Geotechnical Site Investigation Report

for

Proposed Single Dwelling

Project Address: 237 Mccarrs Creek Road, Church Point NSW 2105

Prepared for: Mr. Nima Asgari

Project No: KFMGR-00255

Date: 25/10/2024

DOCUMENT CONTROL

Report: KFMGR-00255

Distribution Register

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2	Secure PDF	Dr. Mohammad Hossein Bazyar	PO Box 213, Baulkham Hills NSW 2153

Revision History

Rev	Date of Issue	Revision Details	Author	Authorized by:
0	25/10/2024	Initial issue	Dr. Mohammad Hossein Bazyar Principal Geotechnical Engineer BEng MEng CPEng NER Design Practitioner	Dr. Mohammad Hossein Bazyar Managing Director

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for Mr. Nima Asgari
Name of Applicant
Address of site 237 Mccarrs Creek Rd, Church Point – NSW – 2105

Declaration made by geotechnical engineer or engineering geologist or coastal engineer (where applicable) as part of a geotechnical report

I, Mohammad H. Bazyar *on behalf of* KFM Geotech Pty Ltd
(Insert Name) (Trading or Company Name)

on this the ______________________ certify that I am a geotechnical engineer or engineering geologist or coastal engineer as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least $10million.

I:
Please mark appropriate box

- ✓ have prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009
- ✓ am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009
- ✓ have examined the site and the proposed development in detail and have carried out a risk assessment in accordance with Section 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm that the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy for Pittwater - 2009 and further detailed geotechnical reporting is not required for the subject site.
- have examined the site and the proposed development/alteration in detail and I am of the opinion that the Development Application only involves Minor Development/Alteration that does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
- have examined the site and the proposed development/alteration is separate from and is not affected by a Geotechnical Hazard and does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
- have provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

Geotechnical Report Details:

Report Title: Geotechnical Site Investigation

Report Date: 25/10/24

Author: Mohammad Hassein Bazyar

Author's Company/Organisation: KFM Geotech

Documentation which relate to or are relied upon in report preparation:

I am aware that the above Geotechnical Report, prepared for the abovementioned site is to be submitted in support of a Development Application for this site and will be relied on by Pittwater Council as the basis for ensuring that the Geotechnical Risk Management aspects of the proposed development have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature ...Mo[signature]...

Name ...Mohammad Hassein Bazyar...

Chartered Professional Status...Chartered...

Membership No. ...3172234...

Company...KFM Geotech Pty Ltd...

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1(a) - Checklist of Requirements For Geotechnical Risk Management Report for Development Application

Development Application for Mr. Nima Asgari
Name of Applicant
Address of site ~~237 Mccarrs Creek Rd, Church Point NSW 2105~~

The following checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Geotechnical Report. This checklist is to accompany the Geotechnical Report and its certification (Form No. 1).

Geotechnical Report Details:

Report Title: Geotechnical Site Investigation
Report Date: 25/10/2024
Author: Mohammad Hossein Bazyar
Author's Company/Organisation: KFM Geotech pty Ltd

Please mark appropriate box

- ∋ Comprehensive site mapping conducted 21/10/2024 (date)
- ∋ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- ∋ Subsurface investigation required
  - ∋ No Justification ....
  - ∋ Yes Date conducted 21/10/2024
- ∋ Geotechnical model developed and reported as an inferred subsurface type-section
- ∋ Geotechnical hazards identified
  - ∋ Above the site
  - ∋ On the site
  - ✓ ∋ Below the site
  - ✓ ∋ Beside the site
- ∋ Geotechnical hazards described and reported
- ∋ Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
  - ∋ Consequence analysis
  - ∋ Frequency analysis
- ∋ Risk calculation
- ∋ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ∋ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ∋ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
- ∋ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
- ∋ Design Life Adopted:
  - ✓ ∋ 100 years
  - ∋ Other .... specify
- ∋ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
- ∋ Additional action to remove risk where reasonable and practical have been identified and included in the report.
- ∋ Risk assessment within Bushfire Asset Protection Zone.

I am aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for ensuring that the geotechnical risk management aspects of the proposal have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated, and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature Moh
Name Mohammad Hossein Bazyar
Chartered Professional Status Chartered
Membership No. 3179034
Company KFM Geotech pty Ltd

Contents

1. INTRODUCTION

KFM Geotech Pty Ltd (KFM) was engaged by Mr. Nima Asgari to conduct a geotechnical site investigation for the proposed single dwelling development at 237 Mccarrs Creek Road, Church Point NSW 2105. The site investigation aimed to provide a geotechnical assessment of the site and advise on geotechnical parameters including subsurface soil profile, site classification, recommendations on suitable footing types, founding depth, and bearing capacity of shallow footings. This investigation will also include a landslip/slope stability risk assessment of the site for the site's existing condition and during/after the development.

It is understood that a residential development is to be constructed at the site. A maximum of 5.8m excavation is required for the garage. The scope of work followed in this investigation complied with the scope of work provided to the client and was approved on 18 October 2024.

The geotechnical investigation involves a desktop study on the published data of the site, a site inspection to assess the site surface conditions, drilling three (3) augured boreholes, and performing a slope risk assessment of the site. This report provides comprehensive details of the fieldwork and laboratory tests, along with insights and recommendations for design and construction practices.

2. SITE DESCRIPTION

The site is located at 237 Mccarrs Creek Road, Church Point NSW 2105. An aerial photograph of the site is shown in Figure 1. The site condition is described below based on the results of our desktop study and the site inspection observations:

- The site is approximately rectangular in shape and covers an approximate area of $514.5m^2$.

- The site is currently vacant and is bordered by vacant properties to the north and east, residential properties to the south, and Mccarrs Creek Road to the west.

- The site slopes upward from the west to the east from RL13.87 to RL27.51. The middle section of the site in which the proposed building is planned has an average slope of 43%. The surface of the steep section is covered by plants, grass and trees.

- No sign of slope instability was observed across the site.

The building in the adjacent southern properties (No. 241 and No. 243) are approximately 3m and 15m away from the proposed building on the site. At No. 241, excavation work has been completed, and the garage floor has been constructed, with the remainder of the building still under construction. Meanwhile, No. 243 contains a two-story building that spans approximately 10 meters in width. Notably the slope of the adjacent sites No. 241 and 243 is roughly the same as the site.

Figure 1. Aerial Photograph of the site

3. PROPOSED DEVELOPMENT

Based on the information derived from the proposed architectural drawings provided by the client (Designed by GREEN MEASURES-No. A001), it is understood that the development includes the construction of a two-story dwelling. The finished levels for the garage floor, ground floor, and first floor of the building are proposed at RL16.725, RL19.645, and RL22.865, respectively. According to the proposed architectural plans, significant excavation will be required for the construction of the building's floor slabs. The maximum excavation depths are 6.2 meters for the garage, 5.6 meters for the ground floor, and 3.4 meters for the first floor.

4. EXISTING AND PUBLISHED DATA

4.1 Site Geology and Soil Landscape

The regional geology map of the area obtained from MinView.geosciecne.nsw.gov.au demonstrates that the site is underlain by the Newport Formation (Tngn) unit. The geology of the unit comprises Interbedded laminite, shale and sandstone; white quartz to quartz-lithic, very fine- to medium-grained sandstone; minor shale breccia and pebble polymictic conglomerate (at base of sandstone units); minor red clays. The information obtained from the site inspection, and fieldwork observations confirm the geology of the site includes mainly Sandstone. The geology map of the site is shown in Figure 2.

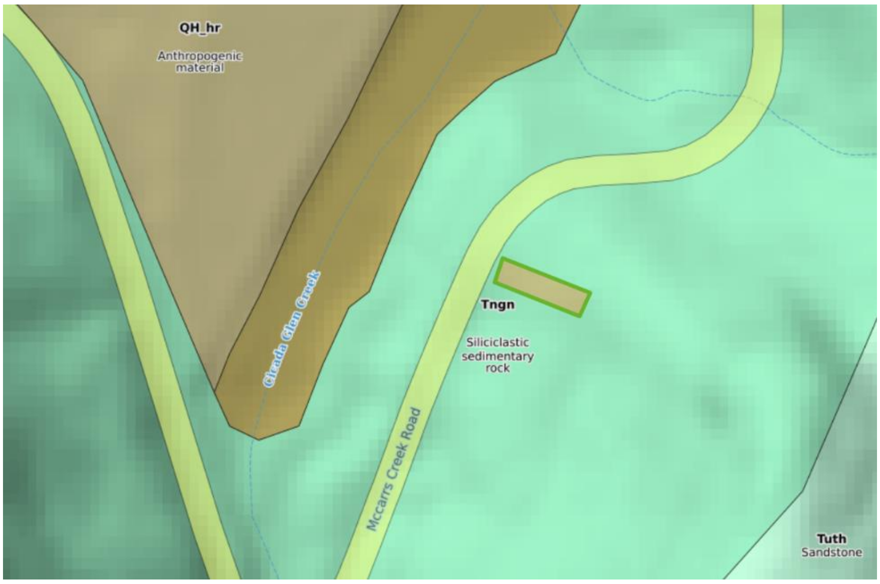


Figure 2. Geology map of Subject site and surroundings

5. SITE SLOPE RISK ASSESSMENT

The Australian Geomechanics Society guideline for Landslide Risk Management (2007) states that the landslide risk of a site is assessed based on the likelihood of a failure mode and the consequence of that failure mode. A qualitative measure is presented for the risk to property and a quantitate approach is proposed for loss of life. The slope stability of a site depends on subsurface materials, their strength, slope angle, and surface/sub-surface drainage. AGS (2007) guidelines consider a risk of 10^{-5} per annum for persons most at risk on new development and a risk of 10^{-4} is considered tolerable for existing slopes/developments if risk treatment options will be employed to maintain or reduce the level of risk. Acceptable risks are usually considered to be one order of magnitude smaller than tolerable risks (10^{-6} per annum for new development and 10^{-5} for existing slopes/developments).

The site is located on a slope having an average slope of 43%. The site's subsurface materials comprise fill with the maximum thickness of 0.4m overlying clay with the depths varying between 0.3 to 3m followed by Sandstone bedrock. No sign of slope instability was observed on-site during the site inspection. The survey plan and ground features in the site observed during our inspection, the fill soil layer of up to 0.4m deep overlying natural clay overlying sandstone bedrock, and lack of sign of slope instability were used in our slope risk assessment for the proposed development on the site.

Applying the Geomechanics Society Guideline for slope risk assessment to the site surface and subsurface conditions at its existing condition, the risk to property and adjacent properties is assessed to be very low. Shallow soil failure with the rare likelihood (one in ten thousand per annum or less) can be the potential mode of failure for the site's existing condition. A minor consequence to the western properties is considered.

The proposed development including the construction of a two-story dwelling with a maximum excavation of 6.1m for the building's ground floor slab and swimming pool is unlikely to increase the risk of soil instability at the site. The risk analysis summary is presented in Table 1.

Table 1. Geotechnical Hazards and Risk Analysis Summary

Failure Modes/Possible Hazard	Assessed Likelihood	Expected Consequences to Property (adjacent)	Assessed Risk to Property	Assessed Risk to Life	Comments
1- Shallow soil slope failure before construction	Rare (10^{-5})	minor	Very Low	1.6×10^{-8}/annum*	This level of risk to life and property is ACCEPTABLE.
2- Shallow soil slope failure during construction of the proposed development	Possible (10^{-3})	minor	moderate	1.6×10^{-6}/annum*	This level of risk to life and property is tolerable but Unacceptable. The recommendations in this report to be followed to make the risk acceptable.

2-Sandstone Wedge failure during construction of the proposed development	Possible (10^{-3})	Minor to medium	Moderate	4×10^{-6}/annum***	This level of risk to life and property is tolerable but Unacceptable. The recommendations in this report to be followed to make the risk acceptable.

* Assuming annual probability 10^{-5}, temporal probability 0.04, spatial probability 0.2, and vulnerability to life of 0.2

** Assuming annual probability 10^{-3}, temporal probability 0.04, spatial probability 0.2, and vulnerability to life of 0.2

*** Assuming annual probability 10^{-3}, temporal probability 0.04, spatial probability 0.2, and vulnerability to life of 0.5

Implementing specific engineering treatments such as founding all the footings into sandstone bedrock and execution of all the excavations based on the advice provided in this report and construction of engineer-designed retaining walls will reduce the risk presented in Table 1. Taking into consideration all the specific engineering controls and following the recommendation provided in this report in the next section, the proposed development is considered to have “an acceptable risk level” for loss of property. The loss of life risk level for the person most at risk is considered to be in the order of 4 in a ten thousand per annum or less. The proposed development where undertaken in accordance with the specific engineering controls is considered to have “an acceptable risk level” for loss of life. Considering the proposed setbacks from the boundary, excavation depth, and foundation works on sandstone bedrock and the distance of the adjacent properties' footings to the proposed excavations, the impact of the proposed development on the properties on the south and west sides of the site is considered minimal. It is also assumed that the required fencing will be set up on-site during the excavation and foundation works to prevent any slump or minor failures towards the southern and eastern sides.

The required engineering controls are listed below:

- All the footings are to be founded in sandstone bedrock.
- Founding levels for footing excavation to be confirmed by a geotechnical engineer

- All excavations are to be fully supported by engineered designed retaining structures or cut battered based on the advice provided in the following sections.
- All fills to be fully supported by the engineered designed retaining walls. All fillings to be undertaken in accordance with AS3798-2007 Guidelines on earthworks for commercial and residential developments
- All sewerage pipes to be connected to the reticulated system
- All Stormwater pipes to be connected to the reticulated system
- Adequate drainage to be provided for all the retaining structures

Having taken into consideration the above and following the guidelines for hillside construction attached to this report (See attached to this report), an acceptable risk is achievable for both property and life for the site existing condition and during/after the development construction and the site is assessed suitable for the construction of the proposed development.

6. FIELD INVESTIGATION

6.1 Fieldwork Methods

KFM Geotech (KFM), Geotechnical Engineer inspected the site on 21 October 2024 and drilled three (3) boreholes using a hand auger to a maximum depth of 1 m (bgl). Further drilling could not be advanced due to hand auger refusal. The boreholes' location is shown in Figure 4.

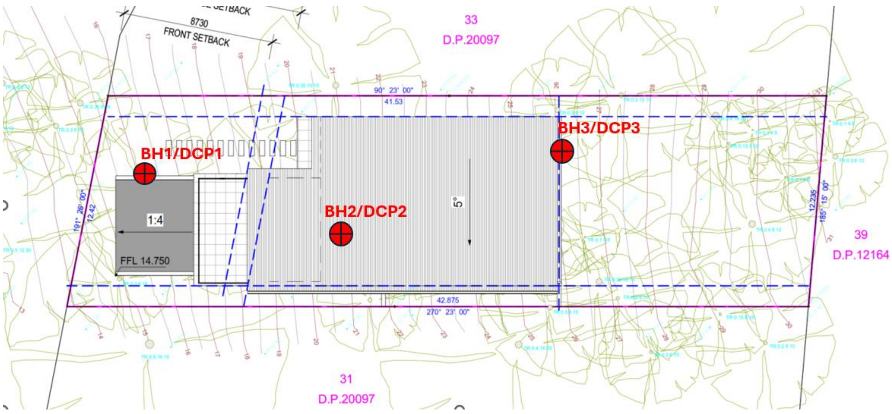


Figure 3. Boreholes Location

To estimate the soil strength and depth of bedrock, three (3) Dynamic Cone Penetrometer (DCP) tests were undertaken adjacent to the boreholes. The boreholes were logged by the KFM geotechnical engineer, and the full description of the subsurface profile encountered in the boreholes is described in the logs attached to this report. The soil profile was logged based on Australian Standard AS1726-2017 “Geotechnical Site Investigation”.

