DRAWING INDEX DA000

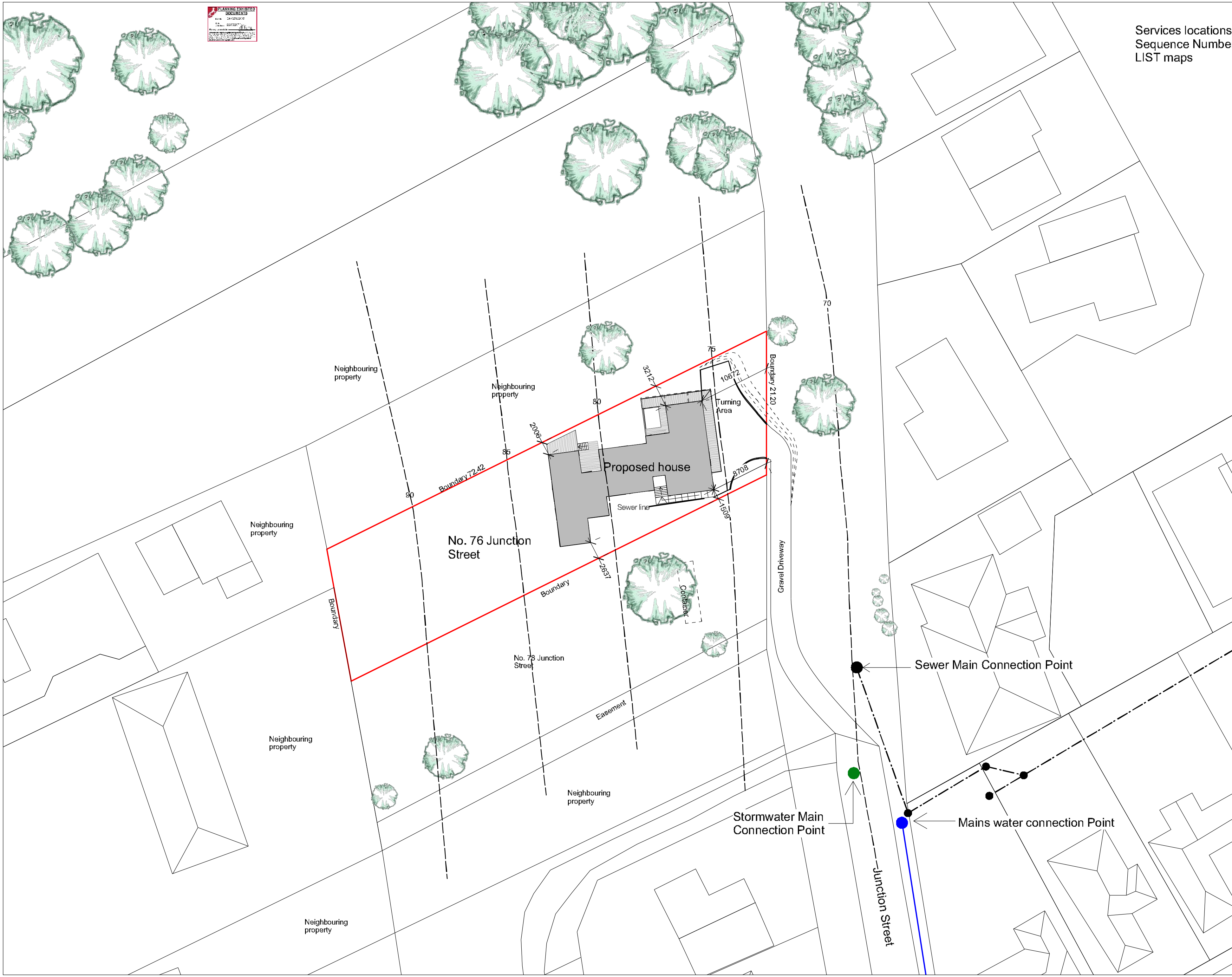
Development Application Set : 02-06-2017

dwg. no.	rev:	dwg. title	date:	by:
DA 000	A	Drawing Index	05-07-2017	PE
DA 101	A	Site Location Plan	05-07-2017	PE
DA 102	A	Site Plan	05-07-2017	PE
DA 103	A	Services Locations	05-07-2017	PE
DA 104	A	Lower Level Plan	05-07-2017	PE
DA 105	A	Stepped Ground Floor Plan	05-07-2017	PE
DA 201	-	Elevations South & West	-	-
DA 202	-	Elevations North & East	-	PE
DA 301	A	Section A-A	05-07-2017	PE

1625 Mah Residence

76 Junction Street,
Newstead
Tasmanina 7250

idw.
architecture + interiors
ACC NO. CC980Y



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DO NOT SCALE OFF DRAWINGS
Report all discrepincies with IDW Architecture + Interiors

NO.	DATE	NOTE
A	5/7/17	Show services connections in street Set back adjustment

Client
Ginny Lim

Address
76 Junction Street
Newstead
Tasmania

Project
Mah Residence

Drawing
Site Location Plan

Dwg No.
DA-101

Scale
1:500 @ A3

Date
02-06-2017

Rev.
A

Job No.
1625

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NO.	DATE	NOTE
A	5/7/17	No build zone adjustment

Client
Ginny Lim

Address
76 Junction Street
Newstead
Tasmania

Project
Mah Residence

Drawing
Site Plan

Dwg No.
DA-102

Scale
1:200 @ A3

Date
02-06-2017

Rev.
A

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1625

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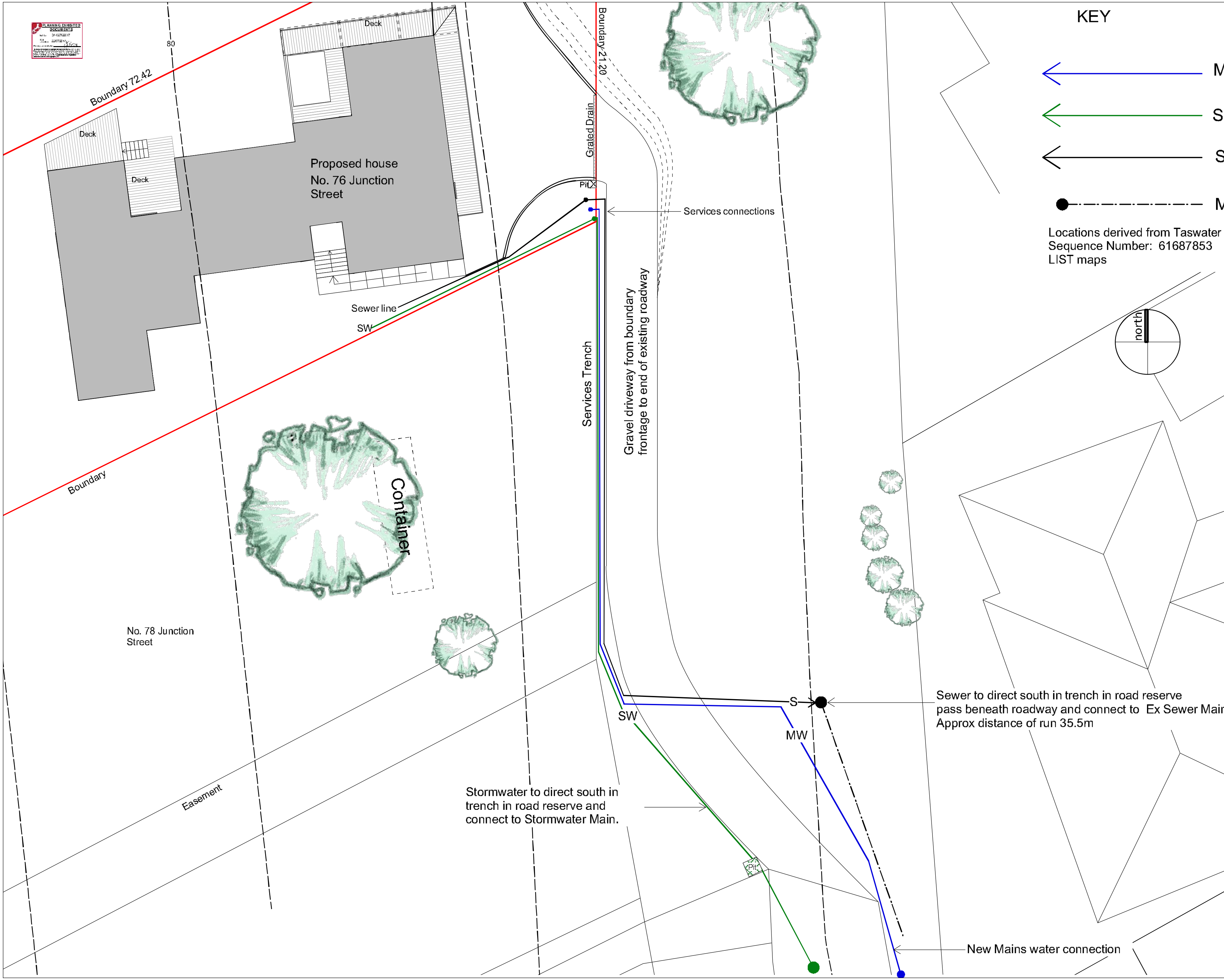

KEY

Mains water (MW)

Storm water (SW)

Sewer(S)

Mains sewer

Locations derived from Taswater plan
Sequence Number: 61687853
LIST maps

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NO.	DATE	NOTE

Client
Ginny Lim

Address
76 Junction Street
Newstead
Tasmania

Project
Mah Residence

Drawing
Services locations

Dwg No.
DA-103

Scale
1:200 @ A3

Date
05-07-2017

Rev.

