may still be observed as this is unavoidable in most structures.

11. Stability Risk Assessment

A desktop study was completed in order to find the evidence of previous instability within the site and surrounding areas. A review of aerial imagery of the site suggests the site was not subject to a recent instability.

A walkover site inspection was undertaken by an experienced geotechnical engineer to observe the slope angles, geological features and drainage conditions within the site and along the road cuts at the upper levels. The ground surface across the site was covered with grasses and no signs of active instability such as tilted trees, tension cracking, severe erosion or rock falls/slumps were noted at the time of the field work. The near surface conditions in the boreholes comprised clays of stiff consistency and bedrock at relatively shallow depths.

The upright position of mature trees within the subject area site and surrounding lots and stability of existing cut batters along the Fern Creek Road all suggest the site was not subject to any recent instability or ground movement. The presence of near surface colluvial/sandy material should however be considered in the design and the cuts in these materials or any filling shall be protected using suitably designed and constructed retaining walls.

Stormwater flows across the site shall be managed effectively to prevent any water aided mass movement of near surface soils into the nominated construction area or lower slopes. Stormwater maintenance manholes were observed along the site boundaries suggesting the subsurface stormwater drainage system has already been installed.

The hazards on the site have been assessed for risk to life and property using the general methodology outlined by the Australian Geomechanics Society (*Landslide Risk Management AGS Subcommittee 2007*).

11.1 Risk to loss of life $R_{(LoL)}$

For loss of life, the individual risk can be calculated from:

$R_{(LoL)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}$

where:

- $R_{(LoL)}$ is the risk (annual probability of loss of life of an individual)
- $P_{(H)}$ is the annual probability of the hazardous event occurring
- $P_{(S:H)}$ is the probability of spatial impact by the hazard (e.g. of the failure reaching the proposed residence/garage taking into account the distance of a given event from the elements)
- $P_{(T:S)}$ is the temporal probability (e.g. of the proposed structures on site being occupied by the individual) at the time of the spatial impact
- $V_{(D:T)}$ is the vulnerability of the individual (probability of loss of life of the individual given the impact)

In accordance with the AGS guidelines, landslide inventory should be formulated by collecting evidence for previous landslides using:

- Aerial photographs;

- Historic records; and
- Field mapping.

The collated data during site inspection and desktop study were used to make an assessment of landslide frequency in the study area. No groundwater seepage were encountered during the subsurface investigation. Considering the presence of relatively shallow bedrock and propose excavations (followed by the construction of retaining walls) for leveling the construction area, deep seated landslide is less likely to occur within the construction area of the site.

Considering the geological and topographical features of the site, a potential hazard would be shallow slumps of surficial slope wash material or earthflows of near surface colluvial/granular material across the stripped areas during construction and following extreme rainfall events. This could be prevented or managed by adopting adequate drainage measures across the site and construction of suitably designed retaining walls.

AGS (2007) recommends some published relationship between verbal descriptor and probabilities (Commentary on Practice Note Guidelines for Landslide Risk Management). According to the reference document and findings of the investigation the following estimation of annual probability of landslide $P_{(H)}$ would be adopted for the site at the current conditions, due to potential scenarios for future instability events:

Hazard Type	**Estimate of Annual Probability $P_{(H)}$**
Erosion	10^{-3}
Localised Instability	10^{-3}
Deep Seated landslide	10^{-4}

The probability for a person occupies the house during a day is estimated 12 hours a day per year. The probability for the presence of a person within the outside areas affected by landslide would also be estimated conservatively 6 hours a day per year.

According to *"Practice Notes Guidelines for Landslide Risk Management, 2007, AGS",* the following factors influence the likelihood of deaths and injuries or vulnerability, $V_{(D:T)}$, of a person who are impacted by a landslide:

- Volume of Landslide;
- Type of slide, mechanism of slide initiation and velocity of sliding;
- Depth of Slide;
- Whether the landslide debris buries the person(s);
- Whether the person(s) are in the open or enclosed in a vehicle or building;
- Whether the vehicle or building collapses when impacted by debris;
- The type of collapse if the vehicle or building collapses.

The examples of vulnerability values *(AGS2007, Appendix F)* were used to adopt an estimate of vulnerability for this assessment. Based on the site observations and for a suitable developed site, the impact of surface erosion or localized instability will be minor (estimated less than 0.5 m^3).

Based on observations made during inspection of the site and subsurface investigation and on the basis that development will be undertaken in general accordance with the comments given in this report, the results of the assessment are outlined in Table 1 for the proposed development:

Table 1: Life Risk Assessment for Proposed Development

Hazard Type	$P_{(H)}$ (1)	$P_{(S:H)}$	$P_{(T:S)}$	$V_{(D:T)}$	Risk $R_{(LoL)}$
Erosion	10^{-3}	0.01	0.75	0.01	$7.5 \text{ X } 10^{-8}$
Localised Instability	10^{-3}	0.1	0.75	0.01	$7.5 \text{ X}10^{-7}$
Deep Seated landslide	10^{-5}	0.25	0.75	0.5	$9.3 \text{ X}10^{-7}$

Note:

(1) assuming adequate risk mitigation measures (e.g drainage, retaining walls, etc) are in place.

AGS suggested a tolerable risk for loss of life of 10^{-5} per annum for new developments and 10^{-4} for existing slopes. As such the proposed site will remain low risk for loss of life of individual which is acceptable in accordance with the reference guide and Council's Geotechnical Risk Management Policy..

11.2 Risk to Property

Table 2 suggests a descriptive term of likelihood of a landslide for an approximate annual landslide probability.

Table 2: Qualitative Measures of Likelihood

Approx. Annual Probability Indicative value	Implied Indicative Landslide Recurrence Interval	Descriptor
10^{-1}	10 years	Almost Certain
10^{-2}	100 years	Likely
10^{-3}	1000 years	Possible
10^{-4}	10,000 years	Unlikely
10^{-5}	100,000 years	Rare
10^{-6}	1,000,000 years	Barely Credible

A qualitative risk assessment for property loss risks has been carried out in accordance with the risk matrix and terms in *AGS 2007*, as outlined in Table 3.

Table 3: Qualitative Risk Analysis Matrix

Likelihood		Consequence to Property(1)				
	Indicative value of Approx. Annual Probability	1: Catastrophic 200%	2: Major 60%	3: Medium 20%	4: Minor 5%	5: Insignificant 0.5%
Almost Certain	10^{-1}	VH	VH	VH	H	M or L
Likely	10^{-2}	VH	VH	H	M	L
Possible	10^{-3}	VH	H	M	M	VL
Unlikely	10^{-4}	H	M	L	L	VL
Rare	10^{-5}	M	L	L	VL	VL
Barely Credible	10^{-6}	L	VL	VL	VL	VL

Where L: low, M: medium, H: high, VL: very low, VH: very high.
Note: (1) As a percentage of the value of the property.

According to Table 2 and Table 3, a descriptive term of '*possible*' may be adopted at the current site conditions due to the erosion potential and subsequent localized slumps over the sloping areas of the site. In order to mitigate the risk of future instability causing damage to the proposed structures, effective site drainage measures will be required to divert any surface run-off from entering the building envelope. In addition and as discussed in preceding sections of this report, the steep cut batters and fill embankments within the allotment shall be protected by suitably designed and constructed retaining walls.

Provided the recommendation of this report are adopted, any localised erosion and shallow slumps may only cause '*insignificant*' damage to the proposed structures (refer to Table 3 above) and the level of risk for damage to property will be considered '*very low*'. This will meet 'acceptable risk management' criteria in accordance with the AGS 2007.

It should be noted that whilst an area may be assessed as being currently stable, unsuitable development or poor construction techniques may trigger instability.

Foundation material will need to be inspected prior to the placement of steel and the pouring of concrete to ensure the design criteria are met. At the completion of earthworks, an inspection of batters and drainage site conditions shall be inspected (by design or geotechnical engineer) to confirm the earthworks have been undertaken in accordance with the design.

12. General Notes

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject project and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive borehole and test pit logs, cross-sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the boreholes and/or test pits are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the boreholes and test pits, or assumed to exist in the excavations, NG should be advised immediately to review these conditions and review recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

The test pit/borehole logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the field work progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The logs and related information depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these borehole locations. Also, the passage of time may result in a change in the soil conditions at these borehole locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the borehole/test pit logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, borehole or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project.

NG cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report; nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.

We trust the above is sufficient for your requirements. Please do not hesitate to contact the undersigned should you require further information or need to discuss any aspect of this report.

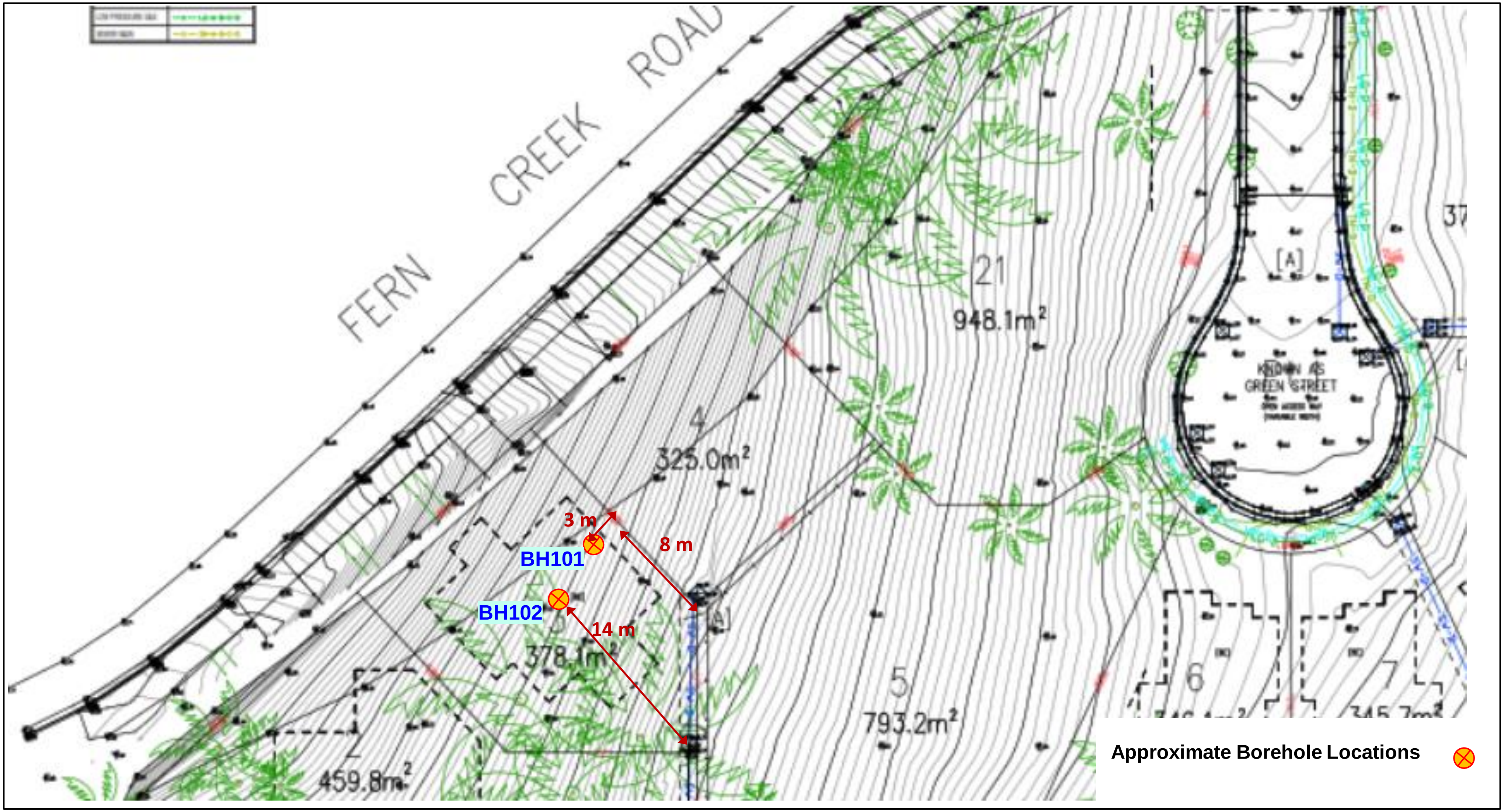
Yours sincerely,

Rasoul Machiani (MIEAust/CPEng/NER)
Senior Geotechnical Engineer
For and on behalf of Nepean Geotechnics

Appendix A

Approximate Borehole Locations,

Conceptual Design Drawings



Drawing 1

Proposed Residential Subdivision

Lot 03, 10 Fern Creek Road, Warriewood

Project No: R22009

Date: 27 January 2022

Nepean Geotechnics
ABN 45 626 934 389
15 Henry Place, Narellan Vale NSW 2567
Email: info@nepeangeotechnics.com.au
Phone: 0447 280 042

DRAWING LIST	
DRAWING NO.	**DRAWING LIST**
000	COVER PAGE
005	BASIX COMMITMENT
010	LOCATION PLAN
020	CUT&FILL PLAN
050	SITE ANALYSIS
120	LOW GROUND FLOOR PLAN
130	GROUND FLOOR PLAN
140	ROOF PLAN
200	ELEVATION
210	ELEVATION
300	SECTION
500	SHADOW DIAGRAM
510	SHADOW DIAGRAM
600	AREA CALCULATION
700	EXTERNAL FINISH SCHEDULE