6.2 Site Subsurface Condition

The result of the site inspection and fieldwork observations indicate that the site subsurface profile comprises fill materials with depths up to 0.4m overlying natural clay with depths between 0.4m to 3.0m overlying sandstone bedrock. The clay with sand layer has a consistency between stiff to hard. The sandstone to the termination depth has the strength of extremely low or better. The subsurface materials are generally described as below:

Topsoil/Fill: Silty clay, dark brown, trace rootlets, moist, poorly compacted, up to 0.4m thick

Natural Soil: Clay, red, brown, medium to high plasticity, firm to hard, to a maximum depth of 3.0m

Bedrock: sandstone, very low strength* or better

Note: higher strength sandstone may be encountered at higher depths.

A summary of the subsurface profile encountered in the borehole/DCPs is presented in Table 1 with the detailed logs attached to this report.

Table 2. Summary of Site Subsurface Profile and estimated bedrock depth

Unit #	Material	Top of Unit (m, below ground level (bgl))		
		BH1 (RL~16)	**BH2 (RL~20.75)**	**BH3 (RL~26)**
1	**Fill**	0.0 (RL16)	0.0 (RL20.75)	0.0 (RL26)
2A	**Clay,** firm to stiff	0.3 (RL15.7)	0.4 (RL20.35)	0.4 (RL25.6)

2B	**Clay,** very stiff to hard	1.6 (RL14.4)	-	2.5 (RL23.5)
3	**Possible sandstone bedrock**	3.0 (RL13)	2.0 (RL18.75)	2.9 (RL23.1)

6.3 Groundwater

Groundwater was not encountered in the boreholes/DCPs during the site investigation. Perched water may be encountered below the soil layer on the sandstone bedrock and in the sandstone defects/joints. It should be noted that the fluctuations in the level of groundwater might occur due to variations in rainfall, temperature, and/or other factors. KFM believes that during the construction of the proposed developmental groundwater flow is unlikely to be encountered and should not be an issue for the construction.

7. DISCUSSION AND RECOMMENDATIONS

7.1 Site/Soil Classification

The depth of fill materials on-site at the drilled boreholes varies between 0.3 to 0.4m. Considering the depth of fill materials and the characteristics and depth of the natural clay depth, the site soil is classified as class “H1” according to AS 2870-2011, “Residential Slabs and Footings” given that the site is not subjected to abnormal moisture conditions. If the footings are founded on the sandstone bedrock, a class “A” can be adopted. A characteristic ground surface movement 'y' is estimated to be in the order of 40mm to 50mm. It is important to note that the recommendations in this report are based solely on the soil profile observed during the investigation, without considering any abnormal moisture conditions as defined in AS2870 – 2011, Clause 1.3.3, that may arise later. If such abnormal moisture conditions occur, they can lead to distress that results in "non-acceptable probabilities of serviceability and safety of the building during its design life," as stated in AS2870-2011, Clause 1.3.1. Should this potential distress be unacceptable to the builder, owner, or other relevant parties, additional fieldwork and revised footing recommendations will be necessary. Abnormal moisture conditions encompass scenarios such as insufficient site drainage during construction, the impact of trees positioned too near the foundation, excessive or irregular garden watering, neglect of site drainage maintenance, unresolved plumbing leaks, and the removal of vegetation from the vicinity of the building post-construction.

7.2 Earthquake Site Sub-Soil Class

Based on the results of the geotechnical investigation, a site sub-soil class of “Ce” –Soil site as per Section 4 Australian Standard AS 1170.4-2007 and a hazard factor (Z) of 0.08 can be adopted for earthquake design of the structure.

7.3 Foundations

The existing fill material is considered unsuitable as the foundation materials of the proposed residential building. The proposed development plans indicate that the building will be constructed on the cuts for the garage, ground floor and first floor. The foundation materials of the floor slabs is inferred to be sandstone bedrock. Engineer-designed foundations should be designed to support the load of the proposed development. Shallow footings founded on sandstone bedrock or piers founded on sandstone bedrock is proposed as the preferred footing system option to transfer the load of the building. It is recommended to find all the footings on the Sandstone bedrock (Unit 3) to minimize the risk of differential settlement.

If required Australian Standard AS 2870-2011, Residential Slabs and Footings to be considered for the design of the building. Sections 3-5 of AS 2870-2011- Residential Slabs and Footings to be followed for the design of the building foundation systems and all the Clauses of Section 6 to comply with construction requirements especially Clause 6.3 temporary excavations, Clause 6.4 construction of slabs and Clause 6.5 construction of strip and pad footings.

The allowable bearing capacity provided in Tables 3 and 4 can be adopted for the design of the shallow/deep footings.

Table 3. Allowable bearing capacity of Shallow Footings

Unit #	Allowable Bearing Capacity (kPa)
2B	250
3	800*

Table 4. Bearing capacity of Deep Foundations (Piers)

Unit #	Allowable End Bearing Capacity (kPa)	Allowable Shaft Adhesion (kPa)	Ultimate End Bearing Capacity (kPa)	Ultimate Shaft Adhesion (kPa)
2A	-	10	-	30
2B	-	20	-	60
3	800*	60*	2500	150

Note: higher strength sandstone may be encountered at higher depths.

The piers are to have a minimum socket length of 1D (D: pier diameter) into Sandstone bedrock (Unit 3). To mobilize the shaft adhesion, the piers to be embedded 3D into the required materials. Unit 1 to be ignored in the pier shaft bearing capacity calculation. Higher-strength Sandstone may be encountered at higher depths subject to a geotechnical site inspection during the construction. A qualified geotechnical engineer to be engaged during the foundation work to confirm the piers end bearing capacity and shaft adhesion. Given the limitations of the investigation using auger, we recommend that the foundation excavations for any type be inspected by a qualified geotechnical engineer during the foundation works to confirm the subsurface conditions. A preliminary geotechnical reduction factor of 0.61 can be adopted for the footing design using the ultimate (Limit) state approach.

To reduce the risk of potential differential settlement, all footings for the building are recommended to be founded on strata of similar strength and stiffness.

7.4 Excavation

7.4.1 Excavatibilty

Reviewing the proposed development drawings, we anticipate the depth of cut for the floors slab construction varies between 3.4m to 6.2m. The excavation class based on SANS 1200D is assessed as soft for the fill and natural clay materials and can be easily achieved using conventional earthworking plants such as small to moderate-size excavators fitted with a digging bucket and with no vibration occurring during the excavation. A hard excavation will be likely encountered for the sandstone bedrock

(Classes V or better). The foundation work in the sandstone bedrock can create major vibration on the site. Lower energy machines such as small rock breakers or even saw cut to be used on site to prevent the noise pollution and vibration. Rock sawing around the perimeter of the excavation area will provide a clean exposed face in the lower parts of the cut area. This will help minimize the potential for instability of the exposed rock face due to fall out of large pieces of rock. The builder shall confirm that peak particle velocities (PPV) of excavation in rock fall within acceptable limits. PPV at the site perimeter should not exceed 5 mm/sec during bedrock excavation using rock breakers. The limit of 5 mm/sec is expected to be achievable if rock breaker equipment or other excavation methods are restricted as indicated in Table 5:

Table 5. Recommendations for Rock Breaking Equipment

Distance from adjoining structure (m)	Maximum Peak Particle Velocity 5 mm/sec		Maximum Peak Particle Velocity 10 mm/sec*	
	Equipment	**Operating Limit Equipment (% of Maximum Capacity)**	**Equipment**	**Operating Limit Equipment (% of Maximum Capacity)**
1.5-2.5	Hand Operated Jackhammer	100	300kg rock hammer	50
2.5-5	300kg rock hammer	50	300kg rock hammer 600kg rock hammer	100 50

7.4.2 Cut Batter and Unsupported Excavation

The proposed development requires major excavation. The excavation in the eastern and northern walls can be managed using cut batters. The excavation in the southern wall may need retention system if the excavation is located inside the zone of influence of the adjacent building. Temporary unsupported excavation/batter of up to 1m into the existing fill and clay layer can be executed sub-vertical. For cuts deeper than 1m and up to 3m in soil, the temporary excavation to be battered with a slope not steeper than 1.5H:1V. Minor slumping could be anticipated in the fill materials and possible natural soil layer and extremely weathered sandstone during rainy times. Excavation into extremely to highly weathered and very low to low strength sandstone can be executed with a slope of not steeper than 1V:0.75H. Excavation in medium to high strength sandstone can be executed vertically to 3m subject to geotechnical site inspection to ensure there is no major defect in the sandstone bedrock. Cut benches are required for cuts higher than 3m. Excavation in Permanent soil batters (if there are any) to 3m depth to be battered with a slope not steeper than 2H:1V. Permanent vertical excavation in sandstone bedrock requires a geotechnical mapping and assessment to check if any support is required. If the above cut batter advise cannot be executed on site, the batters to be supported using shotcrete, soil nail or rock bolts.

7.4.3 Excavation support

Any proposed cantilever retaining wall at the site should be engineer-designed and the soil lateral earth pressure parameters presented in Table 6 to be adopted.

Table 6: Retaining Wall Design Parameters

Unit #	Unit Weight (kN/m^3)	Active Earth Pressure Coefficient	At Rest Earth Pressure Coefficient	Passive Earth Pressure Coefficient/Ultimate Passive Resistance
1	18	0.42	0.59	2.37
2A	19	0.39	0.56	2.56
2B	20	0.36	0.53	2.77
3-very low strength	22	0.3	0.4	300kPa
3-low strength	23	0.15	0.25	900kPa
3-medium or high strength	24	0	0	2000kPa

A trapezoidal distribution behind the retaining wall can be utilized for the design of any supported retaining structures. A maximum lateral earth pressure of 8H kPa can be obtained at a depth of 0.25H (H is the total excavation depth). A maximum lateral earth pressure of 6H kPa may be used for basement walls where wall deflections are not critical.

The parameters presented in Table 6 assume fully drained retaining walls. Free-draining granular materials as back-wall drainage are to be considered in the design and construction of the retaining walls. This material is to be wrapped in a non-woven Geotextile fabric (i.e. Bidim A34 or similar), to prevent the drainage from becoming clogged with clay. If no back-wall drainage is installed in retaining walls, the likely hydrostatic pressures are to be accounted for in the structural design of the retaining walls.

7.4.4 Groundwater and Drainage Considerations During Excavation

No groundwater was encountered during the fieldwork to the maximum depth of investigation of 3m. However, perched groundwater may be encountered below the soil layer on the sandstone bedrock and between the bedrock defects. It is unlikely that the excavations for the proposed development will encounter groundwater. If minor seepage is noted, it can be managed using conventional sump and pump methods. Drainage should be provided behind the retaining walls (if any) and below the ground floor slab. Drainage should be discharged into the stormwater system.

7.5 Earthworks

7.5.1 Site Preparation

The sub-surface profile across the site comprises fill materials to a depth up to 0.4m overlying a clay layer to a depth of 3m followed by sandstone bedrock. All topsoil, organic, and deleterious materials should be stripped from the building footprint and if required stockpiled on a corner of the site for possible re-use. All excavation spoil is to be removed from the site to be classified based on the current Environmental Protection Agency (EPA) waste classification guidelines. The topsoil/fill is to be classified based on EPA NSW-Waste Classification guidelines- Part 1- Classifying waste. Natural soil and sandstone can be classified based on EPA NSW-ENM and VENM guidelines. The exposed materials beneath the ground floor slab are anticipated to be sandstone bedrock and no major preparation unless drainage works is required.

7.5.2 Fill and Re-use of Materials

If a fill layer is required during construction, it is essential to compact the fill materials adequately to prevent undue surface settling. A granular sub-base layer should be positioned below the slab and compacted to establish a separation between the exposed foundation materials and the slab.

The required fill density and minimum frequency of control compaction tests as outlined in AS 3798 should be followed. If imported fill materials are required, suitable materials (preferably granular for controlled fill) as described in Section 4 of AS3798-2007 "Guideline on Earthworks for Commercial and Residential Development" should be used. If required, the suitable fill materials imported to the site to be placed in loose layers of 150-200mm and compacted to 98% of the standard maximum dry density in accordance with AS1289. Generally, the crushed sandstone obtained from the excavation work can be reused as engineered fill within the site.

All fill brought onto the site (if required) is to be certified as 'clean fill' with a VENM/ENM certificate or similar documentation in accordance with EPA guidelines. We recommend all structures to be supported on sandstone bedrock through shallow or deep footings.

7.6 Erosion And Sediment Control

Erosion and Sediment control plan should be implemented before commencing any earthworks for the proposed development. Below are some general guidelines to be taken into consideration:

- ✓ Establish a single entry/exit point when construction work starts
- ✓ Minimize the area to be cleared and provide as much vegetation as possible
- ✓ Install sediment fences along the low side of the site before work begins
- ✓ Ensure the imported fill material/topsoil is within the sediment-controlled plan
- ✓ Fill in and compact all trenches immediately after services have been laid
- ✓ Divert water around the work site and stabilize channels
- ✓ A silt trap to be installed around the site perimeter during construction.
- ✓ Provide a temporary earth drain around the proposed site, if possible, to prevent water-logging within the site
- ✓ Stabilize exposed earth banks/embankment

8. GENERAL RECOMMENDATIONS

- ✓ Utilize a stormwater drainage system to collect surface water and drainage from behind the retaining walls.
- ✓ The builder and plumber must adhere to the drainage requirements specified in AS 2870 to prevent water accumulation near the building footings during and after construction. Homeowners must follow C.S.I.R.O guidelines, which require regular maintenance of the drainage system and management of soil moisture conditions.
- ✓ Exercise caution during excavations near existing footings or easements. If the excavation is within the zone of influence of an existing footing or easement, it must not go deeper than 100mm above the base of the existing footing. The zone of influence is determined by projecting a line upward at a 45° angle from the horizontal, starting from the invert of the existing footing or easement.
- ✓ All on-site earthworks must comply with Australian Standard AS3798, which provides guidelines for earthworks in commercial and residential developments.

9. LIMITATIONS AND CONDITIONS OF THE REPORT

This report is the copyright of KFM Geotech Pty Ltd and any unauthorized reproduction and usage by any person or third party other than the client for whom this investigation was commissioned is strictly prohibited. The results of this investigation should not be used for any other purpose other than that for which it is specifically intended.

This Geotechnical Site Investigation report has been prepared based only on the information provided at the time of this investigation and may not be valid if site conditions change. The findings presented in the report reflect the sub-surface conditions specifically at the designated sampling and testing locations, and only to the depths probed during the investigation and at the time of assessment. It's important to note that sub-surface conditions are subject to abrupt changes influenced by geological processes and human activities. These alterations might occur subsequent to KFM Geotech fieldwork.

KFM Geotech recommendations are formulated based on the observed conditions during the investigation. However, the accuracy of these recommendations may be impacted by undetected variations in ground conditions across the site, extending beyond the sampled areas. Additionally, budget constraints imposed by external parties or limitations in site accessibility may further constrain the scope of advice provided. We recommend that the foundation excavation for any type to be inspected by a qualified geotechnical engineer to confirm the subsurface conditions and advice recommended in this report.

If the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and KFM accepts no responsibility whatsoever for the performance of the building where recommendations are not implemented in full and properly tested, inspected, and documented.

During the earthworks, if site conditions significantly differ from those indicated in this report, KFM Geotech to be contacted to provide further advice.

