UNIVERSAL DRILLING Pty Ltd
319 Valla Road, Valla NSW 2448
ABN: 24 661 315 037
MB: 0401327746

26 March 2025

GJ Gardner Homes -Taree
63 Muldoon Street
Taree NSW 2430
Taree@gjgardner.com.au
PH: (02)65004656

Date of Fieldwork	10.03.2025
Our reference	1003202543SAPPHIREDR-01
Job Order Number	Order Number: au26-113/37
Site Address	No.43 Sapphire Drive, Diamond Beach, NSW 2430
Client / Site Contact	Munuela & Steve QUIRK
Site Plans received building footprint identified Y/N	Y
Land searches (flooding, services, easements)	Sloping block in an established suburb of Diamond Beach.
Site Fill **Subdivisional, Single block** **Controlled / Uncontrolled AS3798 Earthworks** **Report Supplied Y/N** **Report Number:**	Yes minimal at the front of the block (roadside) Single block Assumed Uncontrolled Not at this stage N/A
(A) New Home Build **(B)Virgin Site with prepared pad** **(C)Existing Home rebuild** **(D)Existing Home Addition** **(E)Pool** **(F)Shed**	A
Trees & other impediments	No trees or gardens however drainage from the top(front) of the block has created some soft soils, a complete stripping and inspection of the site is required before construction.

Site Classification (AS 2870)	**Class P**
Site Reactivity	**H1 reactivity**
Reactivity (AS1289.7.1.1 - ISS)	**3.9**
Wind Rating	**N2** (coastal but has topographic protection)

NOTE: A "P" Class site has been applied due to abnormal moisture (site drainage issues)

Introduction

As requested, an investigation has been carried out to determine the foundation conditions at the above site and to classify the site in accordance with AS2870 *'Residential Slabs and Footings'*. All findings should be assessed for suitability by the relevant parties as per Appendix "A" of AS2870, findings and recommendations are in accordance with AS2870 *'Residential slabs and footings'*, AS3798 (Guidelines on Earthworks for commercial and Residential Development) and AS4055 *'Wind loads for housing'* (where applicable or engaged to do so).

This report should be read in conjunction with the attached

- *'CSIRO – Foundation Maintenance & Footing Performance'* publication.
- *Limits with Geotech report*
- *Where applicable or provided to Universal Drilling a site specific AS3798 compliant controlled earthworks report.*


DRILLING SITE INSPECTION DATA

Site Analysis

Is there current evidence of any of the following that would likely have some effect on this site?

Abnormal Site Conditions including:

Existing Fill (>400mm)	☐	Landslip	☐	Floating Boulders	☐
Soft Soils	☒	Reactive Sites	☐	Site Drainage issues	☒
Unstable Slopes	☐	Existing home	☐	Erosion	☐
Rock - difficult to excavate	☐				

Notes: Some soft soils becoming firm over very stiff CLAYS and extremely weathered rock (see Dynamic cone penetrometer results and engineers bearing assessment,a complete stripping of the site will reveal any further soft soils.

Abnormal Moisture Conditions including:

Site drainage and seepage evidence	☒	Proximity to water bodies	☐
Large mature trees on site and adjoining site	☐	Unusual moisture, eg. dams, ponds, drains	☒
Low lying aspect causing water retention	☒	Removal of large trees prior to construction	☐

Notes: Some soft soils due to poor site drainage, this should be arrested when stripping the site and constructing retaining walls to divert stormwater away from the front of the house.

TREE EFFECT SCORE		Option	Option Score	SCORE
Tree characteristics	Canopy	Dense	3	Nil
		Med Dense	2	
		Sparse	1	
	Height	Tall (>15m)	3	
		Med (8-15m)	2	
		Small (<8m)	1	
	Stage of growth	Growing	2	
		Mature	1	
	Drought Resistance	Resistant	2	
		Not Resistant	0	
Ground & Site Conditions	Depth of Fill	≥1m	2	
		<1m	0	
	Adverse Conditions	Yes	1-2	
		No	0	
	Soil Profile Reactivity	H/E	2	
		M	1	
Total Tree Effect Score (sum characteristic scores above)				

NOTES

UNSUITABLE MATERIALS (Reference AS3798 clause 4.3)

"Some materials are unsuitable for forming structural Fill and should be removed to spoil or used in non-critical areas".
In addition to FILL (usually uncontrolled) this practice should be applied to pre-existing ground conditions which may also include natural profiles and root affected soils. Good building practice dictates that all heavy organic strata be scraped clear of the building envelope during the early stages of site preparation, and we have assumed that this will be done in accordance with AS3798 clause 6.1.5.

