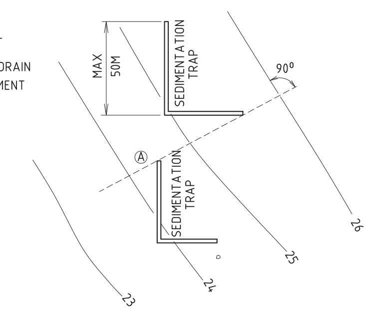
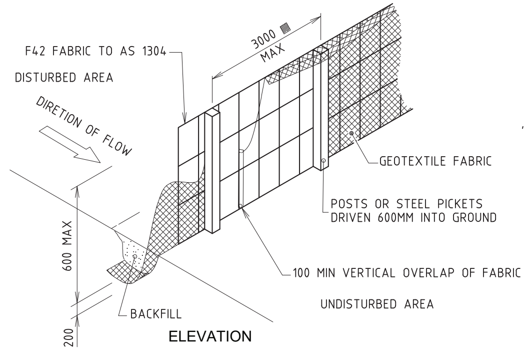
LEGEND

- PROPOSED EDGE OF PAVEMENT
- PROPOSED INVERT OF TABLE DRAIN
- PROPOSED ROOFWATER ALIGNMENT
- INTERFACE
- PROPERTY BOUNDARY
- SEDIMENT FENCES
- CHECK DAMS





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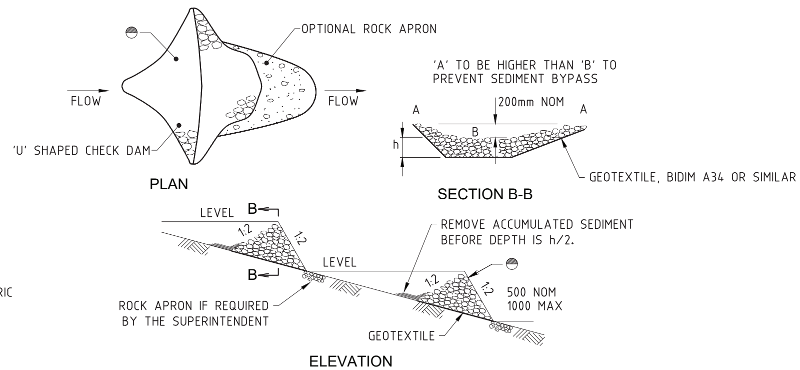
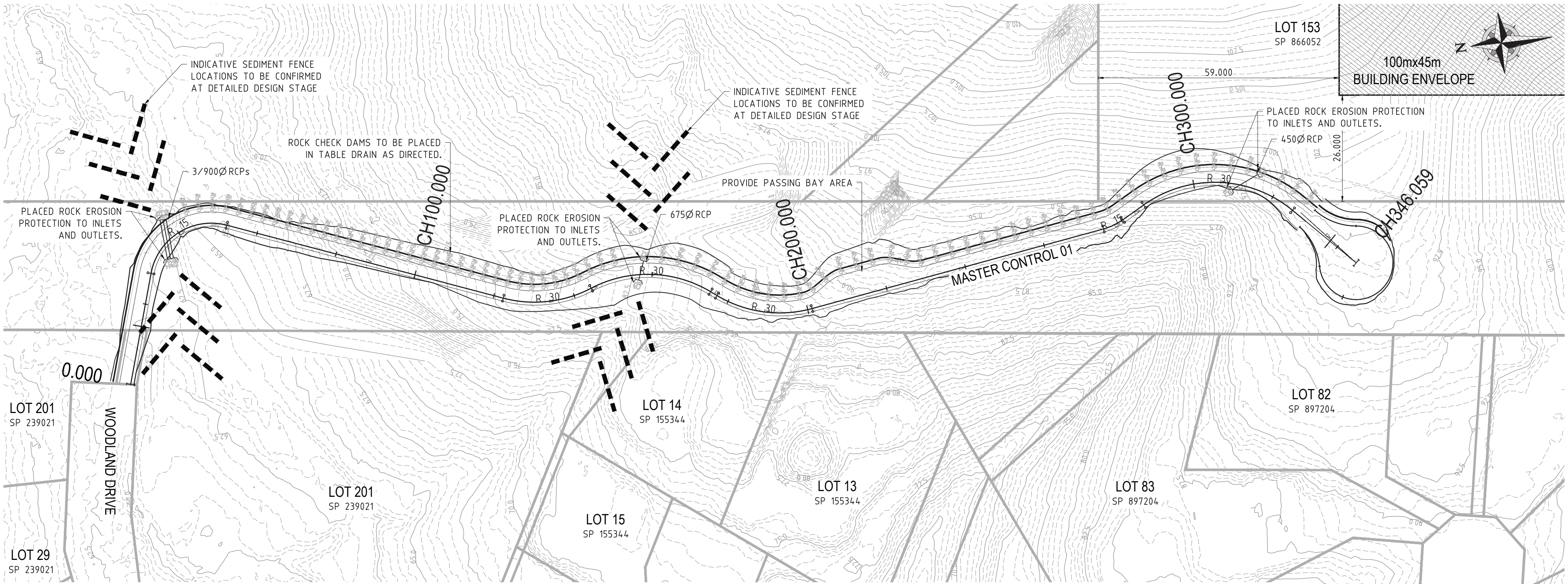
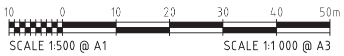


CHECK DAMS FLOW CONTROL
N.T.S





INFORMATION ONLY

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		D		ROAD SAFTEY BARRIER ADDED				
CO-ORDINATE DATUM		C		STORMWATER AMENDED				
		B		AMENDED INFORMATION REQUEST				
HEIGHT DATUM		A		SUBMITTED FOR INFORMATION				
DRAWING No.	REFERENCE DRAWING TITLE							

	BY	DATE
REVIEWED		
RPEQ ENG		
RPEQ No:		

CLIENT

SCALE: NTS

PREPARED BY
0731415
mcmurtrie
CONSULTING ENGINEERS
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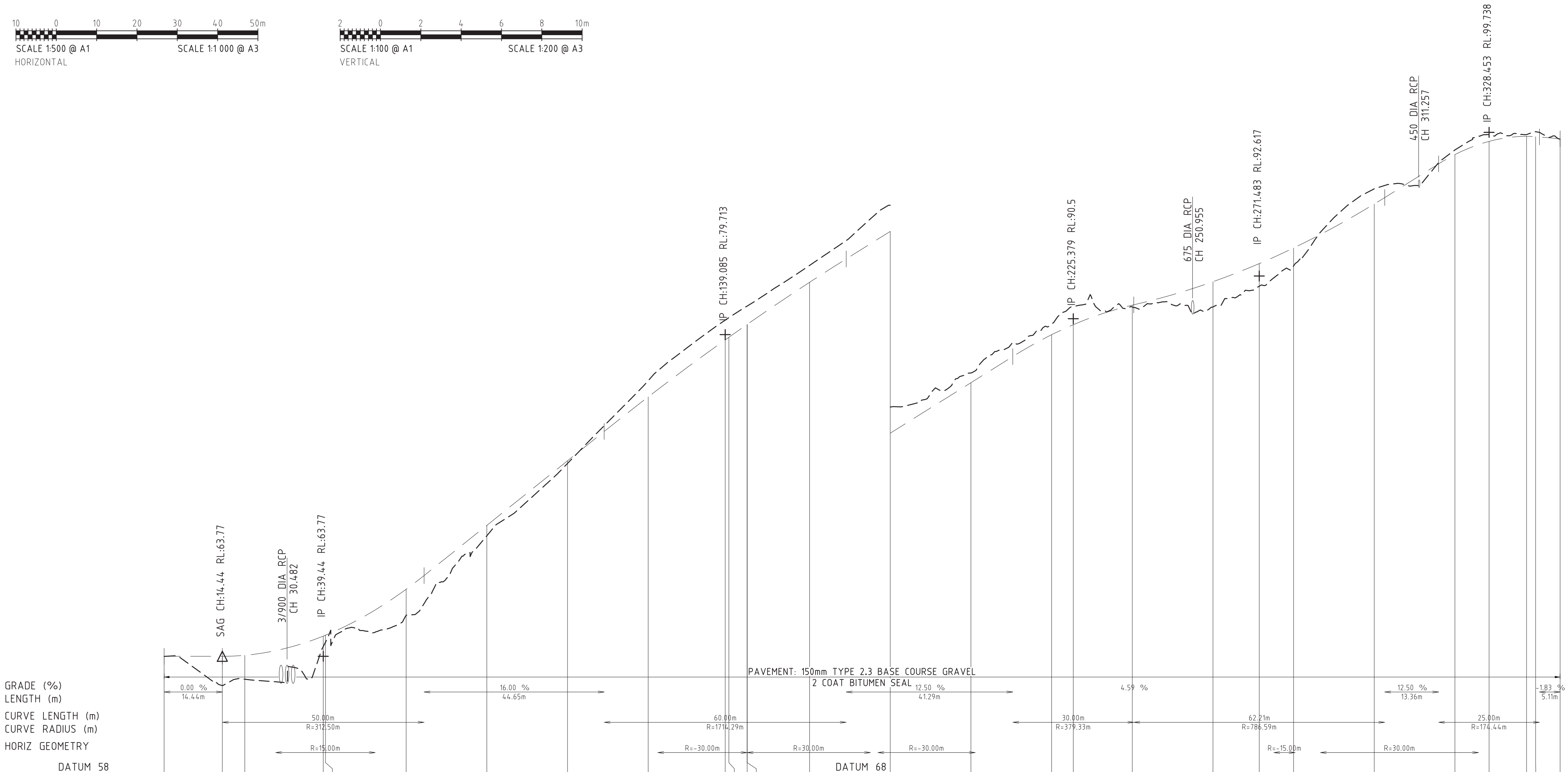
CLIENT DAVID GENTLE
PROJECT HOLT STREET PROPOERTY
TITLE LAYOUT AND DETAILS