10. REFERENCES

- Australian Standard (AS 2870-2011), Residential Slabs and Footings
- Australian Standard (AS 1726-2017), Geotechnical Site Investigations
- Australian Standard (AS 3600-2009), Concrete structures
- Australian Standard (AS 4678-2002), Earth-retaining structures
- Australian Standard (AS 2159.2009), Piling-Design and installation
- Australian Standard (AS 3798-1996), Guidelines on earthworks for commercial and residential developments
- Pells, P.J.N, Mostyn, G, Bertuzzi R and Wong P.K, Classification of Sandstones and Shales in the Sydney Region: A Forty Year Review, Australian Geomechanics, Volume 54: NO.2 June 2019
- Western Sydney Salinity Code of Practice, March 2003

APPENDIX A

Borehole logs

Boring Log

Project: 237 Mccarrs Creek Road, Church Point NSW 2105	**Project Number**: KFMGR-00255	**Client:** Mr. Nima Asgari	**Boring No. BH1 (RL~16)** **Page 1 of 1**
Logged By: SK	**Drilling Date:** 21/10/2024	**Drilling Type:** Hand Auger	**Driller:** MT

Depth (m)	Sample Type	Sample Number	Graphic Log	USCS	**Lithology** **Soil Group Name:** type, color, grain size, other descriptors	Density/ Consistency	Moisture Content	DCP (blows per 100mm penetration)
0.0					**Fill:** silty clay, dark brown, trace rootlets	PC	M	2 5 3
0.5				CH	**Clay,** red, brown, medium to high plasticity	St	M	4 5 4 5 6 6 5
1.0 1. 2.0 2.5					Hand auger terminated at 1.0 m of depth	Vst H		6 5 6 7 5 5 10 8 8 7 8 10 10 12 13 13 16 15 23 25
3.0 3.5 4.0 4.5 5.0					DCP reached refusal at 3.0m of depth due to possible bedrock			R

Consistency		Density		Moisture		Compaction	
S:	Soft	**VL:**	Very Loose	**D:**	Dry	**PC:**	Poorly Compacted
F:	Firm	**L:**	Loose	**M:**	Moist	**MC:**	Moderatly Compacted
St:	Stiff	**MD:**	Medium Dense	**W:**	Wet	**WC:**	Well Compacted
Vst:	Very Stiff	**D:**	Dense				
H:	Hard	**VD:**	Very Dense	B	Bouncing	R	Refusal

Boring Log

Project: 237 Mccarrs Creek Road, Church Point NSW 2105	**Project Number**: KFMGR-00255	**Client:** Mr. Nima Asgari	**Boring No. BH2 (RL~20.75)** **Page 1 of 1**
Logged By: SK	**Drilling Date:** 21/10/2024	**Drilling Type:** Hand Auger	**Driller:** MT

Depth (m)	Sample Type	Sample Number	Graphic Log	USCS	Lithology **Soil Group Name:** type, color, grain size, other descriptors	Density/ Consistency	Moisture Content	DCP (blows per 100mm penetration)
0.0					**Fill:** silty clay, dark brown, trace rootlets	PC	M	1 1 2 3
0.				CH	**Clay,** red, brown, medium to high plasticity	F	M	3 3 3 3 4 3
1.0 1.5					Hand auger terminated at 1.0 m of depth	St		5 5 5 4 5 7 9 5 7 7
2.0 2.5 3.0 3.5 4.0 4.5 5.0					DCP reached bouncing at 2.0m of depth due to possible bedrock			B

Consistency		**Density**		**Moisture**		**Compaction**	
S:	Soft	**VL:**	Very Loose	**D:**	Dry	**PC:**	Poorly Compacted
F:	Firm	**L:**	Loose	**M:**	Moist	**MC:**	Moderatly Compacted
St:	Stiff	**MD:**	Medium Dense	**W:**	Wet	**WC:**	Well Compacted
Vst:	Very Stiff	**D:**	Dense				
H:	Hard	**VD:**	Very Dense	B	Bouncing	R	Refusal

Boring Log

Project: 237 Mccarrs Creek Road, Church Point NSW 2105	**Project Number**: KFMGR-00255	**Client:** Mr. Nima Asgari	**Boring No. BH3 (RL~26)** **Page 1 of 1**
Logged By: SK	**Drilling Date:** 21/10/2024	**Drilling Type:** Hand Auger	**Driller:** MT

Depth (m)	Sample Type	Sample Number	Graphic Log	USCS	Lithology **Soil Group Name:** type, color, grain size, other descriptors	Density/ Consistency	Moisture Content	DCP (blows per 100mm penetration)
0.0					**Fill:** silty clay, dark brown, trace rootlets	PC	M	1 2 2 3
0.5				CH	**Clay,** red, brown, medium to high plasticity	F St	M	3 5 5 5 7 10
1.0 1.5 2.0 2.5					Hand auger terminated at 1.0 m of depth	Vst H		6 7 9 8 7 7 7 9 7 7 7 6 6 5 6 8 13 18 24
3.0 3.5 4.0 4.5 5.0					DCP reached refusal at 2.9m of depth due to possible bedrock			R

Consistency		**Density**		**Moisture**		**Compaction**	
S:	Soft	**VL:**	Very Loose	**D:**	Dry	**PC:**	Poorly Compacted
F:	Firm	**L:**	Loose	**M:**	Moist	**MC:**	Moderatly Compacted
St:	Stiff	**MD:**	Medium Dense	**W:**	Wet	**WC:**	Well Compacted
Vst:	Very Stiff	**D:**	Dense				
H:	Hard	**VD:**	Very Dense	B	Bouncing	R	Refusal

GENERAL NOTES

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726-2017, the Geotechnical Site Investigations. Explanatory notes are located at the bottom of the drilling log sheets. In the "lithology" column, details about the soil/rock group, origin, geology, colour, density/consistency, grain size and other descriptions are presented. The depth of the excavation base for the logged section is noted in the same column at the appropriate depth. If there is a refusal of the excavation/drilling tool, it is documented. The explanatory notes define the terms and symbols used in the preparation of the logs, are described below. Subsurface conditions between the investigation points may vary significantly from conditions encountered at those locations.

Materials Description-Soil

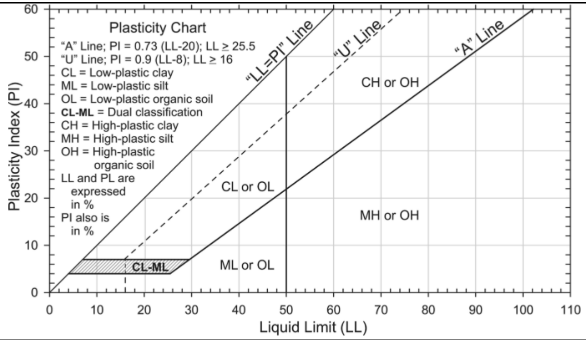
Particle size characteristics of soils

Fraction	Components	Grain	Size (mm)
Oversize	Boulders		>200
	Cobbles		63-200
Coarse-grained soil	Gravel	Coarse	19-63
		Medium	6.7-19
		Fine	2.36-6.7
	Sand	Coarse	0.6-2.36
		Medium	0.21-0.6
		Fine	0.075-0.21
Fine-grained soil	Silt		0.002-0.075
	Clay		<0.002

Soil Group Symbols

Major Divisions		Symbol	Description
Coarse-grained soils	Gravel	GW	Well-graded gravel and gravel- sand mixtures, little or no fines, no dry strength.
		GP	Poorly graded gravel and gravel-sand mixtures, little or no fines, no dry strength.
		GM	Silty gravel, gravel-sand-silt mixtures, zero to medium dry strength.
		GC	Clayey gravel, gravel-sand-clay mixtures, medium to high dry strength.
	Sand	SW	Well Graded Sand, gravelly Sand
		SP	Poorly graded sand and gravelly sand, little or no fines, no dry strength.
		SM	Silty sand, sand-silt mixtures, zero to medium dry strength.
		SC	Clayey sand, sandy-clay mixtures, medium to high dry strength.
Fine-grained soils	Liquid limit < 50%	ML	Inorganic silts of low plasticity, very fine sands, rock flour, silty or clayey fine sands, zero to medium dry strength.
		CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, medium to high dry strength.
		OL	Organic silts and organic silty clays of low plasticity, low to medium dry strength.
	Liquid limit > 50%	MH	Inorganic silts of high plasticity, high to very high dry strength.
		CH	Inorganic clays of high plasticity, high to very high dry strength.
		OH	Organic clays of medium to high plasticity, medium to high dry strength.
Highly organic soil		PT	Peat muck and other highly organic soils.

Plastic properties and moisture condition

<table>
<tr><th>Plastic properties</th><th colspan="3">Moisture condition</th></tr>
<tr><td rowspan="5">
</td><th>Term</th><th>Symbol</th><th>Description</th></tr>
<tr><td>Dry</td><td>D</td><td>Dry, looks and feels dry.</td></tr>
<tr><td>Moist</td><td>M</td><td>Soils feel cool, darkened in colour. There is a tendency for soil to stick together.</td></tr>
<tr><td>Wet</td><td>W</td><td>Soils feel cool, darkened in colour. When handling cohesive soils, free water usually forms on hands; granular soils tend to cohere.</td></tr>
<tr><td colspan="3">It is important to describe the moisture content of cohesive soils according to their liquid limit (LL) or plastic limit (PL) as follows: Moist, dry of plastic limit (w < PL); Moist, near plastic limit (w ≈ PL); Moist, wet of plastic limit (w < PL); Wet, near liquid limit (w ≈ LL), Wet, wet of liquid limit (w > LL).</td></tr>
</table>

Descriptive terms for plasticity of cohesive soils

Descriptive term	Liquid limit range for silt	Liquid limit range for clay
High plasticity	>50	>50
Medium plasticity	Not applicable	>35 & ≤50
Low plasticity	≤50	≤35
Non-Plastic	Not applicable	Not applicable

Consistency of Cohesive Soils- in accordance with AS1726-2017 & Geotechnical Engineering Handbook, R.L

Symbol	Term	Undrained Cohesion (kPa)	Unconfined Strength-Pocket Penetrometer Strength (kPa)	DCP (blows/100mm penetration)	SPT (Blows per 300mm) (N-corrected)	Field Assessment
VS	Very Soft	<12.5	25	0-1	<2	Exudes between fingers when squeezed.
S	Soft	12.5-25	25-50	1-2	2-4	Can be moulded by light finger pressure.
F	Firm	25-50	50-100	2-3	4-8	Can be moulded by strong finger pressure.
St	Stiff	50-100	100-200	3-7	8-15	Cannot be moulded by fingers. Can be indented by thumb pressure.
Vst	Very Stiff	100-200	200-400	7-12	15-30	Can be indented by thumbnail.
H	Hard	>200	>400	>12	>30	Difficult to be indented by thumbnail.

The density of non-cohesive Soils- in accordance with AS1726-2017- Geotechnical Engineering Handbook, R.L

Symbol	Term	Density Index (%)	DCP (blows/100mm penetration)	Corrected SPT (Blows per 300mm)	Field Assessment
VL	Very Loose	<15	0-1	<4	50 mm peg easily driven. Foot imprints easily.
L	Loose	15-35	1-3	4-10	12 mm reinforcing bar easily pushed by hand. Shovels easily.
MD	Medium Dense	35-65	3-8	10-30	12 mm bar needs hammer to drive >200 mm. Shovelling difficult.
D	Dense	65-85	8-15	30-50	50 mm peg hard to drive. 12 mm bar needs hammer to drive <200mm. Needs pick for excavation.
VD	Very Dense	>85	>15	>50	12 mm bar needs hammer to drive <60mm. Picking difficult.

Materials Description-Rock

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-2017.

Description of Weathering

Term	Symbol	Weathering Definition
Residual Soil	Rs	Soil derived from the weathering of 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	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - ie. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly Weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased, or decrease compared to the fresh rock usually because of iron leaching or deposition. The colour and strength of the original rock substance is no longer recognisable.
Moderately Weathered	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly Weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh	Fr	Rock substance unaffected by weathering.

Description of Rock Strength

Term	Symbol	Point Load Index (Is (50)) MPa	Weathering Definition
Extremely Low Strength	EL	<0.03	Easily remoulded by hand to a material with soil properties.
Very Low Strength	VL	0.03-0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30mm can be broken by finger pressure.
Low Strength	L	0.1-0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium Strength	M	0.3-1	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty
High Strength	H	1-3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow; rock rings under hammer.
Very High Strength	VH	3-10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High Strength	EH	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.
Note: Relationship between rock strength test result (Is (50)) and unconfined compressive strength (UCS) will vary with rock type and strength, and should be determined on a site-specific basis. UCS is typically 10 to 30 x Is (50), but can be as low as 5 MPa. KFM uses UCS=16 x Is (50).			

Rock Core Recovery

Core recovery parameter describe the quality of core recovered from a borehole.

$$\text{TCR (Total Core Recovery (\%))} = \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100$$

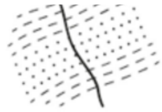
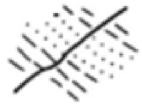
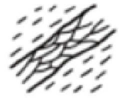
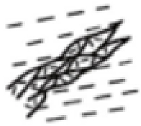
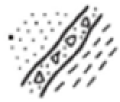
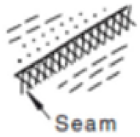
Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD (\%)} = \frac{\sum \text{Axial lengths of core} > 100\text{ mm}}{\text{Length of core run}} \times 100$$

The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Rock Defect Types

Type	Sub-type	Abbreviation	Definition	Diagram
Parting		PT	A surface or crack across which the rock has little or no tensile strength. Parallel or sub-parallel to layering (e.g. bedding) or a planar anisotropy in the rock material (e.g. cleavage). May be open or closed.	
Joint		JT	A surface or crack with no apparent shear displacement and across which the rock has little or no tensile strength, but which is not parallel or sub-parallel to layering or to planar anisotropy in the rock material. May be open or closed.	
Sheared Surface		SH	A near planar, curved or undulating surface which is usually smooth, polished or slickensided and which shows evidence of shear displacement.	
Sheared Zone		SZ	Zone of rock material with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge-shaped blocks.	
Seams	Sheared Seam	SS	Seam of soil material with roughly parallel almost planar boundaries, composed of soil materials with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge-shaped blocks.	
	Crushed Seam	CS	Seam of soil material with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock material which may be more weathered than the host rock. The seam has soil properties.	
	Infield Seam	IS	Seam of soil material usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1 mm thick may be described as a veneer or coating on a joint surface.	
	Extremely Weathered Seam	XWS	Seam of soil material, often with gradational boundaries. Formed by weathering of the rock material in place.	

Details of rock defect spacing

Defect Spacing		Stratification spacing	
Term	**Description**	**Term**	**Spacing(mm)**
Massive	No layering apparent	Thinly laminated	<6
		Laminated	6 to 20
Indistinct	Layering just visible; Properties are little affected	Very thinly bedded	20 to 60
		Thinly bedded	60 to 200
Distinct	Layering (bedding, foliation, cleavage) distinct; rock breaks more easily parallel to layering	Medium bedded	200 to 600
		Thickly bedded	600 to 2000
		Very thickly bedded	>2000

Degree of fracturing

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	20-40 mm Core lengths with some fragments
Fractured	40-200 mm core lengths with short and long sections
Slightly Fractured	200-1000 mm core lengths with some shorter and longer sections
Unbroken	Core lengths mostly > 1000 mm

Descriptions defect shape and roughness

Shape	Abbreviation	Description	Roughness	Abbreviation	Description
Planar	PR	Consistent orientation	Polished	POL	Shiny smooth surface.
Curved	CU	Gradual change in orientation	Slickensided	SL	Grooved or striated surface, usually polished.
Undulating	UN	Wavy surface	Smooth	SM	Smooth to touch. Few or no surface irregularities.
Stepped	ST	One or more well defined steps	Rough	RO	Many small surface irregularities (amplitude generally <1mm). Feels like fine to coarse sandpaper.
Irregular	IR	Many sharp changes in orientation	Very Rough	VR	Many large surface irregularities, amplitude generally >1mm. Feels like very coarse sandpaper.

