1. Drainage Proposal

1.1 Site Particulars

1.1.1 The application site is abutting the Man Kam To Food control office, and possesses an area of approximately 4,364m^2.

1.1.2 There is a natural open stream directly to the north of the application site.

1.1.3 The application site is vacant and unpaved

1.1.4 The application site is in close proximity to the Man Kam To Boundary Control Point and a number of open storage yards and warehouse. The land in close proximity is mainly vacant soil land.

1.2 Level and gradient of the subject site & proposed surface channel

1.2.1 The application site is entirely vacant and unpaved. It can be separated into two areas; the western portion has a very gentle gradient sloping from South to North from about +8.6mPD to +8.4mPD, and the central portion which is separated by a steep slope from the western portion, has a very gentle gradient sloping from South to North from about 7.2mPD to 7.0mPD. While the Southern portion has a higher gradient sloping from South to North from +10.2mPD to +7.2mPD.

1.2.2 An area of approximately 4,364m^2 is proposed to be filled and paved. The proposed paved area will have a gradient sloping from Southwest to Northeast from about +8.6mPD to +8.3mPD, spanning the half of the site. In the Eastern portion, the proposed paved area will begin at the entrance at the Southern portion of the site will have a greater gradient sloping from South to North from about +10.2mPD to 8.6mPD and then will have a gentle gradient from +8.6mPD to 8.3mPD. The two portions will converge and meet at the middle of the site.

1.2.3 The proposed site formation level of the majority of the will be maintained at +8.3mPD to +8.6mPD, which is less than the elevation levels of the site to the East at +11.2mPD and elevations of the land to the South at +8.6mPD to +9.2mPD. The proposed site formation level of the entrance area, will follow the gradient of the surrounding area from +11.2mPD to +8.4mPD at the site. The proposed site formation level will continue to allow the site to receive overland flow from the surrounding area.

1.2.4 The proposed surface channel will be constructed following the proposed gradient of 1:100. As demonstrated in the calculation hereunder, 450mm surface U-channel will be capable to drain the surface runoff accrued at the subject site.

1.2.5 Sections at the entrance of the site will be constructed following a 1:30 and 1:50 gradient, as detailed in the drainage plan (Figure 4). As demonstrated in the calculations below, 150mm surface U-channel will be capable to drain the surface runoff at the respective catchment.

1.3 Catchment area of the proposed drainage provision at the subject site.

1.3.1 It is noted that the land to the South of the application site commands a higher level. The land to the East of the application site is occupied by temporary open storage and is completely fenced off, and has no opening to the proposed site, other than the stream course. And the land to the West of the Site is occupied by Man Kam To Food Office Building, which is downstream from the site, and we assume that there will be no overland flow from the East and West of the site. There is an existing open channel to the north of the site. As such, an external catchment is only found to the South of the application site (Figure 1).

1.3.2 The Site currently receives runoff from the external catchment to the South of the site and this will continue after the proposed development. The runoff is expected to be widespread (rather than at discrete locations), U-channels will be proposed to collect the internal and external drainage.

1.3.3 The intercepted stormwater will then be discharged to the existing open streamcourse to the North of the Site via a proposed 450mm diameter underground pipe.

1.3.4 All the proposed drainage facilities, including the section of surface channel proposed in between the subject site to the streamcourse will be provided and maintained at the applicant's own expense. Also, surface U-channel will be cleaned at regular interval to avoid the accumulation of rubbish/debris which would affect the dissipation of storm water.