Job No.
1625

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ACC. Number. CC980Y

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NO.	DATE	NOTE
A	5/7/17	Show driveway gradient and drainage

Client
Ginny Lim

Address
76 Junction Street
Newstead
Tasmania

Project
Mah Residence

Drawing
Lower level plan

Dwg No.
DA-104

Scale
1:100

Date
02-06-2017

Rev.
A

Job No.
1625

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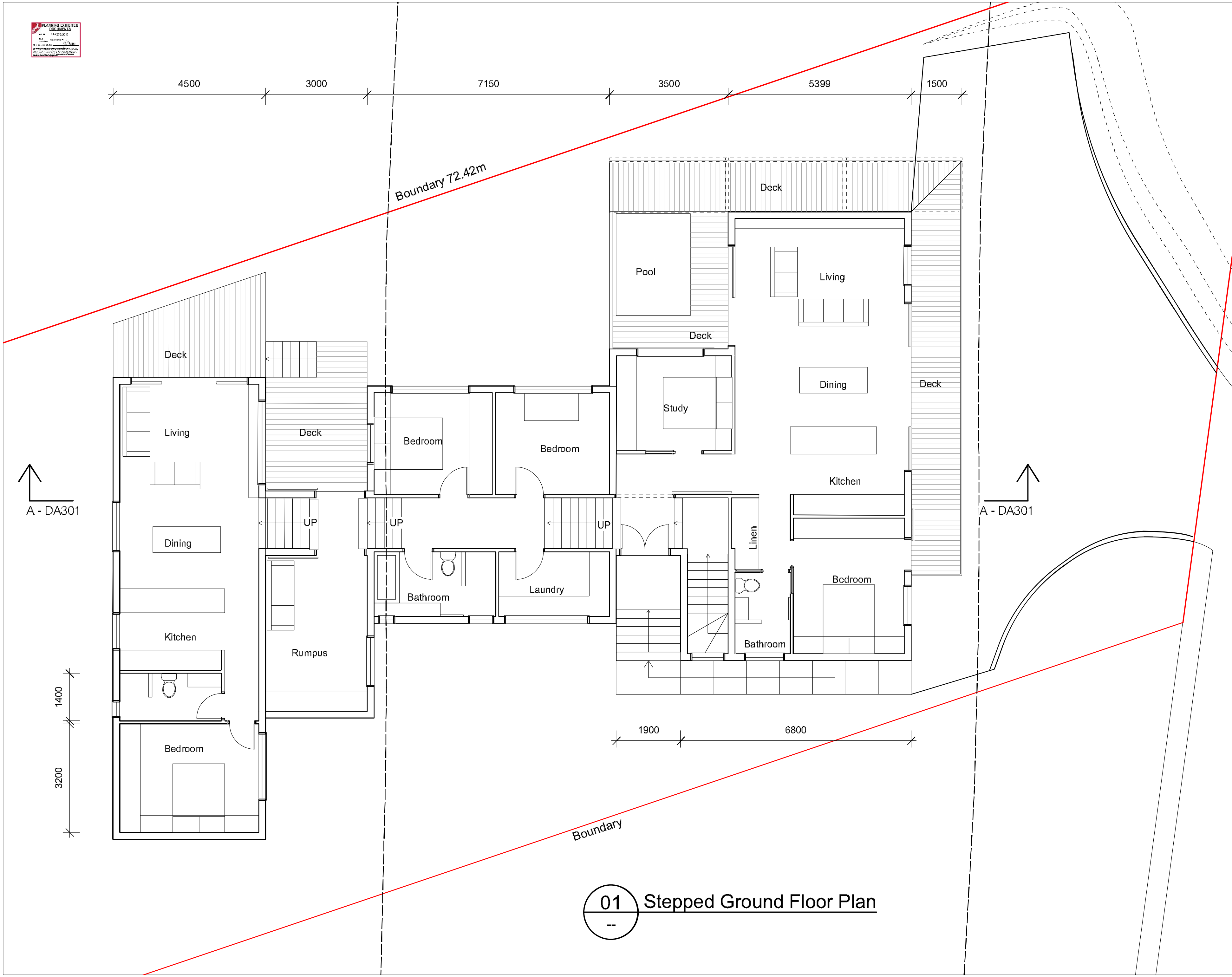

01
--
Stepped Ground Floor Plan

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DO NOT SCALE OFF DRAWINGS
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NO.	DATE	NOTE
A	5/7/17	Balcony extended

Client
Ginny Lim

Address
76 Junction Street
Newstead
Tasmania

Project
Mah Residence

Drawing
Stepped ground floor plan

Dwg No.
DA-105

Scale
1:100

Date
02-06-2017

Rev.
A

Job No.
1625

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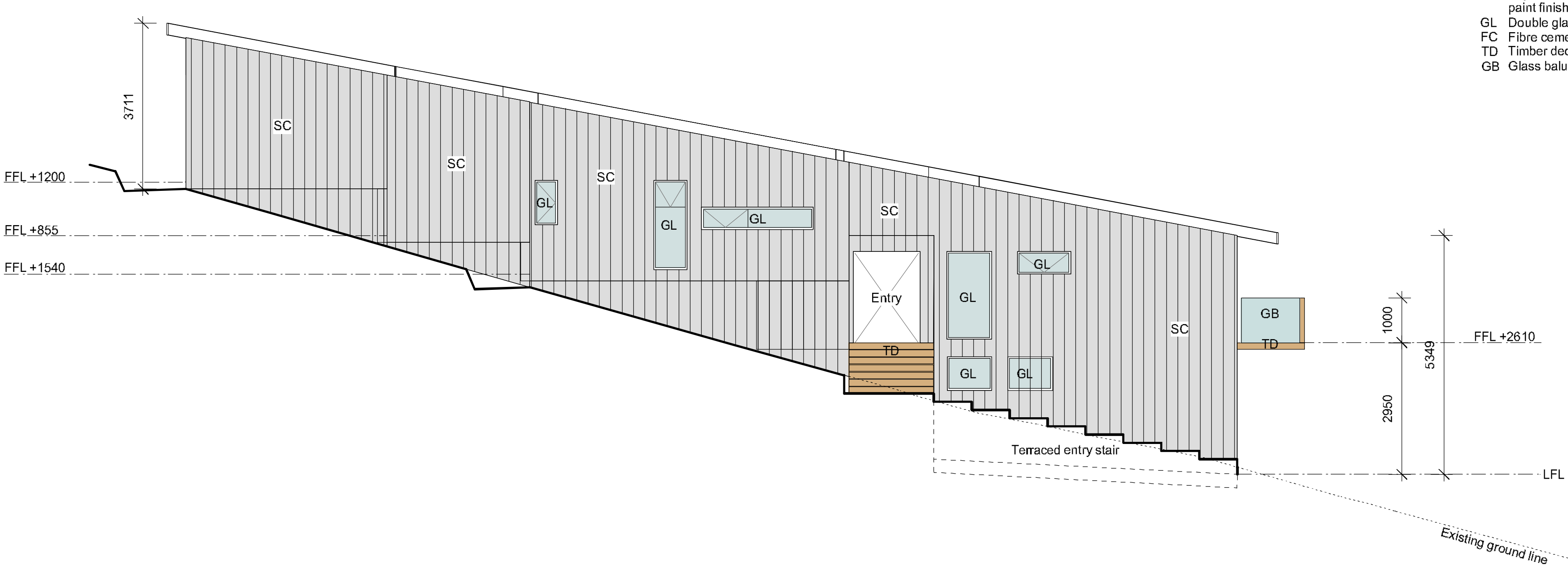

01 Southern Elevation
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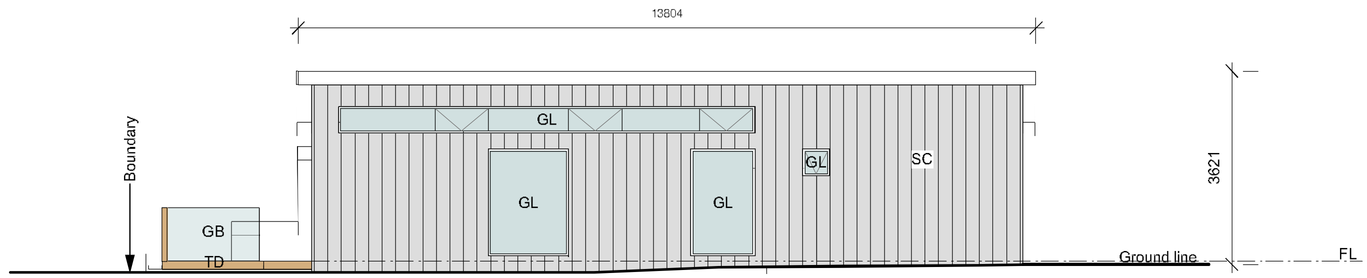

02 Western Elevation
--

Key
Materials

- SC Scyon Axon cladding - smooth 133mm vertical - paint finish colour to be selected
- GL Double glazed window - al frame
- FC Fibre cement sheet - paint finish colour to be selected
- TD Timber decking
- GB Glass balustrade @ 1000H

