GROUNDED
EXPERTISE

Acid Sulfate Soil Management Plan

Proposed Nursery

10-12 Boondah Road, Warriewood NSW

Prepared for Henroth Investments Pty Ltd

Project 85749.04

4 June 2024

Douglas PARTNERS
GROUNDED EXPERTISE

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions, and inaccuracies.

Signature

Date

Author		4 June 2024
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Executive summary

Douglas Partners Pty Ltd (DP) has been engaged by Henroth to complete this Acid Sulfate Soil Management Plan (ASSMP) for the proposed nursery development at 10-12 Boondah Road, Warriewood (the site).

The purpose of this ASSMP is to provide management methods and procedures to minimise environmental impacts resulting from the disturbance of potential acid sulfate soils (PASS) and / or acid sulfate soil (ASS) materials. This ASSMP provides recommendations for acid sulfate soil (ASS) investigations prior to the commencement of works, neutralisation and treatment methods, verification testing requirements and emergency response procedures.

Table of Contents

Page No

Appendices

Acid Sulfate Soil Management Plan
Proposed Nursery
10-12 Boondah Road, Warriewood NSW

1. Introduction

Douglas Partners Pty Ltd (DP) has been engaged by Northern Beaches Council to complete this Acid Sulfate Soil Management Plan (ASSMP) for the 10-12 Boondah Road, Warriewood NSW (the site). The site is shown on Drawing 1, Appendix A.

The ASSMP was prepared in accordance with DP's proposal 85749.04.P.001.Rev0 dated 14 February 2024.

The purpose of this ASSMP is to provide management methods and procedures to minimise environmental impacts resulting from the disturbance of potential acid sulfate soils (PASS) and / or acid sulfate soil (ASS) materials. This ASSMP provides recommendations for acid sulfate soil (ASS) investigations prior to the commencement of works, neutralisation and treatment methods, verification testing requirements and emergency response procedures.

This report must be read in conjunction with all appendices including the notes provided in Appendix A.

2. Site information

Site address	10-12 Boondah Road, Warriewood
Legal description	Lot 4, DP 26902 Lot 9, DP 806132
Area	20,500 m^2
Zoning	RU2 Rural Landscape
Local Council Area	Northern Beaches Council
Current use	Rural Residential and commercial
Surrounding uses	North - Residential (apartments) East - Boondah Road and Sewerage treatment plant South - Rural residential and Warriewood Shopping Centre West - Warriewood Wetlands

The site boundary is shown on **Figure 1**.

Figure 1: Site location

2.1 Topography

The site is relatively flat with a surface level of approximately RL 2-4 m relative to Australian Height Datum (AHD). The site generally slopes towards the south (Narrabeen Creek) and west (Warriewood Wetland). Local relief can vary and in places the site slopes towards Boondah Road to the east.

2.2 Site geology and soils

Quaternary alluvial and estuarine sediment comprising peaty quartz sand, silt, and clay. The geological map information was confirmed by the *Groundwater Measurements, Memorandums 1 to 4, 3-12 Boondah Road, Warriewood.* Project 85749.00, 2016 (DP 2016) which identified deep sands interbedded with clay bands and underlain by bedrock at approximately 20 m to 35 m depth.

The acid sulfate soil risk map indicates that the site is Class 3 acid sulfate soil, i.e., that there is a high probability of containing acid sulfate soils (ASS) between 1-3 m depth.

The Atlas of Australian Acid Sulfate Soils and Salinity identifies the site as being in an area categorised as Ae(p-), acid sulfate soils may be present in floodplains.

The Sydney 1:100,000 Soils Landscape Sheet indicates that the site is underlain by disturbed terrain. Disturbed terrain is described as level plain to hummocky terrain, extensively disturbed by human activity, including complete disturbance, removal or burial of soil. Land fill includes soil, rock, building and waste materials. Turfed fill areas commonly capped with up to 40 cm of sandy loam or up to 60 cm of compacted clay over fill or waste materials.

2.3 Surface water and groundwater

DP completed a groundwater measurement investigation for Henroth reported in a series of memoranda in 2016 (DP 2016). The investigation included the drilling of four boreholes and installation of groundwater wells within the vicinity of the site (one within the site and three within a distance of approximately 500 m of the site). The measured groundwater levels varied from 0.8 m AHD to 1.4 m AHD (1.2 to 2.7 m bgl), rising to the north. The water levels were remeasured in 2019 (8 August 2019) with groundwater levels observed at a depth of 0.7 to 1.3 m AHD (1.0 to 2.9 m bgl). It was anticipated that groundwater below the site will discharge to either Narrabeen Creek 130 m to the south of the site or to Warriewood Wetlands to the west of the site. The aquifer at the site is classified as a surficial sediment aquifer (porous media - unconsolidated).

A search of the Department of Primary Industries Water registered groundwater bore database was completed for DP (2019). There are four registered bores within 100 m of the site. Within 500 m of the site there are a further 12 household and monitoring bores. The details of the bores within 100 m are summarised in Table 1. No additional registered bores were in the records as of the time of completion of this report.

Table 1: Summary of available information from nearby registered groundwater bores

Bore ID authorised purpose completion year status	Location relative to site	Final depth (m)	Standing water level (m bgl)
GW113171 Monitoring 2013	28 m west (Warriewood Square Shopping Centre)	4.5	1.53
GW113169 Monitoring 2013	34 m west (Warriewood Square Shopping Centre)	4.8	1.52
GW113170 Monitoring 2013	47 m west (Warriewood Square Shopping Centre)	5.5	1.2
GW110259 Recreational 2008	96 m south-west (playing field)	5	2

3. Background on acid sulfate soils

ASS are naturally occurring sediments that contain iron sulfides, primarily pyrite, commonly deposited in estuarine environments. The occurrence of ASS is associated with areas or regions that have previously been or are currently estuarine environments. Due to changes in sea level or geomorphologic changes to coastal systems, these sediments are often overlain by terrestrial sediments.

When ASS are exposed to air (e.g. due to bulk excavation or dewatering), the oxygen reacts with iron sulfides in the sediment, producing sulfuric acid. This acid can be produced in large quantities and is highly mobile in water. The sulfuric acid can drain into waterways causing severe short and long term socio-economic and environmental impacts, including damage to man-made structures and natural ecosystems.

ASS can either be classified as 'actual acid sulfate soils' (AASS) which are soils that have already reacted with oxygen to produce acid, or 'potential acid sulfate soils' (PASS). PASS are soils containing iron sulfide that have not been exposed to oxygen (e.g., soils below the water table). PASS therefore have not produced sulfuric acid but have the potential to do so if exposure to oxygen occurs. For the purposes of this report the term PASS is only used for soils which meet the requirements of EPA Waste Classification Guidelines (2014) Part 4 as summarised in Appendix D.

4. Proposed development

It is understood that the proposed development will comprise a commercial nursery with a single storey retail space, parking and footpaths and external plant displays. The concept plans are presented in Appendix A.

It is anticipated that the proposed development will require excavation for services and building foundations to a depth of up to 3 m.

5. Previous investigation

No previous acid sulfate soil investigation has been completed at the site. DP has however conducted a preliminary geotechnical investigation and prepared a memorandum for the site dated 14 December 2016 based on desktop assessment and the groundwater measurement assessment. Based on the inspection of the site and from DP's general understanding of the local geological conditions it was anticipated that the geotechnical model for the site may include:

- filling to depths of 1-2 m; over
- very loose to loose sand with clayey bands to depths of 4-8 m; over
- soft to stiff clay to depths of 10-15 m; over
- dense to very dense sand to depths of 15-20 m; over
- bedrock at depths of about 20-35 m; and

- a shallow groundwater table at depths of about 1-1.5 m (RL0.7 m to RL1.1 m) over most of the site and rising slightly to about RL1.5 m on the slightly elevated northern end of the site. Groundwater levels will fluctuate and may temporarily rise by at least 1 m (or higher and up to flood levels) following prolonged rainfall. Further monitoring would be required to assess fluctuations in groundwater levels.

DP has also undertaken a preliminary contamination assessment (DP 2024). The investigation was limited to shallow test pits and boreholes. The conditions generally comprised sand fill (with anthropogenic inclusions including bricks, concrete, terracotta and sandstone boulders to depths typically between 0.5 m and > 1.5 m underlain by sand. Groundwater was encountered at depths ranging from 0.1 to 0.8 m bgl. Previous test locations are presented on Drawing 1, Appendix B and test pit and borehole logs in Appendix C. The previous test locations provide some information of the expected ground conditions however do not include acid sulfate soil testing.

6. Guidelines and assessment criteria

This ASSMP is devised on the basis of the following guidelines endorsed by EPA and with reference to other national guidelines where considered appropriate:

- Acid Sulfate Soils Management Advisory Committee (ASSMAC) Acid Sulfate Soils Management Guidelines (1998) (ASSMAC, 1998);
- NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014); and
- NSW Roads and Traffic Authority (RTA) Technical Guideline: Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze (RTA, 2005).

Dear, S. E., Williams, K. M., McElnea, A. E., Ahern, C. R., Dobos, S. K., Moore, N. G., & O'Brien, L. E. (2023). *Queensland acid sulfate soil technical manual : soil management guidelines version 5.* Department of Resources and the Department of Environment and Science.

Stone, Y., Ahern, C. R., & Blunden, B. (1998). *Acid Sulfate Soils Manual.* Wollongbar, NSW, Australia: Acid Sulfate Soil Management Advisory Committee.

Sullivan, et al. (2018a). *National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Identification and Laboratory Methods Manual.* Canberra ACT CC BY 4.0: Sullivan, L; Ward, N; Toppler, N; Lancaster, G, Department of Agriculture and Water Resources.

Sullivan, et al. (2018b). *National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Sampling and Identification Methods Manual.* Canberra ACT CC BY 4.0: Sullivan, L; Ward, N; Toppler, N; Lancaster, G, Department of Agriculture and Water Resources.

The assessment criteria adopted for this ASSMP for determination of the presence of PASS / ASS and the verification criteria for treated PASS / ASS is provided in Appendix D.

7. Data gap assessment

It is recommended that prior to the commencement of works acid sulfate soil investigations be undertaken to assess the actual risk of disturbing acid sulfate soils and if ASS are present to determine the appropriate treatment (liming) rate. The data gap assessment will be undertaken in accordance with the recommendations in Sullivan et al (2018a) and shall comprise the following:

- drilling of eight test bores in a grid-based pattern. The test bores shall be extended to a depth of 4.0 m or a minimum of 1.0 m below the maximum depth of the proposed excavation / disturbance;
- collection of soil samples at the surface and then at 0.5 m intervals, at changes in strata and upon signs of potential ASS;
- storage of samples in airtight containers and delivery to the laboratory within 24 hours, or frozen pending dispatch;
- field screening of all samples for pH and pHfox (oxidised pH) in accordance to the procedure outlined in Appendix F;
- testing / analysis of selected / representative samples that exceed the field screening criteria (see Appendix D) for Chromium Reducible Sulphur suite;
- conducting minimum QA / QC procedures including:
  - collection of one field duplicate for every 20 investigative samples,
  - use of standardised field sampling forms, methods and Chains of Custody, and
  - documented calibration of field instruments.

The results shall be compared to the action criteria in Appendix D. If the results exceed the action criteria the ASS Management requirements outlined in Section 8 shall be implemented.

8. Acid sulfate soil management

8.1 Management options

The Acid Sulfate Soils Manual (Stone, Ahern, & Blunden, 1998) and Queensland Acid Sulfate Soil Technical Manual (Dear, et al., 2023) provides the following potential soil management Options:

Option 1	Non-excavation or minimal earthworks (avoidance);
	On-site treatment (neutralisation) followed by: off-site disposal. on-site re-use.
Option 2	Off-site treatment and disposal.
Option 3	On-site reburial below the permanent water table without treatment (PASS only).
Option 4	Off-site reburial below the permanent water table without treatment (PASS only).
Option 5	Hydraulic separation of ASS fines.

Based on the proposed development Option 2 – on-site treatment followed by off-site disposal (and / or on-site reuse) has been identified as the preferred management option, with reference to the relevant guidelines and reference materials

8.2 Proposed management strategy

8.2.1 General

The general process for the treatment of ASS is as follows:

- prepare a treatment pad as described in Section 8.2.2;
- manage ASS during stockpiling and treatment to minimise dust and leachate generation (e.g., by covering, or lightly conditioning with water). If wet weather prevails, stop works and cover the stockpiled soil with plastic sheeting to reduce the formation of leachate;
- untreated stockpiled soils should be treated as soon as possible following excavation. For coarse soils (i.e., sands), treatment should occur within approximately 12 to 18 hours (or less) following excavation. For fine-grained soils (i.e., clays), treatment should occur within approximately 40 to 60 hours following excavation. Faster oxidation rates are possible, particularly in warm weather;
- transport ASS requiring treatment and place on the guard layer of the treatment pad;
- spread the ASS over the guard layer in layers of up to 0.3 m thick, leaving a 1 m buffer between the toe of the spread soil and the containment bund or drain. When spreading the first soil layer, care should be taken not to churn up the guard layer;
- apply agricultural lime (commonly known as aglime) over the 0.3 m layer at the minimum lime dosing rate (refer to Section 8.2.3 and harrow / mix thoroughly. Use of rotary plough equipment (e.g., auger bucket) may be appropriate for cohesive soils, where adequate mixing is difficult to achieve. Note: If ASS materials are too wet, adequate mixing of aglime cannot be achieved and soils may require a period of drying prior to mixing;
- completion of verification testing (as outlined in Section 10) to confirm that the ASS has been adequately neutralised in each layer prior to placement of the next layer to be treated. If verification testing indicates that additional neutralisation is required, add additional aglime (at an appropriate liming rate) and mix as described above;
- continue the spreading / liming / harrowing / verification cycle for each 0.3 m layer until excavation is finished;
- when verification testing indicates that the ASS have been adequately neutralised, the soil may be removed from the treatment pad for disposal off-site in accordance with the waste classification; and
- (or) when verification testing indicates the ASS have been adequately neutralised, subject to geotechnical suitability, the soil may be removed from the treatment pad for on-site reuse in accordance with the site management plan; and
- management of leachate water and groundwater may also be required where leachate is produced and / or if groundwater is impacted by the works as outlined in Section 9 and Appendix HG; and
- a layer of fine agricultural lime ('aglime') should be applied over the base of excavation in ASS to neutralise downward seepage from exposed ASS, or to minimise acidification of groundwater following re-establishment of groundwater levels.

8.2.2 Preparation of treatment pads

The key features of the treatment area and design considerations are summarised below and shown in Figure 2 below:

- treatment pad area – The treatment pad should be of an appropriate area for the volume of soil to be treated / stored, and should be prepared on relatively level or gently sloping ground to minimise the risk of potential instability issues, with a fall to the local drainage sump;
- pad location – The pad should be located as far as practical from any potential ecological receptors (such as drainage lines which enter the stormwater system and nearby water bodies);
- lining – the treatment pad should be lined to minimise the potential for leachate seepage into underlying soils. Options for lining include the following:
  - geosynthetic liner (such as HDPE sheeting);
  - impervious physical barrier, such as a concrete slab or bitumen sealed hardstand;
  - natural low permeability clay; and
  - a compacted clay layer.
- guard layer – A guard layer of fine agricultural lime (‘aglime’) should be applied over the clay subgrade or lining to neutralise downward seepage. For the proposed development, a guard layer of 5 OR 10 kilograms fine aglime per m^2 per 300 mm of placed ASS requiring treatment should be placed at the surface of the treatment pad prior to placement of untreated ASS. The thickness of the guard layer should be adjusted based upon the net acidity in accordance with (Dear, et al., 2023) which is to be determined during data gap assessment;
- the guard layer should be re-applied following removal of treated soils prior to addition of untreated ASS. Guard layers may need to be applied between each placed ASS layer in situations where multiple layers of ASS are placed on the same treatment pad; and
- bunding – the treatment pad should be bunded to contain and collect potential leachate runoff within the treatment pad area and to prevent surface water from entering the treatment pad (i.e., hydrologically isolated). The inner bund slopes should be lined to prevent leachate seeping into the ground surface and sized to prevent overflow of untreated leachate onto the site.

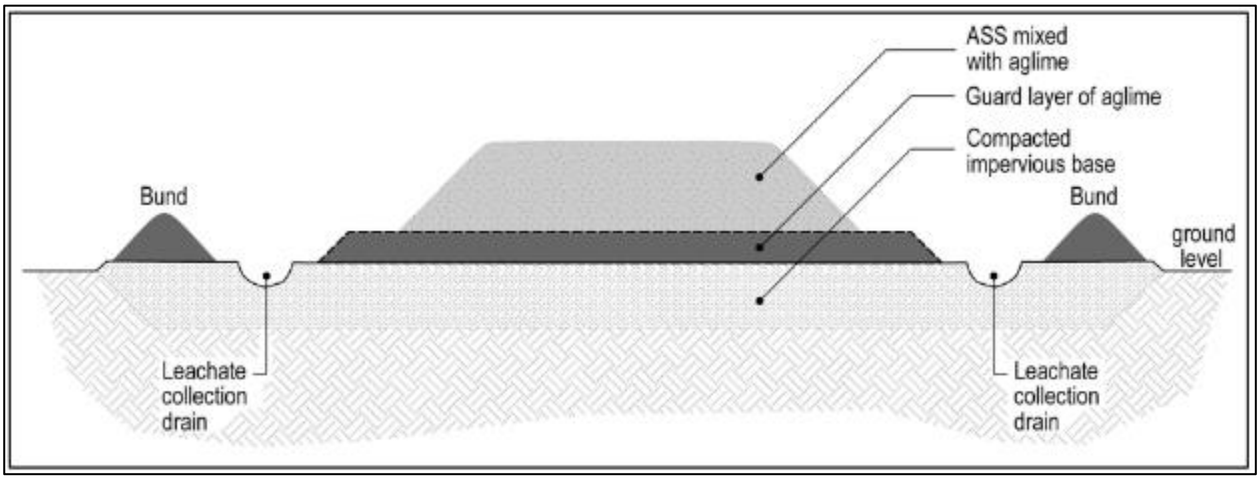

Figure 2: Schematic cross-section of a treatment pad, including compacted impervious base (clay layer), guard layer, leachate collection drains and bunding (source: Dear, et al. (2023))

The table below provides indicative liming rates for the guard layer.

8.2.3 Liming rates

Following the results of the data gap assessment the following table is to be completed to provide a summary of the liming rates (if required).

Table 2: Indicative liming rate

Material	**Net acidity (%S)**	**'Ag' Lime application rate for treatment**	
		Guard layers# (kg/m^2 per m height)	**Stockpiled soil[a] (kg/tonne)**
To be confirm	To be determined using Equation D2 in Appendix D.	5	To be determined using Equations E1 and E2, Appendix E.

Depending upon the source of the aglime and ultimately the representative Effective Neutralising Value (ENV) of the aglime selected, the minimum lime dosing rate may be increased or decreased. Prior to the commencement of works, the minimum lime dosing rate should be finalised following review of the ENV of the selected aglime.

8.2.4 Neutralising materials

Agricultural lime, commonly known as aglime, is the preferred neutralisation material for the management of ASS, as this material is usually the cheapest and most readily available product for acid neutralisation. Furthermore, aglime is slightly alkaline (pH of 8.5 to 9), non-corrosive, of low solubility and does not present handling problems or generate high pH leachate and it only liberates alkalinity in the presence of acid.

Dolomite and calcined magnesia also have low solubility; however, they produce magnesium sulfate during neutralisation reactions which is quite soluble and may degrade water quality in waterways if large quantities are produced. Agricultural lime on the other hand hydrates to gypsum which is less soluble and therefore less likely to affect water quality and also has other beneficial impacts on soil properties particularly soil structure.

- aglime comprises calcium carbonate (CaCO3), typically made from limestone that has been finely ground and sieved to a fine powder. Aglime with the following properties are the preferred neutralising agent;
- purity of at least 98% or better (i.e., NV > 98, where NV is the neutralising value, a term used to rate the neutralising power of different forms of materials relative to pure, fine calcium carbonate which is designated NV = 100);
- NOTE: There could be economic justification for using a less pure grade of aglime, however, under these circumstances, the individual lime dosing rates described in Section 8.2.3 would need to be carefully considered, as the cost savings from using less pure material may be offset by the corresponding increase in the required dosing rates (lime volumes required), and the transport and disposal costs; and

- fine ground (at least <0.5 mm) and dry, as texture and moisture can decrease the effective NV.

Aglime requires no specialised handling, however, use of safe work practices and good hygiene practices are recommended to avoid eye or skin contact and inhalation. Aglime should be stored in a cool, dry, well-ventilated area inaccessible to the general public and removed from incompatible substances and foodstuffs (refer to Aglime SDS for further details). It would be advisable to cover any aglime stockpiles (where relevant) with a tarpaulin both to minimise wind erosion and wetting, as the material is more difficult to spread when wet.

Due to its low solubility in water, aglime is not suitable for the neutralisation of leachate, which requires a product with a very quick reaction and high solubility. The most suitable neutralising agent for leachate and retained drainage water / groundwater is slaked lime or hydrated lime (calcium hydroxide (Ca(OH)2)). This is made by treating burnt lime (calcium oxide (CaO)) with water (slaking) and comes as a fine white powder. It has a typical NV of about 135. Due to its very strong alkalinity (pH or about 12.5 to 13.5), slaked lime or hydrated lime should not be allowed to come into contact with the skin or be inhaled and care must be taken to not overshoot pH adjustment with such alkaline agents. Hydrated lime is not recommended for soil neutralisation. Hydrated lime should be stored in cool protected place (e.g., locked store inaccessible to the general public) away from moisture, strong oxidants or acids and to minimise dust emissions and (refer to Hydrated Lime SDS for further details).

8.3 Alternate strategy or contingency plan

Where the proposed primary management option is not possible, or practical, alternate or contingency strategies, with reference to the applicable guidelines, may be considered and following a ‘fit for purpose’ assessment. These options are outlined in Appendix G.

9. Leachate water and groundwater management

Potential leachate water and groundwater management strategies are provided in Appendix H.

10. Verification testing of treated soils and water

Verification testing to assess whether ASS have been adequately neutralised will be undertaken by means of the following:

- screening tests (pH_F and pH_{FOX}) at the frequencies in Table 3; and
- acid base accounting (e.g., using chromium suite) of testing at the frequencies in Table 3.

Based on a ‘Category H’ treatment level, verification testing of the ASS and leachate water (if present) is required after the addition of lime to test whether the soil / water has been adequately neutralised, whether or not adequate mixing of the ASS has been achieved, and to reduce the risk of acidic water being returned to the environment (including watercourses). The verification testing frequency for ASS is in Table 3.

Table 3: Verification testing frequency for treated acid sulfate soils

Test	Frequency
Field test: pH_F and pH_{Fox} screening	One sample / soil type, OR One sample / 25 m^3 -100 m^3 of treated soil (whichever is the greater frequency), AND
Laboratory analysis: Acid base accounting (including chromium reducible sulfur (S_{cr}) method)	One sample / soil type, OR One sample / 25 m^3 -100 m^3 of treated soil (whichever is the greater frequency), AND One sample / soil type, OR Volumes of <250 m^3 = two samples, OR Volumes 251–500 m^3 = three samples, OR Volumes >500 m^3 and ≤2 %S (≤1247 mol H+/t) = three samples, plus one sample per additional 500 m^3 , OR Volumes of >500 m^3 and >2 %S (>1247 mol H+/t) = three samples, plus one sample per additional 250 m^3 , OR Three samples plus one additional sample / 500 m^3 of treated soil (whichever is the greater frequency), AND At least one sample / 200 mm to 300 mm deep soil treatment layer.

Note:
Verification testing frequencies should be adjusted (either increased or decreased) depending on net acidity value, performance, material quantities and purpose/reuse, and may be subject to change by the appropriate regulatory authority in the event of a review.
Laboratory analysis on untreated soils for each treatment layer should be considered where heterogenous materials are present and initial ASS investigations indicate the presence of existing ANC (unverified).

In addition, the pH of all ponded leachate water around the confines of the treatment bunds and adjacent surface waters should be measured daily and results assessed against the criteria provided in Table 4 and against background (pre-construction) levels. The soil and water contained within the bunded treatment area should not be removed until the target values presented in Table 4 below have been achieved. Treatment of deeper soil layers should not be commenced until the existing surface layer has been validated and removed.