Figure 1: Catchment Area

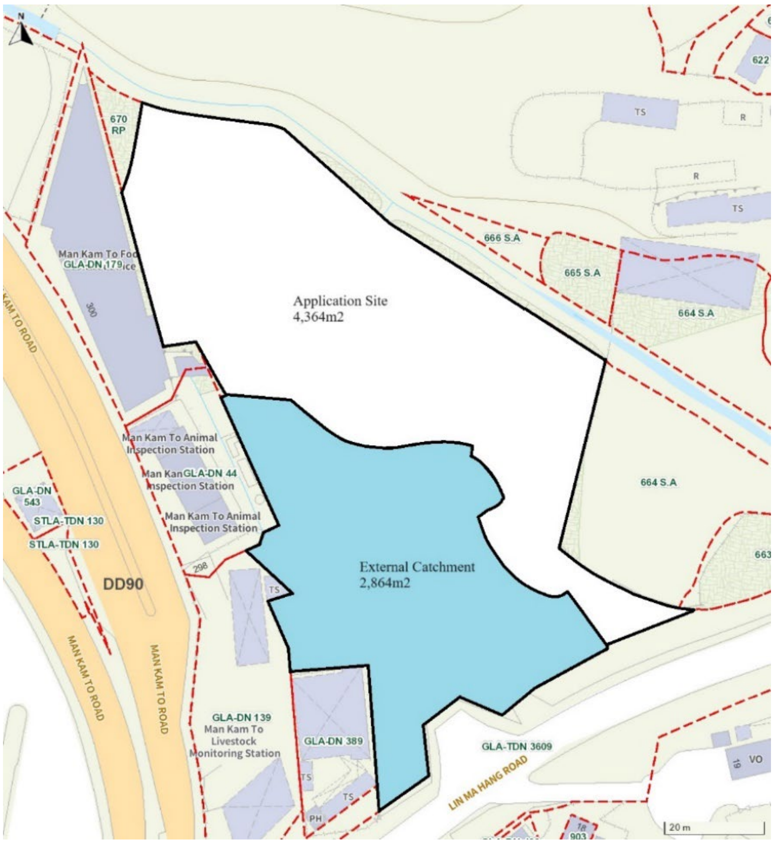
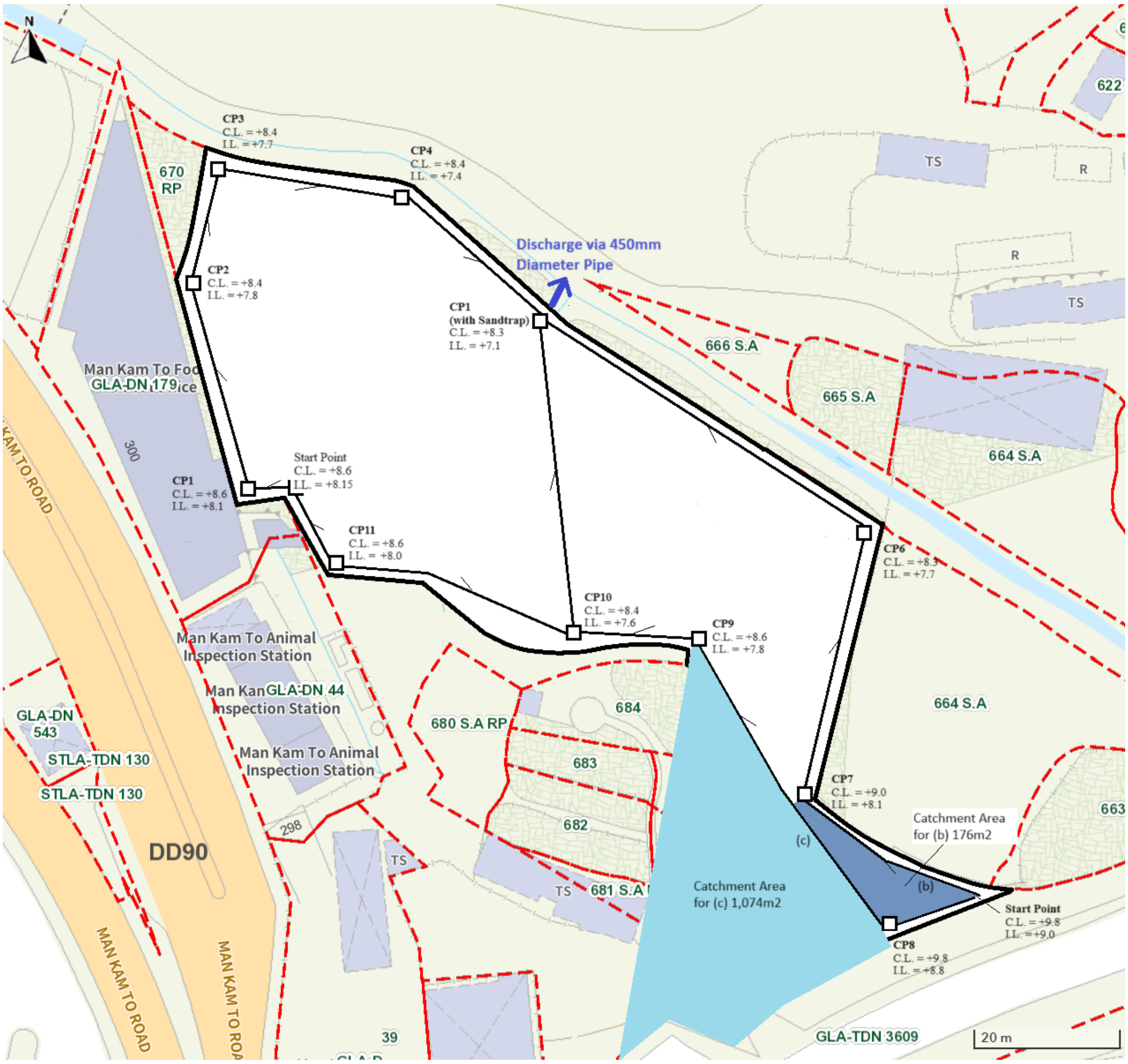


