


Classic Developments

Patterson Block

Section 32 Stormwater Technical Evidence

24/03/2023

Prime3 consulting
182 Arthurs Point Road
Queenstown, 9371

Document Information	
Document Number:	P3TR2200016.00 - SW Technical Evidence
Issue Date:	24/03/2023

Document Control			
Revision	Date	Details	Author
A	24/03/2023	Preliminary issue for client information	Andrew Tipene (CPEng)

Contents

Attachments

List of figures

List of tables

Abbreviations

AEP	Annual Exceedance Probability
LDSCoP	QLDC Land development and Subdivision Code of Practice
CN	Curve Number
HIRDS	High Intensity Rainfall Design System
NIWA	National Institute of Water and Atmospheric Research
ODP	QLDC Operative District Plan
QLDC	Queenstown Lakes District Council
RCP	Representative Concentration Pathways
RMA	Resource Management Act 1991
SCS	Soil Conservation Services
SRM	Standard Rational Method

1. Executive summary

An HEC-HMS model has been built and run with 1%AEP rainfall data to determine the peak flow and volume of runoff from the upper catchment (above State Highway 6) that currently flows onto the Patterson Block. This model also determines the Preconstruction and Postconstruction runoff from the Patterson Block into Woolshed Creek.

Modelling results show that circa 36.6 m^3/s flows must be conveyed from the upper catchments either around or through the Patterson Block development without causing flooding to the development's lots. Upstream catchment conveyance and development flood protection can be achieved through a circa. 11.6m wide open channel along the eastern and northern boundaries of the Patterson Block. Detailed earthwork design and further detailed runoff and conveyance modelling is required to ensure this open channel does not overtop in the future.

e due to increases in climate change rainfall.

The increase in runoff from development in the Patterson Block to 45% impervious can be managed with 4300m^3 of onsite attenuation in the form of a basin(s) along the northern and eastern boundaries or underground storage within the Patterson Block. This attenuation will ensure that there is no increase in downstream peak flows or flooding. Detailed earthworks and hydraulic design is required to ensure all storm events up to and including the 1% AEP are discharged at preconstruction hydraulic regimes (no change to the sites existing runoff).

Stormwater management of the upper catchments flood flows and the developments new impervious area runoff through engineering design is feasible and supports of the proposed plan change.

2. Background

A plan change request under RMA Section 32 for the Subject Site referred to as ‘the Patterson Block’ (Figure 1) is to be submitted by Clark Fortune McDonald (CFM) on behalf of Classic Developments.

Figure 1: Subject Site (Construkt Architects Masterplan)

2.1. Site location

The Patterson Block is located adjacent to the Woolshed Road and Kingston Highway (SH6) intersection prior to the Henleys Farm development (see Figure 2). The land parcels associated with the Patterson Block are referenced as 394 Kingston Road, Kingston 9371 Lot 3 DP 553950 and Lot 1 DP 475609.

Figure 2: Site location

2.2. Topography

The Patterson Block is currently grazed for animal stock and covered with grass land that falls in a North-western direction from 344.4m RL to 324.8m RL (approx. 2.5% slope). The grass land area is currently drained through informal farm drains, but large areas of overland sheet flow can be seen from aerial photos (see Attachment A).

Figure 3: Site elevation plan (LiDAR elevations in m RL)

2.3. Existing Infrastructure and services

The Patterson Block sits to the West of the Remarkable Ranges (Upper Catchment) which sheds runoff to the West across SH6 and across the Patterson Block through gullies, formal open channel drains, culverts and overland sheet flow and farm drains to Woolshed Creek. Flows through Woolshed Creek then flow North through downstream properties, back across SH6 and into the Kawarua River leading to Lake Dunstan. Four existing culverts across SH6 and Woolshed Road (see Figure 4) assist runoff from the Remarkable Ranges across SH6 and Woolshed Road. The existing inlet and outlet inverts of these culverts has been estimated from LiDAR information and presented in Table 1. It is expected that during large storm events (> 10% AEP) the culverts will be overtopped and runoff across SH6 and Woolshed Road is then directed back into the existing open channels and farm drains or continues as overland flow to Woolshed Creek.

Along the Western edge of the Patterson Block and along the Eastern side of Woolshed Creek, are QLDC Water and Wastewater services that service the Jacks Point and Henleys Farm developments. No other public Council services are present within the Patterson Block.