Some examples of Unsuitable materials are as follows:

- Organic soils (Topsoils, root affected subsoils)
- Contaminated materials (through past site usage)
- Silts (or soils with deleterious qualities)
- FILL that contains wood, metal, plastic etc.

CLASS "P" SITES (Reference AS2870 clause 2.1.3)

Class P sites are 'Sites which include soft or unstable foundations, such as soft clay or silts 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.'
A Class P site contains one or more 'problems' that must be specifically addressed by the designer to ensure acceptable footings performance, this can mean in some cases that a 'P class site' is still applied after controlled filling has been placed over unstable foundations (as is often the case given the investigation can happen after earthworks are complete).

SITE FILLING (Reference AS3798 Australian code for residential and commercial earthworks)

If the site requires filling a complete stripping and foundation inspection should be carried out prior to placement of fill identifying all foundation issues, then all works should be conducted in accordance with AS 3798. Relative compaction and oversize material of the selected fill must be controlled (refer AS3798 clause 4.3 a to d). Typically, this will be obtained by a minimum STD MDD Ratio of 95% (AS3798 - Table 5.1) and moisture variation of +/-2% of optimum per 200mm layer or uniform thickness (AS3798 6.2.2 & Table 8.1).

Controlled Fill should be monitored by an independent GTA (Geotechnical Authority).

Controlled fill: (AS2870 2.5.3a)

(i) *'Shallow fill* - The classification of a site with controlled fill not more than 0.8m deep for sand and not more than 0.4 m deep for material other than sand shall be the same as a natural site.'
(ii) *'Deep fill* - The classification of a site with controlled fill deeper than 0.8m for sand shall be the same as a natural site. ***The effect of the fill on the settlement of the underlying soil shall be taken into account***. The classification of a site with controlled material other than sand and deeper than 0.4m shall be Class P.'

Uncontrolled fill: (AS2870 2.5.3b)

(i) *'Shallow fill* - The classification of a site with uncontrolled fill not more than 0.8m deep for sand and not more than 0.4 m deep for material other than sand shall be class P.'
(ii) *'Deep fill* - The classification of a site with uncontrolled fill deeper than 0.8m for sand and 0.4m for material other than sand shall be Class P.'

BUILD WoW Pty Ltd
Structural and Civil Engineering Consulting
ABN 31 602 487 641
157 McHughes Creek Rd.
South Arm NSW 2449
P (02) 7902 5233
E Siggi@jecoback.com

20th March 2025 Our Project No.: 20032025
Site: no. 43 Sapphire Parade – Diamond Beach - NSW
Universal Drilling P/L Job No: 1003202543SAPPHIREDR-01

INDICATIVE ALLOWABLE BEARING CAPACITY ASSESSMENT

We refer to "Universal Drilling Pty Ltd (UDPL)" limited geotechnical soil investigation test reports for the proposed development at the abovementioned address.
The investigation undertaken 10th March 2025 (Conducted to AS 2870 and AS 1726) consisted of two (2) bore logs and 2 (2) DCP's.
From these test results our consultancy specifies the following allowable bearing capacities:

DCP No.	Location (GDA94-MGA56)	Allowable Bearing Capacities (ABC)
BH/01	E/456283.00 N/6454285.00	**100 kPa at 0.2 m below E.S.L*** **300 kPa at 1.6 m below E.S.L**
BH/02	E/456282.31 N/6454267.99	**100 kPa at 0.2 m below E.S.L*** **300 kPa at 1.5 m below E.S.L**

- Allowable Bearing Capacity (ABS) only applies to the nominated depth for a footing width of 0.3m to 0.5m. The nominated layer at the depth of 0.2m below E.S.L is underlain by soil with lesser bearing capacity. The nominated (ABS) is relying on the pressure distribution/reduction with increasing depth below the footings.