Table 4: Target levels of neutralised soil and water

Test	Component	Target level
Monitoring of water (leachate, surface water and groundwater)	pH	pH 6.5 < pH < 8.5, or one pH unit from background levels
	Turbidity	To comply with either values determined in consultation with the Authority or less than local background levels (baseline monitoring required).
	Aluminium (Al) and Iron (Fe)	Establish local water quality data prior to site disturbance and ensure that these values are not exceeded.
	Dissolved Oxygen (DO)	To comply with either values determined in consultation with the Authority or less than local background levels (baseline monitoring required).

Test	Component	Target level
	Electrical Conductivity (EC)	To comply with either value determined in consultation with the Authority or less than local background levels (baseline monitoring required).
Field screening of soil [a]	pH_F	$6.5 \leq pH_F \leq 8.5$
	pH_{FOX}	$6.5 \leq pH_{FOX} \leq 8.5$
Acid Base Accounting (including chromium reducible sulphur (Scr) method)	Net acidity [b]	Zero or negative
	pH_{KCL}	$6.5 \leq pH_{KCL} \leq 10$

Notes:
a used as a guide only to assess when adequate neutralisation and soil mixing has been achieved.
b determined using equations D1or D2, Appendix D

It should be noted that laboratory tests will require at least four days turnaround, possibly longer, and hence sufficient time should be allowed in the treatment programme for such verification testing. Only appropriately skilled staff should collect and test verification samples.

11. General monitoring requirements

It is recommended that prior to commencement of works, a Construction Environmental Management Plan (CEMP) should be developed by the lead contractor. The CEMP should also include a programme for general site monitoring pertinent to the ASS. A typical monitoring programme is provided in Table 5 below and should be implemented by the responsible parties.

Table 5: General monitoring requirements

Task	Frequency	Standard	Reporting/ record keeping	Responsibility
Inception meeting	Pre-start	ASSMP	Minutes	Project Manager, Site supervisor, Environmental Consultant
Site inspection	Daily	Visual/olfactory signs of ASS	File note	Site supervisor
Site inspection	Monthly	Visual/olfactory signs of ASS	File Note	Project Manager
Monitoring of disturbed excavations that are in ASS	Daily	Visual until backfilled	File note	Site supervisor

Task	Frequency	Standard	Reporting/ record keeping	Responsibility
Monitoring of ASS treatment area/s	Daily	Visual Daily pH testing until results show ASS or leachate has been neutralised (refer Section 10 for criteria and testing requirements)	File note and results of pH testing to be recorded in field sheets	Site supervisor
Dewatering excavation in ASS	Prior to planned discharge	Treated and tested to demonstrate compliance with ASSMP guidance or regulatory requirements prior to discharge	Field sheets and permit to discharge	Site supervisor/environmental consultant
Surface Waters	Daily (field parameters) Weekly (Metals), plus prior to and following discharge	pH, EC, DO, Al, total and dissolved Fe testing, tested to demonstrate compliance with ASSMP guidance or regulatory requirements prior to discharge	Field sheets and permit to discharge	Site supervisor/environmental consultant

12. Emergency incident response plan

Construction activities which may cause potential environmental impacts with respect to ASS are summarised in Table 6 below together with recommendations for emergency response procedures.

Table 6: Emergency response procedures

Activity	Enviro. threat	Emergency response
Excavations	Flooding of open excavation causing adjacent groundwater levels to rise, leading to potential acid leachate once the excavation is drained.	Inform site foreman and project manager / environmental officer. Determine pH of groundwater / floodwater in excavation. Correct groundwater / floodwater pH by application of slaked lime (hydrated lime) to bring pH in range of 6.5 to 8.5 or to pre-construction background levels. Drain pit to tanks / ponds for water quality assessment prior to discharge.
Treatment / neutralisation	Soil washes or slips outside of bunded treatment area	Inform site foreman and project manager / environmental officer. Estimate volume of material breaching bund. Conduct pH analysis of adjacent watercourses (if any) and correct pH if potentially impacted. Remove escaped soil into a bunded treatment area.

Activity	Enviro. threat	Emergency response
		Over-excavate impacted area to 0.2m depth, apply and mix lime at rate as for guard layers (5 kg to 10 kg lime per m2 of surface).
	Breach in containment bund	Inform site foreman and project manager / environmental officer. Close breach in bund. Conduct pH analysis of adjacent watercourses (if any). Correct pH in any adjacent watercourse (if required).
	Extracted untreated groundwater, surface water or leachate is exiting the site in an uncontrolled manner.	Inform site foreman and project manager / environmental officer. Restrict / stop source of water. Conduct pH analysis of adjacent watercourses (if any).

For all construction activity incidents which pose a potential environmental impact, an incident report must be completed in order that:

- the cause of the incident may be determined;
- additional control measures may be implemented; and
- work procedures may be modified to reduce the likelihood of the incident re-occurring.

13. Reporting and record keeping

With reference to Dear, et al. (2023), it is good practice for the contractor to maintain a record of treatment of ASS. Such records should include the following details:

- date;
- location / area / treatment pad;
- time of excavation;
- neutralisation process undertaken;
- lime rate utilised including:
  - records which demonstrate a safety factor of 1.5 has been applied in calculating liming rates;
  - receipts showing quantities of aglime purchased;
  - evidence of composition, purity, particle size and effective neutralising value (ENV) of the aglime used;
  - record of aglime use (e.g., per treatment pad, use in guard layers etc); and
  - photographic evidence of incorporation of neutralising agent(aglime).
- results of monitoring;
- disposal and / or re-use location; and

- tonnages and disposal / transfer dockets (if applicable).

A record should also be maintained confirming contingency measures and additional treatment if undertaken. A final report should be issued upon completion of the works presenting the monitoring regime and results and confirming that appropriate management of ASS has occurred during the works.

14. **Conclusions and recommendations**

This ASSMP provides the ASS management procedures to be enacted to minimise the impact of ASS disturbance on the environment during the proposed works.

If ASS are encountered during further investigations or subsequent works then the ASS management procedures provided herein will be enacted to minimise the impact of ASS disturbance on the environment.

15. **References**

DP. (2016). *Groundwater Measurements, Memorandums 1 to 4, 3-12 Boondah Road, Warriewood,.* Project 85749.00, 2016 to 2019: Douglas Partners Pty Ltd.

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Dear, S. E., Williams, K. M., McElnea, A. E., Ahern, C. R., Dobos, S. K., Moore, N. G., & O'Brien, L. E. (2023). *Queensland acid sulfate soil technical manual : soil management guidelines version 5.* Department of Resources and the Department of Environment and Science.

Stone, Y., Ahern, C. R., & Blunden, B. (1998). *Acid Sulfate Soils Manual.* Wollongbar, NSW, Australia: Acid Sulfate Soil Management Advisory Committee.

Sullivan, et al. (2018a). *National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Identification and Laboratory Methods Manual.* Canberra ACT CC BY 4.0: Sullivan, L; Ward, N; Toppler, N; Lancaster, G, Department of Agriculture and Water Resources.

Sullivan, et al. (2018b). *National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Sampling and Identification Methods Manual.* Canberra ACT CC BY 4.0: Sullivan, L; Ward, N; Toppler, N; Lancaster, G, Department of Agriculture and Water Resources.

16. **Limitations**

Douglas Partners (Douglas) has prepared this report for this project at 10-12 Boondah Road, Warriewood NSW in accordance with Douglas' proposal dated 14 February 2024 and acceptance received from Uday Bin Singh dated 14 February 2024. The work was carried out under Douglas' Engagement Terms. This report is provided for the exclusive use of Henroth Investments Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of Douglas, does so entirely at its own risk and without recourse to Douglas for any loss or damage. In preparing this report Douglas has necessarily relied upon information provided by the client and / or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and / or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after Douglas' field testing has been completed.

Douglas' advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by Douglas in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and / or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the (geotechnical / environmental / groundwater) components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. Douglas cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by Douglas. This is because this report has been written as advice and opinion rather than instructions for construction.

Appendix A

About this Report

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

continued next page

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

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Appendix B

Drawings

Notes:
1. Basemap from metromap.com (dated 20/03/2022)
2. Test locations shown are approximate only

Legend

🟥 Site Boundary
✚ Test Pit Location
⊕ Borehole Locations

10 0 10 20 30 40 m

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Henroth Group		
OFFICE:	Sydney	DRAWN BY:	KDP
SCALE:	1:1437 @ A3	DATE:	22.02.2024

TITLE: **Site Location and Location of Tests**
Proposed Nursery
10-12 Bondah Road Warriewood

N

PROJECT No:	85749.04
DRAWING No:	1
REVISION:	0

WARRIEWOOD NURSERY
10-12 BOONDAH ROAD, WARRIEWOOD, NSW 2102

SHEET NUMBER	SHEET NAME	Current Revision
AMP - 0001	COVER SHEET	6
AMP-0002	EXISTING ENVIRONMENT	6
AMP-0003	EXISTING AERIAL	6
AMP-0004	LAND ZONING MAP	6
AMP-0101	SITE PLAN	6
AMP-0111	SHADOW DIAGRAMS-SUMMER SOLSTICE	6
AMP-0112	SHADOW DIAGRAMS-WINTER SOLSTICE	6
AMP-2001	LEVEL G	6
AMP-2002	ROOF PLAN	6
AMP-2101	FLOOR PLANS	6
AMP-4001	ELEVATIONS	6
AMP-4002	SECTIONS	6
AMP-9901	3D VIEWS-SHEET -01	6

Project
WARRIEWOOD
10-12 Boondah Rd, Warriewood, New South Wales 2102

Project Number
230736

Status

Rev.	Date	Description	Iss.	Appr.
1	17/01/2024	DRAFT	RW	
2	02/02/2024	DRAFT	KD	
3	28/02/2024	DRAFT	RW	
4	06/03/2024	DRAFT	RW	
5	27/03/2024	DRAFT	RW	
6	22/05/2024	DRAFT	SU	

Drawing Number
WAR-BUC-AZ-DR-AR-DA-AMP - 0001

Nominated Architect: Anthony Palamara NSW ARN 7274

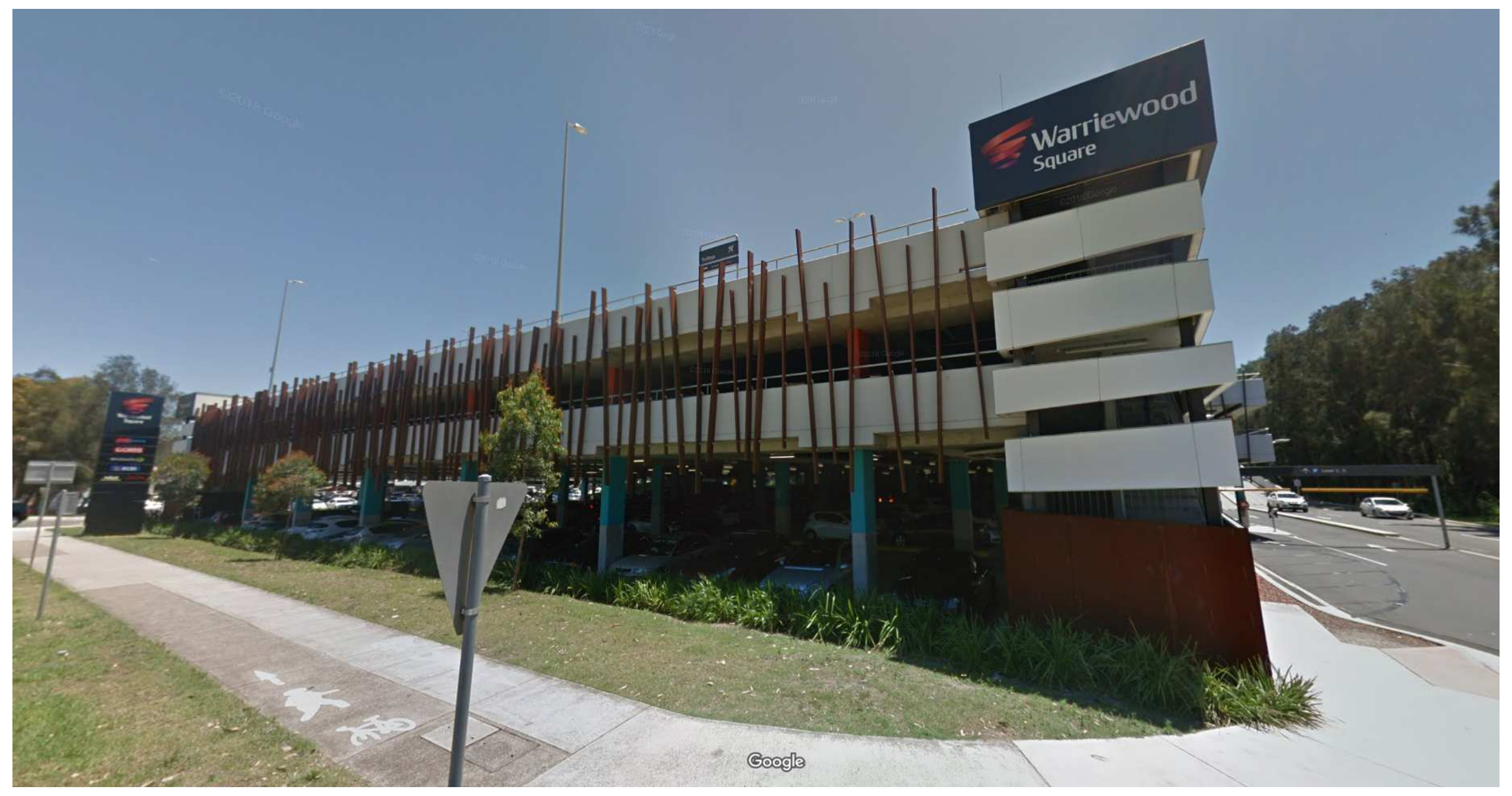
Scale
Not to scale

Revision
6

BUCHAN

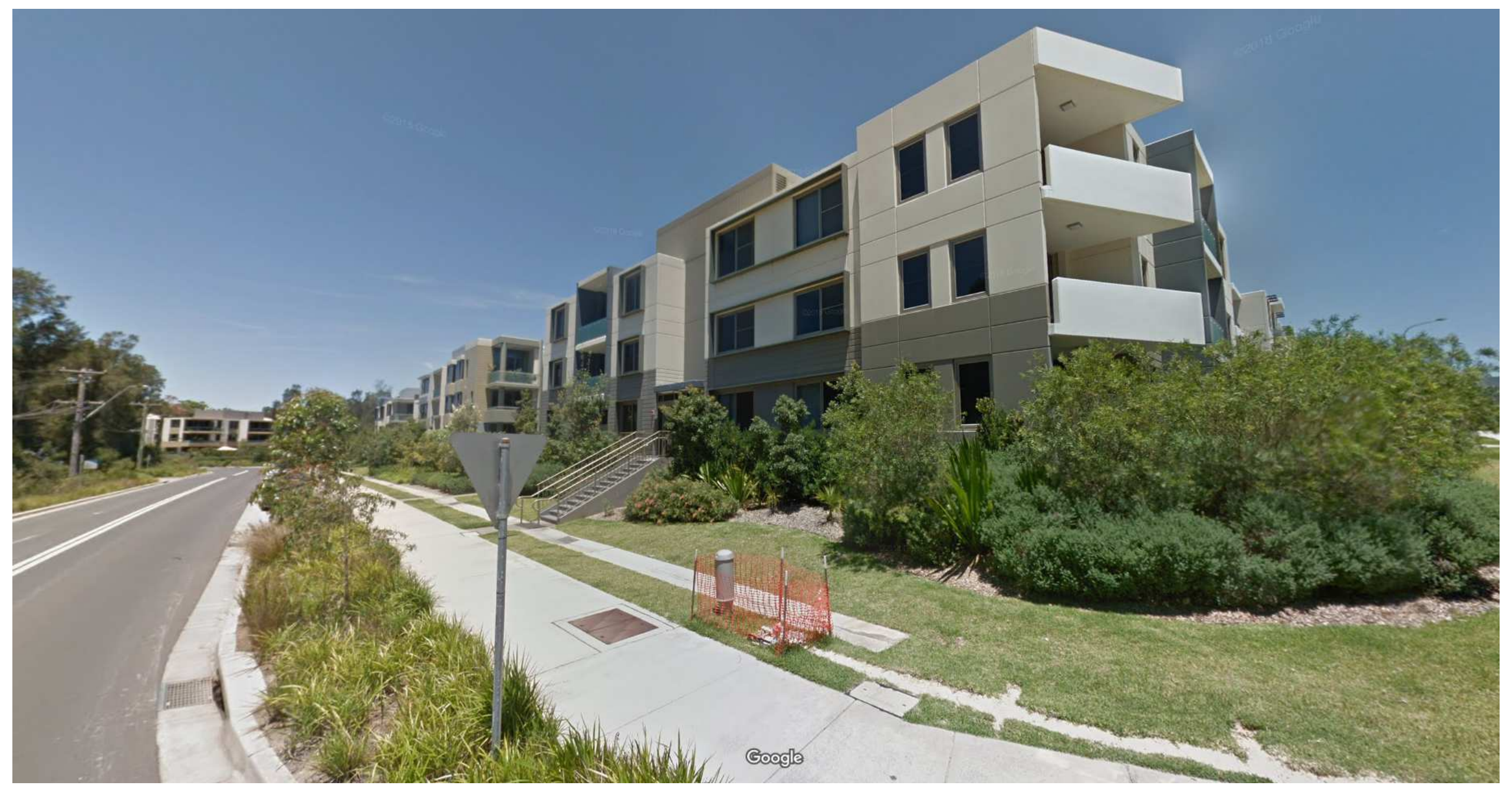
Sydney Studio
+ 61 2 9566 1611 / **buchan.au**

1. SITE



5. ADJOINING SHOPPING CENTRE (WARRIEWOOD SQUARE)

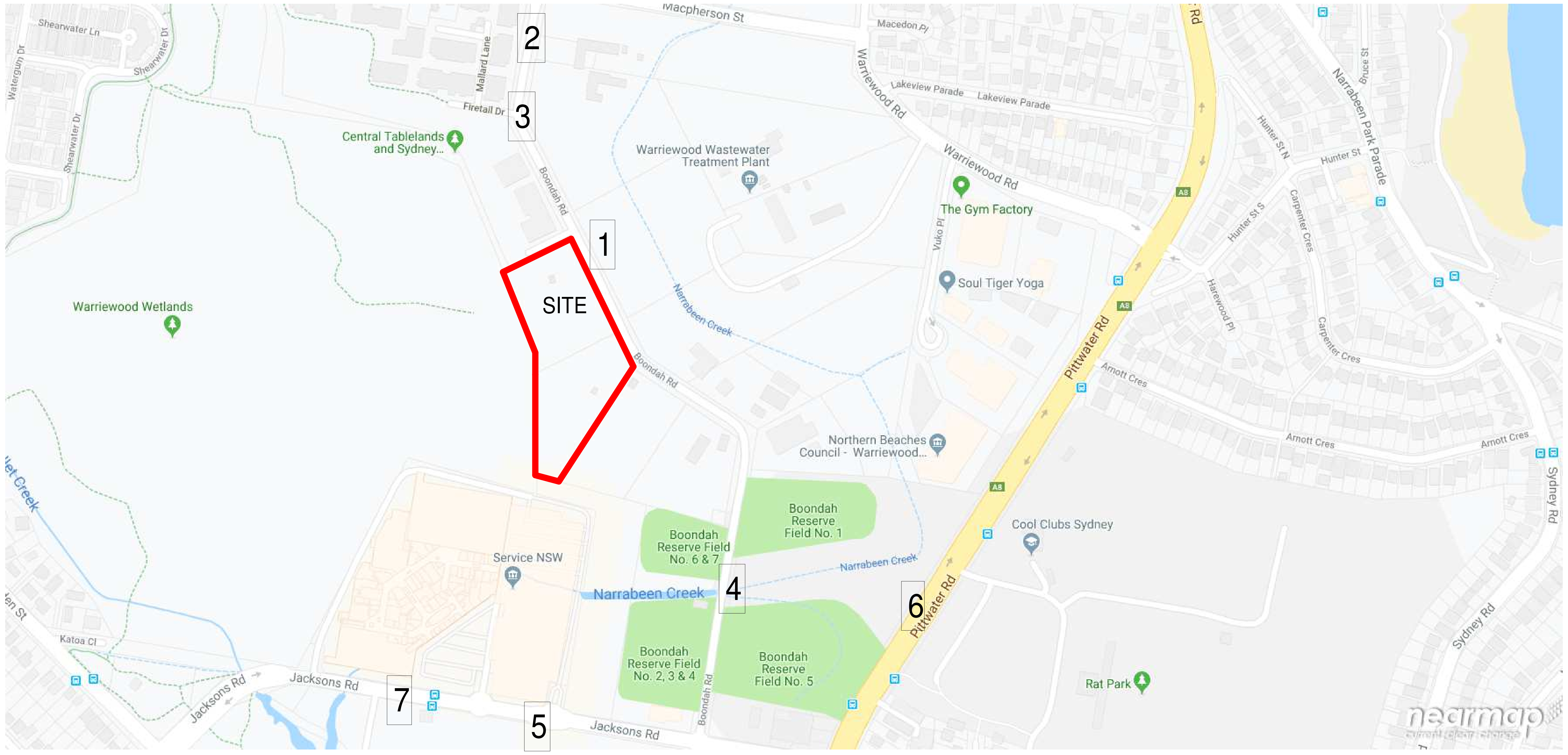
7. NEAR-BY BUS STOPS (JACKSONS ROAD)



2. ADJOINING RESIDENTIAL DEVELOPMENT

6. NEAR-BY B-LINE BUS STOP (PITTWATER ROAD)

3. ADJOINING RESIDENTIAL DEVELOPMENT



4. NEAR-BY PLAYING FIELDS

Project
WARRIEWOOD
10-12 Boondah Rd, Warriewood, New South Wales 2102

Project Number
230736

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3	28/02/2024	DRAFT	RW	
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5	27/03/2024	DRAFT	RW	
6	22/05/2024	DRAFT	SU	

Drawing Number
AMP-0002

Nominated Architect: Anthony Palamara NSW ARN 7274
Do not scale this drawing. Verify all dimensions on site before commencing any work.

Scale

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3	28/02/2024	DRAFT	RW	
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6	22/05/2024	DRAFT	SU	

Drawing Number

AMP-0003

Nominated Architect: Anthony Palamara NSW ARN 7274

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3	28/02/2024	DRAFT	RW	
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5	27/03/2024	DRAFT	RW	
6	22/05/2024	DRAFT	SU	

Drawing Number
AMP-0004

Nominated Architect: Anthony Palamara NSW ARN 7274
Do not scale this drawing. Verify all dimensions on site before commencing any work.

Scale

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NOTES : LANDSCAPE IN THE ROAD RESERVE
AND ON SITE IS INDICATIVE ONLY
(REFER TO LANDSCAPE DETAIL)

Room Schedule	
Name	Area
GARDEN CENTRE	353 m²
MALE	15 m²
DIS. ROOM	6 m²
FEMALE	12 m²
STORAGE	47 m²
PLANT RM	20 m²
Grand total: 6	452 m²

TOTAL PARKING 50 CAR SPACE

━ · ━	**SETBACK LINE**
━ · ━	**BOUNDARY LINE**

1 Site Plan
SCALE 1 : 500

Project
WARRIEWOOD
10-12 Boondah Rd, Warriewood, New South Wales 2102

Project Number
230736

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5	27/03/2024	DRAFT	RW	
6	22/05/2024	DRAFT	SU	

Drawing Number
AMP-0101

Nominated Architect: Anthony Palamara NSW ARN 7274
Do not scale this drawing. Verify all dimensions on site before commencing any work.