Figure 2: Catchment Area for Section (b) and (c)



1.4 Fencing at the subject site.

1.4.1 Fencing is proposed at the North, West, and Southern border of the Site. The alignment is detailed in Figure 3 below.

1.4.2 There will be no gapping in the fence along the North and West border of the Site to prevent debris and other contamination from falling into the streamcourse to the North of the Site

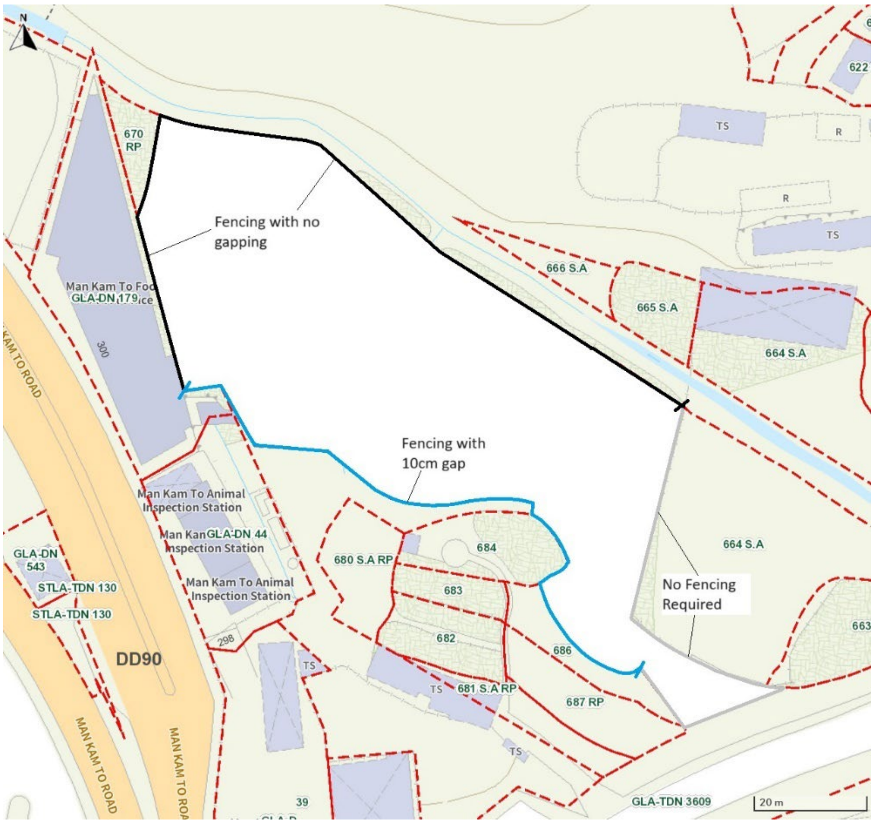
1.4.3 All fencing will be set at least 3m from the natural streamcourse to the North of the Site.

1.4.4 There will be a 10cm gap at the bottom of the fencing at the Southern border of the Site to receive overland flow from the external catchment to the South of the Site.

1.4.5 Subject to the below calculations, it is determined that a 10cm gap is adequate for the overland flow to pass.

1.4.6 The East border of the Site is occupied by another development and it is already fenced, so no additional fencing will be required.

Figure 3: Fencing Location



2 Runoff Estimation

2.1 Proposed Drainage Facilities

2.1.1 Due to the site formation at the entrance, the gradients of section (b) and (c) will be steeper at 1:30 and 1:50 respectively.

