Application for Planning Approval

Land Use Planning and Approvals Act 1993

APPLICATION NO.

DA2024/060

LOCATION OF AFFECTED AREA

138 GUNNERS QUOIN ROAD, OLD BEACH

DESCRIPTION OF DEVELOPMENT PROPOSAL

OUTBUILDING

A COPY OF THE DEVELOPMENT APPLICATION MAY BE VIEWED AT www.brighton.tas.gov.au AND AT THE COUNCIL OFFICES, 1 TIVOLI ROAD, OLD BEACH, BETWEEN 8:15 A.M. AND 4:45 P.M, MONDAY TO FRIDAY OR VIA THE QR CODE BELOW. ANY PERSON MAY MAKE WRITTEN REPRESENTATIONS IN ACCORDANCE WITH S.57(5) OF THE LAND USE PLANNING AND APPROVALS ACT 1993 CONCERNING THIS APPLICATION UNTIL 4:45 P.M. ON **28/05/2024** ADDRESSED TO THE GENERAL MANAGER AT 1 TIVOLI ROAD, OLD BEACH, 7017 OR BY EMAIL AT development@brighton.tas.gov.au. REPRESENTATIONS SHOULD INCLUDE A DAYTIME TELEPHONE NUMBER TO ALLOW COUNCIL OFFICERS TO DISCUSS, IF NECESSARY, ANY MATTERS RAISED.

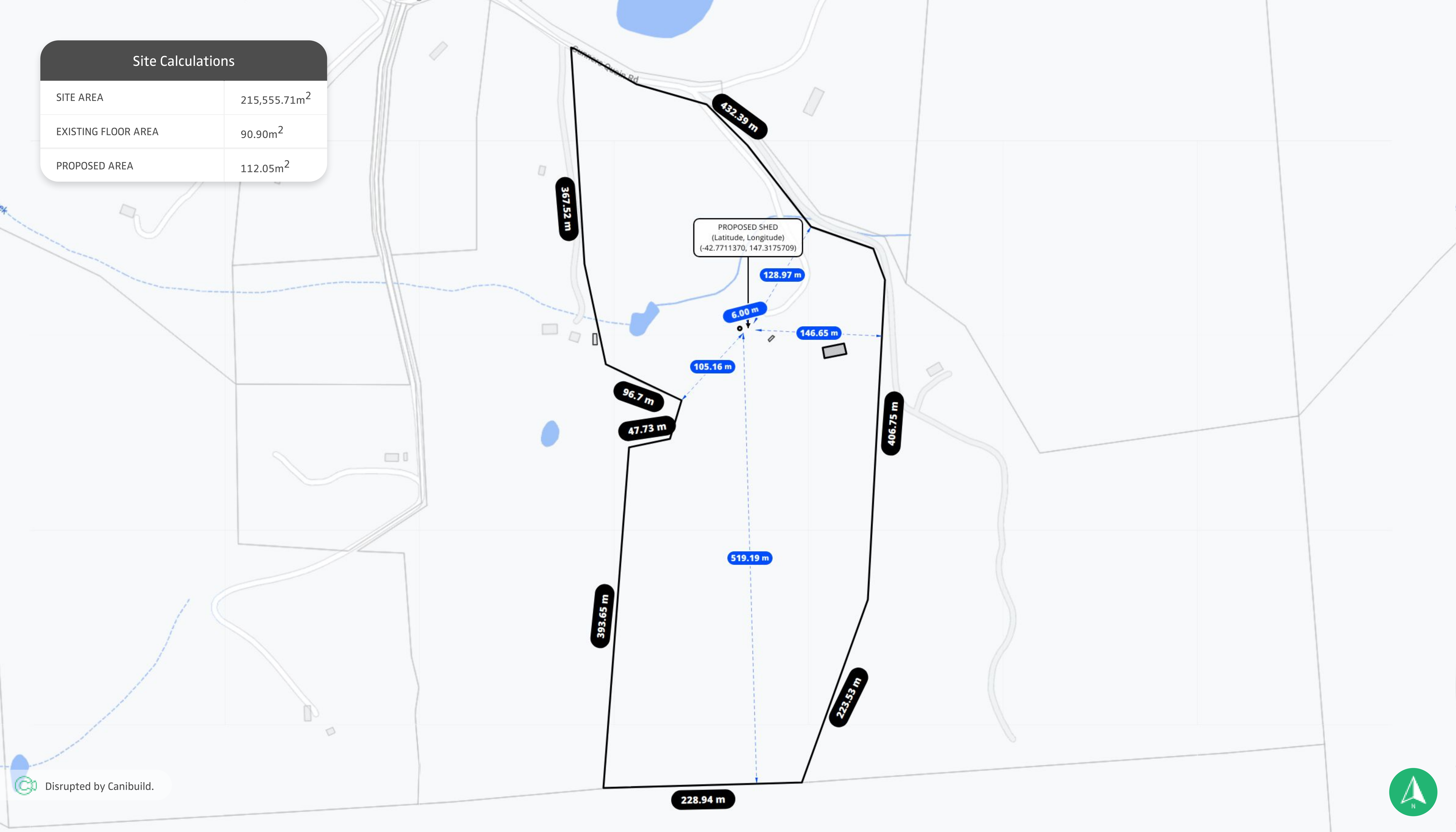
JAMES DRYBURGH
General Manager

SCAN ME

Brighton going places

Site Calculations

SITE AREA	215,555.71m^2
EXISTING FLOOR AREA	90.90m^2
PROPOSED AREA	112.05m^2



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Client Name	Client Email	Client Phone	Signature	Client Name	Client Email	Client Phone	Signature

SHEDS n HOMES

SHEDS. MADE. TOUGH.

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Phone +61431885353

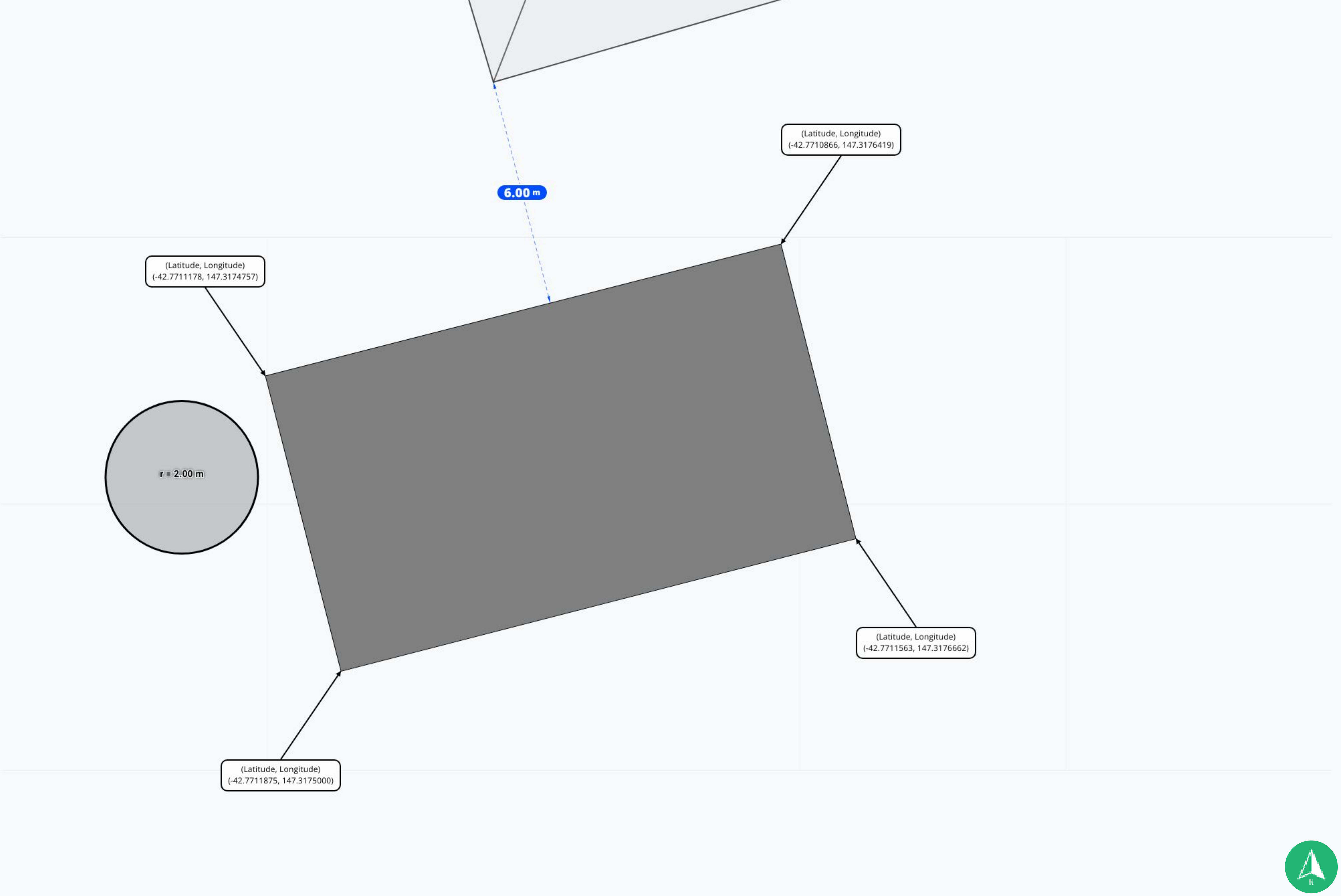
Property Details
138 Gunners Quoin Rd, Old Beach, TAS 7017, Australia
Lot/DP: 2/130998