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Revision
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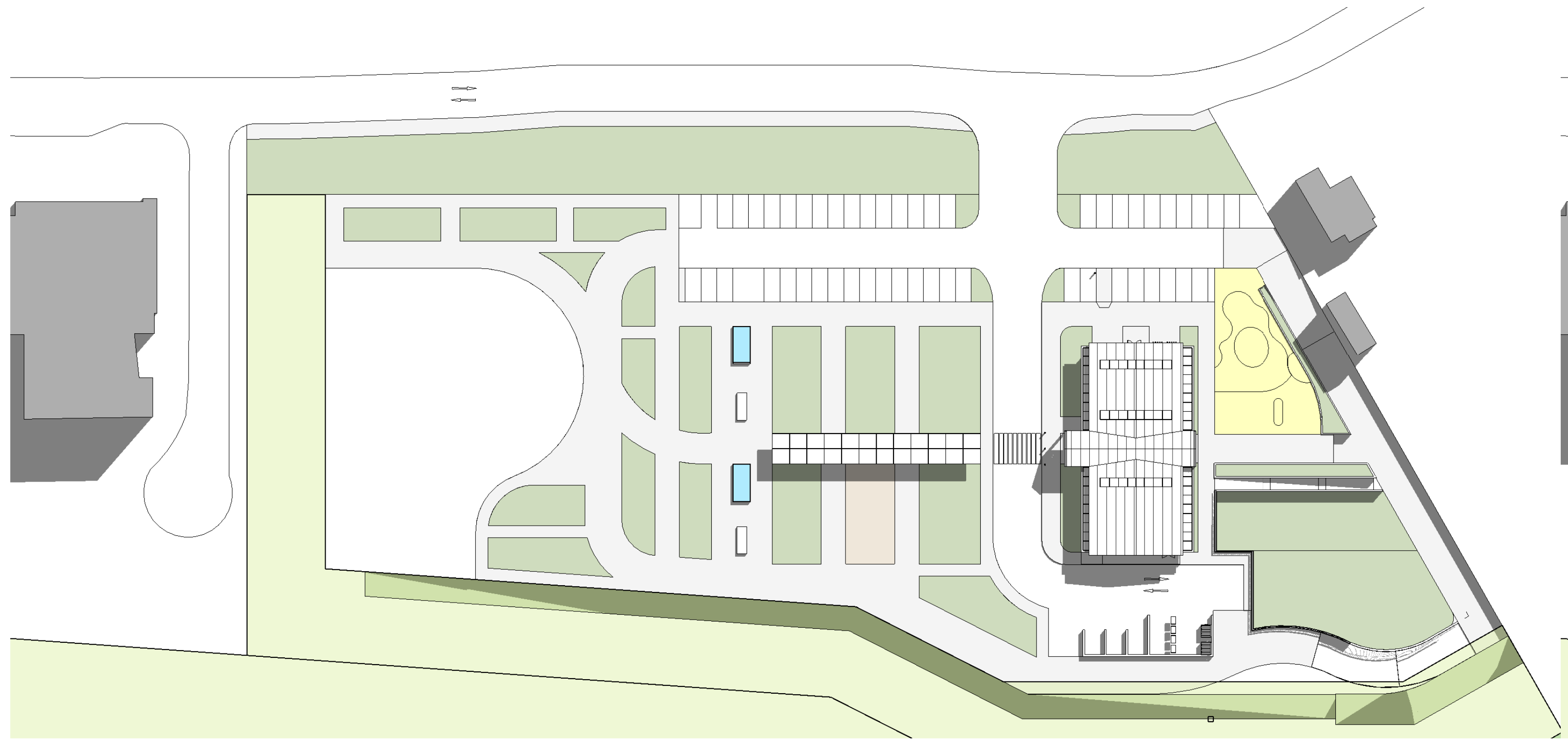

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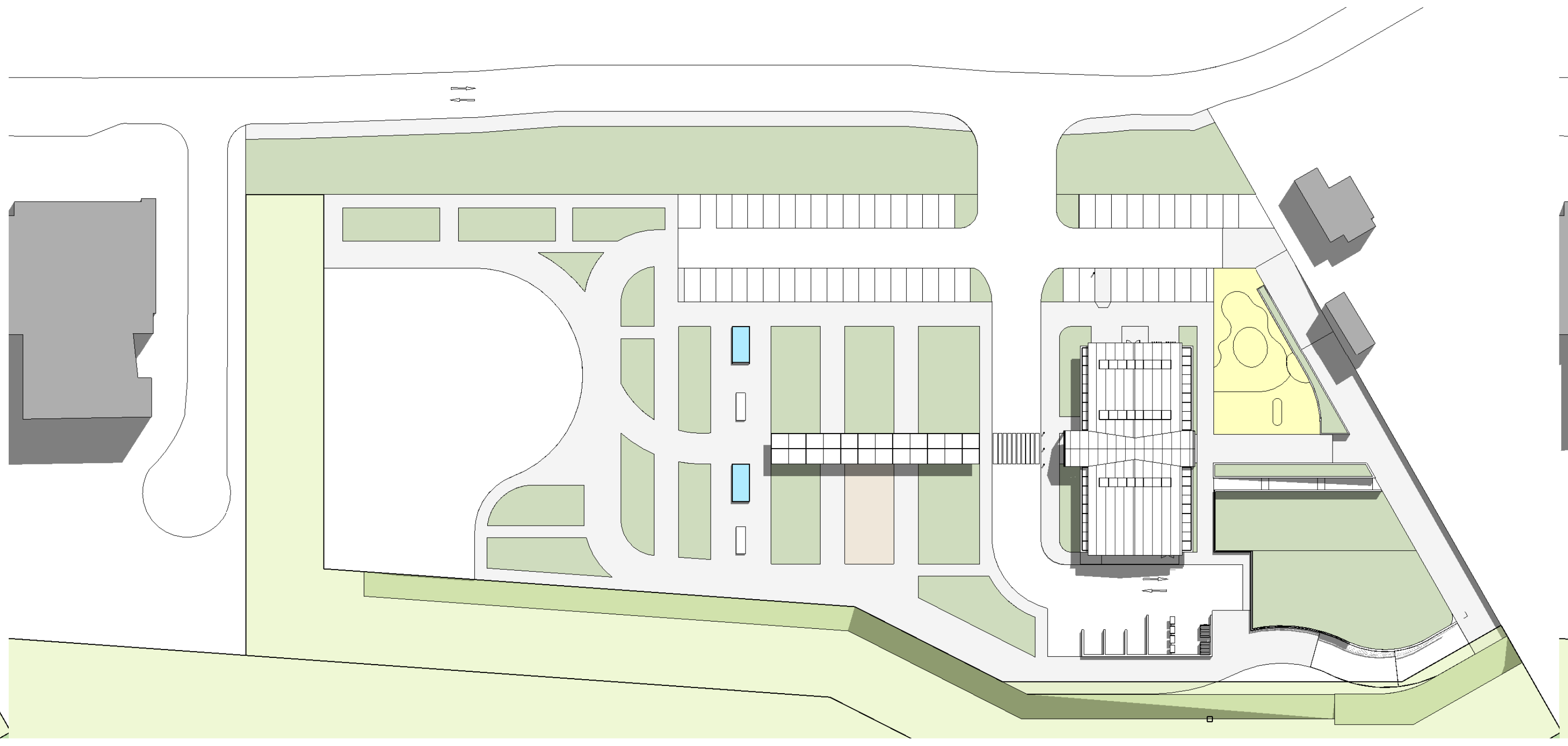

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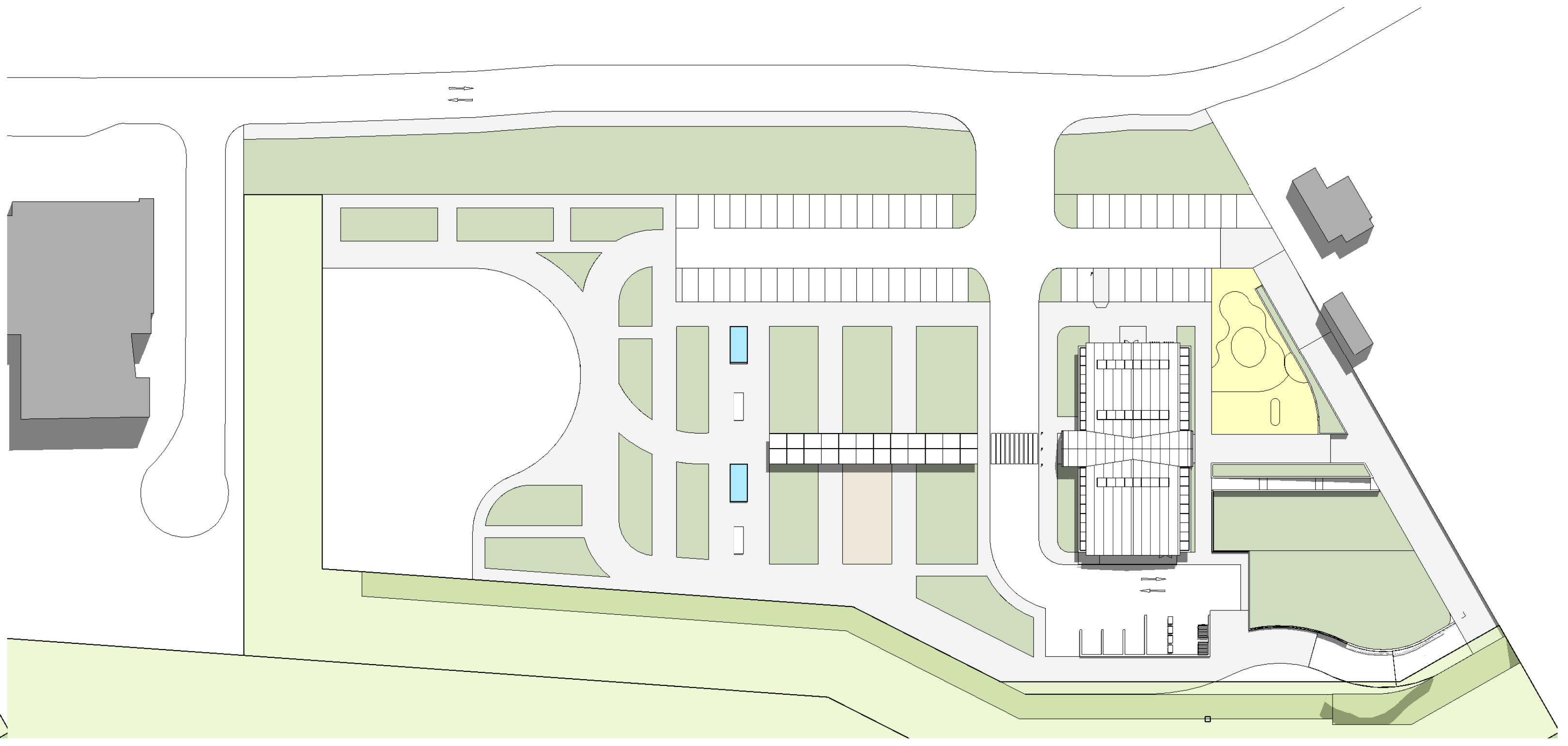

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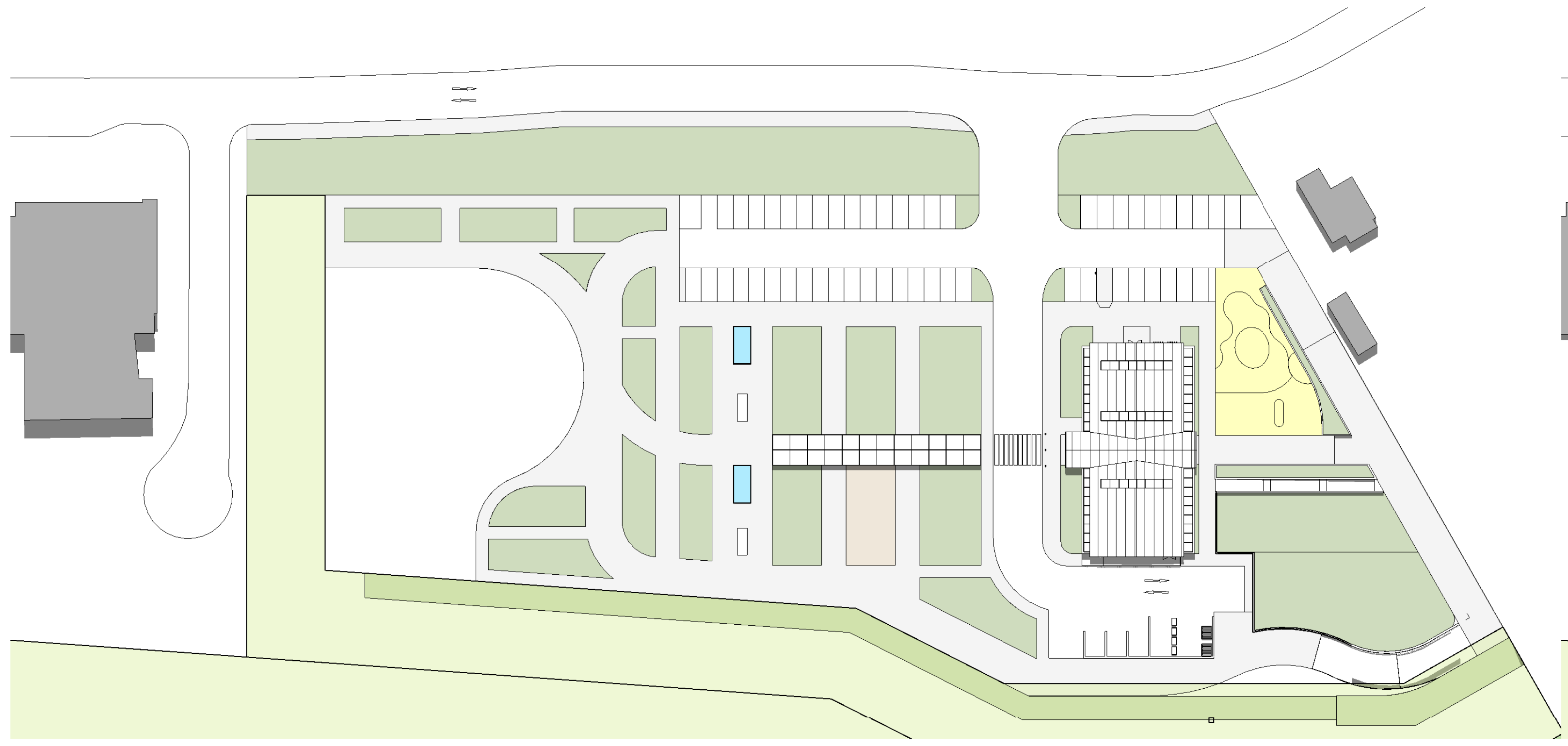

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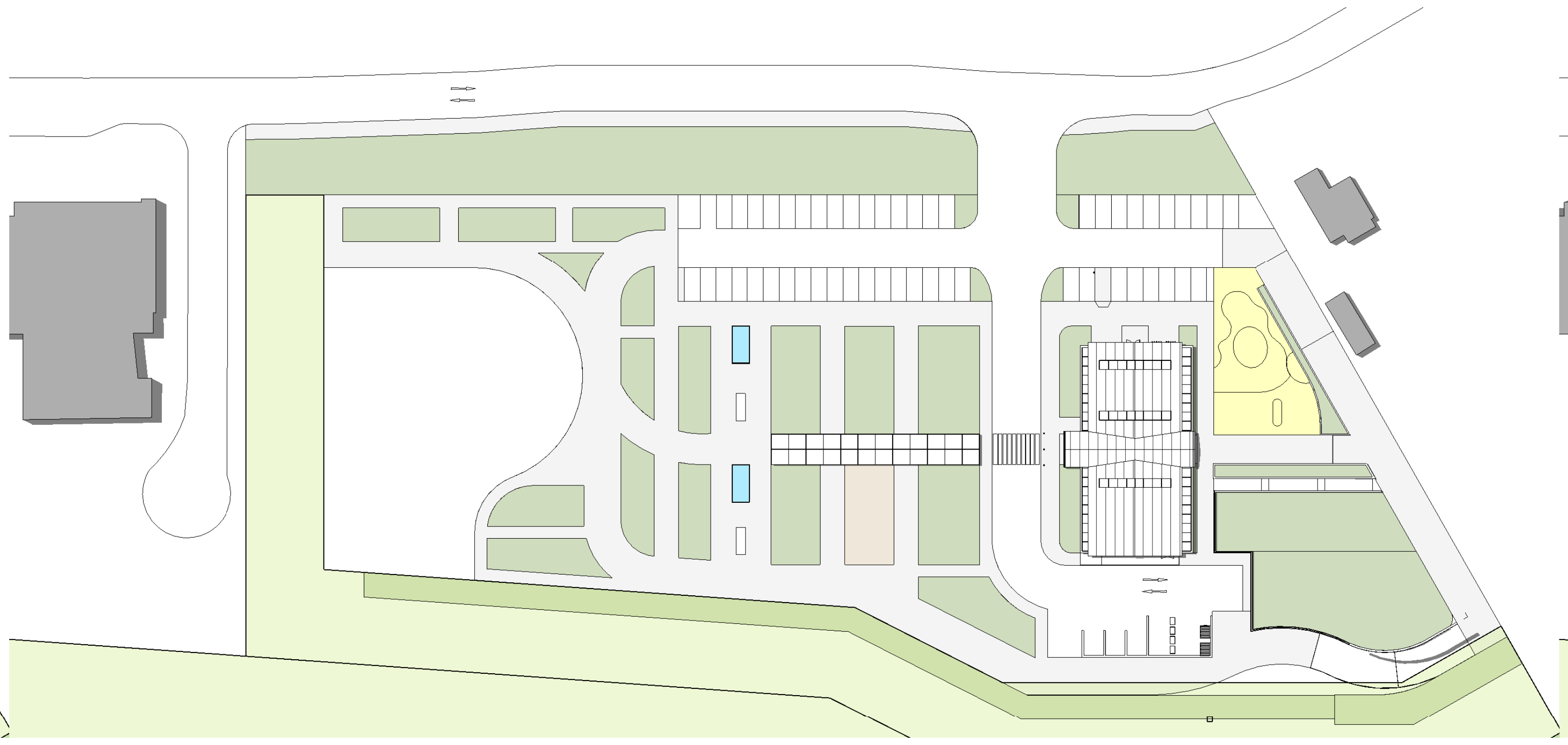

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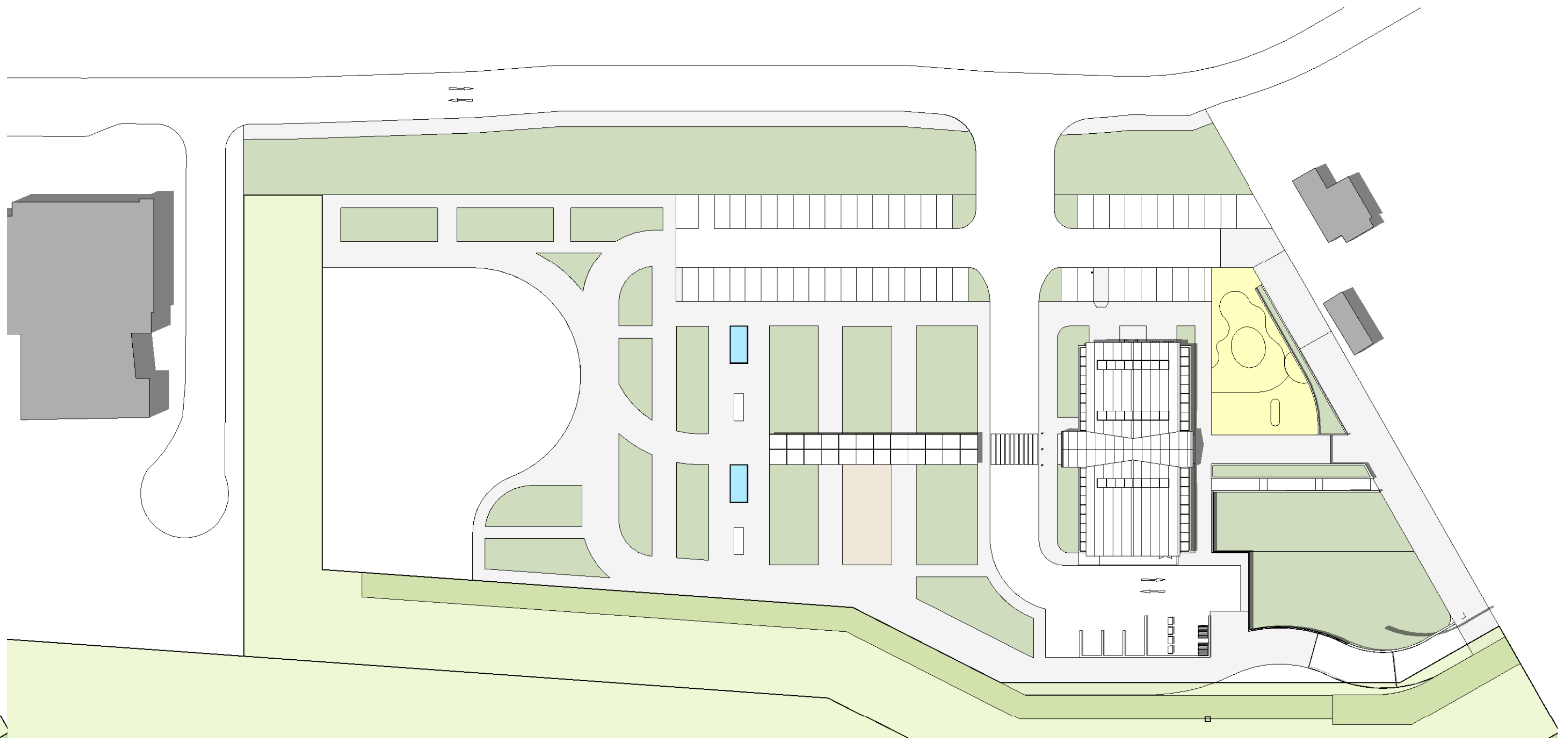

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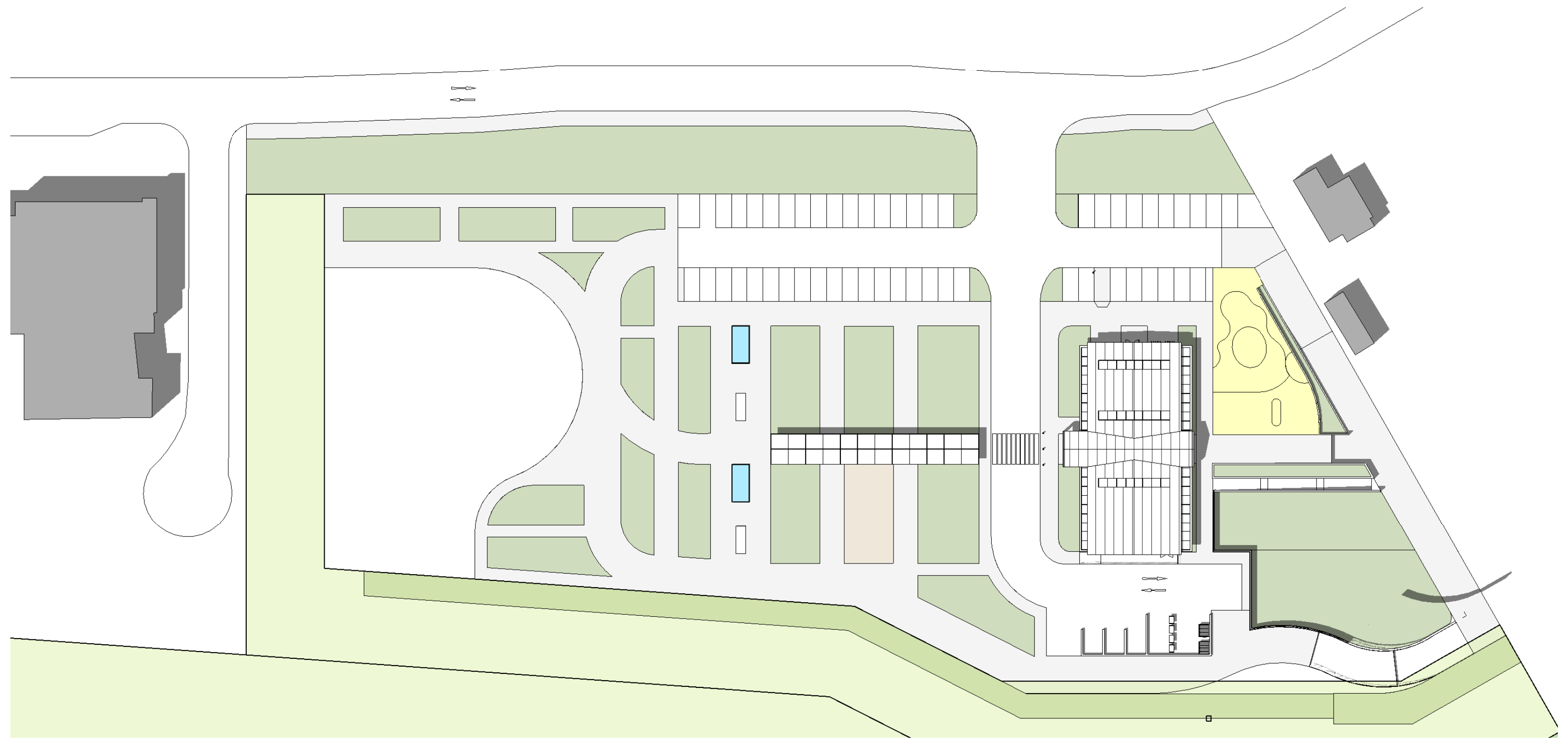

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Project
WARRIEWOOD
10-12 Boondah Rd, Warriewood, New South Wales 2102

Project Number
230736

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5	27/03/2024	DRAFT	RW	
6	22/05/2024	DRAFT	SU	

Drawing Number
AMP-0111

Nominated Architect: Anthony Palamara NSW ARN 7274
Do not scale this drawing. Verify all dimensions on site before commencing any work.