Figure 4: Existing infrastructure and services.

Table 1: Existing Culvert inverts

Culvert Refernce	Inlet Invert (m RL)	Outlet Invert (m RL)	Cover Level - Centre (m RL)
Culvert 1A	339.6	338.8	341.3
Culvert 1B	335.6	334.4	336.7
Culvert 2A	348.0	347.3	347.7
Culvert 2B	337.5	336.4	337.8

3. Scope of works

Prime3 Consulting has been engaged by Classic Developments to provide a stormwater runoff assessment and development stormwater management strategy to support the CFM plan change application.

This work has been undertaken to achieve the following goals:

- Estimate the upper catchment 1% AEP runoff from the Remarkable Ranges into the site.
- Determine feasible upper catchment flow conveyance options through or around the developed site.
- Determine existing (preconstruction) 1% AEP runoff from the site.
- Determine future (postconstruction) 1% AEP runoff from the site.
- Mitigate increases in the sites 1% AEP runoff to have no increase in flows or flood impacts downstream.

This stormwater assessment and management strategy is limited to the 1% AEP storm event used by local Council to determine the risk of development flood inundation and heights for lot levels.

With regards to mitigating increased development stormwater runoff from new impervious areas, the 1 % AEP also provides the largest onsite stormwater volume management system required, i.e., if the 1% AEP can be managed, it is acceptable that smaller storm events can also be managed in detailed design stages.

4. Stormwater modelling.

Stormwater runoff modelling has been undertaken using the SCS method (also known as the CN method) using HEC-HMS modelling software. The USDA TR55 methodology and HEC-HMS User's Manual detail this modelling method.

4.1. Design rainfall.

Rainfall data has been extracted from the NIWA High Intensity Rainfall Design System (HIRDs) V4 website (https://hirds.niwa.co.nz/). The upper catchment runoff assessment has been based on Historical Rainfall data as this determines the existing runoff onto the site that must be managed. While Climate Change affects will see an increase in future flows from the upper catchment these changes have been considered in the proposed Stormwater Management Section 6.1.

An assessment of different rainfall depth data was undertaken for different elevations within the Remarkable Ranges. This assessment showed a 25% increase in rainfall depth from 550m RL (Upper

Peaks) to 350m RL (SH6) within the Remarkable Ranges. This increase in rainfall depth is due to the NIWA HIRDs predictions of higher rainfall at higher elevations. For conservative purposes, runoff for the entire upper catchment was therefore estimated using rainfall data from the higher elevations (see Figure 5 and Table 2).

Figure 5: HIRDS rainfall data location (Upper catchment).

Latitude: -45.0577109, Longitude: 168.794460

Table 2: HIRDS Historical rainfall depths (Upper Catchment)

Duration (hours)	10	20	30	60	2	6	12	24
Duration (Minutes)	600	1200	1800	3600	120	360	720	1440
Depth (mm)	11.2	15.5	19.1	27.4	39.8	71.4	101.0	139.0

Rainfall for the preconstruction and postconstruction development site uses historical and RCP8.5 data respectively at the centre of the development site (see Figure 6, Table 3 and Table 4). RCP8.5 has been used to determine increases in the developments site runoff due to climate change.

Figure 6: HIRDS rainfall data location (Lower catchment).

Latitude: -45.055537, Longitude:168.749220

Table 3: HIRDS Historical rainfall depths (Lower Catchment)

Duration (hours)	10	20	30	60	2	6	12	24
Duration (Minutes)	600	1200	1800	3600	120	360	720	1440
Depth (mm)	11	16.2	20.2	28.8	40.2	64.6	83.9	105

Table 4: HIRDS RCP8.5 (2081-2100) rainfall depths (Lower Catchment)

Duration (hours)	10	20	30	60	2	6	12	24
Duration (Minutes)	600	1200	1800	3600	120	360	720	1440
Depth (mm)	14.9	21.9	27.2	38.9	53.8	83.8	106	129

4.2. Catchments

4.2.1. Upper catchment areas.

Catchment delineation has been undertaken using the LINZ data service (https://data.linz.govt.nz) 2016 and 2021 LiDAR for the Otago - Queenstown LiDAR 1m. Upper catchment breakpoints (catchment runoff points) were determined from the existing SH6 culvert locations directing runoff onto the Patterson Block site. Catchments runoff downstream from Culvert 1A and upstream from Culvert 2A are known to be directed through the Park Ridge and Henley Farm developments (see QLDC consents RM160171 and SH190488). The upper catchment areas shown in Figure 7 and Table 4 have been used for runoff estimation.