Abbreviations & descriptions for coating or Infilling term

Coating	Abbreviation	Description	Defect Aperture		
Clean	CN	No visible coating or infilling	**Aperture**	**Abbreviation**	**Description**
Stain	SN	No visible coating or infilling but surfaces are discoloured by staining	Closed	CL	Closed.
Veneer	VNR	A visible coating of soil or mineral substance but usually unable to be measured (<1mm); may be patchy	Open	OP	Without any infill material.
--------			Infilled	inf	Soil or rock i.e. clay, silt, talc, pyrite, quartz, etc.

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling/Excavation method

C	Core drilling	R	Rotary drilling	SFA	Spiral flight augers	HA	Hand Auger
DT	Diatube Coring	NDD	Non-destructive digging	AD	Auger Drilling	ADH	Hollow Auger
EX	Tracked Hydraulic Excavator	HAND	Excavated by Hand Methods	RT	Rotary Tricone bit	RAB	Rotary Air Blast
RC	Reverse Circulation	PT	Push Tube	WB	Washbore	V	V-Bit
T	TC-Bit	NMLC	Diamond Core - 52 mm dia	NQ	Diamond core - 47 mm dia	HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia	HMLC	Diamond Core - 63 mm dia				

Water

▽ Standing Water Level	◁ Partial water loss
▷ Water Seepage	◀ Complete Water Loss

GWNO GROUNDWATER NOT OBSERVED – Because of drilling water, surface seepage or cave-in of the borehole/ test pit, observation of groundwater, whether present or not, was not possible.

GWNE GROUNDWATER NOT ENCOUNTERED – The borehole/ test pit was dry soon after excavation. In less permeable strata, however, groundwater may exist. It is possible that inflow could have been observed if the borehole/test pit had been left open longer.

SAMPLING & TESTING

Sampling

A	Auger Sample
B	Bulk Sample
DS	Disturbed Sample
ES	Environmental Sample
WS	Water Sample
GS	Gas Sample
U50	Undisturbed Tube Sample (50mm)

Testing

PP	Pocket penetrometer (kPa)
PID	Photo ionisation detector reading in ppm
PM	Pressuremeter test over section noted
PL	Point load strength Is (50) MPa
FP	Field Permeability test over section noted
FVS	Field Vane Shear test expressed as uncorrected shear strength (sv= peak value, sr= residual value)
WPT	Water Pressure tests
DCP	Dynamic Cone Penetrometer test
CPT	Static Cone Penetration test
CPTu	Static Cone Penetration test with pore pressure (u) measurement
SPT	Standard Penetration Test to AS1289.6.3.1-2004

APPENDIX B

Site Photographs

BH1/DCP

BH2/DCP2

BH3/DCP3

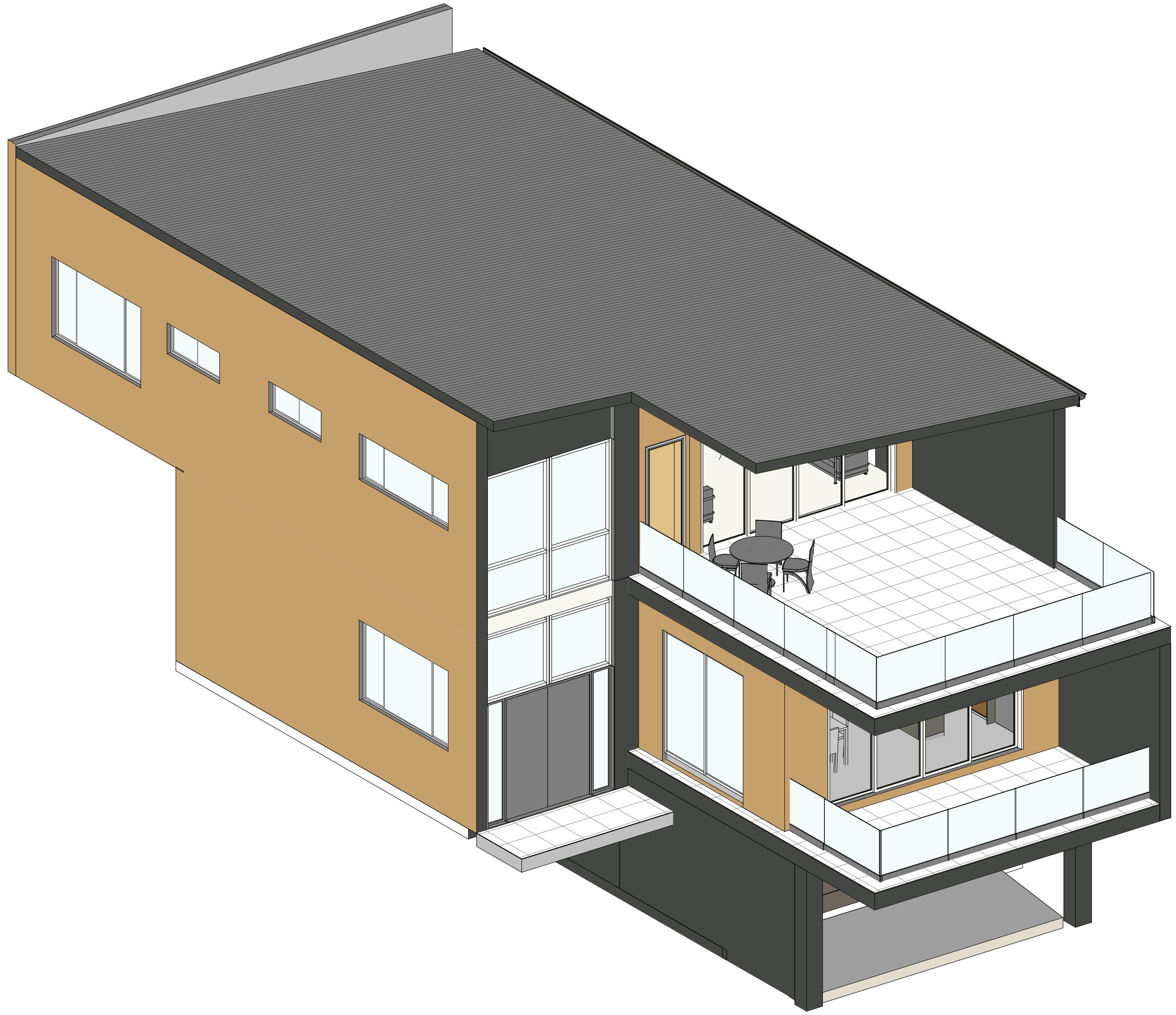
APPENDIX C

Drawings

DEVELOPMENT APPLICATION

237 MCCARRS CREEK ROAD CHURCH POINT 2105
LOT/SECTION /PLAN NO: 32/-/DP20097

PROPOSED SINGLE DWELLING



Prefixes denote the descipline of the drawing:
A= Architectural
S=Structural
M=Mechanical
E=Electrical
P=Plumbing
L=Landscape
AS=Architectural SDA
CD=Construction Drawing

LOCATION PLAN SOURCE: SIX MAPS

NOTES

-DETAILS SHOWN ON THESE PLANS ARE INTENDED TO BE ACCURATE, HOWEVER, INFORMATION WRITTEN ONTO INDIVIDUAL CONTRACTS WILL TAKE PRECEDENCE OVER PLANS.
-DO NOT SCALE ANY OF THE DRAWINGS. USE WRITTEN DIMENSIONS.

AMENDMENTS

REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN: MP	SCALE: 1 : 50	ADDRESS: 237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097	PROJECT NO. A002024041
DRAWN: MP			
CHECKED: -	DATE: 14/09/2024	PROJECT: PROPOSED SINGLE DWELLING	DRAWING NO./TOTAL NO. A-001 / 15
APPROVED: -		CLIENT: MR NIMA	
LGA: NORTHERN BEACHES COUNCIL	STAGE: CONCEPT	DRAWING TITLE: COVER SHEET	REV. NO. A

N

SITE DETAIL:

Site Address: 237 Mccarrs Creek Road Church Point 2105
Lot/Section /Plan No: 32/-/DP20097
Site Area: 514.5m2
Site dimensions: Front 12.42m approx. , Side 41.53/42.875m approx.
NORTHERN BEACHES COUNCIL

Local Environmental Plan

Local Government Area: Pittwater Local Environmental Plan 2014

Land Zone	C4 - Environmental Living
Height Of Building	8.5m
Min. Lot Size	700m2
Floor Space Ratio	NA
Acid Sulfate Soils	Class 5
Local Provisions	Geotechnical Hazard H1
Terrestrial Biodiversity	Biodiversity

Permitted with consent RU1:
Bed and breakfast accommodation; Boat sheds; Building identification signs; Business identification signs; Centre-based child care facilities; Community facilities; **Dwelling houses**; Environmental protection works; Group homes; Health consulting rooms; Home-based child care; Home industries; Jetties; Oyster aquaculture; Places of public worship; Pond-based aquaculture; Respite day care centres; Roads; Secondary dwellings; Tank-based aquaculture; Water recreation structures

SHEET LIST

SHEET	DESCRIPTION	Current Revision
A-001	COVER SHEET	A
A-002	DRWING LIST/CONTROL	A
A-003	GENERAL NOTES	A
A-004	BASIX REQUIREMENTS	A
A-100	SITE ANALYSIS	A
A-101	PROOSED SITE PLAN	A
A-201	GARAGE FLOOR PLAN	A
A-202	GROUND FLOOR LEVEL	A
A-203	FIRST FLOOR PLAN	A
A-207	3D VIEW	A
A-208	3D VIEW	A
A-300	ELEVATIONS	A
A-301	ELEVATIONS	A
A-400	SECTIONS	A
A-500	SHADOW DIAGRAMS	A

AMENDMENTS

REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN: MP	SCALE: 1 : 200	ADDRESS: 237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097	PROJECT NO. A002024041
DRAWN: Approver	DATE: 14/09/2024	PROJECT: PROPOSED SINGLE DWELLING	DRAWING NO./TOTAL NO. A-002 / 15
CHECKED: -		CLIENT: MR NIMA	
APPROVED: -			
LGA: NORTHERN BEACHES COUNCIL	STAGE: CONCEPT	DRAWING TITLE: DRWING LIST/CONTROL	REV. NO. A

AUSTRALIAN STANDARD COMPLIANCE

THE BUILDING SHALL BE CONSTRUCTED IN ACCORDANCE WITH BUT
NOT LIMITED TO THE FOLLOWING AUSTRALIAN STANDARDS.
- AS/NZS 1664 ALUMINIUM STRUCTURES
- AS/NZS 1905 COMPONENTS FOR PROTECTION OF OPENING IN FIRE RESISTANT WALL

- AS 2050 INSTALLATION OF ROOF TILES
- AS 2047 WINDOWS IN BUILDINGS - SELECTION AND INSTALLATION
- AS 2372 COMPOSITE STRUCTURES
- AS 2870 RESIDENTIAL SLABS AND FOOTINGS CONSTRUCTION
- AS 1684 RESIDENTIAL TIMBER FRAMED CONSTRUCTION
- AS 3700 MASONRY STRUCTURES
- AS 3013 ELECTRICAL INSTALLATIONS
- AS 1668 THE USE OF MECHANICAL VENTILATION AND AIR CONDITIONING IN BUILDINGS
- AS 2441 INSTALLATION OF HOSE REELS
- AS 3786 SMOKE ALARMS
- AS 1288 GLASS IN BUILDINGS SELECTION AND INSTALLATION
- AS 2107 ACOUSTICS - RECOMMENDED DESIGN SOUND LEVELS AND REVERBERATION TIMES FOR BUILDING INTERIORS
- AS 3660.1 TERMITE MANAGEMENT - NEW BUILDING WORK -2000

- AS 2890.1-2004 OFF STREET CAR PARKING

SEDIMENT CONTROL NOTES

1. All erosion and sediment control measures, including revegitation and storage of soil and topsoil, shall be implemented to the standards of Soil Conservation of NSW.
2. All drainage works shall be constructed and stabilized as early as possible during development.
3 Sediment traps shall be constructed around all inlets pits, consisting of 450 mm wide by 450mm deep trench.
4. All sediment basins and traps shall be cleaned when structures are a maximum of 60 % full of soil materials, including the maintenance period.
5. All disturbed areas shall be revegitated as soon as the relevant works are completed.
6 Soil and topsoil stockpiles shall be located away from drainage lines and area where water may congregate.
7. Filter shall be constructed by stretching a filter fabric (propex or approved equivelant) between posts at 3.0m centers. Fabric shall be buried 150mm along its lower edge.
8. Refer to concept stormwater engineering for clarity and structure details

BUILDING CODE OF AUSTRALIA Building
Classification: 1
SECTION A General Provisions
Vol. 2 Part 1.3. Clause 1.3.2 Classifications:
CLASS 1: One or more buildings which in association constitute -
(a) Class 1A - A single dwelling, being -
(i) A detached house, or
(ii) One or more attached dwellings, each being a building, separated by a fire resisting wall, including a row house, terrace house, townhouse or villa unit:
CLASS 10: A non-habitable building being a private garage, carport, shed, or the like
BCA 2022 COMPLIANCE
Fire Separation "H3D2 BCA 2022" Part 3.7.1 Fire Separation 3.7.1.1 Application
Compliance with this Part satisfies Performance Requirement sp2.3.1. For
Fire separations.
3.7.1.2 General Concession - Non Combustible materials
The following materials though combustible or containing combustible fibres,
maybe used wherever a non-combustible
is required in the Housing Provisions :
(a) plasterboard, and
(b) perforated gypsum lath with a normal paper finish, and
(c) fibrous-plaster sheet, and
(d) fibre-reinforced cement sheeting, and
(e) pre-finished metal sheeting having a combustible surface finish not exceeding 1mm thick and where the Spread of Flames index of the product is not more than 0;
AND
(f) Banded laminated materials, where -
(i) Each laminate is non-combustible; and
(ii) Each adhesive layer is not more than 1mm thick; and
(iii) The total thickness of adhesive layers is not more than 2mm; and
(iv) The Spread of Flame Index and Smoke Development Index of the
laminated Material as a whole does not exceed 0 and 3 respectively.
3.7.1.3 External Walls of Class 1 of buildings
An external wall of a Class 1 building and any openings in that wall must
comply with 3.7.1.5, if the wall is
less than_
(a) The distance from any point on an external wall of a building to an allotment
boundary or another
building is the distance to that point measured along a line at right angles from the allotment
boundary or external wall of the other building which intersects that point
without obstruction by a
wall complying with 3.7.1.5.
(b) Where a wall within a specified distance is required to be constructed in a
certain manner, only
that part of the wall, (including any openings) within the specified distance, must be constructed in that manner.

