TERRA INSIGHT

No. 60 Macleay Street, Narrawallee NSW

Acidic (and Acidic Sulfate) Soil Management Plan

Prepared for:

Hartwig

Our Ref: TERRA21-502.ASSMP

Prepared for:
Ms Hartwig
C/ Planning Lawyer Solutions
Level 8, 65 York Street Sydney
NSW 2000

7 December 2021

RE: No. 60 Macleay Street, Narrawallee NSW
Acidic (and Acidic Sulfate) Soil Management Plan

Dear Mr Sir,

Please find enclosed the Acid Sulfate Soil Management Plan for the above site in relation to the proposed residential development of the site. The proposed development includes a residential dwelling with pool. This plan should be read in conjunction with the Attachment "Your Report". Should you have any questions please contact the undersigned.

For and on behalf of Terra Insight

Karen Gates
Principal Engineer/ Director
CPEng MIEaust BEng MEngSc(Geot) MEnvMgt MBA

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1 Introduction

The following Acid Sulfate Soil Management Plan (ASSMP) has been prepared for the management of material excavated during the proposed construction of residential building and pool at No. 60 Macleay Street, Narrawallee NSW, here after referred to as the site. Proposed plans are attached in Appendix B. The location of the site is shown on Figure 1. This ASSMP presents the approach and methodology for Acid Sulfate Soils (ASS) management at the site to be followed by the contactor and its subcontractors. It provides a basis for specifications for ASS management. However, it is important to note that this document is not a specification.

2 Environmental Risks Involving Disturbance of ASS

Acid sulfate soils (ASS) are soils that contain iron pyrites. The pyrite is formed under specific conditions. These conditions require the presence of iron, sulphur and organic matter and generally occur only in alluvial soils of Holocene age. The pyrites oxidise when exposed to oxygen and, when combined with water, form sulfuric acid. This normally occurs when soils are changed from anaerobic to aerobic conditions.

The sulfuric acid will leach out of the soil and may lower the pH of receiving waters, increase the levels of metals in the receiving waters (particularly iron and aluminium) and strip the natural neutralising capacity from the receiving waters. These consequences can have a serious impact on the receiving waters and its biosystem. There are two types of ASS. These are:

- **Actual acid sulfate soils (AASS)** which are soils in which the pyrite has already been oxidised and sulfuric acid is present in the soil; and
- **potential acid sulfate soils (PASS)** where the pyrite is present but has not been oxidised.

Both AASS and PASS have the potential to do environmental harm.

3 Objectives

The objective of this ASSMP is to lower the potential environmental impacts associated with the excavations on the site in relation to the proposed construction of footings for the proposed building and swimming pool. Excavations for these works are not expected to exceed 1m in depth. Piling below 1 m depth will adopt methods that do not involve disturbance to the soils or reduction in the elevation of the groundwater table. Piling is to involve screw piling or driven piles. The ASSMP was developed generally in accordance with the following guidelines:

- ASS Manual prepared by the ASS Management Advisory Committee (1998);
- National Environment Protection Measure (1999);
- NSW DECCW Waste Classification Guidelines (2009);
- Australian and New Zealand Guidelines for the Protection of Fresh and Marine Waters (2000);
- QASSIT Acid Sulfate Soil Technical Manual – Soil Management Guidelines (2014) and
- Australian Guidelines for Water Quality Monitoring and Protection (2000).

4 Investigation Findings

4.1 Site location

No. 60 Macleay Street, Narrawallee NSW, is located approximately 600m to the west of Narrawallee Beach and to the south of Narrawallee Creek . The property is formally known as Lot 145 of DP 718994. The property is a large property of about 3.2Ha extent and is bounded by Narrawallee creek to the north, undeveloped woodland to the east and west and residential properties along the southern boundaries. The area proposed for development is an area on the southern portion of the site adjacent to the site access and includes an area of about 650m^2.

4.2 Geology

On-line geological mapping accessed using Minview, indicates the site is predominately underlain by Quaternary aged Coastal backbarrier flat deposits. This material is comprised of fine- to medium-grained quartz-lithic sand with

carbonate and humic components (marine-deposited), indurated sand, silt, clay, gravel, organic mud and peat as shown in Figure 1. This subsurface geology extends south and north of the proposed area for development by at least 100m.

To the south of the site, the surface is underlain by the Snapper Point Formation of the Shoalhaven Group. This unit is comprised of fine- to medium-grained sandstone, pebbly sandstone and polymictic pebble conglomerate (down sequence), medium- to coarse-grained sandstone with lithic pebbles and fragments, minor siltstone (up sequence); brachiopod, bivalve and bryozoan fossils. This unit is expected to underly the coastal deposits at depth.

To the east are beach sands (dunal deposits) associated with wind blown materials. To the north are organic rich estuarine swamp deposits.

4.3 Historical Aerial images

Historical aerial photography of the site (refer Figure 2) indicates that the site and the surrounding area was undeveloped in 1956. The site is located on an elevated area south of a creek and west of an infilled oxbow on the creek. At this time the site and surrounding land is mostly comprised of woodland which extends to a low lying near level coastal plain adjacent to the creek. To the north of the site, an old meander of the Narrawallee Creek is visible potentially traversing through the lower northern portion of the property.

By 1991, subdivision of the area to the south of and including the site has occurred . These works appear to include some localised filling of the old ox bow to the east of the site which is now a drainage feature. Some fill may have been locally placed on the site and on properties around the northern edge of Macleay Street.

From 2004 to the present day, development of residential properties has occurred to the south of the site. The site has remained relatively unchanged except for increase in density of vegetation (mainly trees).

4.4 ASS Maps

ASS is typically located at elevations below 5m AHD, but can be present as high as 12mAHD in rare occurrences. As the site is underlain by alluvium, it is expected that ASS could be present at depths below 5m AHD on the site. The site has an elevation of about 3m falling to 2m to the north of the proposed area for development.

The NSW Department of Land and Conservation (for Milton) indicates the site is within an area that has a low probability of ASS occurrence, with depths of potential ASS occurrence between 1m and 3m below the ground surface. Mapping indicates the area is denoted by Wa2 which is defined as follows:

- Wa2 – area with a low probability of ASS occurrence with soils deposited by ‘Aeolain’ (transported by wind) processes within a ‘sandplain’ with current surface elevation of 2 to 4m AHD.

This means that if ASS is present on the site, it is likely to occur at elevations of 2 m AHD (at or near the ground surface) to -1m AHD. An excerpt from this mapping is shown in Figure 3.

4.5 Surface Conditions

Observations of the site were made at the time of the site inspection. Photographs taken of the general site conditions are provided in Appendix C. These indicate:

- The site within the property appears to be raised above the areas to the north of the site and is at similar elevations to the neighbouring residential properties as shown on photographs 1 to 4.
- The site is relatively flat, with the embankment slopes falling moderately to the north from a height of about 3m down to level land south of the creek with an elevation of 2m and lower.
- The site is vacant of structures and is predominately grassed with some mature trees nearby.
- Land to the north of the site is level and is grassed with mature trees and shrubs throughout as shown on photograph 5.
- Some land to the north of the site had some visible waterlogged in a slight depression just north of the site as shown on photograph 3.

4.6 Subsurface Conditions

The subsurface investigation comprised the excavation of four boreholes to a depths of 2.0m below existing ground surface level. Engineering logs are provided in appendix D. The locations of the test sites are shown on Figure 4. It is noted that in parts the site has been filled. The investigation comprised of four (4) boreholes in total with sampling for ASS undertaken at 0.5m intervals or at changes in material types. It is noted that excavations for the proposed works are not expected to exceed 1.0m depth. The boreholes are named BH01 to BH04. The investigation indicates the site is underlain by the following materials:

- **TOPSOIL:** Silty SAND to clayey SAND; underlain by
- **FILL:** Sandy CLAY to sandy silty CLAY; underlain by
- **ALLUVIAL:** sandy clay to sandy silty CLAY.

4.7 Laboratory testing

The boreholes were sampled and field screened to determine if ASS was present in the soils underlying the site. Samples were collected at 0.5m intervals down to a total depth of 2m. This sampling was done in general accordance with the NSW EPA guidelines for ASS sampling. The exception to this was for the pool.

Excavations for the pool are deemed to be of limited depth (<0.5m) with the pool essentially constructed at or just below the ground surface. Consequently, in accordance with the Australian ASS sampling guidelines (which provides more appropriate current guidelines for ASS sampling and testing) based on no disturbance of the soil within this area below 1.0m depth, sampling and testing was not deemed required. The pool is expected to be located on piered foundations which do not result in the potential for any ASS soils present at depth to become oxidised. Since the field investigation was completed, the location of the pool has been moved to the west. The nearest sampling location in this area is Borehole BH02 which was taken to a depth of RL 0.8m (or about 0.5m below the base of the pool).

All samples were screened using the ASS Field Screening Procedure outlined in the ASSMAC (1998) Acid Sulfate Soils Manual. A summary of the results of acid sulfate soils field screening tests undertaken on samples of soil retrieved from the boreholes is summarised in **Table 4.2** below with laboratory certificates provided in Appendix E.

The ASS field screening did not identify any Actual ASS on the site. However, the ASS field screening identified some strong reactions during the testing with most of the samples showing a drop in pH greater than or equal to one (1). Some samples noted a drop in pH_{fox} to below 4, indicating a moderate potential for ASS to be present.

To determine the potential causes of acid generation, Chromium Suite testing was undertaken on a sample of soil (reference BH02 S3 1.0m depth). The results for this test are provided in Table 3.3 and in appendix E. This testing indicates some acidity (about 25% of the total acidity) is due to sulfur based compounds (which could be acid sulfate soil or other forms of sulfur), however these levels are very low. Other forms of acidity (such as humic material) are generating most of the acidity within the soil.

Table 4-1:Summary of ASS field screening laboratory results

Test Hole Number	Sample Depth (m)	$pH_{(f)}$	$pH_{(fox)}$	Reaction (X slight, XX Moderate, XXX strong, to XXXX extreme)	ΔpH $pH_{(f)}$ - $pH_{(Fox)}$	AASS indicator ($pH_f < 4$)[A]	PASS indicators			Potential for ASS[D]
							pHfox[C] <3	ΔpH[B] (>1)	Strong or very strong reaction	
BH01	0.5	5.4	3.5	XX	1.9	✗	✗	✓	✗	LOW
	1.0	4.9	3.4	X	1.5	✗	✗	✓	✗	LOW
	1.5	4.8	3.6	XXXX	1.2	✗	✗	✓	✓	MODERATE
	2.0	4.9	3.6	XXXX	1.3	✗	✗	✓	✓	MODERATE
BH02	0.5	4.9	4.0	X	0.9	✗	✗	✗	✗	LOW
	1.0	5.2	3.4	XXXX	1.8	✗	✗	✓	✓	MODERATE
	1.5	5.4	3.7	XXXX	1.7	✗	✗	✓	✓	MODERATE
	2.0	5.4	3.5	XXXX	1.9	✗	✗	✓	✓	MODERATE
BH03	0.5	5.1	3.7	XXXX	1.4	✗	✗	✓	✓	MODERATE
	1.0	5.0	3.5	XXX	1.5	✗	✗	✓	✓	MODERATE
	1.5	5.0	3.8	XXXX	1.2	✗	✗	✓	✓	MODERATE
	2.0	5.2	3.7	XXXX	1.5	✗	✗	✓	✓	MODERATE
BH04	0.5	4.9	3.7	XXX	1.2	✗	✗	✓	✓	MODERATE
	1.0	4.8	3.7	XXX	1.1	✗	✗	✓	✓	MODERATE
	1.5	5.3	4.2	XXXX	1.1	✗	✗	✓	✓	LOW
	2.0	5.4	4.4	XXXX	1.0	✗	✗	✗	✓	LOW

Notes to table: *A) This indicator is not used on its own as soils with high organic content can contain humic acid or manganese oxides which also produce a reaction;*
B) where the pH(f) values is lower than 4, this is typically indicative of AASS being present on a site
C) As the ΔpH increases, there is an increased probability that PASS is present.
D) The lower the pH_{fox} the greater the potential for PASS to be present. Where $pH_{fox} < 3$ and there is a strong reaction and high ΔpH, there is a high probability that PASS is present. Where the $pH_{fox} < 4$ the result is less positive and further laboratory testing is required to determine the source of acid generation. Where $pH_{fox} < 5$ the test is inconclusive, sulphides may be present either in small quantities or may be poorly reactive under quick field test conditions or the sample may contain carbonate which neutralises some or all acid production by oxidation. Equally the low value may be due to weak organic acids and there may be no sulphides present. Further testing to identify the cause of acid generation is recommended.
E) Samples which meet all the QASSIT indicators for PASS are assigned a high potential. Samples which meet some of the indicators for PASS are assigned a moderate potential. Samples which show an inconclusive result are assigned a low potential. It is noted that it is possible for some 'non-ASS soils' to generate acid and have all or some of the indicators of ASS. Further testing is required to assess the nature of acid generation.

Table 4-2: Summary of Chromium Suite laboratory test results

Test Location	Soil Type	Depth (m)	pH KCL	Actual Acidity [A] %S (equiv)- TAA	Cr Reducible Acidity (% Sr)	Retained Acidity [C] (% equiv S-S_{nas})	- Acid Neutralising Capacity ANCB (% S)[B]	Net Acidity (%S)	Fineness Factor	Liming Rate excluding ANC (kg/t)
LOR			*0.1*	*2*	*0.02*	*0.02*	*0.01*	*0.02*	*0.5*	*1*
BH02 S2 1.0m	**Sandy CLAY:**	1.0	5.3	0.03	0.009	NA	NA	0.04	1.5	1.7

Notes to table: LOR – level of reporting. NA – not applicable. A) only required where pH_{kci} is < 5.5, B) only required where pH_{kci} is >6.5 C) only required where pH_{kc} <4

4.8 Conclusions

The NSW ASS guidelines require a formal treatment plan for ASS where the level of Net Acidity (% S) is greater than the following:

- Sands and loamy (clayey) sands: 0.03%.
- Sandy Loams (Sandy Clays) and light clays 0.06%
- Medium to heavy Clays 0.1%

The Chromium Suite ASS testing indicates Net Acidity (%S) on the site is typically 0.04% with that generated by sulfur report at 0.009%. These levels are below than the NSW EPA trigger level of 0.06% for the sandy clayey soils. Consequently, a formal management plan is not required for the site in terms of formal management of ASS. However, as the soils do show some acidity, it is recommended that the soils are treated with lime and classified as GSW in terms of disposal. Consequently, this management plan has been drafted to manage the acidic nature of the soils on the site. Soils should be limed if they are to be disturbed at a rate of 1.7kg/tonne.

5 Extent of Proposed Soil Disturbances

Terra Insight Pty Ltd understands that the proposed works includes construction of a residential building and a pool with excavations expected to be no greater than 1.0m depth with potential off-site disposal of soils. Foundations below 1.0m depth will be driven or screw piles with no disturbance to the subsurface soils which will result in their oxidation. Any material, excavated from the site, will require treatment and waste classification prior to disposal off site.

6 Acidic (and Acidic Sulfate) Soil Management Plan

The following management plan has been prepared to adequately manage the acidity risks posed by the disturbance of soils on the site during the construction phase. Based on the %S (equivalent) and %S based acidity detected within the soils and the estimated volume of soil to be disturbed (<100 tonnes) a High Level treatment plan – Category H – is deemed appropriate. The QASSIT (2014) guidelines indicates a 'High Level' management plan should include the advice on the following:

- More detailed plans of disturbance and detailed ASS investigation reports are provided to assessing authorities.
- Soils are treated with an amount of neutralising agent that will counter their existing plus potential acidity (up to the equivalent of 5 tonnes of fine CaCO3).
- The neutralising agent is thoroughly mixed with the soil.
- Bunding of the site using non-ASS material to divert run-on and collect all site runoff during earthworks.
- pH of any pools of water collected within a bund or sump (particularly after rain) is monitored and treated appropriately before release or reuse to keep pH in the range 6.5 to 8.5 (or as per site-specific conditions).
- All leachate from treatment pads and/or discharge water from excavations should be contained and must meet acceptable standards of pH, metal content (particularly iron and aluminium), and turbidity prior to release.
- A guard layer of neutralising material is applied to treatment pad surfaces to help intercept and neutralise leachate from ASS.

6.1 Extent of Proposed Soil Disturbances

Terra Insight Pty Ltd understands that the proposed works include construction of a residential building and pool. The works will require excavation to about 0.5m depth and will likely encounter acidic soil at this depth or lower. Methods that minimise exposure of the soils to oxidising conditions would be beneficial (such as screw piling or driven piles). Any excavated ASS material will require treatment and waste classification prior to disposal off site.

