Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on Geotechnical Assessment

Dalwood Home Site
21 Dalwood Avenue, Seaforth

Prepared for
NSW Ministry of Health

Project 73029.01
May 2019

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	73029.01	Document No.	R.001.Rev2
Document title	Report on Geotechnical Assessment Dalwood Home Site		
Site address	21 Dalwood Avenue, Seaforth		
Report prepared for	NSW Ministry of Health		
File name	73029.01.R.001.Rev2		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Rev0	Delfa Sarabia	Geoff Young	8 May 2019
Rev1	Delfa Sarabia	Geoff Young	16 May 2019
Rev2	Delfa Sarabia	Geoff Young	20 May 2019

Distribution of copies

Status	Electronic	Paper	Issued to
Rev0	1	0	Josh Owen, APP
Rev1	1	0	Josh Owen, APP
Rev2	1	0	Josh Owen, APP

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

	Signature	Date
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Reviewer		20 May 2019

bsi. ISO 9001 Quality Management
FS 604853

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Douglas Partners
Geotechnics / Environment / Groundwater

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Report on Geotechnical Assessment
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1. Introduction

This report details the results of a desktop geotechnical study for a proposed strategic site utilisation of the Dalwood Site at Dalwood Avenue, Seaforth. The assessment is to assist in determining long term health needs, how they are to be accommodated and potentially expanded and to identify opportunities to dispose land surplus to health and community needs. The assessment was commissioned by APP on behalf of NSW Ministry of Health (Health) and carried out in accordance with Douglas Partners Pty Ltd (DP) proposal Ref: SYD190271.P.001.Rev0 dated 12 March 2019.

A previous report was originally prepared in 2012 for the Master Plan being considered at that time. Recently, the Master Plan has been updated to consider a rezoning of land from SP2 – Infrastructure and E2 Environmental Conservation Zone to R2 Low Density Residential Development Zone for future residential purposes and E4 Environmental Living (the Proposal).

This updated assessment has been carried out to provide preliminary geotechnical information for the Proposal.

Douglas Partners has carried out a number of geotechnical investigations in the general area and the information from these investigations has been used to prepare this assessment. Intrusive geotechnical investigation for the proposed redevelopment of the site has not been carried out for the present report but is considered necessary to determine actual subsurface conditions and properties for future detailed design purposes.

2. Site Description

The Dalwood Home site is located on the western side of Dalwood Avenue, Seaforth between Callicoma Road and Gurney Crescent mainly within a residential area as shown in Figure 1. The site is an irregular shaped area of 3.7 ha, measuring approximately 250 m long and about 150 m wide located on the end of an east west trending ridge. The ridge enters the site from the east at about RL 99 m and extends across the centre of the site. Surface levels fall from the ridge to the north, west and south with the lowest point being the south-western corner at RL 68 m.

A portion of the site contains a range of historic and newer buildings and are used for health and community purposes. The remainder of the site has been landscaped with some open areas or is heavily vegetated.

A 2012 survey plan and the Proposal have been used in preparing the drawings for this report and are included in Appendix B as Drawings 1 and 6. The 2012 survey plan in Drawing 1 does not include the changes to the site to date which include carpark to the northeast of Building D, the new Building G, the renovated Building C and additional structures at Building F. Figure 1 below is the latest satellite image

of the site.

Figure 1: Site Setting (Reference: Nearmap image dated 4 March 2019)

The area to the south east corner of the site is the area subject to rezoning as shown on Figure 1 above.

3. Geological Setting

The site is mapped on the Sydney 1:100,000 Series Geological Sheet which indicates that it is underlain by Hawkesbury Sandstone which typically comprises medium to coarse grained quartz sandstone with very minor shale and laminite bands. An excerpt from the Geological Series sheet is shown on Drawing 2 in Appendix B.

The Soil Conservation Service of NSW Soil Landscape Series Sheet for Sydney indicates that the site is underlain by Lambert soil landscape group. Drawing 3 in Appendix B reproduces the relevant section of the Soil Landscape Series Sheet. The Lambert landscape is described as undulating to rolling low hills on Hawkesbury Sandstone with slopes of less than 20% and local relief of 20 – 120 m. The soils on the crests of this soil landscape unit are described as comprising leached sands, grey earths and gleyed podzolic soils. Limitations to development include high soil erosion, rock outcrops, seasonally perched water tables, shallow high permeable soils and very low soil fertility.

4. Observations

A walkover of the site was carried out on 22 November 2012 and recently on 21 March 2019. Some of the features noted are listed below, with photos in Appendix C:

- There are several buildings constructed on the flatter areas of the site which are mainly located on the top of the ridge toward the eastern extremity of the site. Immediate areas around the buildings have generally been improved with landscaping and pavements which have covered the natural features of the area. Refer to Figure 1 on page 2.
- There are several sandstone outcrops on the site including:
  - a 6 m high cliff at the back of the Dalwood Home building which extends to Dalwood Avenue at the eastern end of the site (see Photo 1 in Appendix C);
  - at the back of the Family Care Centre in a small cutting (Photo 2);
  - a flat vegetated area at the western end of the site (Photo 3);
  - a cliff at the western end of the site (Photo 4); and
  - possibly more cliffs in the heavily vegetated section of the south-western corner of the site.
- Filling has been used to provide or expand relatively level areas. Such locations include the area behind Dalwood Home on top of the cliff where there is a crib wall behind crib wall in Photo 1, the open lawn area towards the northern boundary (near Photo 5), and the area south of the Family Care Centre (Photo 6).
- Associated with some filled areas are relatively steep slopes on the edge of the filling. These include the area south of the Family Care Centre and the filling near the northern boundary.
- In the steep slope in filling near the Family Care Centre, a landslide had occurred leaving a severely disturbed scar (Photo 7).
- The western and much of the southern portions of the site have been left undeveloped and are generally covered in heavy vegetation on flat to moderate slopes (Photo 8).
- A sandstone block building (Building F on Drawing 1) has some cracking which is considered to be due to differential settlement of the footings which are probably not on rock.
- The 21 March 2019 site visit was carried out to observe the areas to the north of Buildings D, F and G and the “surplus lands” located to the south of the site. The site features described above are generally unchanged except for a new carpark located to the northeast of Building D and a new Building G located to the east of the new carpark. (see Photo 9 in Appendix C). Heavy vegetation was observed in the surplus lands with rock outcrops visible from the road (see Photo 10 in Appendix C).