3.7.1.5 Construction of External Walls
(a) External walls (including gables) required to be fire resisting (Referred to in
3.7.1.3 or 3.7.1.6) mustextend to the underside of a non-combustible roof covering or non-combustible eaves lining, and must-
(i) have an FRL of not less than 60/60/60 when tested from the outside or
(ii) be of masonry-veneer construction in which the external masonry veneer is not less than 90 mm thick or
(iii) be of masonry construction not less than 90 mm thick
(B) Openings in external walls required to be fire resisting (referred to in 3.7.1.3 or
3.7.1.6] must be protected by-
(i) non operable fire-windows or other construction with an FRL of not less
than --/60/--; or
(ii) self closing solid-core doors not less than 35mm thick.
(c) Sub-floor vents, roof vents, weep holes and penetrations for pipes,
conduits and the like need not comply with (b) above.
(d) Concessions for non-habitable room windows, conduits and the like Despite the requirements in (b) in a non-habitable
room a window that faces the boundary of an adjoining building on the same allotment, not less than 1.2m from that building: providing that-
(i) in a bathroom, laundry or toilet, the opening has an area of not more
than 1.2sqm: or
(ii) in a room other than referred to in (i), opening has an area
of not more than 0.54sqm:
and-
(A) the window is steel framed, there are no opening sashes
and it is glazed in wire glass; or
(B) The opening is enclosed with hollow glass blocks.
3.7.1.8 Separating walls
(a) A wall that separates Class 1 dwellings, or separates a
Class 1 building from A Class 10a building which is not appurtenant to that Class 1 BUILDING, MUST HAVE AN
FRL of not less than 60/60/60, and-
(i) commence at the footings or ground slab: and
(ii) extend-
(A) If the building has a non-combustible roof covering, to the underside of
the roof
the roof covering
SPECIFICATION C1.10 Fire Hazard Properties
Materials used in the building having flamability, smoke developed and
spread of flame indices as set out in Spec C1.10.

Health and Amenity
Part F1: Damp and Weatherproofing
- Stormwater drainage must comply with AS/NZS 3500.3.2
- Roof covering to comply with F1.5
- Sarking must comply with AS/NZS 4200, Part 1 and 2
- Waterproofing of wet areas in buildings to comply with F1.7
- Damp-proof of floors on ground to comply with F1.11
Part F3.7: Fire safety
- Automatic fire detection system to be provided in accordance with Part
3.7.2 General concessions:
Part 3.7.2 Smoke alarms - requirements for smoke:
(a) Smoke alarms must be installed in:
(i) any storey containing bedrooms.
Part3.8: Health and Amenity
-Wet areas within the building must comply with the requirements of Part
3.8.1 Wet Areas.
Part 3.8.6: Sound insulation requirements
Part 3.8.6.2 Sound Insulation Requirements
(a) To provide insulation from air-born and impact a separating wall
Between two or more Class
Buildings, must-
(i) Achieve the weighted sound reduction with spectrum adaption
Term [Rw + Ctr] and discontinuous construction
Requirements, as required by Table 3.8.6.1; and
(ii) Be installed in accordance with the appropriate requirements of
3.8.6.3 and 3.8.6.4
(b) For the purposes of this Part, the Rw + Ctr must be determined
In accordance with AS/NZS 1276.2 or
ISO 717.1using results from laboratory measurements.
Part 3.9: Safe movement and access
The treads and risers of the proposed stairs are to comply with Part 3.9.1.2.
General requirements
3.9.2.6 Windows barriers "protection of openable windows"
General requirements

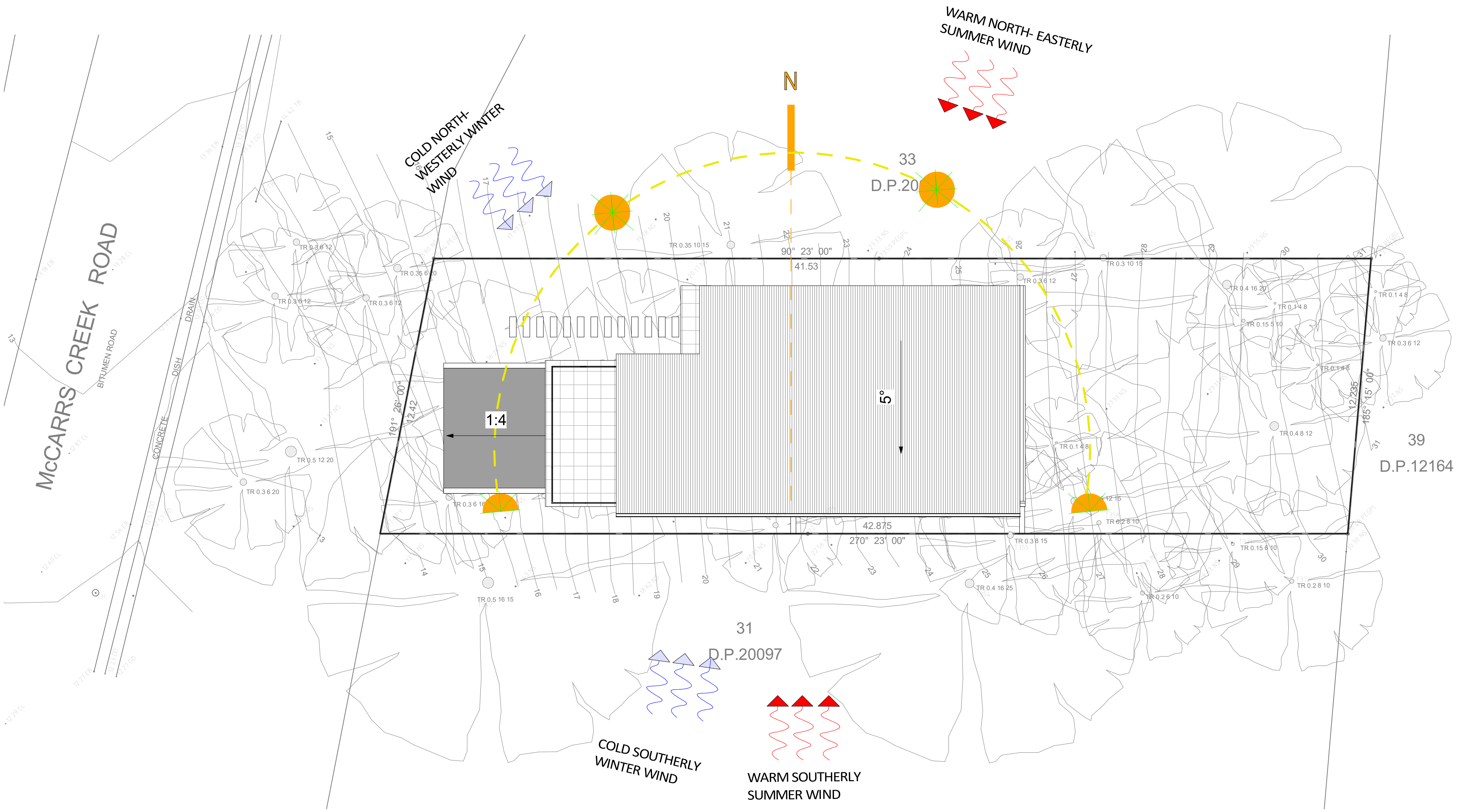
AMENDMENTS

REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN: MP	SCALE:	ADDRESS: 237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097	PROJECT NO. A002024041
DRAWN: Approver			
CHECKED: -	DATE: 14/09/2024	PROJECT: PROPOSED SINGLE DWELLING	DRAWING NO./TOTAL NO. A-003 / 15
APPROVED: -		CLIENT: MR NIMA	
LGA: NORTHERN BEACHES COUNCIL	STAGE: CONCEPT	DRAWING TITLE: GENERAL NOTES	REV. NO. A



SITE ANALYSIS

1 : 200

AMENDMENTS

REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN: MP	SCALE: As indicated	ADDRESS: 237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097	PROJECT NO. A002024041
DRAWN: Approver	DATE: 14/09/2024	PROJECT: PROPOSED SINGLE DWELLING	DRAWING NO./TOTAL NO. A-100 / 15
CHECKED: -		CLIENT: MR NIMA	
APPROVED: -			
LGA: NORTHERN BEACHES COUNCIL	STAGE: CONCEPT	DRAWING TITLE: SITE ANALYSIS	REV. NO. A

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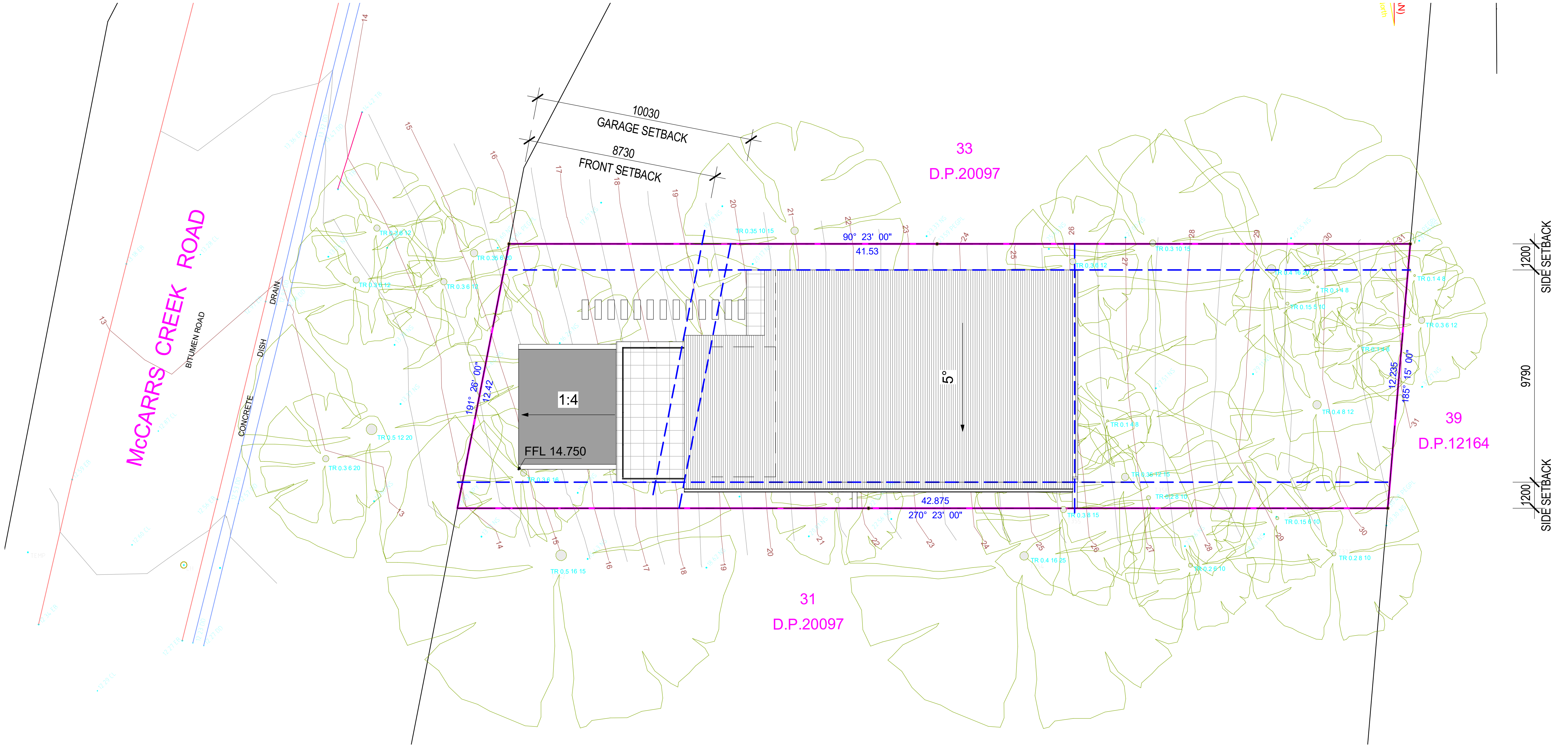

PROOSED SITE PLAN

1 : 200

AMENDMENTS

REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN: MP	SCALE: 1 : 200	ADDRESS: 237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097	PROJECT NO. A002024041
DRAWN: Approver			
CHECKED: -	DATE: 14/09/2024	PROJECT: PROPOSED SINGLE DWELLING	DRAWING NO./TOTAL NO. A-101 / 15
APPROVED: -		CLIENT: MR NIMA	
LGA: NORTHERN BEACHES COUNCIL	STAGE: CONCEPT	DRAWING TITLE: PROOSED SITE PLAN	REV. NO. A

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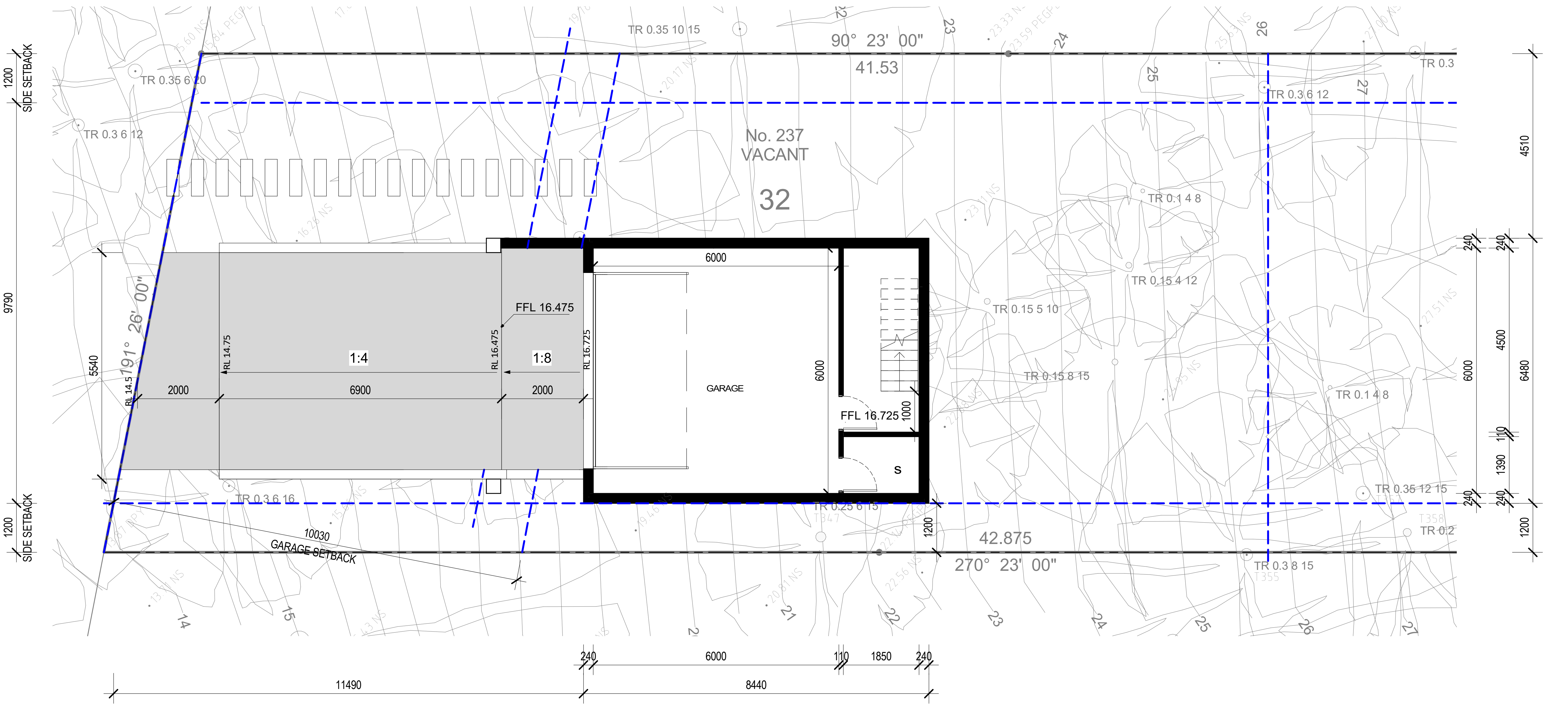

GARAGE FLOOR PLAN

1 : 100

AMENDMENTS

REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN:	MP
DRAWN:	Approver
CHECKED:	-
APPROVED:	-
LGA:	NORTHERN BEACHES COUNCIL