6.2 Training and Orientation

Training and orientation sessions shall be conducted for all Contractors' staff involved in the excavation, transport or handling of acidic soil. The sessions shall be designed to ensure that staff are aware of the acidic soil issues on the

site and are aware of their responsibilities in managing the acidic soil including any ASS. A handout suitable for issue to workers on site is provided in Appendix F.

6.3 Soil Treatment

Lime treatment rates of these soils were calculated according to their existing plus potential acidity. Based on these calculations, **an initial liming rate of 2kg/m^3** of fine agricultural lime is recommended for all soils excavated on the site. We note that this liming rate includes a factor of safety of 1.5 to allow for incomplete mixing of the soils. Some additional lime may be required to adequately neutralise the material prior to disposal. The lime shall be added uniformly to the soils and mixed in well.

We note that the site is elevated above the water table. Any excavation of the soils will increase their exposure to the air. The lime shall be added uniformly to the soils and mixed in well. The following liming procedures (or other equivalent) should be undertaken:

- Where the soils are treated off site, a treatment pad should be designed in general accordance with NSW EPA guidelines (refer Figure 5). Where the soils are treated on site, temporary stockpiling methods can be adopted.
- A guard layer of neutralising agents should be provided at the base of the treatment pad prior to the addition of ASS material. The guard layer should be employed as a precaution to neutralise acidity that has not been adequately treated during the soil neutralisation process.
- ASS material shall be spread in thin (<200mm) layers;
- Addition of lime by hand followed by mixing, using rotators, backhoe bucket, auger or equivalent; and
- Treatment of stockpiled sandy ASS material should commence within 12 hours of the material being excavated.

The type and amount of lime to be applied will be such that a neutralising value (NV) of 100 can be achieved. NV relates to the purity of the lime and an NV of 100 is required to ensure that the lime is effective in neutralising the potential acid. Fine powdered agricultural lime ($CaCO_3$) generally has an NV of 90% to 100% whilst other manufactured forms of lime can have an NV as low as 80%. Where NV is below 100, the amount of lime will have to be adjusted accordingly.

Where off site is disposal is required, as the volume of soil is likely to be minimal, a skip bin could also be used to store and treat the material but must be a sealed bin or protected from rainfall.

6.4 Temporary Stockpiling

Excavated soils should be either placed in temporary stockpiles or transported directly to a specially prepared treatment area for liming. The treatment area should be constructed in accordance with the NSW EPA guidelines (refer Figure 5 for treatment pad details). Alternatively, for small volumes, the soils could be placed in covered skip bins or temporary stockpiled on a bunded plastic sheeted area. Where temporary stockpiling exceeds three nights (this may occur on or off the site):

- Soils will be stockpiled at least 40m from stormwater drains or creeks and if possible, placed in a topographically high area to avoid inundation following heavy rain;
- The soil stockpiles will be bunded (bunds to be of non-ASS materials), and placed on strong impermeable plastic sheeting, and provision made for collection of surface runoff and appropriate sediment, erosion and dust controls;
- The stockpiles will be kept moist and covered with plastic to help slow the oxidation process;
- The stockpiles will also be observed for obvious signs of oxidation, such as jarosite staining;
- Monitoring of the stockpile and associated run-off water will be carried out for the duration of the work by personnel trained in the identification of acid sulfate soil;

Appropriate stormwater and sediment controls should be in place. Where monitoring of the leachate indicates low pH, the addition of lime will be required prior to discharge. If untreated ASS soils are to be stockpiled for a period exceeding 3 nights, further advice shall be sort from a competent ASS professional. Treated ASS material should not be stockpiled for more than 1 week.

6.5 Temporary excavations

Temporary excavations should remain open for the minimum amount of time that is feasibly practical given the nature of the proposed work. Other than the main excavations for services, all excavations should not remain open for extended periods of time (e.g. > 48 hours).

The sides and base of the trenches and excavations should be sprinkled with lime at a rate of 2kg/m^2 to minimise the potential for oxidation of the exposed soils.

Materials excavated from the site must be replaced back within the 48-hour period. Nominal treatment of the excavated materials at a rate of 2kg /m^3 of soil shall be implemented.

6.6 Permanent Excavations

Treatment of permanent excavations will need to consider the environment within which the site is located. It is common for flora and fauna, within areas impacted by ASS, to have adapted to a level of acidity. Excessive neutralisation of soils within these areas can result in alkaline conditions which can negatively impact these environments. It is therefore recommended that the sides and base of excavations are lightly coated with lime at a rate of 2kg/m^2 to minimise the potential for oxidation of the exposed soils which could result in acid run off where the excavated slopes are battered.

6.7 Water Quality Control

The zones of excavation shall be bunded to minimise the potential for stormwater to flow into the site.

Storm water and groundwater that flows into the active excavation works or onto the disturbed areas of the site will need to be treated prior to release.

There shall be no uncontrolled discharge of waters from the site. Sufficient bunding of the site using none ASS material is required. Monitoring of the water collected in the bunded areas shall be tested before discharge. **Table 6-1** outlines the physio-chemical parameters to be tested before discharge.

Table 6-1:–Surface Water Monitoring

	Parameter	Criteria	Frequency
Dewatering Phase	pH	6.5 – 8.5	Daily when waters collected in the excavation are being released from site
	EC	Background plus 10%	
	Turbidity	SS measurements are to be calibrated with the daily turbidity	
	Suspended Solids	< 50 milligrams per litre	Weekly when discharging

Any waters collected in the excavation or during the dewatering activities shall be tested for pH daily before dewatering. If the recorded pH of any sample is less than 6.5, it shall be immediately retested. If the pH is again below 6.5, the pH shall be adjusted by the application of hydrated lime until it is in the range 6.5 to 7.5. Where the pH is less than 4.5 or more than one unit below baseline levels, the ASS Consultant shall be engaged within 6 hours to review the site practices and monitoring results and to recommend remedial measures.

If turbidity or suspended solids do not meet the criteria, the water shall be treated using an approved flocculent in accordance with the Maroon Manual (Version 1.1).

6.8 Rate for Emergency Liming

6.8.1 Emergency Liming of Soil

Where emergency liming is required and additional laboratory testing results are not readily available, the liming of acid sulfate soils may be carried out at a rate of about 2kg lime per tonne of soils. The emergency liming rate is a temporary measure to lower the immediate risk to the environment and may not be sufficient for complete neutralisation.

6.8.2 Emergency Liming of Water

Where emergency liming of water is required either from dewatering or run-off from stockpiles, and laboratory testing results are not available, liming of acidic water may be carried out at a rate such that residual lime is present and the pH of the water is not less than 6. The emergency liming rate is a temporary measure to lower the immediate risk to the environment and may not be sufficient for complete neutralisation.

6.9 ASS Validation

In order to demonstrate that appropriate quantities of lime have been used as specified in this ASSMP, a lime register shall be maintained by the Contractor. The register shall list the lime delivered to the site, verified by delivery dockets, and where the lime has been used. The lime usage shall quantify areas limed and soil volumes treated, liming rates and quantities of lime used.

A minimum of three validation tests for the site works shall be undertaken on the treated ASS. The validation testing shall consist of the measurement of TAA, the measurement of Scr, the pH of the soil after peroxide oxidation (pHfox) and the measurement of excess neutralising capacity to pH 6.5. A soil shall be deemed to be effectively treated when total acidity calculated as TAA plus the acidity equivalent of the measured Scr is less than 1.5 times the measured acid neutralising capacity and pHfox is greater than 6.5.

6.10 Disposal of Untreated ASS Below Water Table

Depending on the timing of the works, stockpiled ASS can be disposed of without treatment provided the following management procedures are followed:

- Visual assessment of temporary stockpiling and pH monitoring does not show evidence of oxidation; and
- The excavated ASS is disposed of below the ground water table within a landfill licenced to accept waste classified as Acid Sulfate Soils.

6.11 Disposal of treated ASS

Once treated with lime, the soils may be disposed of to an appropriately licensed landfill following a waste classification. The waste classification and disposal should be undertaken in accordance with relevant standards and requirements, including the NSW DECCW (2009) Waste Management Guidelines. Following offsite disposal of the acid sulfate soils, no further testing is required for acid sulfate soil purposes.

6.12 Reuse of Treated Soils Onsite

The following monitoring programme (or other approved equivalent) is recommended for lime treated material where the material is to be reused on site for structural or general filling above the water table, prior to its placement:

- Monitoring of soil pH weekly for two weeks. The monitoring frequency may be revised based on the results of the monitoring; and
- Collection and field screening/laboratory testing of soil samples collected from the stockpile to assess the effectiveness of the liming procedure.

Material may be reused on site above the water table once the above criteria are met.

6.13 ASS Validation

In order to demonstrate that appropriate quantities of lime have been used as specified in this ASSMP, a lime register shall be maintained by the Contractor. The register shall list the lime delivered to the site, verified by delivery dockets, and where the lime has been used. The lime usage shall quantify areas limed and soil volumes treated, liming rates and quantities of lime used.

A minimum of 1 validation tests per 250m^3 or one test per truck/bin load shall be undertaken on the treated ASS. It is estimated that about 5 to 10 test may be required. The validation testing shall consist of the measurement of TAA, the measurement of Scr, the pH of the soil (Kcl) and the measurement of excess neutralising capacity. A soil shall be deemed to be effectively treated when total acidity calculated as TAA plus the acidity equivalent of the measured Scr is less than 1.5 times the measured acid neutralising capacity and pH(KCL) is greater than 6.5.

6.14 Monitoring and Reporting

Complete records of testing, treatment and monitoring should be kept by the contractor including the lime register.

Figures

Site Geology

Symbol	Group	Unit	Lithology
QH_es	-	Estuarine swamp	Organic-rich mud, peat, clay, silt, very fine- to fine-grained sand (marine-deposited), fine- to medium-grained sand (fluvially deposited)
QP_bf	-	Coastal deposits - backbarrier flat facies	Fine- to medium-grained quartz-lithic sand with carbonate and humic components (marine-deposited), indurated sand, silt, clay, gravel, organic mud, peat
Pshs	Shoalhaven Group	Snapper Point Formation	Fine- to medium-grained sandstone, pebbly sandstone and polymictic pebble conglomerate (down sequence), medium- to coarse-grained sandstone with lithic pebbles and fragments, minor siltstone (up sequence); brachiopod, bivalve and bryozoan fossils

Site Location

revision	description	drawn	approved	date
	Site location	XJ	KEG	7/12/2021

N

TERRA INSIGHT

client: **Planning Lawyer Solutions**

project: **Acidic Soil (sulfate) Management Plan No. 60 Macleay Street Narrawallee**

scale: NTS

title: **Site Location**

original size: **A3**

project no: **TERRA21-502**

figure no: **FIGURE 1**

Historical Imagery

revision	description	drawn	approved	date
	Historical Aerial Imagery	XJ	KEG	7/12/2021

N

TERRA INSIGHT

scale	NTS
original size	**A3**

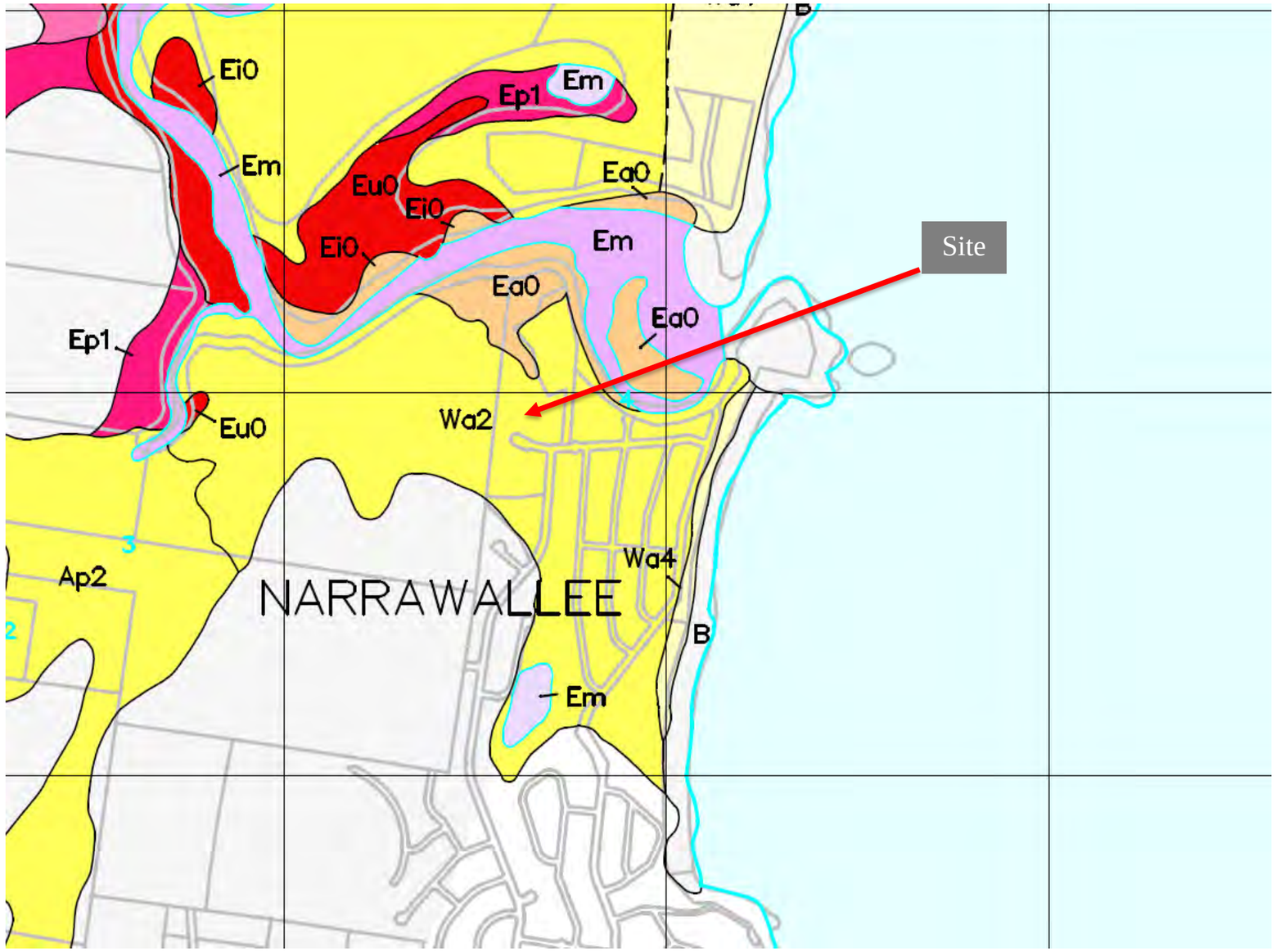
client: **Planning Lawyer Solutions**

project: **Acidic Soil (sulfate) Management Plan**
No. 60 Macleay Street Narrawallee

title: **Historical Imagery**

project no: **TERRA21-502**

figure no: **FIGURE 2**



Milton Acid Sulfate Soil Mapping Excerpt

revision	description	drawn	approved	date
	Acid Sulfate Soil Mapping	XJ	KEG	5/11/2021

N

TERRA INSIGHT

scale	NTS
original size	**A3**

client: **Planning Lawyer Solutions**

project: **Acidic Soil (sulfate) Management Plan**
No. 60 Macleay Street Narrawallee

title: **Acid Sulfate Soil Mapping**

project no: **TERRA21-502**

figure no: **FIGURE 4**

KEY

Map Class Description	Depth to Acid Sulfate Soil Materials		Environmental Risk	Typical Landform Types
HIGH PROBABILITY High probability of occurrence of acid sulfate soil material within the soil profile. The environment of deposition has been suitable for the formation of acid sulfate soil materials. Acid sulfate soil materials are widespread or sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.	Severe environmental risk if bottom sediments are disturbed by activities such as dredging.	Bottom sediments of lakes, lagoons, tidal creeks, rivers and estuaries.
		At or near the ground surface.	Severe environmental risk if acid sulfate soil materials are disturbed by activities such as shallow drainage, excavation or clearing.	Estuarine swamps, intertidal flats and supratidal flats.
		Within 1 metre of the ground surface.	Severe environmental risk if acid sulfate soil materials are disturbed by activities such as shallow drainage, excavation or clearing.	Low alluvial plains, estuarine sandplains, estuarine swamps, backswamps, and supratidal flats.
		Between 1 and 3 metres below the ground surface.	Environmental risk if acid sulfate soil materials are disturbed by activities such as deep excavation for pipelines, dams or deep drains.	Alluvial plains, alluvial swamps, alluvial levees and sandplains.
		Greater than 3 metres below the ground surface.*	Environmental risk if acid sulfate soil materials are disturbed by activities such as deep excavations, eg, large structure foundations or deep dams.	Elevated levees and sandplains, alluvial plains and alluvial swamps in estuarine reaches of catchments.
LOW PROBABILITY Low probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has generally not been suitable for the formation of acid sulfate soil materials. Soil materials are often Pleistocene in age. Acid sulfate soil materials, if present, are sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.	The majority of these landforms are not expected to contain acid sulfate soil materials. Therefore, land management is generally not affected by acid sulfate soils. However, highly localised occurrences may be found, especially near boundaries with environments with a high probability of occurrence. Disturbance of these soil materials will result in an environmental risk that will vary with elevation and depth of disturbance.	Elevated alluvial plains and levees dominated by fluvial sediments. Plains and dunes dominated by aeolian soils. Pleistocene plains. Lacustrine and alluvial bottom sediments.
		At or near the ground surface.		
		Within 1 metre of the ground surface.		
		Between 1 and 3 metres below the ground surface.		
		Greater than 3 metres below the ground surface.*		
NO KNOWN OCCURRENCE Acid sulfate soils are not known or expected to occur in these environments.		No known occurrences of acid sulfate soil materials.	Land management activities not likely to be affected by acid sulfate soils.	Bedrock slopes, elevated Pleistocene and Holocene dunes and elevated alluvial plains.
DISTURBED TERRAIN		Disturbed terrain may include filled areas, which often occur during reclamation of low lying swamps for urban development. Other disturbed terrain includes areas which have been mined or dredged, or have undergone heavy ground disturbance through general urban development or construction of dams or levees. Soil investigations are required to assess these areas for acid sulfate potential.		