Notes:

1. Allowable bearing capacity assumes the subject area (borehole drilling depth) is not underlain by any weaker material.
2. The assessment assumes the subject area will not be inundated by flooding.
3. E.S.L denotes "Existing Surface Level".
4. Build WoW Pty Ltd refers to "Universal Drilling Pty Ltd" disclaimer and limitations for this assessment.

This assessment is in accordance with the relevant codes of Standards Australia and widely accepted engineering principles. This report has been written specifically for the abovementioned site and proposed development only and is not transferrable to any other site or project.
The assessment does state the "ALLOWABLE BEARING CAPACITY" based on the site investigation of "UNIVERSAL DRILLING PTY LTD" only.
Geotechnical stability, Landslide and Load surcharge/implications on other Buildings/Structures are NOT part of the assessment.
The recommendations made in this assessment assume that the test results are representative of the overall subsurface conditions. Should excavations reveal variations from the soil conditions documented in the bore logs, our office should be notified before proceeding with the site work as modifications to the design may be required.

For and on behalf of
Build WoW Pty Ltd

Siggi Schnitzler
M.Eng., RPEQ 7030

Universal Drilling Pty Ltd
319 Valla Road, Valla NSW 2448
Phone: 0401327746

Geotechnical Log - Borehole

BH/1

UTM	: 56H	Drill Rig	: EZIPROBE	Job Number	: 1003202543SAPPHIREDR-01
Easting (m)	: 456283.00	Driller Supplier	:	Client	: GJ GARDNER HOMES -TAREE
Northing (m)	: 6454285.00	Logged By	: AM	Project	: Limited site investigation for a proposed new home
Ground Elevation	: Not Surveyed	Reviewed By	: AM	Location	: no.43 Sapphire Parade, Diamond Beach NSW
Total Depth	: 1.8 m BGL	Date	: 10/03/2025	Loc Comment	:

General comments: Front of block opposite retaining wall

DCP graph	Depth (m)	Soil Origin	Graphic Log	Classification Code	Moisture	Material Description	Consistency/Density	Samples	Testing	Remarks / SAMPLE TYPE
1		Natural		CL	W-M	Natural Sandy CLAY CL: very soft, low plasticity, brown grey, fine to medium grained sand, with low plasticity silt, trace medium sized gravel, organic, wet to moist.	VS			
1	0.2									
4		Natural		CI	M	Natural Sandy CLAY CI: soft to firm, medium plasticity, brown orange, fine to medium grained sand, with medium sized gravel, with low plasticity silt, inorganic, moist.	S-F			
6	0.4									
3		Residual		CI-CH		Residual Silty CLAY CI-CH: soft, medium to high plasticity, orange mottled dark grey, trace fine to medium sized gravel, trace fine grained sand, inorganic, moist.	S			SSWELL
2										
4										
4										
3										
2										
2										
2										
3										
5										
5	1.5									
10		Residual		CI		Residual Silty CLAY CI: stiff to very stiff, medium plasticity, orange grey mottled, trace medium to coarse sized gravel, trace fine to medium grained sand, inorganic, moist, with ex weathered grey orange rock.	St-VSt			
27										
25										
15						**BH/1 Terminated at 1.8m (Terminated on ex weathered rock with clay)**				
20										
19										
21										
26										
TERM										