Some of the features mentioned above are marked on Drawing 4 in Appendix B.

5. Proposed Development

The planning proposal is for an amendment to Manly Local Environmental Plan 2013 on behalf of NSW Ministry of Health. It seeks to rezone Lots 4A, 5A, 6A and 7A in DP 17157, Part of Lot 1 in DP 325720 and Part of Lot 1 in DP 325784 from part SP2 Infrastructure (Health Services Facilities) and part E2 Environmental Conservation to part R2 Low Density Residential and part E4 Environmental Living. The rezoning will accommodate the future establishment of four dwellings on each of the lots.

The planning proposal is supported by a Concept Layout Plan (CLP) which demonstrates a boundary adjustment between Lot 7A DP 17157, Lot 1 DP 325720 and Lot 1 DP 325784 to expand Lot 7A. The CLP shows the future indicative locations for each of the four dwellings, as shown on Figure 2 below.

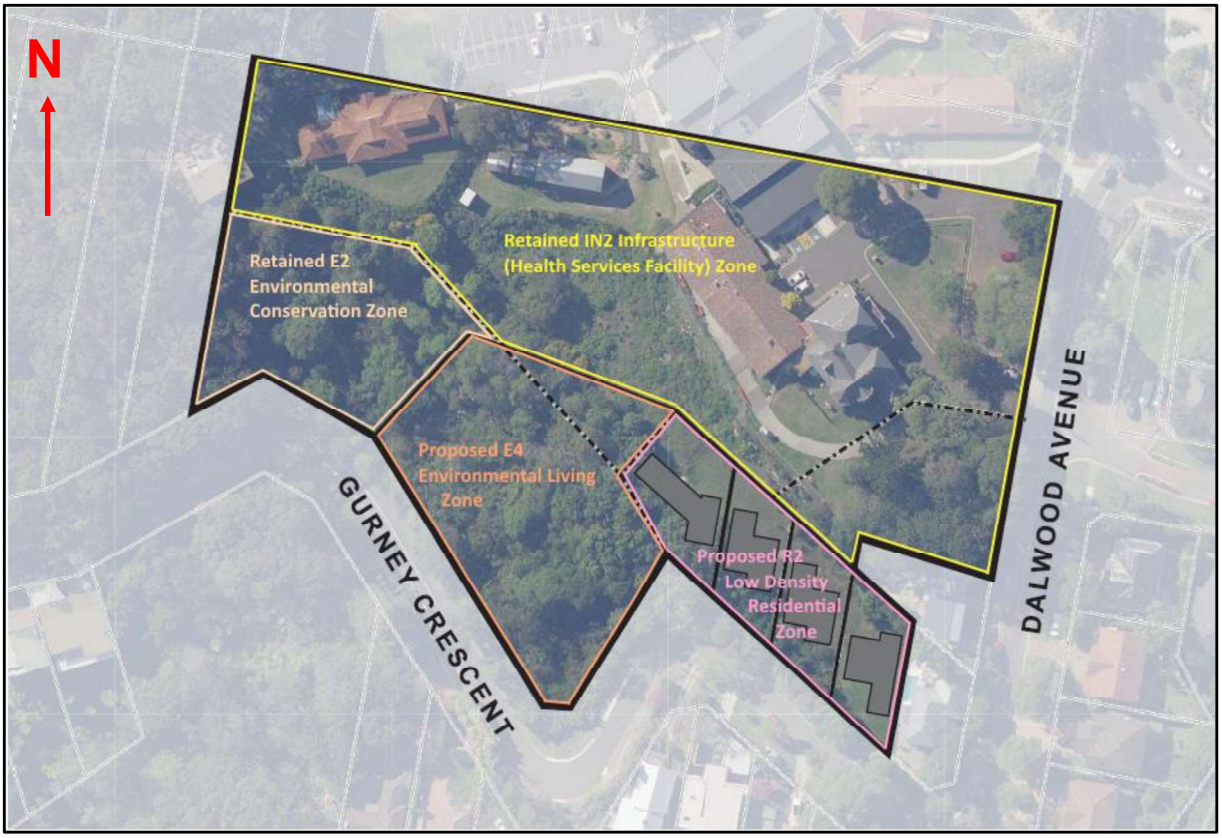


Figure 2: Concept Layout Plan

6. Comments

6.1 General

This assessment indicates that there are no serious geotechnical constraints on the site development. Relatively straight forward techniques can be adopted but each individual structure will require a site-specific investigation so that all the constraints are recognised and dealt with in the final design.

The purpose of this present assessment is to provide information for the development of the proposed CLP. The following comments are based on a site inspection and desktop review of available information. Therefore, they are preliminary in nature and intended as a guide to geotechnical constraints associated with future development at the site.

For detailed design, comprehensive geotechnical investigations should be undertaken to provide information on the subsurface profile in order to more accurately determine design issues and parameters for specific locations and structures.

6.2 Geological Model

The Hawkesbury Sandstone profile generally comprises residual sandy clay or clayey sand over shallow sandstone generally within a few metres of the surface. Sandstone is expected to be found over the entire site and is exposed at the surface in some locations.

Hawkesbury sandstone tends to weather and erode in blocks leaving benches and near vertical cliffs. Over time, slope debris including soil and rock boulders, often known as talus, collects on the benches and forms slopes between the vertical cliffs. The western quarter of the site, which is heavily vegetated, is considered to be an area of small cliffs and talus.

There are some areas of filling on the site generally associated with previous development and some of them are shown on Drawing 4. There are also three cross sections of the site showing the surface levels which are reproduced in Drawing 6.

6.3 Slope Stability

The areas earmarked for residential development in the CLP is generally located on the flatter areas of the site. Slope stability should not be a major issue and should be adequately addressed by batters and engineering designed retaining walls. Individual slope stability assessments can be carried out at specific locations on request and any slope stability issues would be addressed during the geotechnical investigation for site specific developments.

6.4 Site Preparation

Due to the relatively flat areas proposed to be redeveloped for residential dwellings, it is anticipated that only minor cutting and filling will be used to form level working benches for development of the site. In addition, there may be some excavation for basements. Interpolation of existing information suggests that sandy clay/clayey sand may be encountered within the first 1 – 2 m of excavation, however deeper excavation may encounter sandstone. This must be confirmed by drilling and testing during the geotechnical investigation stage for detailed design purposes. The clays should be readily removed using excavators and the rock will probably need large rippers and possibly rock breakers to remove.