A1 | DRAWING NUMBER 0731415-01 | REVISION F

DRAWING LOCATION: S:\PROJECT RECORDS\14-15\0731415-15\ACAD\DRAWINGS\SHEET SETS_INDIVIDUAL DRAWINGS\INDIVIDUAL DRAWINGS\0731415 - PLAN AND SECTIONS _S.P.DWG
PLOT DATE: 6/07/2018 9:05:14 AM



CONTROL LINE DESIGN HEIGHTS	63.77	63.77	63.819	64.77	64.815	67.091	70.26	73.46	76.625	79.451	79.581	80.218	80.218	82.304	84.828	87.328	89.706	90.203	91.171	92.334	93.232	94.006	96.186	98.634	99.29	99.538	99.524	99.415
EXISTING SURFACE	63.768	62.32	62.635	64.255	64.471	65.796	69.744	73.329	77.43	80.433	80.555	81.128	81.129	83.142	86.123	87.812	90.239	91.111	91.086	91.083	92.112	93.113	96.939	98.865	99.627	99.627	99.771	99.399
DEPTH TO EXISTING SURFACE	-0.002	-1.45	-1.185	-0.515	-0.344	-1.295	-0.516	-0.131	0.805	0.982	0.975	0.911	0.91	0.839	1.295	0.484	0.534	0.908	-0.086	-1.251	-1.12	-0.892	0.754	0.231	0.337	0.089	0.247	-0.017
MC CONTROL LINE CHAINAGE	0.000	14.440	20.000	39.440	40.000	60.000	80.000	100.000	120.000	139.085	140.000	144.527	144.531	160.000	180.000	200.000	220.000	225.379	240.000	260.000	271.483	280.000	3[illegible].000	3[illegible].000	3[illegible].53	3[illegible].757	3[illegible].000	3[illegible].059

INFORMATION ONLY

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			D		ROAD SAFTEY BARRIER ADDED				
CO-ORDINATE DATUM			C		STORMWATER AMENDED				
			B		AMENDED INFORMATION REQUEST				
HEIGHT DATUM			A		SUBMITTED FOR INFORMATION				
	DRAWING No.	REFERENCE DRAWING TITLE							

	BY	DATE
REVIEWED		
RPEQ ENG		
RPEQ No:		

CLIENT

SCALE: NTS

PREPARED BY 0731415

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CLIENT DAVID GENTLE
PROJECT HOLT STREET PROPOERTY
TITLE
LONGSECTION

A1 DRAWING NUMBER 0731415-02 REVISION F

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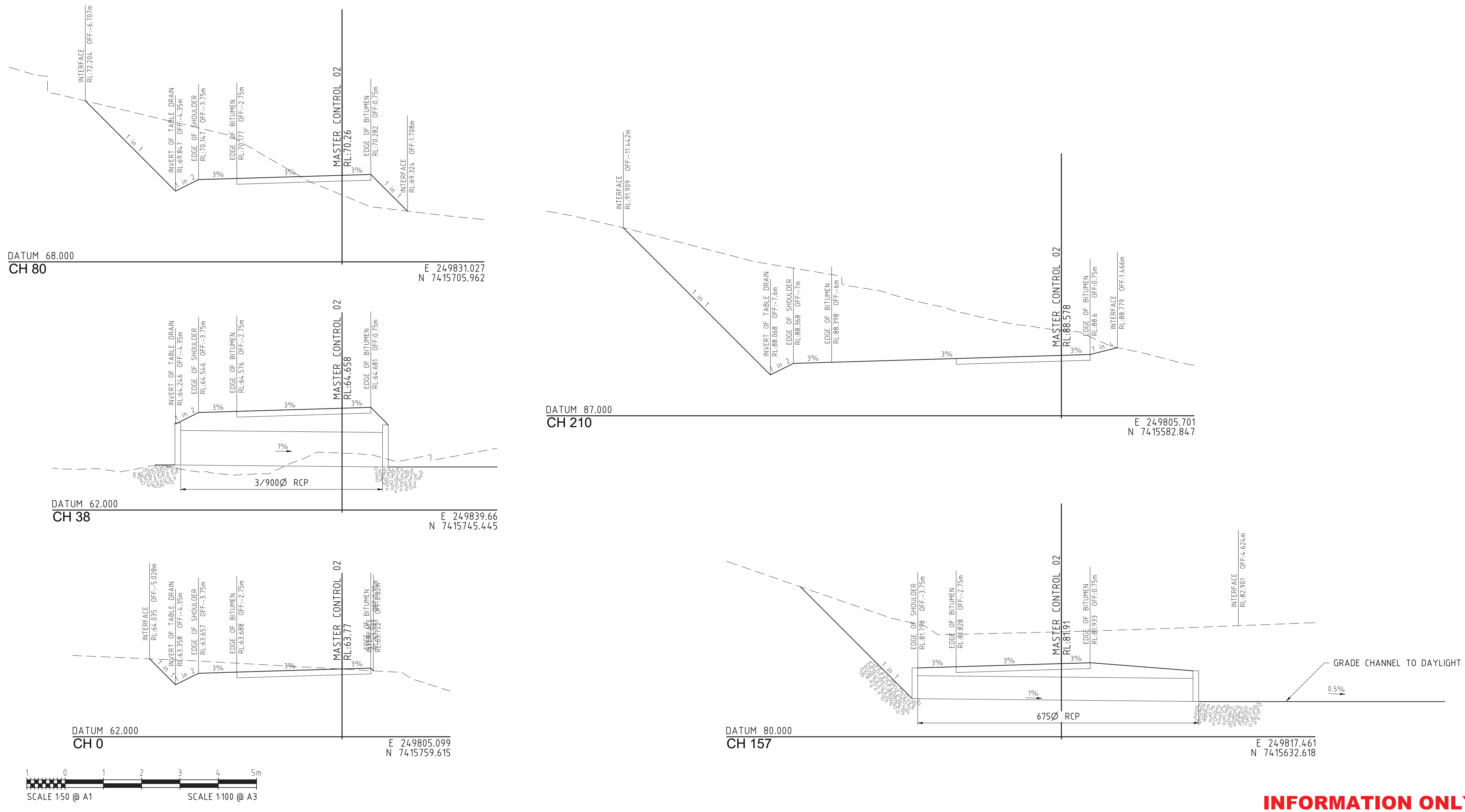

INFORMATION ONLY

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			D		ROAD SAFTEY BARRIER ADDED				
CO-ORDINATE DATUM			C		STORMWATER AMENDED				
			B		AMENDED INFORMATION REQUEST				
HEIGHT DATUM			A		SUBMITTED FOR INFORMATION				
	DRAWING No.	REFERENCE DRAWING TITLE	REV	DATE	REVISION DESCRIPTION	DFT	DFT CHK	DES	DES CHK

	BY	DATE
REVIEWED		
RPEQ ENG		
RPEQ No:		

CLIENT

SCALE: NTS

PREPARED BY 0731415

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CLIENT DAVID GENTLE
PROJECT HOLT STREET PROPOERTY
TITLE CROSS SECTIONS 1

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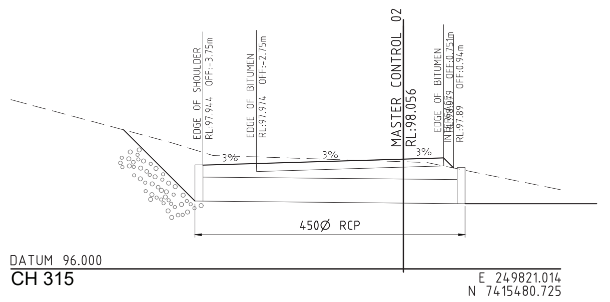

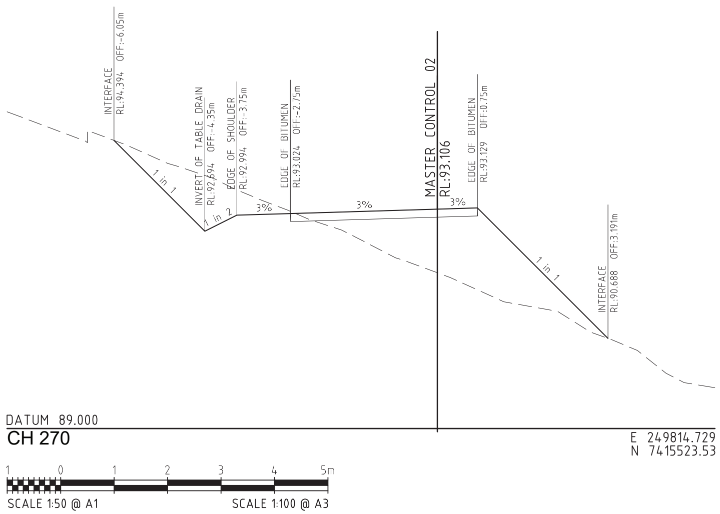

INFORMATION ONLY

SURVEYOR

ADDRESS:

CO-ORDINATE DATUM

HEIGHT DATUM

DRAWING No.	REFERENCE DRAWING TITLE

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F	26/06/18	REALIGNMENT AND REGRADING OF DESIGN				
E		AMENDED GRADE AND WIDENING				
D		ROAD SAFTEY BARRIER ADDED				
C		STORMWATER AMENDED				
B		AMENDED INFORMATION REQUEST				
A		SUBMITTED FOR INFORMATION				

	BY	DATE
REVIEWED		
RPEQ ENG		

RPEQ No:

CLIENT

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SCALE: NTS

PREPARED BY 0731415

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CLIENT DAVID GENTLE

PROJECT HOLT STREET PROPOERTY

TITLE

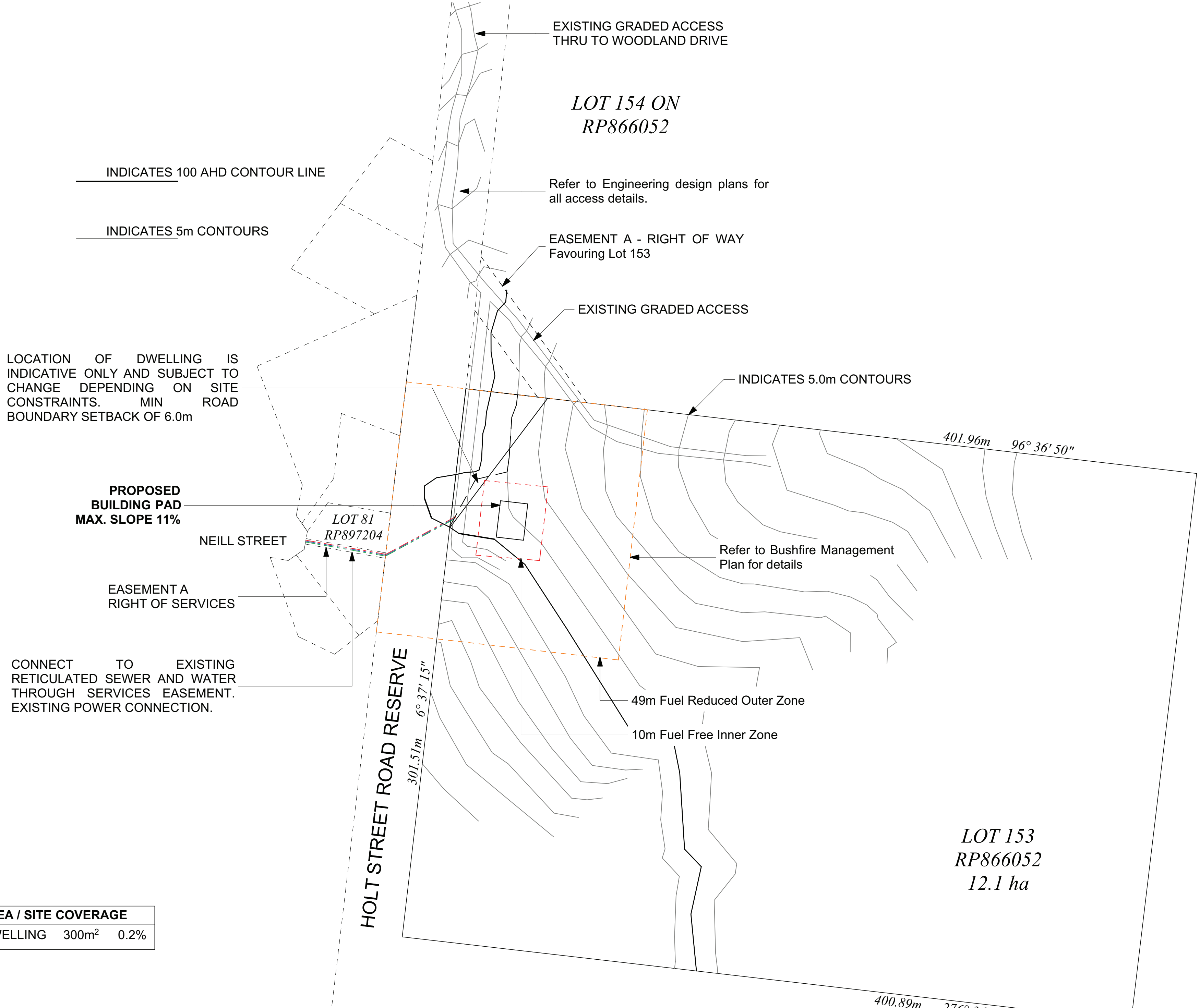
CROSS SECTIONS 2

A1 DRAWING NUMBER 0731415-04 REVISION F

A1 DRAWING

NOTED SCALES RELATE TO A1 DRAWINGS

RPD DETAILS
LOT 153 ON RP866052 - SITE AREA: 12.1 ha (121,000m^2)



AREA / SITE COVERAGE		
DWELLING	300m^2	0.2%

PROPOSED SITE PLAN 1:1000

BAEL BUILDING DESIGN

PO BOX 6267
RED HILL ROCKHAMPTON Q 4701
M: 0438 166 530
E: baelbuildingdesign@bigpond.com
BSA Licence: #1198384
BDAQ Member:#0001235

The Builder shall check and verify all dimensions. All errors and omissions must be verified with the Designer. Do not scale from the drawings. Drawings shall not be used for construction purposes until issued by the Designer 'For Construction'.

Client
ST. LUKE'S HEALING FOUNDATION

Project Name
NEW DWELLING

Project Address
342-350 HOLT STREET, FRENCHVILLE

Drawing Title:
PROPOSED SITE PLAN

Status: DA ISSUE

Scale: as shown at A1
Date:
Sheet Number: 1 of 1
Drawn: RJD

Project No: **1402-01**
Issue No.: **DA1.1**

Plot: 11:05 AM 3/07/2018

1 April 2016 Project No. 16064-001-Rev0

CQ Soil Testing
Attention: Mr Scott Walton

Email: scott@cqsoiltesting.com.au

SLOPE STABILITY ASSESSMENT
342-350 HOLT STREET, FRENCHVILLE

Dear Scott,

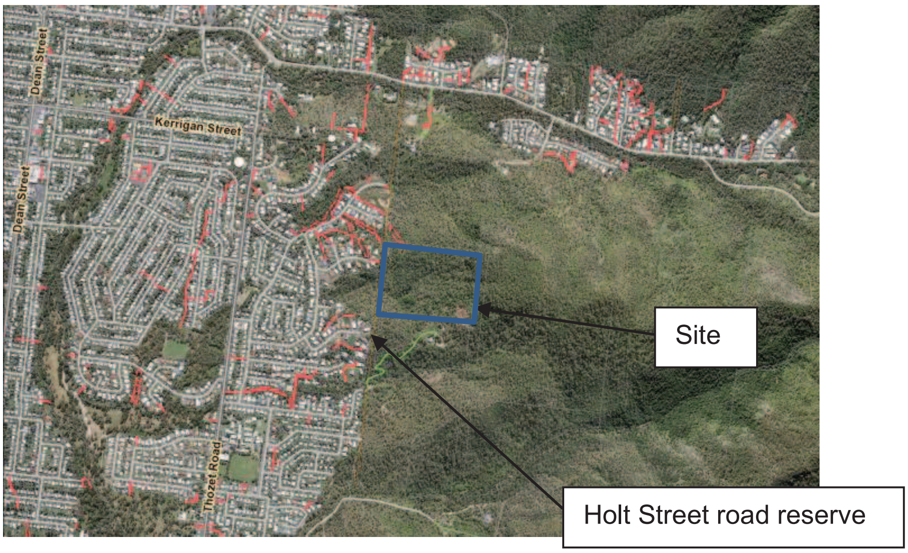
1.0 INTRODUCTION

As requested, Tectonic Geotechnical Pty Ltd (Tectonic) has undertaken a slope stability assessment of a parcel of land 342-350 Holt Street, Frenchville. An Information Request (IR) from Rockhampton Regional Council (RRC) dated 11 August 2015 is for a Material Change of Use for a house at this site. Item 3.1 of that IR requires a slope stability assessment to be undertaken as the proposed building pad has ground slopes of up to 33%.

This report presents the results of our slope stability assessment, together with geotechnical advice for future development. In summary, subject to implementation of the recommendations made herein, there is a Low Risk of slope instability affecting future development at this site in accordance with the Australian Geomechanics Society "*Guidelines for Landslide Risk Management*", dated March 2007 (AGS 2007).

1.1 Details of Site and Development

The property is described as Lot 153 on RP866052 and covers an area of 12.1 ha. The site has road frontage to Holt Street to the west. Residential lots/buildings are located on the western side of Holt Street (road reserve), whilst the eastern side encompassing the subject site comprises dense bushland (Ref: Text Figure 1 on the following page). Access to the site is via an access track off Woodland Drive to the north. A detailed site description is given in Section 2.



Text Figure 1: Aerial photo of site area (courtesy RRC Rock e Plan)

Due to the preliminary nature of this assessment no details are currently available regarding the future proposed development for this site.

The property has access to town water and sewerage services.

1.2 Method and Scope of Investigation

As part of our slope stability assessment, a desk-top study was carried out comprising a review of published geological maps, RRC overlay mapping, a soil test report by CQ Soil Testing (CQ) dated 21 March 2016 (Job No. CQ13445), and site photographs taken by CQ.

The results of the desk-top study are included in Section 2 below.

1.3 Qualifications of Responsible Engineer

This report has been prepared by Mr Darryn Quinn, an RPEQ with more than 20 years' experience in geotechnical engineering, including numerous slope stability projects.

2.0 DESCRIPTION OF EXISTING CONDITIONS

2.1 Geology

Available geological information[1] indicates that the site is underlain by Permian age sedimentary rock (siltstone and lithic sandstone) of the Lakes Creek Formation, which is part of the wider Berserker Group.

The CQ investigation comprised four boreholes drilled to depths of up to 1.1 m below ground level (BGL) in the north-western corner of the site, using a 4WD mounted rotary drilling rig. The boreholes encountered dense clayey sand to depths of 0.6 m to 0.9 m BGL, then very dense clayey sandy gravel (possible extremely weathered rock). All boreholes were terminated at tungsten carbide (TC) drill bit refusal on weathered rock at depths of 0.8 m to 1.1 m BGL.