DEVELOPMENT APPLICATION
PROPOSED DWELLING AT LOT 03,
10 FERN CREEK ROAD,WARRIEWOOD

PREPARED FOR

SKYCORP AUSTRALIA

BASIX COMMITMENTS SUMMERY NOTES
(TO BE READ IN CONJUNCTION WITH BASIX CERTIFICATE)

BASIX Certificate # 1266847S

WATER	No hot water reticulation required			
Fixtures	**All shower heads**	**All toilets**	**All kitchen taps**	**All bathrooms taps**
Rating	3 Star(>4.5 But<=6L/Min)	4 star	5 star	5 star
Alternate water source				
Rain Water Tank	**Type**	**Size**	**Roof area connected**	**Connections**
	Individual RWT	2000L	100 m2	Outdoor tap for landscape only
Swimming pool		....		
	Volume	**Heated**	**Cover**	**Shaded**
	....	....	....	....
ENERGY				
Hot water	**Type**		**Rating**	
	Individual, gas instantaneous		5 star	
Mech. Ventilation	**System**		**Operation Control**	
Bath	Indiv. fan, ducted to facade or roof		Manual Switch On/Off	
L'dry	Indiv. fan, ducted to facade or roof		Manual Switch On/Off	
Kitchen	Indiv. fan, ducted to facade or roof		Manual Switch On/Off	
Cooling System	**Type**		**Living areas**	**Bed rooms**
	1 Phase Air conditioning: Day / Night Zoned		2.5 star (average zone)	2.5 star (average zone)
Heating System	**Type**		**Living areas**	**Bed rooms**
	1 Phase Air conditioning: Day / Night Zoned		2.5 star (average zone)	2.5star (average zone)
Artificial Lighting	**Primary type of artificial lighting is fluorescent or light emitting diode (LED)**			
	No. of Bed rms & study	**No. of Living**	**Each Kitchen, Bath / Toilet**	**L'dry & Hallway**
	All	**All**	**Yes**	**Yes**
Others	**Indoor private Cloth Line**		**Not Required**	
	Outdoor or sheltered Cloth Line		**Yes**	
	Well ventilated Fridge space		**Yes**	
	Kitchen Cook top / Oven		**Gas Cook top + Electric Oven**	
THERMAL	**As per thermal simulation carried out by assessor**			
(refer assessor's stamped drawings)	**External Wall Insulation: R2.8**			
	Ceiling Insulation: R4.5			
	Roof type / colour : Metal roof, Medium Colour (SA 0.475 - 0.7) + SS Foil (R1.3)			
	ALM-002-01 A: Aluminium B SG Clear / tint U=6.6 SHGC =0.441 - 0.539			
	All External doors & windows to be weather sealed			
	Eaves / shading as per drawings			

pti ARCHITECTURE Tourism + Residential
Main Office: Level 2, 68 Sophia Street, Surry Hills NSW 2010
Parramatta Office: Level 15, Deloitte Building, 60 Station Street, Parramatta NSW 2150
+ 61 2 9283 0860 | www.ptiarchitecture.com.au
Nominated Registered Architect: Peter Israel (reg no 5064)
ABN 90 050 071 022

NOTE
1. Contractors to verify all dimensions on site before any shop drawings or work is commenced.
2. Figured dimensions to be taken in preference to scaled dwgs.
3. This drawing is to be read in conjunction with the specification and engineers drawings.

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REV	DESCRIPTION	BY	CHK	DATE
A	DEVELOPMENT APPLICATION	DL	KC/PI	08.11.21
B	SURVEY ISSUE	DL	GF/PI	11.11.21

CLIENT
SKYCORP AUSTRALIA

PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

DRAWING
BASIX COMMITMENT

NORTH

DRAWN	CHECKED
DL, KC	PI / KC
PROJECT No P563	SCALE @A1

disc	stage	dwg no.	revision
B	DA	005	B

1 **LOCATION PLAN**

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CLIENT
SKYCORP AUSTRALIA

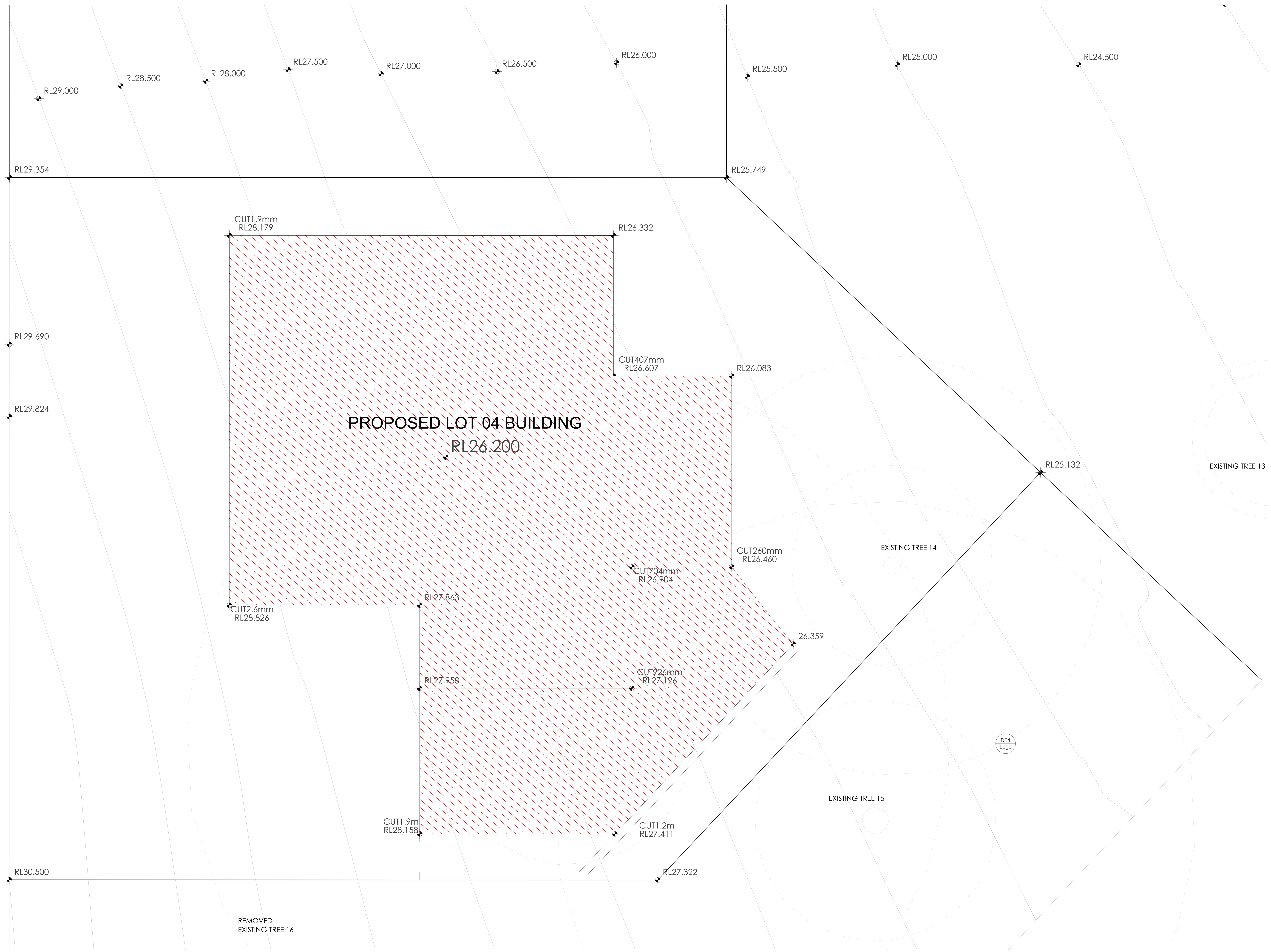
PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

DRAWING
LOCATION PLAN

NORTH

DRAWN	CHECKED
DL, KC	PI / KC
PROJECT No P563	SCALE 1:1000@A1

disc	stage.	dwg no.	revision
B	DA	010	B



1 **CUT&FILL PLAN**
1:50

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SKYCORP AUSTRALIA

PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

DRAWING
CUT&FILL PLAN

NORTH

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PROJECT No P563	SCALE 1:50@A1

disc	stage	dwg no.	revision
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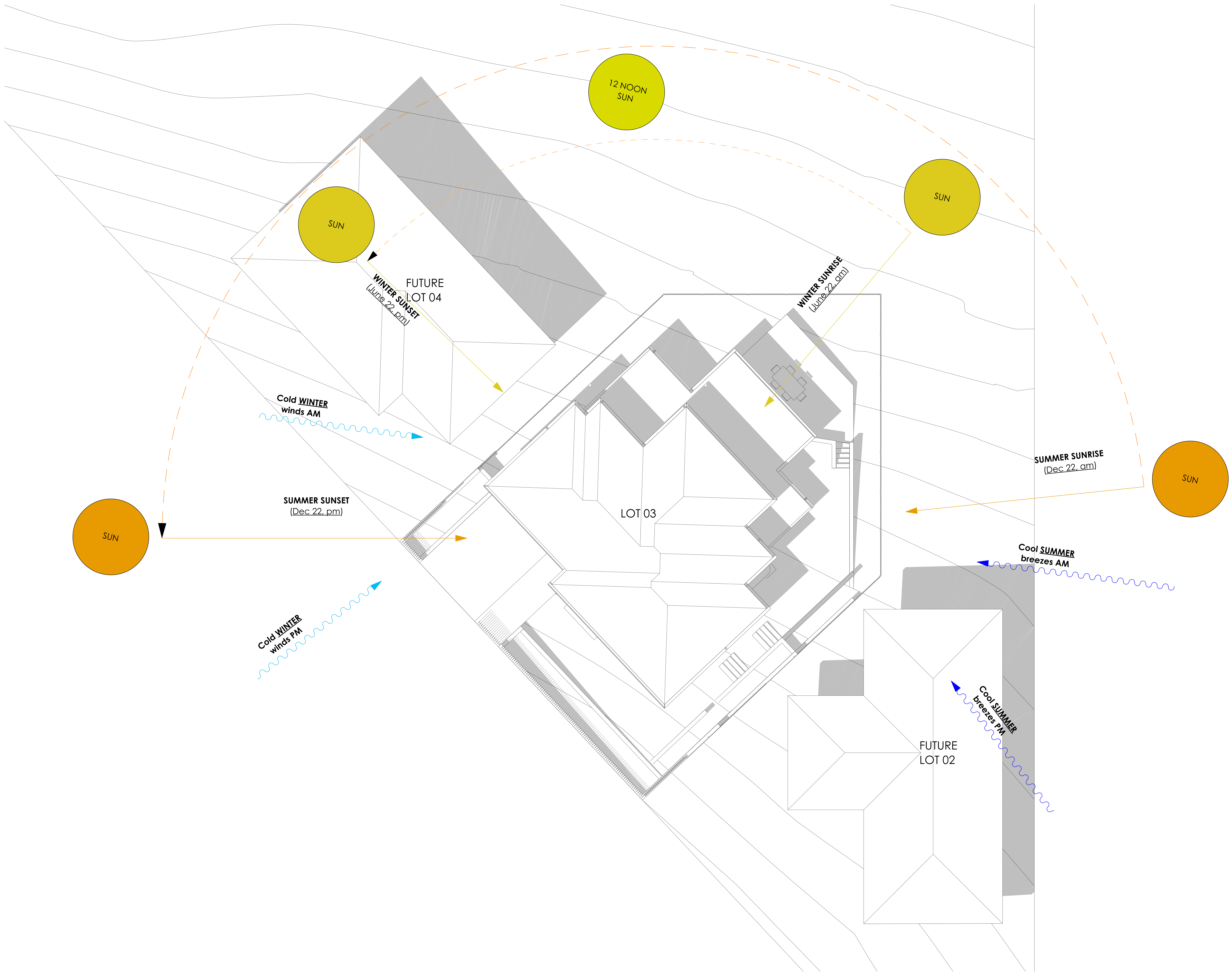