*Deep occurrences of acid sulfate soil materials not able to be confirmed by field inspection and sampling

Landform Process Class		Landform Element				Elevation#	
W	Aeolian	b	Backplain	t	Levee toe	0	0-1 m
A	Alluvium	k	Backswamp	o	Ox-bow	1	1-2 m
B	Beach	m	Bottom sediments	p	Plain	2	2-4 m
E	Estuarine	n	Channel	a	Sandplain	4	>4 m
L	Lacustrine	d	Dune	s	Swamp	Additional Descriptive Codes	
S	Swamp	r	Interbarrier swamp	y	Splay	(p)	Pleistocene
		i	Intertidal flat	u	Supratidal flat	(s)	Acidic scald
		g	Lagoon	w	Swale		
X	Disturbed Terrain*	l	Levee	c	Tidal creek		

*Elevation levels given on the map refer to the elevation of the ground surface at the time of mapping. Depending on the nature of the disturbance, these elevation levels may or may not represent the original ground surface elevation.

#Approximate AHD

Acid Sulfate Soil Mapping Key

revision	description	drawn	approved	date
	ASS Key	XJ	KEG	5/11/2021

TERRA INSIGHT

client:	**Planning Lawyer Solutions**
project:	**Acid Sulfate Soil Investigation** **No. 60 Macleay Street Narrawallee**
scale	NTS
title:	**Acid Sulfate Soil Mapping**
original size	**A3**
project no:	**TERRA21-502**
figure no:	**FIGURE 3**

Test Site Locations

Legend

Terra Test site

revision	description	drawn	approved	date
	Test Site Location	XJ	KEG	5/11/2021

N

TERRA INSIGHT

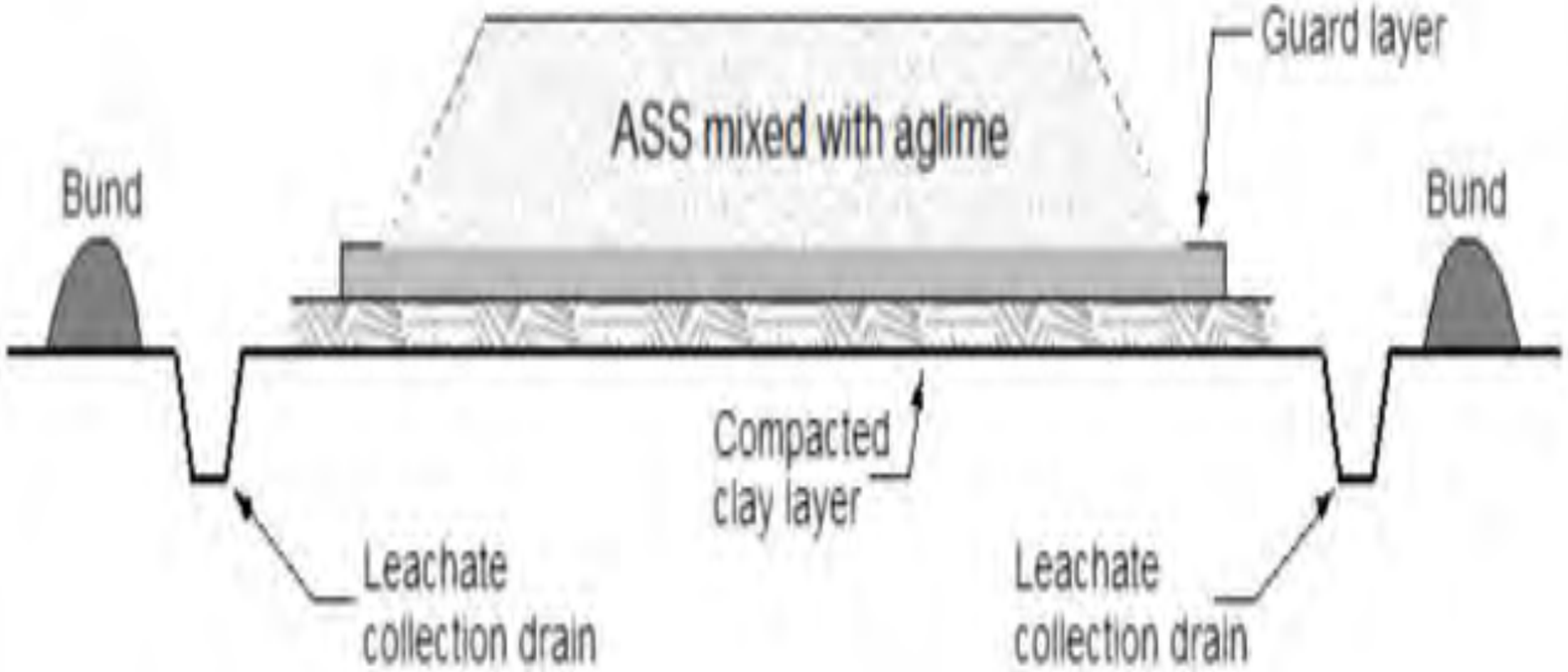
scale	NTS
original size	A3

client: **Planning Lawyer Solutions**

project: **Acidic (Sulfate) Soil Management Plan**
No. 60 Macleay Street Narrawallee

title: **Test Site Locations**

project no: **TERRA21-502** figure no: **FIGURE 4**



revision	description	drawn	approved	date
	ASSMP Treatment Pad	KEG	KEG	27/03/2019

TERRA INSIGHT

scale	NTS
original size	**A3**

client: **Planning Lawyer Solutions**

project: **Acidic Soil (sulfate) Management Plan**
No. 60 Macleay Street Narrawallee

title: **Treatment Pad Cross-Section**

project no: **TERRA21-502** figure no: **FIGURE 5**

Appendix A: Your Report

TERRA INSIGHT

Your Report

These notes have been prepared to help you understand the advice provided in Your Report and its limitations.

Your Report is based on what you tell us

Your Report has been developed based on the information you have provided such as the scope and size of your project. It applies only to the site investigated. If there are changes to the proposed works, then the advice provided within Your Report may need to be reviewed

Your Report is written with your needs in mind

The advice provided within Your Report is also not relevant to another purpose other than that originally specified at the time the report was issued. Please seek advice from Terra Insight before you share Your Report with another third party – except for the purpose for which the report was written.

Terra Insight assumes no responsibility and will not be liable to any other person or organisation for, or in relation to, any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in Your Report.

Your Report is based on what we observed

The advice provided within Your Report assumes that the site conditions, revealed through selective point sampling (undertaken in accordance with normal practices and standards) at a particular point in time, are indicative of the actual conditions on your site. However, the nature of the materials underlying your site is affected by natural processes and the activity of man. Under no circumstances can it be considered that these findings represent the actual state at all points. The subsurface conditions may vary significantly on the other parts of the site, particularly where no nearby sampling and testing work has been carried out.

As a result conditions on your site can change with time; they can also vary spatially. As a result, the actual conditions encountered may differ from those detailed within Your Report. Although nothing can be done to change the actual site conditions which exist, steps can be taken to gain a better understanding of the subsurface conditions underlying your site and reduce the potential for unexpected conditions to be encountered

The advice within Your Report also relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it. Only Terra Insight is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If the details of your project have changed, the site conditions have changed or a significant amount of time as elapsed since our report was written, the advice provided within Your Report may need to be reviewed.

Your Report has been written by a Professional

The report has been prepared using accepted procedures and practices of the consulting profession at the time it was prepared, and the opinions, recommendations and conclusions set out in the report are made in accordance with generally accepted principles and practices of that profession.

Your Report is better when it is kept together

Your Report presents all the findings of the site assessment and should not be copied in part or altered in any way. Keeping Your Report intact reduces the potential for yourself or other design professionals to misinterpret the report.

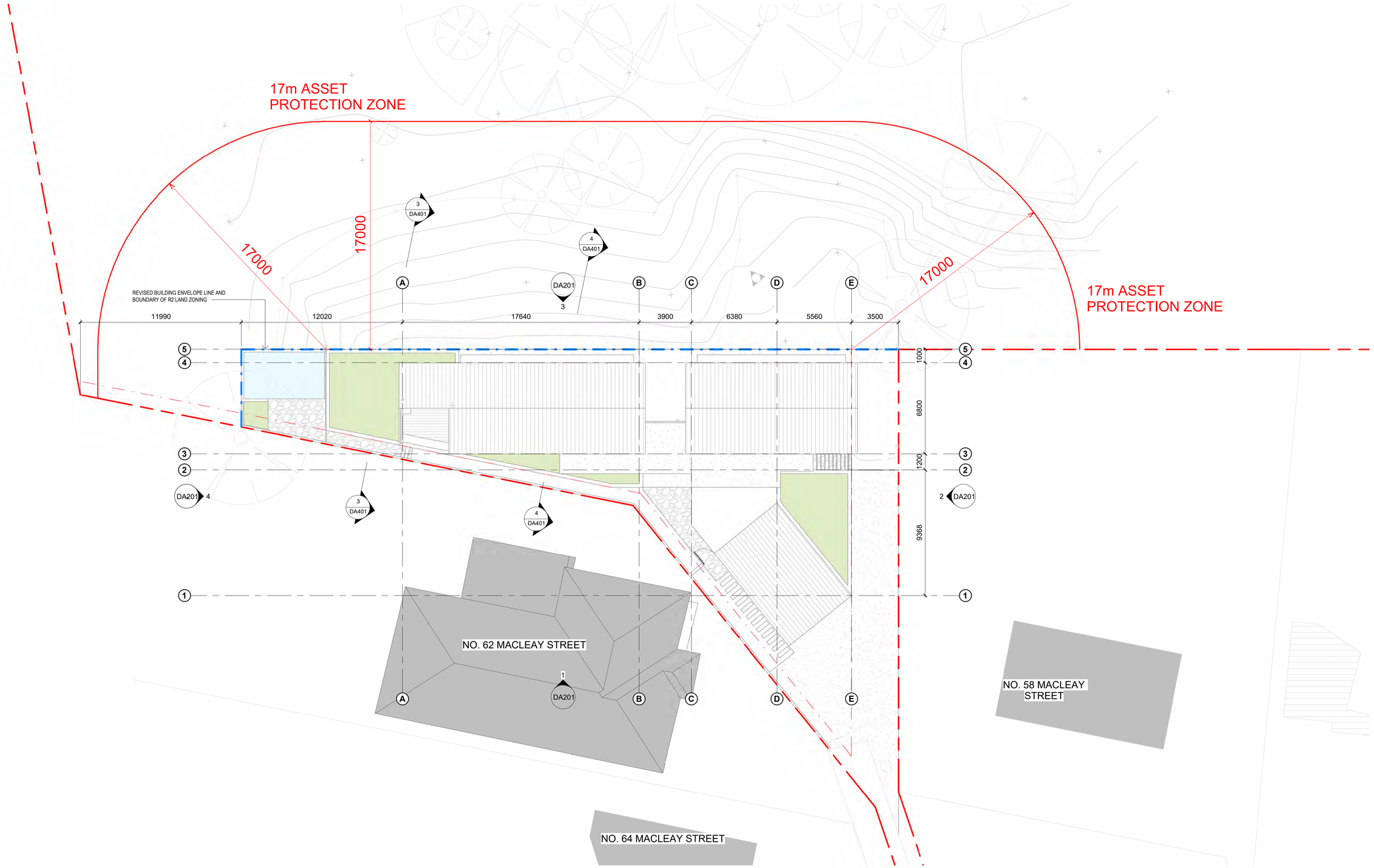
Your Geo-Environmental Report

If Your Report is for geotechnical purposes only, it will not relate any findings, conclusions, or recommendations about the potential for hazardous materials to exist at the site unless you have specifically asked us to do so. If your report is written for Geo-Environmental purposes the following should be noted in addition to the above:

- Advancements in professional practice regarding contaminated land and changes in applicable statues and/or guidelines may affect the validity of this report. Consequently, the currency of conclusions and recommendations in Your Report should be verified if you propose to use this report more than 6 months after its date of issue;
- Your Report is based on information gained from environmental conditions (including assessment of some or all of soil, groundwater, vapour and surface water) and supplemented by reported data of the local area and professional experience. The assessment has been scoped with consideration to industry standards, regulations, guidelines and your specific requirements, which includes budget and timing;
- The characterisation of site conditions is an interpretation of information collected during assessment, in accordance with industry practice. Any interpretation in Your Report is not a complete description of all material on or in the vicinity of the site, due to the inherent variation in spatial and temporal patterns of contaminant presence and impact in the natural environment.
- We may have relied on data and other information provided by you and other qualified individuals in preparing Your Report. We have not verified the accuracy or completeness of such data or information except as otherwise stated in Your Report. For these reasons Your Report must be regarded as interpretative, in accordance with industry standards and practice, rather than being a definitive record.
- For each purpose, a tailored approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible quantify, risks that both recognised and potential contamination posed in the context of the agreed purpose. If the proposed use of the site changes, the assessment may no longer be valid and will need to be reviewed.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Appendix B: Proposed Plans



NOTE:
CHECK ALL DIMENSIONS ON SITE BEFORE COMMENCING FABRICATION. USE FIGURED DIMENSIONS AND DO NOT SCALE OFF THE DRAWINGS.