Subject to review on site, it is expected that excavated material from site could generally be reused as filling. Filling should be placed in layers and compacted in accordance with AS 3798-2007 “Guidelines on earthworks for commercial and residential developments”. Filling should only be placed on areas which have been suitably prepared by removing any vegetation, organic topsoils and other unsuitable

material and providing relatively level benched areas.

Batters may be required on the site and these should generally be no steeper than 2H:1V in soil and very low to low strength rock. Steeper batters may be feasible in rock, however all batters should be reassessed when the layout is finalised. Where there is inadequate space for batters, retaining walls will be required and these should be designed by an engineer taking into account the slope behind the wall and any surcharge loading.

The groundwater table is not expected to be encountered within the area of proposed redevelopment, however some water seepage out of slopes should be expected especially after periods of rain. Adequate surface and subsoil drainage will have to be provided to prevent accumulation of water on the surface and water logging.

6.5 Retaining Walls

If retaining walls are to be used on site, each case should be individually assessed. For relatively low walls, say up to 4 m high, cantilever walls may be possible where some movement of the wall and material behind the wall can be tolerated. Earth pressures acting on the cantilevered free-draining retaining walls can be calculated using a triangular pressure distribution based on an earth pressure coefficient of 0.3 for a level surface behind the wall and using an average bulk unit weight of 20 kN/m^3 for the filling and soil.

Different type retaining walls types such as crib walls or reinforced soil walls may be required for higher walls and these can be individually assessed for each slope as required.

6.6 Foundations

It is generally preferable to found footings on the same bearing stratum to reduce differential settlements. Due to the anticipated shallow depth to rock over most of the areas proposed to be developed, it is suggested that all major structures are founded on rock. Footing types could comprise shallow pad, strip or raft footings. Where the depth to rock increases bored piers or a combination of shallow and deeper footings could be adopted. It is expected that the majority of the rock on site will accommodate allowable bearing pressures well in excess of 1500 kPa.

6.7 Residential Blocks

The CLP identifies lots within the site which are proposed to be developed for residential purposes. There are four lots on the southern side accessed from Gurney Crescent which are proposed to accommodate future dwellings, see Figure 3 below.

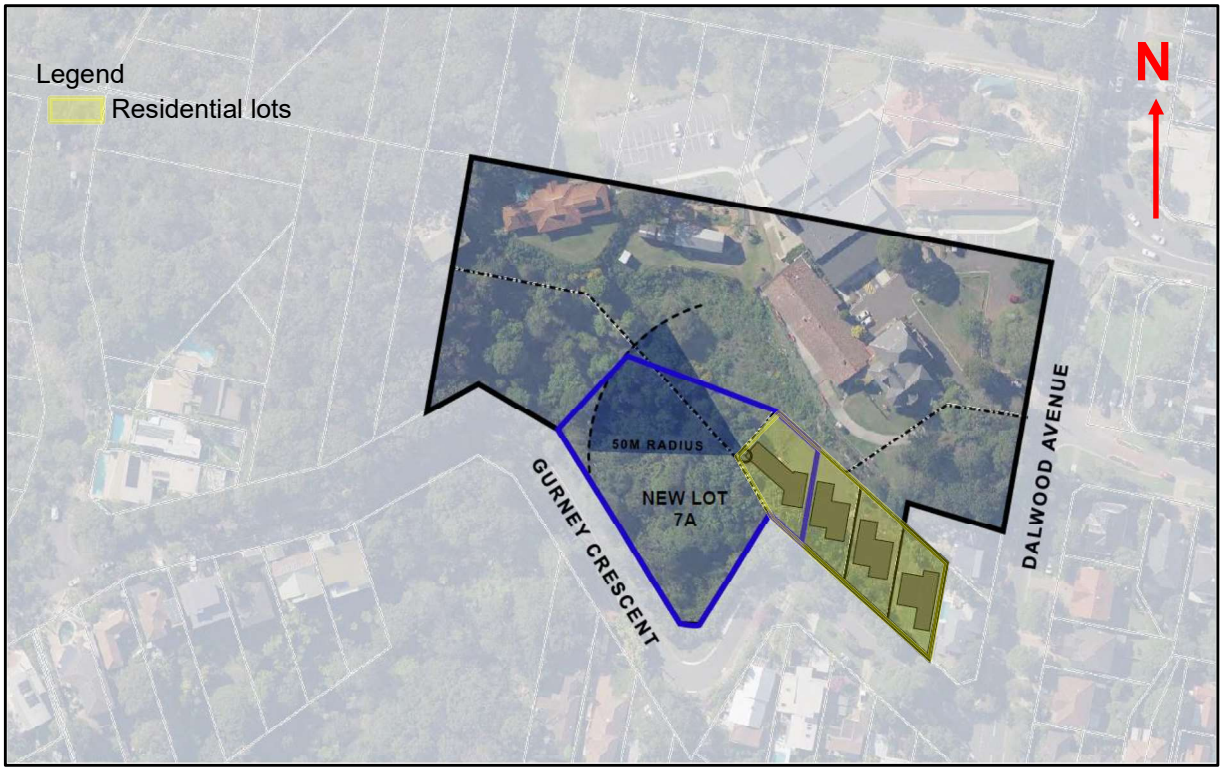


Figure 3: Residential Lots

These lots on the southern side are located on a rock ledge at the base of a sandstone cliff. Rock is expected to be close to the surface which is considered good founding conditions, but hard excavation conditions for installing underground services and levelling the ground surface. In terms of "AS 2870 Residential Slabs and Footings", the individual lots would probably have a site classification of Class A due to the presence of rock close to the surface.

6.8 Further Investigation

Intrusive geotechnical investigation for the proposed development site has not been carried out for this report but is considered necessary to determine actual subsurface conditions and soil properties when development details are further advanced and prior to detailed design (i.e. as part of a DA for future dwellings).

7. Conclusions

Based on DP site observations, preliminary geotechnical model, and experience on similar projects, the proposed residential lots at the south east corner of the site is considered feasible from a geotechnical perspective provided that appropriate additional site investigation is carried out to provide the information necessary for detailed design purposes.

8. Limitations

DP has prepared this report of the Dalwood Site in accordance with DP's proposal dated 12 March 2019. The report is provided for the exclusive use of NSW Ministry of Health for this project only and for the purpose(s) described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the surface conditions only at the specific observation locations and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field work has been completed.