0 **SITE ANALYSIS PLAN**
1:100

PTI ARCHITECTURE Tourism + Residential

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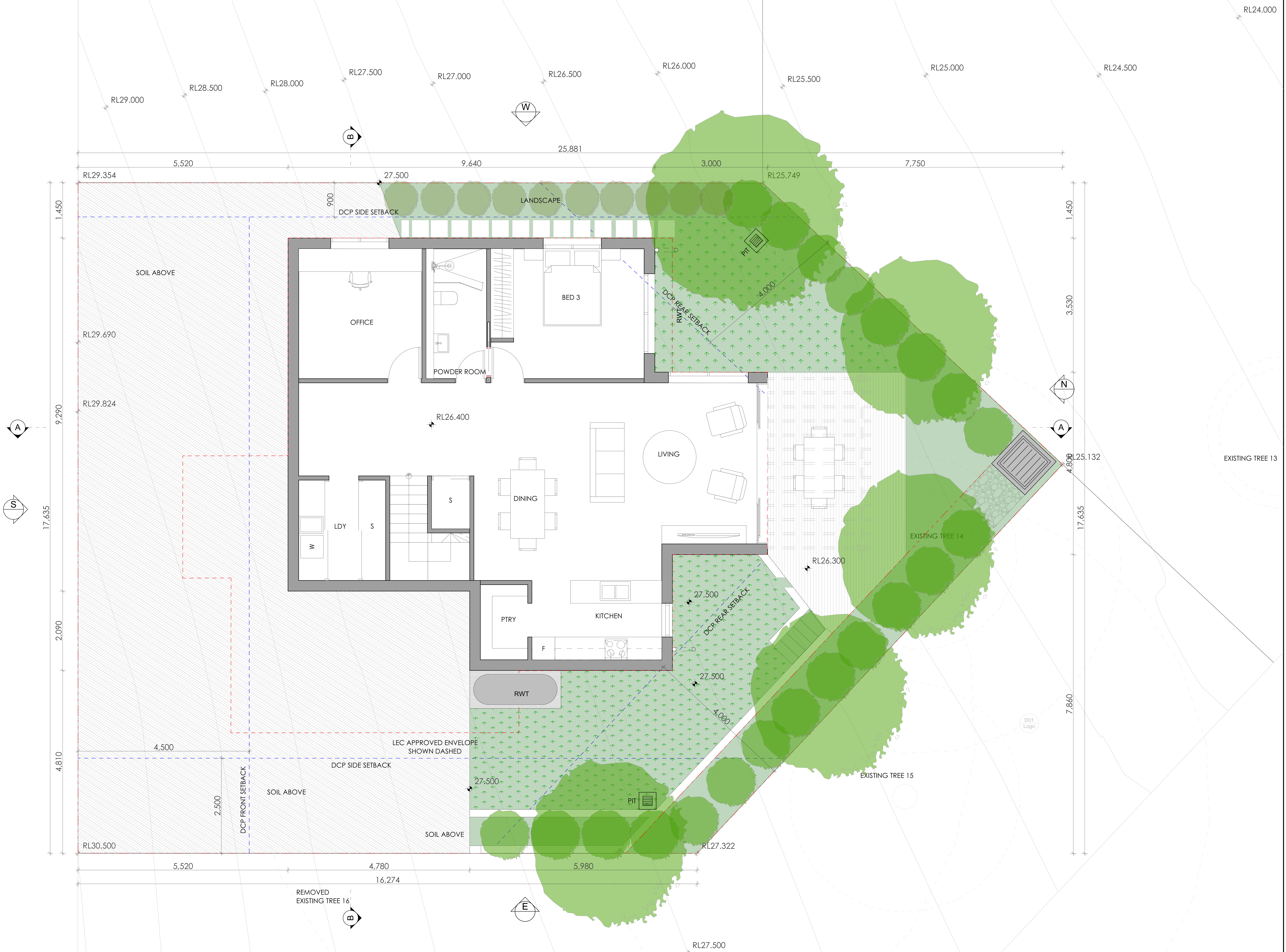
PROJECT: LOT03,10 FERN CREEK ROAD, WARRIEWOOD

DRAWING: SITE ANALYSIS

NORTH

DRAWN: DL, KC
CHECKED: PI / KC
PROJECT No: P563
SCALE: 1:100@A1

disc	stage	dwg no.	revision
B	DA	050	B



1 LOWER GROUND PLAN
1:50

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Nominated Registered Architect: Peter Israel (reg no 5064)
ABN 90 050 071 022

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A	DEVELOPMENT APPLICATION	DL	KC/PI	08.11.21
B	SURVEY ISSUE	DL	GF/PI	11.11.21

CLIENT
SKYCORP AUSTRALIA

PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

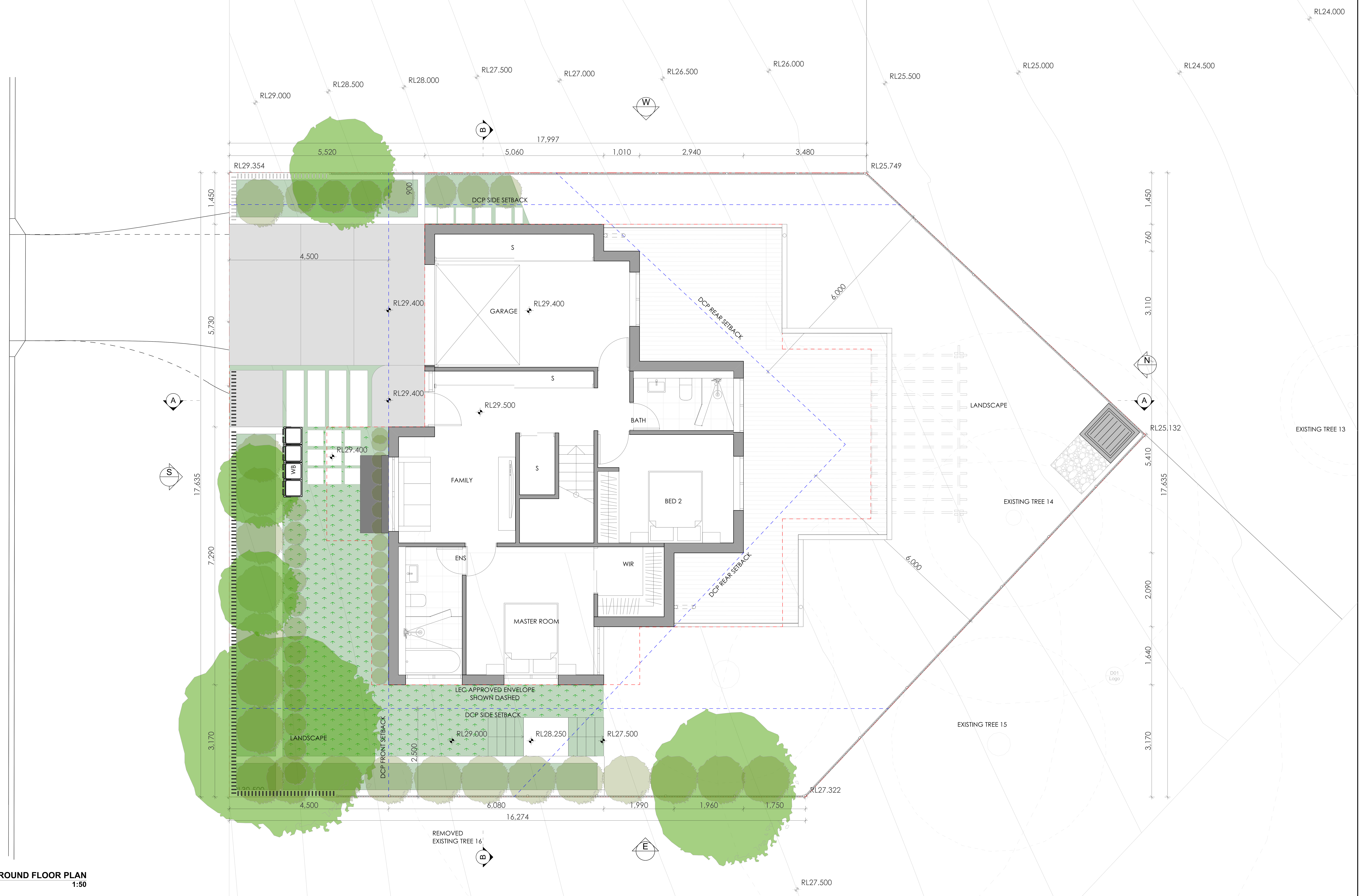
DRAWING
LOW GROUND FLOOR PLAN

NORTH

DRAWN: DL, KC
CHECKED: PI / KC
PROJECT No: P563
SCALE: 1:50@A1

disc	stage	dwg no.	revision
B	DA	120	B

K:\PTI 2019\P563 - 10 Fern Creek Road & 6 - 6A Orchard Street, Warriewood\10_DRAWINGS (PTI)\00_STAGE - SK\01_PLN\20210608_Lots with new survery\20210608_Lot 03_V22.pln Printed: 3/12/2021



1 GROUND FLOOR PLAN
1:50

ARCHITECTURE
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B	SURVEY ISSUE	DL	GF/PI	11.11.21

CLIENT
SKYCORP AUSTRALIA

PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

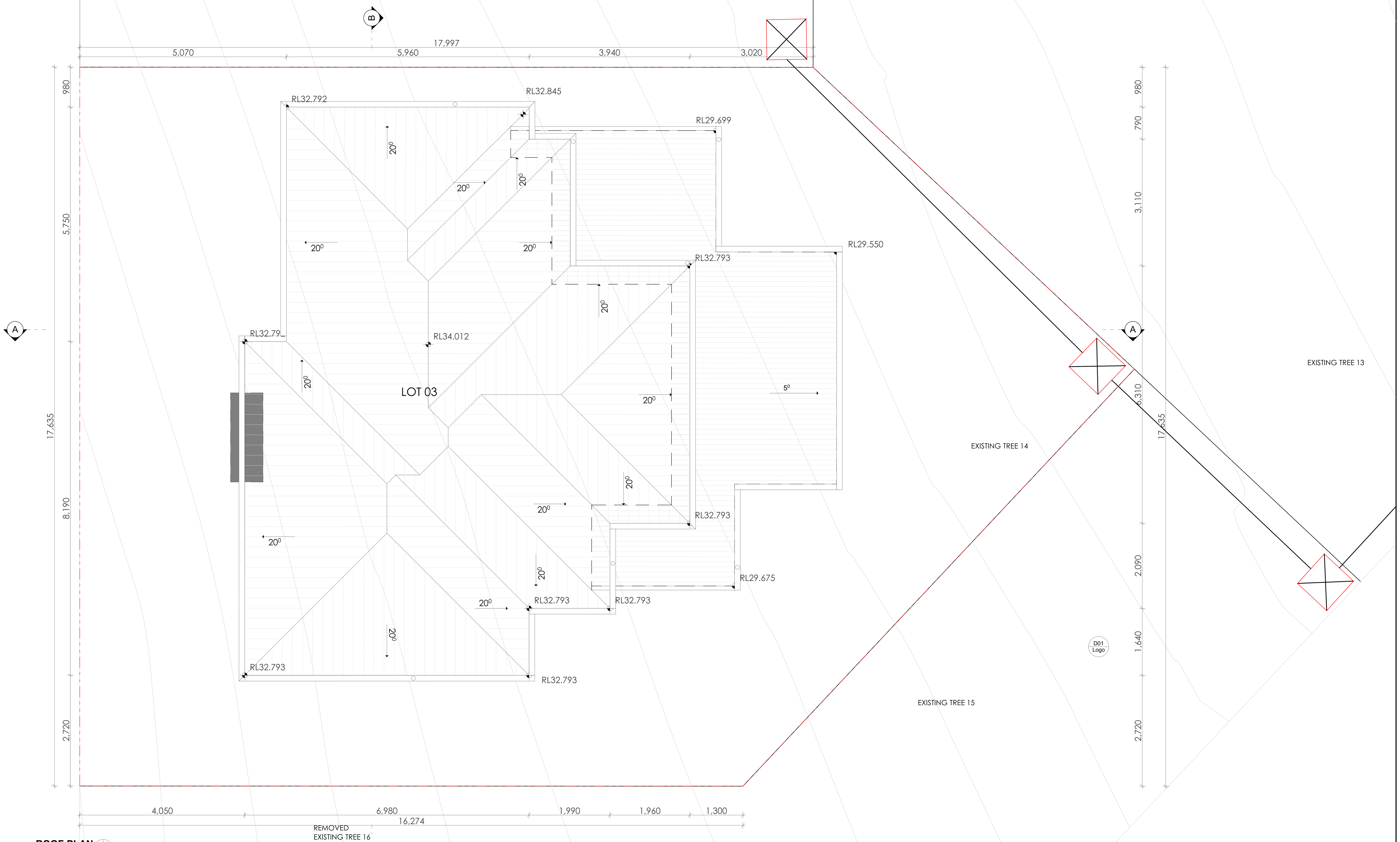
DRAWING
GROUND FLOOR PLAN

NORTH

DRAWN	CHECKED
DL, KC	PI / KC
PROJECT No P563	SCALE 1:50@A1

disc	stage	dwg no.	revision
B	DA	130	B

K:\PTI 2019\P563 - 10 Fern Creek Road & 6 - 6A Orchard Street, Warriewood\10_DRAWINGS (PTI)\00_STAGE - SK\01_PLN\20210608_Lots with new survery\20210608_Lot 03_V22.pln Printed: 3/12/2021