REV	DATE	DETAILS
A	22.10.2021	LEC REVISION DRAFT
B	10.11.2021	APZ ADJUSTED
C	12.11.2021	COUNCIL CONTENTION AMENDMENTS

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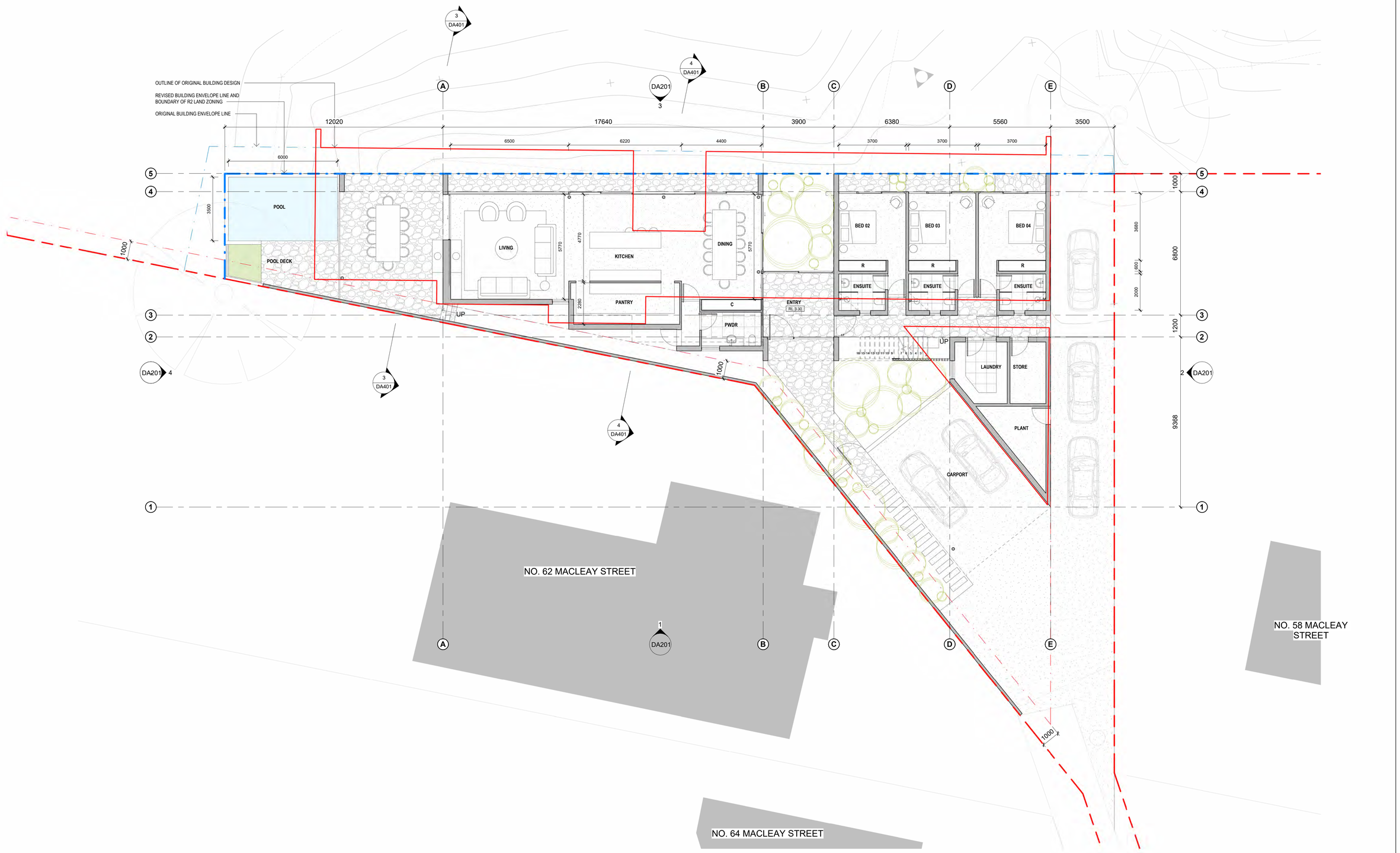
rosebery nsw 2018
t 9662 2720
www.smythandsmyth.com.au
NOMINATED ARCHITECT - DAVID SMYTH - REGISTRATION NO. 10044 NSW

NEW DWELLING AT
60 MACLEAY STREET,
NARRAWALLEE
FOR D & T HARTWIG
project description:

SITE PLAN
this sheet:

north

date: 22.10.2021	scale: 1 : 150	
drawn: JY	checked: DS	
933 project no.	DA100 sheet no.	C revision



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A	22.10.2021	LEC REVISION DRAFT
B	12.11.2021	COUNCIL CONTENTION AMENDMENTS

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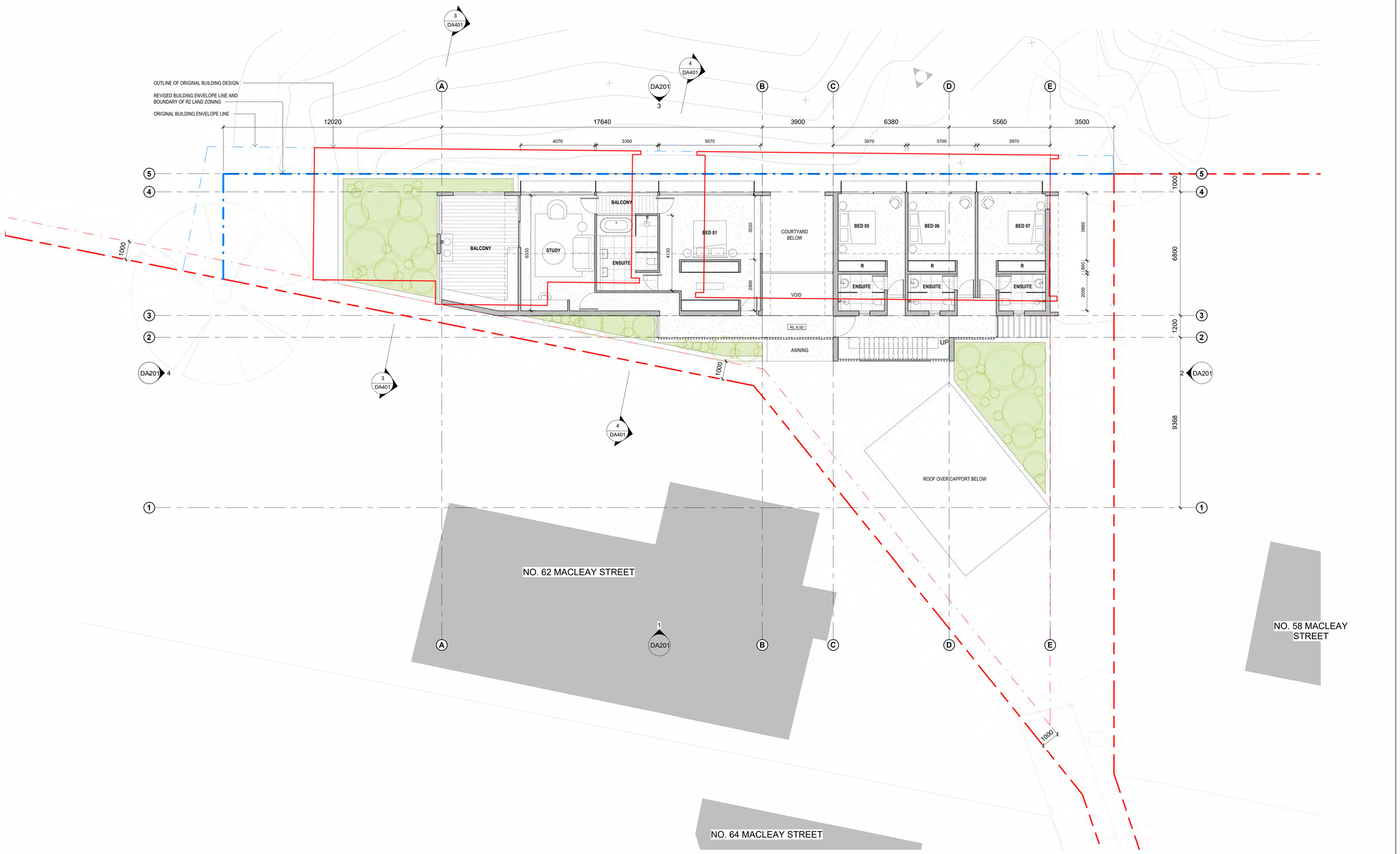
NEW DWELLING AT
60 MACLEAY STREET,
NARRAWALLEE
FOR D & T HARTWIG
project description:

GROUND FLOOR PLAN
this sheet:

north

date: 22.10.2021	scale: 1 : 100
drawn: JY	checked: DS
933 project no.	DA101 sheet no. / B revision



NOTE:
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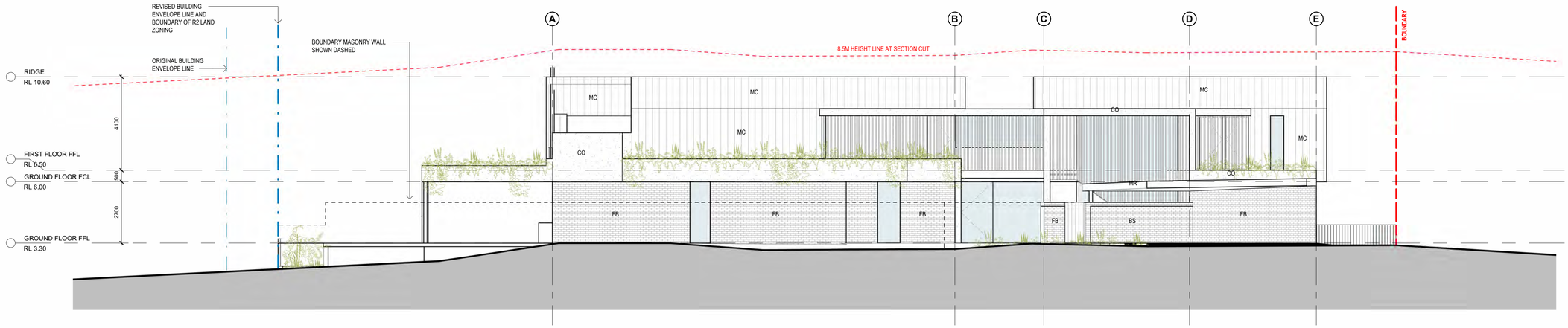
NEW DWELLING AT
60 MACLEAY STREET,
NARRAWALLEE
FOR D & T HARTWIG
project description:

FIRST FLOOR PLAN
this sheet:

north

date: 22.10.2021	scale: 1 : 100
drawn: JY	checked: DS
933 project no.	DA102 sheet no. / B revision



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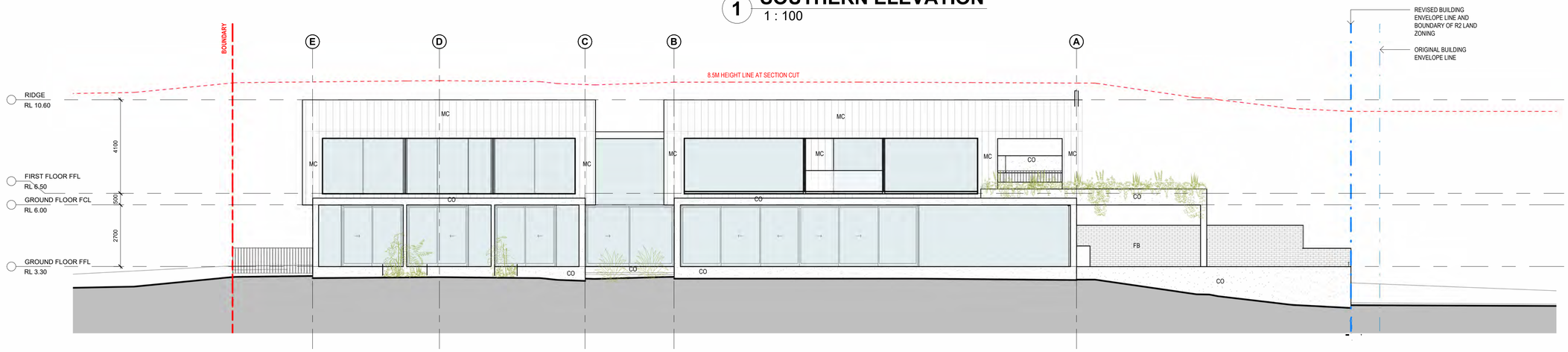

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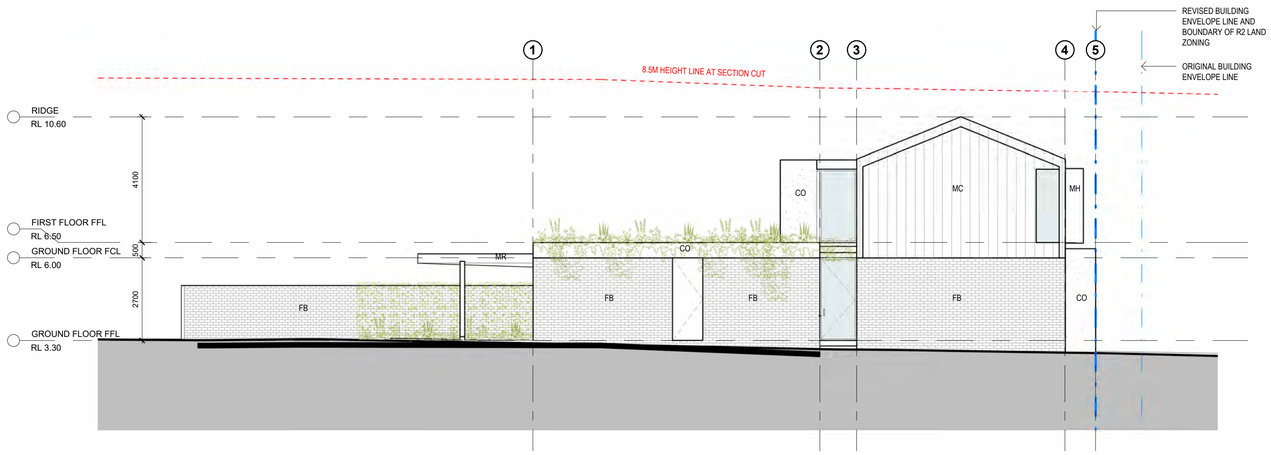

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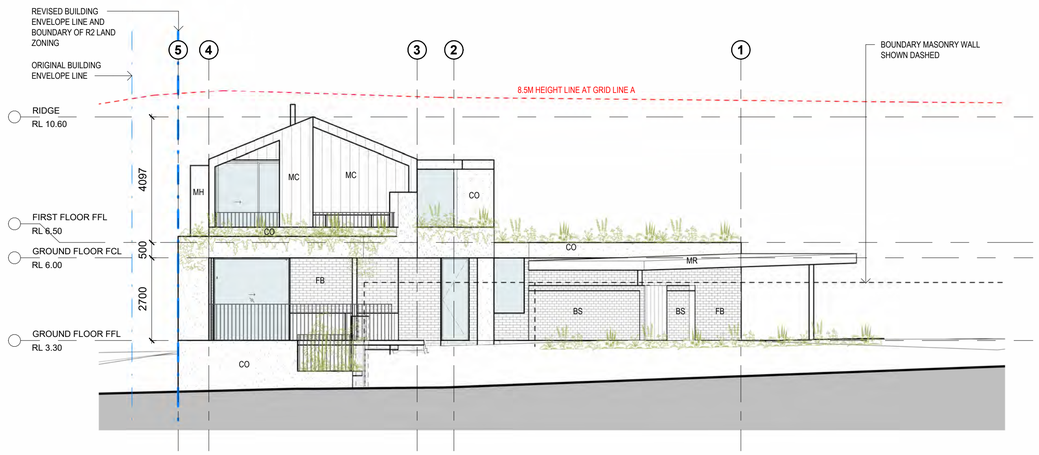

4 WESTERN ELEVATION
1 : 100

NOTE:
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A	22.10.2021	LEC REVISION DRAFT
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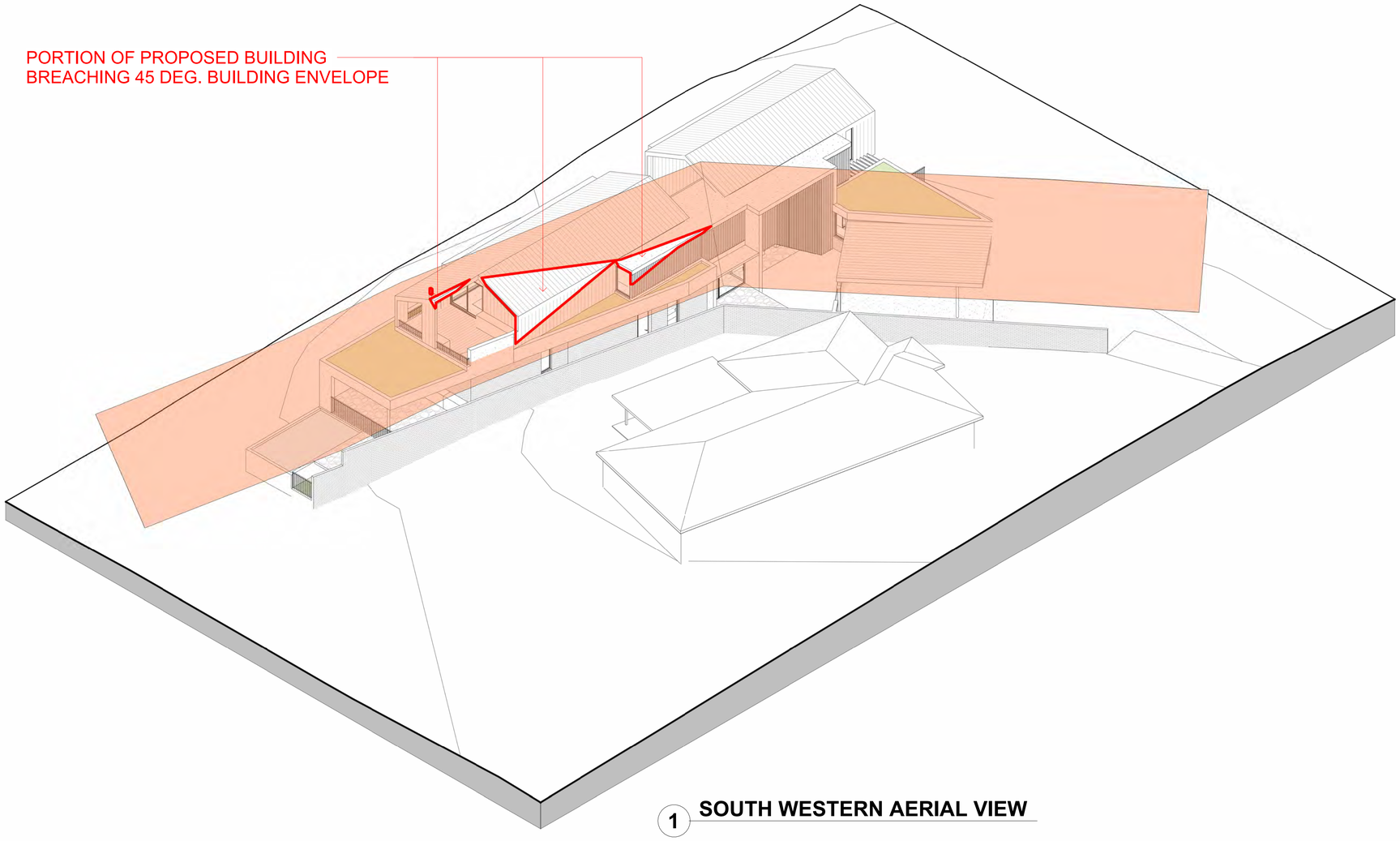
NEW DWELLING AT
60 MACLEAY STREET,
NARRAWALLEE
FOR D & T HARTWIG
project description:

ELEVATIONS
this sheet:

north

date: 22.10.2021	scale: 1 : 100
drawn: JY	checked: DS
933 project no.	DA201 sheet no.
B revision	



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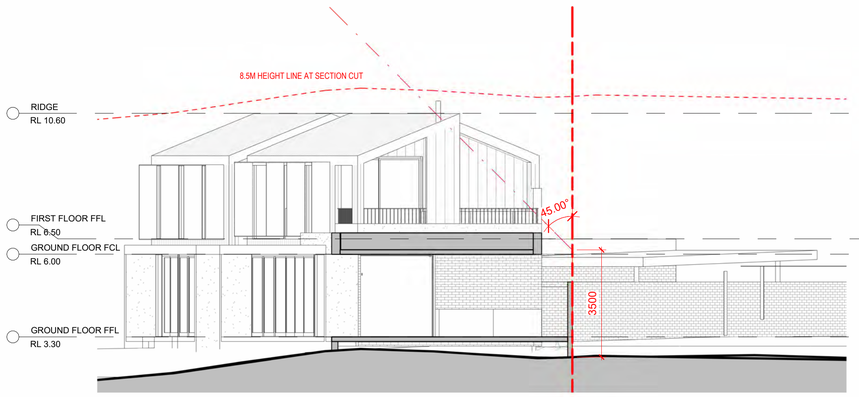

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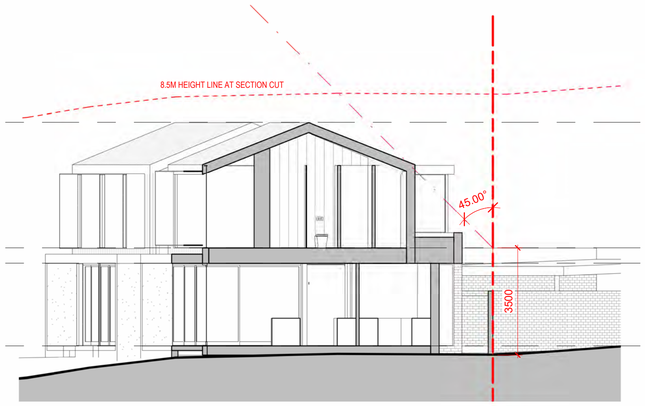

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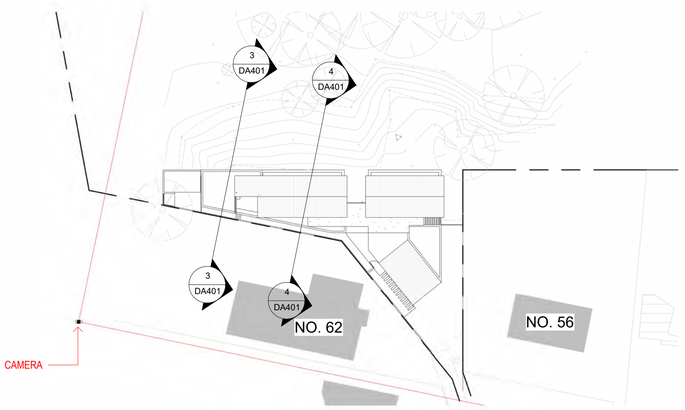

2 KEY PLAN
1 : 500

NOTE:
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REV	DATE	DETAILS
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B	12.11.2021	COUNCIL CONTENTION AMENDMENTS

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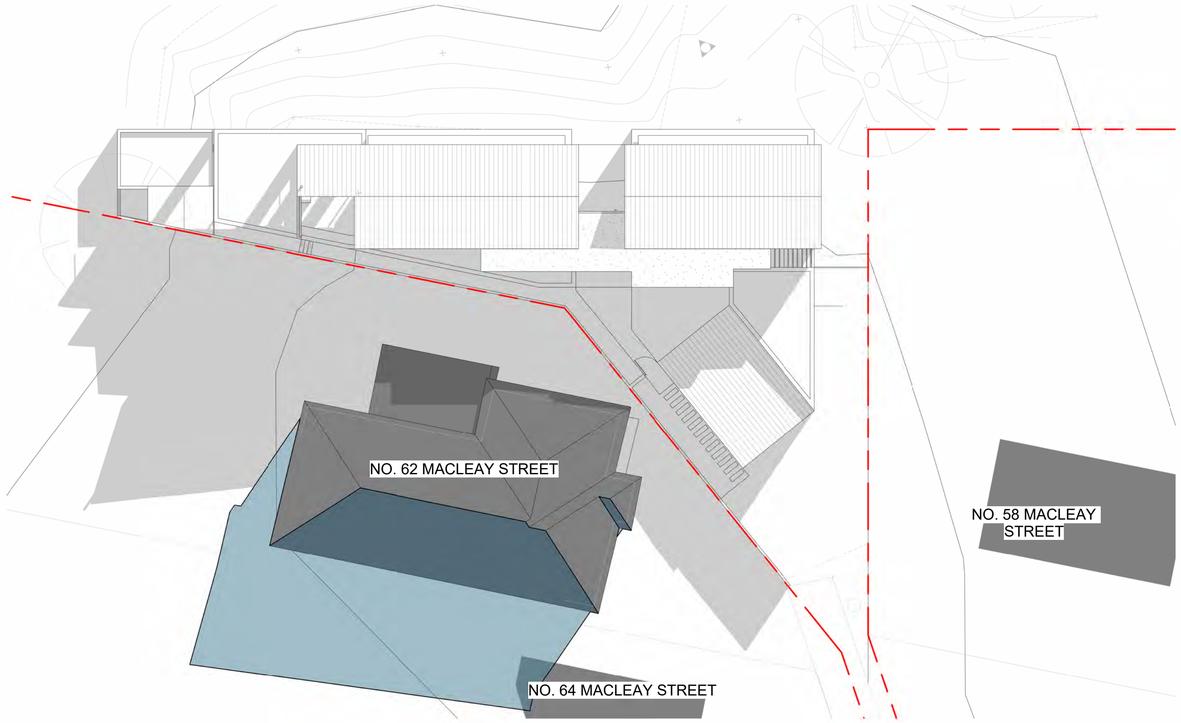
NEW DWELLING AT
60 MACLEAY STREET,
NARRAWALLEE
FOR D & T HARTWIG
project description:

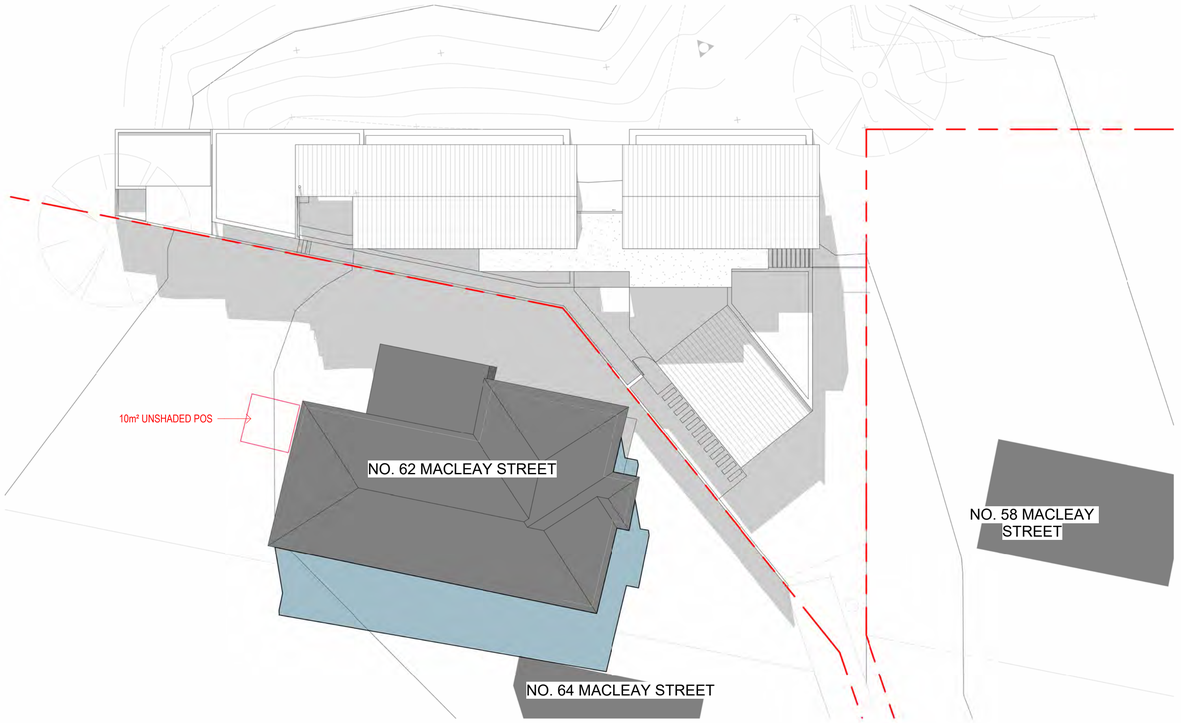
BUILDING ENVELOPE
SETBACK PLANE 3D
this sheet:

north

date: 22.10.2021	scale: As indicated
drawn: JY	checked: DS
933 project no.	DA401 sheet no. / B revision



1 JUNE 21 - 9AM SHADOWS
1 : 200



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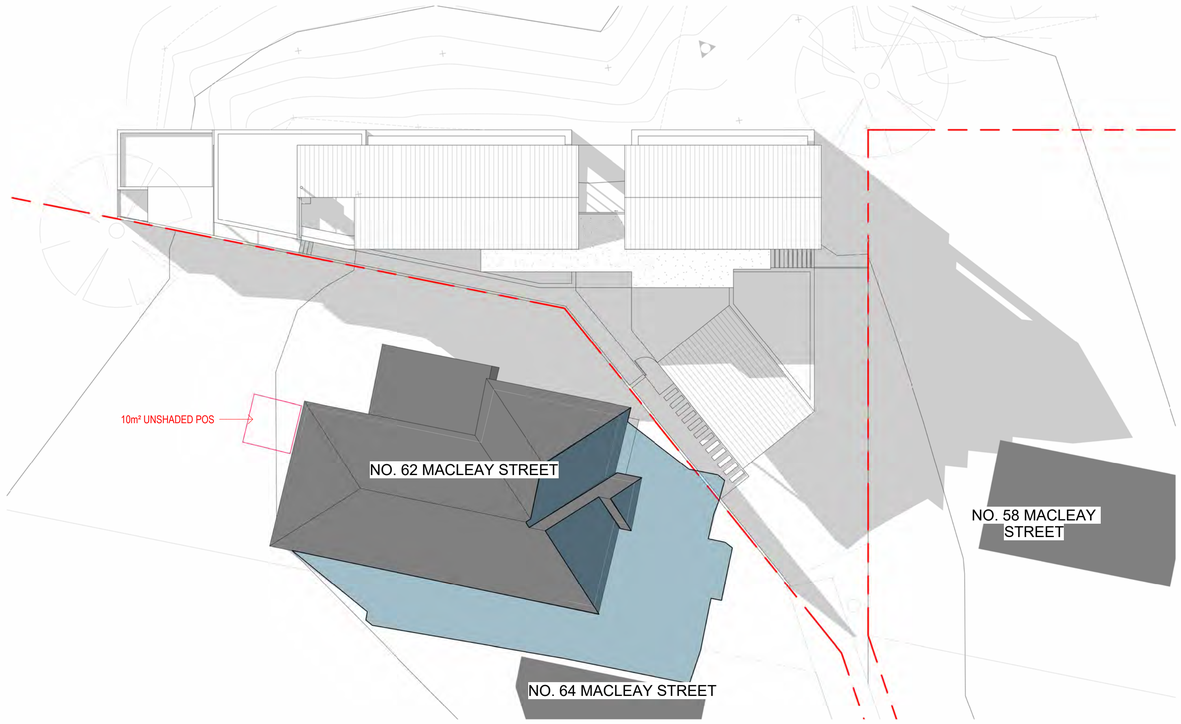

3 JUNE 21 - 3PM SHADOWS
1 : 200

LEGEND

PROPOSED NEW SHADOWS CAST

EXISTING SHADOWS CAST BY NO. 62 MACLEAY ROAD

NOTE:
CHECK ALL DIMENSIONS ON SITE BEFORE COMMENCING FABRICATION. USE FIGURED DIMENSIONS AND DO NOT SCALE OFF THE DRAWINGS.

REV	DATE	DETAILS
A	22.10.2021	LEC REVISION DRAFT
B	08.11.2021	LEC REVISION DRAFT
C	12.11.2021	COUNCIL CONTENTION AMENDMENTS

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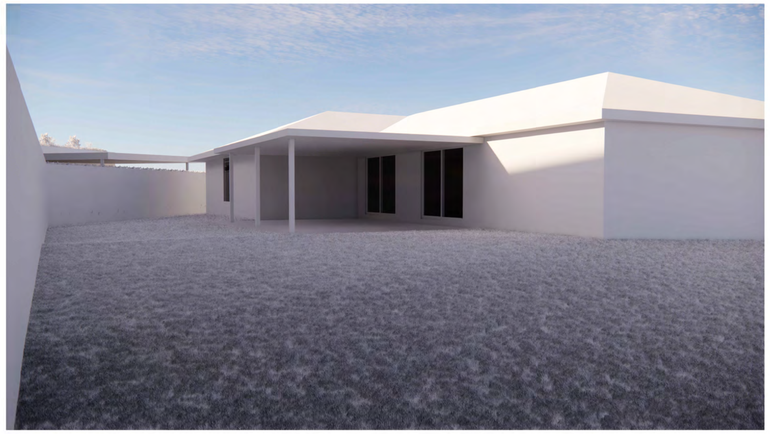
NOMINATED ARCHITECT - DAVID SMYTH - REGISTRATION NO. 10044 NSW

project description: NEW DWELLING AT 60 MACLEAY STREET, NARRAWALLEE FOR D & T HARTWIG

this sheet: SHADOW DIAGRAMS

north

date: 22.10.2021	scale: 1 : 200
drawn: JY	checked: DS
933 project no.	DA410 sheet no.
	C revision



JUNE 21 - 9AM

JUNE 21 - 10AM

JUNE 21 - 11AM

JUNE 21 - 12PM

NO PROPOSED NEW SHADOWS CAST OVER NEIGHBOUR'S OPENINGS

JUNE 21 - 1PM

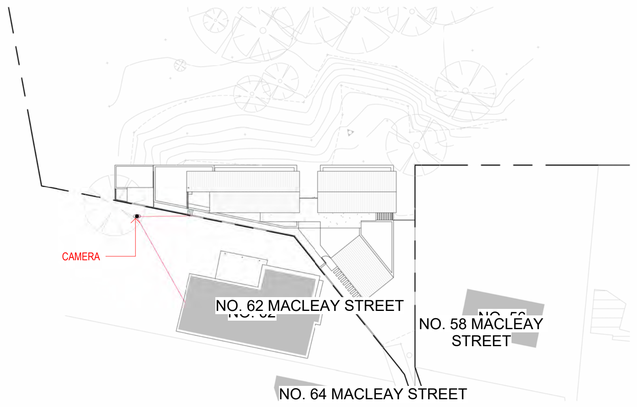
NO PROPOSED NEW SHADOWS CAST OVER NEIGHBOUR'S OPENINGS

JUNE 21 - 2PM

NO PROPOSED NEW SHADOWS CAST OVER NEIGHBOUR'S OPENINGS

JUNE 21 - 3PM

NO PROPOSED NEW SHADOWS CAST OVER NEIGHBOUR'S OPENINGS



KEY PLAN

1 : 500

NOTE:
CHECK ALL DIMENSIONS ON SITE BEFORE COMMENCING FABRICATION. USE FIGURED DIMENSIONS AND DO NOT SCALE OFF THE DRAWINGS.