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Revision
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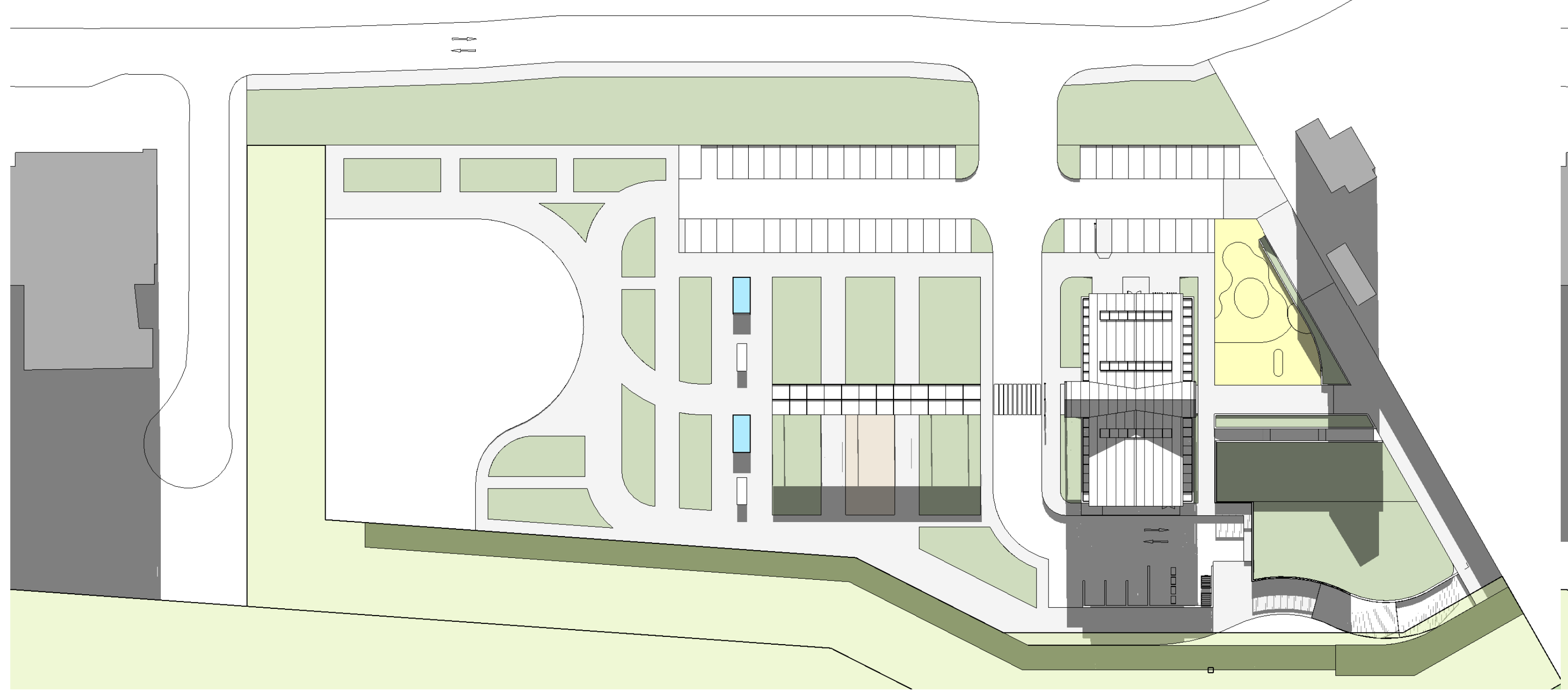

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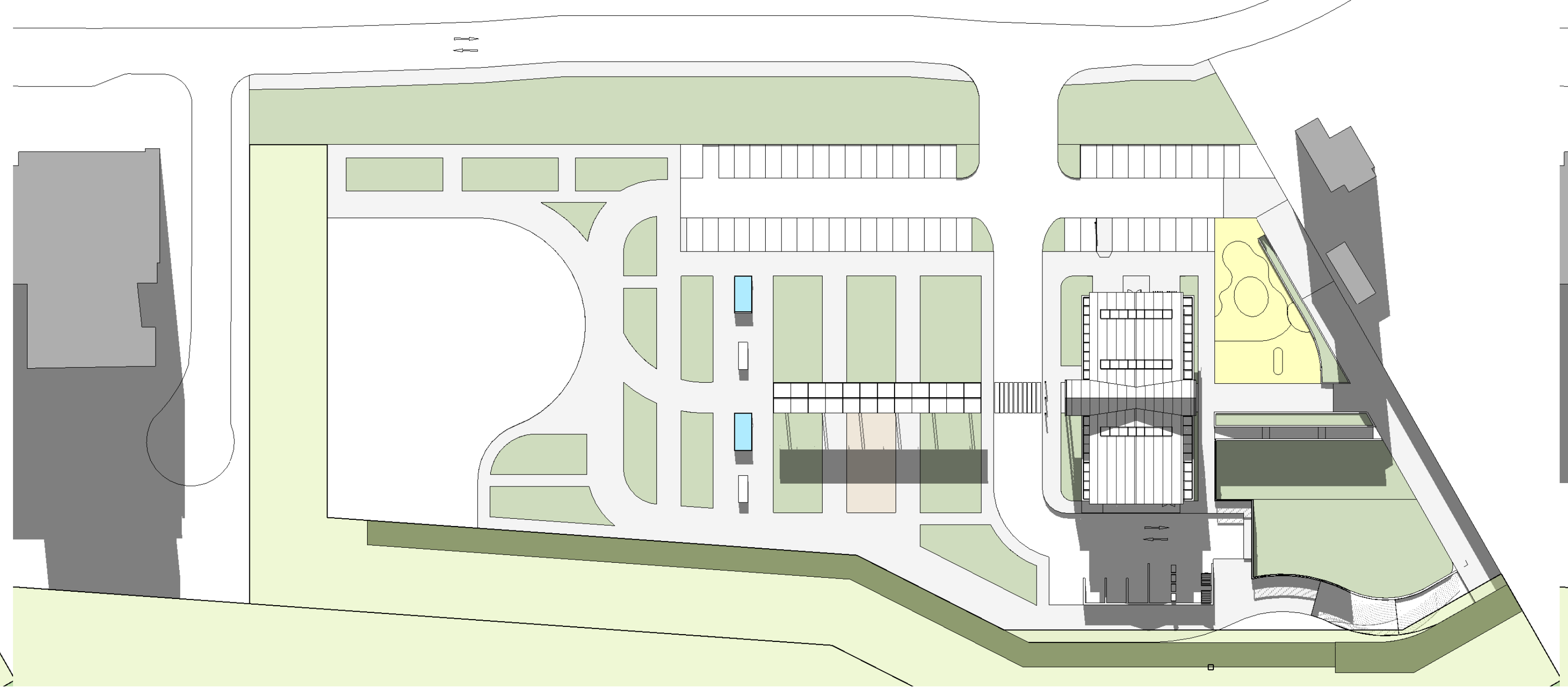

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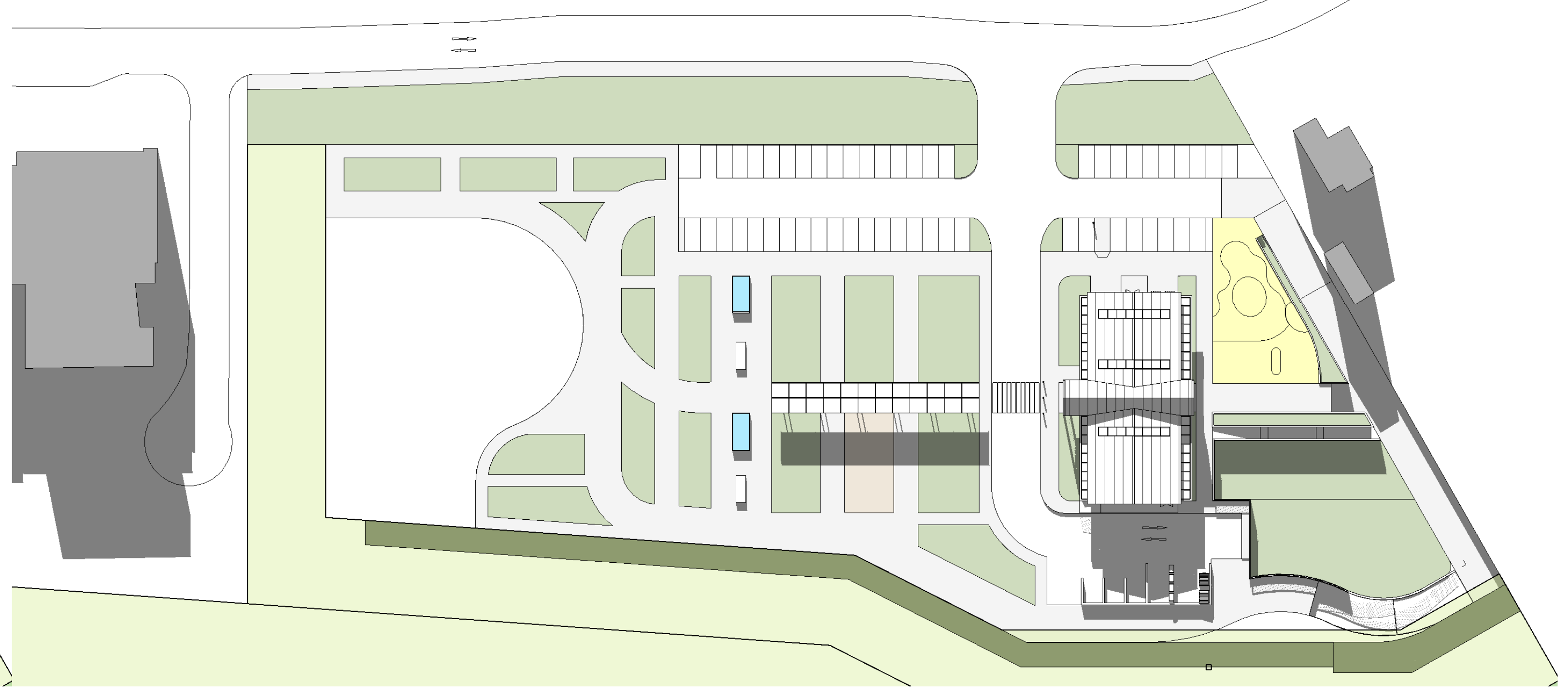

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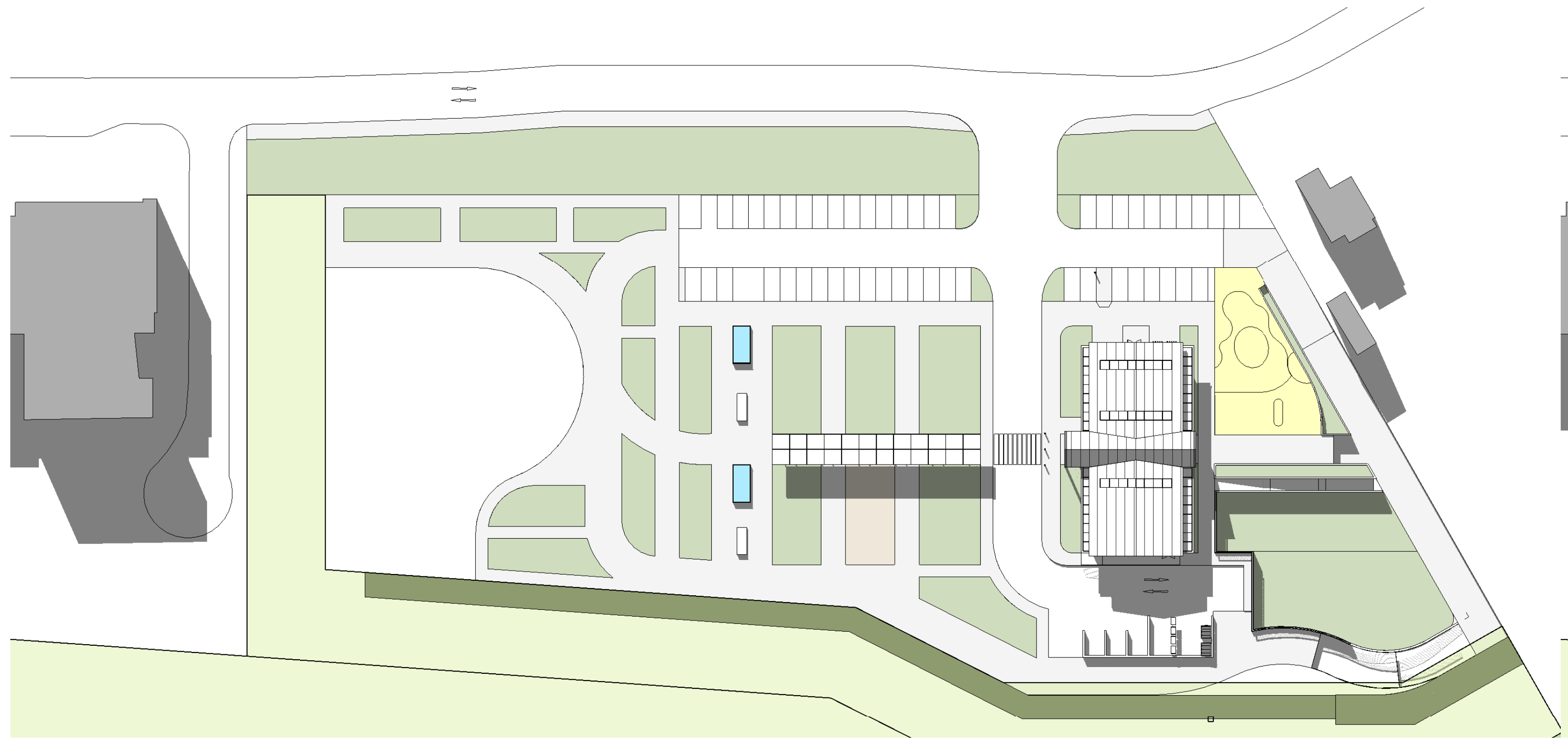

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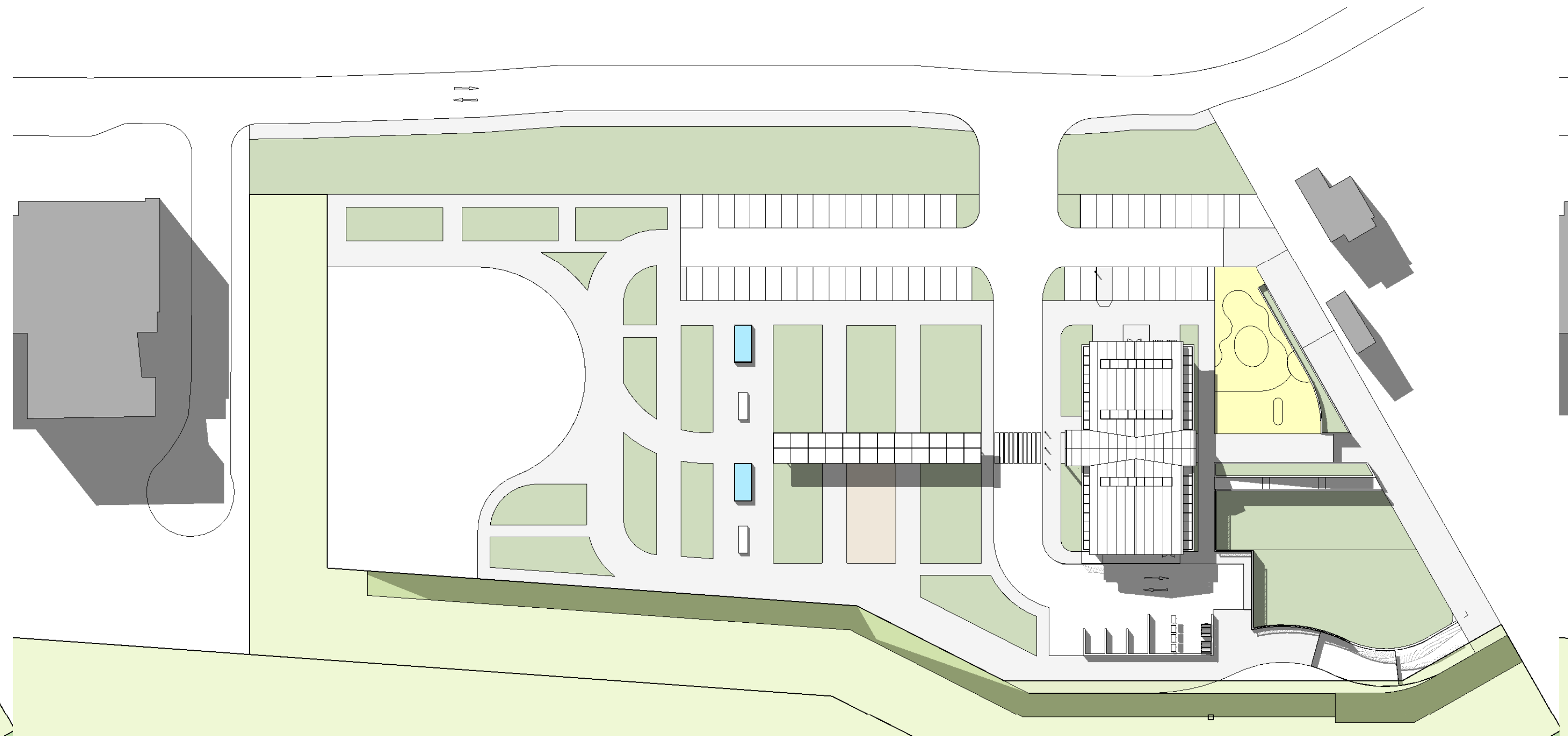

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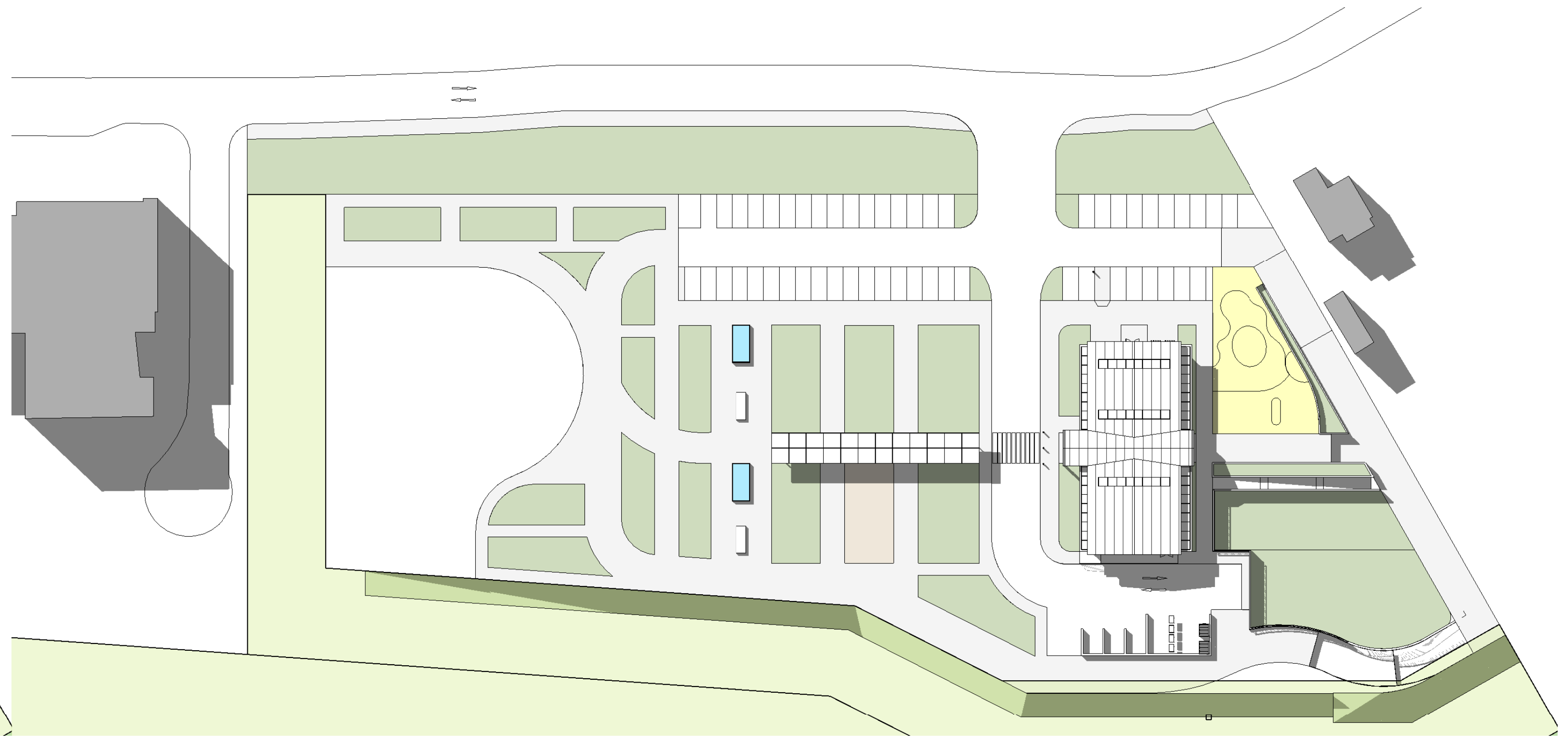