1 **ROOF PLAN** 1:50

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CLIENT
SKYCORP AUSTRALIA

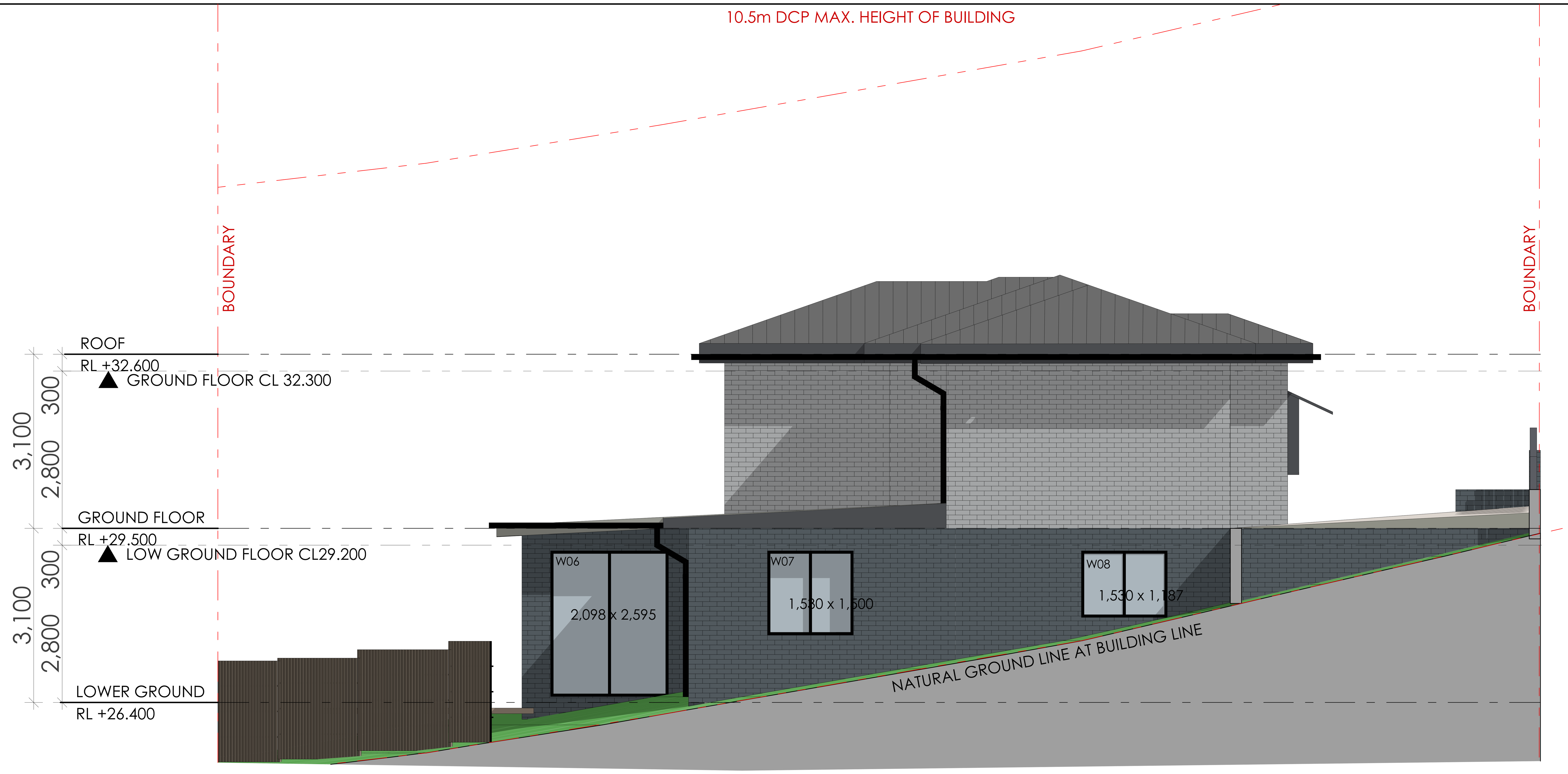
PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

DRAWING
ROOF PLAN

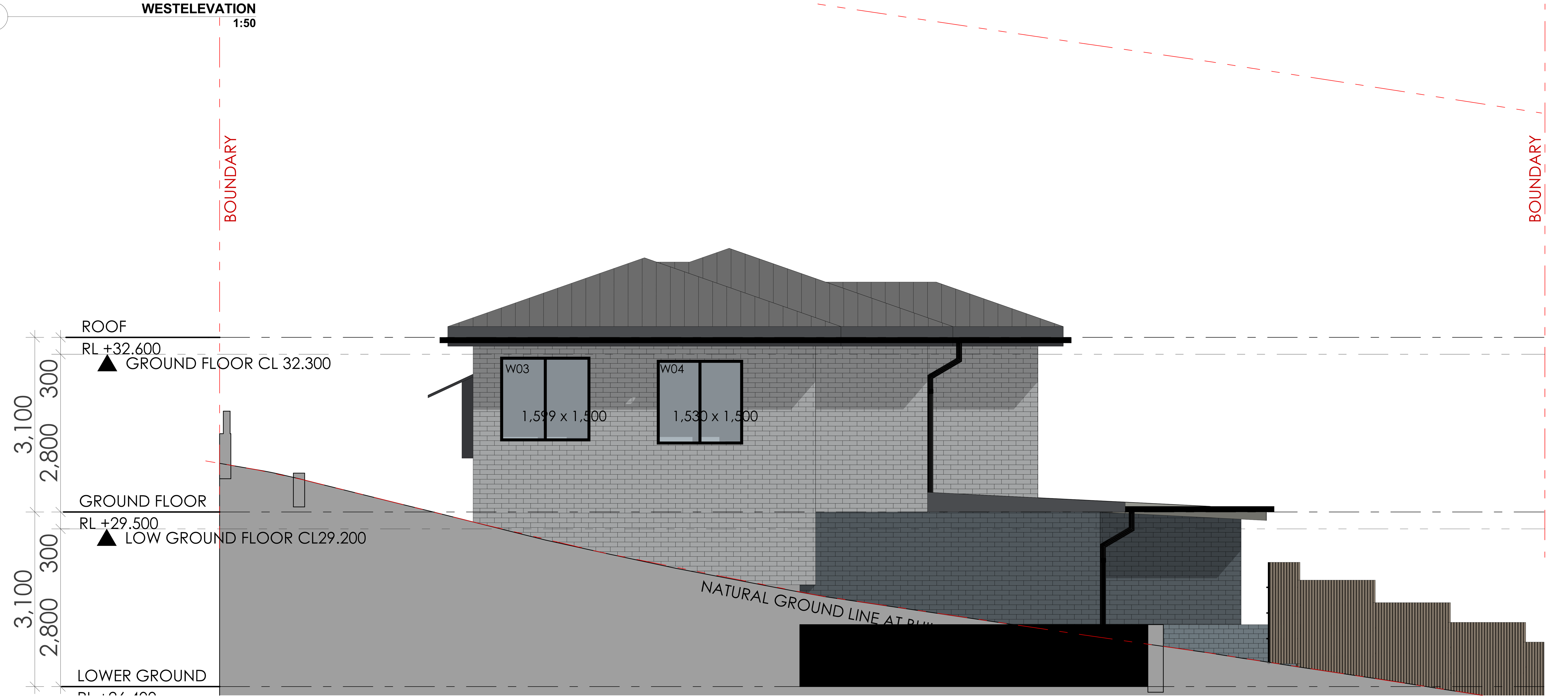
NORTH

DRAWN	CHECKED
DL, KC	PI / KC
PROJECT No P563	SCALE 1:50@A1

disc	stage	dwg no.	revision
B	DA	140	B



W WESTELEVATION 1:50



E EAST ELEVATION 1:50

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CLIENT
SKYCORP AUSTRALIA

PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

DRAWING
ELEVATION

NORTH

DRAWN DL, KC
CHECKED PI / KC
PROJECT No P563
SCALE 1:100@A1

disc	stage	dwg no.	revision
B	DA	200	B

K:\PTI 2019\P563 - 10 Fern Creek Road & 6 - 6A Orchard Street, Warriewood\10_DRAWINGS (PTI)\00_STAGE - SK\01_PLN\20210608_Lots with new survery\20210608_Lot 03_V22.pln Printed: 3/12/2021

N **NORTH ELEVATION**
1:50

S **SOUTHELEVATION**
1:50

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CLIENT
SKYCORP AUSTRALIA

PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

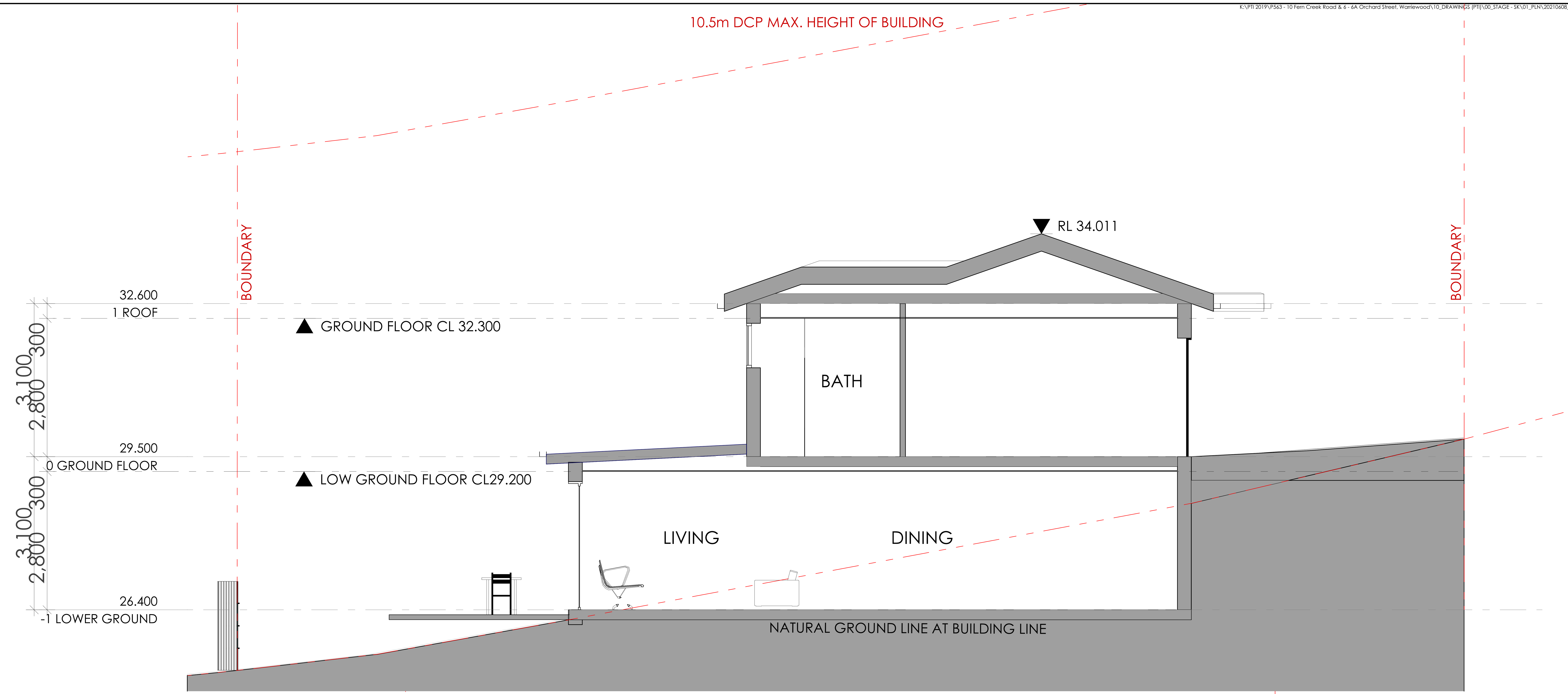
DRAWING
ELEVATION

NORTH

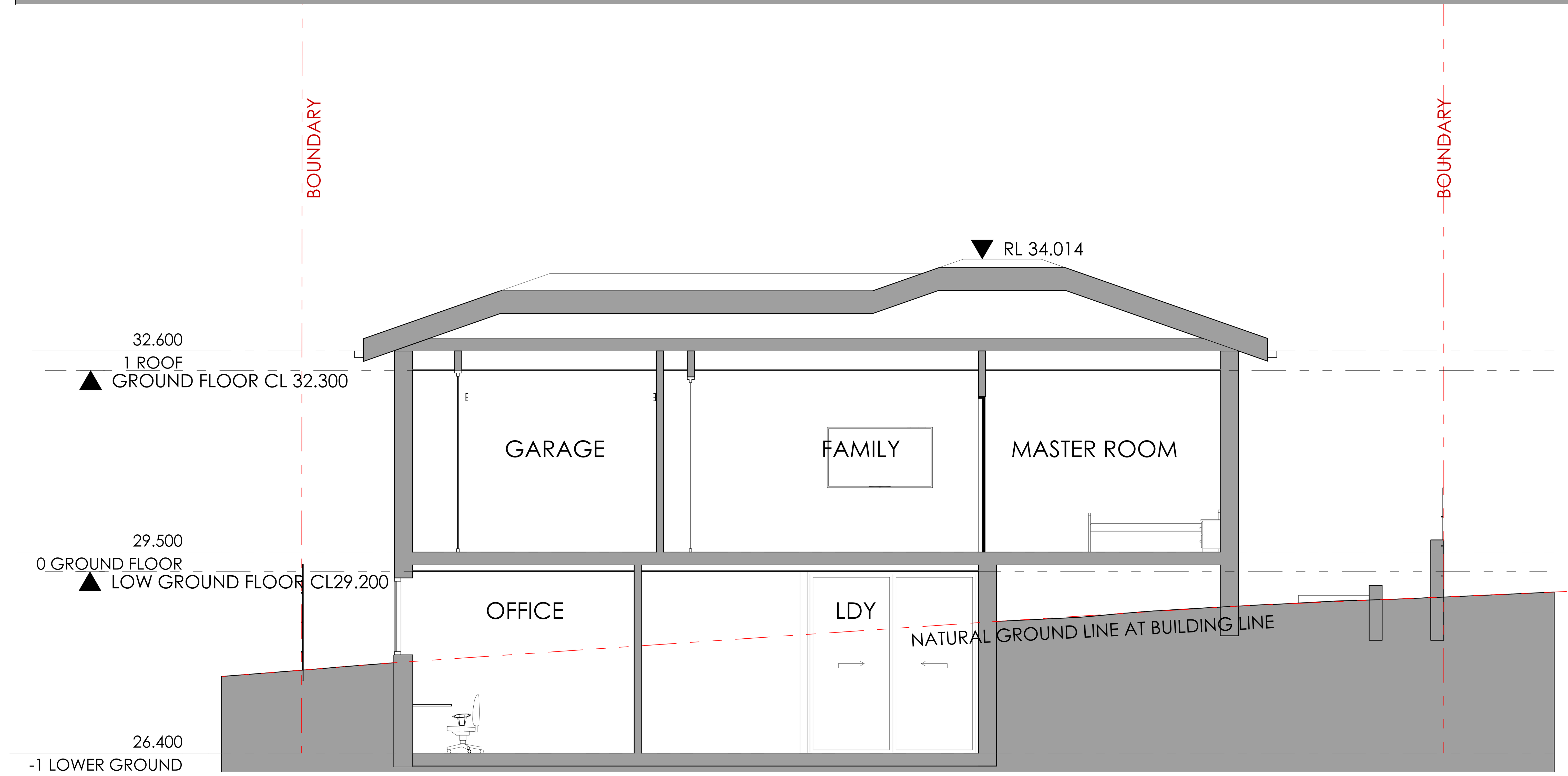
DRAWN	CHECKED
DL, KC	PI / KC
PROJECT No P563	SCALE 1:100@A1