This drawing is to be read in conjunction with all associated specifications, consultants drawings, geotechnical report and other written instructions

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DO NOT SCALE OFF DRAWINGS
Report all discrepincies with IDW Architecture + Interiors

NO.	DATE	NOTE

Client
Ginny Lim

Address
76 Junction Street
Newstead
Tasmania

Project
Mah Residence

Drawing
Proposed Elevations
South & West

Dwg No.
DA-201

Scale
1:100

Date
02-06-2017

Rev. --
Job No. 1625

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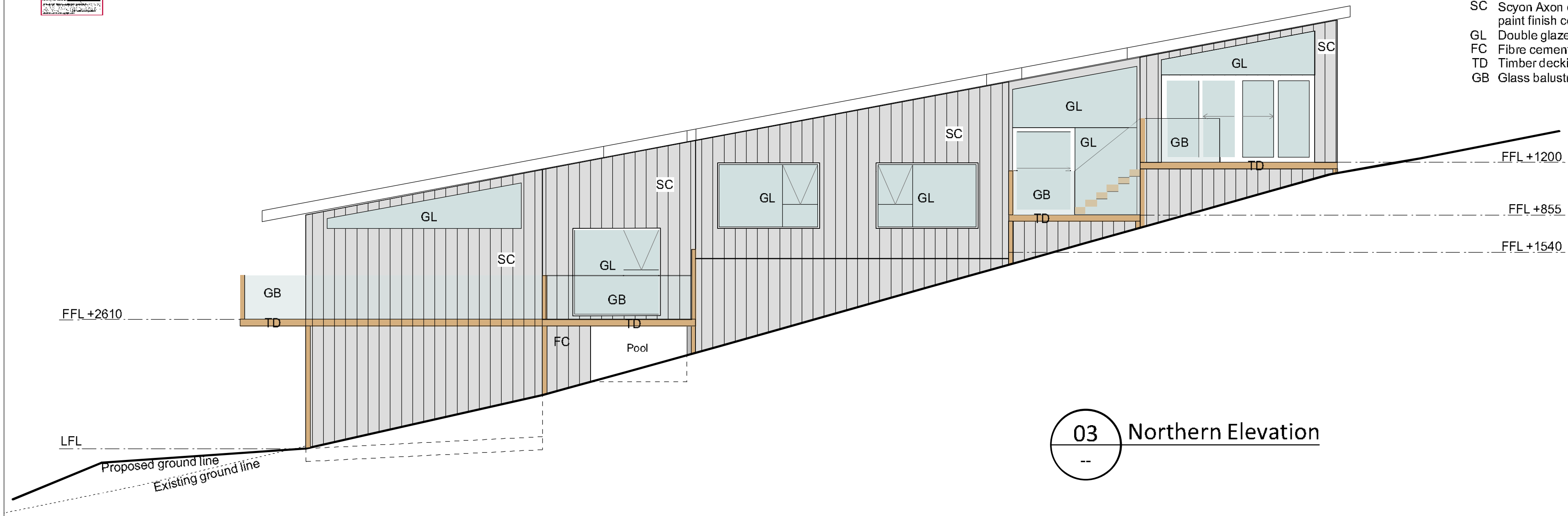
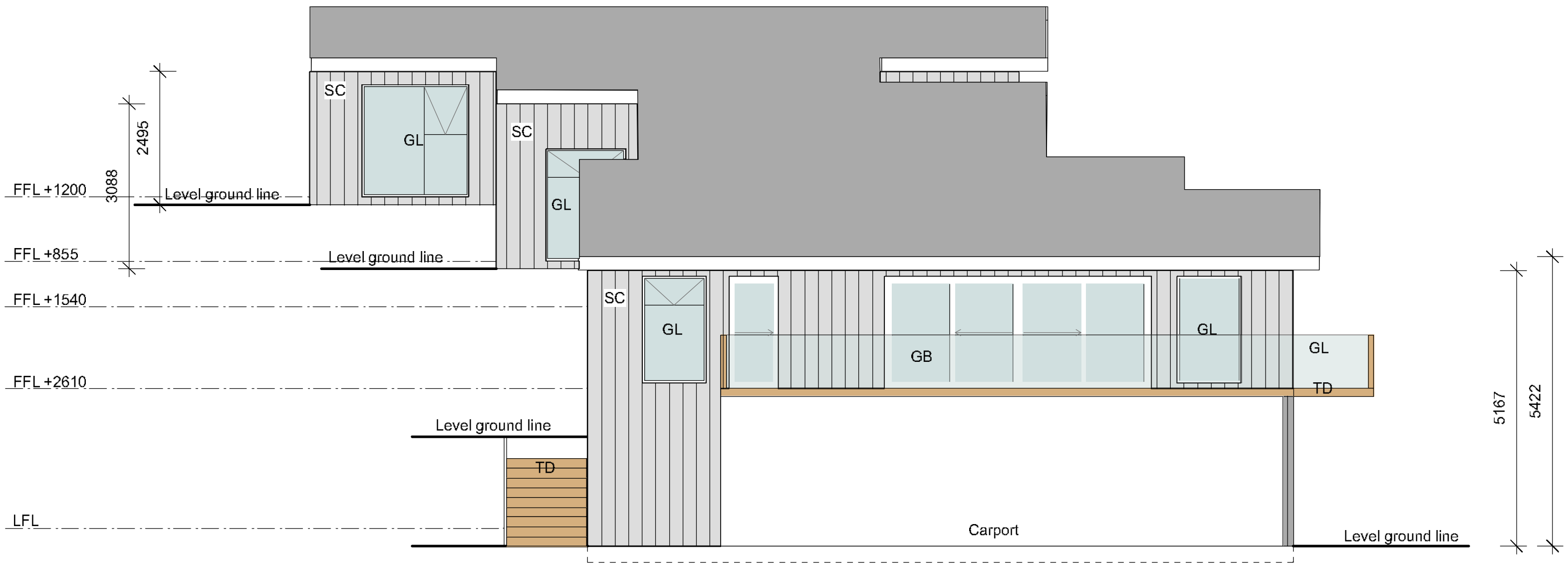


03 -- Northern Elevation



04 -- Eastern Elevation

Key

Materials

SC Scyon Axon cladding - smooth 133mm vertical - paint finish colour to be selected
GL Double glazed window - al frame
FC Fibre cement sheet - paint finish colour to be selected
TD Timber decking
GB Glass balustrade @ 1000H

NO.	DATE	NOTE
A	5/7/17	Extend balcony

Client
Ginny Lim

Address
76 Junction Street
Newstead
Tasmania

Project
Mah Residence

Drawing
Proposed Elevations North & East

Dwg No.
DA-202

Scale
1:100

Date
02-06-2017

Rev.
A

Job No.
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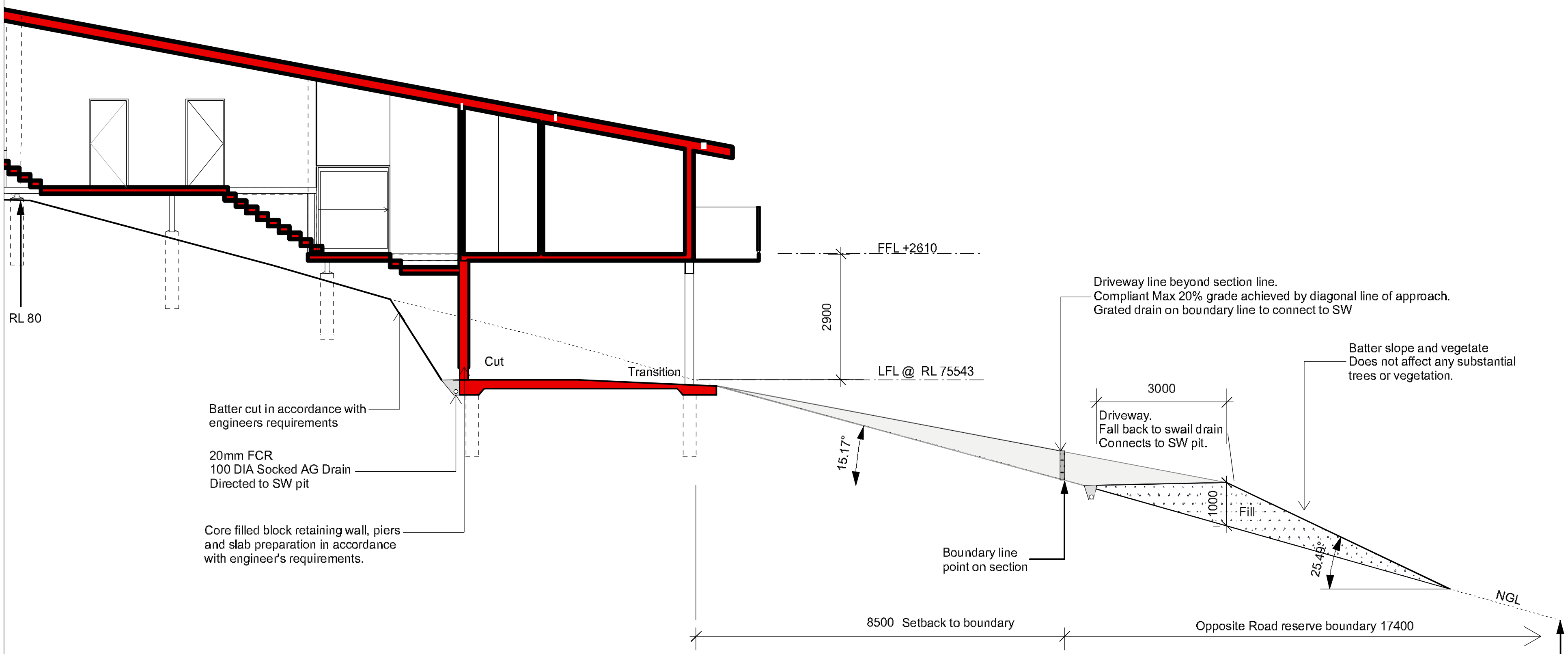