Figure 7: Upper catchment (Remarkable Ranges)

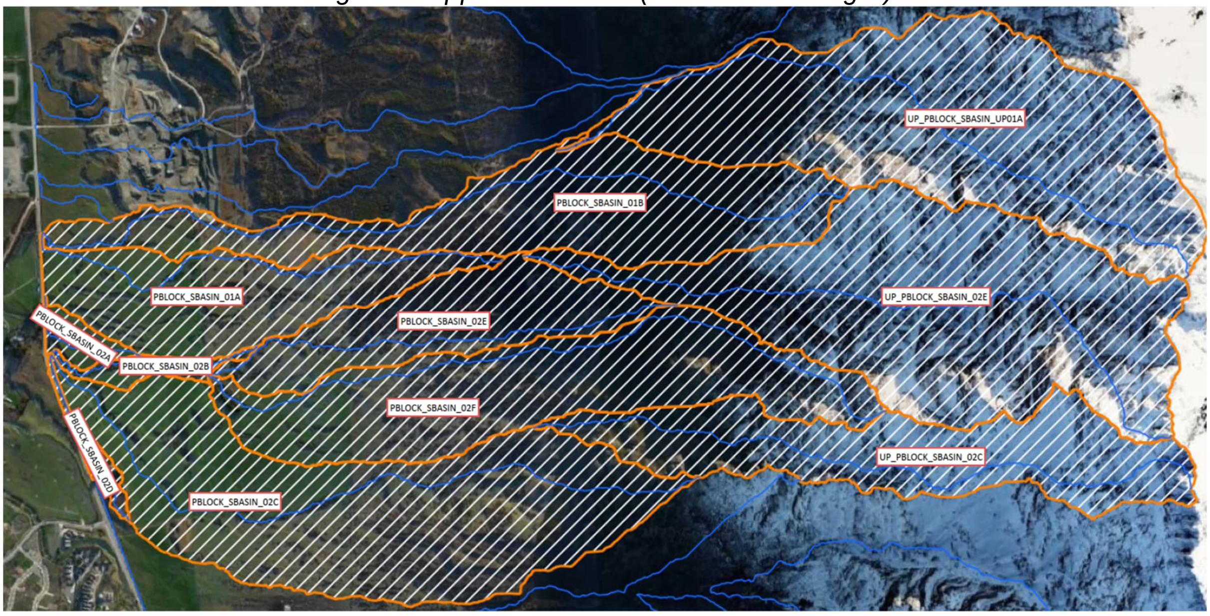


Table 5: Upper catchment areas.

Catchment Reference	Catchment Area (Ha)
UP_PBLOCK_SBASIN_UP01A	86.5
PBLOCK_SBASIN_01A	53.2
PBLOCK_SBASIN_01B	32.6
PBLOCK_SBASIN_02A	3.3

Catchment Reference	Catchment Area (Ha)
PBLOCK_SBASIN_02B	3.6
UP_PBLOCK_SBASIN_02C	44.7
PBLOCK_SBASIN_02C	81.5
PBLOCK_SBASIN_02D	2.1
UP_PBLOCK_SBASIN_02E	87.1
PBLOCK_SBASIN_02E	28.4
PBLOCK_SBASIN_02F	56.0

4.2.2. Lower catchment (development site) area.

The Patterson Block site catchment area (see Figure 8) has been calculated as 24.7ha. While this entire catchment may be developed in stages to a maximum 45% impervious area, this catchment area has been used to determine existing and future runoff and onsite stormwater management volume requirements.

Figure 8: Lower catchment (Development area)

4.3. Soil properties and rainfall losses

Given the bare rock and shallow soil coverage above approx. 450m RL, a Hydrological Soil Group D has been assumed with a SCS CN value of 89.

The land below approx. 450m RL and above 350m RL is known to compromise deep and fractured soil with moderate drainage. A Hydrological Soil Group B has been assumed with a SCS CN value of 65.