Rock exposures were noted in road cuttings located just to the south of the drilling area
(Ref: Text Figure 3).

Text Figure 3: Rock exposure in road cutting

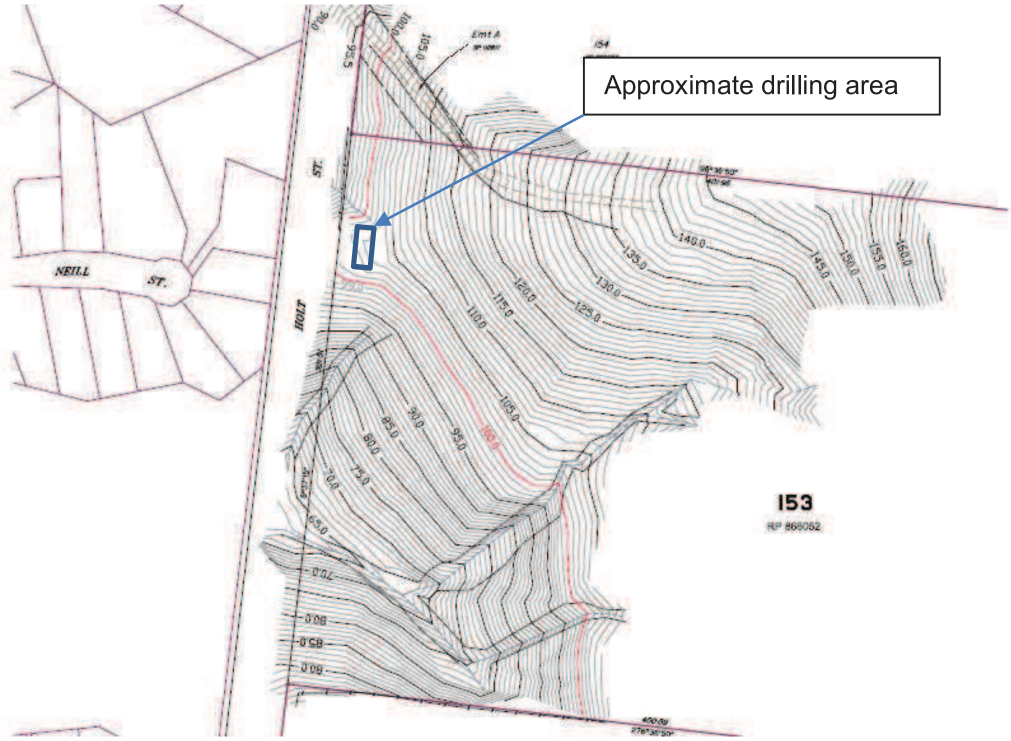
[1] 1:100,000 Rockhampton Geology Map, Sheet 9051, DNRMW, 2006

CQ have classified the site as ***Class S*** (slightly reactive), in accordance with AS2870-2011 *Residential Slabs & Footings*.

No groundwater was mentioned in the CQ borehole reports, with the soil described as dry.

2.2 Topography

As shown in Text Figure 4 below, the site is located on a west/south-west dipping ridge sloping at about 18° to 20° (33% to 35%). A previously proposed house pad in the north-western corner comprises flatter ground (less than about 12% or 7°). Steep sided gullies are located to the south and south-east, which eventually drain away to the west of Holt Street.



Text Figure 4: Survey map showing 1 m ground surface contours (Schelnker Surveying)

2.3 Groundwater

No signs of surface groundwater seepage ('springs') were reported by CQ. CQ boreholes describe the soils as dry.

2.4 Surface Drainage

Natural surface drainage follows the ground surface contours generally towards the west/south-west. Surface water is expected to drain rapidly from the site considering the moderate ground slopes and relatively low permeability of the clayey soils. No signs of soil erosion were observed in photographs provided by CQ.

2.5 Vegetation

The ground surface across the site is covered by tall grass and scattered trees (Ref: Text Figure 5 on the following page).

Text Figure 5: View looking east from originally proposed building pad

2.6 Buildings and Other Structures

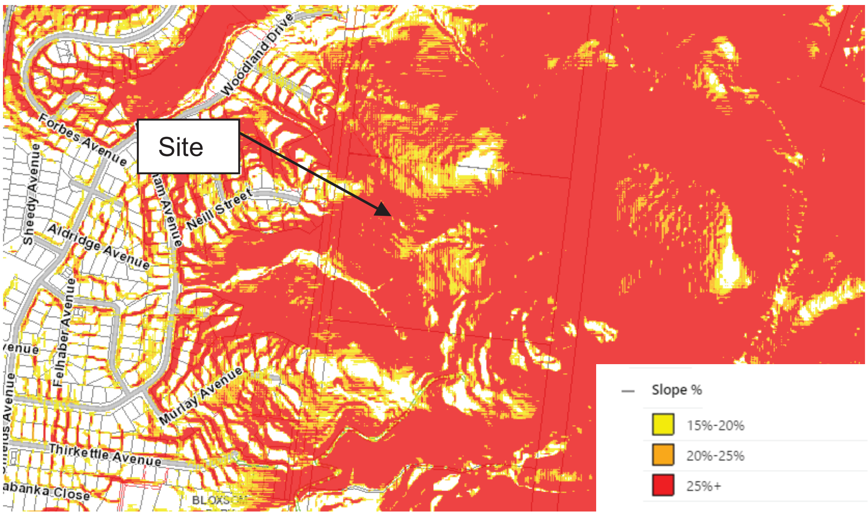
No buildings are located on this lot.

Residences located on the western side of Holt Street comprise single and two storey buildings having masonry and lightweight clad walls.

3.0 ASSESSMENT OF LAND STABILITY

3.1 Existing Conditions

The RRC Planning Scheme Steep Land Overlay (Refer Text Figure 6) indicates that most of the site comprises land sloping at >25% (red shading), with some areas of 20% to 25% (orange shading) and 15% to 20% (yellow shading).



Text Figure 6: Extract from RRC Steep Land Overlay

It should be noted that the RRC map is an indication of land slope rather than potential landslide susceptibility. For slopes over 15%, RRC requires a site specific geotechnical report to address stability.

Based on available information, the site does not exhibit any indicators of slope instability. No landslide back scarps, tension cracks, or areas of naturally 'hummocky' ground are apparent in photographs supplied by CQ. Shallow rock was encountered in the boreholes drilled by CQ.

3.2 Stability Assessment

The risk assessment for this project has been carried out following AGS 2007 Practice Note Guidelines for Landslide Risk Management. Relative levels of risk and their implications are given in Table 1 below and the *Qualitative Terminology for Use in Assessing Risk to Property* is also attached.

Table 1: Stability Risk Levels

Risk Level		Example Implications(1)
VH	Very High Risk	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 value of property.
H	High Risk	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 Risk	May be tolerated in certain circumstances (subject to regulators' approval) but requires investigation, planning and implementation of treatment options to reduce risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	Low Risk	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance required.
VL	Very Low Risk	Acceptable. Manage by normal slope maintenance procedures.

Note: (1) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Considering the existing site conditions (Ref. Section 2), and subject to the implementation of recommendations given below, it is our opinion that there would be a **Low (L) Risk** of global slope instability affecting future development of this site. Regulators (RRC) normally require that a Very Low or Low Risk of landslide affecting property must be demonstrated to enable development approval. Summarised in Table 2 below is our qualitative assessment of landslide risk for the site. A summary of qualitative terminology for use in assessing risk to property is attached (taken from AGS 2007).

Table 2: Details of Qualitative Risk Assessment for Property (AGS 2007

Hazard	Likelihood	Consequence	Assessed Risk	Comments
1: Shallow failure through future fill and/or clayey sand above the foundation depth	**Unlikely**	**Medium**	**Low**	The likelihood of a failure through future fill and/or clayey sand is assessed as **Unlikely** due to the consistency of the materials, shallow depth to rock, and lack of groundwater in the area. The consequence of such a failure would be **Medium** considering the depth of foundations recommended, with the resultant risk being **Low** as per AGS 2007.
2: Deep failure through very dense clayey sandy gravel/weathered rock below the foundation depth	**Rare**	**Major**	**Low**	The likelihood of a deep failure through the very dense gravel/weathered rock is assessed as **Rare** due to the strength of these materials. Although the consequence of such a failure would be **Major**, the resultant risk is **Low** as per AGS 2007.

The potential impacts on slope stability of the development components have been assessed, and the measures recommended below in Section 4 have been designed to mitigate those impacts.

4.0 ASSESSMENT OF DEVELOPMENT IMPACTS

General recommendations to help maintain the stability of the site are given in the document "*Some Guidelines for Hillside Construction*", which is attached.

4.1 Development Areas

Development should generally be confined to ridges and flatter ground where slopes do not exceed 25%. Building near existing gullies should be avoided.

4.2 Earthworks

In order to minimise the load on the slope, any new fill depths should not exceed 1 m unless approved by Tectonic.

Any organic rich topsoil and severely root affected soils must be stripped and removed from the proposed construction area, including proposed fill subgrades.

Any new fill materials should be compacted at moisture contents within the range of -2% to +2% of optimum moisture content for Standard Compaction. Confirmatory testing must be carried out at regular intervals and further details for control and testing of fill are given in Australian Standard AS 3798-2007 "*Guidelines on Earthworks for Commercial and Residential Developments*". Select fill should have a maximum particle size of 100mm for an uncompacted layer thickness of 200mm and shall be compacted by repeated rolling with a small compactor to achieve a dry density ratio of at least 95% of the Standard Maximum Dry Density for cohesive soils, or 70% Dry Density Index for any imported cohesionless soils.

Fill must be 'benched' into the natural soil, over-filled by 0.5 m (horizontally) and then trimmed back to the well compacted material.