1

DA-104

Section A-A

Scale: 1:100

Cut & Fill and reference levels

This drawing is to be read in conjunction with all associated specifications, consultants drawings, geotechnical report and other written instructions

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Report all discrepincies with IDW Architecture + Interiors

NO.	DATE	NOTE
A	5/7/17	Detail for cut & fill RL's

Client
Ginny Lim

Address
76 Junction Street
Newstead
Tasmania

Project
Mah Residence

Drawing
Section A-A Driveway

Dwg No.
DA-301

Scale
1:100

Date
02-06-2017

Rev.	Job No.
A	1625

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LANDSLIDE RISK ASSESSMENT
76 JUNCTION STREET, NEWSTEAD

Prepared for: **Ginny Lim Mah**

Date: 8 March 2017

Document Reference: TG17021/1 - 02report

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Contents

Figures

Appendices

Version	Date	Prepared by	Reviewed by	Distribution
Original	8 March 2017	Alan Chester	Dr Wayne Griffioen	Electronic

1 INTRODUCTION

Tasman Geotechnics was commissioned by Ginny Lim Mah to carry out a Landslide Risk Assessment for 76 Junction Street, Newstead (title reference 32667/32).

The aim of the investigation is to determine if the site is suitable for the proposed development, and/or what constraints would be required for development. A proposed house layout was provided by IDW Architecture & Interiors (drawings 1625_DA_101 to 1625_DA_301, dated 14 February 2017).

In 2013, Tasman Geotechnics conducted a Landslide Risk Assessment for 76 and 78 Junction Street (report TG12088/1 – 02report Rev01, dated 14 May 2013). Results of fieldwork and laboratory testing from that investigation are incorporated in this report.

The scope of the present investigation consisted of:

1. Reviewing information available in the public domain (eg unpublished reports from Mineral Resources Tasmania)
2. Carrying out a site walkover, and
3. Conducting a Landslide Risk Assessment, following the method published by the Australian Geomechanics Society (AGS, 2007c).

This report presents our field investigations, laboratory testing and Landslide Risk Assessment for damage to property. The outcome of the assessment is that the risk profile varies from Very Low to Low for the proposed dwelling **adopting the limitations given in Section 6.**

2 DESK STUDY

2.1 Geology

The regional surface geology is taken from the Mineral Resources Tasmania (MRT), Digital Geological Atlas 1:25,000 Series, Launceston Sheet. The site is mapped as being underlain by Tertiary aged sediments comprising partly consolidated clay, silt and clayey labile sand with rare gravel and lignite, some iron-oxide cemented layers and concretions. An extract of the geology map is presented in Figure 1.

2.2 Landslide Hazard Mapping

The MRT Tasmanian Landslide Hazards Series map, Launceston Slide Susceptibility, 1:25,000 series sheet, shows that the site is located in a landslide with unknown activity. An extract of the Launceston Slide Susceptibility map is presented in Figure 1.

Susceptibility zones were determined by MRT by analysis of source, regression and runout angles of known landslides in the study area. For Launceston Group sediments (which include Tertiary sediments) these angles are 7°, 7° and 8°, respectively. Based on these values, the majority of the site is mapped as a possible source area associated with landslides.

Three active or recent landslides are mapped close to the site, on slopes facing west:

- A deep-seated landslide, known as the Lawrence Vale Landslide, is mapped 350m southwest of the site. The Lawrence Vale landslide is about 200m wide and extends about 200m from crest to toe.
- The second, a shallow slide known as Effingham landslide, is located about 230m west of the site. The slide is about 100m wide and extends 130m from crest to toe.
- The third, also a shallow slide, is located near Powena Street, about 430m west of the site. The slide is about 60m wide and extends 90m from crest to toe.

2.3 Reports on Local Landslips

A search was made of the Mineral Resources Tasmania website for previous investigations at or near the site. Thirty reports were identified that discuss landslip in the Launceston area, five of these relate to the Lawrence Vale slip which is located about 350m to the south west of the site and on the west side of Talbot Road, while a further 2 reports discuss other sites within 500m to the east and south east of the site. No reports were identified that discuss the shallow dormant or fossil slide mapped at the site.

Of the reports discussing Lawrence Vale slip, the most recent and possibly most comprehensive, investigation was by **Ezzy and Mazengarb (2007)**. The Lawrence Vale slip is a combination of translational and rotational failure. It covers an area of about 36,000m^2, and involved the displacement of about 214,000m^3 of soil at about 12m depth (Ezzy and Mazengarb, 2007).

Based on fieldwork, Ezzy and Mazengarb identified two units that are involved with the landslip (Ezzy and Mazengarb, 2007):

- *LF1, medium to high plastic clays with banded silt, fine clayey sand and ironstone (dominant colours grey and reds) and*
- *LF2, dominantly clayey sand layers with banded gravel, ironstone, clay and silt (dominant colours grey and yellowish brown).*

The LF1 unit is the upper layer and about 10m thick, while the underlying LF2 unit can be more than 20m thick. Underlying the LF2 unit was "*claystone and sandstone with banded coal, silty sand and clay*". Ezzy and Mazengarb concluded that the "*sediments are locally dipping westward and are a critical factor in the development of the landslides at Lawrence Vale*". Thus, west-facing slopes have a higher susceptibility to landslip than east-facing slopes, all other factors being equal.

In addition, the build-up of pore pressures in LF2 (a semi-confined aquifer) underlying LF1, a clay unit of high plasticity and low shear strength, was considered a significant factor contributing to the Lawrence Vale slip. Monitoring of groundwater levels in 11 piezometers allowed the development of a hydrogeological model for the Lawrence Vale area. The monitoring showed a rapid rise of groundwater level in the semi-confined aquifer in response to rainfall events. Groundwater recharge occurs where the aquifer is exposed at the surface (ie the crest of the ridge at Talbot Road) and potentially via fissures in the overlying clay unit.

The other 2 reports are summarised as follows.

Knight (1973) presents the results of a backhoe investigation for units on McKellar Road. The address is not identified, however, the contours shown on the site plan suggest the site could be located at the western end of Atlas Street (see Figure 1). The test pits typically encountered clayey sand overlying sandy clay. The report concluded that the "*land is … considered safe against landslip so long as it is not unduly disturbed*". The report also noted that "*in view of the low bearing strength materials which were found in holes 2 and 4, settlement of foundations could occur*". Further investigation was recommended if buildings over one storey were planned.

Stevenson (1984) presents a stability assessment for a subdivision at Beverley Hills Road. Seven test pits were excavated, which typically encountered high plasticity clays and ironstone gravel bands. The report states that "*steeper areas that have been outlined are confirmed and should be avoided for building purposes. The avoidance of these areas is not absolute, but any building in them should require specialized investigation and design by a recognized geotechnical engineer…*".

2.4 Proposed Development

The floor level of the proposed house is designed to follow the slope: being above the natural slope. Although no structural engineering has been carried out, the house and internal walls appear to be founded on bored piers.

A garage is located near Junction Street. The proposed garage floor is about 1.3m below the existing ground level. A 2m x 3m external pool is proposed midway along the northern part of the house. The pool base is up to 0.6m below existing ground level. While fill is proposed below the driveway, the drawings do not show how the fill platform finishes at the property boundary.

3 FIELD WORK

Tasman Geotechnics carried out field work on this site for a previous report (TG12088/1) on 28 November, 2012. The fieldwork at the time consisted of a site walk over and the drilling of one borehole (BH1) to a depth of 4m, using a 4WD mounted auger rig. Disturbed samples were taken at depths of 0.5m, 1m, 2m and 3m. Due to the steepness of the site it was not possible to access the site with the 4WD drill rig; hence the borehole was drilled near the eastern boundary of the site.

The engineering log of the borehole is presented in Appendix A, and the location is shown in Figure 2.

Observations were made of geomorphological features and measurements were made of the changes in slope on site. These are shown in Figure 2 and discussed in Section 4.1.