DP's advice is based upon the conditions encountered during this assessment. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

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

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

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

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

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

Copyright

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

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

Information for Contractual Purposes

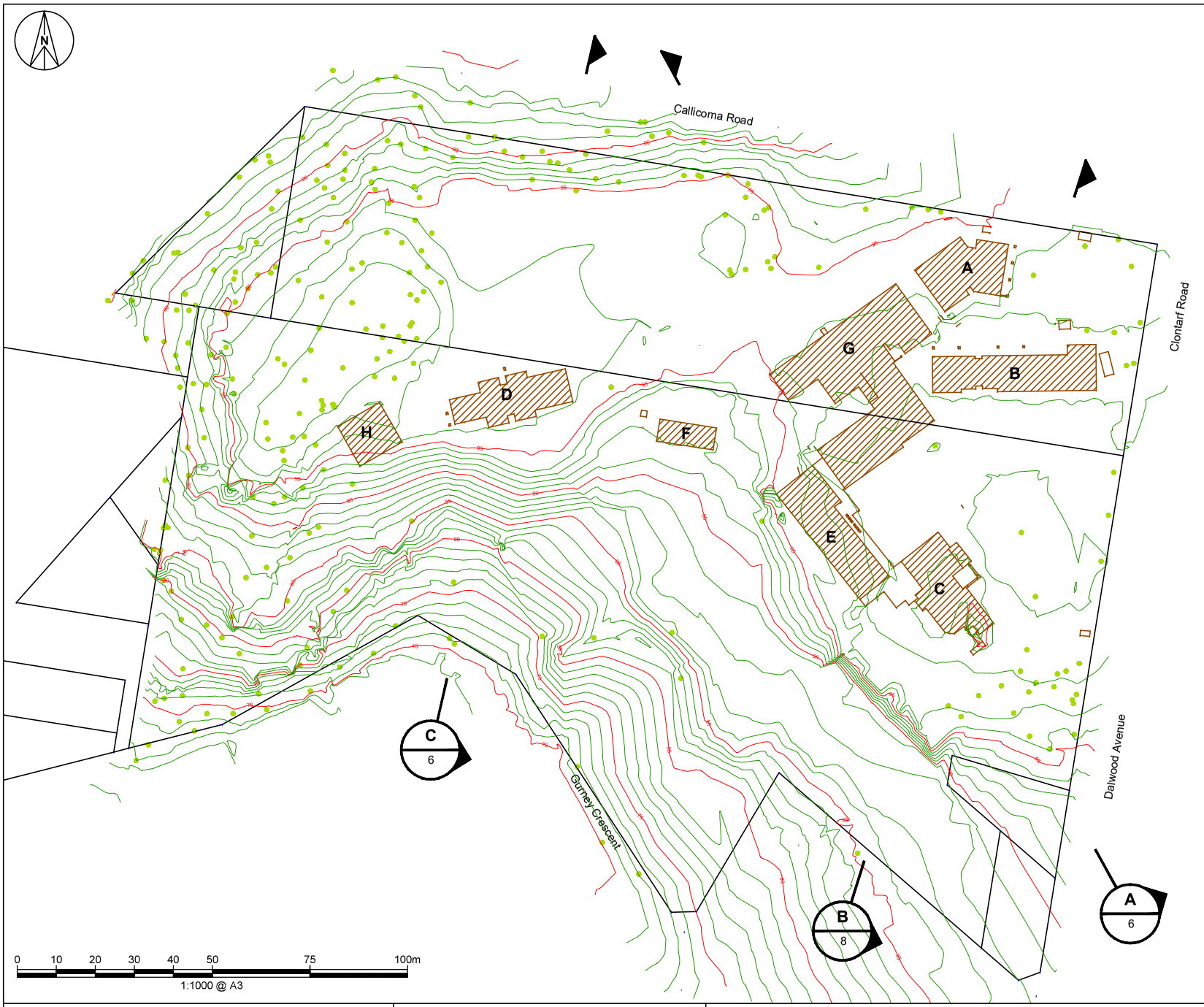
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate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

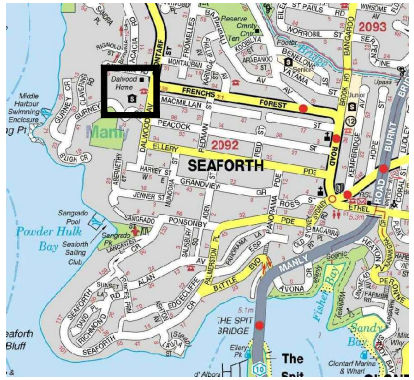
Site Inspection

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

Appendix B

Drawings





Location plan

Legend

- Building
- 95 Existing contour (5m)
- Existing contour (1m)
- Vegetation
- Cadastral
- A / 7 Section location

Buildlings

A. Child Care Centre
B. Spilstead Centre
C. Dalwood Home
D. Family Care Centre
E. Brick Building
F. Store Building
G. Brick Building
H. Shed

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Geotechnics / Environment / Groundwater

CLIENT: NSW Ministry of Health		TITLE: **2012 Site Survey**
OFFICE: Sydney	DRAWN BY: JCP/DS	**Dalwood Site**
SCALE: As shown	DATE: May 2019	**Dalwood Avenue, Seaforth**