SCALE: 1 : 100
DATE: 14/09/2024
STAGE: CONCEPT

ADDRESS: 237 Mccarrs Creek Road Church Point 2105
Lot/Section /Plan No: 32/-/DP20097

PROJECT: PROPOSED SINGLE DWELLING
CLIENT: MR NIMA
DRAWING TITLE: GARAGE FLOOR PLAN

PROJECT NO. A002024041
DRAWING NO./TOTAL NO. A-201 / 15
REV. NO. A

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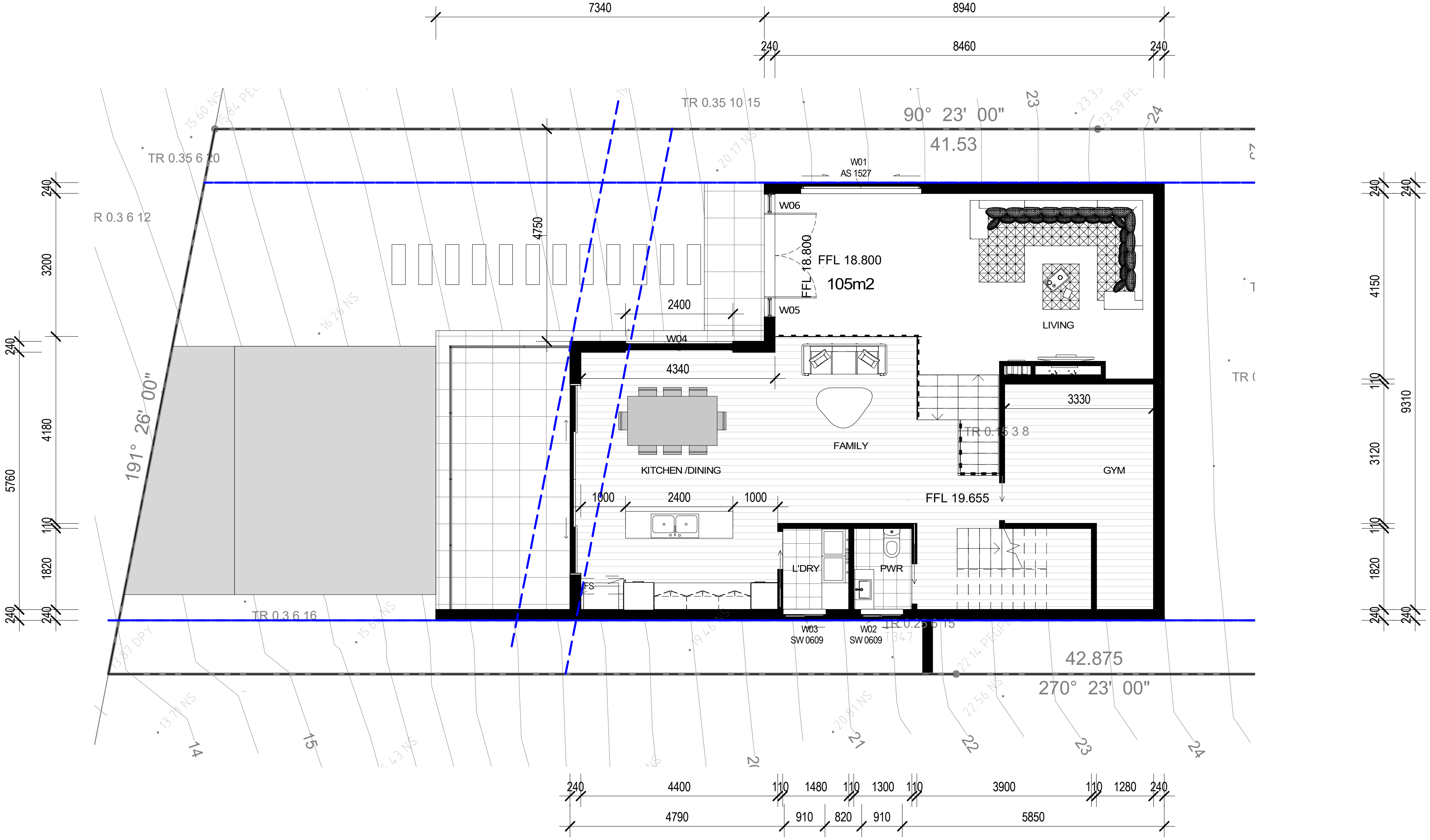

GROUND FLOOR LEVEL

1 : 100

AMENDMENTS		
REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN: MP	SCALE: 1 : 100	ADDRESS: 237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097	PROJECT NO. A002024041
DRAWN: Approver	DATE: 14/09/2024	PROJECT: PROPOSED SINGLE DWELLING	DRAWING NO./TOTAL NO. A-202 / 15
CHECKED: -		CLIENT: MR NIMA	
APPROVED: -			
LGA: NORTHERN BEACHES COUNCIL	STAGE: CONCEPT	DRAWING TITLE: GROUND FLOOR LEVEL	REV. NO. A

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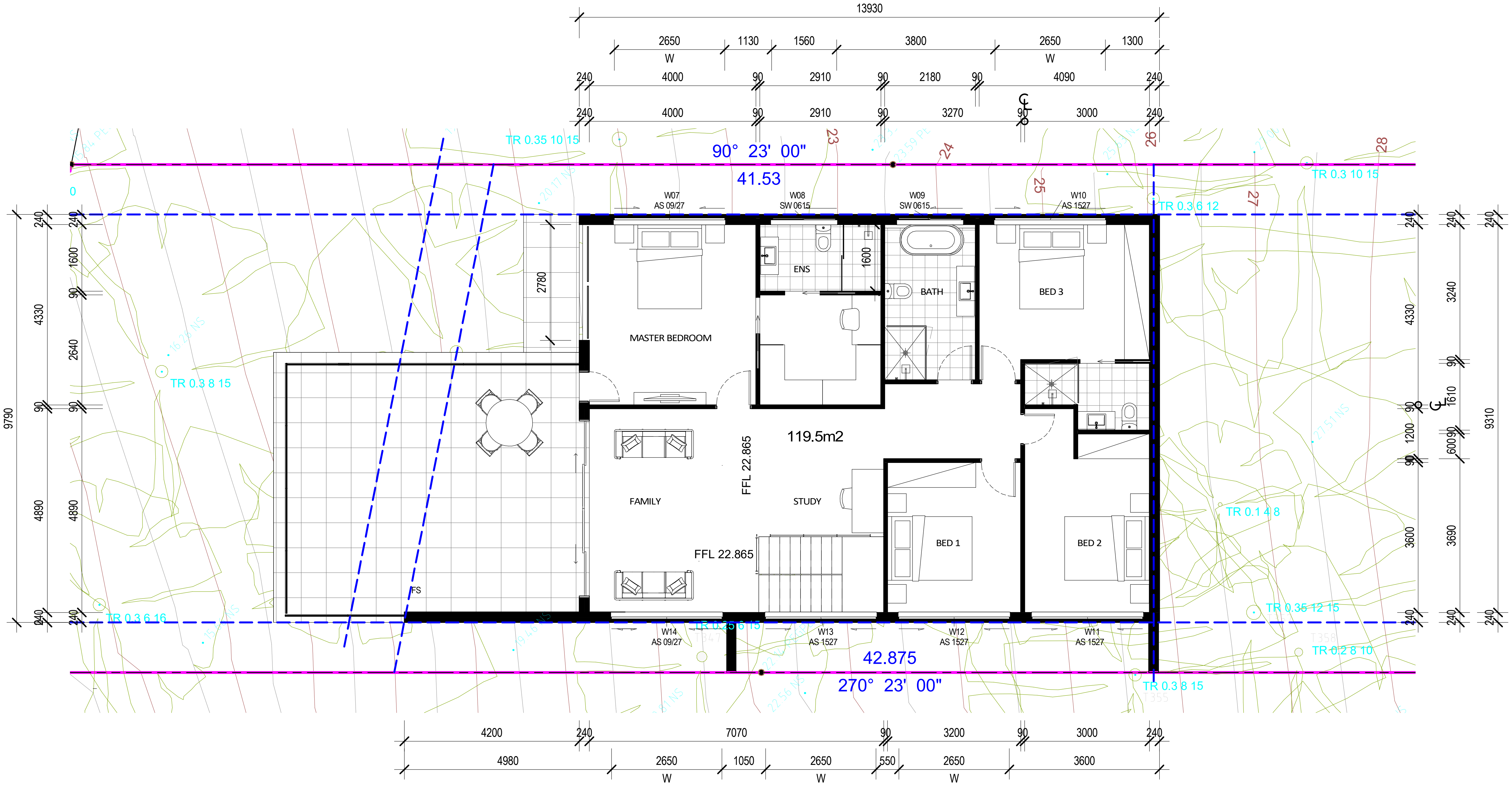


FIRST FLOOR PLAN

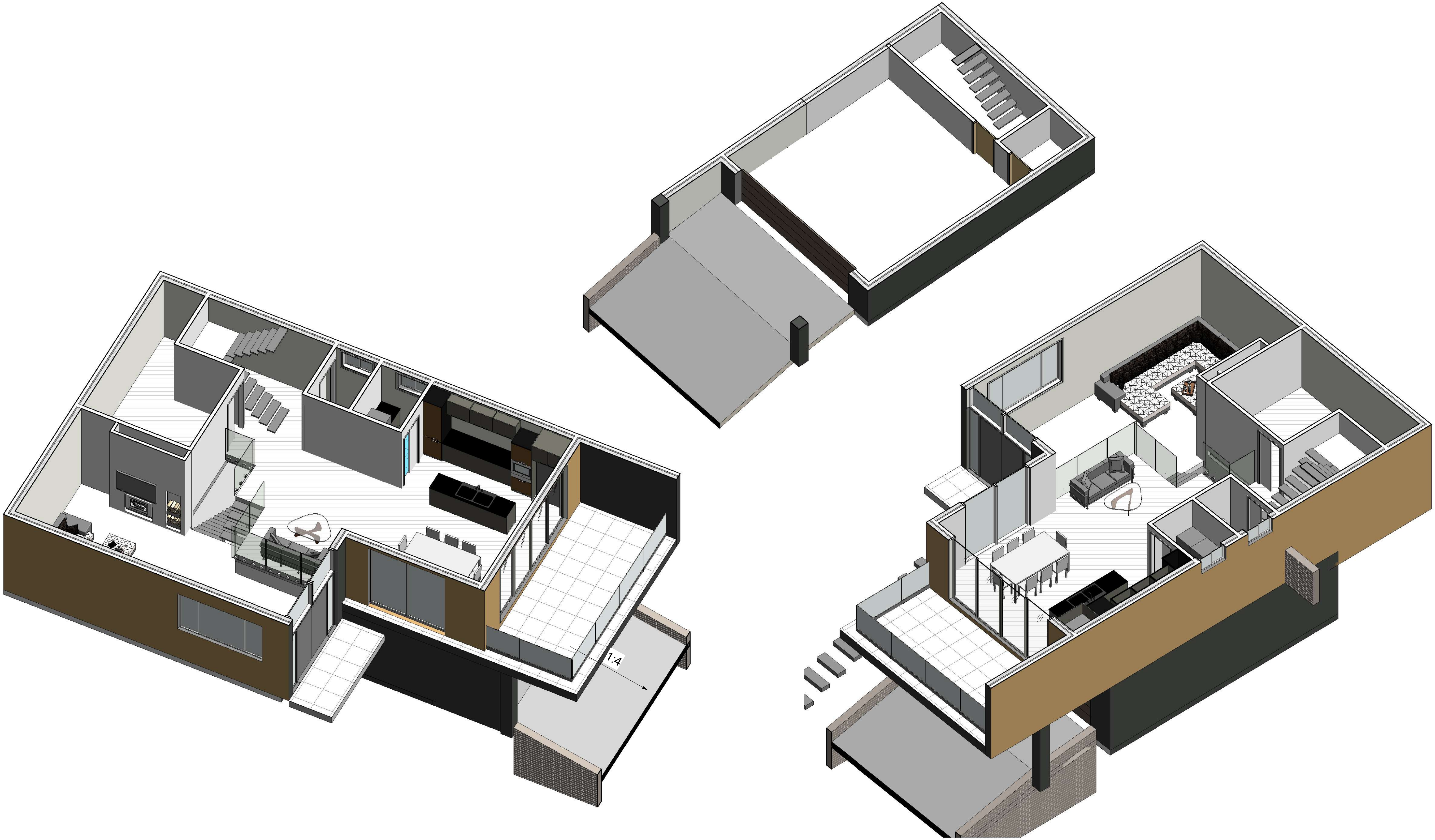
1 : 100

AMENDMENTS		
REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN: MP	SCALE: 1 : 100	ADDRESS: 237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097		PROJECT NO. A002024041	N
DRAWN: Approver					
CHECKED: -	DATE: 14/09/2024	PROJECT: PROPOSED SINGLE DWELLING		DRAWING NO./TOTAL NO. A-203 / 15	
APPROVED: -		CLIENT: MR NIMA			
LGA: NORTHERN BEACHES COUNCIL	STAGE: CONCEPT	DRAWING TITLE: FIRST FLOOR PLAN		REV. NO. A	



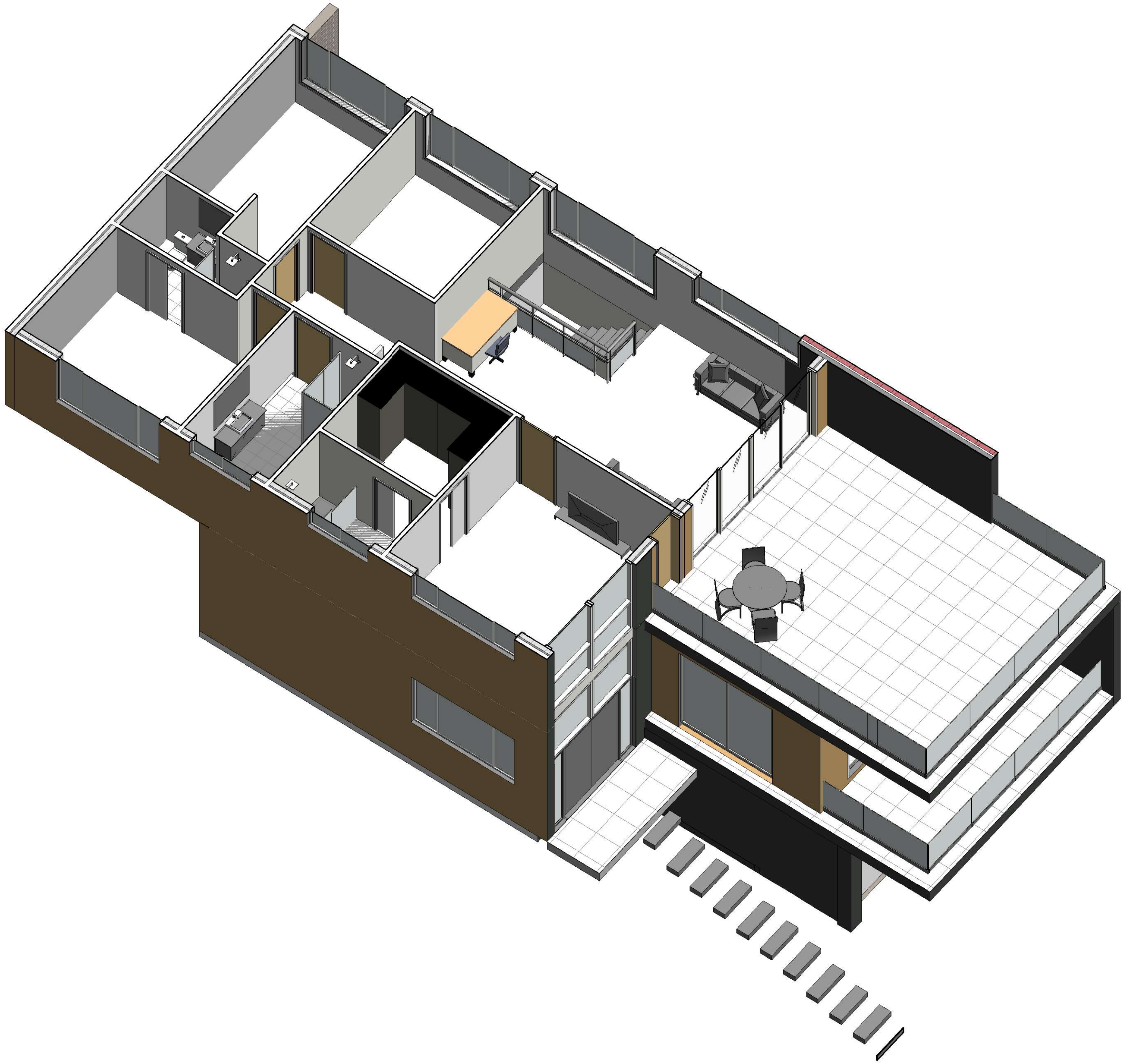
AMENDMENTS

REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN: MP	SCALE:	ADDRESS: 237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097	PROJECT NO. A002024041
DRAWN: Approver			
CHECKED: -	DATE: 14/09/2024	PROJECT: PROPOSED SINGLE DWELLING	DRAWING NO./TOTAL NO. A-207 / 15
APPROVED: -		CLIENT: MR NIMA	
LGA: NORTHERN BEACHES COUNCIL	STAGE: CONCEPT	DRAWING TITLE: 3D VIEW	REV. NO. A