Two disturbed samples were tested by Tasman Geotechnics for Atterberg Limits. The laboratory results are discussed in Section 4.2.

A further site walkover was conducted by an Engineering Geologist from Tasman Geotechnics on 22 February, 2017 to see if any changes had occurred at the site since the previous investigation.

4 RESULTS OF INVESTIGATION

4.1 Site Observations

The site is located about mid-slope of an east-facing hill side that falls from Talbot Road (at about 110m AHD) to McKellar Road/Strahan Road (at about 50m AHD). The whole hill side has a convex appearance: approximately 5˚ slopes near Talbot Road, increasing to a maximum of about 20˚ between Talbot Road and Junction Street, then flattening to about 10˚ east of Junction Street.

The maximum slope angle at the site is 18˚, and is typically about 15˚. There was no evidence of recent landslip at the site.

The site is within a residential area, although areas with steep slopes on the west side of Junction Street are presently vacant. A recent subdivision (Roman Court) has been developed about 300m north of the site, while another subdivision (Lennon Rise and Harrison Way) is located immediately downhill of the site.

A formal road has not been constructed adjacent to the site. The site is covered with long grass.

Since 2012, a shipping container has been placed along the eastern end of 78 Junction Street. The container has been fitted out for temporary accommodation. No other changes were noted at the site since 2012.

4.2 Laboratory Results

Two samples from BH1 were tested by Tasman Geotechnics in 2012 for Atterberg Limits and particle size distribution. The results are summarized in Table 1.

Table 1. Summary of laboratory test results

Parameter	Sample Depth	
	0.9 to 1.0m	2.9 to 3.0m
Liquid Limit (%)	67	58
Plastic Limit (%)	20	11
Plasticity Index (%)	47	47
Linear Shrinkage (%)	15	15
% gravel	5	4
% sand	24	47
% fines	71	49

Thus, the sample from 0.9 to 1m depth is considered a high plasticity sandy clay with Unified Soil Classification System (USCS) symbol CH. The sample from 2.9 to 3m depth is a fine to medium grained clayey sand, with high plasticity fines, USCS symbol SC.

4.3 Subsurface Profile

The borehole showed a soil profile consisting of very stiff to hard, silty clay. At the surface the clay was brown but it became orange below a depth of 0.5m. At about 2.5m depth, the sand content increases, such that the soil becomes a clayey sand, with high plasticity fines.

There was no evidence of slickensides in the clay encountered in the borehole.

No water inflow was observed while drilling the borehole.

5 LANDSLIDE RISK ASSESSMENT

5.1 Methodology

The risk is a combination of the likelihood and the consequences for the hazard in question. Thus both likelihood and consequences are taken into account when evaluating a risk and deciding whether treatment is required.

The qualitative likelihood, consequence and risk terms used in this report for risk to property are given in Appendix B and are based on the Landslide Risk Management Guidelines, published by Australian Geomechanics Society (AGS, 2007). The risk terms are defined by a matrix that brings together different combinations of likelihood and consequence. Risk matrices help to communicate the results of risk assessment, rank risks, set priorities and develop transparent approaches to decision making.

5.2 Hazard Identification

Based on the site observations and available information discussed in the sections above and our local knowledge, the following landslide hazards are identified for the site:

> **Reactivation of existing (regional) landslip**. Based on the recent MRT mapping, the site is located on a large (shallow) landslip. The failure mechanism of the slip has not been accurately defined or investigated, but is likely to be a large scale rotational/translational failure involving 100,000's of m^3 of material. Slips of this kind are likely to have occurred when sea levels or rainfall were much higher. Therefore re-activation of this slip could occur due to elevated groundwater levels at a regional scale (eg impeded groundwater drainage or increased surface infiltration) possibly combined with extensive excavation/erosion at the toe to disturb the existing equilibrium. The likelihood for reactivation of the existing slip is estimated to be Unlikely.

Medium scale (up to about 8m deep) rotational landslides. These slips can occur where slopes are locally steep, or have been steepened by earthworks (cut or fill, for example for construction of Junction Street) and would involve up to 10,000 m^3. Localized soil erosion, eg from poor control of surface runoff and gully erosion, can also create slopes that are locally steep. Locally elevated groundwater levels may also result in medium scale slips. A possible contribution to locally elevated groundwater levels is increased infiltration, such as from runoff accumulating behind poorly drained retaining walls or a leaking pool. The likelihood of a medium scale slip due to ongoing soil erosion is estimated to be Possible if there is no erosion control, but Rare if there is erosion control. The likelihood due to elevated groundwater levels is estimated to be Rare if retaining walls and the pool surround are drained, increasing to Possible if they are not drained.

Small scale (up to about 2m deep) rotational slides may occur in shallow excavations, or fill platforms that are not retained. Small slumps may occur 10 to 20 years after construction. If retained, the likelihood of such slumps occurring is Rare.

While not a 'land slip', the occurrence of creep movement is acknowledged. Creep movement may induce failure of structures if not adequately considered in the design. Recommendations to design for creep are given in Section 6.

The identification of the potential hazards considers both the site and nearby properties, and is necessary to address stability issues that may negatively impact upon the site and influence the risk to property.

5.3 Risk to Property

The following table summarises the risk to property of a landslide event for the "present conditions" and for the "site with dwelling" that has **adopted the limitations in Section 6**.

Table 2. Landslide risk profiles for damage to property

Scenario		Likelihood	Consequence	Risk
Regional scale landslip	Present conditions	Unlikely	Minor: there is no structure on the site	Low
	Site with dwelling	Unlikely: house does not have significant impact on overall slope	Medium: if dwelling is designed to "ride" on the landslide	Low
Medium scale landslip	Present conditions	Possible: runoff is not managed	Minor: there is no structure on the site	Moderate
	Site with dwelling	Rare: if runoff is managed, subsoil drains installed and retaining walls engineer designed.	Minor to Medium: depending on location of head scarp, and no widening of Junction St	Low to Very Low
Small scale landslip	Present conditions	Unlikely: no excavations or fills presently at the site	Insignificant: there is no structure on the site	Very Low
	Site with dwelling	Rare: if excavations are retained and engineer designed	Minor to Medium: if slip is close to dwelling Insignificant: if away from buildings	Low to Very Low Very Low

5.4 Summary of Risk Assessment Results

The risk profile derived above shows that the risk for the slope under existing conditions varies from Very Low to Moderate.

The risk profile for the site after development varies from Very Low to Low, **provided the limitations listed in Section 6** are incorporated in the design.

6 RECOMMENDATIONS

In order to ensure the future site development does not increase the risk profile above Moderate, it is recommended that the following limitations be enforced:

- A default Site Classification for the site is Class "P" according to AS2870 due to the site being located in a landslip of unknown activity. Notwithstanding, the footings founded in the brown silty clay may be designed for an equivalent Class "H2" according to AS2870-2011 (characteristic surface movement, y_s = 70mm). The super structure should be constructed from light weight materials, articulated and flexible.
- A raft or stiffened slab will allow the structure to "ride" on a regional scale landslide. Strip footings founded at least 0.6m below ground level may be proportioned for an allowable bearing capacity of 200kPa.
- If bored piers are used, they should be joined together with ground beams to create a rigid footing system. Bored piers should be founded at least 2m below ground level, and may be proportioned for an allowable bearing capacity of 300kPa.
- Fill should be kept to a minimum at the site. Fill depths should not exceed 0.8m above the present ground level and be compacted. Recommendations for compaction criteria can be provided by Tasman Geotechnics if required.
- Where excavation is required, the depth of excavation should not exceed 1.5m. Excavations more than 1m deep should be retained. Excavation up to 1.5m is acceptable, provided the excavation is retained and the perpendicular walls are designed to provide shear support. Active earth pressures acting on retaining walls should consider the slope of the backfill and be multiplied by 6 to simulate creep loading. [Active earth pressure is generated by a wedge of soil pushing against the retaining wall. In creep, successive soil wedges uphill of the retaining wall push against the wall. The factor 6 represents the cumulative effect of these wedges].
- A soil friction angle of 30° may be adopted for the natural soil when designing retaining walls. Subsurface and surface drainage should be provided behind all retaining walls.
- To protect against wetting of the soil from a leaking swimming pool, a subsoil drainage system should be installed at the base of the pool. Seepage collected in subsoil drains around the pool and from behind retaining walls should be piped to the storm water drains.
- Cut slopes and fill batters should be sloped at a maximum of 1V:2.5H (about 22°). Steeper slopes will need to be retained by an engineer designed retention system. All batter faces should be protected against erosion (eg by vegetation).
- Excavation for future construction or widening of Junction Street should have an engineer designed retention system on the uphill side. The retaining wall should be designed for similar earth pressures as recommended above.
- Storm water from roofs may be collected in storage tanks, or should be piped to the storm water system. Surface runoff from driveways and overflow from the storage tanks should be discharged to the storm water system.
- Maintenance of surface runoff, vegetation, drains and retaining structures and other measures described above are the responsibility of the site owner.
- Tasman Geotechnics should be involved to review design drawings to ensure they meet the limitations listed above. In addition, Tasman Geotechnics should be involved (eg by site visits) at strategic times during the execution of the works.
- Examples of good hillside construction practice are provided in "Australian Geoguide LR8 (Construction Practice)", presented in Appendix C.
- Consideration should be given to placing a covenant on the title quoting the landslide risk profile (Table 2) and the above limitations, in order that all future home owners are aware of the Risk and of the importance of land and water management.