2.1.2 Subject to the below calculations, it is determined that 150mm surface U-channel which is made of concrete is adequate for sections (b) and (c) to intercept the storm water from their respective catchment areas.

2.1.3 Subject to the below calculations, it is determined that 450mm surface U-channel which is made of concrete along the site periphery is adequate to intercept storm water passing through and generated at the application site.

2.1.4 The intercepted stormwater will then be discharged to the existing natural stream to the north of the application site as shown in Figure 5 via a proposed 450mm diameter underground pipe.

2.1.5 The flow capacities of the proposed U-channel are calculated using the Chart for the Rapid Design of Channels. Runoff from corresponding Site Catchments (calculated based on a return period of 50 years), the capacity estimations are included below.

3 Drainage Calculation for the proposed Provision of Drainage Facilities at the Application Site

3.1 Runoff Estimation

3.1.1 Rational method is adopted for estimating the designed run-off

$$Q=0.278\ C \times I \times A$$

Table 1: Runoff Coefficients

Surface Characteristics	Runoff Coefficient
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Grassland (Heavy Soil)	
Flat	0.13-0.25
Steep	0.25-0.35
Grassland (Sandy Soil)	
Flat	0.05-0.15
Steep	0.15-0.2

Assuming that:

I. The total catchment area is about 7,228m^2, including the area of external catchment of approximately 2,864m^2 and the existing site area of about 4,364 m^2;
II. Approximately 4,642 m^2 is hard paved, and therefore the value of run-off co-efficient (k) is taken as 0.95.
III. Approximately 2,586 m^2 is unpaved and covered in heavy soil, and therefore the value of run-off co-efficient (k) is taken at 0.25.

Difference in Land Datum = 10.2m –8.3m = 1.9m
L = 118.5m
Average fall = 1.60m in 100m

According to the Brandsby-Williams Equation adopted from the "Stormwater Drainage Manual – Planning, Design and management" published by the Drainage Services Department (DSD),

Time of Concentration (t_c) = $0.14465[L/(H^{0.2} \times A^{0.1})]$
t_c = $0.14465[118.5/(1.6^{0.2} \times 7,228^{0.1})]$
t_c = 6.414 minutes

The rainfall intensity *i* is determined by using the Gumbel Solution:

$$i = \frac{a}{(td + b)^c}$$

Where *I* = Extreme mean intensity in mm/hr
td = Duration in minutes (td≤240)
a, b, c = Storm constants given in the table below

Table 2: Storm Constants for Different Return Periods of North District Area

Return Period T(years)	2	5	10	20	50
a	439.1	448.1	454.9	462.3	474.6
b	4.10	3.67	3.44	3.21	2.90
c	0.484	0.437	0.412	0.392	0.371

i = $474.6/[6.414+2.90]^{0.371}$

i = 207.4mm/hr

By Rational Method, Q = $0.95\times$ 207.4mm/hr $\times$ 4,642 /3600 +0.25$\times$ 207.4mm/hr $\times$ 2,586/3600

Q = 290l/s = 0.290m^3/s = 17,418 l/min

In accordance with the Chart of the Rapid Design of Channels in "Geotechnical Manual for Slopes" (Appendix I), 450mm surface U-channel in 1:100 gradient is considered adequate to dissipate all the stormwater accrued by the application site. The intercepted stormwater will then be discharged to the existing natural stream to the north of the application site as shown in Figure 4.

4 Drainage Calculation for section (b) of the proposed Provision of Drainage Facilities at the Application Site

4.1 Runoff Estimation

4.1.1 Rational method is adopted for estimating the designed run-off

$$Q=0.278\ C \times I \times A$$

Assuming that:

I. The catchment area is about 176m^2;
II. The entire area of 176 m^2 is proposed to be hard paved, and therefore the value of run-off co-efficient (k) is taken as 0.95.