The catchment below SH6 (350m RL) comprises similar soils above SH6 and below 450m RL but has been cultivated through farm practices. A Hydrological Soil Group B has been assumed with a SCS CN value of 61.

Rainfall losses (Initial Abstraction) above 450m RL have been assumed zero due to the steep rock coverage. Below 450 m RL an initial abstraction of 5mm has been assumed.

4.4. Time of concentration.

The SCS method time of concentration has been determined from each catchment's CN value, longest flowpath length and slope, which is presented in Table 6.

Table 6: Catchment time of concentration.

Catchment Reference	Tc (mins)
UP_PBLOCK_SBASIN_01A	22.3
PBLOCK_SBASIN_01A	39.2
PBLOCK_SBASIN_01B	35.6
UP_PBLOCK_SBASIN_02C	20.5
UP_PBLOCK_SBASIN_02E	21.6
PBLOCK_SBASIN_02A	18.3
PBLOCK_SBASIN_02B	26.1

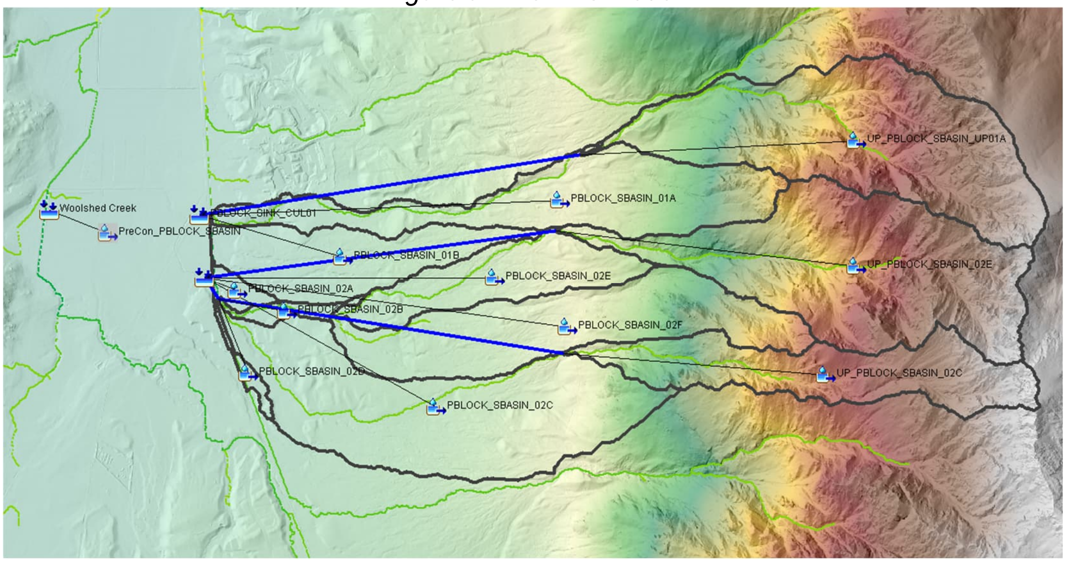
Catchment Reference	Tc (mins)
PBLOCK_SBASIN_02C	39.0
PBLOCK_SBASIN_02D	25.4
PBLOCK_SBASIN_02E	29.1
PBLOCK_SBASIN_02F	32.3
PATTERSON BLOCK (PRECONSTRUCTION)	34.2
PATTERSON BLOCK (POSTCONSTRUCTION)	15.7

4.5. Stormwater model

HECHMS was used to model runoff from the catchment areas and SCS method parameters above with flows routed through reaches to the two SH6 culverts. The peak catchment flows and volumes are shown in Table 7 and combined flows at the SH6 culverts are shown in

Table 8 below. The Patterson Block sites preconstruction and postconstruction peak flows and runoff volumes are also shown at the bottom of Table 7.

Figure 9: HECHMS model



5. Stormwater modelling results

Table 7: 1% AEP runoff peak flows and volumes.