disc	stage	dwg no.	revision
B	DA	210	B

K:\PTI 2019\P563 - 10 Fern Creek Road & 6 - 6A Orchard Street, Warriewood\10_DRAWINGS (PTI)\00_STAGE - SK\01_PLN\20210608_Lots with new survery\20210608_Lot 03_V22.pln Printed: 3/12/2021



A **SECTION A**
1:50



B **SECTION B**
1:50

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B	SURVEY ISSUE	DL	GF/PI	11.11.21

CLIENT
SKYCORP AUSTRALIA

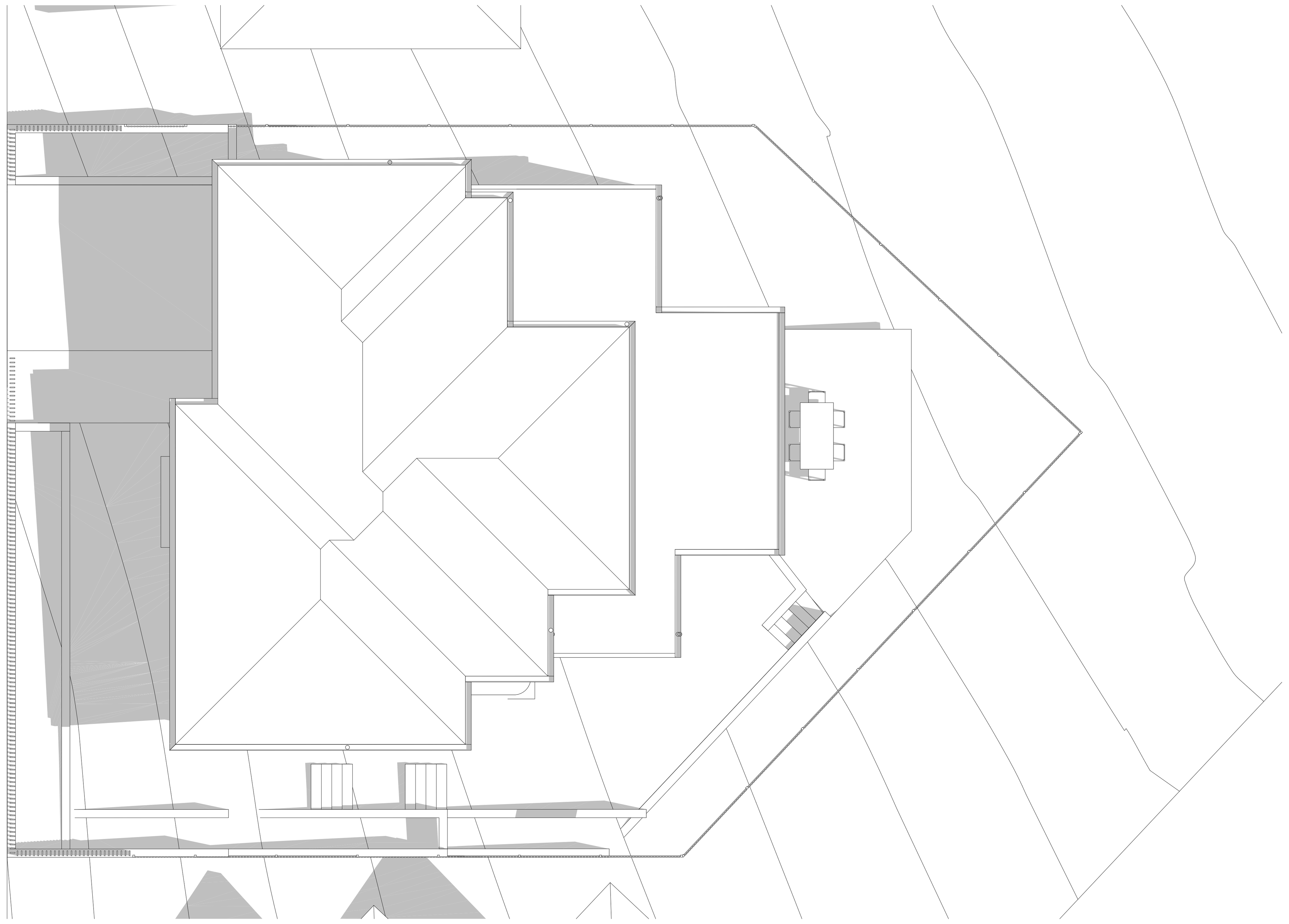
PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