Temporary batter slopes may be formed at 1V:1H in natural soils and rock. Permanent batter slopes should be constructed at a maximum grade of 1V:2H in stiff (or stiffer) natural clay materials and controlled fill, and 1V:1H in extremely low strength (or stronger) rock.

Permanent soil or fill batters will require erosion protection (e.g. revegetation or surface protection).

4.3 Retaining Structures

Where there is insufficient space to batter cut or fill embankments these slopes should be retained using engineer designed structures founded as described in Section 4.3 below. Retaining structures greater than 1 m high will require engineer design and certification of construction.

We suggest the following parameters may be adopted for retaining wall design:

- Friction Angle: 25 degrees (clay soils)
- Active Earth Pressure Coefficient: 0.4
- Unit Weight: 18 kN/m³

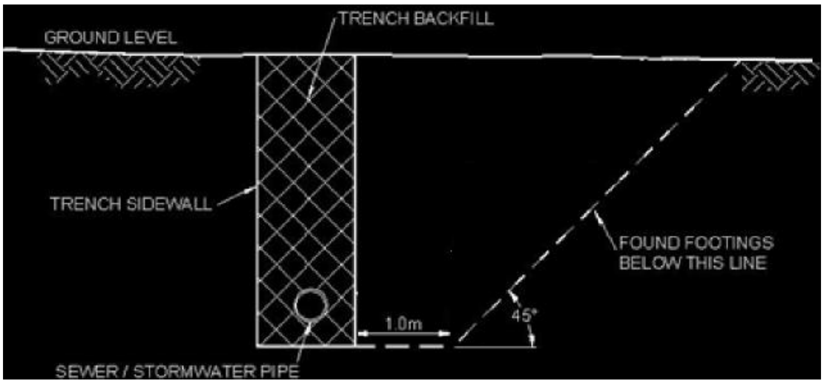
These parameters do not include allowance for surcharge above the wall, or additional loads imposed by sloping ground.

4.4 Footing Design

Footings for future buildings and any retaining walls should penetrate at least 0.3 m into very dense clayey sandy gravel/weathered rock. CQ borehole results indicate that footing depths would be about 0.9 m to 1.2 m BGL prior to future earthworks. Excavations may result in suitable foundation materials being exposed at subgrade level, however where future fill is proposed, foundation depths will be greater. Slab beams, strip/pad footings, short bored piles, or concrete pedestals founded 0.3 m into very dense clayey sandy gravel/weathered rock may be designed using an allowable bearing capacity of 400 kPa.

CQ have advised that site reactivity is equivalent to Class S, in accordance with the definitions given in AS2870. Design of the footing system must take the potential site reactivity into account.

All footings should found such that they are not adversely affected by any adjacent excavations, batter slopes, trenches, or retaining walls that are not designed to support building loads. Footings should found at least below a plane extending 1 m horizontally from the base of trenches/batter slopes/excavations/retaining walls, then rising up at 1V:1H, as illustrated in Text Figure 7.



Text Figure 7: Footing depth required to avoid trench interaction

Footing bases must be cleaned following mechanical excavation to expose undisturbed materials over the full base area. It is recommended that footings be inspected by an experienced engineer prior to placement of steel reinforcement to confirm allowable bearing pressures and cleanliness of excavations.

If any soil conditions encountered during construction are found to differ from those noted in the geotechnical investigation, CQ and Tectonic should be notified immediately and an inspection carried out to determine if changes to footing design are required.

4.5 Drainage

Surface diversion drainage should be constructed above the crest of any new cut or fill embankments (e.g. grassed or landscaped swales or diversion mounds).

Adequate site drainage should be installed to ensure that natural runoff is directed away from building walls and footings.

Subsurface drainage must be installed behind future retaining walls in order to prevent the development of hydrostatic pressure (e.g. slotted ‘aggi’ pipe wrapped in filter ‘sock’ placed in gravel backfill).

All excess stormwater collected around the site (including overflow from rainwater tanks) must be directed by pipes or lined channels to either an existing stormwater system along Holt Street (if present) or the gully located to the south.

To maintain the stability of the site, subsurface disposal of stormwater must not be undertaken.

4.6 Further Investigation

Once development plans for the site are available, further geotechnical investigation and slope stability assessment will be required to confirm constraints and parameters for design and construction.

5.0 SUMMARY & CONCLUSIONS

Based on the findings of our assessment we consider, from a geotechnical viewpoint, that there is generally a Low Risk of slope instability affecting development of this site. This advice is subject to implementation of the recommendations given in this report, in particular:

- Minimising fill depths to 1 m unless supported by an engineered retaining wall, or approved by Tectonic.
- Supporting structures on footings taken into natural very dense clayey sandy gravel/weathered rock.
- Ensuring that stormwater collected by drainage, including tank overflow, is directed to the existing council stormwater system along Holt Street (if present) or to the gully located to the south.
- Further geotechnical investigation and slope stability assessment once development plans are available.

6.0 LIMITATIONS

Your attention is drawn to the document Limitations, which is attached to this letter report.

Please contact the undersigned should you wish to discuss any of the above matters.

Yours faithfully

TECTONIC GEOTECHNICAL PTY LTD

Darryn Quinn BEng (Geological) RPEQ 7602
Principal Geotechnical Engineer

Attachments: Qualitative Terminology for Use in Assessing Risk to Property
Some Guidelines for Hillside Construction
Limitations

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	5×10^{-2}	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	5×10^{-3}	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	5×10^{-4}	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	5×10^{-5}	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	5×10^{-6}	100,000 years	200,000 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 over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	**1: CATASTROPHIC 200%**	**2: MAJOR 60%**	**3: MEDIUM 20%**	**4: MINOR 5%**	**5: INSIGNIFICANT 0.5%**
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or **L** (5)
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: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.