Catchment Reference	Catchment Area (Ha)	Peak Flow (m3/s)	Runoff Volume (1000m3)
UP_PBLOCK_SBASIN_01A	86.5	9.3	97.2
PBLOCK_SBASIN_01A	53.2	2.6	34.6
PBLOCK_SBASIN_01B	32.6	1.7	21.2
UP_PBLOCK_SBASIN_02C	3.3	5.0	50.2
UP_PBLOCK_SBASIN_02E	3.6	9.5	97.9
PBLOCK_SBASIN_02A	44.7	0.2	2.2
PBLOCK_SBASIN_02B	81.5	0.2	2.3
PBLOCK_SBASIN_02C	2.1	4.0	52.9
PBLOCK_SBASIN_02D	87.1	0.1	1.4
PBLOCK_SBASIN_02E	28.4	1.6	18.5
PBLOCK_SBASIN_02F	56.0	3.0	36.5
PATTERSON BLOCK (PRECONSTRUCTION)	24.7	1.0	9.3
PATTERSON BLOCK (POSTCONSTRUCTION)	24.7	2.6	21.0

Table 8: Existing upper catchment flows at existing culvert locations.

SH6 Crossing	Peak Flow (m3/s)
Culvert 1A	13.5
Culvert 2A	23.1

5.1. Rational Method Model validation

The Standard Rational Method (SRM) provides a catchment runoff estimation that can be used to verify results of the SCS method HECHMS model. The following SRM parameters were used to estimate the Rational methods catchment runoff.

Table 9: Rational method parameters

Catchment Area	Runoff Coefficient	Hortons *n* value
Upper Catchment +450m RL	0.80	0.012
Upper Catchment +350m RL	0.45	0.015
Development Catchment (Preconstruction)	0.35	0.025
Development Catchment (Postconstruction) Impervious	0.95	0.012

Runoff peak flow and volume comparisons between the Rational method and SCS method are shown in Table 10 and Table 11. The percentage variance roughly shows that the HECHMS model provides sensible results. Some larger variance in peak flow for some smaller catchments is expected when comparing the SCS and Rational method, but these variances show that the SCS method estimates larger peak flows, and the smaller catchments have very little influence on the total catchments peak flow.

Table 10: Rational method runoff flow variance.

Catchment Reference	Catchment Area (Ha)	Rational Peak Flow (m3/s)	SCS Peak Flow (m3/s)	% Variance
UP_PBLOCK_SBASIN_01A	86.5	9.3	9.3	0.0%
PBLOCK_SBASIN_01A	53.2	2.6	2.6	-0.7%
PBLOCK_SBASIN_01B	32.6	1.6	1.7	3.4%
UP_PBLOCK_SBASIN_02C	44.7	5.0	5.0	0.0%
UP_PBLOCK_SBASIN_02E	87.1	9.5	9.5	0.0%
PBLOCK_SBASIN_02A	3.3	0.2	0.2	17.9%
PBLOCK_SBASIN_02B	3.6	0.2	0.2	10.4%
PBLOCK_SBASIN_02C	81.5	4.0	4.0	0.0%
PBLOCK_SBASIN_02D	2.1	0.1	0.1	12.1%
PBLOCK_SBASIN_02E	28.4	1.5	1.6	5.9%
PBLOCK_SBASIN_02F	56.0	2.9	3.0	2.3%
PATTERSON BLOCK (PRECONSTRUCTION)	24.7	9.3	9.3	0.0%
PATTERSON BLOCK (POSTCONSTRUCTION)	24.7	5.0	5.0	0.0%

Table 11: Rational method runoff volume variance.

Catchment Reference	Catchment Area (Ha)	Rational Runoff Volume (m3)	SCS Runoff Volume (m3)	% Variance
UP_PBLOCK_SBASIN_01A	86.5	96.2	97.2	1.0%
PBLOCK_SBASIN_01A	53.2	33.3	34.6	3.7%
PBLOCK_SBASIN_01B	32.6	20.4	21.2	3.9%
UP_PBLOCK_SBASIN_02C	3.3	49.7	50.2	1.1%
UP_PBLOCK_SBASIN_02E	3.6	96.8	97.9	1.1%
PBLOCK_SBASIN_02A	44.7	2.1	2.2	4.7%
PBLOCK_SBASIN_02B	81.5	2.2	2.3	4.3%
PBLOCK_SBASIN_02C	2.1	51.0	52.9	3.7%
PBLOCK_SBASIN_02D	87.1	1.3	1.4	4.4%
PBLOCK_SBASIN_02E	28.4	17.7	18.5	4.2%
PBLOCK_SBASIN_02F	56.0	35.0	36.5	4.0%
PATTERSON BLOCK (PRECONSTRUCTION)	24.7	96.2	97.2	1.0%
PATTERSON BLOCK (POSTCONSTRUCTION)	24.7	49.7	50.2	1.1%

6. Stormwater management

6.1. Upstream catchment conveyance

The estimated 36.6m3/s 1% AEP flows crossing SH6 and entering the Paterson Block site requires diversion around the development. Flows of this magnitude cannot be managed through the site via roads and green spaces.