REV	DATE	DETAILS
A	22.10.2021	LEC REVISION DRAFT
B	08.11.2021	LEC REVISION DRAFT
C	12.11.2021	COUNCIL CONTENTION AMENDMENTS

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NOMINATED ARCHITECT - DAVID SMYTH - REGISTRATION NO. 10044 NSW

NEW DWELLING AT
60 MACLEAY STREET,
NARRAWALLEE
FOR D & T HARTWIG
project description:

SHADOWS CAST ON NO. 62 MACLEAY STREET ON JUNE 21
this sheet:

north

date: 22.10.2021	scale: 1 : 500
drawn: JY	checked: DS
933 project no.	DA411 sheet no.
C revision	

Appendix C: Site Images

Photograph 1: View of the site looking west along the elevated back barrier berm.

Photograph 2: View looking north-east along the site.

Photograph 3: View looking south-west from lower portion of property towards the site with water ponding.

Photograph 4: View looking south-east looking towards the site.

revision	description	drawn	approved	date
	Plate1	XJ	KEG	19/11/2021

TERRA INSIGHT

client:	**Planning Lawyer Solutions**
project:	**Acid Sulfate Soil Investigation** **No. 60 Macleay Street Narrawallee**
Title	**Images of the site**
scale	NTS
original size	**A3**
project no:	**TERRA21-502**
Plate no:	**1**

Photograph 5: View looking north at level area.

Photograph 6: Material encountered in BH01.

Photographs 7: Material encountered in BH02.

Photograph 8: Natural material encountered on DCP tip.

revision	description	drawn	approved	date
	Plate2	XJ	KEG	19/11/2021

TERRA INSIGHT

client:	**Planning Lawyer Solutions**
project:	**Acid Sulfate Soil Investigation** **No. 60 Macleay Street Narrawallee**
Title	**Images of the site**
scale	NTS
original size	**A3**
project no:	**TERRA21-502**
Plate no:	**2**

Appendix D: Engineering Logs

TERRA INSIGHT

How to interpret the engineering logs in Your Report

FIELD DECRIPTIONS OF SOILS

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)				USC	PRIMARY NAME
COARSE GRAINED SOILS More than 65% of materials less than 63 mm is larger than 0.075 mm	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	GRAVEL
			Predominantly one size or a range of sizes with more intermediate sizes missing.	GP	GRAVEL
		GRAVELS WITH FINES Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	SILTY GRAVEL
			Plastic fines (for identification procedures see CL below)	GC	CLAYEY GRAVEL
	SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes	SW	SAND
			Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	SAND
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).	SM	SILTY SAND
			Plastic fines (for identification procedures see CL below).	SC	CLAYEY SAND

FINE GRAINED SOILS More than 35% of material less than 63 mm is smaller than 0.075 mm	IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm (Note a 75Um particle is about the smallest particle that is visible to the naked eye.)				
		DRY STRENGTH	DILATANCY	TOUGHNESS	USC	PRIMARY NAME
	SILTS & CLAYS Liquid limit less than 50	None to Low	Quick to slow	None	ML	SILT
		Medium to High	None	Medium	CL	CLAY
		Low to medium	Slow to very slow	Low	CL	ORGANIC SILT
	SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium	MH	SILT
		High	None	High	CH	CLAY
		Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC	Readily identified by colour, odour, spongy feel and frequently by fibrous texture by fibrous texture.				PT	PEAT

● Low plasticity – Liquid Limit w_L less than 35%. ● Medium plasticity – w_L between 35% and 50%. ● High plasticity – w_L greater than 50%.

Particle size descriptive terms

NAME	SUBDIVISION	SIZE
Boulders Cobbles		>200 mm 63 mm to 200 mm
Gravel	coarse medium fine	20 mm to 63 mm 6 mm to 20 mm 2.36 mm to 6 mm
Sand	coarse medium fine	600 µm to 2.36 mm 200 µm to 600 µm 75 µm to 200 µm

Minor components

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

TERRA INSIGHT

How to interpret the engineering logs in Your Report

Moisture condition

TERM	DEFINITION
Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

Soil structure

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

Consistency of cohesive soils

TERM	UNDRAINED STRENGTH s_u (kPa)	VISUAL OBSERVATION IN FIELD
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 – 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 – 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 – 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 – 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

Density of granular soils

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 – 35
Medium Dense	35 – 65
Dense	65 – 85
Very Dense	Greater than 85

Geological origin

TRANSPORTED SOILS

Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TERRA INSIGHT

How to interpret the engineering logs in Your Report

FIELD DESCRIPTIONS OF ROCK

The descriptive terms used by Terra Insight are given below. They are broadly consistent with Australian Standard AS1726-1993.

Rock Substance	In engineering terms rock substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

Classification of weathering products

Term	Abbreviation	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 Material	XW	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	HW	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	MW	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	SW	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	FR	Rock substance unaffected by weathering.

Notes on Weathering:

AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.

Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

Rock substance strength terms

Term	Abbreviation	UCS (MPa)	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	VL	<2	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	M	6 to 20	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	60 to 200	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	EH	>200	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index Is(50). The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

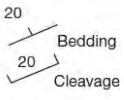
SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

TERRA INSIGHT

How to interpret the engineering logs in Your Report

Common defects observed in rock

Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
Sheared Zone (Note 3)	Zone of rock substance 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.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties			
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.

Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

DEFECT SHAPE TERMS

Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Veneer	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

TERRA INSIGHT

Borehole No.
BH01
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA21-502

Client:	Planning Lawyer	Commenced:	26/10/2021
Project Name:	Geotechincal Investigation	Completed:	26/10/2021
Hole Location:	No. 60 Macleay Street, Narrawallee NSW	Logged By:	XJ
Hole Position:	269705.0 m E 6090146.0 m N MGA94 Zone 56	Checked By:	KG

Drill Model and Mounting:	1.8t excavator	Inclination:	-90°	RL Surface:	3.10 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	Gary Fox

Drilling Information								Soil Description					Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm Termination	Structure and Additional Observations
			Not Encountered	S1 0.00-0.50 m					SM	Silty SAND: fine to medium sand, grey, low plasticity	M	MD	3 8 4	TOPSOIL
									CI-CH	Silty Sandy CLAY: medium to high plasticity, yellow brown, fine to medium sand	M	F	2	FILL
				S2 0.50-1.00 m		2.6	0.5		CI	Sandy CLAY: medium plasticity, brown, fine to medium sand	M	St	10 6 9 4	
									CI	Silty Sandy CLAY: medium plasticity, white, fine to medium plasticity	M	St	7 6	ALLUVIAL SOIL
				S3 1.00-1.50 m		2.1	1.0		CI	Sandy CLAY: medium plasticity, red brown, fine to coarse sand, with fine to medium sub angular gravels			6 11 9 8	
				S4 1.50-2.00 m		1.6	1.5				M	VSt	9 5 4 5 6 5	
						1.1	2.0			Hole Terminated at 2.00 m Target			5	
						0.6	2.5						5 4 6 8 9 9 8	
						0.1	3.0							
						-0.4	3.5							

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

TERRA INSIGHT

Borehole No.
BH02
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA21-502

Client:	Planning Lawyer	Commenced:	26/10/2021
Project Name:	Geotechincal Investigation	Completed:	26/10/2021
Hole Location:	No. 60 Macleay Street, Narrawallee NSW	Logged By:	XJ
Hole Position:	269691.0 m E 6090163.0 m N MGA94 Zone 56	Checked By:	KG

Drill Model and Mounting:	1.8t excavator	Inclination:	-90°	RL Surface:	2.90 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	Gary Fox

Drilling Information								Soil Description					Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm	Structure and Additional Observations
				S1 0.00-0.50 m					CL-CI	Clayey SAND: fine to medium sand, grey brown, low plasticity fines	W	F		TOPSOIL
									CI-CH	Silty Sandy CLAY: medium plasticity, white, fine to medium sand				ALLUVIAL SOIL
				S2 0.50-1.00 m		2.4	0.5				D - M	St		
									SW	Sandy CLAY: medium plasticity, red brown, fine to coarse sand, with fine to medium sub angular gravels				
				S3 1.00-1.50 m		1.9	1.0				M	St		
				S4 1.50-2.00 m		1.4	1.5							
						0.9	2.0			Hole Terminated at 2.00 m Target				
						0.4	2.5							
						-0.1	3.0							
						-0.6	3.5							

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

TERRA INSIGHT

Borehole No.
BH03
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA21-502

Client:	Planning Lawyer	Commenced:	26/10/2021
Project Name:	Geotechincal Investigation	Completed:	26/10/2021
Hole Location:	No. 60 Macleay Street, Narrawallee NSW	Logged By:	XJ
Hole Position:	269704.0 m E 6090158.0 m N MGA94 Zone 56	Checked By:	KG

Drill Model and Mounting:	1.8t excavator	Inclination:	-90°	RL Surface:	3.00 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	Gary Fox

Drilling Information								Soil Description					Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm Termination	Structure and Additional Observations
			Not Encountered	S1 0.00-0.50 m					SW	Clayey SAND: fine to medium sand, grey brown, low plasticity fines	M - W	F	3	TOPSOIL
									Cl	Sandy CLAY: medium plasticity, orange brown and yellow brown and grey mottled, fine to medium sand	M	St	4 4 7	FILL
				S2 0.50-1.00 m		2.5	0.5		Cl	Silty Sandy CLAY: medium plasticity, white, fine to medium sand	D - M	St	8 7 8	ALLUVIAL SOIL
				S3 1.00-1.50 m		2.0	1.0		Cl	Sandy CLAY: medium plasticity, red brown, fine to coarse sand, with fine to medium sub angular gravels	M	St	7 14 11 14 8 9 5 8	
				S4 1.50-2.00 m		1.5	1.5						6 6 3 3 4	
						1.0	2.0			Hole Terminated at 2.00 m Target			4 9 11 7 6	
						0.5	2.5						5 4 6 5 4	
						0.0	3.0						5 4 4 4 5	
						-0.5	3.5						6 5	

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

TERRA INSIGHT

Borehole No.
BH04
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA21-502

Client:	Planning Lawyer	Commenced:	26/10/2021
Project Name:	Geotechincal Investigation	Completed:	26/10/2021
Hole Location:	No. 60 Macleay Street, Narrawallee NSW	Logged By:	XJ
Hole Position:	269711.0 m E 6090151.0 m N MGA94 Zone 56	Checked By:	KG

Drill Model and Mounting:	1.8t excavator	Inclination:	-90°	RL Surface:	3.10 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	Gary Fox

Drilling Information								Soil Description					Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm	Structure and Additional Observations
				S1 0.00-0.50 m					SM	Silty SAND: fine to medium sand, grey, low plasticity	M - W	MD		TOPSOIL
				S2 0.50-1.00 m		2.6	0.5		CI-CH	Silty Sandy CLAY: medium to high plasticity, yellow brown, fine to medium sand	M	St		FILL
				S3 1.00-1.50 m		2.1	1.0		CI	Sandy CLAY: medium plasticity, brown, fine to medium sand	M	VSt		ALLUVIAL SOIL
				S4 1.50-2.00 m		1.6	1.5		CI	Silty Sandy CLAY: medium plasticity, white, fine to medium plasticity	M	St		
						1.1	2.0			Hole Terminated at 2.00 m Target				
						0.6	2.5							
						0.1	3.0							
						-0.4	3.5							

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

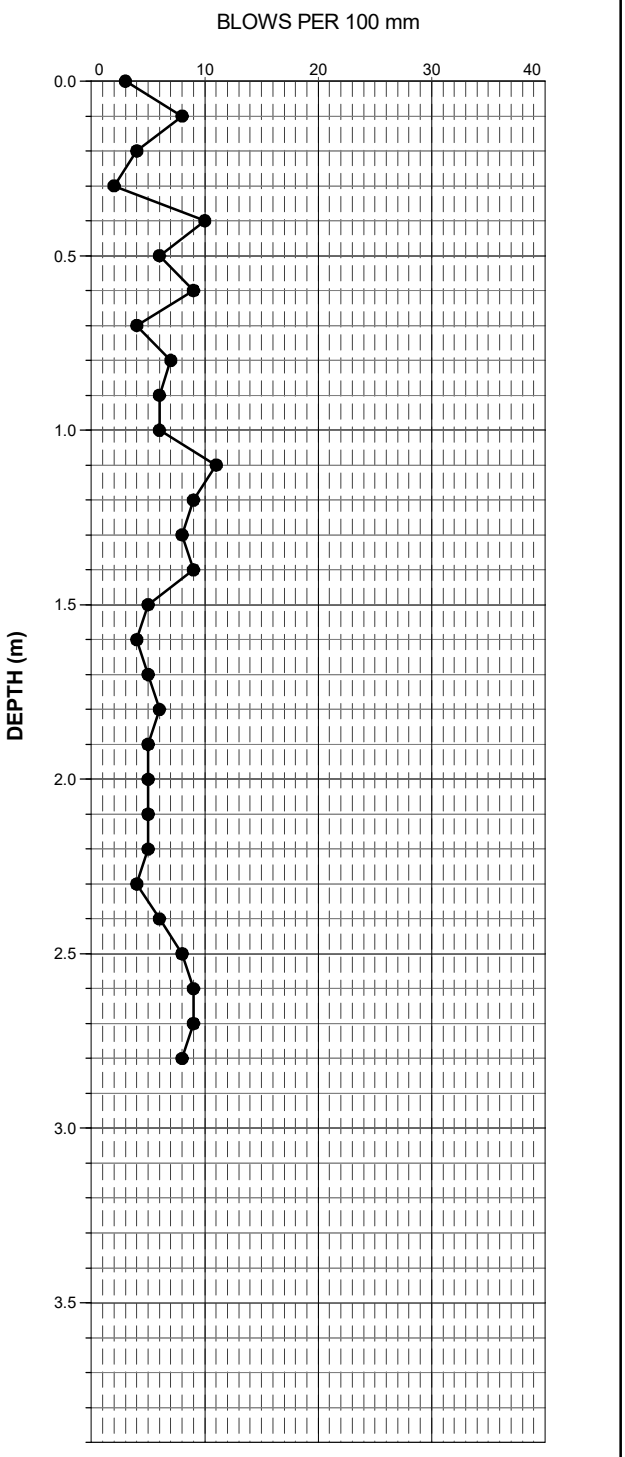
TERRA INSIGHT

9 KG DYNAMIC CONE PENETROMETER

Hole ID: **BH01**

CLIENT	: Planning Lawyer	POSITION	:	SHEET	: 1 OF 1
CONTRACTOR	:	EASTING	: 269705.0 m	STATUS	:
PROJECT	: Geotechincal Investigation	NORTHING	: 6090146.0 m	LOGGED BY	: XJ
LOCATION	: No. 60 Macleay Street, Narrawallee NSW	COORD. SYS.	: MGA94 Zone 56	DRILL DATE	: 26/10/2021
PROJECT No.	: TERRA21-502	GROUND RL	: 3.10 m AHD		

DEPTH (m)	NO OF BLOWS PER 100 mm
0.00	3
0.10	8
0.20	4
0.30	2
0.40	10
0.50	6
0.60	9
0.70	4
0.80	7
0.90	6
1.00	6
1.10	11
1.20	9
1.30	8
1.40	9
1.50	5
1.60	4
1.70	5
1.80	6
1.90	5
2.00	5
2.10	5
2.20	5
2.30	4
2.40	6
2.50	8
2.60	9
2.70	9
2.80	8



Final Depth (m)	2.80

RIG	:	CHECKED BY	: KG	REMARK
INCLINATION	:	CHECKED DATE	: 26/10/2021	Termination
AZIMUTH	:	APPROVED BY	: KG	
HOLE DIA.	:	APPROVED DATE	: 26/10/2021	