(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

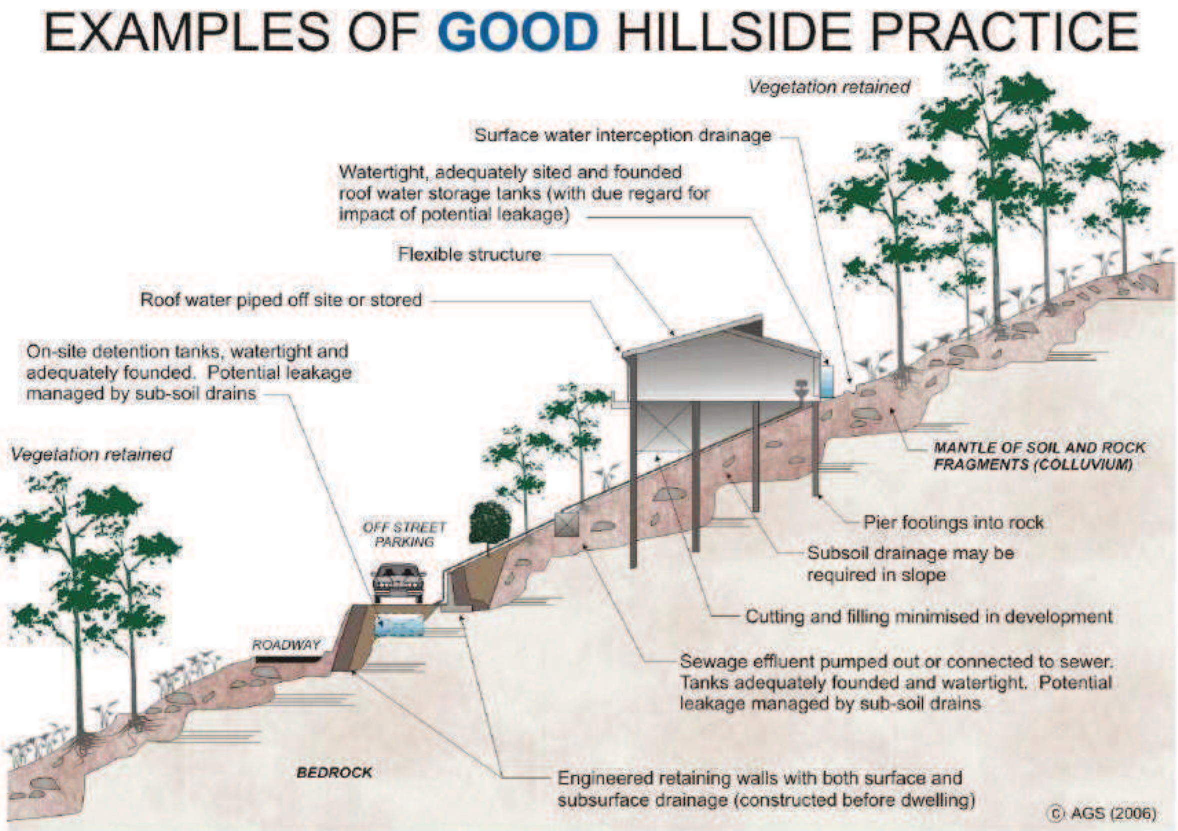
RISK LEVEL IMPLICATIONS

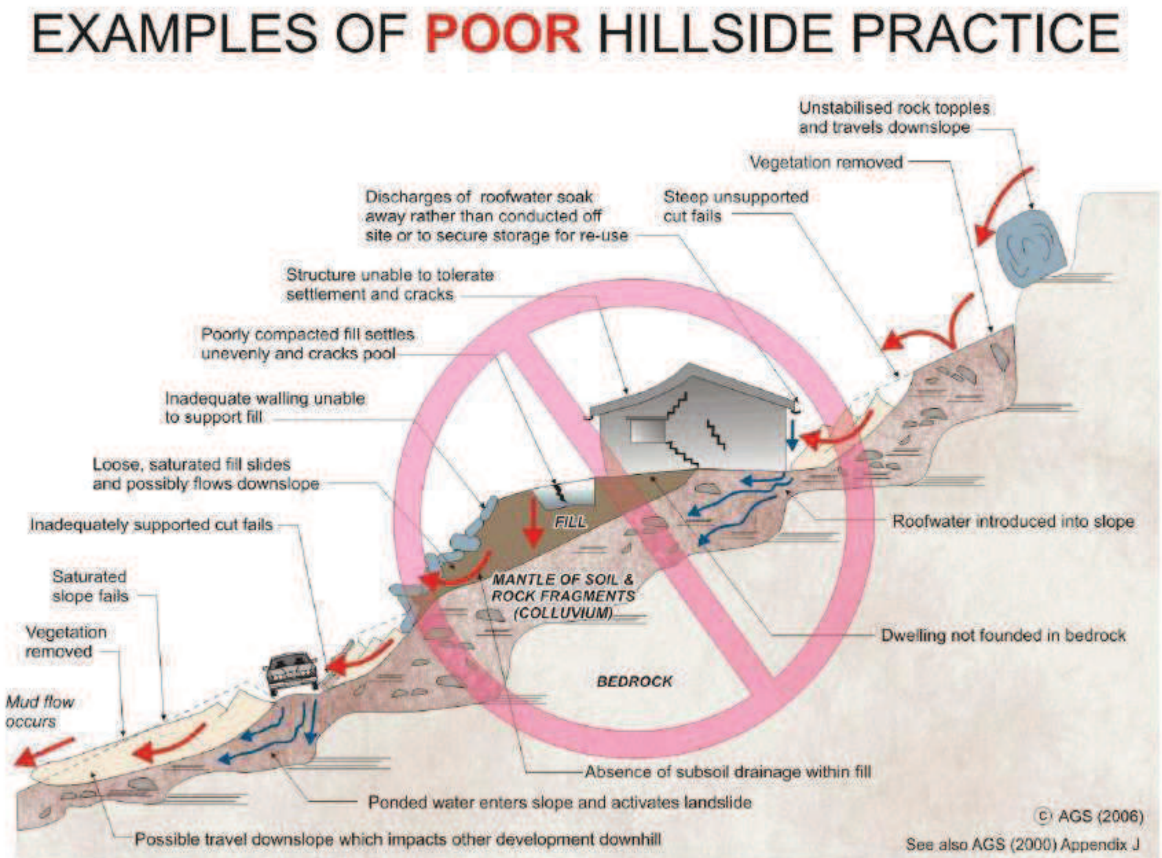
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	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 RISK	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 RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	


EXAMPLES OF GOOD HILLSIDE PRACTICE
Vegetation retained
Surface water interception drainage
Watertight, adequately sited and founded roof water storage tanks (with due regard for impact of potential leakage)
Flexible structure
Roof water piped off site or stored
On-site detention tanks, watertight and adequately founded. Potential leakage managed by sub-soil drains
Vegetation retained
MANTLE OF SOIL AND ROCK FRAGMENTS (COLLUVIUM)
OFF STREET PARKING
Pier footings into rock
Subsoil drainage may be required in slope
Cutting and filling minimised in development
ROADWAY
Sewage effluent pumped out or connected to sewer. Tanks adequately founded and watertight. Potential leakage managed by sub-soil drains
BEDROCK
Engineered retaining walls with both surface and subsurface drainage (constructed before dwelling)
© AGS (2006)


EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles unevenly and cracks pool
Inadequate walling unable to support fill
Loose, saturated fill slides and possibly flows downslope
FILL
Roofwater introduced into slope
Inadequately supported cut fails
MANTLE OF SOIL & ROCK FRAGMENTS (COLLUVIUM)
Saturated slope fails
Dwelling not founded in bedrock
Vegetation removed
BEDROCK
Mud flow occurs
Absence of subsoil drainage within fill
Ponded water enters slope and activates landslide
© AGS (2006)
Possible travel downslope which impacts other development downhill
See also AGS (2000) Appendix J

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mcmurtrie
CONSULTING ENGINEERS

Stormwater Management

Holt Street Property (Lot 153 on RP866052)

Rockhampton, Queensland

St Luke's Healing Foundation

September 2016

Revision B

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Stormwater Management

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Rev.	Description	Prepared By		Reviewed By		Date
		Name	Ini.	Name	Ini.	
B	RPEQ Certification	Mayur Mathev	[signature]	Ian McMurtrie	[signature]	02.09.16
A	Issued for Approval	Mayur Mathev	MM	-	-	11.07.16

Authorised: Ian McMurtrie
RPEQ 1347
For McMurtrie Consulting Engineers

Contents

Stormwater Management

Holt Street Property (Lot 153 on RP866052)

1.0 INTRODUCTION

This study considers stormwater discharge relevant to the existing pre-developed state and looks at the impact on water levels resulting from the post development conditions. Hydrologic assessment and design flows for the subject site have been completed using the Rational Method in accordance with Queensland Urban Drainage Manual (QUDM, 3rd edition 2013 – provisional), Section 4.

2.0 CATCHMENT HYDROLOGY

2.1 Catchment C1

Rainfall Data	Rainfall volumes and temporal patterns have been determined using Intensity Frequency Duration (IFD) Curves published on CMDG, Stormwater Drainage Design – D5.	
IFD Location	East of Bruce Highway and Berserker Ranges, CMDG D5 – Fig D5.04.17	
Level Control	Obtained from Google Earth Contour	
Pre - Development	Description	Open Space – Medium Density Bush
	Fraction Impervious	0
	Coefficient of Discharge	0.84
	Area (Ha)	2.85
	Time of Concentration (mins)	9.24
Post - Development	Description	Mostly Open Space with small percentage of impervious area (part of sealed driveway and building)
	Fraction Impervious	0.1
	Coefficient of Discharge	0.84
	Area (Ha)	2.85
	Time of Concentration (mins)	9.24

ARI	Q100 - Pre (m^3/sec)	Q10 - Post (m^3/sec)	Q100 - Post (m^3/sec)
Discharge	1.770	0.948	1.770

2.2 Catchment C2

Rainfall Data	Rainfall volumes and temporal patterns have been determined using Intensity Frequency Duration (IFD) Curves published on CMDG, Stormwater Drainage Design – D5.	
IFD Location	East of Bruce Highway and Berserker Ranges, CMDG D5 – Fig D5.04.17	
Level Control	Obtained from Google Earth Contour	
Pre - Development	Description	Open Space – Medium Density Bush
	Fraction Impervious	0
	Coefficient of Discharge	0.84
	Area (Ha)	23.3
	Time of Concentration (mins)	11.91
Post - Development	Description	Mostly Open Space with small percentage of impervious area (part of sealed driveway and building)
	Fraction Impervious	0.1
	Coefficient of Discharge	0.84
	Area (Ha)	23.3
	Time of Concentration (mins)	11.91

ARI	Q100 - Pre (m^3/sec)	Q10 - Post (m^3/sec)	Q100 - Post (m^3/sec)
Discharge	13.657	7.345	13.657

The Q100 pre and post development discharge for the site is same as the fraction impervious for post development is less than 0.2. Refer Appendix A for detailed hydrology analysis.

3.0 CROSS DRAINAGE STRUCTURES

This access has been designed for 10 year average recurrence interval immunity. The cross drainage (culverts) structures at chainages 33.5m and 147.5m have been designed to for minor system in accordance with QUDM 2013, Table 7.3.1.

3.1 Chainage 33.5m

The allowable outlet velocity for the cross drainage structure is limited to 4 m/s to avoid erosion at downstream of the outlet. The downstream bed is lined with rock (refer Catchment Plan in Appendix A and Austroads 2013, Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodway, Section 3.7.2). Three pipes of the same size has been assumed to cater for Q10 discharge. Therefore the discharge per cell is 2.45 m^3/sec.

Discharge	Q	m^3/sec	2.450
Allowable Outlet Velocity	V_o	m/sec	4.000
Culvert Area	A	m^2	0.613
Culvert Pipe Diameter	D	m	0.883

Therefore three 900 diameter concrete pipes have been proposed to cater for Q10 discharge. To reduce the energy of the flow further at the outlet and control of bed scour rock pad will be installed.

3.2 Chainage 147.5m

The allowable outlet velocity for this structure is limited to 2.7 m/s to avoid erosion at downstream of the outlet. The downstream bed is assumed to be grass cover (refer Austroads 2013, Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodway, Section 3.7.2).

Discharge	Q	m^3/sec	0.948
Allowable Outlet Velocity	V_o	m/sec	2.700
Culvert Area	A	m^2	0.351
Culvert Pipe Diameter	D	m	0.669

Therefore 675 diameter concrete pipe has been proposed to cater for Q10 discharge. Rock pad will be installed the outlet to reduce the energy of the flow and control of bed scour.

During 100 year ARI the proposed table drain will be carrying the rest of the Q100 discharge. Refer Appendix B for Table Drain Capacity calculations. Rock check dams will be installed in the table drain to reduce the velocity and bed scour.