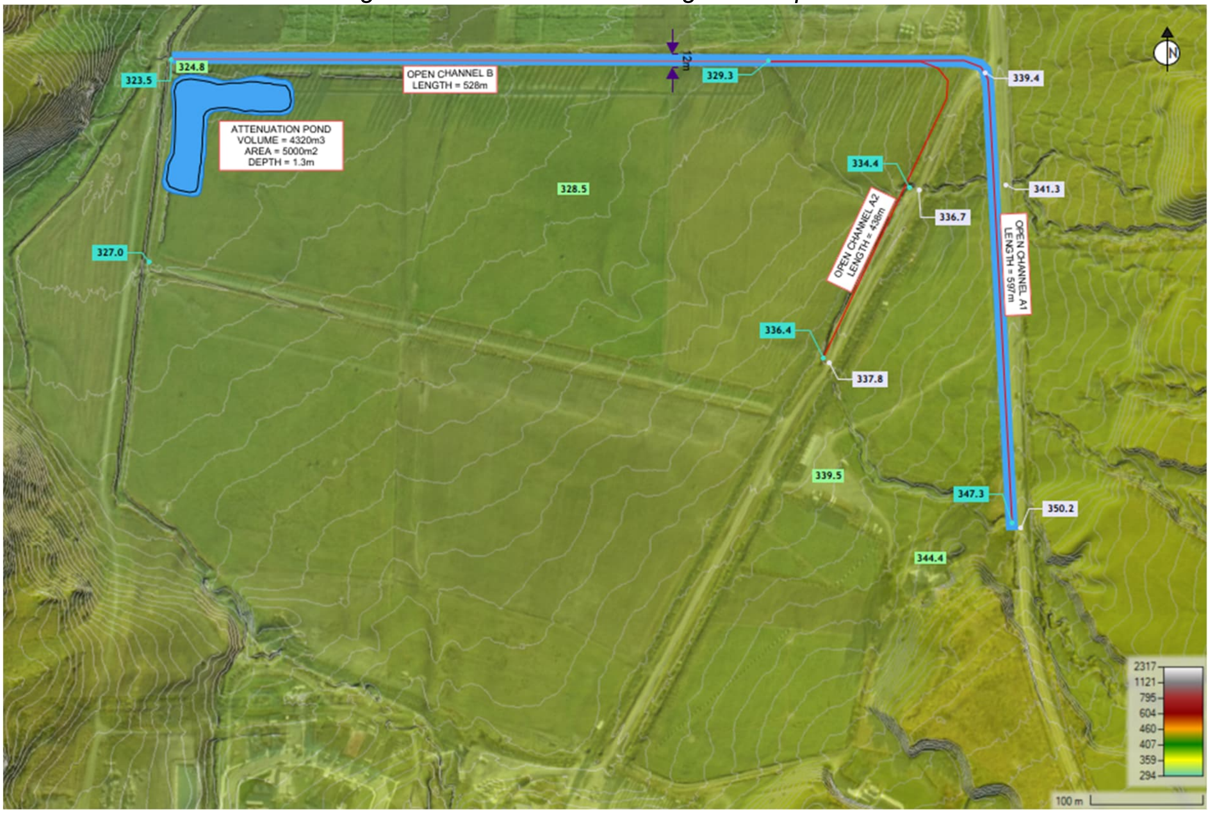
Using the Mannings equation for the analysis of open Trapezoidal Channels flows, a 11.6 wide and 1.4m deep open channel (6m base width with 1:2 side slopes) with 1.5% longitudinal grade is required to convey the 36.6m3/s flows. This flow will have a 1.1m flow depth at 4.2m/s velocity providing 300mm freeboard to surrounding ground levels. Two alignment options are possible for this open channel, as shown in Figure 10. Both alignments are feasible based on upstream and downstream ground levels. It is expected that detailed earthworks designs will show that it is feasible to have an open channel along SH6 and between the Park Ridge and the Patterson Block developments. It is noted that Stage 1 of the Park Ridge development currently diverts upper catchment runoff across Patterson Block into Park Ridge with an open channel along the southern boundary of Park Ridge.