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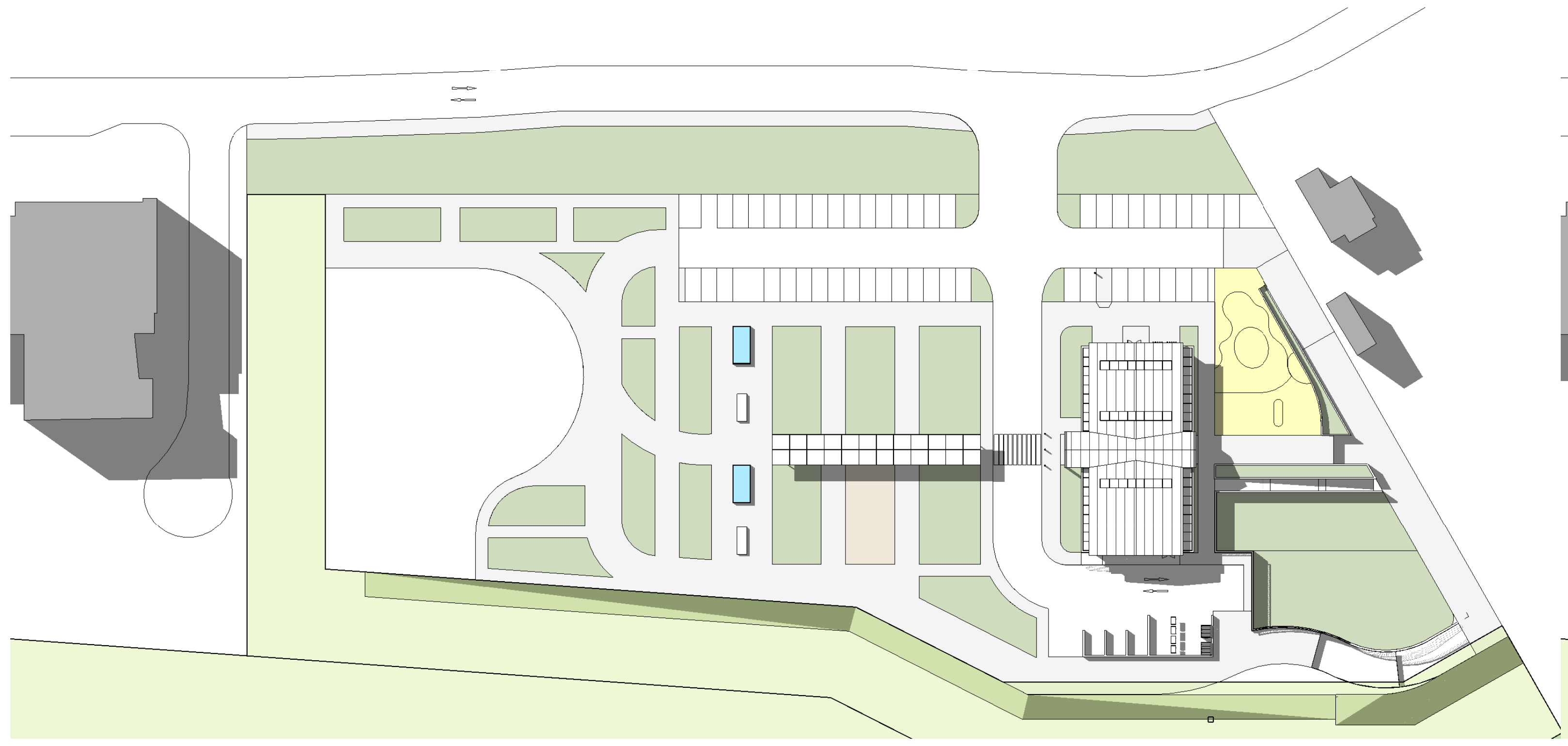

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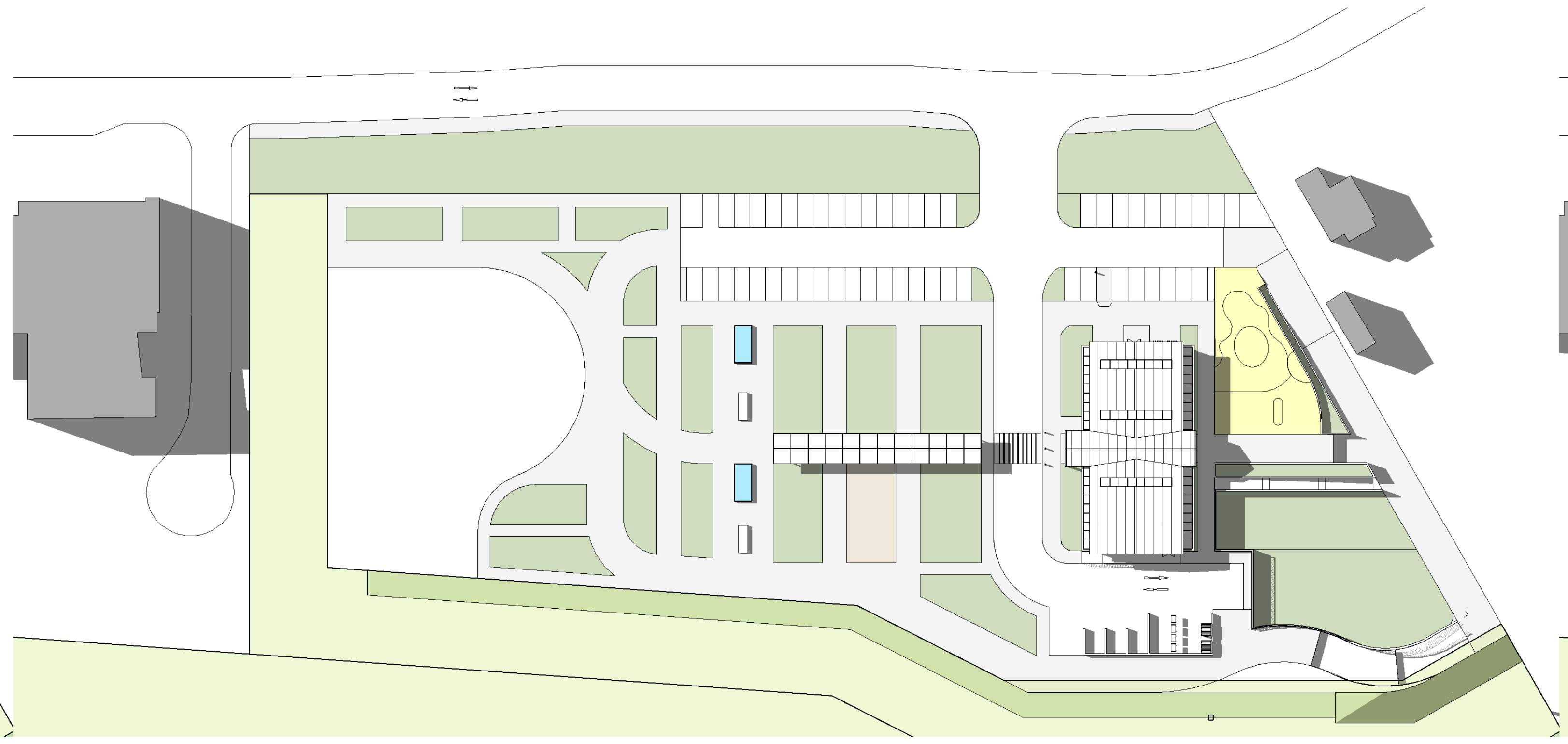

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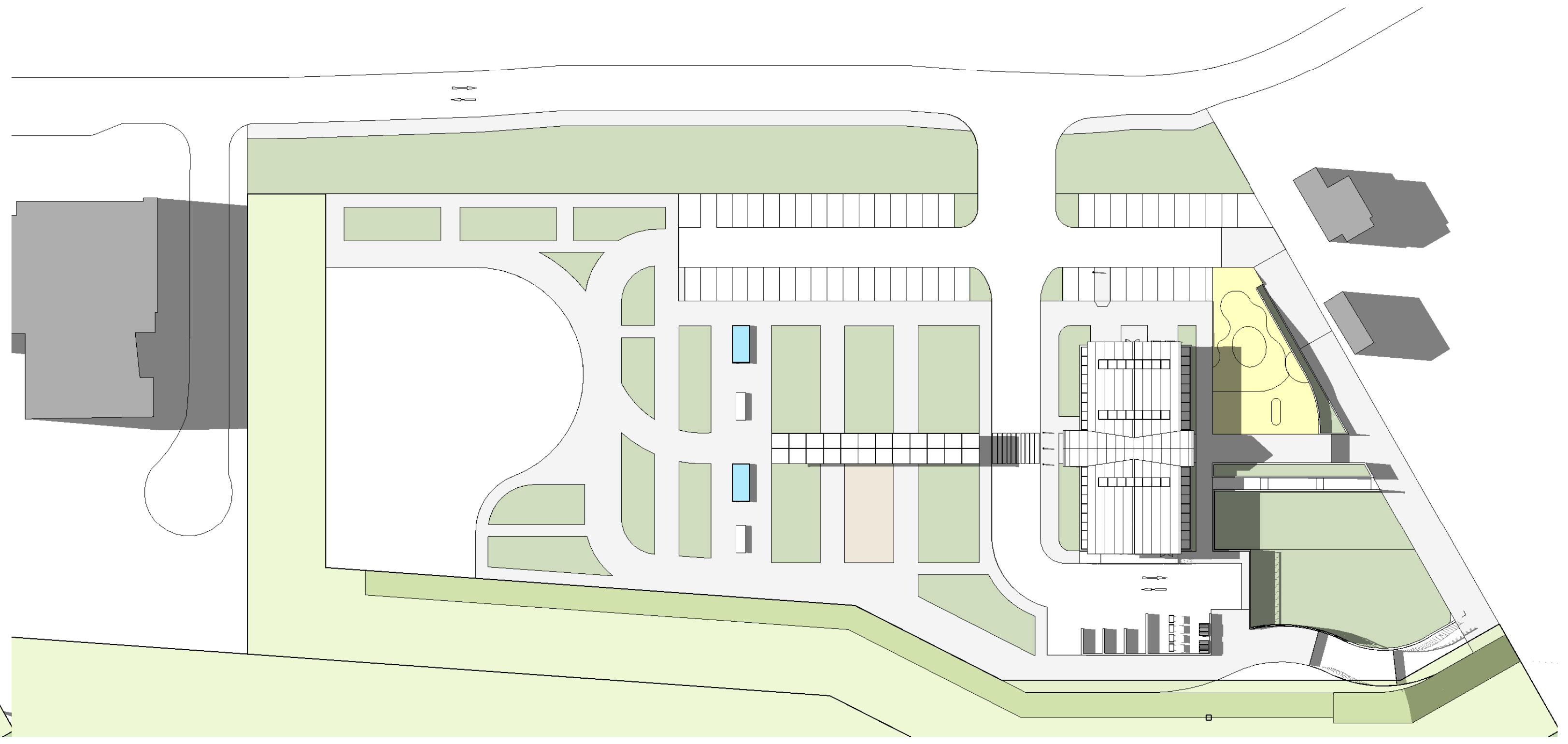

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Project
WARRIEWOOD
10-12 Boondah Rd, Warriewood, New South Wales 2102

Project Number
230736

Status

Rev.	Date	Description	Iss.	Appr.
1	17/01/2024	DRAFT	RW	
2	02/02/2024	DRAFT	KD	
3	28/02/2024	DRAFT	RW	
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6	22/05/2024	DRAFT	SU	

Drawing Number
AMP-0112

Nominated Architect: Anthony Palamara NSW ARN 7274

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Scale
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N

Revision
6

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1 LEVEL G PLAN

SCALE 1 : 500

Project

WARRIEWOOD

10-12 Boondah Rd, Warriewood, New South Wales 2102

Project Number

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Status

Rev.	Date	Description	Iss.	Appr.
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5	27/03/2024	DRAFT	RW	
6	22/05/2024	DRAFT	SU	

Drawing Number

AMP-2001

Nominated Architect: Anthony Palamara NSW ARN 7274

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Scale

1 : 500 @A1

N

Revision

6

BUCHAN

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1 MP_PLAN_ROOF PLAN

SCALE 1 : 500

Project
WARRIEWOOD
10-12 Boondah Rd, Warriewood, New South Wales 2102

Project Number
230736

Status

Rev.	Date	Description	Iss.	Appr.
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6	22/05/2024	DRAFT	SU	

Drawing Number
AMP-2002

Nominated Architect: Anthony Palamara NSW ARN 7274
Do not scale this drawing. Verify all dimensions on site before commencing any work.

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Revision
6

BUCHAN

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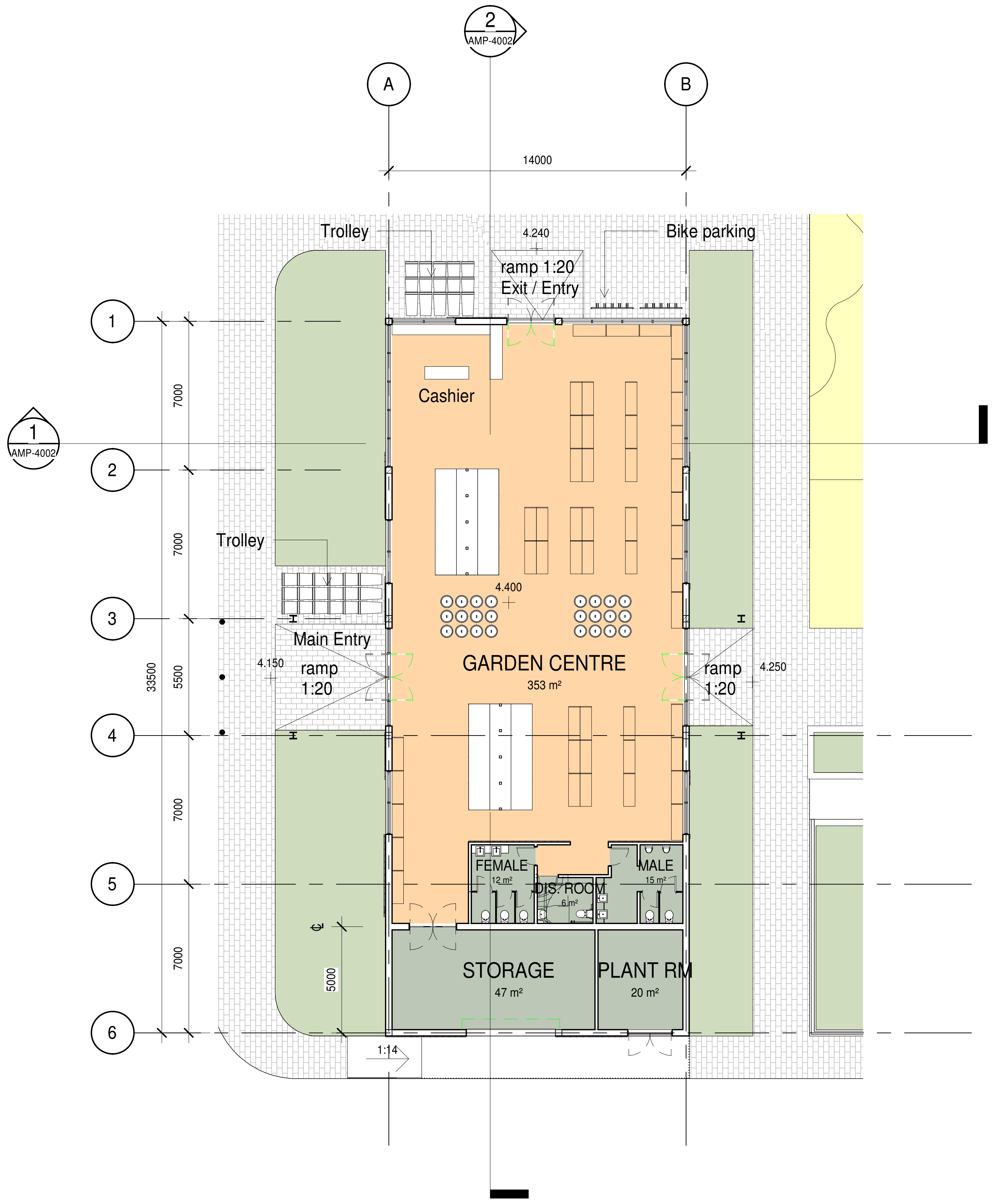

1 GROUND FLOOR PLAN

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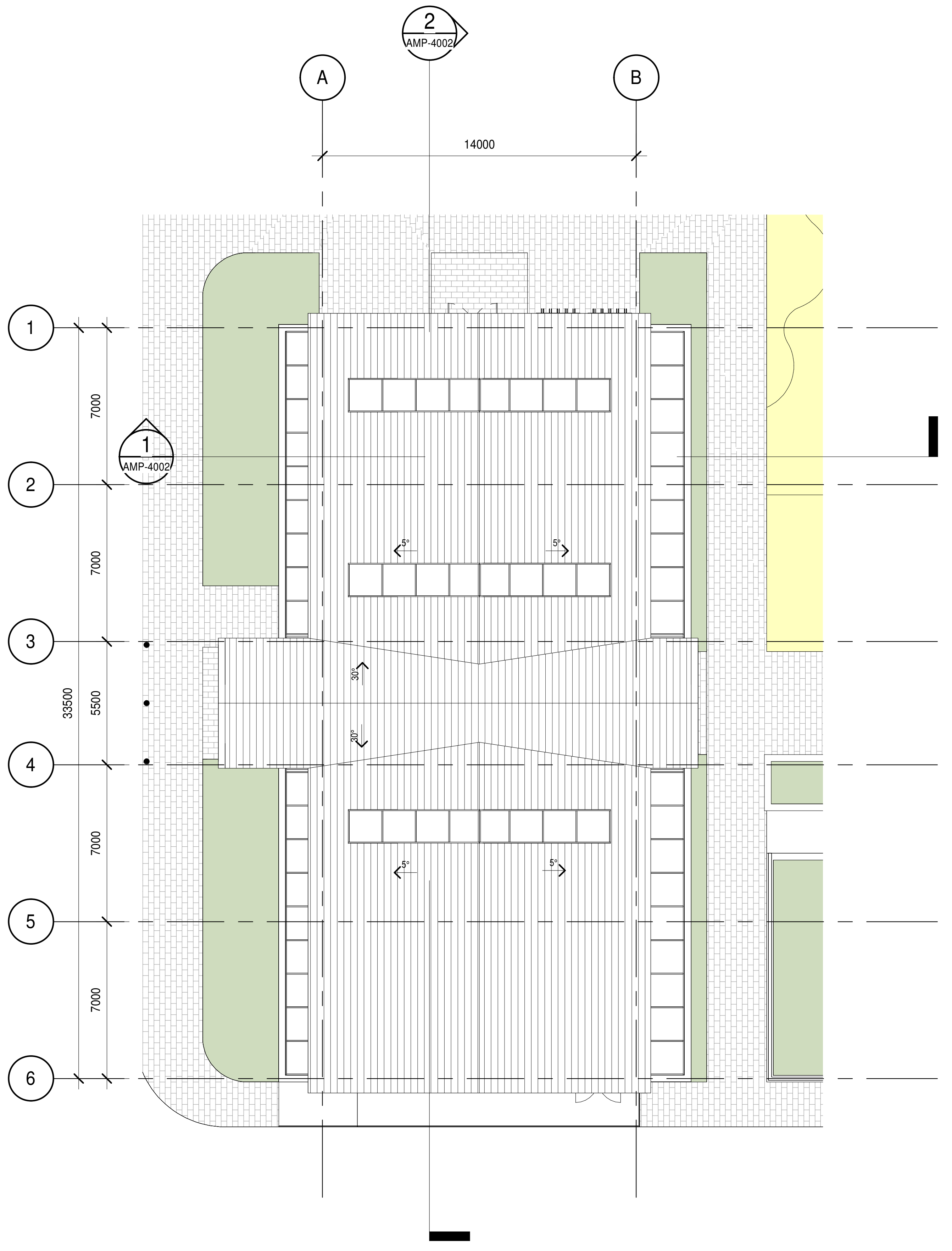

2 ROOF PLAN

SCALE 1 : 200

Room Schedule	
Name	Area
GARDEN CENTRE	353 m²
MALE	15 m²
DIS. ROOM	6 m²
FEMALE	12 m²
STORAGE	47 m²
PLANT RM	20 m²
Grand total: 6	452 m²

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Project Number
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Drawing Number
AMP-2101

Nominated Architect: Anthony Palamara NSW ARN 7274

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Revision
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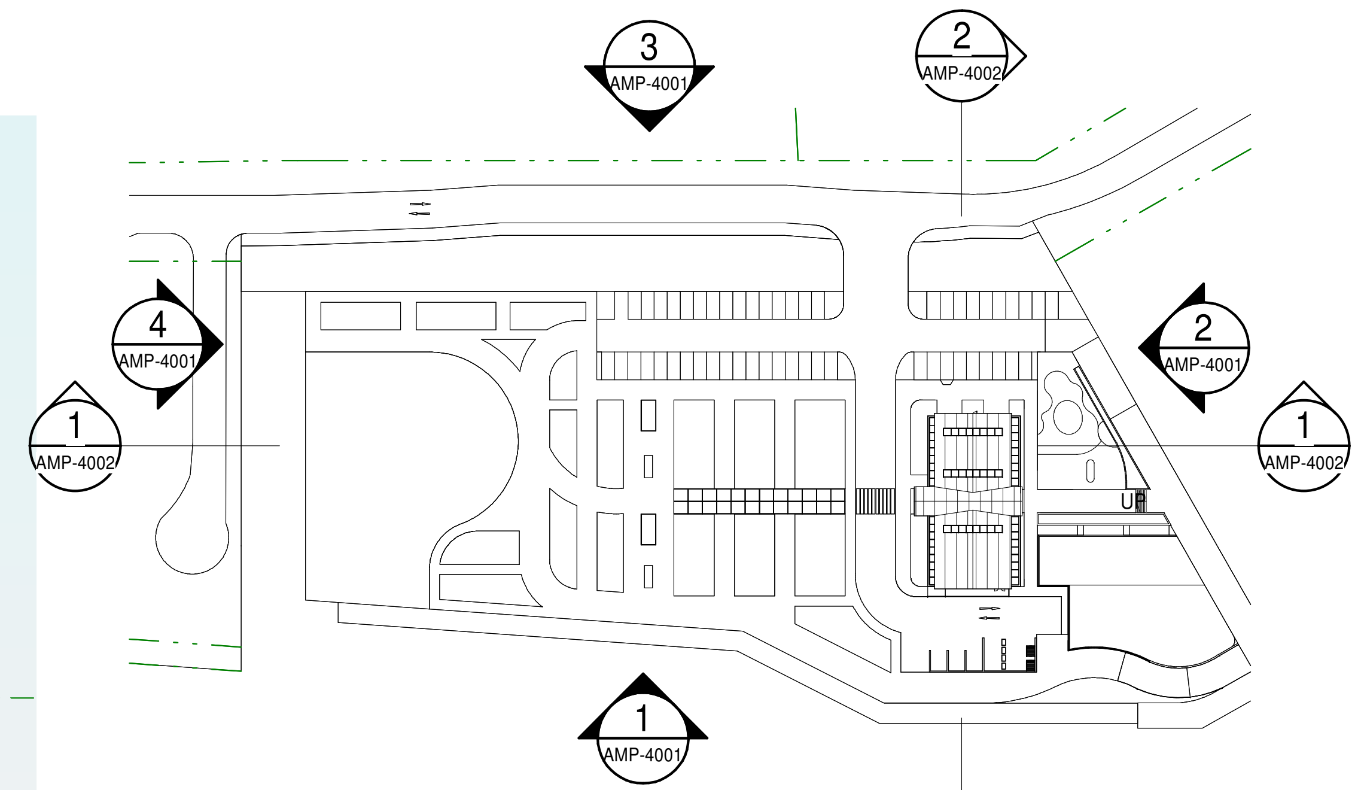

KEY PLAN

1 WEST ELEVATION
AMP-2001
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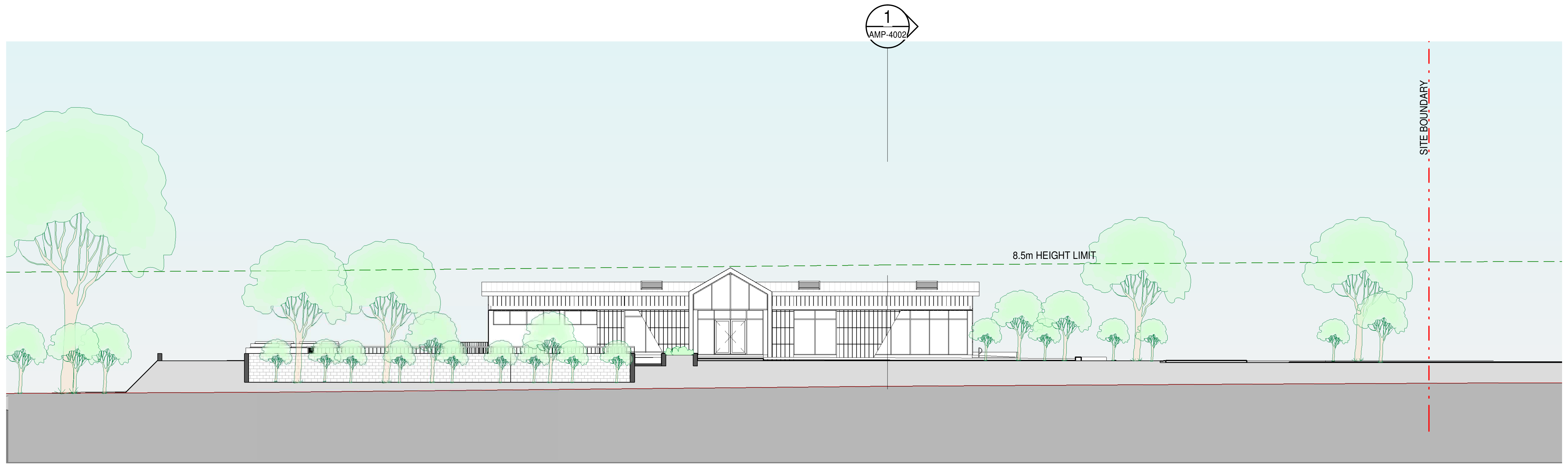


2 8 BOONDAH ROAD STREET VIEW - SOUTH ELEVATION
-
SCALE 1 : 250

4 NORTH ELEVATION SPINE BILL DRIVE
-
SCALE 1 : 250

3 10-12 BOONDAH ROAD STREET VIEW - EAST ELEVATION
-
SCALE 1 : 250

Project
WARRIEWOOD
10-12 Boondah Rd, Warriewood, New South Wales 2102

Project Number
230736

Status

Rev.	Date	Description	Iss.	Appr.
1	17/01/2024	DRAFT	RW	
2	02/02/2024	DRAFT	KD	
3	28/02/2024	DRAFT	RW	
4	06/03/2024	DRAFT	RW	
5	27/03/2024	DRAFT	RW	
6	22/05/2024	DRAFT	SU	

Drawing Number
AMP-4001

Nominated Architect: Anthony Palamara NSW ARN 7274
Do not scale this drawing. Verify all dimensions on site before commencing any work.