Difference in Land Datum = 9.8m –9.0m = 0.8m

L = 22m

Average fall = 3.64m in 100m

According to the Brandsby-Williams Equation adopted from the "Stormwater Drainage Manual – Planning, Design and management" published by the Drainage Services Department (DSD),

Time of Concentration (t_c) = $0.14465[L/(H^{0.2}\times A^{0.1})]$

t_c = $0.14465[22/(3.64^{0.2}\times 176^{0.1})]$

t_c = 1.466 minutes

The rainfall intensity *i* is determined by using the Gumbel Solution:

$$i = \frac{a}{(td+b)^c}$$

Where *I* = Extreme mean intensity in mm/hr

td = Duration in minutes (td≤240)

a, b, c = Storm constants given in the table below

Table 2: Storm Constants for Different Return Periods of North District Area

Return Period T(years)	2	5	10	20	50
a	439.1	448.1	454.9	462.3	474.6
b	4.10	3.67	3.44	3.21	2.90
c	0.484	0.437	0.412	0.392	0.371

i = $474.6/[1.466+2.90]^{0.371}$

i = 274.7mm/hr

By Rational Method, Q = 0.95× 274.7mm/hr × 176 /3600

Q = 13l/s = 0.013m^3/s = 766 l/min

In accordance with the Chart of the Rapid Design of Channels in "Geotechnical Manual for Slopes" (Appendix II), 150mm surface U-channel in 1:30 gradient is considered adequate to dissipate all the stormwater accrued by the catchment area.

5 Drainage Calculation for Section (c) of the proposed Provision of Drainage Facilities at the Application Site

5.1 Runoff Estimation

5.1.1 Rational method is adopted for estimating the designed run-off

$$Q=0.278\ C \times I \times A$$

Assuming that:

I. The catchment area for section (c) of the proposed drainage facility is about 998m^2;
II. Approximately 272 m^2 is hard paved, and therefore the value of run-off co-efficient (k) is taken as 0.95.
III. Approximately 726 m^2 is unpaved and covered in heavy soil, and therefore the value of run-off co-efficient (k) is taken at 0.25.

Difference in Land Datum = 10.2m –8.6m = 1.6m

L = 57m

Average fall = 2.81m in 100m

According to the Brandsby-Williams Equation adopted from the "Stormwater Drainage Manual – Planning, Design and management" published by the Drainage Services Department (DSD),

Time of Concentration (t_c) = $0.14465[L/(H^{0.2}\times A^{0.1})]$

t_c = $0.14465[57/(2.81^{0.2}\times 998^{0.1})]$

t_c = 3.362 minutes

The rainfall intensity i is determined by using the Gumbel Solution:

$$i = \frac{a}{(td + b)^c}$$

Where *I* = Extreme mean intensity in mm/hr

td = Duration in minutes (td≤240)

a, b, c = Storm constants given in the table below

Table 2: Storm Constants for Different Return Periods of North District Area

Return Period T(years)	2	5	10	20	50
a	439.1	448.1	454.9	462.3	474.6
b	4.10	3.67	3.44	3.21	2.90
c	0.484	0.437	0.412	0.392	0.371

i = $474.6/[3.362+2.90]^{0.371}$

i = 240.3mm/hr

By Rational Method, Q = 0.95× 240.3mm/hr × 272 /3600 +0.25× 240.3mm/hr × 726/3600

Q = 29l/s = 0.029m^3/s = 1762 l/min

In accordance with the Chart of the Rapid Design of Channels in "Geotechnical Manual for Slopes" (Appendix II), 150mm surface U-channel in 1:50 gradient is considered adequate to dissipate all the stormwater accrued by the catchment area.