DRAWING
SECTION

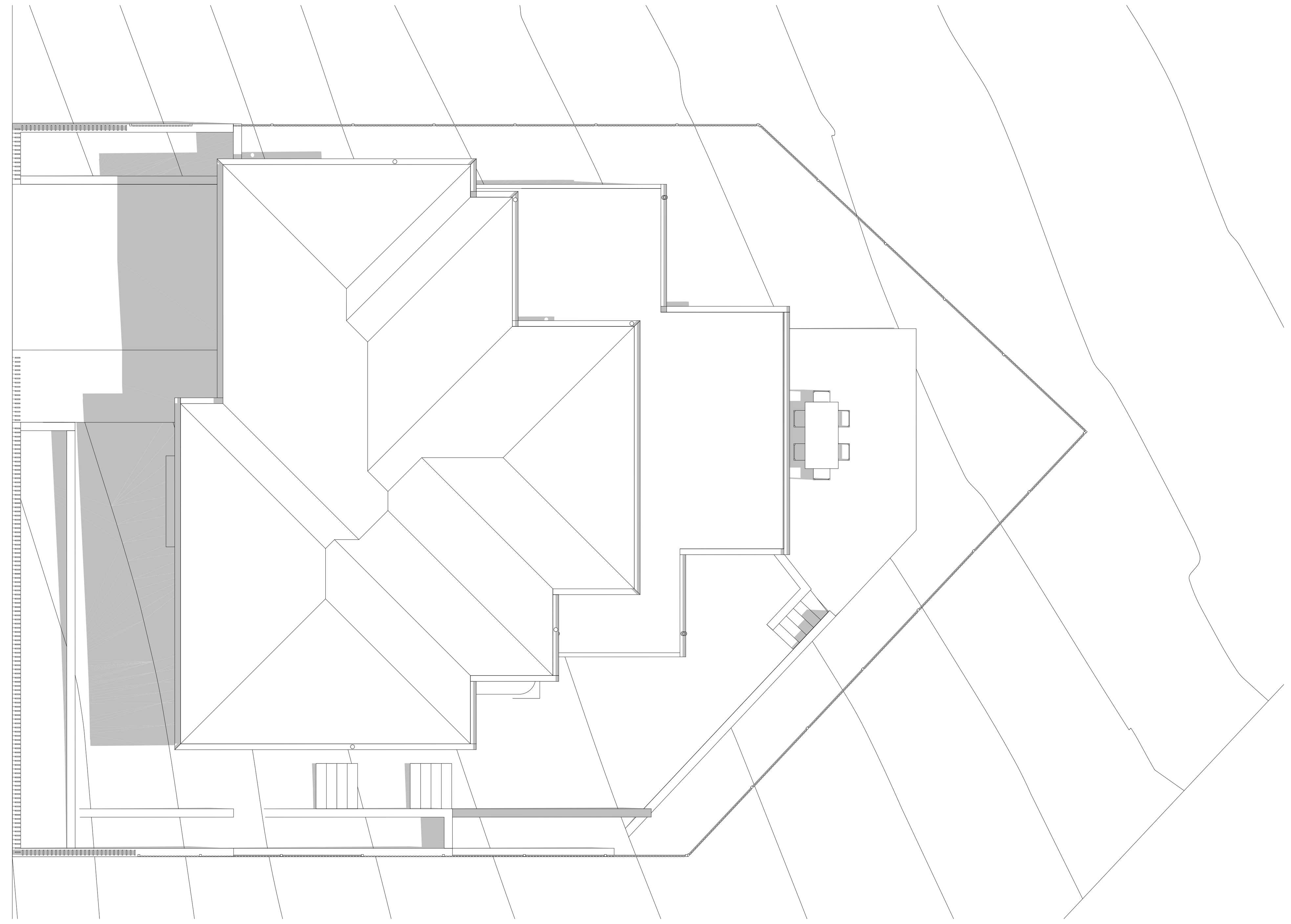
NORTH

DRAWN	CHECKED
DL, KC	PI / KC
PROJECT No P563	SCALE 1:100@A1

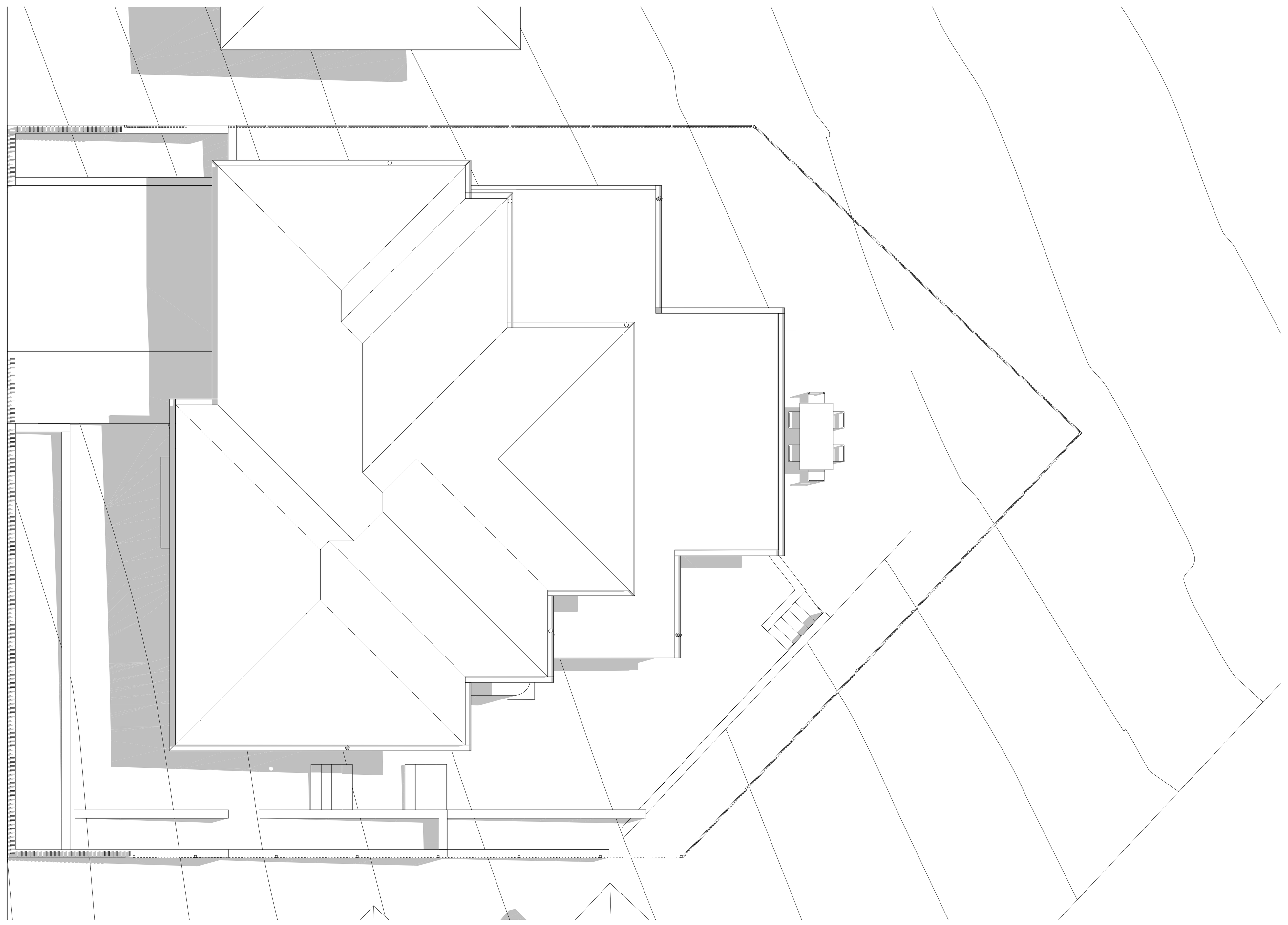
disc	stage	dwg no.	revision
B	DA	300	B



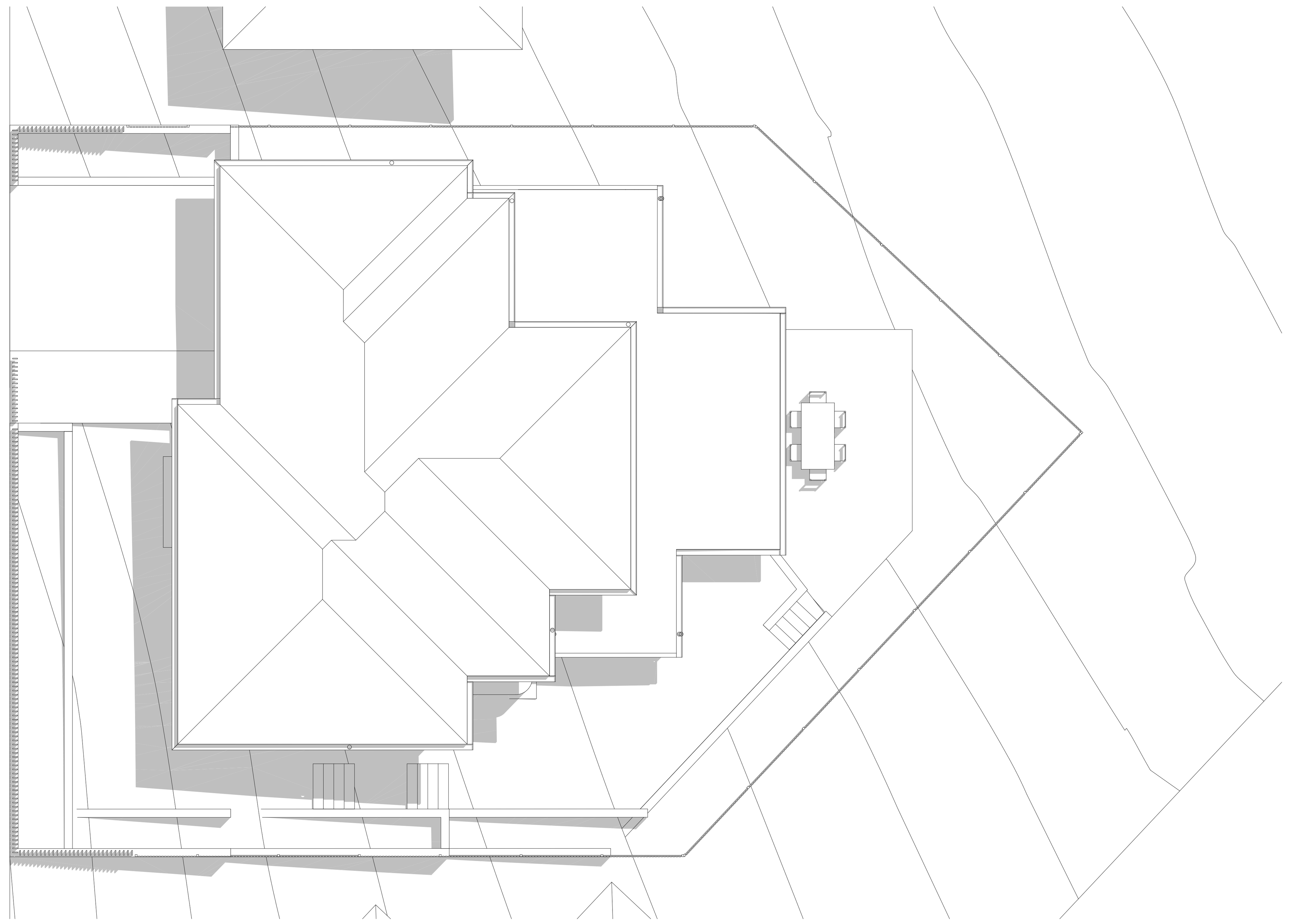
1 **SHADOW DIAGRAM JUNE 21 9AM**
1:100



2 **SHADOW DIAGRAM JUNE 21 10AM**
1:100



3 **SHADOW DIAGRAM JUNE 21 11AM**
1:100



4 **SHADOW DIAGRAM JUNE 21 12PM**
1:100

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A	DEVELOPMENT APPLICATION	DL	KC/PI	08.11.21
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CLIENT
SKYCORP AUSTRALIA

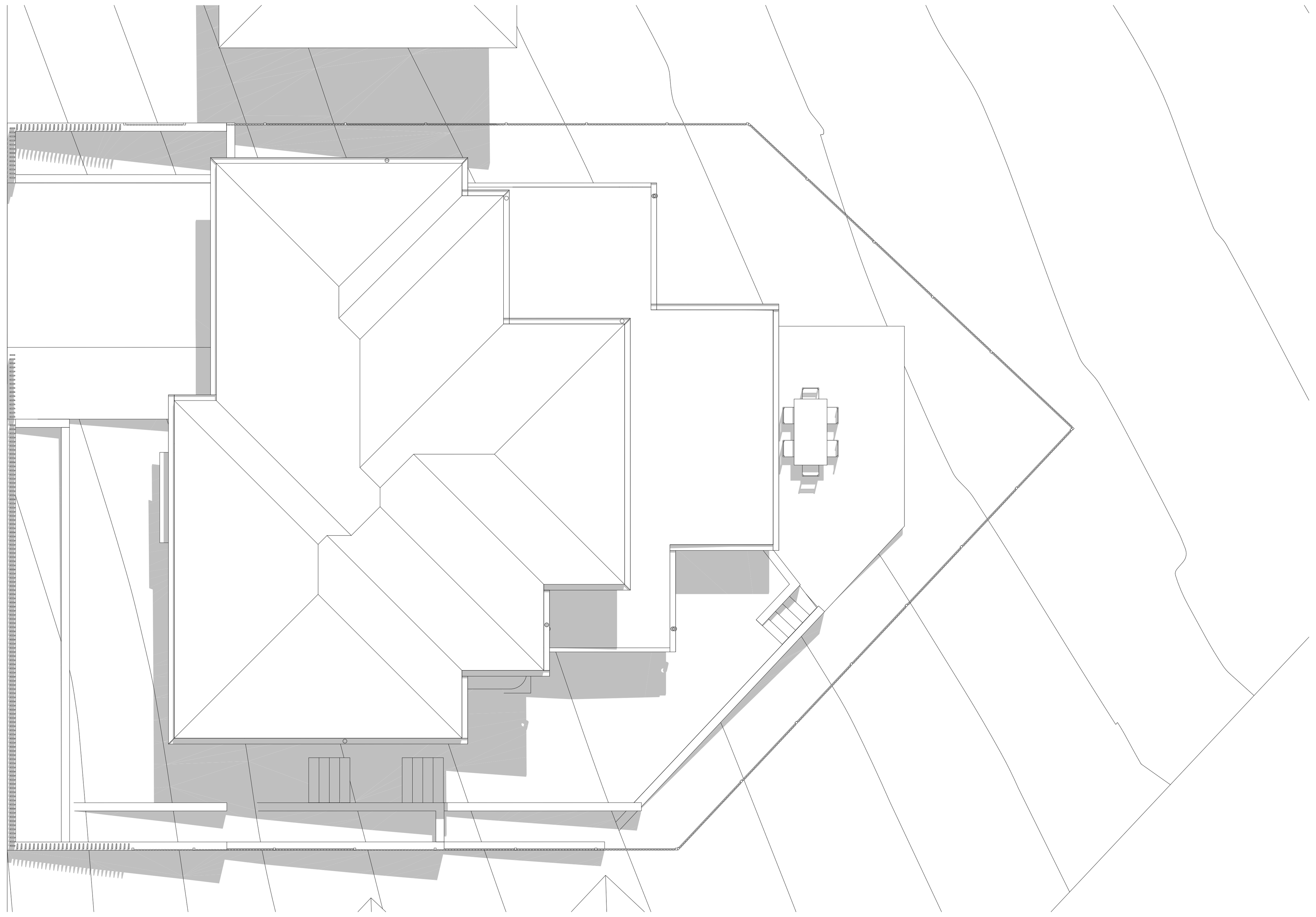
PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

DRAWING
SHADOW DIAGRAM

NORTH

DRAWN	CHECKED
DL, KC	PI / KC
PROJECT No P563	SCALE 1:100@A1

disc	stage	dwg no.	revision
B	DA	500	B



5 **SHADOW DIAGRAM JUNE 21 1PM**
1:100

6 **SHADOW DIAGRAM JUNE 21 2PM**
1:100

7 **SHADOW DIAGRAM JUNE 21 3PM**
1:100

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B	SURVEY ISSUE	DL	GF/PI	11.11.21

CLIENT
SKYCORP AUSTRALIA

PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

DRAWING
SHADOW DIAGRAM

NORTH

DRAWN	CHECKED
DL, KC	PI / KC
PROJECT No P563	SCALE 1:100@A1

disc	stage	dwg no.	revision
B	DA	510	B

PROJECT INFORMATION - DEVELOPMENT APPLICATION	m/m²	COMPLIANCE
SITE AREA (LOT 04) 378.1m²		
PERMISSABLE GFA	N/A	Y
PROPOSED GFA	165.78m²	
LOT WIDTH AT FRONT BUILDING LINE	17.6m	Y
LANDSCAPE		
REQUIRED LANDSCAPING AREA (45% OF SITE AREA)	170.1m²	Y
PROPOSED LANDSCAPING TOTAL AREA	188.83m²	
PROPOSED COMPLIANT LANDSCAPE AREA	157.28m²	
PROPOSED NON COMPLIANT LANDSCAPE AREA	31.55m²	
PRIVATE OPEN SPACE		
REQUIRED PRIVATE OPEN SPACE	24m²	Y
PROPOSED PRIVATE OPEN SPACE	24.02m²	