0 2.5 5 10 15M

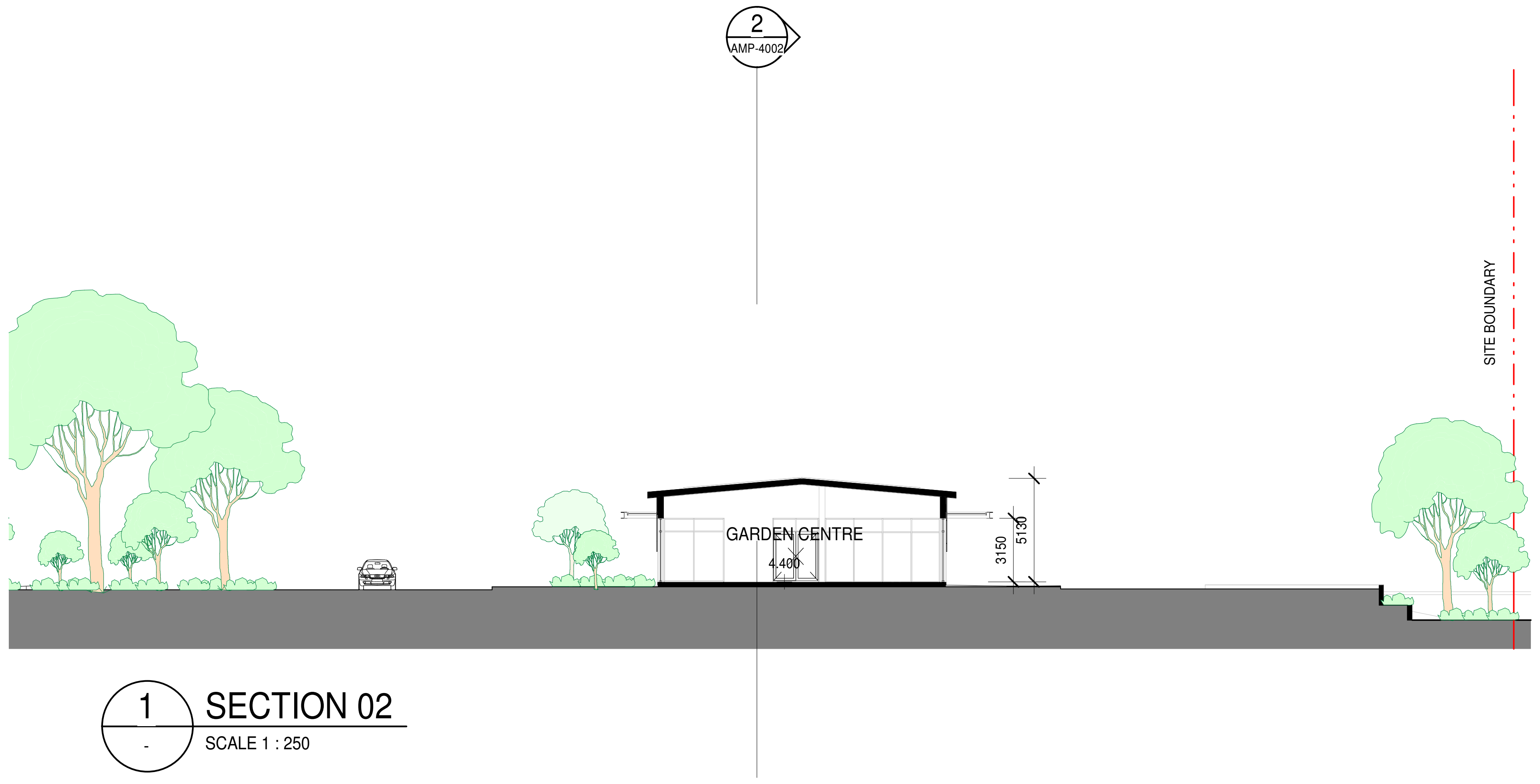
Scale
1 : 250 @A1

N

Revision
6

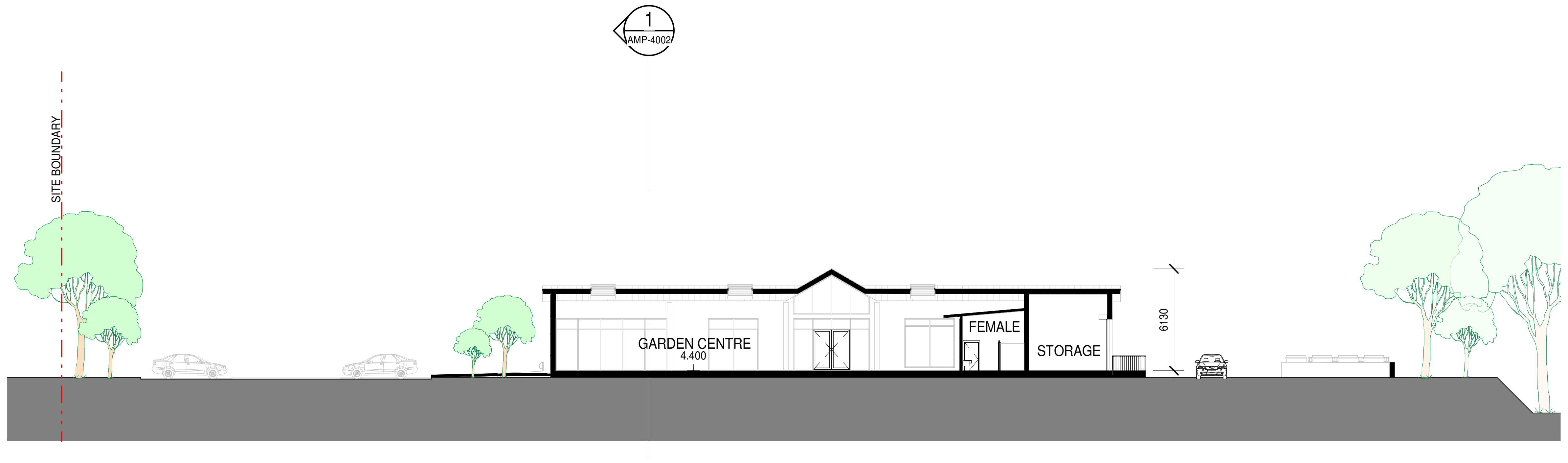
BUCHAN

Sydney Studio
+ 61 2 9566 1611 / **buchan.au**



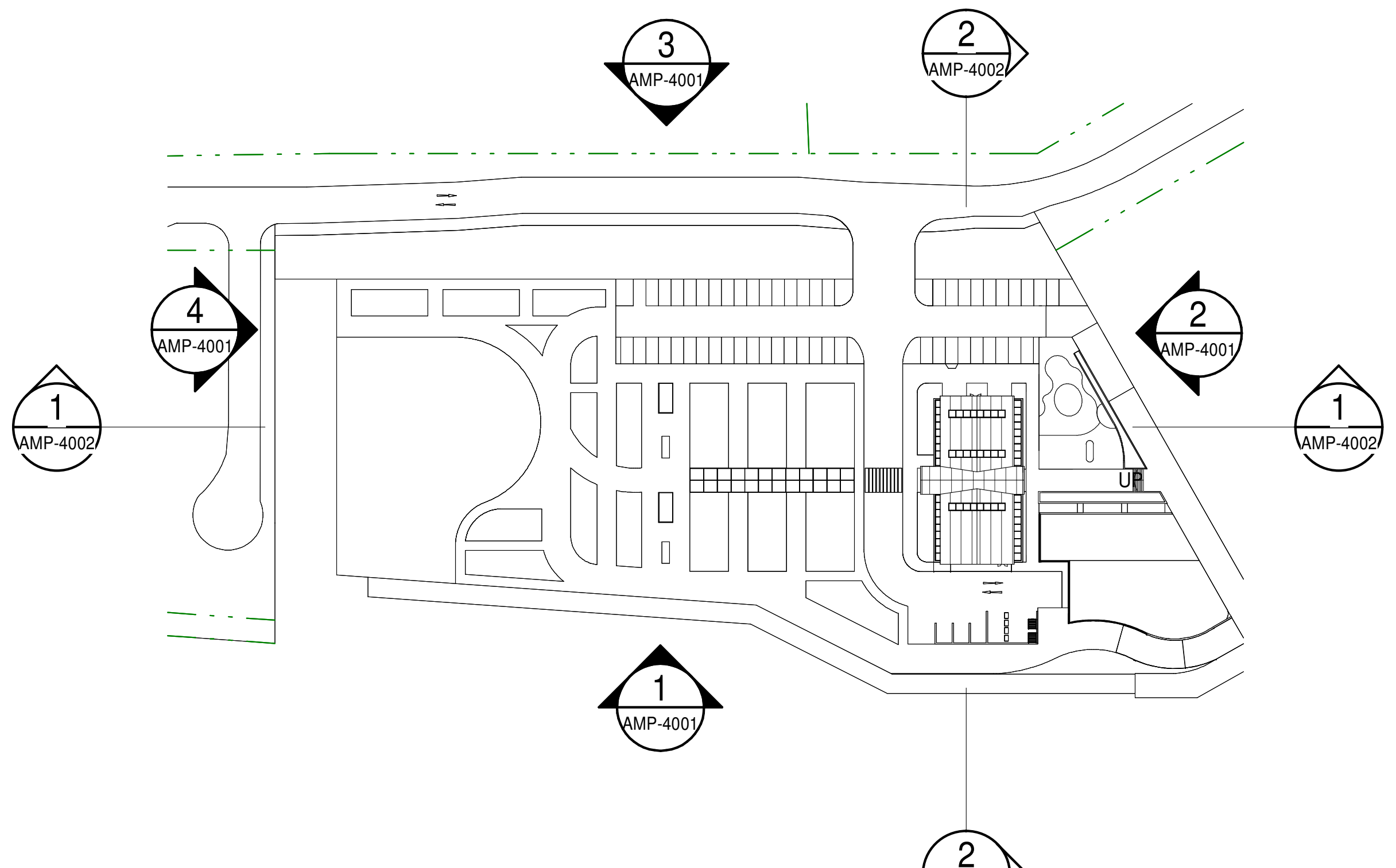
SECTION 02

SCALE 1 : 250



SECTION 01

SCALE 1 : 250



KEY PLAN

Project
WARRIEWOOD
10-12 Boondah Rd, Warriewood, New South Wales 2102

Project Number
230736

Status

Rev.	Date	Description	Iss.	Appr.
1	17/01/2024	DRAFT	RW	
2	02/02/2024	DRAFT	KD	
3	28/02/2024	DRAFT	RW	
4	06/03/2024	DRAFT	RW	
5	27/03/2024	DRAFT	RW	
6	22/05/2024	DRAFT	SU	

Drawing Number
AMP-4002

Nominated Architect: Anthony Palamara NSW ARN 7274
Do not scale this drawing. Verify all dimensions on site before commencing any work.

0 2.5 5 10 15M

Scale
1 : 250 @A1

N

Revision
6

BUCHAN

Sydney Studio
+ 61 2 9566 1611 / **buchan.au**

Project
WARRIEWOOD
10-12 Boondah Rd, Warriewood, New South Wales 2102

Project Number
230736

Status

Rev.	Date	Description	Iss.	Appr.
1	17/01/2024	DRAFT	RW	
2	02/02/2024	DRAFT	KD	
3	28/02/2024	DRAFT	RW	
4	06/03/2024	DRAFT	RW	
5	27/03/2024	DRAFT	RW	
6	22/05/2024	DRAFT	SU	

Drawing Number
AMP-9901

Nominated Architect: Anthony Palamara NSW ARN 7274
Do not scale this drawing. Verify all dimensions on site before commencing any work.

Scale
Not to scale

Revision
6

BUCHAN

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Appendix C

Borehole and Test Pit Logs

BOREHOLE LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 2.3 AHD
EASTING: 342262
NORTHING: 6270514
DIP/AZIMUTH: 90°/--

BORE No: BH01
PROJECT No: 85749.02
DATE: 29/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	VWP Construction Details
		FILL: grey-brown, medium to coarse silty sand, trace roots, moist	E	0.0 0.1		PID<1		
	0.2	SAND: fine to medium, dark grey, moist, loose						
2								
			E	0.4 0.5		PID<1		
		Below 0.65m: dark grey-orange						
		Below 0.8m: saturated					▼ 29-03-22	
			E	0.9 1.0		PID<1		
	1 1.0	Bore discontinued at 1.0m due to collapse						1
1								

RIG: Hand Auger to 1.0m **DRILLER:** VV **LOGGED:** VV **CASING:** Uncased
TYPE OF BORING: Hand Tools
WATER OBSERVATIONS: Groundwater observed at 0.8m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 2.3 AHD
EASTING: 342244
NORTHING: 6270492
DIP/AZIMUTH: 90°/--

BORE No: BH02
PROJECT No: 85749.02
DATE: 29/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	VWP Construction Details
		FILL: grey-brown, medium to coarse silty sand, trace roots, moist	▨	E*	0.0 0.1		PID<1		
	0.2	SAND: fine to medium, dark grey, moist, loose	░						
2			░						
			░	E	0.4 0.5		PID<1		
		Below 0.65m: dark grey-orange	░						
		Below 0.8m: saturated	░					▼ 29-03-22	
			░	E	0.9 1.0		PID<1		
	1 1.0	Bore discontinued at 1.0m Target depth reached							1
1									

RIG: Hand Auger to 1.0m **DRILLER:** VV **LOGGED:** VV **CASING:** Uncased
TYPE OF BORING: Hand Tools
WATER OBSERVATIONS: Groundwater observed at 0.8m
REMARKS: *Field Replicate BD01 taken at 0.0-0.1m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 1.8 AHD
EASTING: 342203
NORTHING: 6270457
DIP/AZIMUTH: 90°/--

BORE No: BH03
PROJECT No: 85749.02
DATE: 29/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	VWP Construction Details
		FILL: grey-brown, medium to coarse silty sand, rootlets, moist	▨	E	0.0 0.1		PID<1		
	0.3	SAND: fine to medium, dark grey	⁙	E	0.4 0.5		PID<1	▼ 29-03-22	
	0.5	Bore discontinued at 0.5m due to collapse							

RIG: Hand Auger to 0.5m **DRILLER:** VV **LOGGED:** VV **CASING:** Uncased
TYPE OF BORING: Hand Tools
WATER OBSERVATIONS: Groundwater observed at 0.5m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 2.6 AHD
EASTING: 342253
NORTHING: 6270533
DIP/AZIMUTH: 90°/--

BORE No: BH04
PROJECT No: 85749.02
DATE: 29/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	VWP Construction Details
				Type	Depth	Sample	Results & Comments		
		FILL: dark grey-black, clayey silt, with roadbase gravel, moist	▨	E	0.0 0.1		PID<1		
	0.3	Bore discontinued at 0.3m Auger Refusal in fill							
2									
	1								1
1									

RIG: Hand Auger to 0.3m **DRILLER:** VV **LOGGED:** VV **CASING:** Uncased
TYPE OF BORING: Hand Tools
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 4.1 AHD
EASTING: 342185
NORTHING: 6270586
DIP/AZIMUTH: 90°/--

BORE No: TP11
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	VWP Construction Details
4		FILL/SANDY Silt: dark grey, with terracotta, brick and tiles, moist	▨	E*	0.0 0.1		PID<1		
	0.2	Bore discontinued at 0.2m Refusal on possible sandstone boulder							
	1								1
3									

RIG: Hand Auger to 0.2m **DRILLER:** VV **LOGGED:** VV **CASING:** Uncased
TYPE OF BORING: Hand Tools
WATER OBSERVATIONS: No free groundwater observed
REMARKS: *Field Replicate BD03 taken at 0.0-0.1m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 3.1 AHD
EASTING: 342221
NORTHING: 6270510

PIT No: TP05
PROJECT No: 85749.02
DATE: 29/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
3		FILL: dark grey-brown, sandy silt, roots and rootlets, moist		E	0.0 0.1		PID<1		
	0.2	Fill: fine to medium, sand, orange-brown, trace terracotta, plastic and tiles		E	0.4 0.5		PID<1		
	0.5	SAND: fine to medium, dark grey-brown, moist							
		Below 0.8m: grey-brown, saturated		E	0.9 1.0		PID<1	▼ 29-03-22	
2	1								1
		Below 1.3m: pale grey		E	1.4 1.5		PID<1		
	1.5	Pit discontinued at 1.5m Target depth reached							

RIG: 3.5 T Excavator with 450mm wide bucket **LOGGED:** VV **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: Groundwater observed at 0.8m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 2.0 AHD
EASTING: 342200
NORTHING: 6270492

PIT No: TP06
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
2		FILL: orange-brown, medium to coarse sand, roots and rootlets	▨	E*	0.0 0.1		PID<1		
	0.2	SAND: fine to medium, dark grey, moist							
		Below 0.4m: pale grey, saturated		E	0.4 0.5		PID<1	▼ 30-03-22	
	0.5	Pit discontinued at 0.5m Target depth reached							
1	1								1

RIG: 3.5 T Excavator with 450mm wide bucket **LOGGED:** VV **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: Groundwater observed at 0.4m

REMARKS: *Field Replicate BD02 taken at 0.0-0.1m

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 2.8 AHD
EASTING: 342179
NORTHING: 6270528

PIT No: TP07
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Sampling & In Situ Testing: Depth	Sampling & In Situ Testing: Sample	Sampling & In Situ Testing: Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
		FILL: dark grey-black, clayey silt, terracotta, roots and rootlets, trace sandstone fragments		E	0.0 0.1		PID<1		
	0.2	FILL/SAND: fine to medium, pale-grey, with shale gravel, moist		E	0.4 0.5		PID<1		
2		Below 0.8m: saturated							
	1			E	0.9 1.0		PID<1	▼ 30-03-22	1
		Below 1.3m: dark grey-black, possible natural		E	1.4 1.5		PID<1		
	1.5	Pit discontinued at 1.5m Target depth reached							
1									

RIG: 3.5 T Excavator with 450mm wide bucket **LOGGED:** VV **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: Groundwater observed at 0.9m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 2.8 AHD
EASTING: 342230
NORTHING: 6270580

PIT No: TP08
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
				Type	Depth	Sample	Results & Comments		
		FILL/SANDY Silt: dark grey-brown, trace terracotta, brick, roots and rootlets	▨	E	0.0 0.1		PID<1		
	0.1	Pit discontinued at 0.1m due to test pit collapse (saturated soils)							
2									
	1								1
1									

RIG: 3.5 T Excavator with 450mm wide bucket

LOGGED: VV

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 3.9 AHD
EASTING: 342200
NORTHING: 6270550

PIT No: TP09
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
		FILL/SANDY Silt: dark brown and grey, with fine wood fragments and mulch	▨	E	0.0 0.1		PID<1		
	0.2	FILL: pale grey, sand, trace wood, dry	▨	E	0.4 0.5		PID<1		
	0.5	Pit discontinued at 0.5m Terminated on possible concrete or sandstone boulder							
3									
	1								1
2									

RIG: 3.5 T Excavator with 450mm wide bucket

LOGGED: VV

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 3.9 AHD
EASTING: 342200
NORTHING: 6270550

PIT No: TP09A
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
				Type	Depth	Sample	Results & Comments		
		FILL/SANDY Silt: dark brown and grey, with fine wood fragments and mulch	▩	E	0.0		PID<1		
	0.2	FILL: pale grey, sand, trace wood and concrete gravel, dry	▩	E	0.2		PID<1		
	0.4	Pit discontinued at 0.4m Terminated on possible concrete or sandstone boulder			0.5				
3									
	1								1
2									

RIG: 3.5 T Excavator with 450mm wide bucket **LOGGED:** VV **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 3.9 AHD
EASTING: 342196
NORTHING: 6270574

PIT No: TP10
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm)
				Type	Depth	Sample	Results & Comments		5 10 15 20
		FILL/Sandy SILT: grey-brown, root and rootlets, with wood and mulch, moist	▨	E	0.0 0.1		PID<1		
	0.2	Fill: fine to medium, sand, grey and orange, trace terracotta, moist.	▨	E	0.3 0.4		PID<1		
	0.4	Pit discontinued at 0.4m Refusal on possible sandstone boulder							
3									
	1								1
2									

RIG: 3.5 T Excavator with 450mm wide bucket

LOGGED: VV

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 4.1 AHD
EASTING: 342181
NORTHING: 6270617

PIT No: TP12
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm)
				Type	Depth	Sample	Results & Comments		5 10 15 20
		FILL: medium gravel, moist		E	0.0		PID<1		
4	0.1	FILL/CLAY: orange and pale grey, trace terracotta, moist			0.1				
				E	0.2		PID<1		
	0.3	FILL/SAND: fine to medium, dark grey-brown, trace terracotta			0.3				
				E	0.4		PID<1		
					0.5				
		Below 0.8m: grey-orange, possible natural							
				E	0.9				
	1				1.0			▼ 30-03-22	1
3									
	1.5	Pit discontinued at 1.5m Target depth reached							

RIG: 3.5 T Excavator with 450mm wide bucket **LOGGED:** VV **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: Groundwater observed at 1.0m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 4.3 AHD
EASTING: 342164
NORTHING: 6270620

PIT No: TP13
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Sampling & In Situ Testing: Depth	Sampling & In Situ Testing: Sample	Sampling & In Situ Testing: Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
		FILL/SAND: medium to coarse, dark grey, roots and rootlets	▨	E	0.0 0.1		PID<1		
4	0.2	FILL/SAND: medium to coarse, orange-grey, with sandstone gravel, moist Below 0.4m: dark grey-brown	▨	E	0.4 0.5		PID<1		
3	0.8	FILL/CLAY: dark grey and orange, clayey sand, trace sandstone gravel, moist	▨	E	0.9 1.0		PID<1	▼ 30-03-22 (1.0)	
	1.4	FILL/CLAY: orange and pale grey, moist	▨	E	1.4 1.5		PID<1		
	1.5	Pit discontinued at 1.5m Target depth reached							

RIG: 3.5 T Excavator with 450mm wide bucket
LOGGED: VV
SURVEY DATUM: MGA94

WATER OBSERVATIONS: Groundwater observed at 1.0m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 3.7 AHD
EASTING: 342184
NORTHING: 6270631

PIT No: TP14
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
		FILL/SAND: fine to medium, grey-brown, roots and rootlets	☒	E*	0.0 0.1		PID<1		
	0.2	SAND: fine to medium, dark grey-brown, moist	⁘						
				E	0.4 0.5		PID<1		
3									
		Below 0.8m: saturated						▼ 30-03-22	
				E	0.9 1.0		PID<1		
1	1.0	Pit discontinued at 1.0m due to collapse in saturated soils							1
2									

RIG: 3.5 T Excavator with 450mm wide bucket

LOGGED: VV

SURVEY DATUM: MGA94

WATER OBSERVATIONS: Groundwater observed at 0.8m

REMARKS: *Field Replicate BD04 taken at 0.0-0.1m

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Henroth Investments Ltd
PROJECT: Proposed Bulky Goods Store
LOCATION: 10-12 Boondah Road, Warriewood

SURFACE LEVEL: 3.2 AHD
EASTING: 342208
NORTHING: 6270619

PIT No: TP15
PROJECT No: 85749.02
DATE: 30/3/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
				Type	Depth	Sample	Results & Comments		
		FILL/SAND: fine to medium, dark grey-brown, moist	▨	E*	0.0 0.1		PID<1		
3	0.1	SAND: fine to medium, dark grey, moist	∴	E	0.4 0.5		PID<1		
		Below 0.8m: pale grey						▼ 30-03-22	
1	1.0	Pit discontinued at 1.0m due to collapse							1
2									

RIG: 3.5 T Excavator with 450mm wide bucket **LOGGED:** VV **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: Groundwater observed at 0.8m

REMARKS: *Field Replicate BD05 taken at 0.0-0.1m

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

Terminology, Symbols and Abbreviations

November 2023

Introduction to Terminology, Symbols and Abbreviations

Douglas Partners' reports, investigation logs, and other correspondence may use terminology which has quantitative or qualitative connotations. To remove ambiguity or uncertainty surrounding the use of such terms, the following sets of notes pages may be attached Douglas Partners' reports, depending on the work performed and conditions encountered:

- Soil Descriptions;
- Rock Descriptions; and
- Sampling, insitu testing, and drilling methodologies

In addition to these pages, the following notes generally apply to most documents.