AMENDMENTS

REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN:	MP
DRAWN:	Approver
CHECKED:	-
APPROVED:	-
LGA:	NORTHERN BEACHES COUNCIL

SCALE:

DATE: 14/09/2024

STAGE: CONCEPT

ADDRESS: 237 Mccarrs Creek Road Church Point 2105
Lot/Section /Plan No: 32/-/DP20097

PROJECT: PROPOSED SINGLE DWELLING

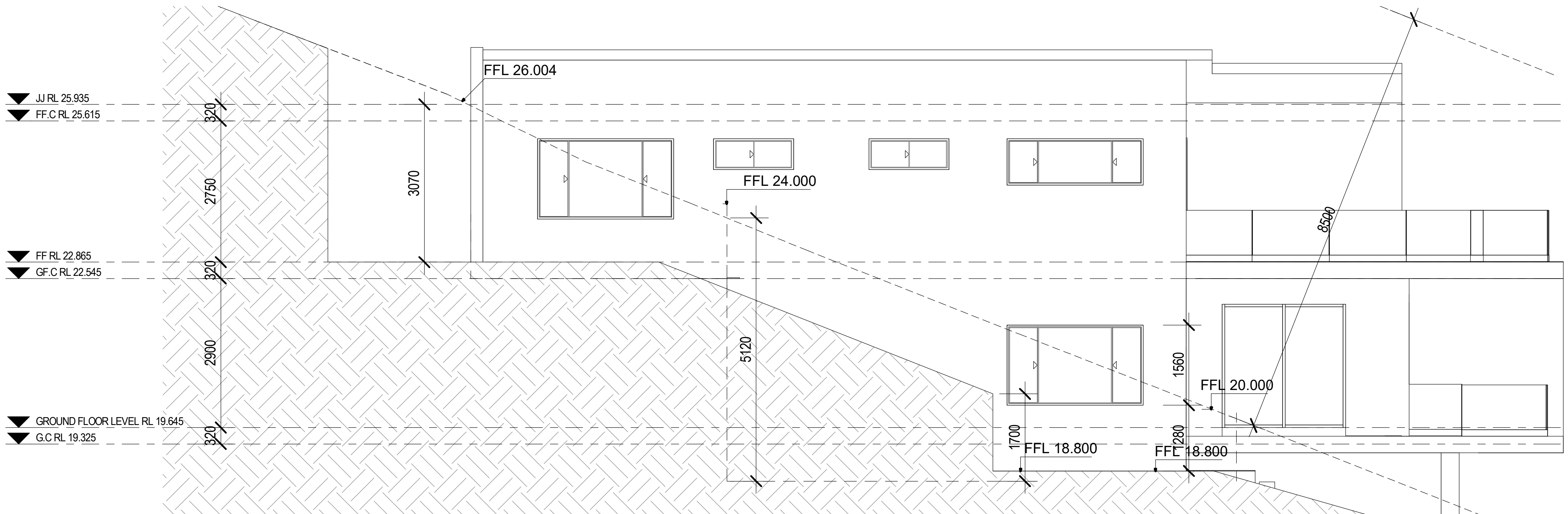
CLIENT: MR NIMA

DRAWING TITLE: 3D VIEW

PROJECT NO. A002024041

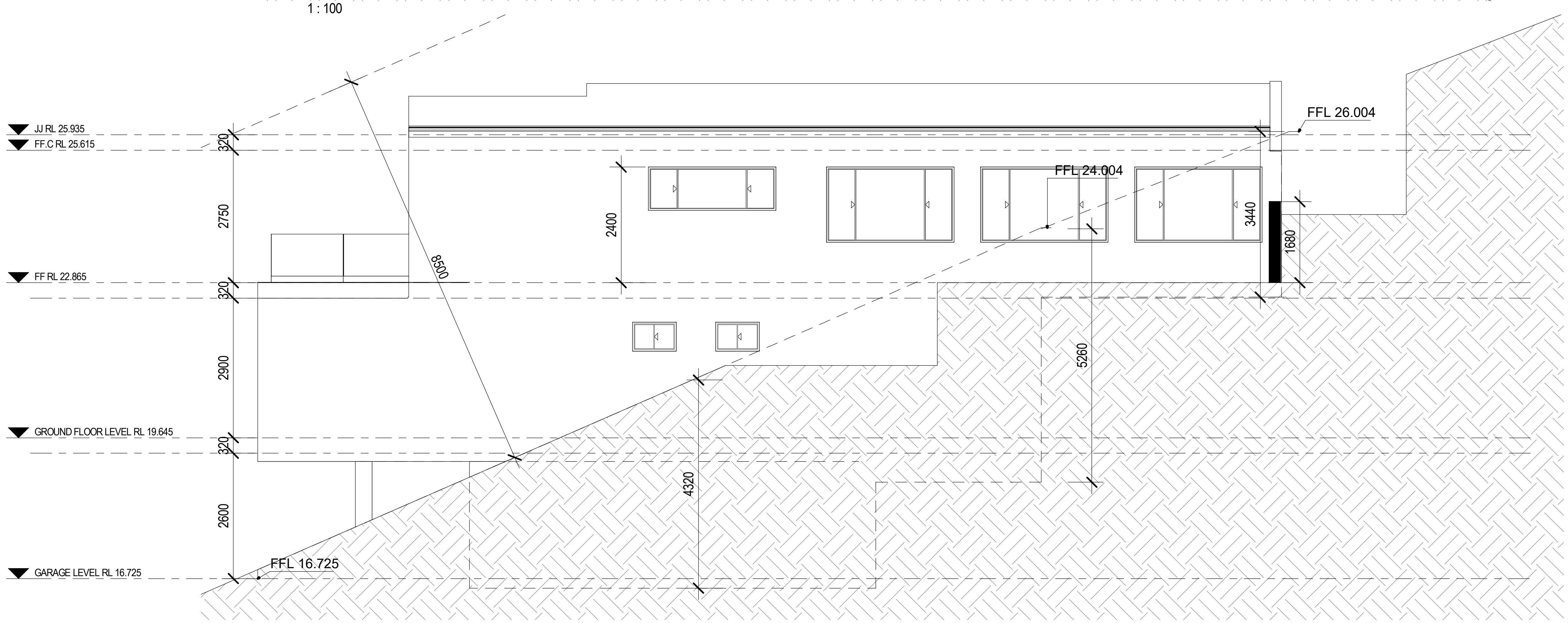
DRAWING NO./TOTAL NO. A-208 / 15

REV. NO. A



NORTH ELEVATION

1 : 100



SOUTH ELEVATION

1 : 100

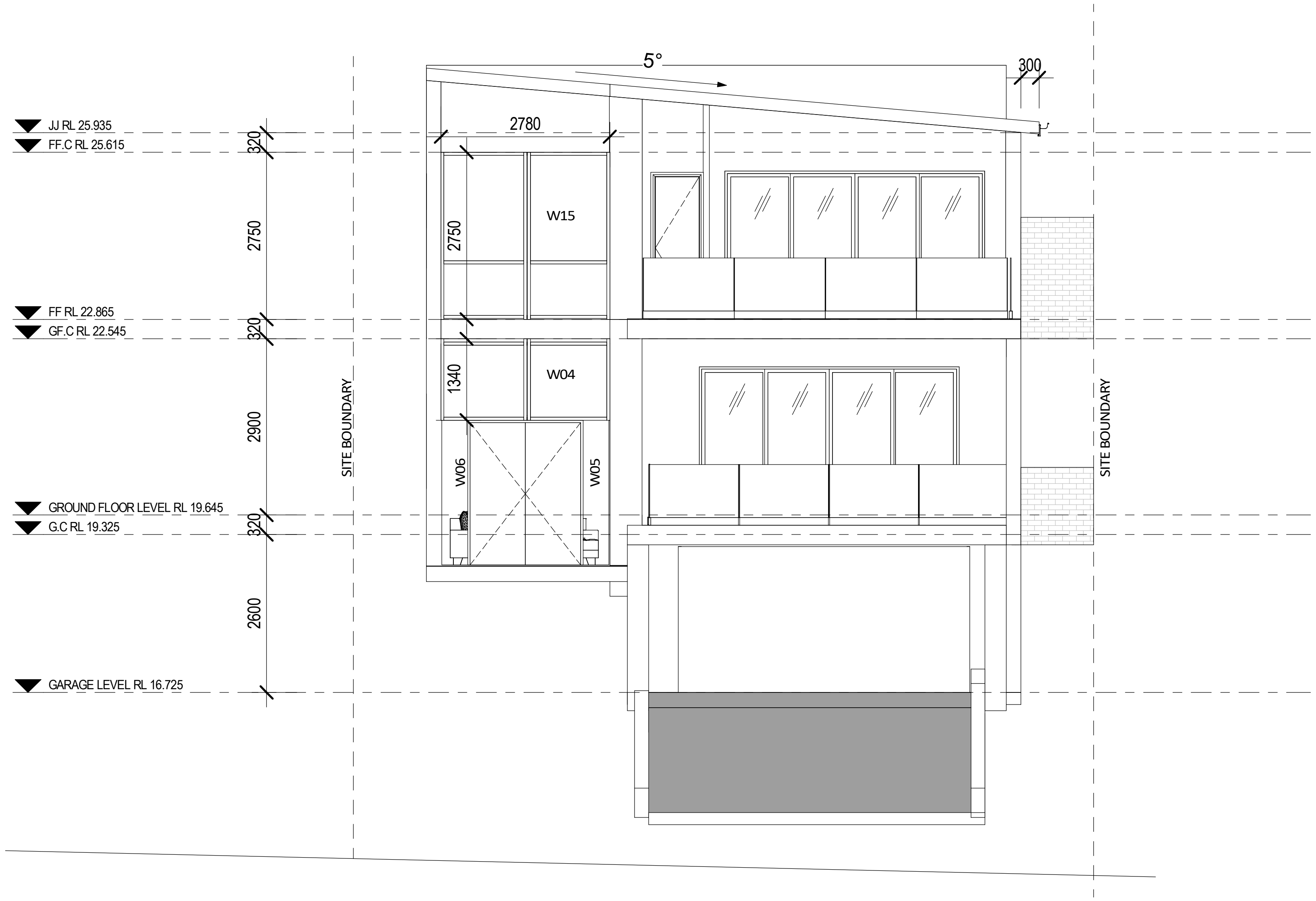
AMENDMENTS

REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN:	MP
DRAWN:	Approver
CHECKED:	-
APPROVED:	-
LGA:	NORTHERN BEACHES COUNCIL
SCALE:	1 : 100
DATE:	14/09/2024
STAGE:	CONCEPT
ADDRESS:	237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097
PROJECT:	PROPOSED SINGLE DWELLING
CLIENT:	MR NIMA
DRAWING TITLE:	ELEVATIONS
PROJECT NO.	A002024041
DRAWING NO./TOTAL NO.	A-300 / 15
REV. NO.	A