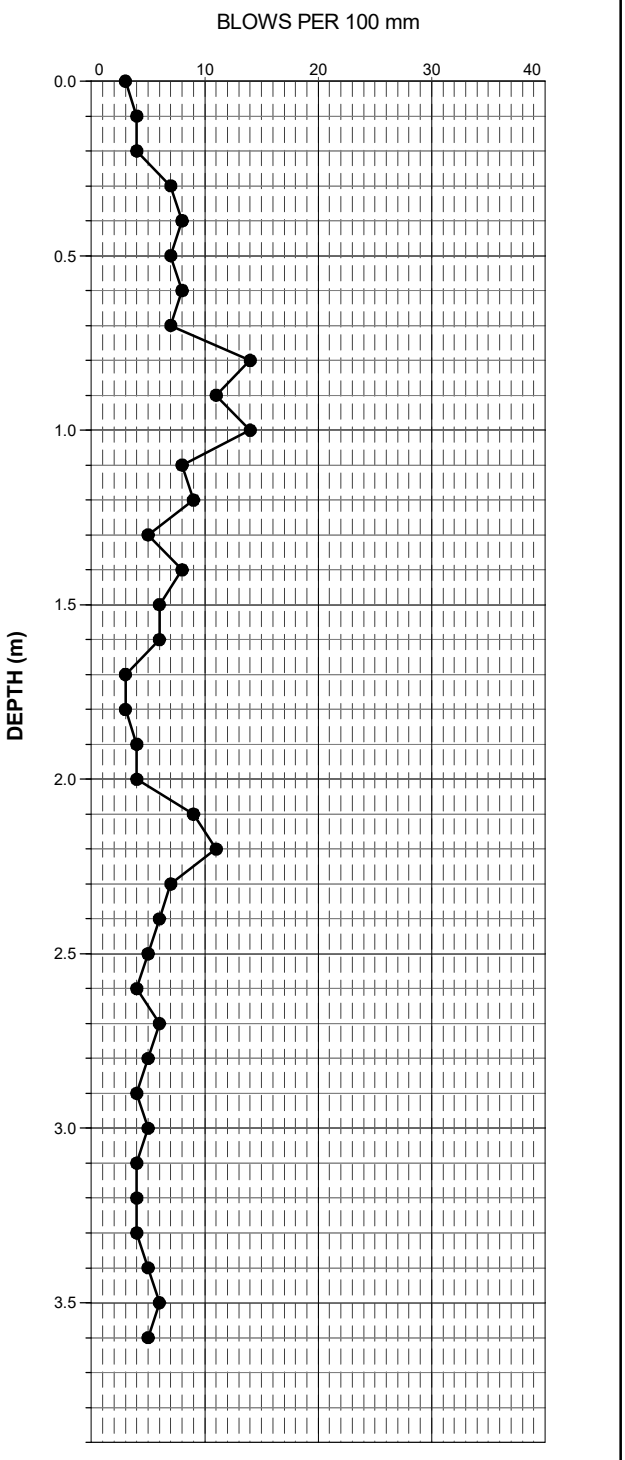
TERRA INSIGHT

9 KG DYNAMIC CONE PENETROMETER

Hole ID **BH03**

CLIENT	: Planning Lawyer	POSITION	:	SHEET	: 1 OF 1
CONTRACTOR	:	EASTING	: 269704.0 m	STATUS	:
PROJECT	: Geotechincal Investigation	NORTHING	: 6090158.0 m	LOGGED BY	: XJ
LOCATION	: No. 60 Macleay Street, Narrawallee NSW	COORD. SYS.	: MGA94 Zone 56	DRILL DATE	: 26/10/2021
PROJECT No.	: TERRA21-502	GROUND RL	: 3.00 m AHD		

DEPTH (m)	NO OF BLOWS PER 100 mm
0.00	3
0.10	4
0.20	4
0.30	7
0.40	8
0.50	7
0.60	8
0.70	7
0.80	14
0.90	11
1.00	14
1.10	8
1.20	9
1.30	5
1.40	8
1.50	6
1.60	6
1.70	3
1.80	3
1.90	4
2.00	4
2.10	9
2.20	11
2.30	7
2.40	6
2.50	5
2.60	4
2.70	6
2.80	5
2.90	4
3.00	5
3.10	4
3.20	4
3.30	4
3.40	5
3.50	6
3.60	5



Final Depth (m)	3.60

RIG	:	CHECKED BY	: KG	REMARK
INCLINATION	:	CHECKED DATE	: 26/10/2021	Termination
AZIMUTH	:	APPROVED BY	: KG	
HOLE DIA.	:	APPROVED DATE	: 26/10/2021	

Appendix E: Laboratory Certificates

TerraInsight Pty Ltd
U34 no 10-12 Sylvester Ave
Unanderra
NSW 2626

Attention: **Karen Gates**

Report **835474-S**
Project name 60 MACLEY ST NARRAWALLEE
Project ID TERRA21-502
Received Date Oct 26, 2021

Client Sample ID			BH01_S1_0.5	BH01_S2_1.0	BH01_S3_1.5	BH01_S4_2.0
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**W21-Oc56618**	**W21-Oc56619**	**W21-Oc56620**	**W21-Oc56621**
Date Sampled			**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	5.4	4.9	4.8	4.9
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	3.5	3.4	3.6	3.6
Reaction Ratings*[S05]	0	-	2.0	1.0	4.0	4.0

Client Sample ID			BH02_S1_0.5	BH02_S2_1.0	BH02_S3_1.5	BH02_S4_2.0
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**W21-Oc56622**	**W21-Oc56623**	**W21-Oc56624**	**W21-Oc56625**
Date Sampled			**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	4.9	5.2	5.4	5.4
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	4.0	3.4	3.7	3.5
Reaction Ratings*[S05]	0	-	1.0	4.0	4.0	4.0

Client Sample ID			BH03_S1_0.5	BH03_S2_1.0	BH03_S3_1.5	BH03_S4_2.0
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**W21-Oc56626**	**W21-Oc56627**	**W21-Oc56628**	**W21-Oc56629**
Date Sampled			**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	5.1	5.0	5.0	5.2
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	3.7	3.5	3.8	3.7
Reaction Ratings*[S05]	0	-	4.0	3.0	4.0	4.0

Client Sample ID			BH04_S1_0.5	BH04_S2_1.0	BH04_S3_1.5	BH04_S4_2.0
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**W21-Oc56630**	**W21-Oc56631**	**W21-Oc56632**	**W21-Oc56633**
Date Sampled			**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	4.9	4.8	5.3	5.4
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	3.7	3.7	4.2	4.4
Reaction Ratings*[S05]	0	-	3.0	3.0	4.0	4.0

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Acid Sulfate Soils Field pH Test	Brisbane	Nov 04, 2021	7 Days

- Method: LTM-GEN-7060 Determination of field pH (pHF) and field pH peroxide (pHFOX) tests

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web: www.eurofins.com.au
email: EnviroSales@eurofins.com

Eurofins Environment Testing Australia Pty Ltd
ABN: 50 005 085 521

Melbourne
6 Monterey Road
Dandenong South VIC 3175
Phone : +61 3 8564 5000
NATA # 1261 Site # 1254

Sydney
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16 Mars Road
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NATA # 1261 Site # 18217

Brisbane
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NATA # 1261 Site # 20794

Newcastle
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PO Box 60 Wickham 2293
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Eurofins ARL Pty Ltd
ABN: 91 05 0159 898

Perth
46-48 Banksia Road
Welshpool WA 6106
Phone : +61 8 6253 4444
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Eurofins Environment Testing NZ Limited
NZBN: 9429046024954

Auckland
35 O'Rorke Road
Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Company Name: TerraInsight Pty Ltd
Address: U34 no 10-12 Sylvester Ave
Unanderra
NSW 2626

Project Name: 60 MACLEY ST NARRAWALLEE
Project ID: TERRA21-502

Order No.:
Report #: 835474
Phone: 0458 008 030
Fax:

Received: Oct 26, 2021 4:53 PM
Due: Nov 2, 2021
Priority: 5 Day
Contact Name: Karen Gates

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Acid Sulfate Soils Field pH Test
Melbourne Laboratory - NATA # 1261 Site # 1254						
Sydney Laboratory - NATA # 1261 Site # 18217						
Brisbane Laboratory - NATA # 1261 Site # 20794						X
Mayfield Laboratory - NATA # 1261 Site # 25079						
Perth Laboratory - NATA # 2377 Site # 2370						
External Laboratory						
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**	
1	BH01_S1_0.5	Oct 26, 2021		Soil	W21-Oc56618	X
2	BH01_S2_1.0	Oct 26, 2021		Soil	W21-Oc56619	X
3	BH01_S3_1.5	Oct 26, 2021		Soil	W21-Oc56620	X
4	BH01_S4_2.0	Oct 26, 2021		Soil	W21-Oc56621	X
5	BH02_S1_0.5	Oct 26, 2021		Soil	W21-Oc56622	X
6	BH02_S2_1.0	Oct 26, 2021		Soil	W21-Oc56623	X
7	BH02_S3_1.5	Oct 26, 2021		Soil	W21-Oc56624	X
8	BH02_S4_2.0	Oct 26, 2021		Soil	W21-Oc56625	X
9	BH03_S1_0.5	Oct 26, 2021		Soil	W21-Oc56626	X

Date Reported:Nov 05, 2021

Date Reported:Nov 05, 2021

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web: www.eurofins.com.au
email: EnviroSales@eurofins.com

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ABN: 50 005 085 521

Melbourne
6 Monterey Road
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Auckland
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Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

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Company Name: TerraInsight Pty Ltd
Address: U34 no 10-12 Sylvester Ave
Unanderra
NSW 2626

Project Name: 60 MACLEY ST NARRAWALLEE
Project ID: TERRA21-502

Order No.:
Report #: 835474
Phone: 0458 008 030
Fax:

Received: Oct 26, 2021 4:53 PM
Due: Nov 2, 2021
Priority: 5 Day
Contact Name: Karen Gates

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Acid Sulfate Soils Field pH Test
Melbourne Laboratory - NATA # 1261 Site # 1254						
Sydney Laboratory - NATA # 1261 Site # 18217						
Brisbane Laboratory - NATA # 1261 Site # 20794						X
Mayfield Laboratory - NATA # 1261 Site # 25079						
Perth Laboratory - NATA # 2377 Site # 2370						
External Laboratory						
10	BH03_S2_1.0	Oct 26, 2021		Soil	W21-Oc56627	X
11	BH03_S3_1.5	Oct 26, 2021		Soil	W21-Oc56628	X
12	BH03_S4_2.0	Oct 26, 2021		Soil	W21-Oc56629	X
13	BH04_S1_0.5	Oct 26, 2021		Soil	W21-Oc56630	X
14	BH04_S2_1.0	Oct 26, 2021		Soil	W21-Oc56631	X
15	BH04_S3_1.5	Oct 26, 2021		Soil	W21-Oc56632	X
16	BH04_S4_2.0	Oct 26, 2021		Soil	W21-Oc56633	X
Test Counts						16

Date Reported:Nov 05, 2021

Date Reported:Nov 05, 2021

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

Units

mg/kg: milligrams per kilogram
mg/L: milligrams per litre
ug/L: micrograms per litre
ppm: Parts per million
ppb: Parts per billion
%: Percentage
org/100mL: Organisms per 100 millilitres
NTU: Nephelometric Turbidity Units
MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

The acceptance criteria should be used as a guide only and may be different when site specific Sampling Analysis and Quality Plan (SAQP) have been implemented

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs..

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM where no positive PFAS results have been reported have been reviewed and no data was affected.

.

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
Acid Sulfate Soils Field pH Test				Result 1	Result 2	RPD			
pH-F (Field pH test)*	W21-Oc56624	CP	pH Units	5.4	5.4	pass	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
S05	Field Screen uses the following fizz rating to classify the rate the samples reacted to the peroxide: 1.0; No reaction to slight. 2.0; Moderate reaction. 3.0; Strong reaction with persistent froth. 4.0; Extreme reaction.

Authorised by:

Ursula Long	Analytical Services Manager
Myles Clark	Senior Analyst-SPOCAS (QLD)

Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

TerraInsight Pty Ltd
U34 no 10-12 Sylvester Ave
Unanderra
NSW 2626

Attention: **Karen Gates**

Report **839296-S**
Project name 60 MACLEY ST NARRAWALLEE
Project ID TERRA21-502
Received Date Nov 08, 2021

Client Sample ID			**BH02_S2_1.0**
Sample Matrix			**Soil**
Eurofins Sample No.			**B21-No20230**
Date Sampled			**Oct 26, 2021**
Test/Reference	LOR	Unit	
Extraneous Material			
<2mm Fraction	0.005	g	24
>2mm Fraction	0.005	g	< 0.005
Analysed Material	0.1	%	100
Extraneous Material	0.1	%	< 0.1
Chromium Suite - NASSG (Excluding ANC)			
CRS suite - NASSG (Excluding ANC) - Liming Rate	1	kg CaCO3/t	1.7
CRS suite - NASSG (Excluding ANC) - Net Acidity (Acidity Units)	10	mol H+/t	22
CRS Suite - NASSG (Excluding ANC) - Net Acidity (Sulfur Units)	0.02	% S	0.04
pH-KCL	0.1	pH Units	5.3
Acid trail - Titratable Actual Acidity	2	mol H+/t	17
sulfidic - TAA equiv. S% pyrite	0.003	% pyrite S	0.030
Chromium Reducible Sulfur[S04]	0.005	% S	0.009
Chromium Reducible Sulfur -acidity units	3	mol H+/t	5.6
Sulfur - KCl Extractable	0.02	% S	N/A
HCl Extractable Sulfur Correction Factor	1	factor	2.0
HCl Extractable Sulfur	0.02	% S	N/A
Net Acid soluble sulfur	0.02	% S	N/A
Net Acid soluble sulfur - acidity units	10	mol H+/t	N/A
Net Acid soluble sulfur - equivalent S% pyrite[S02]	0.02	% S	N/A
Acid Neutralising Capacity (ANCbt)	0.01	% CaCO3	N/A
Acid Neutralising Capacity - acidity (a-ANCbt)	2	mol H+/t	N/A
Acid Neutralising Capacity - equivalent S% pyrite (s-ANCbt)[S03]	0.02	% S	N/A
ANC Fineness Factor		factor	1.5
CRS Suite - Net Acidity (Sulfur Units)	0.02	% S	0.04
CRS Suite - Net Acidity (Acidity Units)	10	mol H+/t	22
CRS Suite - Liming Rate[S01]	1	kg CaCO3/t	1.7
% Moisture	1	%	12

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Extraneous Material	Brisbane	Nov 09, 2021	6 Week
- Method: LTM-GEN-7050/7070			
Chromium Suite - NASSG (Excluding ANC)	Brisbane	Nov 09, 2021	6 Week
- Method: LTM-GEN-7070 Chromium Reducible Sulfur Suite			
% Moisture	Brisbane	Nov 09, 2021	14 Days
- Method: LTM-GEN-7080 Moisture			

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web: www.eurofins.com.au
email: EnviroSales@eurofins.com

Eurofins Environment Testing Australia Pty Ltd
ABN: 50 005 085 521

Melbourne
6 Monterey Road
Dandenong South VIC 3175
Phone : +61 3 8564 5000
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IANZ # 1290

Company Name: TerraInsight Pty Ltd
Address: U34 no 10-12 Sylvester Ave
Unanderra
NSW 2626

Project Name: 60 MACLEY ST NARRAWALLEE
Project ID: TERRA21-502

Order No.:
Report #: 839296
Phone: 0458 008 030
Fax:

Received: Nov 8, 2021 12:59 PM
Due: Nov 15, 2021
Priority: 5 Day
Contact Name: Karen Gates

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Moisture Set	Chromium Suite - NASSG (Excluding ANC)
Melbourne Laboratory - NATA # 1261 Site # 1254							
Sydney Laboratory - NATA # 1261 Site # 18217							
Brisbane Laboratory - NATA # 1261 Site # 20794						X	X
Mayfield Laboratory - NATA # 1261 Site # 25079							
Perth Laboratory - NATA # 2377 Site # 2370							
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	BH02_S2_1.0	Oct 26, 2021		Soil	B21-No20230	X	X
Test Counts						1	1

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

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ug/L: micrograms per litre
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ppb: Parts per billion
%: Percentage
org/100mL: Organisms per 100 millilitres
NTU: Nephelometric Turbidity Units
MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

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TEQ	Toxic Equivalency Quotient
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

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RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

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Results >20 times the LOR : RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs..

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM where no positive PFAS results have been reported have been reviewed and no data was affected.

.