Abbreviation Codes

Site conditions may also be presented in a number of different formats, such as investigation logs, field mapping, or as a written summary. In some of these formats textual or symbolic terminology may be presented using textual abbreviation codes or graphic symbols, and, where commonly used, these are listed alongside the terminology definition. For ease of identification in these note pages, textual codes are presented in these notes in the following style `XW`. Code usage conforms with the following guidelines:

- Textual codes are case insensitive, although herein they are generally presented in upper case; and
- Textual codes are contextual (i.e. the same or similar combinations of characters may be used in different contexts with different meanings (for example `PL` is used for plastic limit in the context of soil moisture condition, as well as in `PL(A)` for point load test result in the testing results column)).

Data Integrity Codes

Subsurface investigation data recorded by Douglas Partners is generally managed in a highly structured database environment, where records "span" between a top and bottom depth interval. Depth interval "gaps" between records are considered to introduce ambiguity, and, where appropriate, our practice guidelines may require contiguous data sets. Recording meaningful data is not always appropriate (for example assigning a "strength" to a concrete pavement) and the following codes may be used to maintain contiguity in such circumstances.

Term	Description	Abbreviation Code
Core loss	No core recovery	`KL`
Unknown	Information was not available to allow classification of the property. For example, when auguring in loose, saturated sand auger cuttings may not be returned.	`UK`
No data	Information required to allow classification of the property was not available. For example if drilling is commenced from the base of a hole predrilled by others	`ND`
Not Applicable	Derivation of the properties not appropriate or beyond the scope of the investigation. For example providing a description of the strength of a concrete pavement	`NA`

Graphic Symbols

Douglas Partners' logs contain a "graphic" column which provides a pictorial representation of the basic composition of the material. The symbols used are directly representing the material name stated in the adjacent "Description of Strata" column, and as such no specific graphic symbology legend has been provided in these notes.

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Soil Descriptions

Terminology
Symbols
Abbreviations

March 2024

Introduction

All materials which are not considered to be "in-situ rock" are described in general accordance with the soil description model of AS 1726-2017 Part 6.1.3, and can be broken down into the following description structure:

The "classification" comprises a two character "group symbol" providing a general summary of dominant soil characteristics. The "name" summarises the particle sizes within the soil which most influence its behaviour. The detailed description presents more information about composition, condition, structure, and origin of the soil.

Classification, naming and description of soils require the relative proportion of particles of different sizes within the whole soil mixture to be considered.

Particle size designation and Behaviour Model

Solid particles within a soil are differentiated on the basis of size.

The engineering behaviour properties of a soil can subsequently be modelled to be either "fine grained" (also known as "cohesive" behaviour) or "coarse grained" ("non cohesive" behaviour), depending on the relative proportion of fine or coarse fractions in the soil mixture.

Particle Size Designation	Particle Size (mm)	Behaviour Model	
		Behaviour	Approximate Dry Mass
Boulder	>200	Excluded from particle behaviour model as "oversize"	
Cobble	63 - 200		
Gravel[1]	2.36 - 63	Coarse	>65%
Sand[1]	0.075 - 2.36		
Silt	0.002 - 0.075	Fine	>35%
Clay	<0.002		

[1] – refer grain size subdivision descriptions below

The behaviour model boundaries defined above are not precise, and the material behaviour should be assumed from the name given to the material (which considers the particle fraction which dominates the behaviour, refer "component proportions" below), rather than strict observance of the proportions of particle sizes. For example, if a material is named a "Sandy CLAY", this is indicative that the material exhibits fine grained behaviour, even if the dry mass of coarse grained material may exceed 65%.

Component proportions

The relative proportion of the dry mass of each particle size fraction is assessed to be a "primary", "secondary", or "minor" component of the soil mixture, depending on its influence over the soil behaviour.

Component Proportion Designation	Definition[1]	Relative Proportion	
		In Fine Grained Soil	In Coarse Grained Soil
Primary	The component (particle size designation, refer above) which dominates the engineering behaviour of the soil	The clay/silt component with the greater proportion	The sand/gravel component with the greater proportion
Secondary	Any component which is not the primary, but is significant to the engineering properties of the soil	Any component with greater than 30% proportion	Any granular component with greater than 30%; or Any fine component with greater than 12%
Minor[2]	Present in the soil, but not significant to its engineering properties	All other components	All other components

[1] As defined in AS1726-2017 6.1.4.4

[2] In the detailed material description, minor components are split into two further sub-categories. Refer "identification of minor components" below.

Composite Materials

In certain situations, a lithology description may describe more than one material, for example, collectively describing a layer of interbedded sand and clay. In such a scenario, the two materials would be described independently, with the names preceded or followed by a statement describing the arrangement by which the materials co-exist. For example, "INTERBEDDED Silty CLAY AND SAND".

Soil Descriptions

Classification

The soil classification comprises a two character group symbol. The first character identifies the primary component. The second character identifies either the grading or presence of fines in a coarse grained soil, or the plasticity in a fine grained soil. Refer AS1726-2017 6.1.6 for further clarification.

Soil Name

For most soils, the name is derived with the primary component included as the noun (in upper case), preceded by any secondary components stated in an adjective form. In this way, the soil name also describes the general composition and indicates the dominant behaviour of the material.

Component [1]	**Prominence in Soil Name**
Primary	Noun (eg "CLAY")
Secondary	Adjective modifier (eg "Sandy")
Minor	No influence

[1] – for determination of component proportions, refer component proportions on previous page

For materials which cannot be disaggregated, or which are not comprised of rock or mineral fragments, the names "ORGANIC MATTER" or "ARTIFICIAL MATERIAL" may be used, in accordance with AS1726-2017 Table 14.

Commercial or colloquial names are not used for the soil name where a component derived name is possible (for example "Gravelly SAND" rather than "CRACKER DUST").

Materials of "fill" or "topsoil" origin are generally assigned a name derived from the primary/secondary component (where appropriate). In log descriptions this is preceded by uppercase "FILL" or "TOPSOIL". Origin uncertainty is indicated in the description by the characters (?) , with the degree of uncertainty described (using the terms "probably" or "possibly" in the origin column, or at the end of the description).

Identification of minor components

Minor components are identified in the soil description immediately following the soil name. The minor component fraction is usually preceded with a term indicating the relative proportion of the component.

Minor Component Proportion Term	**Relative Proportion**	
	In Fine Grained Soil	**In Coarse Grained Soil**
With	All fractions: 15-30%	Clay/silt: 5-12% sand/gravel: 15-30%
Trace	All fractions: 0-15%	Clay/silt: 0-5% sand/gravel: 0-15%

The terms "with" and "trace" generally apply only to gravel or fine particle fractions. Where cobbles/boulders are encountered in minor proportions (generally less than about 12%) the term "occasional" may be used. This term describes the sporadic distribution of the material within the confines of the investigation excavation only, and there may be considerable variation in proportion over a wider area which is difficult to factually characterise due to the relative size of the particles and the investigation methods.

Soil Composition

Plasticity

Descriptive Term	**Laboratory liquid limit range**	
	Silt	**Clay**
Non-plastic materials	Not applicable	Not applicable
Low plasticity	≤50	≤35
Medium plasticity	Not applicable	>35 and ≤50
High plasticity	>50	>50

Note, Plasticity descriptions generally describe the plasticity behaviour of the whole of the fine grained soil, not individual fine grained fractions.

Grain Size

Type		**Particle size (mm)**
Gravel	Coarse	19 - 63
	Medium	6.7 - 19
	Fine	2.36 – 6.7
Sand	Coarse	0.6 - 2.36
	Medium	0.21 - 0.6
	Fine	0.075 - 0.21

Grading

Grading Term	**Particle size (mm)**
Well	A good representation of all particle sizes
Poorly	An excess or deficiency of particular sizes within the specified range
Uniformly	Essentially of one size
Gap	A deficiency of a particular size or size range within the total range

Note, AS1726-2017 provides terminology for additional attributes not listed here.

Soil Condition

Moisture

The moisture condition of soils is assessed relative to the plastic limit for fine grained soils, while for coarse grained soils it is assessed based on the appearance and feel of the material. The moisture condition of a material is considered to be independent of stratigraphy (although commonly these are related), and this data is presented in its own column on logs.

Applicability	Term	Tactile Assessment	Abbreviation code
Fine	Dry of plastic limit	Hard and friable or powdery	w<PL
	Near plastic limit	Can be moulded	w=PL
	Wet of plastic limit	Water residue remains on hands when handling	w>PL
	Near liquid limit	"oozes" when agitated	w=LL
	Wet of liquid limit	"oozes"	w>LL
Coarse	Dry	Non-cohesive and free running	D
	Moist	Feels cool, darkened in colour, particles may stick together	M
	Wet	Feels cool, darkened in colour, particles may stick together, free water forms when handling	W

The abbreviation code NDF, meaning "not-assessable due to drilling fluid use" may also be used.

Note, observations relating to free ground water or drilling fluids are provided independent of soil moisture condition.

Consistency/Density/Compaction/Cementation/Extremely Weathered Material

These concepts give an indication of how the material may respond to applied forces (when considered in conjunction with other attributes of the soil). This behaviour can vary independent of the composition of the material, and on logs these are described in an independent column and are generally mutually exclusive (i.e it is inappropriate to describe both consistency and compaction at the same time). The method by which the behaviour is described depends on the behaviour model and other characteristics of the soil as follows:

- In fine grained soils, the "consistency" describes the ease with which the soil can be remoulded, and is generally correlated against the materials undrained shear strength;
- In granular materials, the relative density describes how tightly packed the particles are, and is generally correlated against the density index;
- In anthropogenically modified materials, the compaction of the material is described qualitatively;
- In cemented soils (both natural and anthropogenic), the cemented "strength" is described qualitatively, relative to the difficulty with which the material is disaggregated; and
- In soils of extremely weathered material origin, the engineering behaviour may be governed by relic rock features, and expected behaviour needs to be assessed based the overall material description.

Quantitative engineering performance of these materials may be determined by laboratory testing or estimated by correlated field tests (for example penetration or shear vane testing). In some cases, performance may be assessed by tactile or other subjective methods, in which case investigation logs will show the estimated value enclosed in round brackets, for example (VS).

Consistency (fine grained soils)

Consistency Term	Tactile Assessment	Undrained Shear Strength (kPa)	Abbreviation Code
Very soft	Extrudes between fingers when squeezed	<12	VS
Soft	Mouldable with light finger pressure	>12 - ≤25	S
Firm	Mouldable with strong finger pressure	>25 - ≤50	F
Stiff	Cannot be moulded by fingers	>50 - ≤100	St
Very stiff	Indented by thumbnail	>100 - ≤200	VSt
Hard	Indented by thumbnail with difficulty	>200	H
Friable	Easily crumbled or broken into small pieces by hand	-	Fr

Relative Density (coarse grained soils)

Relative Density Term	Density Index	Abbreviation Code
Very loose	<15	VL
Loose	>15 - ≤35	L
Medium dense	>35 - ≤65	MD
Dense	>65 - ≤85	D
Very dense	>85	VD

Note, tactile assessment of relative density is difficult, and generally requires penetration testing, hence a tactile assessment guide is not provided.

Soil Descriptions

Compaction (anthropogenically modified soil)

Compaction Term	Abbreviation Code
Well compacted	WC
Poorly compacted	PC
Moderately compacted	MC
Variably compacted	VC

Cementation (natural and anthropogenic)

Cementation Term	Abbreviation Code
Moderately cemented	MOD
Weakly cemented	WEK

Extremely Weathered Material

AS1726-2017 considers weathered material to be soil if the unconfined compressive strength is less than 0.6 MPa (i.e. less than very low strength rock). These materials may be identified as “extremely weathered material” in reports and by the abbreviation code XWM on log sheets. This identification is not correlated to any specific qualitative or quantitative behaviour, and the engineering properties of this material must therefore be assessed according to engineering principles with reference to any relic rock structure, fabric, or texture described in the description.

Soil Origin

Term	Description	Abbreviation Code
Residual	Derived from in-situ weathering of the underlying rock	RS
Extremely weathered material	Formed from in-situ weathering of geological formations. Has strength of less than ‘very low’ as per as1726 but retains the structure or fabric of the parent rock.	XWM
Alluvial	Deposited by streams and rivers	ALV
Fluvial	Deposited by channel fill and overbank (natural levee, crevasse splay or flood basin)	FLV
Estuarine	Deposited in coastal estuaries	EST
Marine	Deposited in a marine environment	MAR
Lacustrine	Deposited in freshwater lakes	LAC
Aeolian	Carried and deposited by wind	AEO
Colluvial	Soil and rock debris transported down slopes by gravity	COL
Slopewash	Thin layers of soil and rock debris gradually and slowly deposited by gravity and possibly water	SW
Topsoil	Mantle of surface soil, often with high levels of organic material	TOP
Fill	Any material which has been moved by man	FILL
Littoral	Deposited on the lake or seashore	LIT
Unidentifiable	Not able to be identified	UID

Cobbles and Boulders

The presence of particles considered to be “oversize” may be described using one of the following strategies:

- Oversize encountered in a minor proportion (when considered relative to the wider area) are noted in the soil description; or
- Where a significant proportion of oversize is encountered, the cobbles/boulders are described independent of the soil description, in a similar manner to composite soils (described above) but qualified with “MIXTURE OF”.

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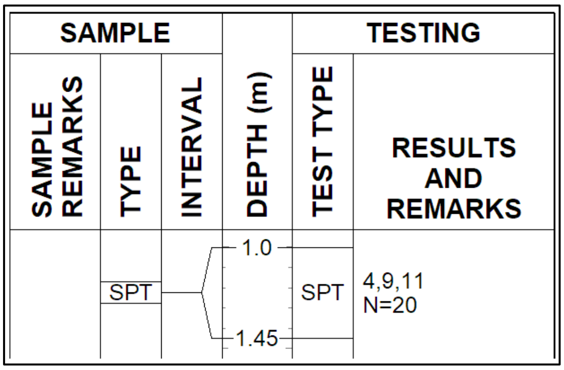
Sampling, Testing and Excavation Methodology

Terminology
Symbols
Abbreviations

March 2024

Sampling and Testing

A record of samples retained, and field testing performed is usually shown on a Douglas Partners' log with samples appearing to the left of a depth scale, and selected field and laboratory testing (including results, where relevant) appearing to the right of the scale, as illustrated below:



Sampling

The type or intended purpose for which a sample was taken is indicated by the following abbreviation codes.

Sample Type	Code
Auger sample	A
Acid Sulfate sample	ASS
Bulk sample	B
Core sample	C
Disturbed sample	D
Environmental sample	ES
Gas sample	G
Piston sample	P
Sample from SPT test	SPT
Undisturbed tube sample	U[1]
Water sample	W
Material Sample	MT
Core sample for unconfined compressive strength testing	UCS

[1] – numeric suffixes indicate tube diameter/width in mm

The above codes only indicate that a sample was retained, and not that testing was scheduled or performed.

Field and Laboratory Testing

A record that field and laboratory testing was performed is indicated by the following abbreviation codes.

Test Type	Code
Pocket penetrometer (kPa)	PP
Photo ionisation detector (ppm)	PID
Standard Penetration Test x/y = *x* blows for *y* mm penetration HB = hammer bouncing HW = fell under weight of hammer	SPT
Shear vane (kPa)	V
Unconfined compressive strength, (MPa)	UCS

Field and laboratory testing (continued)

Test Type	Code
Point load test, (MPa), axial (A), diametric (D), irregular (I)	PLT(_)
Dynamic cone penetrometer, followed by blow count penetration increment in mm (cone tip, generally in accordance with AS1289.6.3.2)	DCP/150
Perth sand penetrometer, followed by blow count penetration increment in mm (flat tip, generally in accordance with AS1289.6.3.3)	PSP/150

Groundwater Observations

▷	seepage/inflow
∇	standing or observed water level
NFGWO	no free groundwater observed
OBS	observations obscured by drilling fluids

Drilling or Excavation Methods/Tools

The drilling/excavation methods used to perform the investigation may be shown either in a dedicated column down the left-hand edge of the log, or stated in the log footer. In some circumstances abbreviation codes may be used.

Method	Abbreviation Code
Direct Push	DP
Solid flight auger. Suffixes: /T = tungsten carbide tip, /V = v-shaped tip	AD[1]
Air Track	AT
Diatube	DT[1]
Hand auger	HA[1]
Hand tools (unspecified)	HAND
Existing exposure	X
Hollow flight auger	HSA[1]
HQ coring	HQ3
HMLC series coring	HMLC
NMLC series coring	NMLC
NQ coring	NQ3
PQ coring	PQ3
Predrilled	PD
Push tube	PT[1]
Ripping tyne/ripper	R
Rock roller	RR[1]
Rock breaker/hydraulic hammer	EH
Sonic drilling	SON[1]
Mud/blade bucket	MB[1]
Toothed bucket	TB[1]
Vibrocore	VC[1]
Vacuum excavation	VE
Wash bore (unspecified bit type)	WB[1]

[1] – numeric suffixes indicate tool diameter/width in mm

Appendix D

Action Criteria

1. Introduction

This appendix details the acid sulfate soil action criteria, acid sulfate soil treatment verification criteria, equations for net acidity and waste classification criteria. The action criteria are based on Sullivan *et al* (2018b).

2. Action criteria

The following section provides the action criteria to determine if the soil is classified as PASS / ASS and therefore if acid sulfate soil management is required.

2.1 Field screening

Field screening indicators do not form part of the Assessment Criteria as such but can be used to provide an indication of the ASS status and to assist in selecting samples for laboratory testing.

Field screening is indicative only and can give false positive and false negative indications of the presence of ASS. False positives can be caused by organic matter, which often "froths" during oxidation. False negatives can be caused by shells in the soil. Indicators of ASS from field screening comprise:

- field pH is less than or equal to pH 4;
- pHfox is less than 3.5;
- a decrease of more than 1 pH unit from the field pH to the pHfox;
- bubbling, production of heat or release of sulphur odours during pHfox testing; and
- change in colour from grey to brown tones during oxidation.

2.2 Laboratory analysis

The action criteria trigger are the basis for determining if a ASSMP is required. They are based on Net Acidity. As clay content tends to influence a soil's natural buffering capacity, the action criteria are grouped by three broad texture categories – coarse, medium and fine. If the Net Acidity of any individual soil tested is equal to or greater than the action criterion a detailed ASS management will need to be prepared.

The test results can be used to evaluate the presence / absence of ASS in accordance. If the results indicate the absence of ASS treatment is not required. The following Table 1 provides the action criteria.

Table 1: Action criteria

Type of material		Net acidity#			
		1-1000 t Materials disturbed		>1000 t Materials disturbed	
Texture range (NCST 2009)*	**Approximate clay content %)**	**% S-equiv (oven dried basis)**	**Mol H+/t (oven dried basis)**	**% S-equiv (oven dried basis)**	**Mol H+/t (oven dried basis)**
Fine: light medium to heavy clay	>40	≥ 0.1	≥ 62	≥ 0.03	≥ 18
Medium: clayey sand to light clays	5-40	≥ 0.06	≥ 36	≥ 0.03	≥ 18
Coarse and Peats: sands to loamy sands	<5	≥ 0.03	≥ 18	≥ 0.03	≥ 18

* If bulk density values are not available for the conversion of cubic meters to tonnes of soil, then the default bulk densities based on the soil texture in Table 2 may be used.

Net Acidity can only include a soil material's measured Acid Neutralising Capacity where this measure has been corroborated by other data (for example slab incubation data) that demonstrates the soil material does not experience acidification during complete oxidation under field conditions (Equation C1). Where the Acid Neutralising Capacity has not been corroborated, the Net Acidity must be determined using Equation C2.

Table 2: Default bulk densities based on soil texture

Texture	Bulk density (t/m^3)
Sand	1.8
Loamy Sand	1.8
Sandy Loam	1.7
Loam	1.6
Silty Loam	1.5
Clay Loam	1.5
Clay	1.4
Peat	1.0

3. Verification of treatment

The following section provides the equations and methods of verifying that the neutralisation treatment has been successful / completed.

3.1 Field screening

Field screening results will be considered to be acceptable when the results are below the adopted criteria. When soils do meet the following criteria, confirmatory laboratory testing should be undertaken.

- field pH is ≥ 5.5 (but ideally between pH 6.5 and 8.5); and
- pHfox ≥ 6.5.

3.2 Laboratory testing

The soil will be considered successfully treated where:

- pHKCL is ≥ 6.5;
- (total actual acidity) TAA = 0; and
- net acidity ≤ 0. Net Acidity must be determined by one of the methods outlined in Section D3.2.1

3.2.1 Net acidity

Net Acidity is the quantitative measure of the acidity hazard of ASS. It is determined from an Acid Base Accounting (ABA) approach using one of the equations below. Equations C1 and C2 are used to determine the net acidity prior to treatment of ASS / PASS and therefore if acid sulfate soil treatment and / or management plan is required. Equation C3 is used to determine the neutralisation treatment has been successful.

- Equation D1 - when the effectiveness of a soil's measured Acid Neutralising Capacity has been corroborated by other data demonstrating the soil does not experience acidification during complete oxidation under field conditions, or
- Equation D2 - when the effectiveness of a soil's measured Acid Neutralising Capacity has not been corroborated by other data, or
- Equation D3 – when the effectiveness of a management approach involving the addition of liming materials is being verified post treatment via calculation of the Verification Net Acidity.

Equation D1 Net Acidity whereby acid neutralising capacity (ANC) has been corroborated by other data.

Net Acidity = potential sulfidic acidity + actual acidity + retained acidity – Acid Neutralising Capacity.

Net Acidity = Scr + S-TAA at pH 6.5 + SNAS - s-ANCBT.

Equation D2 Net Acidity whereby ANC has not been corroborated by other data.

Net Acidity = potential sulfidic acidity + actual acidity + retained acidity.

Net Acidity = Scr + S-TAA at pH 6.5 + SNAS.

Equation D3 Verification Net Acidity.

Verification Net Acidity = potential sulfidic acidity + actual acidity + retained acidity – (post neutralised Acid Neutralising Capacity – pre neutralised Acid Neutralising Capacity)

Verification Net Acidity = Scr + S-TAA at pH 6.5 + SNAS – (ANCBT of treated material – ANCBT of untreated material)

4. Off-site disposal requirements

Prior to disposal off-site the soil must be classified in accordance with the relevant guidelines.

4.1 Virgin excavated natural material

The POEO Act defines virgin excavated natural material (VENM) as:

'*natural material (such as clay, gravel, sand, soil or rock fines):*

(a) that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities; and

(b) that does not contain any sulfidic ores or soils or any other waste.

and includes excavated natural material that meets such criteria for virgin excavated natural material as may be approved for the time being pursuant to an EPA Gazettal notice.'