Sheet Name	Sheet no.	Lic no.	Job no.
Site Plan	1		

Design

Scale
1:4000@A3

1st version date:	Current version date:	Version #
05/03/2024	08/03/2024	5



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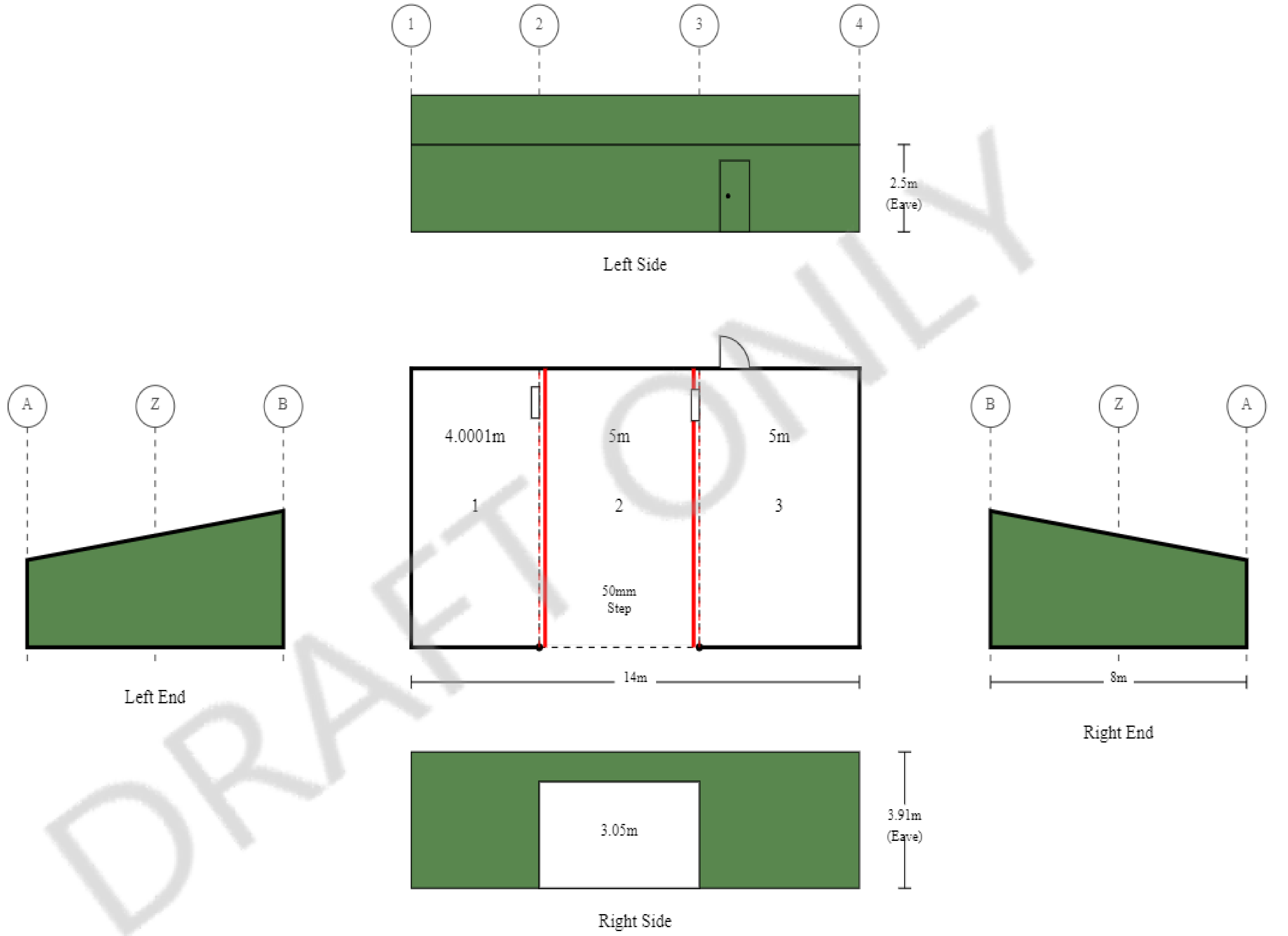
Property Details
138 Gunners Quoin Rd, Old Beach, TAS 7017, Australia
Lot/DP: 2/130998

Sheet Name	Sheet no.	Lic no.	Job no.
Site Plan	3		

Design

Scale
1:100@A3

1 st version date:	Current version date:	Version #
05/03/2024	08/03/2024	5



Purchaser Name: Phil Millington

Site Address: 138 Gunners Quoin Rd Old Beach TAS 7017 Australia

Drawing # DILLONA2311014-3

Print Date: 13/03/24

Layout

NOT FOR CONSTRUCTION

Not to Scale

Seller: Sheds N Homes Hobart
Name: Sarah Harriss
Phone: (03) 6263 6545
Fax:
Email: sarah.harriss@shedsnhomes.com.au

SOIL & WATER MANAGEMENT PLAN (SWMP)

To be read and undertaken in accordance with PLANNING PERMIT CONDITIONS for "CONSTRUCTION" as specified by the Permit Authority.

BUILDING CONTRACTOR/S TO ENSURE

- Excavation does not commence until all necessary permits, licenses and approval are issued by the permit authority
- Schedule earthworks in phases throughout the project to ensure natural ground is disturbed for the shortest possible time
- Avoid unnecessary and/or excessive vegetation disturbance
- Install erosion and sediment control measures, as specified in the Soil and Water Management Plan (SWMP)
- MONITOR SEDIEMENT CONTROL MEASURES AT LEAST WEEKLY AND AFTER EACH RAINFALL EVENT
- Early construction of retaining walls to prevent collapse of newly excavated ground
- Early installation of Stormwater & Sewer pipework
- Service trenches to remain open no longer than necessary

ALL EXCAVATED MATERIAL SHALL BE REMOVED FROM SITE AND
DISPOSED OF AT APPROVED DISPOSAL LOCATION

ANY FILL IS TO BE IMPORTED AND INSTALLED PURSUANT TO
PART 4.2.4 *FILLING UNDER CONCRETE SLABS* ABCB HOUSING
PROVISIONS

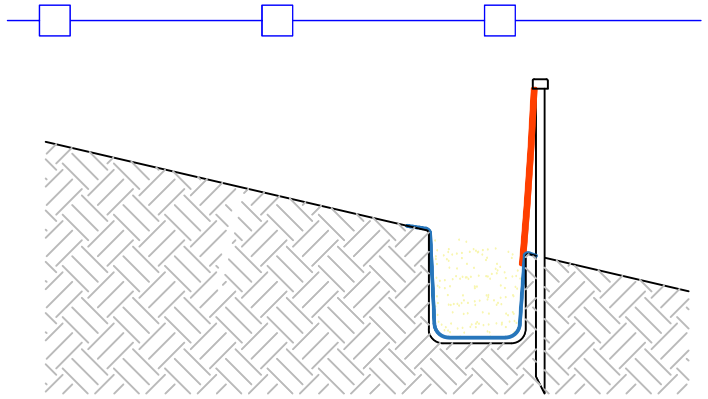
STORMWATER COLLECTED ON ROOF TO NEW WATER TANK
WATER TANK OVERFLOW TO OPEN SWALE DRAIN IN LINE WITH
CONTOURS TO ALLOW FOR NATURAL DISCHARGE

● NEW WATER TANK

SWMP

Scale: 1:200

SEDIMENT FENCE



DIMENSION NOTE:
Use written dimensions only. Do not scale from drawings. All figured dimensions are to be used as a guide only. It is imperative that all dimensions, setouts and levels be confirmed on site by the Builder/Surveryor/or sub-contractor prior to the commencement of work, manufacture and installation. It is imperative that the Builder/sub-contractor and/or manufacturer ensures a full set of plans are on hand and reference has been made to the general notes.

SHEDS n HOMES
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BLST Pty Ltd
57 Cove Hill Road, Bridgewater 7030
EMAIL: hobart@shedsnhomes.com.au

CLIENT NAME:
PHILLIP MILLINGTON

PROJECT ADDRESS:
138 GUNNERS QUION ROAD, BRIDGEWATER

PROJECT:
NEW SHED

DRAWING TITLE:
SOIL & WATER MANAGEMENT PLAN

DATE:	SCALE:	DRAWN BY:
10/05/2024	1:200	BH

REVISION No:	SHEET SIZE:	JOB No:	SHEET No:
R:1	A3	SNH24-016	C02.0

GEOTECHNICAL SITE INVESTIGATION AND DISPERSIVE SOIL ASSESSMENT

138 GUNNERS QUOIN ROAD - OLD BEACH
PROPOSED SHED

Client:	**Sheds n Homes**
Certificate of Title:	**130998/2**
Investigation Date:	**Thursday, 11 April 2024**

Refer to this Report As

Enviro-Tech Consultants Pty. Ltd. 2024. Geotechnical Site Investigation Report for a Proposed Shed, 138 Gunners Quoin Road - Old Beach. Unpublished report for Sheds n Homes by Enviro-Tech Consultants Pty. Ltd., 11/04/2024.

Report Distribution

This report has been prepared by Enviro-Tech Consultants Pty. Ltd. for the use by parties involved in the proposed development of the property named above.

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Limitations of this report

In some cases, variations in actual Site conditions may exist between subsurface investigation boreholes. This report only applies to the tested parts of the Site, and if not specifically stated otherwise, results should not be interpreted beyond the tested areas.

The Site investigation is based on the observed and tested soil conditions relevant to the inspection date. Subsurface conditions may change laterally and vertically between test Sites, so discrepancies may occur between what is described in the reports and what is exposed by subsequent excavations. No responsibility is therefore accepted for any difference in what is reported, and actual Site and soil conditions for parts of the investigation Site which were not assessed at the time of inspection.