Figure 4: Drainage Plan

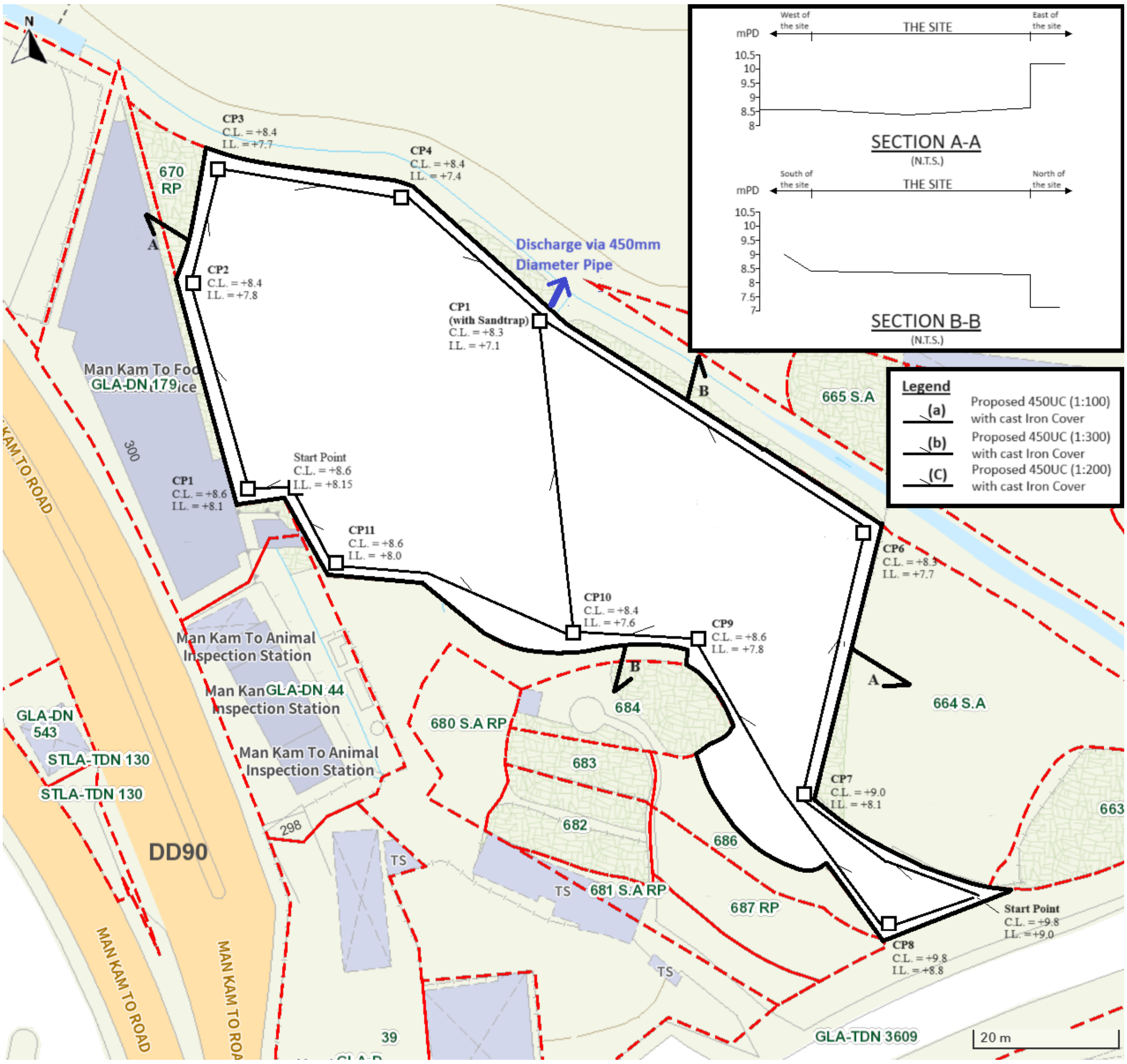


Figure 5 Connection Detail

Connection to Existing Stream

Connection Detail

6 Checking the Capacity of the 450mm Diameter underground pipe

Manning Equation

$$V = R^{2/3} \times S_f^{0.5}/n$$

$$R = \frac{\pi r^2}{2\pi r}$$

$$R = \frac{r}{2}$$

Diameter	=	0.45m
r	=	0.45m/2 = 0.225m
R	=	0.225m/2 = 0.1125m
n	=	0.012 $s/m^{1/3}$
		(Table 13 of Stormwater Drainage Manual)
V	=	$[0.15^{2/3}]\times[0.01^{0.5}]/0.012$
V	=	1.94m/sec

Maximum Capacity $Q_{Max} = V \times A$

A	=	πr^2
A	=	$\pi \times 0.225^2$
A	=	$0.159m^2$
Q_{Max}	=	$1.94m/sec \times 0.159m^2$
Q_{Max}	=	$0.309m^3/sec$
$0.309m^3/sec$	>	$0.290m^3/sec$
Q_{Max}	>	Q

A 450mm diameter pipe has sufficient capacity to discharge the runoff estimation from the catchment area

7 Runoff from Upstream Catchment Area

7.1 Runoff Estimation

7.1.1 Rational method is adopted for estimating the designed run-off

$$Q=0.278\ C \times I \times A$$

Assuming that:

IV. The Upstream catchment area is about $409{,}693m^2$; A layout plan of the assumed catchment area is indicated in Figure 6

V. Approximately 11,814 m^2 is asphalt or dirt road, and some concrete areas, and therefore the value of run-off co-efficient (k) is taken as 0.80.