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
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3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
LCS - % Recovery							
Chromium Suite - NASSG (Excluding ANC)							
pH-KCL	%	100			80-120	Pass	
Acid trail - Titratable Actual Acidity	%	91			80-120	Pass	
Chromium Reducible Sulfur	%	97			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
Chromium Suite - NASSG (Excluding ANC)				Result 1	Result 2	RPD			
CRS suite - NASSG (Excluding ANC) - Liming Rate	B21-No24550	NCP	kg CaCO3/t	1.6	1.6	1.0	30%	Pass	
CRS suite - NASSG (Excluding ANC) - Net Acidity (Acidity Units)	B21-No24550	NCP	mol H+/t	21	22	1.0	30%	Pass	
CRS Suite - NASSG (Excluding ANC) - Net Acidity (Sulfur Units)	B21-No24550	NCP	% S	0.03	0.03	1.0	30%	Pass	
pH-KCL	B21-No24550	NCP	pH Units	9.4	9.4	<1	30%	Pass	
Acid trail - Titratable Actual Acidity	B21-No24550	NCP	mol H+/t	< 2	< 2	<1	30%	Pass	
sulfidic - TAA equiv. S% pyrite	B21-No24550	NCP	% pyrite S	< 0.003	< 0.003	<1	30%	Pass	
Chromium Reducible Sulfur	B21-No24550	NCP	% S	0.034	0.035	1.0	30%	Pass	
Chromium Reducible Sulfur -acidity units	B21-No24550	NCP	mol H+/t	21	22	1.0	30%	Pass	
Sulfur - KCl Extractable	B21-No24550	NCP	% S	N/A	N/A	N/A	30%	Pass	
HCl Extractable Sulfur	B21-No24550	NCP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur	B21-No24550	NCP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur - acidity units	B21-No24550	NCP	mol H+/t	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur - equivalent S% pyrite	B21-No24550	NCP	% S	N/A	N/A	N/A	30%	Pass	
Acid Neutralising Capacity (ANCbt)	B21-No24550	NCP	% CaCO3	2.8	3.0	4.0	30%	Pass	
Acid Neutralising Capacity - equivalent S% pyrite (s-ANCbt)	B21-No24550	NCP	% S	0.91	0.95	4.0	30%	Pass	
ANC Fineness Factor	B21-No24550	NCP	factor	1.5	1.5	<1	30%	Pass	
CRS Suite - Net Acidity (Sulfur Units)	B21-No24550	NCP	% S	< 0.02	< 0.02	<1	30%	Pass	
CRS Suite - Net Acidity (Acidity Units)	B21-No24550	NCP	mol H+/t	< 10	< 10	<1	30%	Pass	
CRS Suite - Liming Rate	B21-No24550	NCP	kg CaCO3/t	< 1	< 1	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
S01	Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil' multiply 'reported results' x 'wet bulk density of soil in t/m3'
S02	Retained Acidity is Reported when the pHKCl is less than pH 4.5
S03	Acid Neutralising Capacity is only required if the pHKCl if greater than or equal to pH 6.5
S04	Acid Sulfate Soil Samples have a 24 hour holding time unless frozen or dried within that period

Authorised by:

Ursula Long	Analytical Services Manager
Myles Clark	Senior Analyst-SPOCAS (QLD)

Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Appendix F: ASS Handouts for residential developments

Urban Development in Acid Sulfate Soil

August 1998

Urban development and acid sulfate soils

Urban development in the coastal zone is often undertaken in areas that contain acid sulfate soils (ASS). In the past, subdivisions have been developed in these areas without appropriate management measures resulting in the foundations of houses corroding, landscaping which would not grow, sewage and water pipes which needed replacing and iron stained drains running with acid water.

The pressure of urban development as well as more intensive agricultural activities has resulted in increased disturbance of these soils with consequential degradation of the water quality in coastal waters. This has contributed to significant impacts on commercial and oyster industry productivity as well as on the recreational fishing and tourist industry.

What are acid sulfate soils?

Acid sulfate soils contain iron sulfides. Iron sulfides are found underneath the watertable or in a waterlogged condition. While under water, these soils are stable and the sulfides do not cause a problem. When the sulfides are exposed to air as a result of drainage, the construction of levees or even deep cultivation, they form sulfuric acid. In addition to reducing the productivity of the land the acid leachate can acidify adjoining drains, wetlands, creeks and estuaries leading to severe environmental damage as well as loss of fisheries productivity.

The pH is a measure of acidity. Each unit of pH represents a 10 fold change in the concentration of acidity. For example, pH 5 is 10 times more acid than pH 6. The pH of water is usually around neutral approximately pH 7-8. When water has a pH of 5.5 or below, it can kill fish, restrict plant growth and reduce agricultural productivity, and corrode metal and damaging concrete foundations and engineering structures.

Acid sulfate soils contain pyrite which, when exposed to air, forms sulfuric acid. For every tonne of pyrite completely oxidised, 1.6 tonnes of pure sulfuric acid is produced. If the soils remain covered or waterlogged and air is excluded, no acid is generated.

When the soils are excavated or drained by activities such as land formation, drainage, road and marina construction and the laying of pipes, acid is generated which can leach out acidifying soils resulting in severe off-site and on-site environmental impacts. Without appropriate management measures, impacts can include poor plant growth and failed landscaping with consequent erosion problems, corrosion of concrete drains, pipes and the foundations of buildings and bridges, and the degradation of water quality in lakes, creeks or rivers resulting in the killing of fish, increased mosquito populations and water unsuitable for recreational or drinking purposes.

Where do acid sulfate soils occur?

Acid sulfate soils are naturally occurring soils typically in low-lying coastal areas less than five metres above the high tide level. In NSW, acid sulfate soils has been found in every coastal estuary and embayment. The Acid Sulfate Soils Risk Maps developed by Department of Land and Water Conservation indicate the areas where acid sulfate soils are likely to be present. It is estimated that there are over 400,000 ha of acid sulfate soils already impacted by existing and new activities.

What do you need to do if acid sulfate soils are present

Where earthworks or dredging are proposed in coastal areas likely to contain acid sulfate soils, a preliminary assessment should be made to determine if acid sulfate soils would be disturbed. If likely, an acid sulfate soils management plan should be developed. This information sheet outlines how to recognise and confirm the presence of acid sulfate soils and to minimise the impact on the environment during construction and ongoing management of the development.

Preliminary assessment to identify acid sulfate soils

Acid sulfate material could be found at any low lying development sites on coastal floodplains particularly if adjacent a tidal rivers and estuaries. You can identify the presence and approximate distribution of acid sulfate soils by using existing mapping information and on-site indicators and field tests. This information is necessary as a first step in developing sustainable management strategies for acid sulfate soils.

Desktop assessment

Desktop assessments of acid sulfate soil maps, topographical maps and aerial photographs can help determine the likely presence of acid sulfate soils. The acid sulfate soil planning and risk maps for coastal areas in NSW (Department of Land and Water Conservation) should be the first step in the investigation. These maps can provide a useful indicator as to the likely presence or absence of acid sulfate soil by identifying areas of high, low or no probability of finding acid sulfate soils in the landscape. The maps do not describe the actual severity of acid sulfate soils (ie the percentage of iron sulfides).

Other indicators for the presence of acid sulfate soils include:

- soils deposited in river and on estuary floodplains below approximately 5-10 m
- coastal wetlands or back swamp areas; waterlogged or scalded areas; interdune swales or underlying coastal sand dunes
- areas where the dominant vegetation is mangroves, reeds, rushes and other swamp-tolerant or marine vegetation such as swamp mahogany, paper bark and swamp oak.

Surface inspection

Actual acid sulfate soils occur where the sulfides in the soils have been exposed to the air and acid is currently being generated. A field inspection for indicators of actual acid sulfate conditions can confirm that acid sulfate material is present on the site. The indicators include soils with pH less than 4; unusually clear or milky green drain water with a pH of less than 5.5; extensive rust-coloured iron stains on any drain surfaces, or iron-stained drain water and ochre deposits; butter-coloured jarosite present in surface spoil, on any material excavated and left exposed or in augured material showing yellow jarositic horizons or red, iron oxide mottling or corrosion of concrete and/or steel structures.

However, just because there are no indicators for actual acid sulfate soils, it doesn't mean that acid sulfate soils are not present. Where the iron sulfides have not been exposed to oxygen, then visual identification may prove difficult. These "potential" acid sulfate soils have the potential to generate acid after they are disturbed and exposed to air. Potential acid sulfate soils are typically waterlogged estuarine sands or silty sands; mid to dark grey to dark greenish grey in colour; soft, buttery consistency of a clay; or pH neutral.

Sub-surface inspection and sampling

The next step is to examine the soil profile by using an auger or backhoe pit. (Caution: take care when digging backhoe pits to ensure they do not slump). (See ASS Manual).

- sample the soil to at least the depth of the proposed excavation or estimated drop in watertable height if the groundwater level is likely to be disturbed. Due to the uneven distribution of iron sulfides in the soil, take at least five samples in any one area to understand the likely distribution
- if dredging is to be undertaken, when sampling of dredge material, attention should be paid when collecting sediment samples to ensure that fine silt and clay fraction containing high concentrations of iron sulfides do not drain from the sample during collection.

The pH of the samples should be tested in the field using a pH meter. If the pH is less than 4, it confirms the presence of actual acid sulfate soils. The Peroxide Test (described in the ASS Manual) provides a field test for potential acid sulfate soils. If any of the preliminary assessment indicates that acid sulfate soils could be present, engage a consultant to undertake a more rigorous soil survey and sampling program.

Laboratory Analysis

The conclusions drawn from the desk top assessment or field inspection should always be confirmed with laboratory analysis. Representative samples should be send for laboratory analysis, to confirm if acid sulfate soils are present and at what concentrations. It is recommended that qualified consultants do the sampling and a laboratory using methods in the ASS Manual undertake the analysis. Further information for determining the concentration of acid sulfate soil, its potential acid generation potential and management options can be found in the ASS Manual.

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Sustainable management of acid sulfate soils

Acid sulfate soils are manageable. It is important to recognise the constraints they pose to extractive industries and to manage the resource accordingly. The most sensible way to manage these soils is to incorporate their management into the operational plan for the extraction of the resource.

Know your site

The best way to minimise the impacts is to understand the distribution and characteristics of the acid sulfate material on the site. You need to know:

- where the acid sulfate soils occur (both laterally and with depth)
- the likely volume of actual acid sulfate soils to be disturbed and the likely quantity of iron
- the size fractions of the resource and what type of material the iron sulfide is associated with (silt, sand, gravel or clay)
- the surface and sub-surface hydrology of the site

Deciding on a Management Strategies

Once you know understand the characteristics of acid sulfate, you can make informed management decisions to reduce the risks to the environment and your liability. Options include:

- avoid disturbing acid sulfate soils by avoiding excavation where they are located
- if acid sulfate soil locations cannot be avoided, layout the site to avoid disturbing the acid sulfate material or lowering the watertable
- if acid sulfate soils are to be disturbed, neutralise the acid generation potential, neutralise any acid produced and prevent any acid leaving the site
- if acid sulfate soils have previously been disturbed on the site, design the extraction program to manage any acid already being produced and minimise further production
- ensure that excavated material is managed so that if it is to be used on-site or off-site for any purpose, acid will not be generated.

Outline of Management Options

- ***Avoid acid sulfate soils***

If a soil survey identifies areas containing acid sulfate soils within the excavation site, the most environmentally responsible approach is to avoid the disturbance of these areas. Selection of alternative non-acid sulfate sites in most cases is a preferable to costly remediation of environmental impacts caused by disturbing acid sulfate.

- ***Place iron sulfide sediments under water***

If you do excavate potential acid sulfate material, one option is to place this material or the iron sulfide components that have been separated from the extractive material immediately below the watertable. This may involve over-excavation of an area to provide a disposal site. This option is only practical when an appropriate water balance can be maintained indefinitely and it does not result in turbidity in natural waterbodies.

- ***Collect and treat acid leachate***

If the iron sulfide content of soil is very low, you may be able to oxidise the sulfides by exposing the soil to air and collect and treat the acid produced following exposure to air. If you decide on this approach which may take months to reach completion, the runoff and drainage waters must be contained so as not to contaminate any waters including groundwater. You will need to design containment structures which incorporate barriers or liners to contain all the acid leachate produced from the oxidised sulfides. The design of these structures needs to take local climatic conditions into account. The leachate needs to be neutralised to pH 6.5 - 7.5 using lime before disposal.

- ***Neutralising acid soil***

Traditional methods of ameliorating acid soils have relied on the addition of lime ($CaC0_3$). The ability of the soil itself to neutralise the acid (buffering capacity) depends on the amount of exchangeable bases, carbonates and easily weatherable silicate minerals in the soil. However, even though a soil may have buffering capacity, it could be exceeded by the acid-generating capacity of the soil. The soil's buffering capacity is not related solely to the quality of buffering materials present but, more importantly, to the available surface area and distribution in the soil. In many cases, the buffering agents (naturally occurring marine shell or added lime) may be too coarse to neutralise the acid before it is leached. Any liming material must be thoroughly mixed with the soil if all the acid generated by oxidation of iron sulfides is to be neutralised. The amounts of lime needed may be very large.

- ***Separation of acid sulfate material***

In wet dredging operations, it may be possible to separate the acid sulfate fines from the 'clean' excavated material by sluicing or hydrocycloning techniques. The concentrated acid sulfate fine material can the treated using the methods described above (if appropriate), In estuarine locations, the iron sulfide fraction can contain very high concentrations of salt reducing the possible disposal or treatments options.

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Prepare an Acid Sulfate Soils Management Plan

The management plan should outline how acid sulfate soils will be managed during all stages to minimise impacts on the environment, including the clearing of the site, earth works and landscaping and the digging of foundations for any structures on the site. It should include contingency measures to deal with unpredicted occurrences and monitoring to demonstrate that mitigation measure are effective and no un-acceptable impacts occur.

The Management Plan

Prior to undertaking works in acid sulfate soils, a management plan should be developed setting out

- how the extraction will be staged to minimise impacts; the quality controls to ensure operator reliability
- the management of the excavated material, its temporary storage, treatment and use
- the leachate and sediment control procedures and protocols
- contingency measures in case unexpected acid related incidents occur
- monitoring program

Where acid sulfate material is excavated as part of the proposal, the short and long-term management of the material should be considered. Ideally, the extracted acid sulfate material should immediately be managed so that:

1. the sulfidic material is not able to be oxidised (eg placed back in an anaerobic environment preferably below the watertable) or.
2. the sulfidic material may oxidise under controlled situation with all leachate produced neutralised or
3. the sulfidic material is separated out and managed by one of the methods above.

If it is necessary to stockpile the excavated material prior to treatment or disposal, provisions should be made to safely store the material. Stockpiles of acid sulfate soils should be located in settings that ensure minimal environmental impact from any acidic leachate produced. The design of stockpile(s) should:

- establish leachate collection and treatment systems including an impervious pad on which to place the stockpile
- minimise the surface area exposed to oxidation - consider using some form of capping if storage is for longer than a few weeks
- minimise the amount of infiltration of water - consider using some form of capping
- establish diversion banks upslope to prevent run-on water
- establish sediment control structure to ensure sulfidic material is not eroded - consider using some form of capping

The time between excavation and acid generation depends on the texture, mineralogy, temperature and bacterial activity of the excavated material. Take particular care with sand sediments, which oxidise and leach rapidly. Oxidation in clays is often slower than in sands because air does not penetrate as quickly.

Excavation and Drainage Principles

The following "rules of thumb" should apply when considering excavation or drainage:

1. Where areas are "scalded" or degraded and devoid of vegetation, no further drainage or excavation should be undertaken. Remediation strategies should be developed.
2. Where the sulfidic layers is at a depth below the soil surface of less than 0.5 metres, these areas should be left undrained with the minimum of disturbance. Generally these areas are best left waterlogged.
3. Where the sulfidic layer is between 0.5 and 2.0 m from the surface, drainage and excavation should only be attempted in accordance with a properly designed management plan.
   - *if the sulfidic layer is 0.5 to 1 metre below the soil surface*, excavation should be limited to cuts less than 30 mm.
   - *if the sulfidic layer is 1 metre to 1.5 metres below the soil surface*, excavation should be limited to cuts less than 0.5 m.
   - *if sulfidic layers more than 1.5 metres below the surface*, excavation should be limited to cuts no greater than 1 metre.

Monitoring is most important

Monitoring is most important when dealing with acid sulfate material. Discharged water must have a pH between 6.5-8.5 and be licensed (in NSW by the Environment Protection Authority).

ACID SOIL ACTION An initiative of the NSW Government.
For further information on the assessment and management of acid sulfate soils, consult the ASS Manual. This leaflet has been produced by NSW ASSMAC. Inquiries: Jon Woodworth, Acid Sulfate Soils Information Officer, Acid Sulfate Soils Management Advisory Committee, NSW Agriculture, Wollongbar Agricultural Institute, Bruxner Highway, WOLLONGBAR NSW 2477 Telephone 02 6626 1340, Fax 02 6628 1744

damage or loss whatsoever which has occurred or may occur in relation to that person taking or not taking (as the case may be) action in respect of any representation, statement or advice referred to above.