Universal Drilling Pty Ltd
319 Valla Road, Valla NSW 2448
Phone: 0401327746

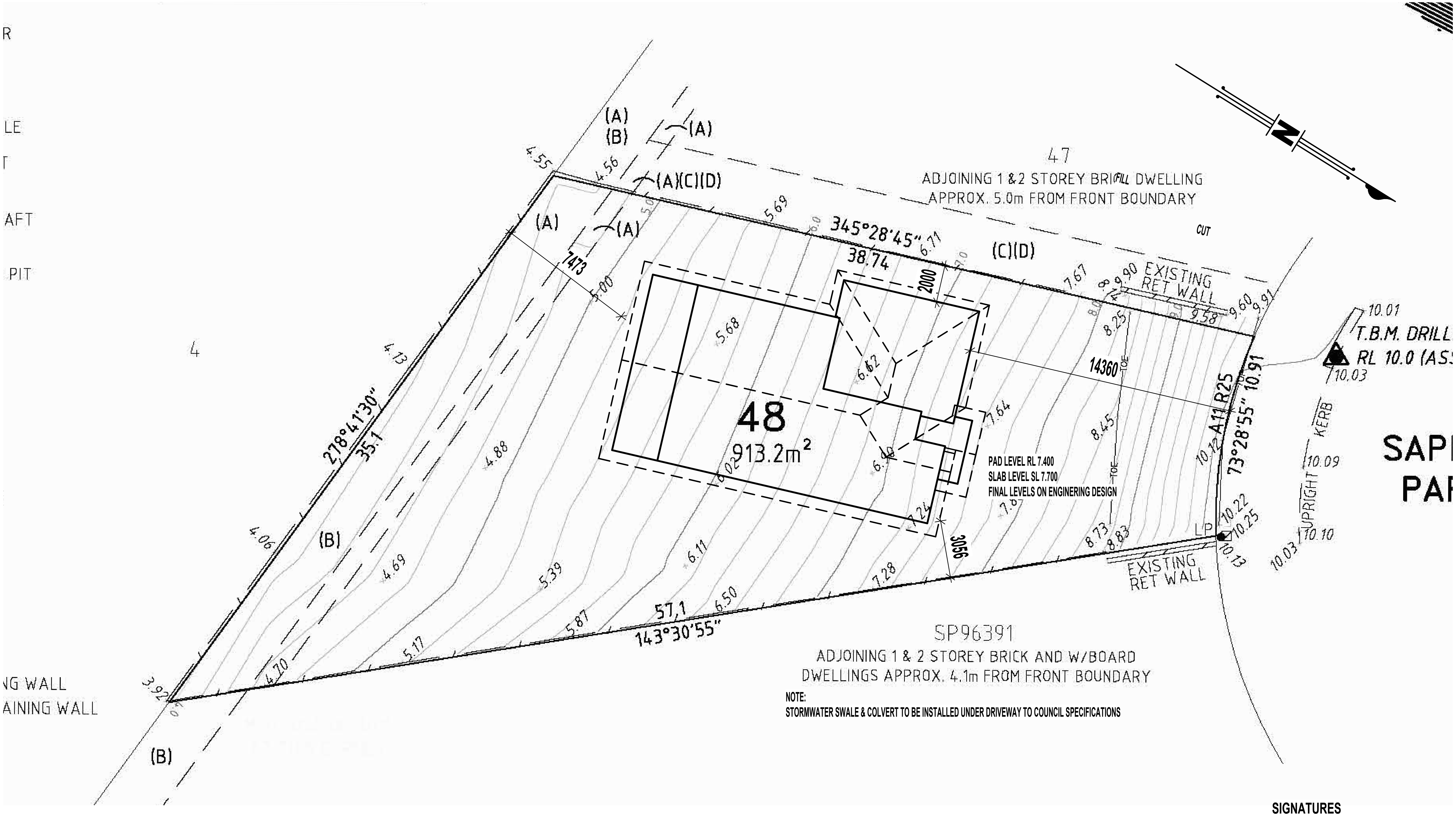
Geotechnical Log - Borehole

BH/2

UTM	: 56H	Drill Rig	: EZIPROBE	Job Number	: 1003202543SAPPHIREDR-01
Easting (m)	: 456282.31	Driller Supplier	:	Client	: GJ GARDNER HOMES -TAREE
Northing (m)	: 6454267.99	Logged By	: AM	Project	: Limited site investigation for a proposed new home
Ground Elevation	: Not Surveyed	Reviewed By	: AM	Location	: no.43 Sapphire Parade, Diamond Beach NSW
Total Depth	: 1.8 m BGL	Date	: 10/03/2025	Loc Comment	:

General comments: Rear of block

DCP graph	Depth (m)	Soil Origin	Graphic Log	Classification Code	Moisture	Material Description	Consistency/Density	Samples	Testing	Remarks
1		Natural		CL	W-M	Natural Sandy CLAY CL: very soft, low plasticity, brown grey, fine to medium grained sand, with low plasticity silt, trace medium sized gravel, organic, wet to moist.	VS			
1	0.2									
4		Natural		CI	M	Natural Sandy CLAY CI: soft to firm, medium plasticity, brown orange, fine to medium grained sand, with medium sized gravel, with low plasticity silt, inorganic, moist.	S-F			
4										
5										
4	0.6									
3		Residual		CI-CH		Residual Silty CLAY CI-CH: soft, medium to high plasticity, red orange grey, trace fine to medium sized gravel, trace fine grained sand, inorganic, moist.	S			
3										
2										
3										
3	1.1									
6		Residual		CI-CH		Residual Silty CLAY CI-CH: firm to stiff, medium to high plasticity, red orange grey, trace fine to medium sized gravel, trace fine grained sand, inorganic, moist.	F-St			
8										
9	1.4									
12		Residual		CI		Residual Silty CLAY CI: very stiff to hard, medium plasticity, orange grey mottled, trace medium to coarse sized gravel, trace fine to medium grained sand, inorganic, moist, with ex weathered grey orange rock.	VSt-H			
22										
28										
TERM										
						BH/2 Terminated at 1.8m (Terminated on ex weathered rock with clay)				



SIGNATURES

OWNER	DATE / /
OWNER	DATE / /
BUILDER	DATE / /

SITE PLAN
1 : 200

G.J. Gardner. HOMES
G.J. GARDNER TAREE
I & C Homes Pty Ltd
A.B.N: 20 615 605 920 License: 309023C
63 Muldoon Street, Taree NSW, 2430
P: (02) 6500 4656 W: www.gjgardner.com.au
E: taree@gjgardner.com.au

CULBURRA 255
HAMPTONS

TONY JAMES DESIGN PTY LTD
A.B.N: 96 486 946 536
Q.B.C.C License: 10632`7
V.B.A License: DP-AD-44789
M: 0412 832 646
P: (07) 5665 9230
E: anthony@tonyjames.com.au
W: www.tonyjames.com.au

CLIENT: STEVE 7 MUNUELA QUIRK

DRAWING TITLE: SITE PLAN

PROJECT: PROPOSED NEW RESIDENCE
LOT 48 DP 883373
43 SAPHIRE PARADE
DIAMOND BEACH NSW 2430

PAGES: 02 OF 13 | SHEET SIZE: A3
JOB NO:
DRAWN: TJ
DATE: 21/01/2025

FLOOR AREAS:	
LEVEL ONE	114.46 m²
GROUND FLOOR	82.24 m²
GARAGE	44.00 m²
BALCONY	24.25 m²
PORCH	5.96 m²
	270.91 m²

REV:	DETAILS:	DATE:
1	PRELIMINARY ISSUE	21/01/2025

0401 327 746
319 Valla Road, Valla NSW 2448
alex.matthew@unidrill.com.au

319 Valla Road, Valla NSW 2448	P: 0401327746 F:
43 Sapphire Dr	
Client No:	Job No: 1003202543SAPPHIREDR-01
Client: GJ GARDNER HOMES -TAREE	
Project: Limited site investigation for a proposed new home	
Address: no.43 Sapphire Parade, Diamond Beach NSW	

Legend:

Borehole Locations

Image Source: NearMap		Viewed: 2025-03-12	
Drawn By: AM	Checked By: AM	Date: 2025-03-12	Figure: 1

Foundation Maintenance and Footing Performance: A Homeowner's Guide

PUBLISHING

BTF 18-2011 replaces Information Sheet 10/91

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

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

Soil Types

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

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870-2011, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

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

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

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

Erosion

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

Saturation

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

Seasonal swelling and shrinkage of soil

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

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

Shear failure

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

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes

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

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

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

Unevenness of Movement

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

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

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

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

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

Effects of Uneven Soil Movement on Structures

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

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

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

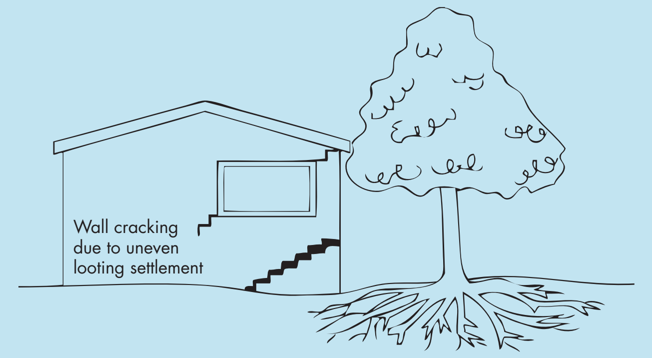
Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends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