PROJECT No:	73029.01
DRAWING No:	1
REVISION:	0

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Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: NSW Ministry of Health	TITLE: **Geology Map** **Dalwood Site** **Dalwood Avenue, Seaforth**	PROJECT No: 73029.01
	OFFICE: Sydney / DRAWN BY: JCP/DS		DRAWING No: 2
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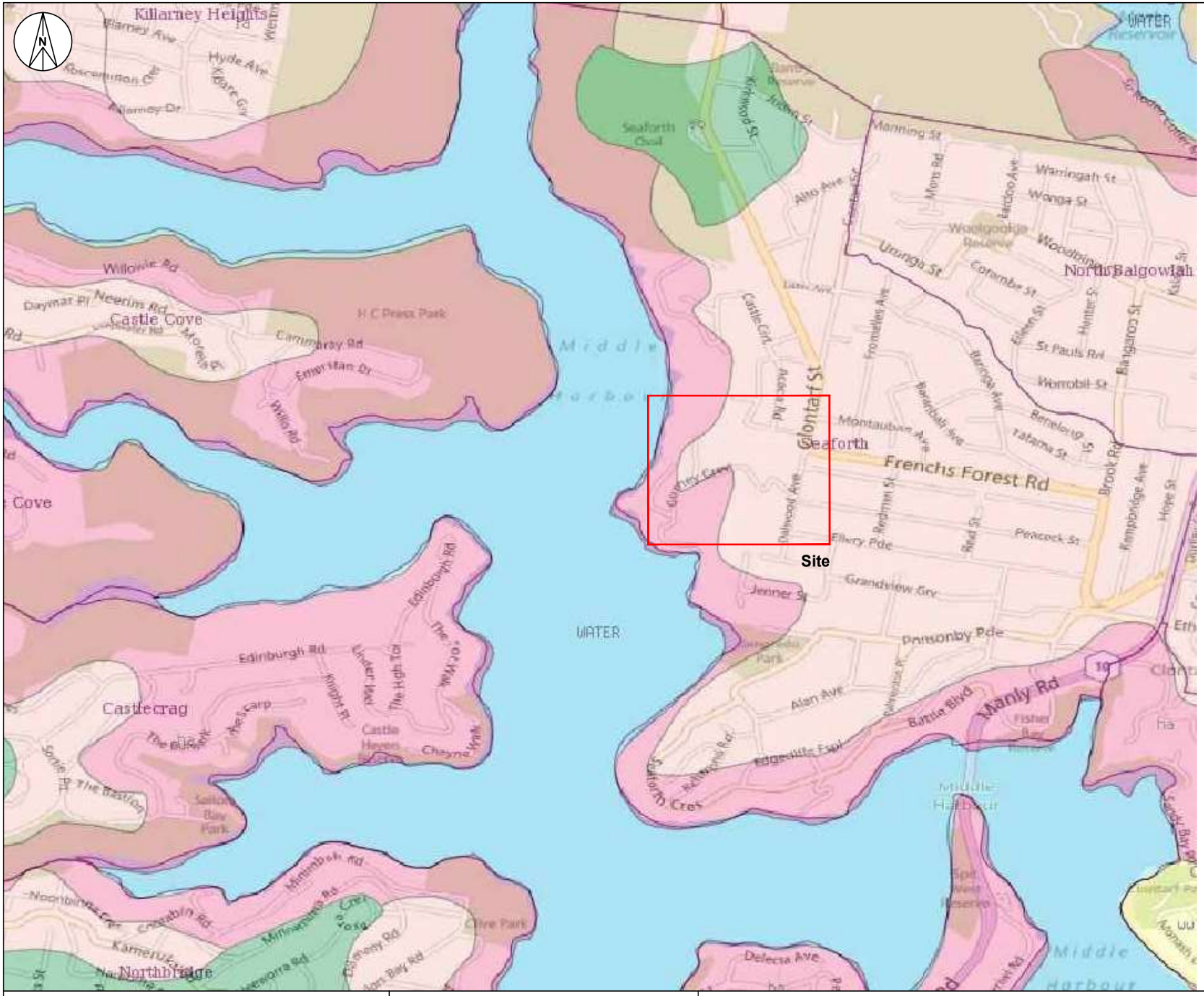

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: NSW Ministry of Health	TITLE: **Soil Landscape Map** **Dalwood Site** **Dalwood Avenue, Seaforth**	PROJECT No: 73029.01
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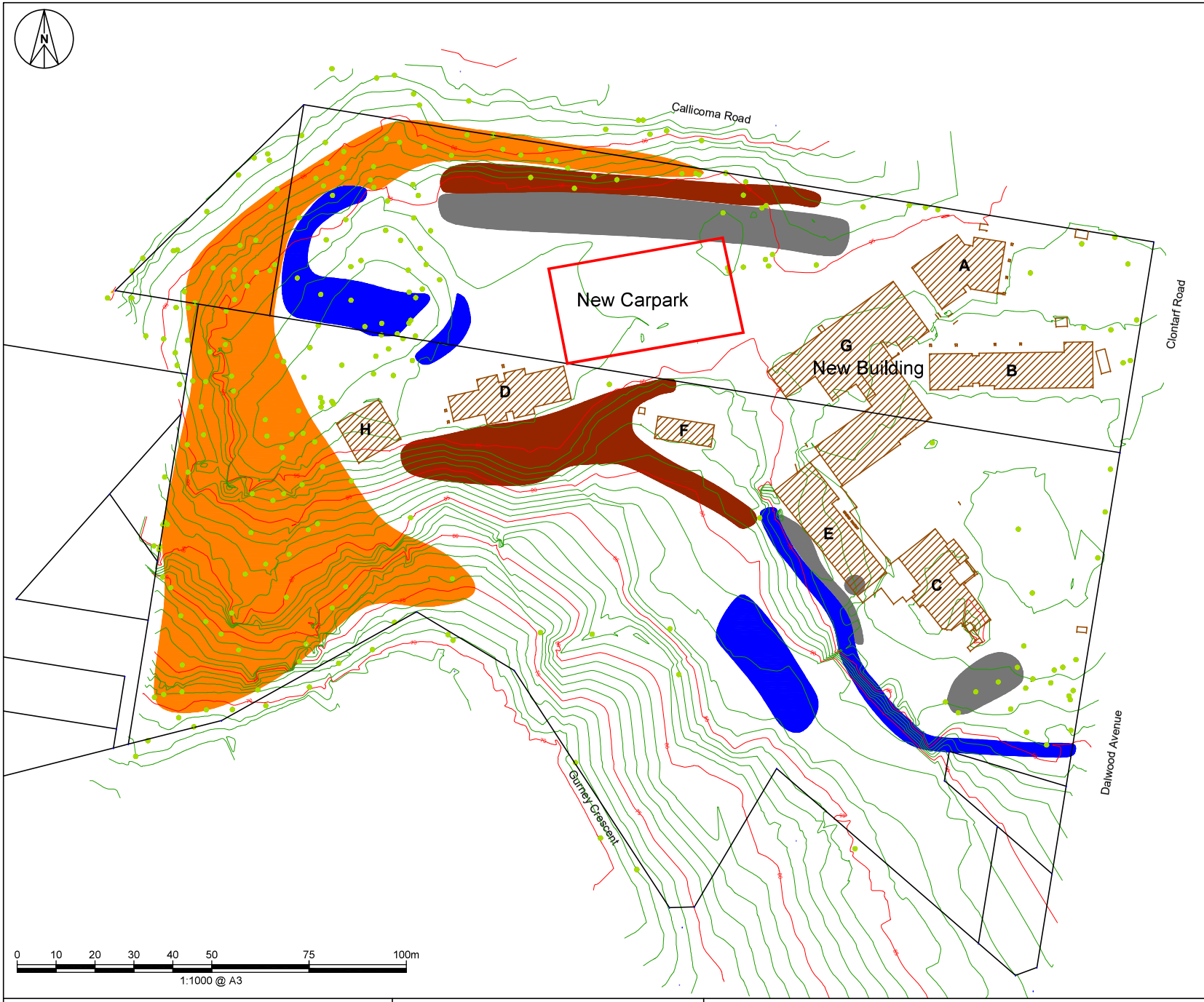