PASS / ASS and treated PASS / ASS cannot be classified as VENM.

4.2 Waste classification

If soil is proposed to be disposed to landfill (post treatment), it must be classified in accordance with the POEO Act, including the current guidelines, namely:

- NSW EPA Waste Classification Guidelines (2014) (EPA, 2014).

5. Disposal as PASS

Further guidance for the disposal of untreated soil as PASS is provided in Appendix G.

6. References

ANZG (2018) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

NEPC (2013) *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013).*

Acid Sulfate Soils Management Advisory Committee (ASSMAC) Acid Sulfate Soils Management Guidelines (1998) (ASSMAC, 1998).

NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014).

Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018, National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0 (Sullivan *et al* 2018a).

Appendix E

Liming Rate Equation

1. Introduction

This Appendix provides the equations for the calculation of liming rates.

2. Liming rates

The required liming rate can be calculated from one of the following formulas.

Equation E1:

$$\textit{Neutralising Material Required (kg)per tonne of soil (t)} = \left(\frac{\%\,\mathrm{S\ x\ }623.7}{19.98}\right)\ \mathrm{x}\ \frac{100}{\mathrm{ENV}(\%)}\ x\ FOS$$

Equation E2:

$$\textit{Neutralising Material Required (kg)per unit volume of soil } (m^3) = \left(\frac{\%\,\mathrm{S\ x\ }623.7}{19.98}\right)\ \mathrm{x}\ \frac{100}{\mathrm{ENV}(\%)}\ x\ D\ x\ FOS$$

Where:

net acidity (%S) is derived using the maximum Net Acidity (%S) using the methods in Appendix C;

623.7 = % S to mol H^+ / t;

19.98 converts mol H^+ / t to kg $CaCO_3$/tonne;

FOS (factor of safety) = a minimum value of 1.5 needs to be adopted, although values of up to 2 can be suitable;

ENV = Effective Neutralising Value (e.g. Approx. 98% for fine (0.3 mm grain size) ag lime with an NV of 98%).

D = bulk density, site specific results can be used, or the bulk densities in Table 2 of Appendix C should be used

Notes: The ENV is calculated based on the molecular weight, particle size and purity of the neutralising agent and should be assessed for proposed materials in accordance with ASSMAC (1998).

An initial liming rate (kg $CaCO_3$/t) based on the laboratory result calculation (excluding ANC) is considered appropriate based on it including a safety factor of 1.5 and the use of ag lime with an NV of at least 98% and a grain size of less than 0.3 mm. The laboratory result must be multiplied by the soils bulk density (D) to convert to lime rate per volume of soil (kg $CaCO_3/m^3$).

Depending upon the source of the ag-lime and ultimately the representative ENV of the ag-lime selected, the minimum lime dosing rate may be increased or decreased. Prior to the commencement of works, the minimum lime dosing rate should be finalised following review of the ENV of the selected ag-lime.

The liming rate to be calculated from the analytical results should therefore be considered as a "starting point", and pH monitoring should be conducted during treatment to assess the progress of the neutralisation and the need for additional mixing and / or addition of ag lime. Soil will only be considered to have been successfully treated when all soil has been verified in accordance with Section 10 of the ASSMP and Appendix D.

3. References

Dear, S. E., Williams, K. M., McElnea, A. E., Ahern, C. R., Dobos, S. K., Moore, N. G., & O'Brien, L. E. (2023). *Queensland acid sulfate soil technical manual : soil management guidelines version 5*. Department of Resources and the Department of Environment and Science.

Dear, S., Ahern, C., O'Brien, L., Dobos, S., McElnea, A., Moore, N., & Watling, K. (2014). *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines*. (QASSIT). Brisbane: Department of Science: Department of Science, Information, Technology, Innovation and the Arts, Queensland Government.

NEPC. (2013). *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013) [NEPM]*. Australian Government Publishing Services Canberra: National Environment Protection Council.

NSW EPA. (2014). *Waste Classification Guidelines, Part 4: Acid Sulfate Soils*. NSW Environment Protection Authority.

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Sullivan, L., Ward, N., Toppler, N., & Lancaster, G. (2018). *National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Identification and Laboratory Methods Manual*. Canberra ACT CC BY 4.0: Department of Agriculture and Water Resources.

Sullivan, L., Ward, N., Toppler, N., & Lancaster, G. (2018). *National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Sampling and Identification Methods Manual*. Canberra ACT CC BY 4.0: Department of Agriculture and Water Resources.

Appendix F

Field Screening Procedure

1. Introduction

This section details the field screening procedure.

2. Field pH test method

- calibrate battery powered field pH meter according to manufacturer's instructions;
- prepare the test tubes in a tube rack. Mark the rack with the depths to identify the top and bottom of the profile. Use separate racks for the pHF and pHFOX tests to prevent cross contamination from violent pHFOX reactions;
- conduct tests at intervals on the soil profile of 0.25 m, or at least one test per soil layer / horizon, whichever is lesser;
- for each layer place approximately half a teaspoon of soil into each of the tubes. It is important the two sub-samples come from the same depth and are similar in characteristics;
- place enough deionised (DI) water in the pHF test tube to make a paste similar to 'grout mix' or 'white sauce'; stir the soil:water paste to ensure all soil 'lumps' are removed (demineralised water can be substituted; never use tap water). Water must be added to the soil samples within 10 minutes of sampling to reduce the risk of reduced inorganic sulphur (RIS) oxidation; monosulfidic material may start to oxidise in less than 5 minutes, substantially affecting pHF results;
- immediately place the pH spear point electrode into the soil:water paste, ensuring the spear point is completely submerged. Never stir the paste with the electrode as this may damage the semi-permeable glass membrane;
- measure the pHF with the calibrated pH meter;
- wait for the reading to stabilise and record the pH measurement; and
- all measurements should be recorded on a data sheet.

3. Oxidised pH (pHfox) test method

It is recommended that 30% hydrogen peroxide (H2O2) be used in the pHFOX test.

Hydrogen peroxide (30%) is highly corrosive, and care should be taken when handling and using the peroxide. Safety glasses and gloves should be worn when handling and using peroxide. All chemical bottles should be clearly labelled, and Safety Data Sheets (SDS) should be kept with the chemicals at all times. Appropriate health and safety precautions should be adhered to. Peroxide should be kept in the fridge when not in use.

The procedure for the field pH peroxide test (pHFOX) is outlined below:

- adjust the pH of the H2O2 to between 4.5 and 5.5 before going into the field. While stirring, add a few drops of dilute NaOH and regularly check the pH with a calibrated electrode until the correct range is reached. Allow the peroxide to stand for 15 minutes and then recheck the pH. As H2O2 degrades over time, only buffer small quantities at a time and refrigerate when not in use;
- calibrate battery powered field pH meter according to manufacturer's instructions;
- prepare heat-resistant tubes in a tube rack. Mark the rack with the depths to identify the top and bottom of the profile. Use separate racks for the pHF and pHFOX tests to prevent cross contamination from violent pHFOX reactions;
- conduct pHFOX tests at intervals on the soil profile of 0.25 m or at least one per horizon, whichever is lesser;
- to the pHFOX tube, prepared while sampling for pHF, add sufficient 30% H2O2 (at room temperature) to cover the soil, then stir the mixture;
- rate the reaction of soil and peroxide using the reaction scale in Table 1;
- allow approximately 15 minutes for any reactions to occur. The reaction may be rapid and vigorous if substantial RIS is present. If the reaction is violent and the soil:peroxide mix may overtop the tube, use a wash bottle to add small amounts of deionised or demineralised water to cool and calm the reaction. Do not add too much water as this may dilute the mixture and affect the pH value;
- add a further 1–2 mL of H2O2, mix, allow to react for 15 minutes and rate the reaction. Continue this process until the soil:peroxide mixture reaction has slowed. This will ensure most of the RIS have reacted;
- if there is no initial reaction, individual tubes containing the soil:peroxide mixture can be placed in direct sunlight. This may encourage the initial reaction to occur;
- wait for the soil:peroxide mixture to cool. This may take up to 10 minutes as the reaction can exceed 90 °C. Check the temperature rating of the pH meter and probe as high temperatures can damage the electrode and result in inaccurate readings. A more accurate pH is recorded if a temperature probe is used, however, this may be impractical in some field situations;
- place the spear point pH electrode into the soil:peroxide mixture, ensuring the spear point is completely submerged. Never stir the paste with the electrode as this may damage the semipermeable glass membrane;
- measure the pHFOX with the calibrated pH meter;
- wait for the reading to stabilise and record the pHFOX measurement; and
- all measurements should be recorded on a data sheet.

Table 1: Soil reaction rating scale for the pHfox test

Reaction scale	Rate of reaction
L	Low Reaction
M	Medium Reaction
H	High Reaction
X	Extreme Reaction
V	Volcanic Reaction

The rate of the reaction generally indicates the level of RIS present but depends also on texture and other soil constituents. A soil containing very little RIS may only have a slight reaction (L), however, a soil containing high levels of RIS (remember the exact level of RIS cannot be determined using the pHFOX test) is more likely to have an extreme / volcanic reaction (X–V), although there are exceptions. This rating scale alone should not be used to identify ASS. It is not a very reliable feature in isolation as there are other factors including manganese and organic acids which may trigger reactions. Reactions with organic matter tend to be more 'frothing' and do not tend to generate as much heat as sulfidic reactions. Manganese reactions can be quite extreme, but do not tend to lower the pHFOX.

4. References

Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018, National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0 (Sullivan *et al* 2018a).

Appendix G

Contingency Plan

1. Introduction

This Appendix provides the contingency options to the selected management option.

For the purpose of this ASSMP, PASS are defined by NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014) Part 4 (Acid Sulfate Soils). PASS are defined as:

- 'soils that contain iron sulfides or sulfidic materials that have not been exposed to air and thus are not oxidised. The pH of these soils in their undisturbed state is 5.5 or more, making them neutral or slightly alkaline; and
- they meet the definition of 'virgin excavated natural material' (VENM) under the Protection of the Environment Operations Act 1997, even though they contain sulfidic ores or soils.

Where VENM is defined as:

The Protection of the Environment Operations Act 1997 (POEO Act) defines virgin excavated natural material (VENM) as:

'natural material (such as clay, gravel, sand, soil or rock fines):

(a) that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities and

(b) that does not contain any sulfidic ores or soils or any other waste and includes excavated natural material that meets such criteria for virgin excavated natural material as may be approved for the time being pursuant to an EPA Gazettal notice.'

2. Off-site treatment and disposal

Where on site treatment of PASS is not possible and / or practical then off-site treatment at a facility appropriately licenced to accept and treat such soil can be considered. The following general procedure is recommended for off-site treatment:

The below works will be undertaken:

- loading the soil into trucks. Note if the soils are wet, they will be heavier than soils as normally transported at field moisture. This should be taken into consideration when loading trucks to ensure that trucks are not overloaded;
- transport must be conducted in a sealed truck which prevents water leaking from the truck during transport;
- completion of site records of the above and all information required by the treatment facility, and provision of copies of these records to the treatment facility;
- transporting of soil to the treatment facility;

- once the ASS have been accepted by the treatment facility they will treat and manage it in accordance with their EPL conditions, subject to the verification procedures documented herein. The liming rate will be based on the liming rate presented in this report or based on results that supersede those presented herein), refer to Section 8.2 of this ASSMP;
- verification of the treatment of the ASS and classification of the soil by an Environmental Consultant; and
- transport of the treated, classified ASS to the final receiving site / disposal facility.

3. Off-site disposal as PASS

3.1 PASS criteria

EPA (2014), Part 4 states that Potential ASS may be disposed of in water below the permanent water table, provided:

- the soils meet the definition of VENM in all aspects other than the presence of sulfidic soils or ores;
- the pH of soils in their undisturbed state is pH 5.5 or more;
- the soil has not dried out or undergone any oxidation of its sulfidic minerals;
- soil is received at the disposal point within 16 hours of excavation, and kept wet at all times between excavation and reburial at the disposal point;
- appropriate records are provided to the receiving site with every truck load confirming that it meets the above criteria; and
- the receiving site meets its obligations under EPA (2014) and its Licence conditions.

For the purposes of this ASSMP, potential acid sulfate soils (PASS) are defined in accordance with the NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014) Part 4 (Acid Sulfate Soils).

This classification is applicable for direct disposal of untreated PASS to a facility licenced by the EPA to accept PASS.

Prior approval from the relevant licensed facility and the NSW EPA is recommended prior to implementation of this disposal methodology.

3.2 Disposal as PASS

The below works will be undertaken by appropriately trained staff:

- agreement with receiving site on acceptance times for trucks, and allowable time lapse between excavation and acceptance by receiving site;
- soils will be kept wet at all times, and should be sprayed with water if required to keep them wet;
- recording of the excavation date, time and source chainage of the excavated soil;

- inspection of the excavated soil for moisture content, material texture / signs of contamination concern, such as anthropogenic odours, staining or inclusions by all personnel involved in the management / handling of the spoil;
- if visual inspection of the spoil identifies materials not consistent with the materials assessed *in situ* (e.g., anthropogenic impact or fill are observed), then the spoil will be segregated for further assessment;
- measuring the pH in at least one sample per 50 m^3, or a minimum of 10 per shift, using a calibrated pH meter;
- if the pH is less than 5.5, the soil will not be classified as PASS, and the soil will be segregated for further assessment and treatment;
- loading the soil into trucks and ensuring the soil is moist enough to prevent it drying out during transport. Note: due to the soils being wet, they will be heavier than soils as normally transported at field moisture (PASS estimated to be approximately 2 t/m^3). This should be taken into consideration when loading trucks to ensure that trucks are not overloaded;
- soil should be loaded and transported as soon as possible to minimise the risk of oxidisation, which prevents it from being classified as PASS;
- transport must be conducted in a sealed truck which prevents water leaking from the truck during transport;
- completion of site records of the above;
- completion of records of all information required by the receiving site, and provision of copies of these records to the receiving site, including copies sent with the truck driver for the load being carried;
- transporting of soil meeting the PASS requirements to the receiving site within 16 hours of excavation (or earlier if required by the receiving site);
- once the PASS have been accepted by the receiving site they are required to manage it in accordance with their EPL conditions and NSW EPA guidelines (NSW EPA, 2014). It is not the role of this document to discuss management of soil once they have been accepted by the receiving site; and
- any soil which is rejected by the receiving facility will be transported back to the site and managed in accordance with the ASSMP.

4. Reburial on-site

Where possible (and if practical to do so) the ASS can be reburied on site, several metres below the permanent water line / at least 1 m deeper than the seasonally lowest water table provided the soil meets the definition of PASS and the soil is reburied before the soil has a chance to oxidise. Strategic reburial.

For the purpose of this ASSMP, PASS are defined by NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014) Part 4 (Acid Sulfate Soils). PASS are defined as:

- ‘soils that contain iron sulfides or sulfidic materials that have not been exposed to air and thus are not oxidised. The pH of these soils in their undisturbed state is 5.5 or more, making them neutral or slightly alkaline.

There are a number of risks associated with this management option, as outlined in detail in (Dear, et al., 2023), including:

- maintaining oxygen exclusion at all stages during the burial process;
- ability to keep oxygen away from final placement area in the long term;
- difficulty in locating the seasonally lowest water table (ideally established through long-term monitoring prior to works commencing);
- difficulties in placement and compaction of soils beneath a permanent water table; and
- potential resuspension of materials.

If reburial is proposed, development of site-specific management procedures, monitoring requirements and verification testing will be required with reference to (Dear, et al., 2023).

5. References

E. (2023). *Queensland acid sulfate soil technical manual : soil management guidelines version 5.* Department of Resources and the Department of Environment and Science.

NSW EPA. (2014). *Waste Classification Guidelines, Part 4: Acid Sulfate Soils.* NSW Environment Protection Authority.

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Sullivan, L., Ward, N., Toppler, N., & Lancaster, G. (2018). *National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Identification and Laboratory Methods Manual.* Canberra ACT CC BY 4.0: Department of Agriculture and Water Resources.

Appendix H

Water and Groundwater Management Plan

1. Introduction

Water is the main mechanism by which acid and metals from oxidised ASS are mobilised and transported. Careful management of water is therefore paramount to the effective management of potential adverse impacts from ASS disturbance. Management is required to provide control of treated waters for discharge and provide some margin for heavy rain periods.

The below sections provide potential strategies for management, assessment and disposal of water leaching from ASS, surface water and water from groundwater dewatering.

1.1 Leachate and surface water collection

All water that has been in contact with ASS / assumed ASS must be managed, assessed, treated and appropriately disposed of in accordance with development consent conditions.

1.2 Dewatering and extracted groundwater

Significant dewatering is not anticipated, however at detailed acid sulfate soil assessment has not been completed is provided as a contingency. This section must be updated upon completion of the data gap assessment and, if appropriate, dewatering monitoring requirements may be reduced or removed.

In general, risks associated with dewatering in areas underlain by ASS include:

- acidification of in situ soils drained within the dewatering cone of depression and difficulties associated with neutralising these in situ soils (this can also impact the possible PASS classification of some soils);
- acidification of groundwater remaining within the dewatering cone of depression after the system has re-flooded;
- iron, aluminium and heavy metal contamination of groundwater arising from mobilisation of these compounds under low pH conditions; and
- acidification and contamination of surface water bodies which receive groundwater.

It is considered that there is the potential to expose soils within the proposed excavation areas to air which will allow some acidification to take place.

The dewatering should be designed to not significantly affect groundwater levels outside of the areas of excavation, and therefore the potential for oxidation of ASS outside of the excavation areas is expected to be limited.

The following dewatering risk management methods are recommended for the project:

- drawdown outside of the excavation areas should be minimised;
- drawdown as close as practical to the invert excavation depth;
- minimise the time and volume of exposed ASS (i.e., stage excavation and dewatering); and
- monitoring and treatment prior to disposal of the dewatering effluent.

1.3 Water storage and treatment

Water from dewatering and the ASS leachate should either be pumped directly to an on-site treatment plant for treatment or should be stored in a tank or lined drains / detention basin prior to assessment / treatment.

At a minimum, the combined storage should be designed to store enough water to contain leachate and extracted water from a 1 in 10-year (1 hour) storm event.

1.4 Water assessment for disposal

All water which has potentially come into contact with ASS requires assessment (and if necessary, treatment). Minimum recommended monitoring is provided in Table 1, below. The consent authority in the local jurisdiction should be consulted for specific approvals and target levels for disposal. It is further recommended that pre-disposal water assessment of groundwater and receiving bodies is conducted to ensure the target levels in Table 1 are suitable (i.e., adjustment of these target levels may be appropriate, subject to approval by the consent authority, where background concentrations for the receiving environment differ from the target levels in Table 1).

Table 1: Suggested water monitoring frequencies and target levels for disposal to stormwater (subject to regulatory approval)

Test	Frequency	Target level for disposal to stormwater
pH	Water detention basin/ tank: During storage/ treatment as required to allow timely treatment. Less than 24 hours prior to any planned discharge. Daily during discharge period. For unplanned discharges (i.e. due to rain), within 5 days of the cessation of the rainfall event Treatment Plant: During storage / treatment as required to allow timely treatment; and Daily during discharge period.	pH 6.5 to 8.5, or one pH unit from background levels of receiving water
Electrical Conductivity (EC)		
Dissolved Oxygen (DO)		80-110 (%saturation) (~6.6-9.1 mg/L at 25°C) with reference to ANZECC 2000 DTVs or as per regulatory requirements
Total Suspended Solids (TSS)	Laboratory analysis: Immediately prior to disposal; and Monthly checks during discharge period; and As required based on visual observations and if field	≤50 mg/L or equivalent turbidity measure (in NTU) where a statistical correlation between the TSS and turbidity has been determined
Oil and Grease		Non observable

Test	Frequency	Target level for disposal to stormwater
Iron (total and soluble) and Aluminium	parameters indicate a risk (e.g. low pH; and Visual assessment of discolouration: Daily during discharge	No obvious sign of iron staining/ settlement ≤0.3 mg/L total iron ≤0.8 µg/L total Aluminium @ < pH 6.5 ≤55 µg/L total Aluminium @ > pH 6.5
Potential contaminants [including VOC, PAH, TPH, BTEX, OCP and total metals (aluminium, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, tin, zinc)]	Laboratory analysis: One round of testing before first disposal of ASS impacted water. If first round of testing exceeds target levels then further testing prior to disposal is required	ANZG (2018) Trigger Levels for 99% Level of Protection for fresh / marine ecosystems if no licence conditions are available

Notes:

VOC	Volatile organic compounds
PAH	Polycyclic aromatic hydrocarbons
BTEX	Benzene, toluene, ethylbenzene, xylenes
TPH	Total petroleum hydrocarbons
OCP	Organochlorine pesticides

1.5 Treatment

1.5.1 General

The potential impacts of ASS on water generally comprise a decrease in pH, possible elevated TSS / turbidity, iron, aluminium, and other metals.

Treatment of water from construction sites is commonly required for pH and TSS. Aeration and removal of TSS also generally decreases metal concentrations in the water. Therefore, an on-site water treatment plant is considered likely to be suitable for treatment of ASS impacted water that has not been oxidised.

An alternate treatment method for pH is provided in Section 1.5.2 in case treatment of excess water above the capacity of the treatment plant is required.

If a suitable treatment method for man-made contaminants in the water (e.g., VOC, PAH, TPH, BTEX, OCP, metals etc) cannot be implemented, an alternate disposal method may be required (e.g., trucking off-site to a liquid waste disposal facility or disposal to sewer in accordance with a specific Trade Waste Agreement which would need to be obtained from the relevant water / wastewater authority.

1.5.2 Alternate pH treatment method

It is noted that aglime is generally not suitable for the treatment of leachate / dewatering effluent due to its low solubility in water. A commercial pH adjustment product can be used, or else slaked lime (hydrated lime) as discussed below.

Alternative neutralisation materials include calcined magnesia (magnesium hydroxide, burnt magnesite, or magnesia) and calcium hydroxide (commonly called slaked or hydrated lime).

Calcined magnesia (magnesium hydroxide, burnt magnesite, or magnesia) produces a two-step reaction, which proceeds rapidly at acidic pH and slows down as higher pH is approached, and hence reduces the potential for over-neutralisation. It should be added to the leachate as a slurry and mixing achieved via use of an agitator.

A calcium hydroxide (commonly called slaked or hydrated lime) solution can be produced by stirring calcium oxide (commonly called quicklime) into water, in a container of sufficient volume (for example, a plastic 200 litre drum). The slurry should be allowed to settle, and the clear solution (which will be caustic, with a pH of approximately 12.5 to 13) can be pumped or sprayed into the standing water in small amounts, with some agitation and monitoring. This procedure should be continued until the pH is adjusted to acceptable levels. Adequate care should be taken not to “overshoot” the desired pH with calcium hydroxide.

Quicklime is very reactive, and relatively corrosive (due to its caustic nature). When quicklime is mixed with water, the resulting reaction generates heat. Therefore, if utilised, the material should be added in increments to a large amount of water to control the reaction. Slaked or quicklime should not be allowed to come into contact with the skin or be inhaled during use.

The amount of neutraliser required to be added to the discharged groundwater can be calculated from the equation below:

Equation 2:

$$\text{Alkali Material Required (kg)} = \frac{M_{\text{Alkali}} \times 10^{-\text{pHinitial}}}{2 \times 10^{3}} \times V$$

Where: M_{Alkali} = molecular weight of alkali material (g/mole) (molecular weight of slaked lime ($Ca(OH)_2$) = 74 g/mole.)

pH initial = initial pH of leachate

V = volume of leachate (litres)

As a guide, the approximate quantities of slaked lime required to neutralise acidic water (i.e., raise existing pH to pH 7) are provided in Table 2.

Table 2: Approximate liming rates for water (based on slaked lime (kg of $Ca(OH)_2$))

Water pH	Volume		
	10 m^3	50 m^3	100 m^3
2	3.7	18.5	37
3	0.37	1.85	3.7
4	0.037	0.185	0.37
5	0.0037	0.0185	0.037
6	0.00037	0.00185	0.0037

1.6 Water discharge

Following treatment (if required) the water should be assessed to determine if it meets discharge criteria. Water meeting the conditions can then be disposed of accordingly.

Depending on site conditions, alternative options for water disposal include on-site reinjection, overland infiltration or infiltration via excavation or surface water body.

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