No responsibility is accepted for subsequent works carried out or activities onsite or through climate variability including but not limited to placement of fill, uncontrolled earthworks, altered drainage conditions or changes in groundwater levels.

This report has been prepared based on provided plans detailed herein. Should there be any significant changes to these plans, then this report should not be used without further consultation. This report should not be applied to any project other than indicated herein.

At the time of construction, if conditions exist which differ from those described in this report, it is recommended that the base of all footing excavations be inspected to ensure that the founding medium meets that requirement referenced herein or stipulated by an engineer before any footings are poured.

An assessment of building settlement was not within the scope of works.

Investigation Summary

Site Classification

According to AS2870 – 2011 and after considering the known details of the proposed building and works (herein referred to as the Site), the geology, soil conditions, soil properties, and drainage of the Site have been classified as the following:

CLASS P based on the following problematic ground conditions identified at the site:

- Class 1 dispersive soils are present at the Site with CLASS P foundation conditions requiring specialised management measures to mitigate erosion hazards.

Notwithstanding the problematic soil conditions observed at the Site, ordinarily the soil would be classified as Class M.

Site Investigation

The Site investigation is summarised in Table 1.

Table 1 Summary of Site Investigation

Client	**Sheds n Homes**
Project Address	138 Gunners Quoin Road - Old Beach
Council	Brighton
Planning Scheme	Tasmanian Planning Scheme
Inundation, Erosion or Landslip Overlays	None
Proposed	Shed
Investigation	Fieldwork was carried out by an Engineering Geologist on the 11/4/2024
Site Topography	The building site has a moderate slope of approximately 12% (7°) to the west
Site Drainage	The site receives overland flow runoff directly from the east.
Soil Profiling	Two investigation holes were direct push sampled from surface level around the proposed shed (Appendix A):
Investigation Depths	The target excavation depth was estimated at 2.3 m. Borehole BH01 was direct push sampled to 1.6 m (ending in DOLERITE) and Borehole BH02 was direct push sampled to 2.1 m (ending in Silty SAND). Borehole logs and photos are presented in Appendix B & C.
Soil moisture and groundwater	All recovered soil at the site ranged from dry to slightly moist. Groundwater was not encountered.
Geology	According to 1:25,000 Mineral Resources Tasmania geological mapping (accessed through The LIST), the geology comprises: Quaternary Colluvium.

Soil Profiles

The geology of the site has been recorded and described in accordance with Australian Standard AS1726 for Geotechnical Site Investigations which includes the Unified Soil Classification System (USCS). Soil layers and where applicable, bedrock layers are summarised in Table 2.

Table 2 Soil Summary Table

#	Layer	Details	USCS	BH01	BH02
1	Clayey GRAVEL	SOIL & COBBLES/BOULDERS: Clayey GRAVEL, dark brown, well sorted, with sand, with silt, trace roots, 5 % roots; sub-angular gravel; 45% DOLERITE cobbles/boulders, MD-D	GC	0-0.2 DS@0.1	0-0.1
2	Silty CLAY	Silty CLAY, light olive brown, medium plasticity, with sand, trace roots, 5 % roots, VSt-H	CI	0.2-0.8 DS@0.5	0.1-0.8 DS@0.1 DS@0.5
3	Silty SAND	SOIL & COBBLES: Silty SAND trace gravel, pale olive, well sorted, fine grained sand; sub-angular gravel; 5% MUDSTONE cobbles, VD	SM	0.8-1.5 DS@1.2	0.8-2.1 DS@1.5
4	DOLERITE	DOLERITE Bedrock		1.5-1.6 PL@1.5 REF	

Consistency[1]	**VS** Very soft; **S** Soft; **F** Firm; **St** Stiff; **Vst** Very Stiff; **H** Hard.
Density[2]	**VL** Very loose; **L** Loose; **MD** Medium dense; **D** Dense; **VD** Very Dense
Rock Strength	**EL** Extremely Low; **VL** Very Low; **L** Low; M Medium; **H** High; **VH** Very High; **EH** Extremely High
PL	Point load test (lump)
DS	Disturbed sample
PV	Pocket vane shear test
FV	Downhole field vane shear test
U50	Undisturbed 48mm diameter core sample collected for laboratory testing.
REF	Borehole refusal
INF	DCP has continued through this layer and the geology has been inferred.

Planning

BRI-S7.0 East Baskerville Dispersive Soils Specific Area Plan

Pursuant to Section 54 of the Land Use Planning and Approvals Act 1993 (LUPAA), a dispersive soil management plan is to be prepared by a suitably qualified person, that details:

(a) the dispersive potential of soils in the vicinity of the proposed development, water drainage lines, infiltration areas and trenches, water storages, ponds, dams and disposal areas;

(b) the potential of the development to affect or be affected by erosion, including gully and tunnel erosion;

(c) an analysis of the level of risk and potential consequences to the development and the level of risk to users of the development; and

(d) proposed management measures to reduce risk to an acceptable level.

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[1] Soil consistencies are derived from a combination of field index, DCP and shear vane readings.

[2] Soil density descriptions presented in engineering logs are derived from the DCP testing.

Design Recommendations

General

For Class P Sites, the designer should be a qualified engineer experienced in the design of footing systems for buildings.

Plumbing

If FILL[3] works are proposed at the Site, such that resulting FILL OTHER THAN SAND exceeds 0.4 m depth or SAND FILL exceeds 0.8 m depth, then a CLASS P applies to the plumbing classification. To ensure applicability of Table 3 *it is recommended that SAND or FCR fill is used around proposed pipework in preference to CLAY excavated from around the Site.*

The extent of soil movement (Ys) around pipework may be assessed with reference to Table 3 for various depth ranges.

When determining the appropriate classification, consideration is to be given to future cut and fill with reference to borehole locations at the time of testing (see borehole easting and northings in Appendix B for details). Where precise vertical elevations are not available in the logs, elevations may be obtained from a survey representative of site levels at the time of soil testing.

*Table 3 Millimetres soil movement (Ys) for determining plumbing requirements for various soil depths **

Building	**Profiles**	**P***	**E Ys >75**	**H2 Ys 60-75**	**H1 Ys 40-60**	**M Ys 20-40**	**S Ys 0-20**	**A Ys 0**
Dwelling	BH01,BH02	No				0-0.2	0.2-0.8	0.8-3

* Depths in this table are based on surfaces at the time of testing and do not allow for the influence of any additional fill added to the soil profile. If additional fill is proposed to be added at these locations, then the reactivity will need to be recalculated depending on the thickness and reactivity of any additional fill added.

Plumbing – Class P

This standard applies to buildings located on problematic soils which are to be managed. This standard applies to buildings located on Sites which are classified as Class P according to Table 3 or are to be reclassified as Class P as detailed above due to proposed cut or fill works.

Where Class P is applicable, all sanitary drains and fixtures are to be designed in accordance with Appendix G of AS3500.2.

With Class P sites, consideration is given to factors including but not limited to, filled/cut sites, soil dispersion, slope instability or loose/collapsing soils, soft clay/silt soils. In this case, for a non-Class P (Class A) classification to apply, management is required for:

- soil dispersion

Recommendations for dispersive soil management including for pipework are presented in the dispersive soil management section of this report. Plumbing – Class A and S

In the case where pipework falls into the Class A to S depth range presented in Table 3, provided all Class P management measures have been applied, the drainage system requires Nil additional protection, and shall be installed in accordance with AS/NZS 3500 series.

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[3] FILL depth - For a slab, depth measured from the underside of the footing to the natural surface level. For a strip or pad footing system, depth measured from the finished ground level to the natural surface level.

Plumbing – Class M

Based on the Soil testing at the time of the Site visit, with pipework at 0.7 m depth, some if not all of the pipework will generally fall within the M Class depth range with up to 40 mm of soil movement expected around pipework.

With reference to Table 3, where pipework falls into the Class M depth range, all stormwater and sanitary plumbing drains and discharge pipes that are provided with fittings (or other devices to allow for movement) to be set at the midposition of their range of possible movement at the time of installation, so as to allow for movement equal to 0.5ys in any direction from the initial setting. Pipe wrappings may be included at critical points There are no additional plumbing requirements provided that Class P management measures are adhered too.

AS3500.2:2021 Appendix G of AS3500.2:2021 should be referred for general advice.

Site Drainage

Subsurface drains to remove groundwater shall not be used within I .5 m of the building unless designed according to engineering principles.

Due to the presence of the dispersive soils, stormwater absorption trenches need to be avoided at the Site. Intercepted surface water and groundwater should ideally be diverted via nonperforated piping into a dedicated swale drain/mounds which is appropriately designed for stormwater dispersion across the surface of the Site. Any swale drain/mound used at the Site should use natural nondispersive soil filling from the Site (Layers 1 or 2) or imported nondispersive imported clay soils. Deep cuts (deeper than 0.3m) should be avoided for the swales and if in doubt, gypsum should be applied. Mounds comprising of layer 1 materials may be stabilised with 10% bentonite to prevent erosion.

Surface drainage shall be considered in the design of the footing system, and necessary modifications shall be included in the design documentation. The surface drainage of the site shall be controlled from the beginning of the preparation and construction of the site. The drainage system shall be completed after the completion of the building construction.

Ideally, the areas around the footprint of the building should be graded or drained so that the water cannot pond against or near the building. As soon as footing construction has been completed, the ground immediately adjacent to the building should be graded to a uniform fall of 50mm minimum away from the building over the first metre. The final provision of paving to the edge of the building can greatly limit soil moisture variations due to seasonal wetting and drying.