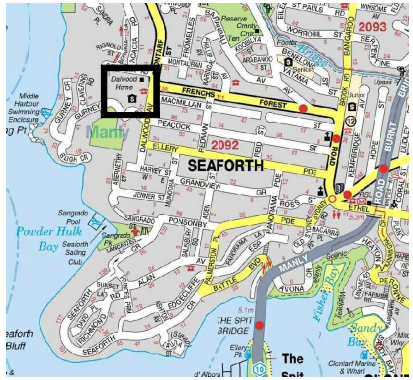

Location plan

Legend

- Building
- 95 Existing contour (5m)
- Existing contour (1m)
- Cadastral
- Outcropping rock
- Filling
- Filling and steep slopes
- Vegetated talus slopes

Buildlings

A. Child Care Centre
B. Spilstead Centre
C. Dalwood Home
D. Family Care Centre
E. Brick Building
F. Store Building
G. Brick Building
H. Shed

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: NSW Ministry of Health		TITLE: **Site Observations**
OFFICE: Sydney	DRAWN BY: JCP/DS	**Dalwood Site**
SCALE: As shown	DATE: May 2019	**Dalwood Avenue, Seaforth**

PROJECT No: 73029.01
DRAWING No: 4
REVISION: 0

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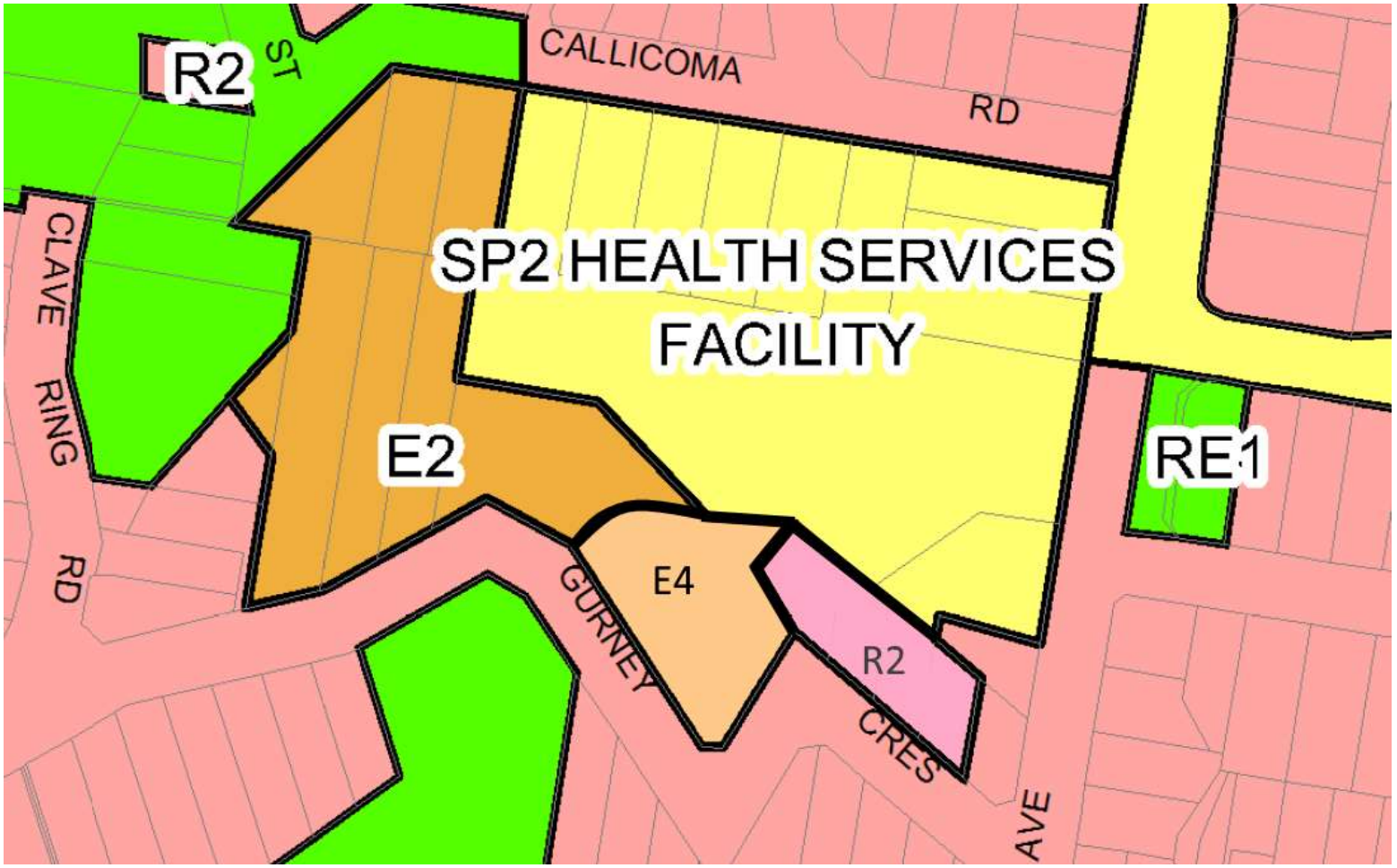

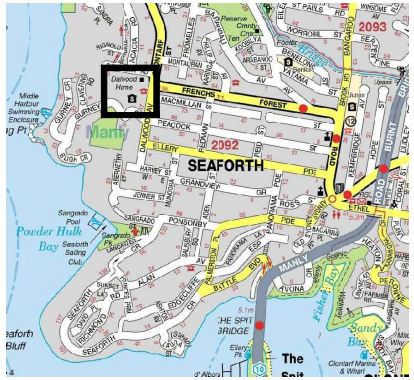

Location plan

LEGEND

Zones
SP2 - Infrastructure
E2 - Environmental Conservation
R2 - Low Density Residential
E4 - Environmental Living