PROPOSED SITE AREA

PROPOSED GROSS FLOOR AREA

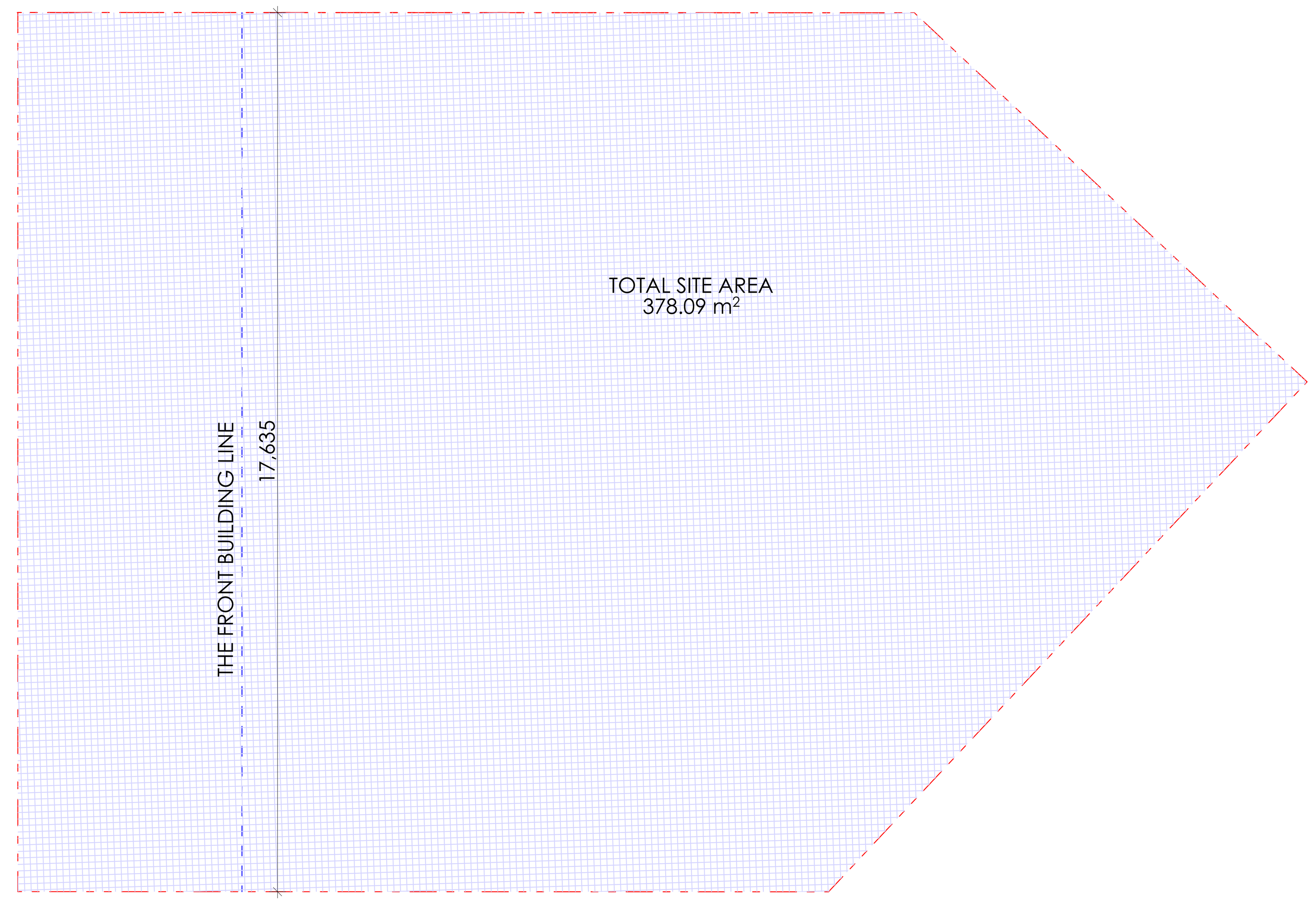
PROPOSED ARTICULATON ZONE

PROPOSED PRIVATE OPEN SPACE

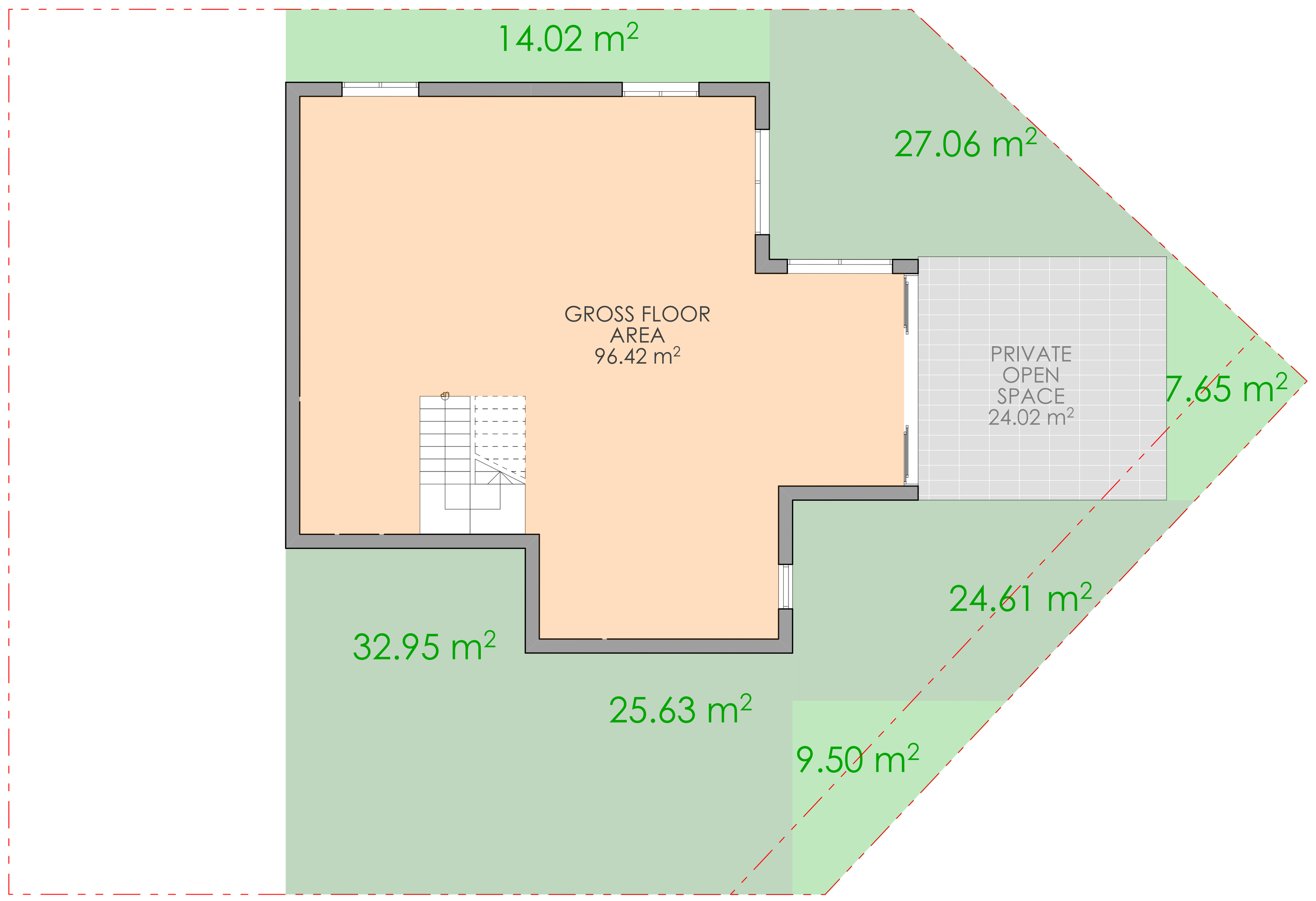
PROPOSED COMPLIANT LANDSCAPE AREA

PROPOSED NON COMPLIANT LANDSCAPE AREA

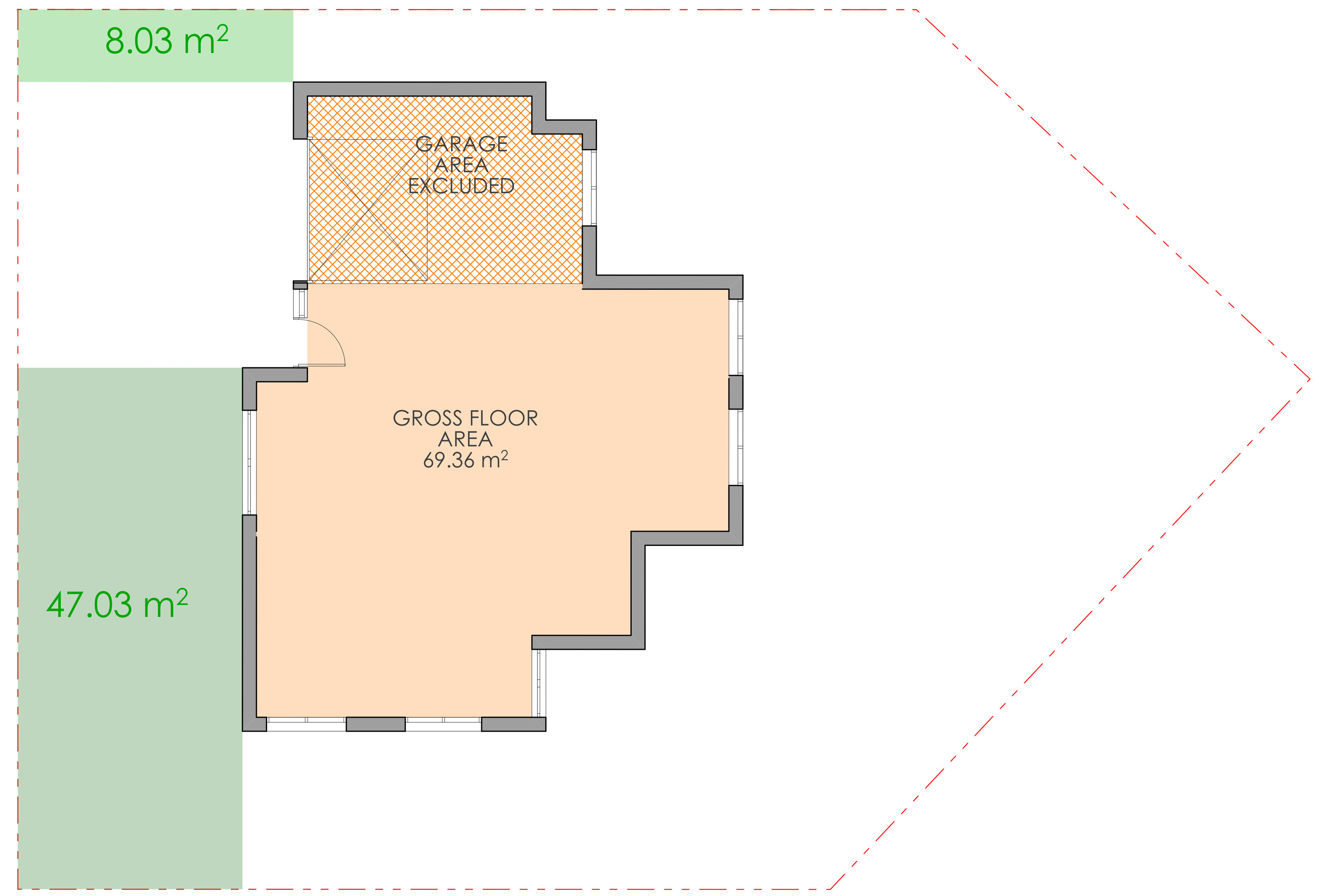
PROPOSED AREA EXCLUDED



0 **SITE AREA PLAN**
1:100



1 **LOW GROUND FLOOR AREA PLAN**
1:100



2 **GROUND FLOOR AREA PLAN**
1:100

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CLIENT
SKYCORP AUSTRALIA

PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

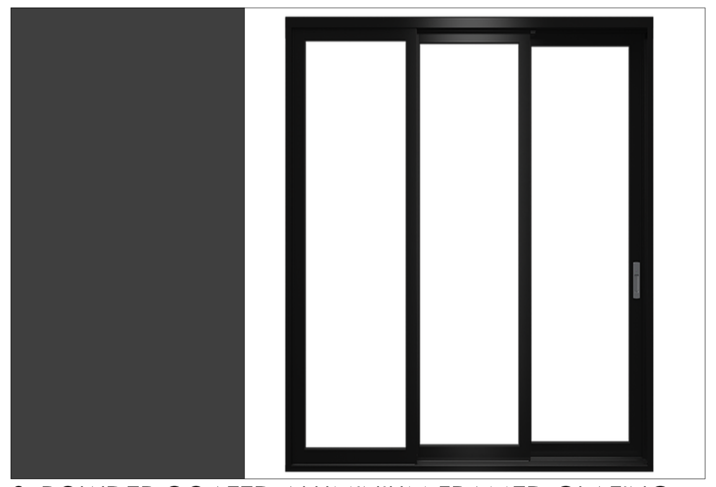
DRAWING
AREA CALCULATION

NORTH

DRAWN	CHECKED
DL, KC	PI / KC
PROJECT No P563	SCALE 1:100@A1

disc	stage	dwg no.	revision
B	DA	600	B

1. AUSTRAL BRICKS BRAHMAN GRANITE



2. POWDER COATED ALUMINIUM FRAMED GLAZING

3. COLORBOND MONUMENT METAL ROOF

4. AUSTRAL BRICKS MAJESTIC GREY

5. RENDER &PAINT - DULUX WAYWARD GREY

pti ARCHITECTURE Tourism + Residential

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REV	DESCRIPTION	BY	CHK	DATE
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CLIENT
SKYCORP AUSTRALIA

PROJECT
LOT03,10 FERN CREEK ROAD, WARRIEWOOD

DRAWING
EXTERNAL FINISH SCHEDULE

NORTH

DRAWN
DL, KC

CHECKED
PI / KC

PROJECT No
P563

SCALE
1:100, 1:500@A1

disc	stage	dwg no.	revision
B	DA	700	B

Appendix B

Soil & Rock Descriptions Sheets,

Borehole Logs (BH101 & BH102)

Soil & Rock Descriptions

The methods of descriptions and classifications used by Nepean Geotechnics in this report are in general accordance with Australian Standard AS1726 -1993 as detailed in the following tables:

Soil Classification

Grading

Term		Particle Size(mm)
Coarse Grained Soils (more than 50% of material is larger than 0.075mm)	Boulders	>200
	Cobbles	63 – 200
	Gravels	2.36 – 63
	Sand	0.075 – 2.36
Fine Grained Soils (more than 50% of material is smaller than 0.075mm)	Silt	0.002 – 0.075
	Clay	<0.002

Consistency (Cohesive Soils)

Term	Undrained Shear Strength (kPa)	Field Guide to Consistency
Very soft	≤ 12	Exudes between the fingers when squeezed in hand
Soft	>12 ≤25	Can be moulded by light finger pressure
Firm	>25 ≤50	Can be moulded by strong finger pressure
Stiff	>50 ≤100	Can not be moulded by fingers/can be indented by thumb
Very stiff	>100 ≤200	Can be indented by thumb nail
Hard	>200	Can be indented with difficulty by thumb nail

Consistency (Non-Cohesive Soils)

Term	Density Index (%)
Very loose	≤ 15
Loose	>15 ≤35
Medium dense	>35 ≤65
Dense	>65 ≤85
Very dense	>85