Permanent Cut Batters – Soil and Rock

To ensure that cuts remain serviceable, it is recommended that unretained cuts in soil do not exceed 1V: 3H and unsupported baters in bedrock do not exceed 2V: 1H. Before cuts are approached by workers, cuts must be appropriately scaled to remove any loose soil. The bedrock should not be increased beyond 2.0 m height, without inspection by a suitably qualified person to ensure that these cuts are safe to work under.

Filling Works

In the case where filling works are proposed at the Site:

- Dispersive soil is not to be used as fill unless it has been stabilised with gypsum and compacted.
- Any proposed filling works must be in accordance with AS3798 'Earthworks for Residential and Commercial Developments'.
- Before placing fill for landscaping, all topsoil should be removed from the filled area.
- Ideally, the fill should be free draining and placed to prevent water ponding. The fill should be placed in layers no greater than 150mm height and suitably compacted.

Long-term erosion management

The following measures are generally recommended for maintaining long-term erosion stability of soil slopes:

- Slopes exceeding 1V: 4H and up to 1V: 3H will need to be effectively stabilised with mulch/topsoil mixes, drill/broadcast seeding, hydroseeding or soil binders.
- Slopes up to 1V:2Hcan be stabilised with straw mulching.
- Slopes exceeding 1V: 2H and up to 1V:1.5H may be effectively stabilised with hydromulching.
- Slopes exceeding 1V:1.5H but no greater than 1V: 1H will generally require measures such as erosion control blankets.

Earth-Retaining Structures

Any excavations higher than 1.0m and exceeding the recommended batter angle should be supported with a retaining wall engineered that allows free drainage of the retained soil and rock.

Dispersive soils

The results presented in Attachment D indicate that moderately to severely dispersive soils are present in soil Layer 3 above the bedrock. There is sufficient information to indicate that soil Layer 3 is dispersive in all areas of concern upgradient and downgradient of the works area.

Soil Layers 1 and 2 offer considerable resilience to erosion and are important barriers which must be kept in place where possible to prevent contact between fresh water and Layer 3. Where dispersive Layer 3 has been already disturbed the following management measures are applicable.

Dispersive soil is to be managed in accordance with Emerson Class number recommendations presented below. Appendix F also provides some background information on the management of Emerson Class 1 soil.

In all cases, gypsum is a proven to be an effective erosion control to be applied directly to dispersive soils. Gypsum will displace sodium ions in clay and replace with calcium which improves soil structure, shear strength, and erosion resilience. Higher application rates of gypsum are required with higher soil cation exchange capacity, higher pH and lower Emerson Class number, and Table 4 is to be used as a guide for determining the required application rates with reference to soil dispersion testing results presented in Table 6.

Table 4 Prescribed gypsum application rates – see Emerson soil testing results

	Gypsum Application Rate (pH < 7.5)
Class 3	0 to 0.3 kg/m2
Class 2	0.5 kg/m2
Class 1	1.0 kg/m2

Emerson Class 1 (soil Layer 3)

It is recommended that measures are put in place to limit the disturbance to the CLASS 1 dispersive CLAY soils which include:

- Surfacing such as topsoil or pavement should cover all Class 1 exposed soil at the Site
- Gypsum is to be applied to the exposed Class 1 soil surface at the prescribed rate according to Table 4 including recently cut embankments, drainage, and service trenches and anywhere the topsoil has been removed exposing the underlying soil to rainwater.

Permanent Cuts and Batters

- It is very common for cuts to intersect perched groundwater and where this occurs in association with dispersive soils, tunnel erosion may develop within cuttings.
- Perched groundwater may also move within dispersive soil which has been used as FILL, resulting in tunnel formation throughout the fill. Nondispersive topsoil layers which are removed to form a bench, are also entry points where percolating groundwater may cause erosion.
- Cuts on the Site have the potential to allow fresh water originating from upslope to spill over the top of Class 1 dispersive soils within the embankment. In worst case scenarios, groundwater may also begin discharging out of cuts causing tunnel erosion.
- If cuts are necessary, a measure for managing dispersive soil is to apply a sand barrier over the cut face to assist in reducing soil wash out.
- Cuts should ideally intersect the bedrock so there is opportunity to divert any groundwater seepage away from vulnerable areas including the dwelling.
- To create an effective barrier to soil dispersion, it needs to be ensured that the cuts proposed in Class 1 soils are managed with the following layering (in this order):
    - Gypsum at a rate indicated in Table 4.
    - A 0.2 m thick layer of SAND
    - Topsoil
    - Erosion control (see erosion control section)
- These management measure needs to be put in place as soon as the cuts are excavated, to ensure tunnels do not develop, as this can increase groundwater flow rates and exacerbate soil erosion.
- A low-profile landscaping retaining wall (eg. sleepers) at the toe the cut can greatly assist in retaining eroded material and retaining the sand barrier.
- It is essential to divert surface water and groundwater away from the crest and toe of cuts. A drain at the toe is critical to prevent water from moving across exposed freshly cut dispersive soil surfaces and potentially back through FILL including beneath paved surfaces.

Retaining Walls

- Retaining walls should be avoided unless there is confidence that groundwater is not able to move beneath the base of retaining wall footings. Gypsum will assist is reducing erosion damage, and it is always recommended that retaining walls are founded onto bedrock in this circumstance.
- Where retaining walls are proposed, freshly cut surfaces in Class 1 soils should be stabilised with gypsum at a rate indicated in Table 4. The surface of the cuts are to be topped with a 0.2 m thick sand layer before applying drainage cloth and drainage aggregate.

Drainage

- Surface drainage over Class 1 soils should ideally occur through concrete spoon drains rather than swale drains. Where swale drains are preferred, gypsum should be applied to Class 1 soils beneath the topsoil layers at the prescribed rate according to the soil pH.
- Subsurface drains should be avoided in Class 1 soils. Where required, Class 1 soils must be surfaced with gypsum at the prescribed rate.
- Water it to be diverted from the drainage area from groundwater discharge points via a non-perforated drainage pipe.

Pipework

All proposed service trenches are to be backfilled with sand and gypsum to reduce tunnel erosion susceptibility. Gypsum application rates should be followed as per dispersive soil recommendations within this report. Non-dispersive clay topsoil should be placed back over the top of the service trenches and compacted in place to prevent water ingress.

In areas where drainage trenches or drainage alignments are proposed, drains must be surface with gypsum before backfilling to reduce tunnel erosion susceptibility. An application rate of 1.0kg/m2 is recommended in this instance.

Filling

- Any proposed filling and particularly near areas supporting building structures should be carefully managed by either excluding the Class 1 soil altogether from the fill or treating the Layer 3 soil by applying the gypsum to the surface of compacted soil layers.
- If selecting the gypsum treatment option, 300mm lifts will need to be managed based on application rates presented in Table 4, and 150 mm lifts are proposed, then the gypsum application rate will need to be halved.
- It is important that all soil at the Site is well compacted close to or at the optimum moisture content, particularly around proposed building structures.
- Paving over filled surfaces will greatly reduce the risk of tunnel erosion, provided that cut off drains are installed upgradient of filled areas to prevent groundwater and surface water seepage through the base of the fill.
- Pavement and or spoon drains should tie into bedrock cuts to ensure all surface water is intercepted before it migrates beneath the pavement.
- It is normal practice to remove topsoil before placing fill, but in the case where the topsoil is non-dispersive (Class 4 or higher), then in some cases it may be more problematic to remove topsoil which is assisting in creating a barrier between dispersive soils and groundwater. Therefore, soil Layers 1 and 2 should be retained wherever possible beneath fill.
- In this case, it filling works is proposed, it is recommended that only 0.1 m of topsoil is removed from the surface of the Site before emplacing gypsum at the prescribed rate and fill.
- Ideally, all dispersive soil may be stripped out and replaced with non-dispersive soil, and non-dispersive layers may then be used as backfill.

Earthworks Recommendations

Building Pad Preparation

Any organic matter or other deleterious materials will need to be removed from the building envelope.

Unless otherwise stated in an engineering report, fill or loose, soft, low bearing capacity soil should either be removed from the building pad, or otherwise footings should ideally be established to the base of this material.

Earthworks should be carried out in accordance with AS3798 'Earthworks for Residential and Commercial Developments'. Unsuitable materials in structural fill are listed in AS2870 Section 4.3.

Pad Preparation - Compaction

Ordinarily, compaction is not recommended for CLAY soils, but in this case, Emerson Class 1 to Class 2 soil layers is to be compacted if exposed at surface.

It is recommended that any sand or granular soils across the building pad, filled areas and the base of the footing excavations are compacted with several passes with a medium weight (~80 kg) plate compactor (80 kg).

Bored Piers – Impediments

There were no obvious impediments to auguring such as cobbles/boulders obstructions or shallow groundwater.

Foundation Maintenance

Details on appropriate site and foundation maintenance practises from the CSIRO BTF 18 Foundation Maintenance and Footing Performance: A Homeowner's Guide are presented in Appendix G of this report.

Risk Assessment

It is concluded that overall risk from dispersive soils is moderate to high, but through the management measures presented above, this risk may be reduced to low.