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

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

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

Trees can cause shrinkage and damage



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

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

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

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

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

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

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

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

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

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

Effects on framed structures

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

Effects on brick veneer structures

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

Water Service and Drainage

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

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

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

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

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

Ground drainage

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

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

Protection of the building perimeter

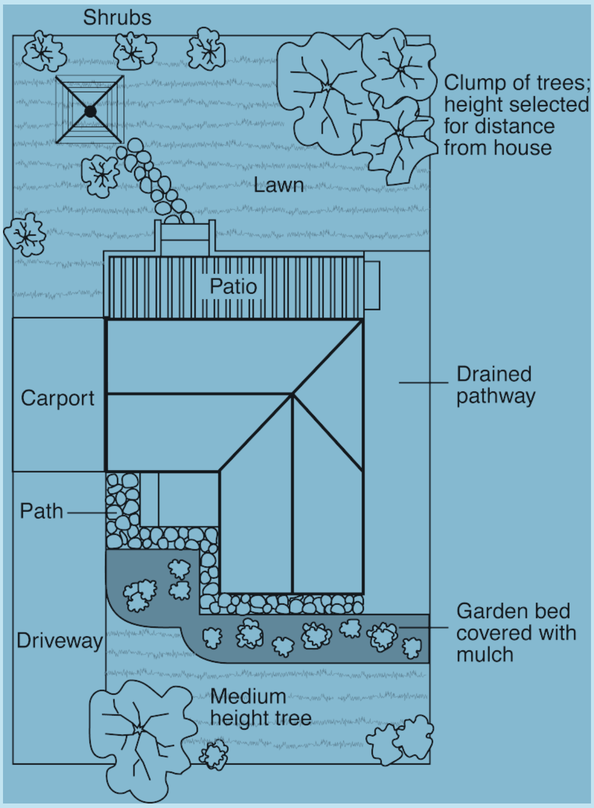
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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

Distributed by

CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia

Tel (03) 9662 7666 Fax (03) 9662 7555 www.publish.csiro.au

Email: publishing.sales@csiro.au

UNIVERSAL DRILLING
319 Valla Road, Valla NSW 2448
ABN: 24 661 315 037
MB: 0401 327 746

Limitations within a Geotechnical Assessment and Report

Geotechnical Assessment is based extensively on the judgement and opinion of the Geotechnical Authority who relies to a large extent on previous experience in similar field conditions to make his assessment. It is far less exact than other engineering disciplines and geotechnical reports are tailored to the specific needs of each client. A report prepared for a consulting Civil Engineer may not be adequate for a Construction Contractor or even for some other consulting Engineers.
This report was prepared expressly for the Client and for the purposes intended by the Client. It should not be used for other purposes without specific technical advice.

The Report is for the benefit of the Client and no other party. Universal Drilling assumes no responsibility and will not be liable to any other person for any matter dealt with or any conclusions expressed within the report or for any omissions or negligent act of Universal Drilling or for any loss or damage suffered by any other party relying on matters dealt with or conclusions expressed in the report. Other parties should not rely upon the report or the accuracy and completeness of its conclusions and should make their own enquiries and obtain independent advice where necessary.

Scope of Service: This Geotechnical Limited Site Assessment has been prepared in accordance with the scope of services set out in the proposal or as otherwise agreed between the Client and Universal Drilling.

Reliance on Data: In preparing Assessment, Universal Drilling has relied upon the data referred to in this report; except where otherwise stated, Universal Drilling has not verified the accuracy or completeness of the data, statements, opinions and facts supplied by others in reaching its findings and conclusions in the report. Universal Drilling will not be liable in relation to incorrect conclusions should any data or condition be incorrect or have been concealed, withheld, or otherwise not fully disclosed to Universal Drilling.