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: NSW Ministry of Health	TITLE: **Latest Master Plan** **Dalwood Site** **Dalwood Avenue, Seaforth**	PROJECT No: 73029.01
	OFFICE: Sydney DRAWN BY: JCP/DS		DRAWING No: 5
	SCALE: As shown DATE: May 2019		REVISION: 0

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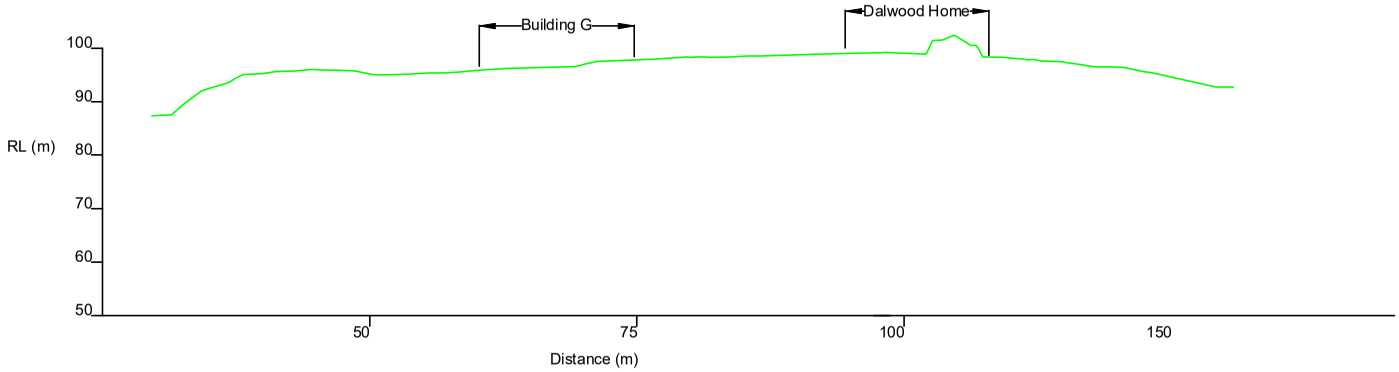
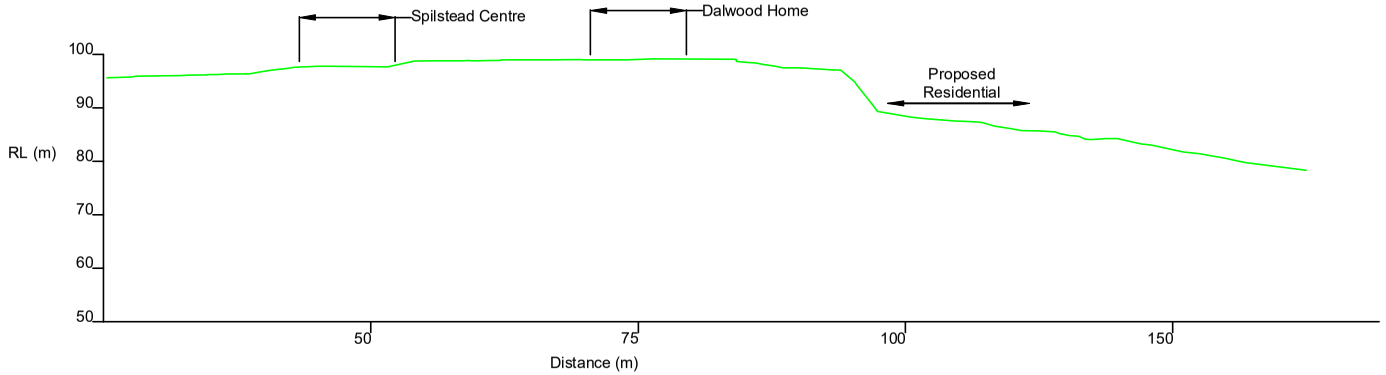
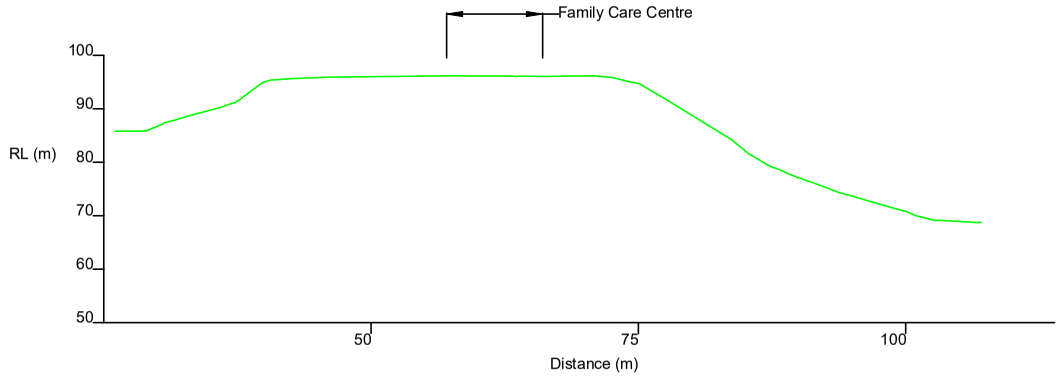


Section A



Section B



Section C

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: NSW Ministry of Health	TITLE: **Sections** **Dalwood Site** **Dalwood Avenue, Seaforth**	PROJECT No: 73029.01
	OFFICE: Sydney / DRAWN BY: JCP/DS		DRAWING No: 6
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Appendix C

Site Photographs

Photo 1 – View of sandstone cliff at back of Dalwood Home

Photo 2 – View of outcropping rock at back of Family Care Building

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs 2012** **Strategic Site Utilisation** **Dalwood Avenue, Seaforth**	PROJECT: 73029 .01 PLATE No: 1 REV: A
	CLIENT: NSW Ministry of Health	DATE: May 2019

Photo 3 – View of outcropping sandstone at western end of site

Photo 4 – View of sandstone cliffs within vegetated area

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs 2012** **Strategic Site Utilisation** **Dalwood Avenue, Seaforth**	PROJECT: 73029 .01 PLATE No: 2 REV: A
	CLIENT: NSW Ministry of Health	DATE: May 2019