7 REFERENCES

Australian Geomechanics Society (2007c), “Practice Note Guidelines for Landslide Risk Management 2007”, *Australian Geomechanics,* Vol 42, No 1, p63 – 114, March 2007.

Ezzy A. R. and C Mazengarb “Lawrence Vale Landslide Investigations: Implications for Landslide Hazard Assessment in Launceston”, Tasmanian Geological Survey Record 2007/04.

Knights C.J. (1973) “Investigation of a site for Masonic Home flatlets, McKellar Road, Launceston“, Department of Mines, Tasmania, Unpublished Report No 1973/90 (3 pages)

Stevenson P.C. (1984) “Stability assessment of a proposed subdivision at Beverley Hills Road, Punchbowl, Launceston” Department of Mines, Tasmania, Unpublished Report No 1984/23 (10 pages)

TASMAN geotechnics

Important information about your report

These notes are provided to help you understand the limitations of your report.

Project Scope

Your report has been developed on the basis of your unique project specific requirements as understood by Tasman Geotechnics at the time, and applies only to the site investigated. Tasman Geotechnics should be consulted if there are subsequent changes to the proposed project, to assess how the changes impact on the report's recommendations.

Subsurface Conditions

Subsurface conditions are created by natural processes and the activity of man.

A site assessment identifies subsurface conditions at discreet locations. Actual conditions at other locations may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time.

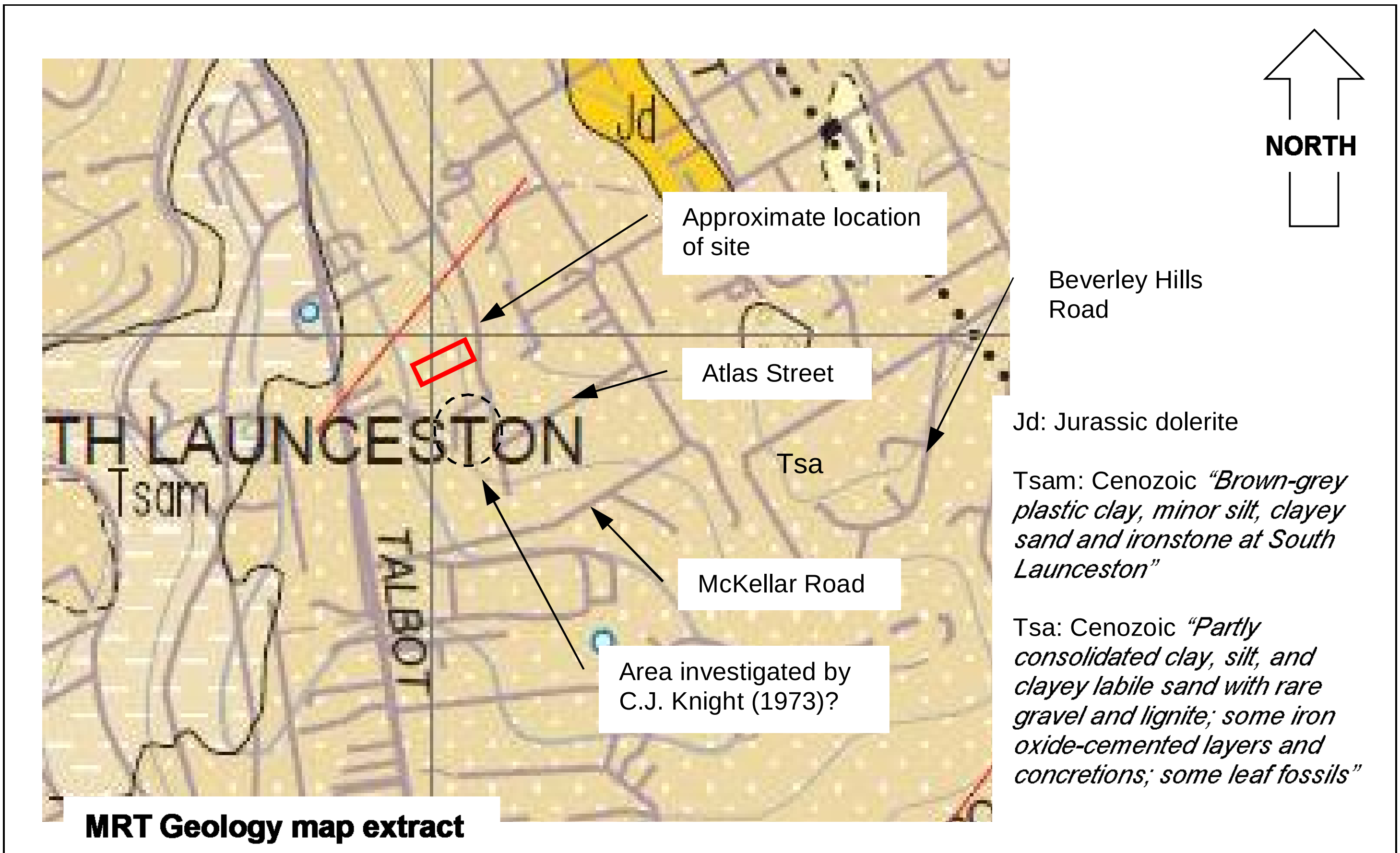
Nothing can be done to change the conditions that exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, the services of Tasman Geotechnics should be retained throughout the project, to identify variable conditions, conduct additional investigation or tests if required and recommend solutions to problems encountered on site.

Advice and Recommendations

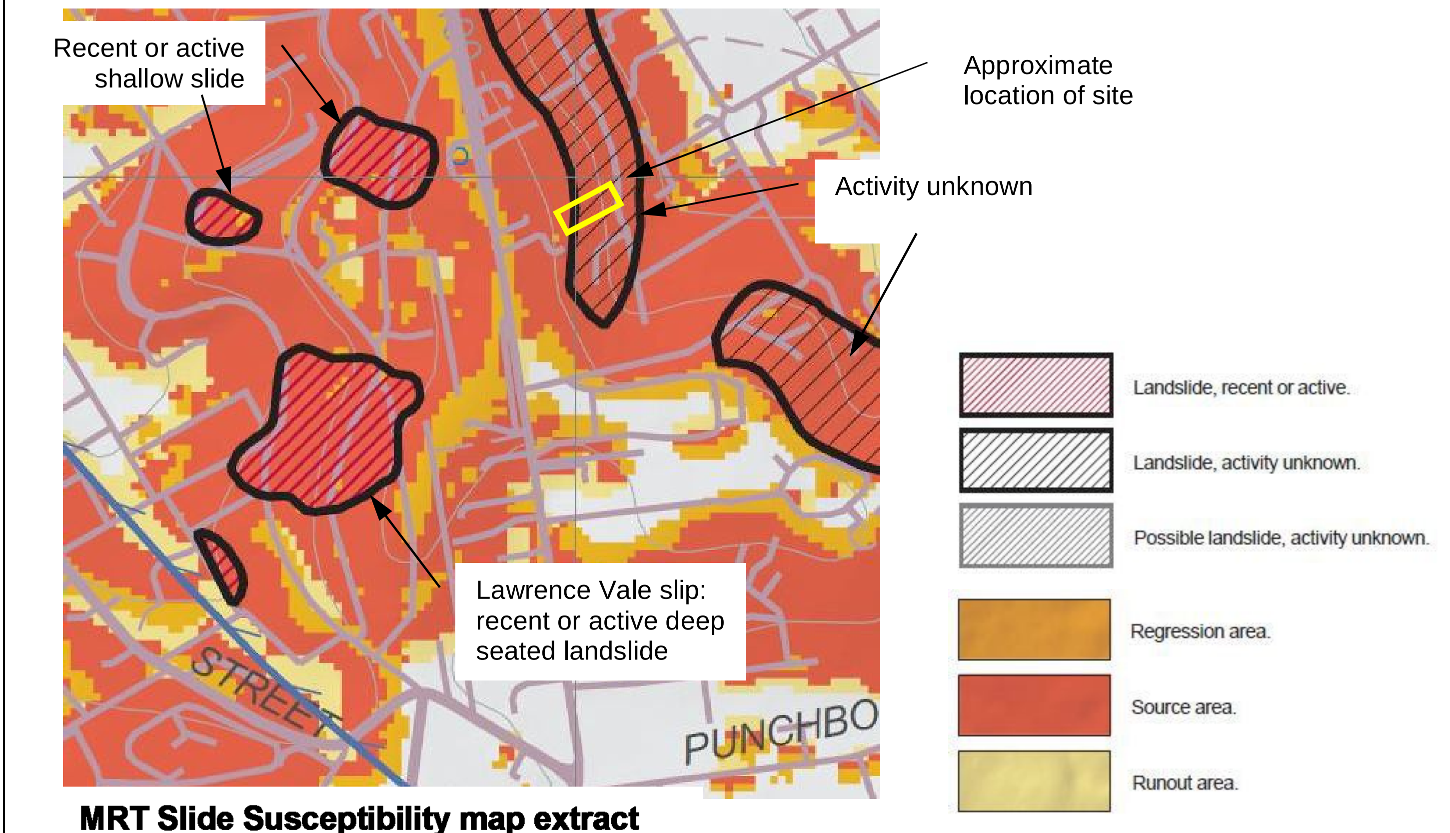
Your report contains advice or recommendations which are based on observations, measurements, calculations and professional interpretation, all of which have a level of uncertainty attached.