Appendix A

Hydrology Analysis

CATCHMENT PLAN
NOT TO SCALE

INFORMATION ONLY

SURVEYOR								
ADDRESS:								
CO-ORDINATE DATUM								
HEIGHT DATUM	A		SUBMITTED FOR INFORMATION					
	REV	DATE	REVISION DESCRIPTION	DRAFT	DESIGN	RPEQ ENG	DATE	

	BY	DATE
DRAFT		
DESIGN		
CHECKED		
REVIEWED		
RPEQ ENG		
RPEQ No:		

CLIENT

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SCALE: NTS

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CLIENT DAVID GENTLE
PROJECT HOLT STREET PROPERTY
TITLE STORMWATER CATCHMENT PLAN

A1 | DRAWING NUMBER 0731415-SK-01 | REVISION A

Stormwater Design
Rational Method

Project No:	**073-14-15**
Project Description:	**Holt Street Property**
Design Details:	**Q100 Pre-Development, C1**

Coefficient of Discharge Section

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Fractions Impervious	f_i		0.000	QUDM 2013, Table 4.5.1	***Open Space***
1 hour ARI 10 rainfall intensity	$^{1hr}i_{10}$	mm/hr	71.9	CMDG 2015, D5, Fig D5.04.16	
Frequency Factor	F_y		1.20	QUDM 2013, Table 4.5.2	***Q100 Pre-Development, C1***
10yr Coefficient of Discharge	C_{10}		0.7	QUDM 2013, Table 4.5.3 or 4.5.4	***Table 4.5.4, Medium Density Bush, Medium Soil Permeability***
"y' yr Coefficient of Discharge	C_y		0.84	QUDM 2013, Eqn 4.4 $= F_y \times C_{10}$	
Adopted Coefficient of Discharge is:	C_y		**0.84**	***Where a coefficient of discharge calculated from Equation 4.4 for an urban catchment exceeds 1.00, it should be arbitrarily set to 1.0 in accordance with 'the recommendations of Australian Rainfall and Runoff (1998).***	

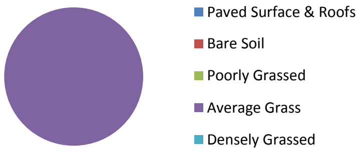
Time of Concentration

Overland Sheet Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	L	m	20	QUDM 2013, Table 4.6.4	

Breakdown of Horton's Surface Areas

	n	**m^2**	***%***	
Paved Surface & Roofs	0.015	0	0%	0.000
Bare Soil	0.0275		0%	0.000
Poorly Grassed	0.035		0%	0.000
Average Grass	0.045	100	100%	0.045
Densely Grassed	0.060		0%	0.000
Total		**100**		**0.045**



Description	Symbol	Unit	Value	Reference	Comments
Horton's surface roughness factor	n		0.045		***Refer above for breakdown of areas***
Slope of surface	S	%	40.0		
Overland sheet flow travel time	t	min	6.24	QUDM 2013, Eqn 4.5 $= (107\, n\, L^{0.333}) / S^{0.2}$	*Friend's Equation (QUDM 2013, Eqn 4.5)*

Overland Concentrated Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	L	m	470	QUDM 2013, Section 4.6.6 (b)	
Fall of channel	S	%	24.0		
Overland concentrated flow travel time	t	min	3.00	QUDM 2013, Fig 4.8	

Total Flow Time

Total flow travel time	t	min	9.24

Peak Flow Rate Calculation

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
"y' yr Coefficient of Discharge	C_y		0.84	As above	
Catchment Area	A	ha	2.85		
Average rainfall intensity for a design duration of '*t*' hours (calculated above) and an ARI of 'y' years	^tI_y	mm/hr	266	CMDG 2015, D5, Fig D5.04.17	
Peak Flow Rate for an ARI of 'y' years	Q_y	m^3/sec	**1.770**	QUDM 2013, Eqn 4.2	

Stormwater Design
Rational Method

Project No:	**073-14-15**
Project Description:	**Holt Street Property**
Design Details:	**Q10 Post-Development, C1**

Coefficient of Discharge Section

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Fractions Impervious	f_i		0.100	QUDM 2013, Table 4.5.1	
1 hour ARI 10 rainfall intensity	$^{1hr}i_{10}$	mm/hr	71.9	CMDG 2015, D5, Fig D5.04.16	
Frequency Factor	F_y		1.00	QUDM 2013, Table 4.5.2	***Q10 Post-Development, C1***
10yr Coefficient of Discharge	C_{10}		0.7	QUDM 2013, Table 4.5.3 or 4.5.4	***Table 4.5.4, Medium Density Bush, Medium Soil Permeability***
"y' yr Coefficient of Discharge	C_y		0.70	QUDM 2013, Eqn 4.4 $= F_y \times C_{10}$	
Adopted Coefficient of Discharge is:	C_y		**0.70**	***Where a coefficient of discharge calculated from Equation 4.4 for an urban catchment exceeds 1.00, it should be arbitrarily set to 1.0 in accordance with 'the recommendations of Australian Rainfall and Runoff (1998).***	

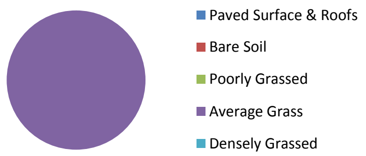
Time of Concentration

Overland Sheet Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	*L*	m	20	QUDM 2013, Table 4.6.4	

Breakdown of Horton's Surface Areas

	n	***m²***	***%***	
Paved Surface & Roofs	0.015	0	0%	0.000
Bare Soil	0.0275		0%	0.000
Poorly Grassed	0.035		0%	0.000
Average Grass	0.045	100	100%	0.045
Densely Grassed	0.060		0%	0.000
Total		**100**		**0.045**



Horton's surface roughness factor	*n*		0.045		***Refer above for breakdown of areas***
Slope of surface	*S*	%	40.0		
Overland sheet flow travel time	*t*	min	6.24	QUDM 2013, Eqn 4.5 $= (107\,n\,L^{0.333}) / S^{0.2}$	*Friend's Equation (QUDM 2013, Eqn 4.5)*

Overland Concentrated Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	*L*	m	670	QUDM 2013, Section 4.6.6 (b)	
Fall of channel	*S*	%	24.0		
Overland concentrated flow travel time	*t*	min	3.00	QUDM 2013, Fig 4.8	

Total Flow Time

Total flow travel time	*t*	min	9.24	

Peak Flow Rate Calculation

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
"y' yr Coefficient of Discharge	C_y		0.70	As above	
Catchment Area	*A*	ha	2.85		
Average rainfall intensity for a design duration of '*t*' hours (calculated above) and an ARI of 'y' years	$^{t}I_y$	mm/hr	171	CMDG 2015, D5, Fig D5.04.17	
Peak Flow Rate for an ARI of 'y' years	Q_y	m^3/sec	**0.948**	QUDM 2013, Eqn 4.2	

Stormwater Design
Rational Method

Project No:	**073-14-15**
Project Description:	**Holt Street Property**
Design Details:	**Q100 Post-Development, C1**

Coefficient of Discharge Section

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Fractions Impervious	f_i		0.100	QUDM 2013, Table 4.5.1	
1 hour ARI 10 rainfall intensity	$^{1hr}i_{10}$	mm/hr	71.9	CMDG 2015, D5, Fig D5.04.16	
Frequency Factor	F_y		1.20	QUDM 2013, Table 4.5.2	***Q100 Post-Development, C1***
10yr Coefficient of Discharge	C_{10}		0.7	QUDM 2013, Table 4.5.3 or 4.5.4	***Table 4.5.4, Medium Density Bush, Medium Soil Permeability***
"y' yr Coefficient of Discharge	C_y		0.84	QUDM 2013, Eqn 4.4 $= F_y \times C_{10}$	

Adopted Coefficient of Discharge is:	C_y		**0.84**	***Where a coefficient of discharge calculated from Equation 4.4 for an urban catchment exceeds 1.00, it should be arbitrarily set to 1.0 in accordance with 'the recommendations of Australian Rainfall and Runoff (1998).***

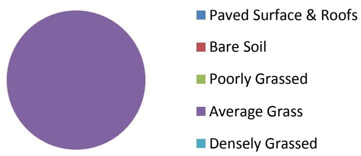
Time of Concentration

Overland Sheet Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	L	m	20	QUDM 2013, Table 4.6.4	

Breakdown of Horton's Surface Areas

	n	***m²***	***%***	
Paved Surface & Roofs	0.015	0	0%	0.000
Bare Soil	0.0275		0%	0.000
Poorly Grassed	0.035		0%	0.000
Average Grass	0.045	100	100%	0.045
Densely Grassed	0.060		0%	0.000
Total		**100**		**0.045**



Horton's surface roughness factor	n		0.045		***Refer above for breakdown of areas***
Slope of surface	S	%	40.0		
Overland sheet flow travel time	t	min	6.24	QUDM 2013, Eqn 4.5 $= (107\, n\, L^{0.333}) / S^{0.2}$	*Friend's Equation (QUDM 2013, Eqn 4.5)*

Overland Concentrated Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	L	m	470	QUDM 2013, Section 4.6.6 (b)	

Fall of channel	S	%	24.0	
Overland concentrated flow travel time	t	min	3.00	QUDM 2013, Fig 4.8

Total Flow Time

Total flow travel time	t	min	9.24

Peak Flow Rate Calculation

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
"y' yr Coefficient of Discharge	C_y		0.84	As above	
Catchment Area	A	ha	2.85		
Average rainfall intensity for a design duration of '*t*' hours (calculated above) and an ARI of 'y' years	^tI_y	mm/hr	266	CMDG 2015, D5, Fig D5.04.17	
Peak Flow Rate for an ARI of 'y' years	Q_y	m³/sec	**1.770**	QUDM 2013, Eqn 4.2	

Stormwater Design
Rational Method

Project No:	**073-14-15**
Project Description:	**Holt Street Property**
Design Details:	**Q100 Pre-Development, C2**

Coefficient of Discharge Section

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Fractions Impervious	f_i		0.000	QUDM 2013, Table 4.5.1	***Open Space***
1 hour ARI 10 rainfall intensity	${}^{1hr}i_{10}$	mm/hr	71.9	CMDG 2015, D5, Fig D5.04.16	
Frequency Factor	F_y		1.20	QUDM 2013, Table 4.5.2	***Q100 Pre-Development, C2***
10yr Coefficient of Discharge	C_{10}		0.7	QUDM 2013, Table 4.5.3 or 4.5.4	***Table 4.5.4, Medium Density Bush, Medium Soil Permeability***
"y' yr Coefficient of Discharge	C_y		0.84	QUDM 2013, Eqn 4.4 $= F_y \times C_{10}$	
Adopted Coefficient of Discharge is:	C_y		**0.84**	***Where a coefficient of discharge calculated from Equation 4.4 for an urban catchment exceeds 1.00, it should be arbitrarily set to 1.0 in accordance with 'the recommendations of Australian Rainfall and Runoff (1998).***	