Management Summary

The main aspects needing to be considered include:

- Shallow diversion mounds comprising of non-dispersive Layer 1 soils stabilised with bentonite or Layer 2 soils upslope of cuts. Source material must not be excavated any deeper than 0.3 m from any part of the Site.
- Stabilising cuts with sand, and building spoon drains into bedrock at the toe of cuts, diverting water over paved surfaces to be collected in pipework for diversion towards spoon drains or the onsite dam to the west of the building Site.
- All water should be collected and piped away from the building Site.
- Gypsum is to be used on all exposed Layer 3 soil, and service trenches are to be backfilled with sand and gypsum.
- Wherever possible, discharging groundwater must be drained away from the building Site.
- The bedrock is an effective barrier to groundwater movement and any retaining walls should be constructed on the bedrock to block groundwater movement.
- Any existing tunnels are to be backfilled with a sand and gypsum mix. The head of the tunnel must be intersected with a long upgradient cut off mound (diverting surface water flow away from problem areas), and all surrounding soil stabilised with gypsum.

K Taylor

Kris Taylor, BSc (hons)

Environmental & Engineering Geologist

Notes About Your Assessment

The Site classification provided and footing recommendations including foundation depths are assessed based on the subsurface profile conditions present at the time of fieldwork and may vary according to any subsequent *Site works* carried out. *Site works* may include changes to the existing soil profile by cutting more than 0.5 m and filling more than 0.4 to 0.8 m depending on the type of material and the design of the footing. All footings must be founded through fill *other than* sand not exceeding 0.4 m depth or sand not exceeding 0.8 m depth, or otherwise a Class P applies (AS2870 Clauses 2.5.2 and 2.5.3).

For reference, borehole investigation depths relative to natural soil surface levels are stated in borehole logs where applicable.

In some cases, variations in actual Site conditions may exist between subsurface investigation boreholes. At the time of construction, if conditions exist which differ from those described in this report, it is recommended that the base of all footing excavations be inspected to ensure that the founding medium meets the requirement referenced herein or stipulated by an engineer before any footings are poured.

The site classification assumes that the performance requirements as set out in Appendix B of AS 2870 are acceptable and that site foundation maintenance is carried out to avoid extreme wetting and drying.

It is the responsibility of the homeowner to ensure that the soil conditions are maintained and that abnormal moisture conditions do not develop around the building. The following are examples of poor practises that can result in abnormal soil conditions:

- The effect of trees being too close to a footing.
- Excessive or irregular watering of gardens adjacent to the building.
- Failure to maintain Site drainage.
- Failure to repair plumbing leaks.
- Loss of vegetation near the building.

The pages that make up the last six pages of this report are an integral part of this report. The notes contain advice and recommendations for all stakeholders in this project (i.e. the structural engineer, builder, owner, and future owners) and should be read and followed by all concerned.

References

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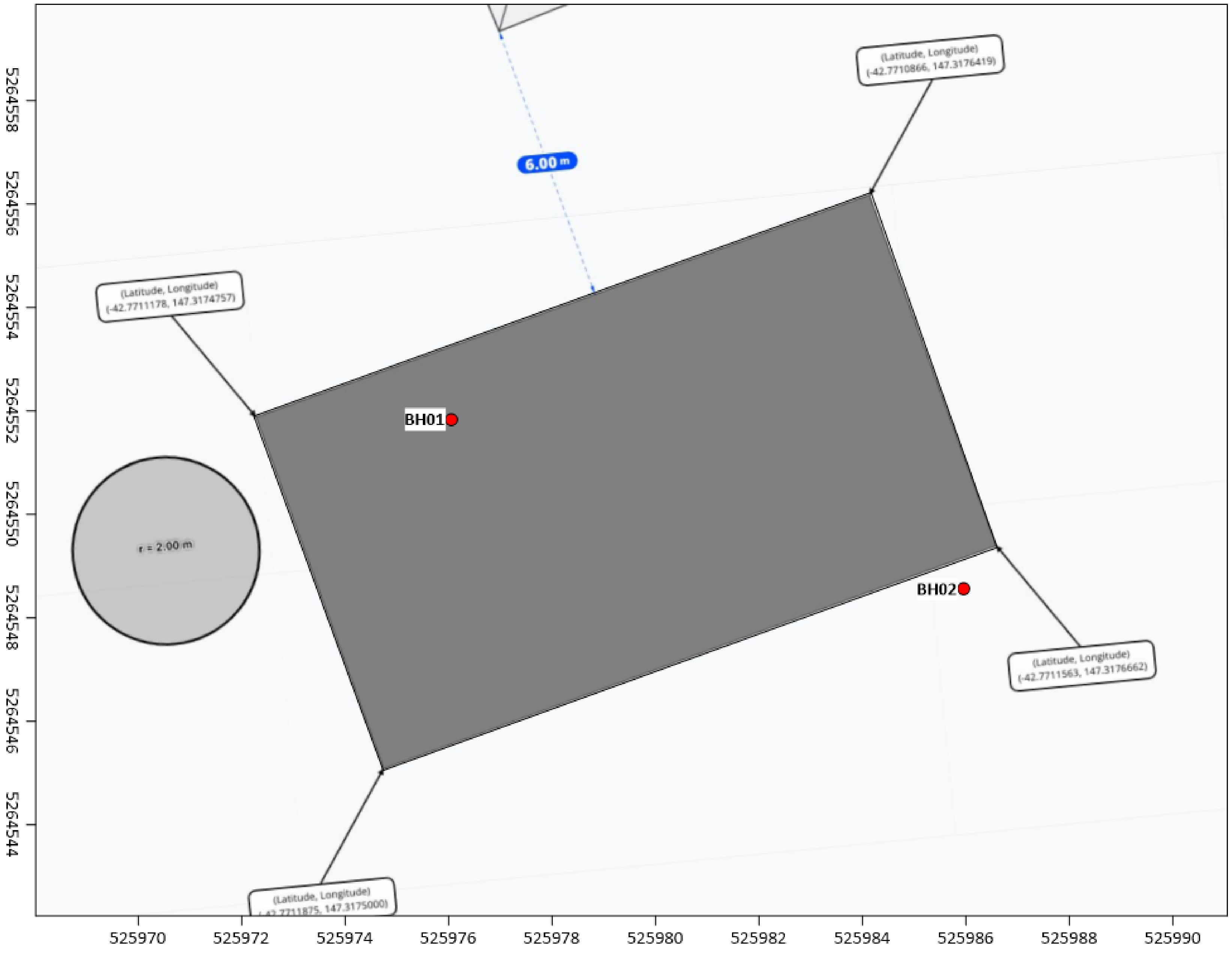
Appendix A Mapping

Site Borehole Locations



Appendix B Borehole Logs

enviro·tech CONSULTANTS

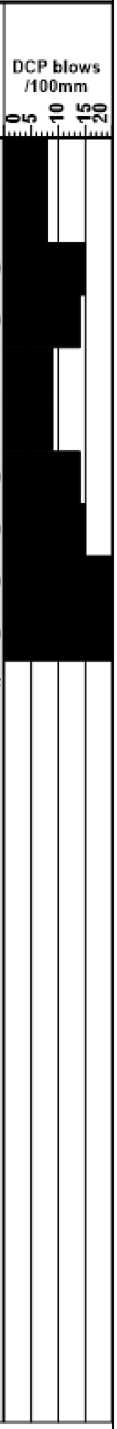
Positioning: GDA94 & mAHD

ASSESSMENT: Geotechnical Site Investigation
STRUCTURE: Shed
EASTING: 525976
NORTHING: 5264552
ACCURACY
HORIZ: 1.2m **VERT:** ~0.1m

Borehole BH01
DATE TESTED: 11/04/2024
LOGGED BY: M. Scalisi
ELEVATION: 238.2

LOCATION: 138 Gunners Quoin Road - Old Beach
CLIENT: Sheds n Homes
EQUIPMENT: AMS Powerprobe 9120 RAP
ESTIMATED GROUND m (m AHD):

DEPTH (m)	GRAPHIC	DESCRIPTION	DENSITY CONSIST. STRENGTH	LAYER	ELEVATION (mAHD)	MOISTURE Index	%	Well	SAMPLE	TEST	Cu (kPa)	UCS (kg/cm²)	BLOW COUNT
0.0	GC	SOIL & COBBLES/BOULDERS: Clayey GRAVEL, dark brown, well sorted, with sand, with silt, trace roots, 5 % roots, gravel 45%, fine to medium grained, sub-angular; 45% DOLERITE cobbles/boulders	dense	1	238.2	Dry			DS				8.0 8.0
0.5	CI	Silty CLAY, light olive brown, medium plasticity, with sand, trace roots, 5 % roots	very stiff to hard	2	238.0 237.8 237.6	Slightly Moist			DS				15.0 14.0 9.0 9.0 14.0 15.0
1.0	SM	SOIL & COBBLES: Silty SAND trace gravel, pale olive, well sorted, fine grained sand, gravel 15%, medium grained, sub-angular; 5% MUDSTONE cobbles	very dense	3	237.4 237.2 237.0 236.8				DS				24.0 20.0 REF
1.5		DOLERITE Bedrock		4	236.6				PL	IS 50			



Direct Push Sampler Refusal on DOLERITE Bedrock

End of borehole at 1.6m depth.

GROUNDWATER: Not Encountered

PAGE 1 of 1

TESTING: Penetrometer: AS 1289.6.3.2

Where penetrometer blows per 100mm are less than 1, the distance travelled per blow is measured and converted back to blows per 100mm.