The recommendations are based on the assumption that subsurface conditions encountered at the discreet locations are indicative of an area. This can not be substantiated until implementation of the project has commenced. Tasman Geotechnics is familiar with the background information and should be consulted to assess whether or not the report's recommendations are valid, or whether changes should be considered.

The report as a whole presents the findings of the site assessment, and the report should not be copied in part or altered in any way.

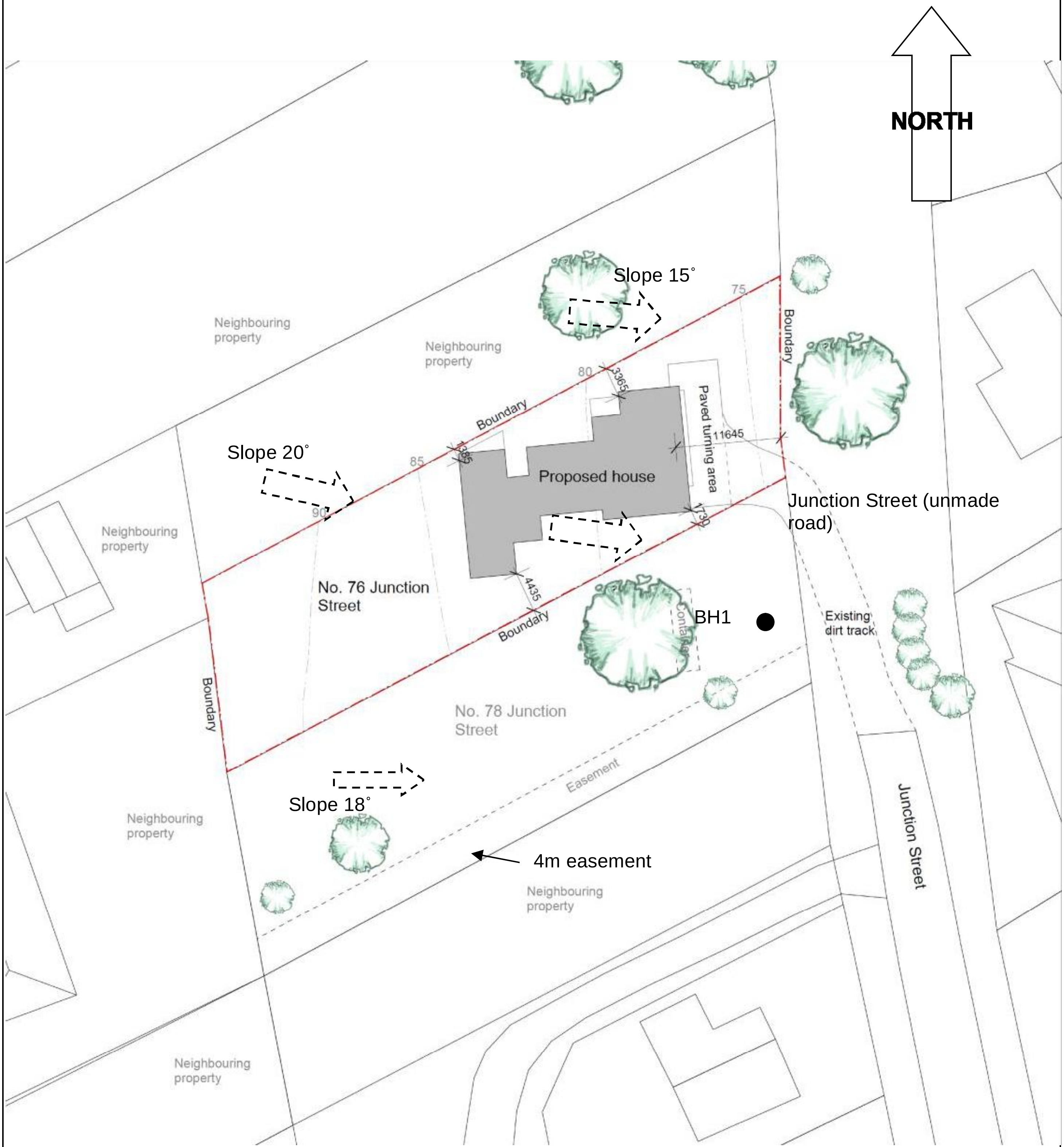


MRT Geology map extract



MRT Slide Susceptibility map extract

drawn	WG	TASMAN geotechnics	client:	Ginny Lim Mah
approved	WG		project:	Landslide Risk Assessment, 76 Junction Street, Newstead
date	1/3/2017			
scale	NTS		title:	MRT Map Extracts
original size	A4		project no: TG17021/1 – 02report	figure no: FIGURE 1



drawn	AC	TASMAN geotechnics	client:	Ginny Lim Mah
approved	WG		project:	Landslide Risk Assessment 76 Junction Road, Launceston
date	6/3/2017			
scale	NTS		title:	Site Layout and Borehole Location
original size	A4		project no: TG17021/1 – 02report	figure no: FIGURE 2

Appendix A

Borehole Log

SOIL DESCRIPTION EXPLANATION SHEET

TASMAN geotechnics

Soils are described in accordance with the Unified Soil Classification System (USCS), as shown in the following table.

FIELD IDENTIFICATION

COARSE GRAINED SOILS	more than 50% of material less than 63mm is larger than 0.075mm	GRAVELS	GW	Well graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		GRAVELLY SOILS	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
		SANDS	SW	Well graded sands and gravelly sands, little or no fines
			SP	Poorly graded sands and gravelly sands, little or no fines
		SANDY SOILS	SM	Silty sand, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines

					DRY STRENGTH	DILATANCY	TOUGHNESS
FINE GRAINED SOILS	more than 50% of material less than 63mm is less than 0.075mm	SILT & CLAY, liquid limit less than 50%	ML	Inorganic silts, very fine sands or clayey fine sands	None to low	Quick to slow	None
			CL	Inorganic clays or low to medium plasticity, gravelly clays, sandy clays and silty clays	Medium to high	None to very slow	Medium
			OL	Organic silts and organic silty clays of low plasticity	Low to medium	Slow	Low
		SILT & CLAY, liquid limit greater than 50%	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts	Low to medium	Slow to none	Low to medium
			CH	Inorganic clays of high plasticity, fat clays	High	None	High
			OH	Organic clays of medium to high plasticity	Medium to high	None to very slow	Low to medium
PEAT			Pt	Peat muck and other highly organic soils			

Particle size descriptive terms

Name	Subdivision	Size
Boulders		>200mm
Cobbles		63mm to 200mm
Gravel	coarse	20mm to 63mm
	medium	6mm to 20mm
	fine	2.36mm to 6mm
Sand	coarse	600µm to 2.36mm
	medium	200µm to 600µm
	fine	75µm to 200µm

Consistency of cohesive soils

Term		Undrained strength	Field guide
Very soft	VS	<12kPa	A finger can be pushed well into soil with little effort
Soft	S	12 - 25kPa	Easily penetrated several cm by fist
Firm	F	25 - 50kPa	Soil can be indented about 5mm by thumb
Stiff	St	50-100kPa	Surface can be indented but not penetrated by thumb
Very stiff	VSt	100-200kPa	Surface can be marked but not indented by thumb
Hard	H	>200kPa	Indented with difficulty by thumb nail
Friable	Fb	-	Crumbles or powders when scraped by thumb nail

Moisture Condition

Dry (D)	Looks and feels dry. Cohesive soils are hard, friable or powdery. Granular soils run freely through fingers.
Moist (M)	Soil feels cool, darkened in colour. Cohesive soils are usually weakened by moisture presence, granular soils tend to cohere.
Wet (W)	As for moist soils, but free water forms on hands when sample is handled

Cohesive soils can also be described relative to their plastic limit, ie: <Wp, =Wp, >Wp
The plastic limit is defined as the minimum water content at which the soil can be rolled into a thread 3mm thick.

Density of granular soils

Term	Density index
Very loose	<35%
Loose	15 to 35%
medium dense	35 to 65%
Dense	65 to 85%
Very dense	>85%

Minor Components

Term	Proportions	Observed properties
Trace of	Coarse grained: <5% Fine grained: <15%	Presence just detectable by feel or eye. Soil properties little or no different to general properties of primary component.
With some	Coarse grained: 5-12% Fine grained: 15-30%	Presence easily detected by feel or eye. Soil properties little different to general properties of primary component.