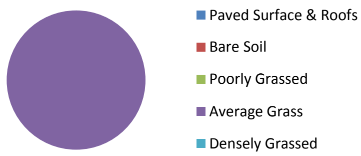
Time of Concentration

Overland Sheet Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	*L*	m	20	QUDM 2013, Table 4.6.4	

Breakdown of Horton's Surface Areas

	n	***m²***	***%***	
Paved Surface & Roofs	0.015	0	0%	0.000
Bare Soil	0.0275		0%	0.000
Poorly Grassed	0.035		0%	0.000
Average Grass	0.045	650	100%	0.045
Densely Grassed	0.060		0%	0.000
Total		**650**		**0.045**



Horton's surface roughness factor	*n*		0.045		***Refer above for breakdown of areas***
Slope of surface	*S*	%	35.0		
Overland sheet flow travel time	*t*	min	6.41	QUDM 2013, Eqn 4.5 $= (107\, n\, L^{0.333}) / S^{0.2}$	*Friend's Equation (QUDM 2013, Eqn 4.5)*

Overland Concentrated Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	*L*	m	785	QUDM 2013, Section 4.6.6 (b)	
Fall of channel	*S*	%	24.0		
Overland concentrated flow travel time	*t*	min	5.50	QUDM 2013, Fig 4.8	

Total Flow Time

Total flow travel time	*t*	min	**11.91**	

Peak Flow Rate Calculation

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
"y' yr Coefficient of Discharge	C_y		0.84	As above	
Catchment Area	*A*	ha	23.3		
Average rainfall intensity for a design duration of '*t*' hours (calculated above) and an ARI of 'y' years	${}^tI_y$	mm/hr	251	CMDG 2015, D5, Fig D5.04.17	
Peak Flow Rate for an ARI of 'y' years	Q_y	m^3/sec	**13.657**	QUDM 2013, Eqn 4.2	

Stormwater Design
Rational Method

Project No:	**073-14-15**
Project Description:	**Holt Street Property**
Design Details:	**Q10 Post-Development, C2**

Coefficient of Discharge Section

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Fractions Impervious	f_i		0.100	QUDM 2013, Table 4.5.1	
1 hour ARI 10 rainfall intensity	$^{1hr}i_{10}$	mm/hr	71.9	CMDG 2015, D5, Fig D5.04.16	
Frequency Factor	F_y		1.00	QUDM 2013, Table 4.5.2	***Q10 Post-Development, C2***
10yr Coefficient of Discharge	C_{10}		0.7	QUDM 2013, Table 4.5.3 or 4.5.4	***Table 4.5.4, Medium Density Bush, Medium Soil Permeability***
"y' yr Coefficient of Discharge	C_y		0.70	QUDM 2013, Eqn 4.4 $= F_y \times C_{10}$	
Adopted Coefficient of Discharge is:	C_y		**0.70**	***Where a coefficient of discharge calculated from Equation 4.4 for an urban catchment exceeds 1.00, it should be arbitrarily set to 1.0 in accordance with 'the recommendations of Australian Rainfall and Runoff (1998).***	

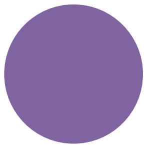
Time of Concentration

Overland Sheet Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	*L*	m	20	QUDM 2013, Table 4.6.4	

Breakdown of Horton's Surface Areas

	n	m^2	*%*	
Paved Surface & Roofs	0.015	0	0%	0.000
Bare Soil	0.0275		0%	0.000
Poorly Grassed	0.035		0%	0.000
Average Grass	0.045	650	100%	0.045
Densely Grassed	0.060		0%	0.000
Total		**650**		**0.045**



Horton's surface roughness factor	*n*		0.045		***Refer above for breakdown of areas***
Slope of surface	*S*	%	35.0		
Overland sheet flow travel time	*t*	min	6.41	QUDM 2013, Eqn 4.5 $= (107\, n\, L^{0.333}) / S^{0.2}$	*Friend's Equation (QUDM 2013, Eqn 4.5)*

Overland Concentrated Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	*L*	m	870	QUDM 2013, Section 4.6.6 (b)	
Fall of channel	*S*	%	24.0		
Overland concentrated flow travel time	*t*	min	5.50	QUDM 2013, Fig 4.8	
Total Flow Time					
Total flow travel time	*t*	min	11.91		

Peak Flow Rate Calculation

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
"y' yr Coefficient of Discharge	C_y		0.70	As above	
Catchment Area	*A*	ha	23.3		
Average rainfall intensity for a design duration of '*t*' hours (calculated above) and an ARI of 'y' years	^tI_y	mm/hr	162	CMDG 2015, D5, Fig D5.04.17	
Peak Flow Rate for an ARI of 'y' years	Q_y	m^3/sec	**7.345**	QUDM 2013, Eqn 4.2	

Stormwater Design
Rational Method

Project No:	**073-14-15**
Project Description:	**Holt Street Property**
Design Details:	**Q100 Post-Development, C2**

Coefficient of Discharge Section

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Fractions Impervious	f_i		0.100	QUDM 2013, Table 4.5.1	
1 hour ARI 10 rainfall intensity	$^{1hr}i_{10}$	mm/hr	71.9	CMDG 2015, D5, Fig D5.04.16	
Frequency Factor	F_y		1.20	QUDM 2013, Table 4.5.2	***Q100 Post-Development, C2***
10yr Coefficient of Discharge	C_{10}		0.7	QUDM 2013, Table 4.5.3 or 4.5.4	***Table 4.5.4, Medium Density Bush, Medium Soil Permeability***
"y' yr Coefficient of Discharge	C_y		0.84	QUDM 2013, Eqn 4.4 $= F_y \times C_{10}$	
Adopted Coefficient of Discharge is:	C_y		**0.84**	***Where a coefficient of discharge calculated from Equation 4.4 for an urban catchment exceeds 1.00, it should be arbitrarily set to 1.0 in accordance with 'the recommendations of Australian Rainfall and Runoff (1998).***	

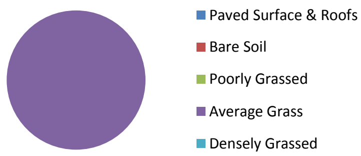
Time of Concentration

Overland Sheet Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	L	m	20	QUDM 2013, Table 4.6.4	

Breakdown of Horton's Surface Areas

	n	**m^2**	***%***	
Paved Surface & Roofs	0.015	0	0%	0.000
Bare Soil	0.0275		0%	0.000
Poorly Grassed	0.035		0%	0.000
Average Grass	0.045	650	100%	0.045
Densely Grassed	0.060		0%	0.000
Total		**650**		**0.045**



Horton's surface roughness factor	n		0.045		***Refer above for breakdown of areas***
Slope of surface	S	%	35.0		
Overland sheet flow travel time	t	min	6.41	QUDM 2013, Eqn 4.5 $= (107\, n\, L^{0.333}) / S^{0.2}$	*Friend's Equation (QUDM 2013, Eqn 4.5)*

Overland Concentrated Flow Time

Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
Flow path Length	L	m	785	QUDM 2013, Section 4.6.6 (b)	
Fall of channel	S	%	24.0		
Overland concentrated flow travel time	t	min	5.50	QUDM 2013, Fig 4.8	

Total Flow Time

Total flow travel time	t	min	11.91

Peak Flow Rate Calculation

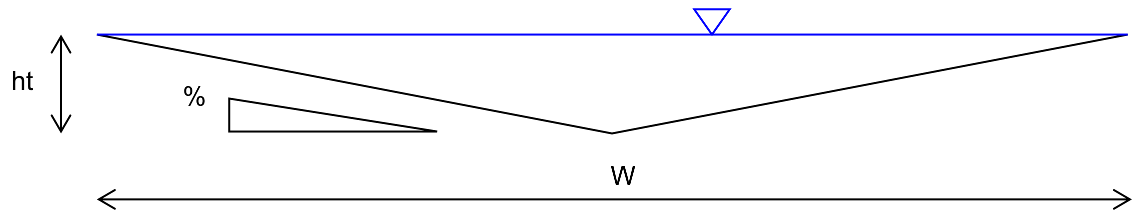
Description	*Symbol*	*Unit*	*Value*	*Reference*	*Comments*
"y' yr Coefficient of Discharge	C_y		0.84	As above	
Catchment Area	A	ha	23.3		
Average rainfall intensity for a design duration of '*t*' hours (calculated above) and an ARI of 'y' years	^tI_y	mm/hr	251	CMDG 2015, D5, Fig D5.04.17	
Peak Flow Rate for an ARI of 'y' years	Q_y	m^3/sec	**13.657**	QUDM 2013, Eqn 4.2	

Appendix B

Table Drain Capacity

Open Channel Flow Capacity
"V" Shape Table Drain

Project No:	**073-14-15**
Project Descrption:	**Holt Street Property**



Descrption	Symbol	Units	
Manning's Roughness	n		0.030
Hydraulic Radius	Rh	m	0.13
Wetted Perimeter	P	m	1.34
Area	A	m^2	0.18
Flow depth	ht	m	0.300
Inverted Crossfall	%	m/m	0.50
Longitudinal Grade	S	m/m	0.2000
Flow Width	W	m	1.200
Velocity	V	m/s	3.91
Flow Rate	Q	m^3/s	0.70