Additional consideration for climate change effects on the 1% AEP and consideration for larger storm events such as the PMF (circa 0.05% AEP) should also be considered in detailed designs. It is expected that with climate change impacts on the 1% AEP upper catchment flows, either the open channel will require widening or bunding to hold increased flows. While the PMF storm event will likely overflow any formal drainage, flowpaths that do not inhibit evacuation or emergency vehicles require consideration in detailed designs.

6.2. Onsite stormwater management

Onsite stormwater management required to reduce postconstruction to preconstruction flows from within the development site is feasible using onsite attenuation. A water balance using the SCS method is shown in Attachment D. This water balance calculates the preconstruction and postconstruction runoff flows and volumes and uses a 1min water balance to determine the required storage volume and outlet control to achieve necessary runoff attenuation to preconstruction flow rates. The resulting water balance shows that a 4320 m^3 attenuation basin is required. At 1.0m depth, (existing ground level to Woolshed Creek invert plus 300mm freeboard) this basin is required to be approximately 5000 m2 in area (with 1:3 side slopes) shown in Figure 10.

Figure 10: Stormwater management options



7. Model findings and discussion.

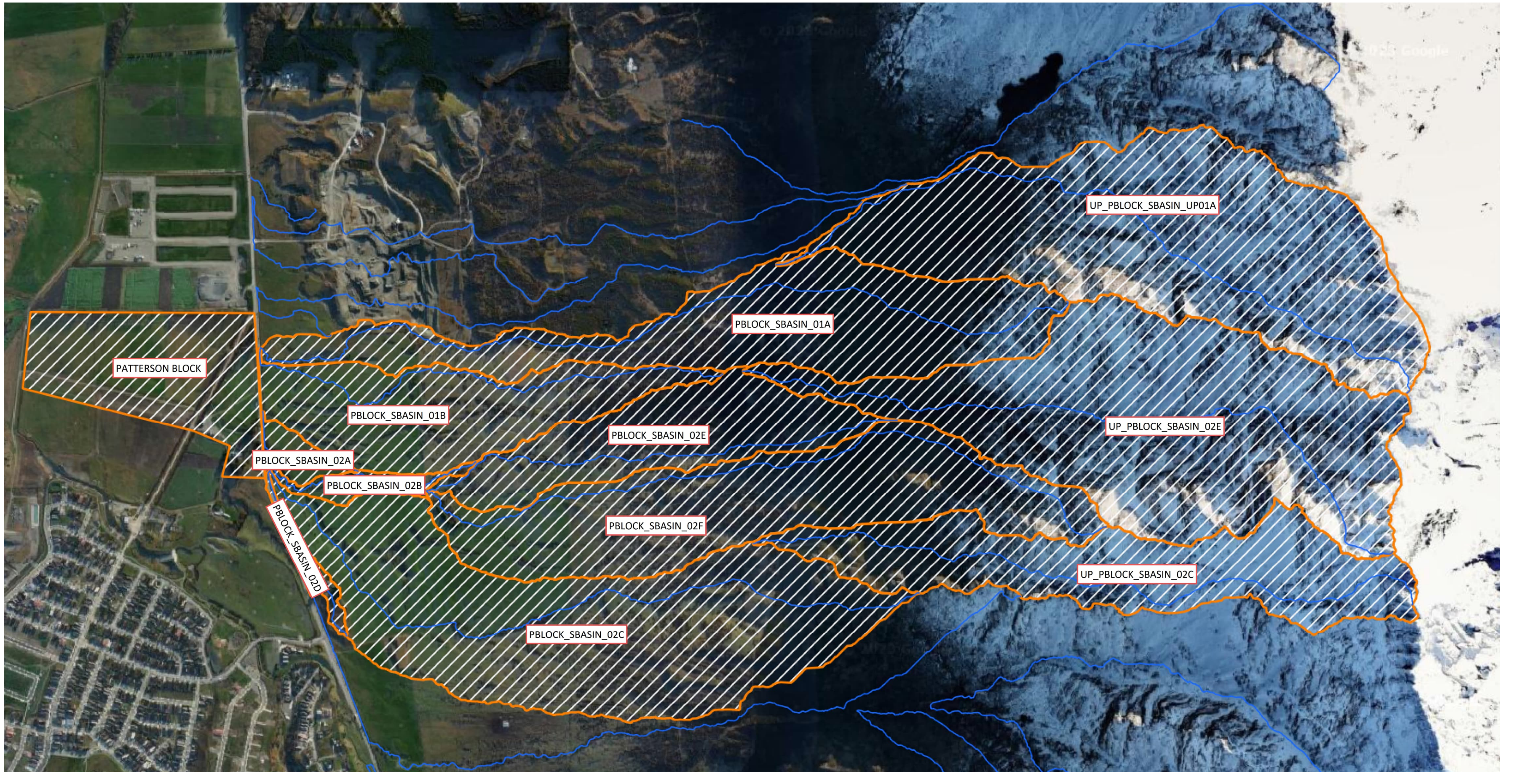
The modelling work undertaken has determined that a significant upper catchment flow of circa. 36.6 m^3/s currently flows across the Paterson Block in the 1%AEP storm event. This flow must be managed by diverting runoff with engineered structures to mitigate flood risks to the proposed development.