DS: disturbed sample; PV: pocket vane; PP: pocket penotrometer; FV: downhole field vane; U50: undisturbed 50mm sample; REF: DCP refusal

enviro·tech
CONSULTANTS
Positioning: GDA94 & mAHD

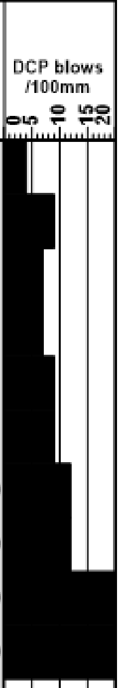
ASSESSMENT: Geotechnical Site Investigation
STRUCTURE: Shed
EASTING: 525986
NORTHING: 5264548.5
ACCURACY
HORIZ: 0.61m **VERT:** ~0.1m

Borehole BH02

DATE TESTED: 11/04/2024
LOGGED BY: M. Scalisi
ELEVATION: 239.9

LOCATION: 138 Gunners Quoin Road - Old Beach
CLIENT: Sheds n Homes
EQUIPMENT: AMS Powerprobe 9120 RAP
ESTIMATED GROUND m (m AHD):

DEPTH (m)	GRAPHIC	DESCRIPTION	DENSITY CONSIST. STRENGTH	LAYER	ELEVATION (mAHD)	MOISTURE Index	%	Well	SAMPLE	TEST	Cu (kPa)	UCS (kg/cm²)	BLOW COUNT
0.0	GC	SOIL & COBBLES/BOULDERS: Clayey GRAVEL, dark brown, well sorted, with sand, with silt, trace roots, 5 % roots, gravel 45%, fine to medium grained, sub-angular; 45% DOLERITE cobbles/boulders	medium dense	1		Dry							4.0
0.5	CI	Silty CLAY, light olive brown, medium plasticity, with sand, trace roots, 5 % roots	very stiff to hard	2	239.8 239.6 239.4 239.2	Slightly Moist			DS DS				9.0 7.0 7.0 9.0 9.0 12.0 12.0
1.0 1.5 2.0	SM	SOIL & COBBLES: Silty SAND trace gravel, pale olive, well sorted, fine grained sand, gravel 15%, medium grained, sub-angular; 5% MUDSTONE cobbles	very dense	3	239.0 238.8 238.6 238.4 238.2 238.0 237.8	Slightly Moist			DS				20.0 30.0 REF
		Direct Push Sampler Refusal on SOIL & COBBLES: Silty SAND trace gravel End of borehole at 2.1m depth.											



GROUNDWATER: Not Encountered

PAGE 1 of 1

TESTING: Penetrometer: AS 1289.6.3.2

Where penetrometer blows per 100mm are less than 1, the distance travelled per blow is measured and converted back to blows per 100mm.

DS: disturbed sample; PV: pocket vane; PP: pocket penotrometer; FV: downhole field vane; U50: undisturbed 50mm sample; REF: DCP refusal

Appendix C Core Photographs

BH01

BH02

*** 1 metre core tray length**

Appendix D Geotechnical Testing

Dynamic Cone Penetrometer (DCP)

Dynamic cone penetrometer (DCP) testing was conducted according to AS 1289.6.3.2 with the results presented in Appendix B.

Linear shrinkage

Disturbed soil samples (DS) are collected for linear shrinkage testing with soil laboratory testing conducted according to AS 1289.3.4.1. The results of the linear shrinkage tests are presented in Table 5.

Table 5 Linear shrinkage index test results

Layers	Soil	Hole ID	Depth (m)	Field Moisture %	Linear Shrinkage %
1	Clayey GRAVEL	BH01	0.1-0.2	7.2	3
2	Silty CLAY	BH02	0.5-0.6	18.9	10

Soil Dispersion (Emerson aggregate test)

Select soil samples were tested for sodicity using the Emerson Class number method according to AS1289.3.8.1. The results presented in Table 6 demonstrate that:

- Soils collected from the Site which are shallower than 0.5 m were either not dispersive (Emerson Class 4 or greater) or were slightly dispersive (Emerson Class 3). Therefore, no specific management measures are required.
- Layer 3 at depth of between 0.8 m and bedrock comprises both Emerson Class 1 and Emerson Class 2 category soils which are considered ***moderately to severely dispersive.***

It is recommended that the dispersive soils are adequately managed corresponding to the Emerson Class number and pH value, as detailed in the recommendations section of this report.

Table 6 Summary of the Emerson class results.

Layer	Soil	Depth	Sample ID	Emersion Class	Date Tested	Water	pH
1	Clayey GRAVEL	0.1	BH01 0.1	Class 8	17/04/2024	DI 22°C	
2	Silty CLAY	0.1	BH02 0.1	Class >4	17/04/2024	DI 22°C	
2	Silty CLAY	0.5	BH01 0.5	Class >4	17/04/2024	DI 22°C	
2	Silty CLAY	0.5	BH02 0.5	Class >4	17/04/2024	DI 22°C	
3	Silty SAND	1.2	BH01 1.2	Class 2	17/04/2024	DI 22°C	6.24
3	Silty SAND	1.5	BH02 1.5	Class 1	17/04/2024	DI 22°C	6.49

Appendix E Geotechnical Interpretation

Footing Minimum Target Depths

Footing design for the proposed structures are to consider the depths of limiting layers at the base of Class P soils where present. Where practical/allowable, thickened beams may be deepened through problematic soil layers according to engineering specifications (Table 7). Table 8 should be referred to where only 50kPa allowable bearing capacity is required.

Table 7 also presents a summary of the estimated soil depths and associated layers where less than 5mm of vertical soil movement can expected due to soil moisture fluctuations from normal seasonal wetting and drying cycles. Where 5mm tolerances are required, concentrated loads including but not limited to slab edge or internal beam or strip footings shall be supported directly on piers in accordance with minimum target layer depths presented in Table 7, with considerations given to required bearing capacities in accordance with Table 8.

Table 7 Soil characteristic surface movements and recommended footing minimum target depths

Footing Target Layers	**BH01**	**BH02**
Surface movement Ys (mm)	25	25
Soil class	M	M
Base of problem soil layer (m)*	-	-
Layer at base of problem soil*	-	-
Pier minimum target depth (m)[#]	0.8	0.8
Pier minimum target layer[#]	2	2

- No problem layers encountered

*Base of problematic soil depth and target layer at test location to achieve 100 kPa allowable bearing capacity or greater.

[#] Target depth and layer where Ys values from normal wetting and drying cycles are estimated at less than 5mm vertical movement

Soil Bearing Capacity

Soil allowable bearing capacity was calculated from correlations with DCP blow counts. Where high clay and silt content is observed in the soil, soil allowable bearing capacity is determined from undrained shear strengths using a field vane. Interpretive bearing capacity values are presented in Table 8.

Table 8 Soil allowable bearing capacities and problematic ground conditions.

Depth from (m)	**Allowable Bearing Capacity (kPa)**	
	BH01	**BH02**
0	**>400***	**200***
0.1	**>400**	**>400**
0.2	**>400**	**280**
0.3	**>400**	**280**
0.4	**>400**	**>400**
0.5	**>400**	**>400**
0.6	**>400**	**>400**
0.7	**>400**	**>400**
0.8	**>400**	**>400**
0.9	**>400**	**>400**
1	REF	REF
1.1		
1.2		
1.3		
1.4		
1.5	**DOLERITE**	

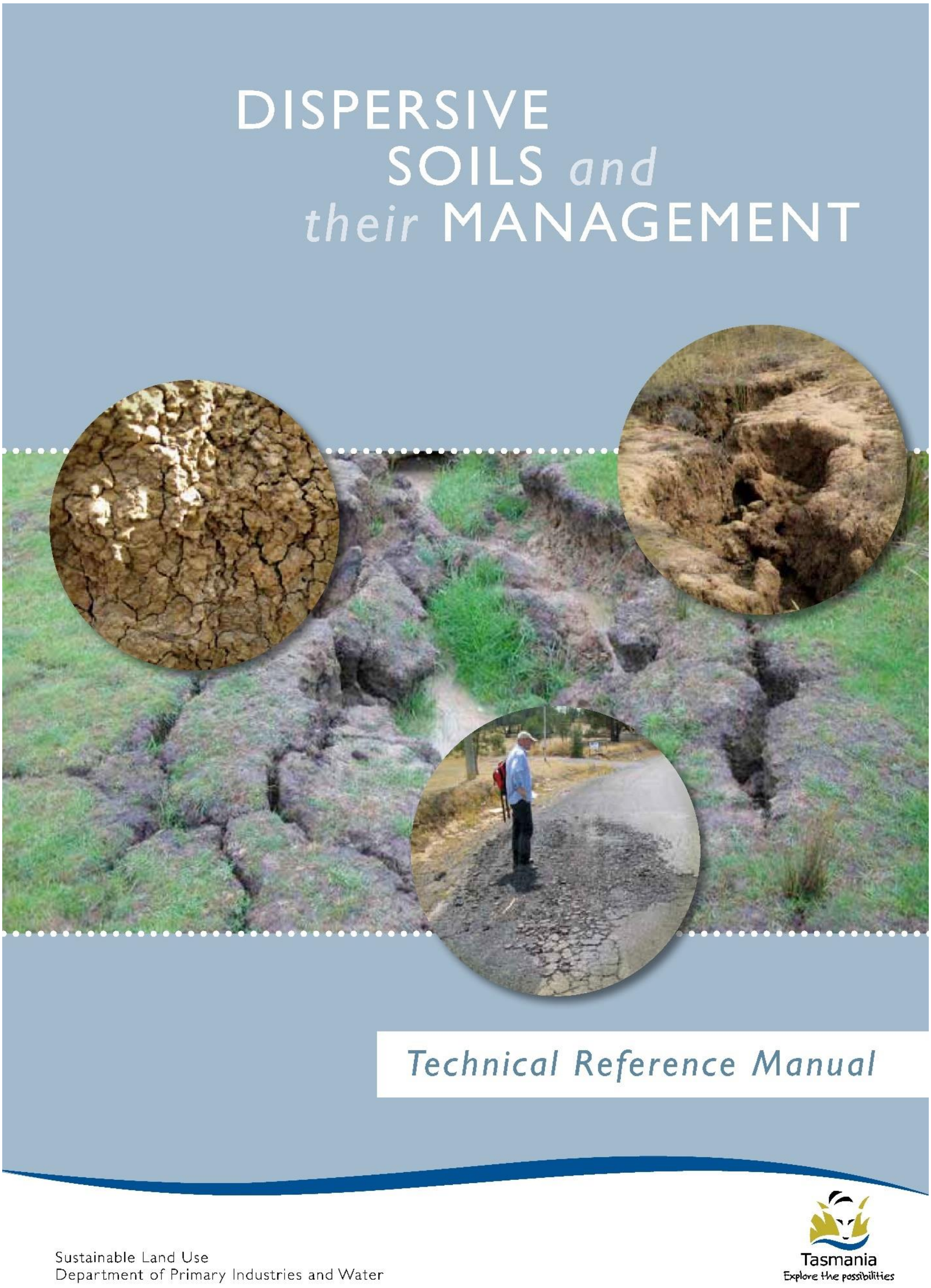
Correlations drawn from DCP and vane shear testing.
REF - Penetrometer Refusal
^ Footings to be founded through the FILL
~ Problematic soil layer attributed to loose, soft, or low allowable bearing capacity soil (<100 kPa)
*Soil layer expected at the base of problematic soil layers at test location (or at surface where problematic soils not encountered) to achieve 100 kPa allowable bearing capacity or greater.