Rock Classification

Strength of Rock Material

Term	Letter Symbol	Point Load Index, Is_{50} (MPa)	Filed Guide to Strength
Extremely low	EL	≤0.03	Easily remoulded by hand to a material with soil properties
Very low	VL	>0.03 ≤0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; pieces up to 3 cm thick can be broken by finger pressure
Low	L	>0.1 ≤0.3	Easily scored with a knife; indentations 1 – 3 mm show in the specimen with firm blows of the pick point; a piece of core 150 mm long may be broken by hand
Medium	M	>0. 3 ≤1.0	Readily scored with a knife; a piece of core 150 mm long can be broken by hand with difficulty
High	H	>1 ≤3	A piece of core 150 mm long cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer
Very high	VH	>3 ≤10	Hand specimen breaks with pick after more than one blow; rock rings under hammer

Rock Material Weathering Classification

Term	Letter Symbol	Filed Guide to Strength
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	XW	Rock is weathered to such an extent that has 'soil' properties (i.e. either disintegrated or can be remoulded in water)
Highly weathered	HW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually be ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering in pores
Slightly weathered	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

Nepean Geotechnics Pty Ltd
ABN 45 626 934 389
15 Henry Place, Narellan Vale NSW 2567
Email: info@nepeangeotechnics.com.au
Phone: 0447 280 042

Borehole Log

Client:	Skycorp Australia Pty Ltd	**Surface Level:**	N/A	**Job No. :**	R22009
Project:	Proposed Residential Subdivision	**South:**	Refer to site	**Borehole:**	BH101
Location:	Lot 03, 10 Fern Creek Road	**Easting:**	plan	**Date:**	27-January-2022
	Warriewood NSW	**Logged/Checked by:**	RM	**Sheet:**	1 of 1

Method	Groundwater	Sample	DCP	SPT	RL	Depth (m)	Classification Symbol	Material Description	Moisture Content	Consistency	Pocket Penetrometer (kPa)	Origin
Solid Flight Auger			2 3				SM	SILTY SAND dark grey, moist, loose, with rootlets	M	L		Topsoil
			5 5 5			0.5	SC	CLAYEY SAND grey/brown, dry to moist, loose to medium dense, with trace gravel	D	L/MD		Colluvium
			2 3 5 6				CI	SILTY SANDY CLAY grey/brown/red brown, moist, firm to stiff	M	St		Natural
			6 6 6			1.0	CI	SILTY CLAY light brown, moist, stiff to very stiff	M	St		Natural
			12 12 12			1.5	CI	GRAVELLY CLAY pale grey, dry, stiff to very stiff .. trace extremely weathered rock	D	St		Residual
						2.0 2.5	XW	SHALE/SANDSTONE pale grey/brown, extremely to highly weathered	D			Rock
						3.0 3.5 4.0		Borehole Termination				

Rig: Ute Mounted Christie Rig

Water Observations: N/A

Nepean Geotechnics

Nepean Geotechnics Pty Ltd
ABN 45 626 934 389
15 Henry Place, Narellan Vale NSW 2567
Email: info@nepeangeotechnics.com.au
Phone: 0447 280 042

Borehole Log

Client:	Skycorp Australia Pty Ltd	**Surface Level:**	N/A	**Job No. :**	R22009
Project:	Proposed Residential Subdivision	**South:**	Refer to site	**Borehole:**	BH102
Location:	Lot 3, 10 Fern Creek Road	**Easting:**	plan	**Date:**	27-January-2022
	Warriewood NSW	**Logged/Checked by:**	RM	**Sheet:**	1 of 1

Method	Groundwater	Sample	DCP	SPT	RL	Depth (m)	Classification Symbol	Material Description	Moisture Content	Consistency	Pocket Penetrometer (kPa)	Origin
Solid Flight Auger			1 2 22+				SM	SILTY SAND grey, moist, loose, with rootlets	M	L		Topsoil
							SC	SAND/SILTY SAND dark grey, dry , loose , with gravels	D	L/MD		Colluvium
						0.5	SC	CLAYEY SAND brown/red brown, dry, medium dense, medium coarse grained	M	MD		Natural
							CI	SILTY SANDY CLAY brown/light brown, moist, stiff	M	St		Natural
						1.0 1.5	CI	SILTY CLAY pale grey, dry to moist, stiff, with trace gravel	D	St		Residual
						2.0 2.5	XW	SHALE/SANDSTONE pale grey/brown, extremely to highly weathered, with trace highly weathered rock (dark brown)	D			Rock
						3.0 3.5 4.0		Borehole Termination				

Rig: Ute Mounted Christie Rig

Water Observations: N/A

Appendix C

Foundation Maintenance and Footing Performance

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.

Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter

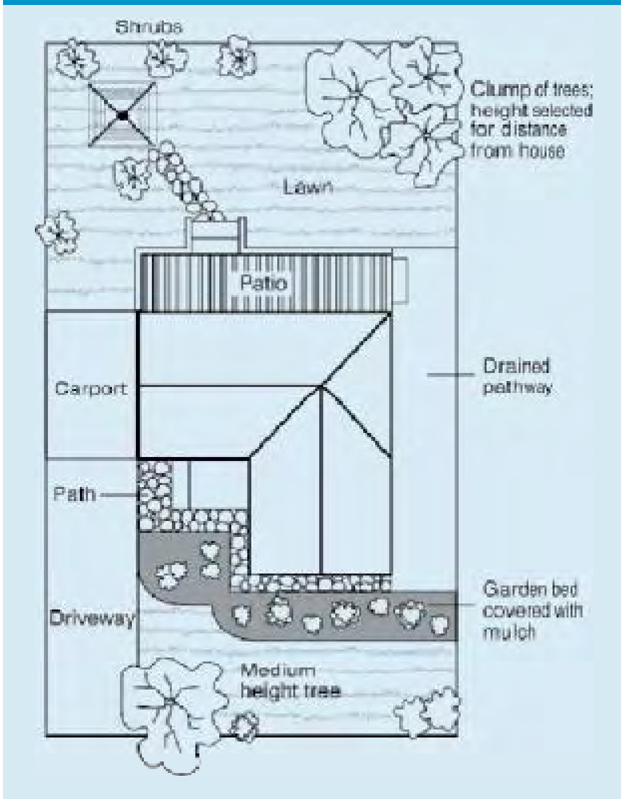
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation
In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden
The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees
Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs
State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation
Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.

The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.

Further professional advice needs to be obtained before taking any action based on the information provided.

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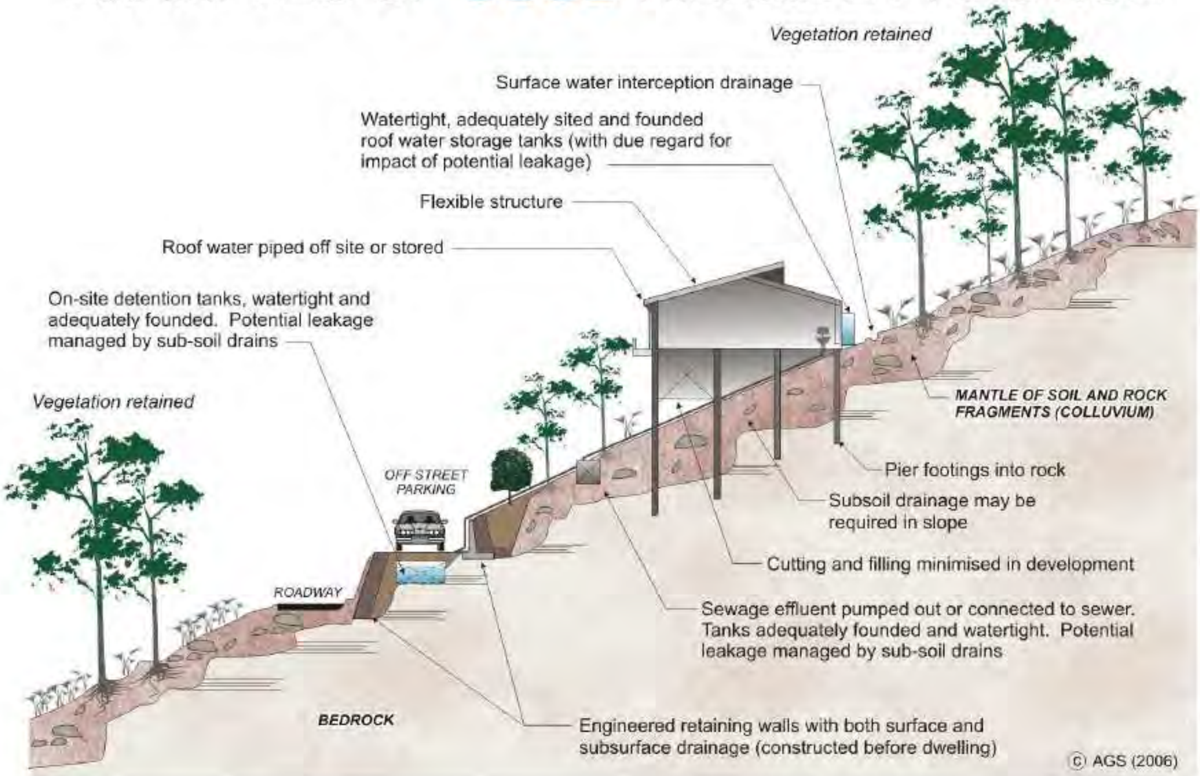
Appendix D

Guidelines on Hillside Developments

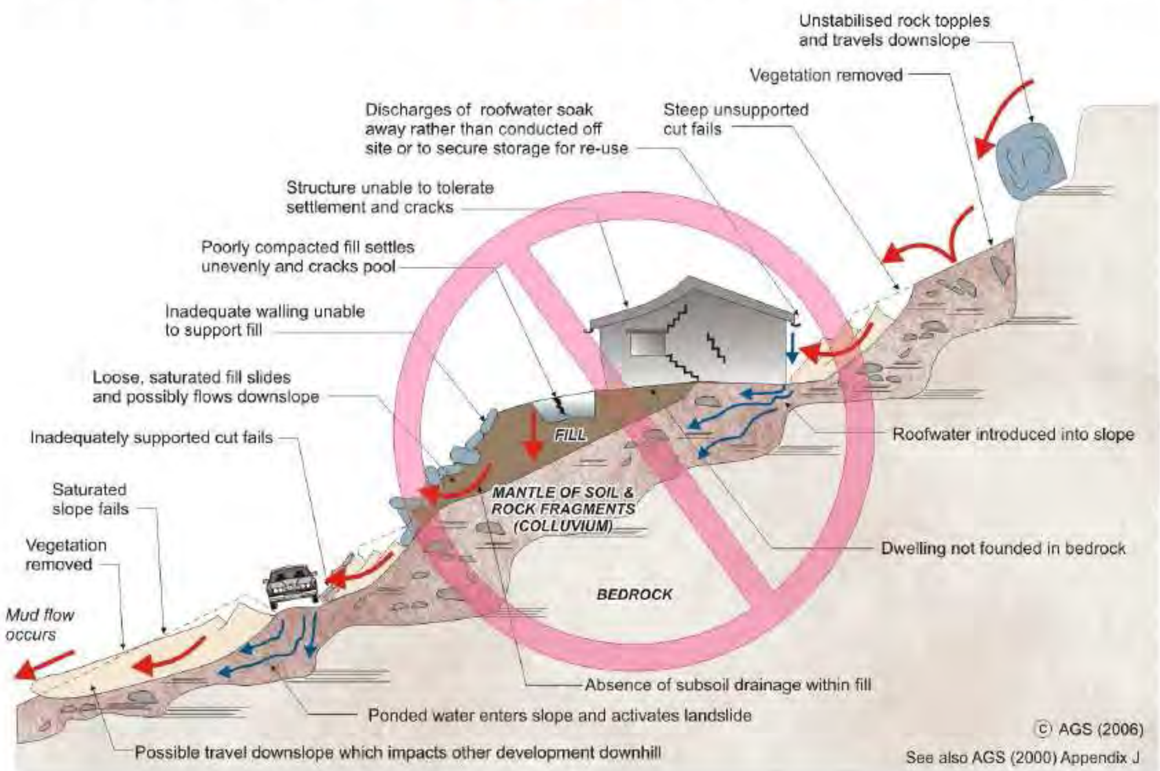
APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	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.
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.
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.	

EXAMPLES OF GOOD HILLSIDE PRACTICE



EXAMPLES OF POOR HILLSIDE PRACTICE



Appendix E

Geotechnical Hazard Overlay Map

Pittwater Local Environmental Plan 2014

Geotechnical Hazard Map - Sheet GTH_012

Geotechnical Hazard

- W — Geotechnical Hazard H1
- AE — Geotechnical Hazard H2

Cadastre

- Cadastre 7/7/2012
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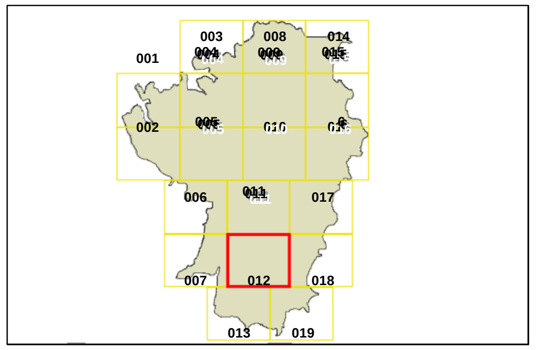

Projection: GDA 1994
MGA Zone 56

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Scale: 1:10,000 @ A3

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