Photo 5 – Open lawn near northern boundary

Photo 6 –Filled slope near Family Care Centre

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs 2012** **Strategic Site Utilisation** **Dalwood Avenue, Seaforth**	PROJECT: 73029 .01 PLATE No: 3 REV: A
	CLIENT: NSW Ministry of Health	DATE: May 2019

Photo 7 – Landslide at back of Family Care Centre

Photo 8 –Heavy vegetated natural slope at western end of site

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs 2012** **Strategic Site Utilisation** **Dalwood Avenue, Seaforth**	PROJECT: 73029 .01 PLATE No: 4 REV: A
	CLIENT: NSW Ministry of Health	DATE: May 2019

Photo 9 – New Carpark and New Building G

Photo 10 – Heavy vegetated with sandstone outcrops along Gurney Crescent

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs 2019** **Strategic Site Utilisation** **Dalwood Avenue, Seaforth**	PROJECT: 73029 .01 PLATE No: 5 REV: A
	CLIENT: NSW Ministry of Health	DATE: May 2019

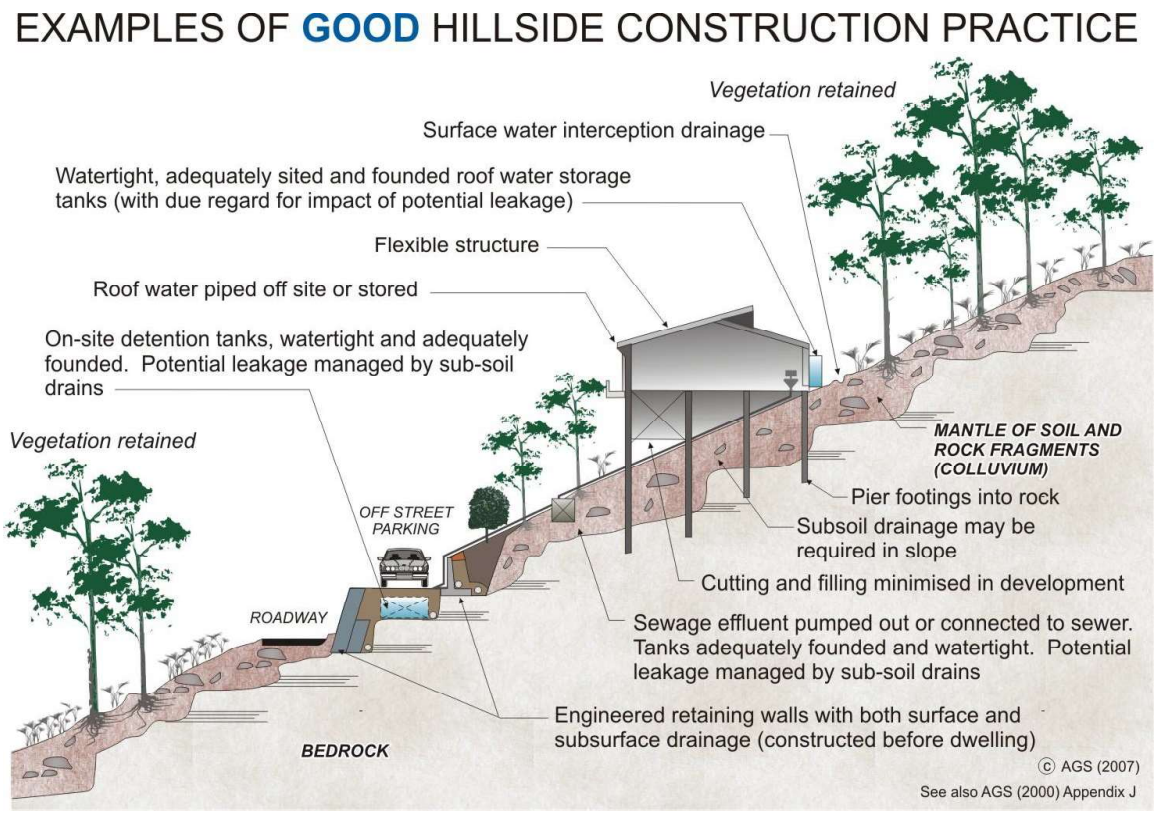
Appendix D

Development Guidelines

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that in level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfil the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

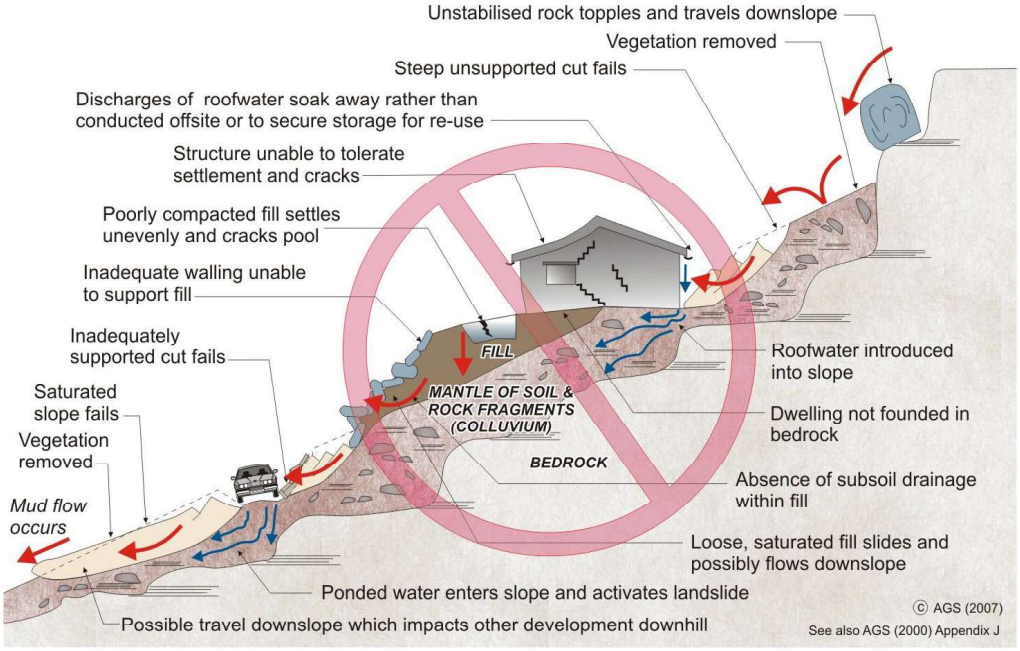
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF **POOR** HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soak into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herring bone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal

GeoGuide LR10 - Coastal Landslides

- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.