Characteristic Surface Movement (Ys)

The characteristic surface movement (soil reactivity) is calculated according to AS 2870 Section 2.3. The calculations are based on Iss % testing results where applicable and are based on complete soil profiles for boreholes drilled within the building Site.

According to AS 2870 Section 2.3, calculations consider the depth of groundwater and bedrock. Soil characteristic surface movements from normal wetting and drying cycles are presented in Table 7.

Appendix F Class 1 Dispersive Soil Management



DISPERSIVE
SOILS *and*
their MANAGEMENT

Technical Reference Manual

Sustainable Land Use
Department of Primary Industries and Water

Tasmania
Explore the possibilities

4.1 MANAGEMENT OPTIONS FOR TUNNEL EROSION

Past efforts to repair tunnel erosion in agricultural landscapes have relied on mechanical destruction of the tunnel system by deep ripping, contour furrowing, and contour ripping. Unfortunately many of these techniques either failed or resulted in tunnel re-emergence in an adjacent areas (Floyd 1974, Boucher 1995). The use of these 'agricultural' techniques is inappropriate in peri-urban areas where tunnel repair requires a low incidence of re-failure due to the potential for damage to infrastructure. Experience with the construction of earth dams using dispersive clays, demonstrates that repair and prevention of tunnel erosion in urban and peri-urban environments is best achieved using a combination of,

» Identification and avoidance of dispersive soils.

» Precise re-compaction.

» Chemical amelioration.

» Sand blocks and barriers.

» Topsoil, burial and revegetation.

4.2 IDENTIFICATION AND AVOIDANCE OF DISPERSIVE SOILS

The risk of tunnel erosion resulting from construction activities on dispersive soils can often be reduced or eliminated by identifying and avoiding areas containing dispersive soils. The presence and severity of dispersive soils can vary enormously over short distances (Figure 13). In many instances, large scale (ie 10 x 10 or 20 x 20 meter grid) soil survey and screening of soils for dispersion, (using the Emerson crumb test - section 3, Appendix I) can be used to site dwellings and infrastructure away from dispersive soils. Advice should be sought from a suitably qualified and experienced engineer or soil professional.

Figure 13. The severity (or sodium content) and depth of dispersive subsoils can vary considerably over short distances. (a). At this site highly dispersive subsoils exist meters away from (b) non-dispersive soils.

4.3 COMPACTION

Ritchie (1965) demonstrated that the degree of compaction within the dam wall was the single most important factor in reducing dam failure from piping (tunnel erosion). A high degree of compaction reduces soil permeability, restricting the movement of water and dispersed clay through the soil matrix, which decreases the severity of dispersion and restricts tunnel development (Vacher *et al.* 2004). However, dispersive soils can be difficult to compact as they lose strength rapidly at or above optimum moisture content, and thus may require greater compactive force than other soils (McDonald *et al.* 1981). Bell & Bryun (1997) and Bell and Maud (1994) suggest that dispersive clays must be compacted at a moisture content 1.5 -2% above the optimum moisture content in order to achieve suficent density to prevent piping (Elges 1985).

Construction of structures such as earth dams and footings for buildings with dispersive soils require geotechnical assessment and advice from a qualified and experienced engineer, in order to determine compaction measures such as the optimal moisture content, number of passes, and maximum thickness of compacted layers.

Normal earth moving machinery including bull-dozers, excavators and graders do not provide sufficient compactive force to reduce void spaces or achieve adequate compaction in dispersive soils. A sheepsfoot roller of appropriate weight is usually required to compact dispersive soils. By comparison a D6 dozer applies only 0.6 kg/cm^2 pressure compared to 9.3 kg/cm^2 for a sheepsfoot roller (Sorensen 1995).

4.4 CHEMICAL AMELIORATION

Initiation of tunnel erosion is predominantly a chemical process, so it makes sense to use chemical amelioration strategies when attempting to prevent or repair tunnel erosion in dispersive soils. Despite the widespread use of gypsum and lime to treat sodic soils in agriculture, the use of gypsum and lime to treat tunnel affected areas has been relatively rare (Boucher 1990).

Hydrated lime (calcium hydroxide) has been widely used to prevent piping in earth dams. Rates of application have varied depending on soils and degree of compaction used in construction. Laboratory testing usually indicates that only around 0.5 – 1.0% hydrated lime is required to prevent dispersion, however difficulties with application and mixing necessitate higher rates of application (Moore *et al.* 1985). Moore *et al.* (1985) cite examples of the use of hydrated lime to control piping in earth dams at rates between 0.35% (N.S.W. Australia) and 4% (New Mexico). Elgers (1985), and McElroy (1987) recommend no less than 2% hydrated lime (by weight of the total soil material) to prevent dispersion within dam embankments, while Bell and Maud (1994) suggest that 3% - 4% by mass of hydrated lime should be added to a depth of 0.3m on the upper face of embankments. In alkaline (pH >7.0) soils (most sodic subsoils in Tasmania are neutral or alkaline) the effectiveness of hydrated lime is reduced by the formation of insoluble calcium carbonate (Moore *et al.* 1985), such that gypsum is preferred to hydrated lime. It is important to note that agricultural lime (calcium carbonate) is not a suitable substitute for hydrated lime due to its low solubility (McElroy 1987). Also note that excessive applications of lime may raise soil pH above levels required to sustain vigorous plant growth.

Gypsum (calcium sulphate) is more effective than lime for the treatment of dispersive soils as it increases the electrolyte concentration in the soil solution as well as displacing sodium with calcium within the clay structure (Raine and Loch 2003). Gypsum is less commonly used than hydrated lime in dam construction and other works due to its lower solubility, and higher cost. Elges (1985) recommends that in construction, a minimum of 2% by mass of gypsum be used. Bell and Maud (1994) present a means of calculating the amount of gypsum required to displace excess sodium and bring ESP values within desired limits (normally < 5). Be aware that application of excessive amounts of gypsum may cause soil salinity to temporarily rise beyond the desired level for plant growth.

NOTE:

- Use of gypsum in Tasmania is covered under the Fertiliser Act 1993, which has established the allowable limit for cadmium and lead at 10 mg/kg and 5 mg/kg for mercury.
- Gypsum is usually imported into Tasmania from Victoria or South Australia, which have different standards for allowable heavy metal content.
- Purchasers of gypsum should check with suppliers to ensure that gypsum imported into Tasmania is compliant with current regulations.

Alum (aluminium sulphate) has been effectively used to prevent dam failure and protect embankments from erosion. Application rates are not well established. Limited data suggests mixtures of 0.6 – 1.0% (25% solution of aluminium sulphate) (Bell and Bruyn 1997, McElroy 1987) to 1.5% (Ouhadi, and Goodarzi 2006) of the total dry weight of soil may be appropriate. Alum is however highly acidic (pH 4-5), and thus alum treated soils will need to be capped with topsoil in order to establish vegetation (Ryker 1987). Soil testing is required to establish appropriate application rates for Tasmanian soils.

Long chain polyacrylamides have been shown to increase aggregate stability, reduce dispersion and maintain infiltration rates in dispersive soils (Levy *et al.* 1992, Raine and Loch 2003). However the effect is highly variable between various polyacrylamide products and the chemical and physical properties of the soil. The benefit of polyacrylamides is generally short due to their rapid degradation (Raine and Loch 2003). Further advice and laboratory testing should be conducted before using polyacrylamides to protect earth dams from piping failure.

Note that appropriate application rates for gypsum, hydrated lime, alum and polyacrylamides have not been established for dispersive soils in Tasmania. Extensive laboratory assessment of materials used for the construction of dams or embankments is required before locally relevant 'rules of thumb' can be established for the use of these products.