ENGINEERING BOREHOLE LOG

TASMAN geotechnics

Borehole no. BH1

Sheet no. 1 of 1
Job no. TG12088/1

Client : MV Consulting
Project : LSA
Location : 76-78 Junction Street Launceston

Date : 28/11/2012
Logged By : AC

Drill model : Proline auger, 4WD mounted
Hole diameter : 120mm
Slope : deg
Bearing : deg
RL Surface :
Datum :

Method	Penetration (1 2 3 4)	Notes Samples Tests	Water	Depth (m)	Graphic Log	Classification	Material Description	Moisture Condition	Consistency density, index	Structure, additional observations
auger				0.00		CH	SILTY CLAY, high plasticity, brown	D	H	
		D		0.50						
							becomes orange			
		D		1.00				M	V.St.	
				1.50						
		D		2.00				M	V.St.	
				2.50			becoming CLAYEY SAND, fine to medium grained, orange			
		D		3.00				M	V.St.	
				3.50						
				4.00			Terminated @ 4m, still going			

Appendix B

Landslide Risk Terminology

Terminology for use in Assessing Risk to Property

These notes are provided to help you understand concepts and terms used in Landslide Risk Assessment and are based on the "Practice Note Guidelines for Landslide Risk Management 2007" published in *Australian Geomechanics* Vol 42, No 1, 2007.

Likelihood Terms

The qualitative likelihood terms have been related to a nominal design life of 50 years. The assessment of likelihood involves judgment based on the knowledge and experience of the assessor. Different assessors may make different judgments.

Approximate Annual Probability	Implied indicative Recurrence Interval	Description	Descriptor	Level
10^{-1}	10 years	The event is expected to occur over the design life	Almost Certain	A
10^{-2}	100 years	The event will probably occur under adverse conditions over the design life	Likely	B
10^{-3}	1000 years	The event could occur under adverse conditions over the design life	Possible	C
10^{-4}	10,000 years	The event might occur under very adverse conditions over the design life	Unlikely	D
10^{-5}	100,000 years	The event is conceivable but only under exceptional circumstances over the design life	Rare	E
10^{-6}	1,000,000 years	The event is inconceivable or fanciful for the design life	Barely Credible	F

Qualitative Measures of Consequence to Property

Indicative Cost of Damage	Description	Descriptor	Level
200%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequential damage.	Catastrophic	1
60%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequential damage	Major	2
20%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequential damage.	Medium	3
5%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works	Minor	4
0.5%	Little damage.	Insignificant	5

The assessment of consequences involves judgment based on the knowledge and experience of the assessor. The relative consequence terms are value judgments related to how the potential consequences may be perceived by those affected by the risk. Explicit descriptions of potential consequences will help the stakeholders understand the consequences and arrive at their judgment.

Qualitative Risk Analysis Matrix – Risk to Property

Likelihood		Consequences to Property				
	Approximate annual probability	1: Catastrophic	2: Major	3: Medium	4: Minor	5: Insignificant
A: Almost Certain	10^{-1}	VH	VH	VH	H	L
B: Likely	10^{-2}	VH	VH	H	M	L
C: Possible	10^{-3}	VH	H	M	M	VL
D: Unlikely	10^{-4}	H	M	L	L	VL
E: Rare	10^{-5}	M	L	L	VL	VL
F: Barely credible	10^{-6}	L	VL	VL	VL	VL

NOTES:

1. The risk associated with Insignificant consequences, however likely, is defined as Low or Very Low

2. The main purpose of a risk matrix is to help rank risks and set priorities and help the decision making process.

Response to Risk

In general, it is the responsibility of the client and/or regulatory and/or others who may be affected to decide whether to accept or treat the risk. The risk assessor and/or other advisers may assist by making risk comparisons, discussing treatment options, explaining the risk management process, advising how others have reacted to risk in similar situations and making recommendations. Attitudes to risk vary widely and risk evaluation often involves considering more than just property damage (eg environmental effects, public reaction, business confidence etc).

The following is a guide to typical responses to assessed risk.

Risk Level		Example Implications
VH	Very High	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than the value of the property.
H	High	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	Moderate	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	Low	Usually accepted by regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	Very Low	Acceptable. Manage by normal slope maintenance procedures

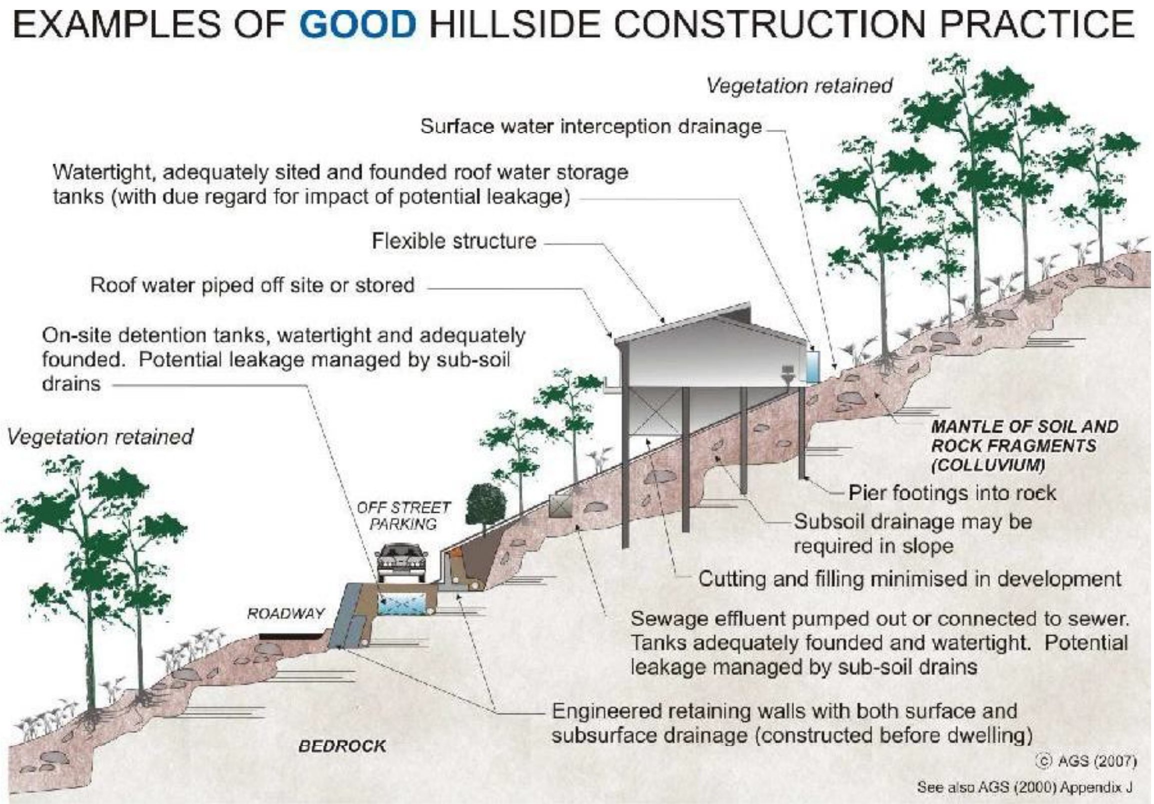
Appendix C

Australian Geoguide LR8 – Hillside Construction Practice

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.

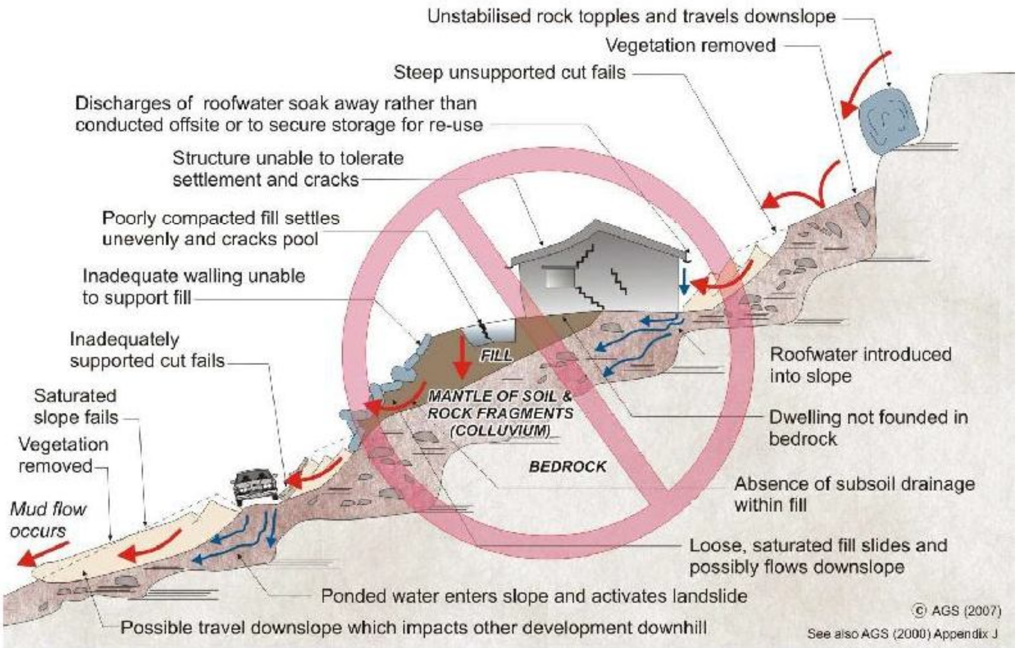
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing 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.