WEST ELEVATION

1 : 100

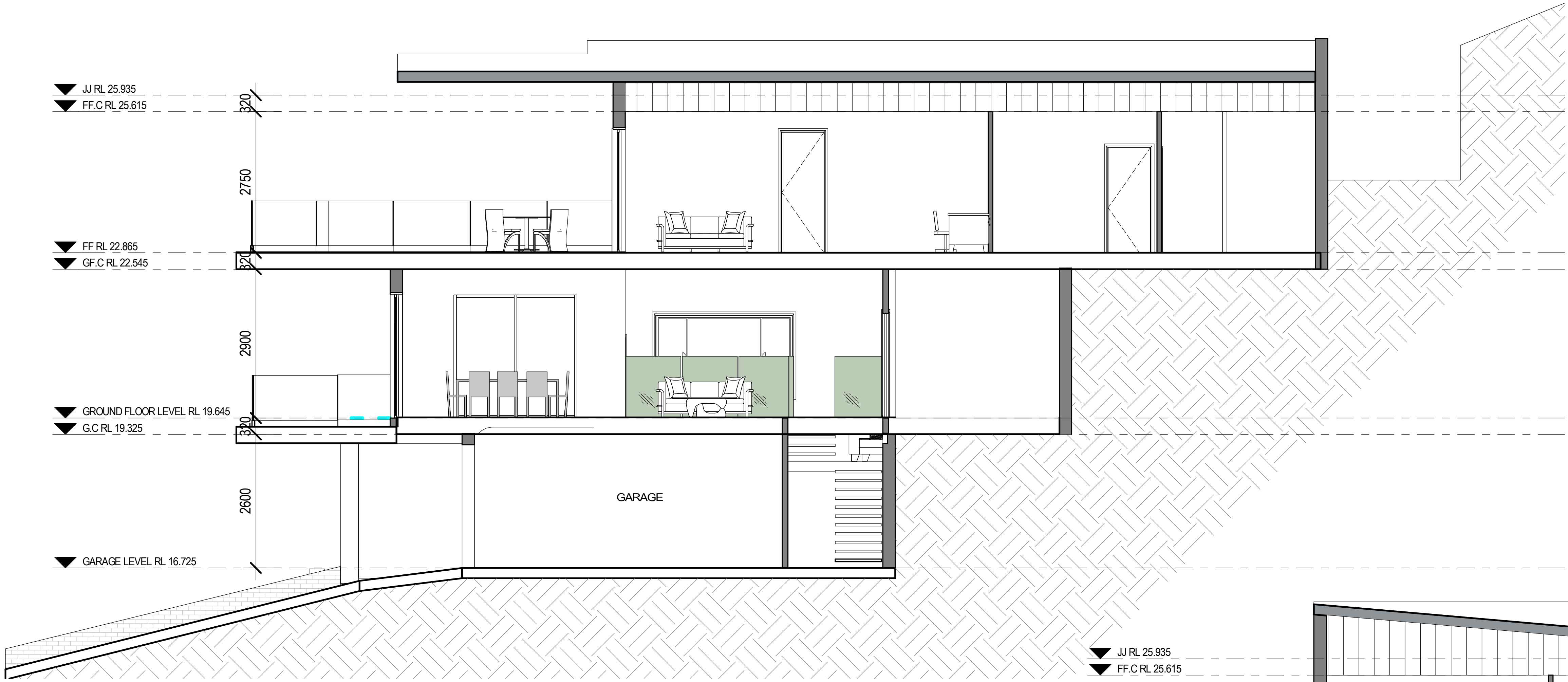
AMENDMENTS

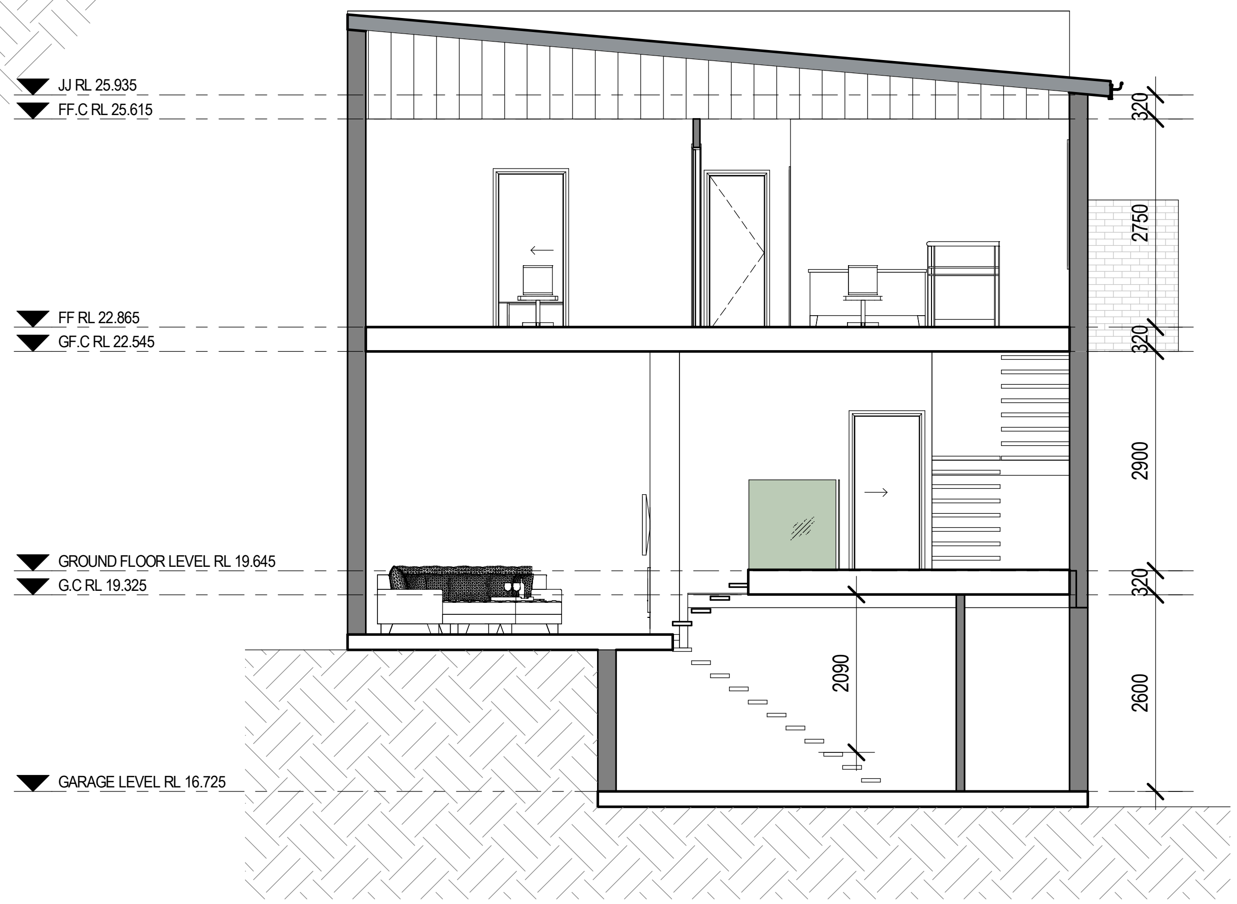
REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN: MP	SCALE: 1 : 100	ADDRESS: 237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097	PROJECT NO. A002024041
DRAWN: Approver			
CHECKED: -	DATE: 14/09/2024	PROJECT: PROPOSED SINGLE DWELLING	DRAWING NO./TOTAL NO. A-301 / 15
APPROVED: -		CLIENT: MR NIMA	
LGA: NORTHERN BEACHES COUNCIL	STAGE: CONCEPT	DRAWING TITLE: ELEVATIONS	REV. NO. A





AMENDMENTS

REV	DATE	DESCRIPTION
A	14/09/2024	CONCEPT DESIGN

GREEN MEASURES
37/5 GOOD STREET, PARRAMATTA, NSW 2151
PHONE: 0470279597

GREEN MEASURES

DESIGN: MP	SCALE: 1 : 100	ADDRESS: 237 Mccarrs Creek Road Church Point 2105 Lot/Section /Plan No: 32/-/DP20097	PROJECT NO. A002024041
DRAWN: Approver			
CHECKED: -	DATE: 14/09/2024	PROJECT: PROPOSED SINGLE DWELLING	DRAWING NO./TOTAL NO. A-400 / 15
APPROVED: -		CLIENT: MR NIMA	
LGA: NORTHERN BEACHES COUNCIL	STAGE: CONCEPT	DRAWING TITLE: SECTIONS	REV. NO. A

APPENDIX D

AGS- Landslip Risk Assessment and Hillside Construction Guideline

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	**1: CATASTROPHIC 200%**	**2: MAJOR 60%**	**3: MEDIUM 20%**	**4: MINOR 5%**	**5: INSIGNIFICANT 0.5%**
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or **L** (5)
B - LIKELY	10^{-2}	VH	VH	H	M	**L**
C - POSSIBLE	10^{-3}	VH	H	M	M	**VL**
D - UNLIKELY	10^{-4}	H	M	**L**	**L**	**VL**
E - RARE	10^{-5}	M	**L**	**L**	**VL**	**VL**
F - BARELY CREDIBLE	10^{-6}	**L**	**VL**	**VL**	**VL**	**VL**

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable 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 value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated 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 practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		**Implied Indicative Landslide Recurrence Interval**		**Description**	**Descriptor**	**Level**
Indicative Value	**Notional Boundary**					
10^{-1}		10 years		The event is expected to occur over the design life.	ALMOST CERTAIN	A
	$5x10^{-2}$		20 years			
10^{-2}		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY	B
	$5x10^{-3}$		200 years			
10^{-3}		1000 years		The event could occur under adverse conditions over the design life.	POSSIBLE	C
	$5x10^{-4}$		2000 years			
10^{-4}		10,000 years		The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
	$5x10^{-5}$		20,000 years			
10^{-5}		100,000 years		The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
	$5x10^{-6}$		200,000 years			
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		**Description**	**Descriptor**	**Level**
Indicative Value	**Notional Boundary**			
200%		Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
	100%			
60%		Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
	40%			
20%		Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
	10%			
5%		Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
	1%			
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

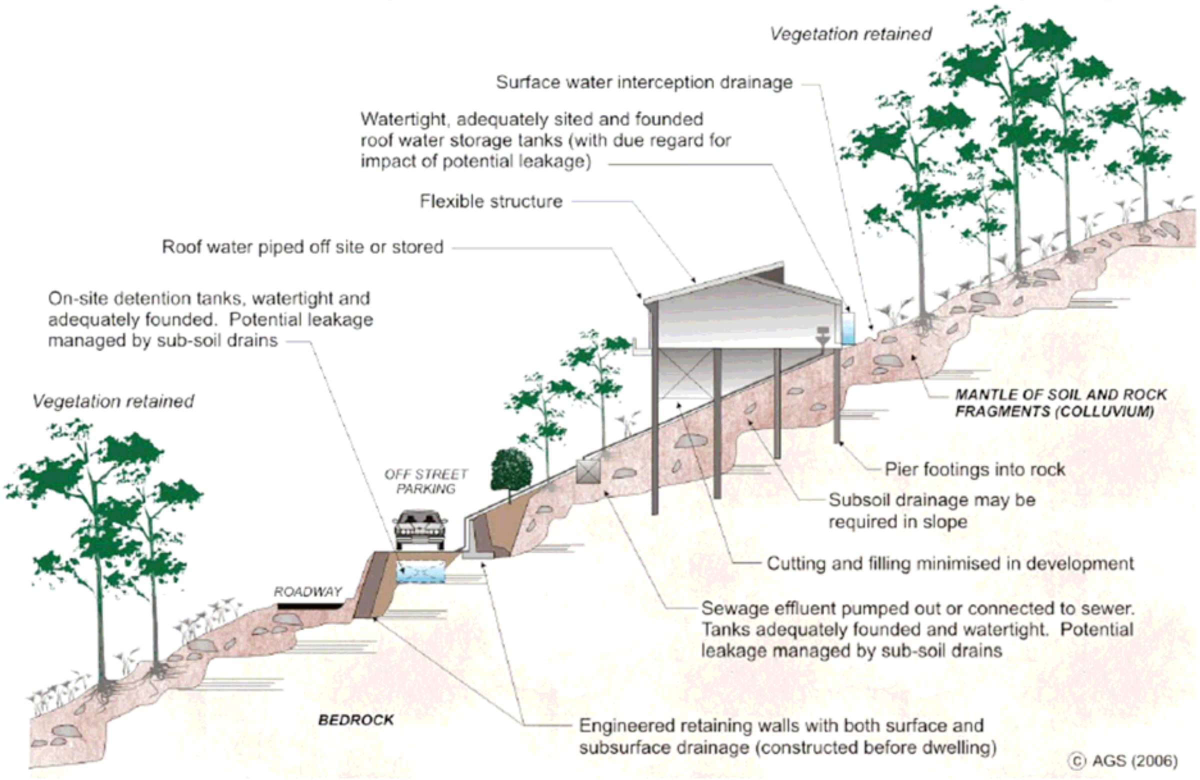
(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

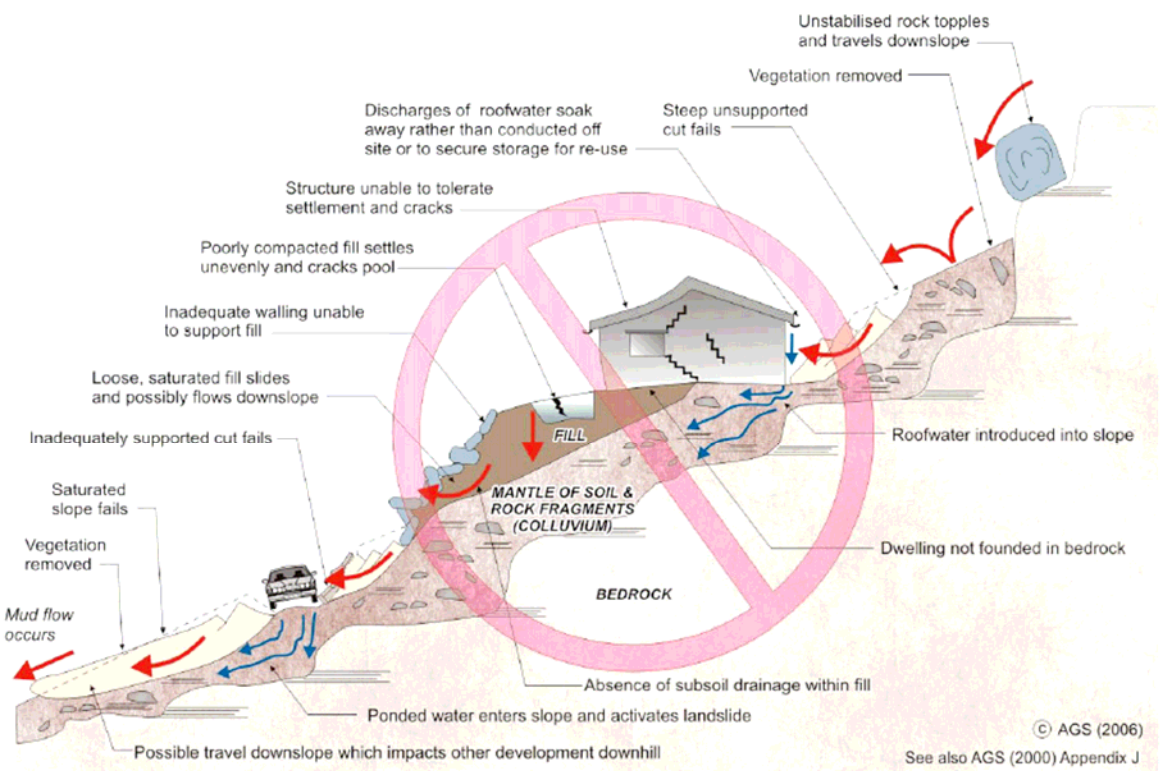
APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	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



Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO PUBLISHING

BTF 18-2011 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 2870-2011, 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, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes

1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

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.

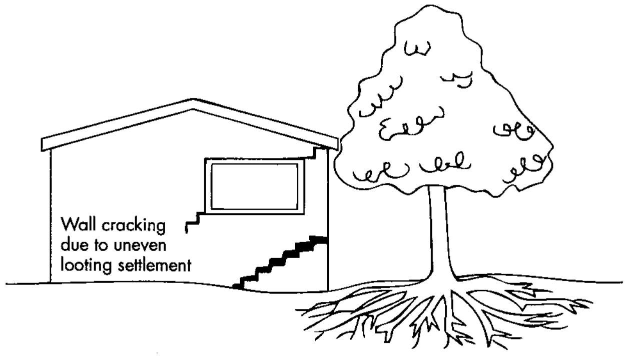
Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends 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.

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.

Trees can cause shrinkage and damage



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 causes 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 2870-2011.

AS 2870-2011 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

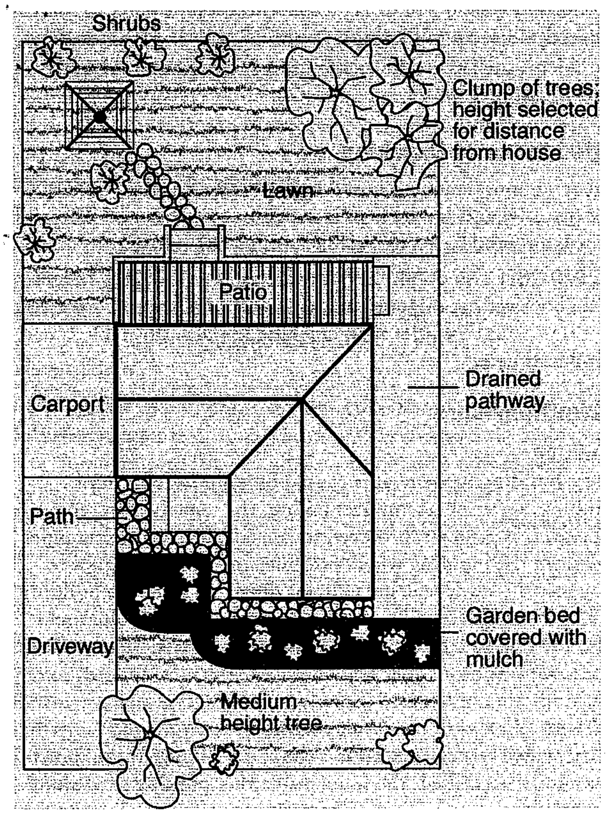
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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 should

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 depends on number of cracks	4

Gardens for a reactive site



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.

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