VI. Approximately 397,879 m^2 is unpaved and covered in heavy soil, and therefore the value of run-off co-efficient (k) is taken at 0.25.

Difference in Land Datum	=	78.2m –7.1m = 71.1m
L	=	764m
Average fall	=	9.31m in 100m

According to the Brandsby-Williams Equation adopted from the "Stormwater Drainage Manual – Planning, Design and management" published by the Drainage Services Department (DSD),

Time of Concentration (t_c)	=	$0.14465[L/(H^{0.2}\times A^{0.1})]$

t_c = $0.14465[764/(9.31^{0.2} \times 409{,}693^{0.1})]$

t_c = 19.43 minutes

The rainfall intensity *i* is determined by using the Gumbel Solution:

$$i = \frac{a}{(td + b)^c}$$

Where *I* = Extreme mean intensity in mm/hr

td = Duration in minutes (td≤240)

a, b, c = Storm constants given in the table below

Table 2: Storm Constants for Different Return Periods of North District Area

Return Period T(years)	2	5	10	20	50
a	439.1	448.1	454.9	462.3	474.6
b	4.10	3.67	3.44	3.21	2.90
c	0.484	0.437	0.412	0.392	0.371

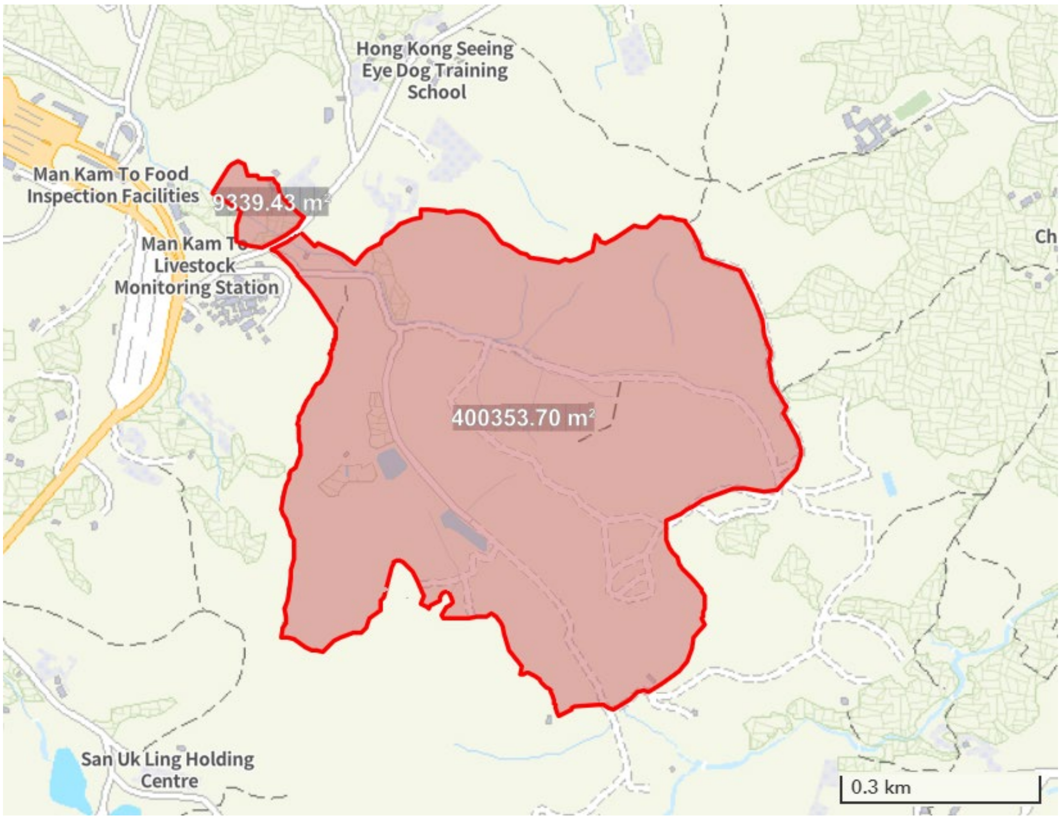
i = $474.6/[19.43+2.90]^{0.371}$

i = 149.9mm/hr

By Rational Method, Q = 0.80× 149.9mm/hr × 11,814 /3600 +0.25× 149.9mm/hr × 397,879/3600