4.5 SAND BLOCKS AND SAND BARRIERS

Sand filters were first developed to prevent piping in earth dams. Sand filters prevent dam failure by trapping entrained sand and silt, blocking the exit of the tunnel and preventing further tunnel development (Sherard *et al.* 1977). Following the work of Sherard *et al.* (1977), Richley (1992 and 2000) developed the use of sand blocks to prevent tunnel erosion during installation of an optical fibre cable in highly dispersive soils near Campania, Tasmania. The sand blocks work slightly differently to the sand filters in that they allow the free water to rise to the surface through the sand. The use of sand blocks has recently been modified by Hardie *et al.*, (2007) to prevent re-initiation of tunnel erosion along an optical fibre cable near Dunalley. Modifications to the original technique developed by Richley (1992 and 2000) include (Figure 14 &15);

- Upslope curved extremities to prevent the structure from being by-passed.
- Geotextile on the downslope wall to prevent collapse or removal of sand following settlement or erosion.
- Application of gypsum (around 5% by weight) to ensure infiltrating water contains sufficiently electrolyte to prevent further dispersion.
- Earth mound upslope of the structure to prevent run-on entering the sand blocks.

Figure 15. (a) Installation of sandblock perpendicular to a service trench. Note securing of geotextile to the optical fibre cable to prevent water flowing past the sand block. (b) Sandblock before final topsoiling.

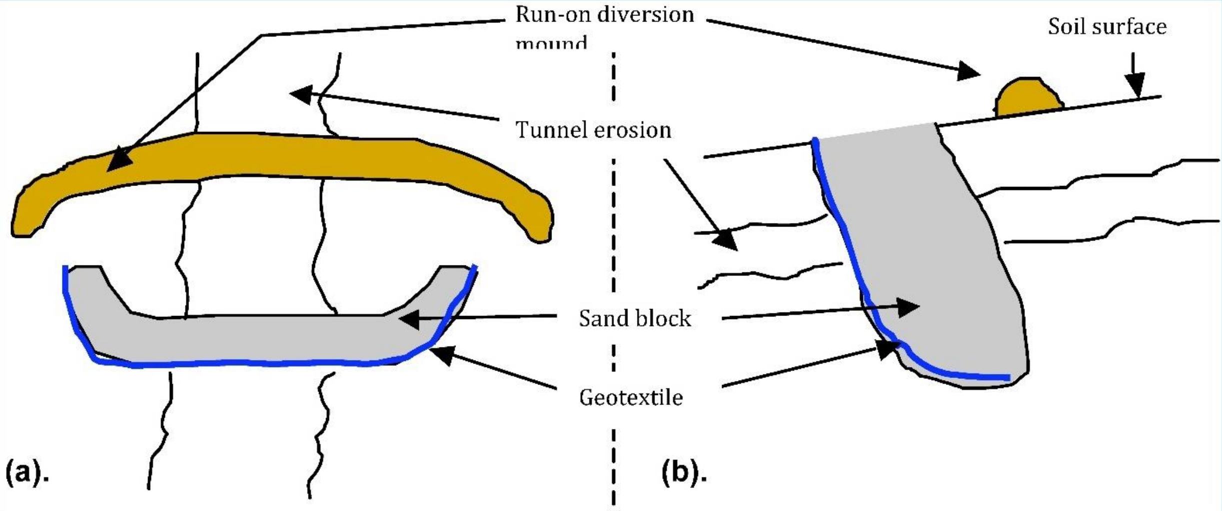


Figure 14. Modified sand block design. (a) plan view, (b) cross section view. The depth of the sand block is determined by the depth of dispersive soils or tunnel erosion. The span length of the structure is determined by the width of the tunnelling.

4.6 USE OF TOPSOIL / BURIAL AND REVEGETATION

Topsoil or burial of exposed dispersive soils reduces the likelihood of subsoil dispersion and initiation of tunnel erosion by;

- Providing a source of salt to increase the electrolyte content of infiltration water.
- Preventing desiccation and subsoil cracking.
- Promoting even infiltration.
- Providing a protective cover from raindrop impact.
- Providing a suitable medium for revegetation.

Topsoil minimises the interaction between water and dispersive clays by providing both a physical and chemical barrier. Topsoil also reduces soil desiccation and development of surface cracks (Sorensen 1995). It is suggested that exposed dispersive subsoils be covered with at least 150mm of non dispersive topsoil and sown with an appropriate mix of grass species. In some cases it will be necessary to protect the topsoil from erosion with 'jute' cloth or similar product.

The suitability of planting trees in tunnel affected areas is influenced by the amount of annual rainfall and frequency of soil cracking resulting from desiccation. Boucher (1995) recommends the preferred option for revegetation of reclaimed tunnel erosion is a widely spaced tree cover in association with a combination of perennial and annual pastures, rather than a dense stand of trees or pasture alone. Experience in Tasmania suggests that in low rainfall areas, or areas in which existing trees or shrubs cause soil drying and cracking, the preferred option for revegetating tunnel affected land is a dense healthy pasture. In high rainfall areas, dense plantings of trees have been successfully used to repair or stabilise tunnel erosion for example Colclough (1973) successfully used Pinus radiata to stabilise tunnel-gully affected land in a moderate rainfall area near Tea Tree, Tasmania.

5.0 ACTIVITIES THAT INCREASE THE RISK OF EROSION ON DISPERSIVE SOILS

ACTIVITIES THAT INCREASE RISK OF INITIATING TUNNEL EROSION, INCLUDE;

- » Removal of topsoil.
- » Soil excavation or expose of subsoils to rainfall.
- » Supply of services via trenches.
- » Construction of roads and culverts in dispersive subsoils.
- » Installation of sewage and grey water disposal systems in dispersive subsoils.
- » Dam construction from dispersive soils.

OPTIONS FOR REDUCING THE RISK OF TUNNEL EROSION DURING CONSTRUCTION AND DEVELOPMENT WORKS ON DISPERSIVE SOILS INCLUDE,

- » Where possible do not remove or disturb topsoil or vegetation.
- » Ensure that dispersive subsoils are covered with an adequate layer of topsoil.
- » Avoid construction techniques that result in exposure of dispersive subsoils.
- » Use alternatives to 'cut and fill' construction such as pier and post foundations.
- » Where possible avoid the use of trenches for the supply of services ie water & power.
- » If trenches must be used, ensure that repacked spoil is properly compacted, treated with gypsum and topsoiled.
- » Consider alternative trenching techniques that do not expose dispersive subsoils.
- » Ensure runoff from hard areas is not discharged into areas with dispersive soils.
- » If necessary create safe areas for discharge of runoff.
- » If possible do not excavate culverts and drains in dispersive soils.
- » Consider carting non-sodic soil to create appropriate road surfaces and drains without the need for excavation.
- » Ensure that culverts and drains excavated into dispersive subsoils are capped with non-dispersive clays mixed with gypsum, topsoiled and vegetated.
- » Avoid use of septic trench waste disposal systems; consult your local council about the use of alternative above ground treatment systems.
- » Where possible do not construct dams with dispersive soils, or in areas containing dispersive soils.
- » If dams are to be constructed from dispersive clays, ensure you consult an experienced, qualified civil engineer to conduct soil tests before commencing construction.
- » Construction of dams from dispersive soils is usually possible, using one or a combination of: precise compaction, chemical amelioration, capping with non-dispersive clays, sand filters and adequate topsoiling.

With all forms of construction on dispersive soils, ensure you obtain advice and support from a suitably experienced and qualified engineer or soil professional before commencing work.

Foundation Maintenance and Footing Performance:

A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

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

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

Soil Types

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

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

Causes of Movement

Settlement due to construction

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

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

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

Erosion

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

Saturation

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

Seasonal swelling and shrinkage of soil

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

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

Shear failure

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

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

GENERAL DEFINITIONS OF SITE CLASSES

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

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

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

Unevenness of Movement

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

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

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

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

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

Effects of Uneven Soil Movement on Structures

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

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

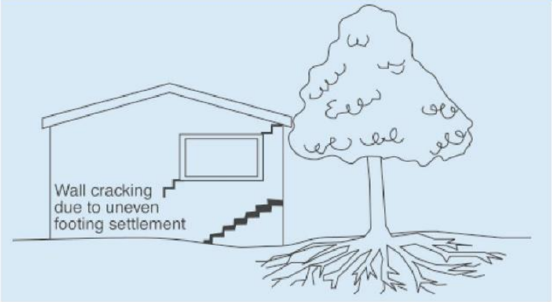
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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

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

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

Trees can cause shrinkage and damage



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

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

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

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

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

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

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

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

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

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

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

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

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

Water Service and Drainage

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

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

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

Seriousness of Cracking

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

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

Prevention/Cure

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

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

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

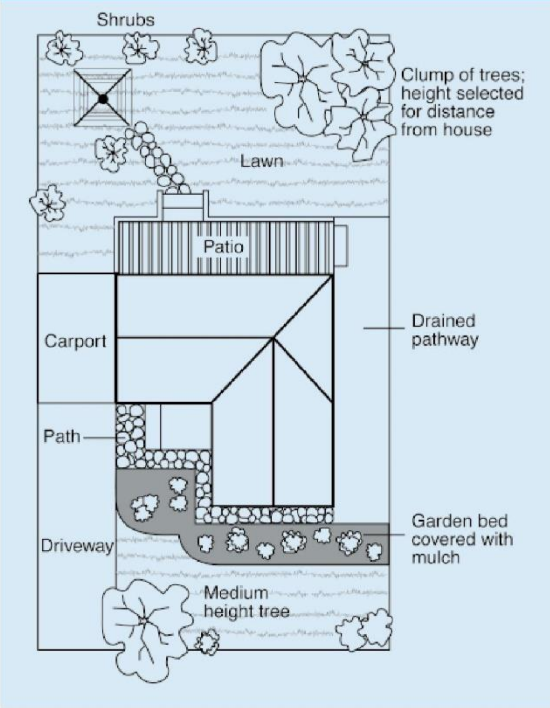
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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

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