The modelling undertaken has been verified as rational and is considered conservative with the use of high elevation rainfall data and runoff parameters. ‘Snow melt’ and ‘Climate change’ considerations are expected to be within the model’s conservative results. Further modelling iterations are required to confirm ‘Snow melt’ and ‘Climate change’ impacts and ensure future engineered structures are deigned appropriately. The proposed land development and topography does not indicate that the engineered stormwater management structures for the upper catchment flows are unfeasible.

The sites development area has a relatively constant grade towards Woolshed Creek and onsite stormwater management is feasible with kerb, channel and pipe reticulation. Increased runoff created by the development’s impervious areas is manageable with onsite attenuation. Further detailed hydraulic modelling may show that some unattenuated development runoff is advantageous to maintaining preconstruction hydraulic regimes through the release of onsite runoff prior to upper catchment flows crossing the site.

Attachment A. Site photos

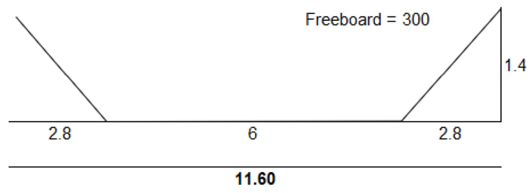
Attachment B. Catchment plan



Attachment C. Open channel calculations

Analysis of open Trapezoidal Channels by Manning's Equation

BASE WIDTH	6.0 (m)	SIDE SLOPE; 1 V IN	2 (z)	Required Flow, Q =	36.6	(m^3/s)
GRADE; 1 IN	67.0	SIDE SLOPE; 1 V IN	2 (z)	Required Velocity, V =		m/s
		MANNINGS n	0.025			



NORMAL DEPTH CALULATIONS

Q=(AR^2/3)*S^0.5/n

CRITICAL DEPTH CALCULATIONS

Q^3/B=Q^2/g

NORMAL DEPTH =	**1.065**	(m)	CRITICAL DEPTH =	**1.334**
V =	**4.23**	(m/s)		
Calculated Q =	**36.60**	(m^3/s)		

Calculations

Fr =	1.47	FLOW RATE =	36.60 (m3/s)	ALTERNATE METHOD	
v2/2g	0.91	A^3/B =	136.557	Yc = (4zTE - 3b + SQRT(16z^2H^2 + 16zHb + 9b^2))/(10z)	
		Q^2/g =	136.557		
		Fr =	1.000	VELOCITY HEAD =	0.91070148
A =	8.66 (m^2)	Vcrit =	3.164 (m/s)	TOTAL ENERGY	
P =	10.76 (m)	V/Vcrit	1.336	(TE) =	1.975726964
R =	0.80 (m)			CRITICAL DEPTH =	1.434
S =	0.015	A =	11.569 (m^2)		
		P =	11.968 (m)	ALTERNATE METHOD 2 (Straub 1982)	
Energy	1.97572696 m	R =	0.967 (m)	Yc = 0.81(Q^2/g/z^0.75/b^1.25)^0.27 - b/30/z	
		S =	0.015		
		TOP WIDTH	11.34 (m)	CRITICAL DEPTH =	1.350

Attachment D. Onsite attenuation calculations