Q = 4,536l/s = 4.536m^3/s

Figure 6: Upstream Catchment Area



8 Checking the Capacity of the Natural Stream

Manning Equation

$$V = R^{2/3} \times S_f^{0.5}/n$$

$$R = \frac{L \times D}{2D+L}$$

L	=	3.1m
D	=	0.9m
R	=	[3.1×0.9]/[2×0.9+3.1]
R	=	0.57m
n	=	0.033 s/m$^{1/3}$
		(Table 13 of Stormwater Drainage Manual, Assuming straight, Natural stream, with weeds and stones, in good condition)
V	=	[0.57$^{2/3}$]×[0.01$^{0.5}$]/0.033
V	=	2.08m/sec

Maximum Capacity Q_{Max} = V × A

A	=	L × D
A	=	3.1 × 0.9
A	=	2.79m^2
Q_{Max}	=	2.08m/sec × 2.79m^2
Q_{Max}	=	5.81m^3/sec
5.81m^3/sec	>	0.290m^3/sec + 4.536 m^3/sec
5.81m^3/sec	>	4.83 m^3/sec
Q_{Max}	>	Q

The existing streamcourse has enough capacity to receive runoff from the upstream catchment as well as the runoff from the proposed development.

9 Checking the Adequacy of Fence Gapping for Overland Flow

Assuming that

i. The area of external catchment of approximately 2,864m^2;

ii. Approximately 278 m^2 is hard paved, and therefore the value of run-off co-efficient (k) is taken as 0.95.

iii. Approximately 2,586 m^2 is unpaved and covered in heavy soil, and therefore the value of run-off co-efficient (k) is taken at 0.25.

iv. As the overland flow is from the external catchment to the South of the site, we assume the overland flow is received along the fencing at the Southern border only, which is about 104m in length (L)

v. We assume the overland flow from the external catchment is widespread.

vi. The gapping in the fencing is set at 10cm (D)

vii. The capacity of the gapping is closest to a concrete lined channel in good condition (n=0.014 s/m$^{1/3}$)

9.1.1 Overland Flow From External Catchment

Runoff Estimation

Rational method is adopted for estimating the designed run-off

$$Q = 0.278\ C \times I \times A$$

Difference in Land Datum	=	10.2m –8.4m = 1.8m
L	=	76m
Average fall	=	2.37m in 100m

According to the Brandsby-Williams Equation adopted from the "Stormwater Drainage Manual – Planning, Design and management" published by the Drainage Services Department (DSD),

Time of Concentration (t_c)	=	$0.14465[L/(H^{0.2} \times A^{0.1})]$
t_c	=	$0.14465[76/(2.37^{0.2} \times 2{,}864^{0.1})]$
t_c	=	4.17 minutes

The rainfall intensity *i* is determined by using the Gumbel Solution:

$$i = \frac{a}{(td + b)^c}$$

Where	*I*	= Extreme mean intensity in mm/hr
	td	= Duration in minutes (td≤240)
	a, b, c	= Storm constants given in the table below

Table 2: Storm Constants for Different Return Periods of North District Area

Return Period T(years)	2	5	10	20	50
a	439.1	448.1	454.9	462.3	474.6
b	4.10	3.67	3.44	3.21	2.90
c	0.484	0.437	0.412	0.392	0.371

i	=	$474.6/[4.17+2.90]^{0.371}$
i	=	229.7mm/hr

By Rational Method, Q	=	0.95× 229.7mm/hr × 278/3600
		+0.25× 229.7mm/hr × 2,586/3600
Q	**=**	**58l/s = 0.058m^3/s**

9.1.2 Adequacy of Fencing Gap

Manning Equation

$$V = R^{2/3} \times S_f^{0.5}/n$$

$$R = \frac{L \times D}{2D + L}$$

L	=	104m
D	=	0.1m
R	=	[104×0.1]/[2×0.1+104]
R	=	0.10m
n	=	0.014 $s/m^{1/3}$
		(Table 13 of Stormwater Drainage Manual)
V	=	$[0.10^{2/3}] \times [0.01^{0.5}]/0.014$

$$V = 1.54m/sec$$

Maximum Capacity $Q_{Max} = V \times A$

$$A = L \times D$$

$$A = 104 \times 0.1$$

$$A = 10.4m^2$$

$$Q_{Max} = 1.54m/sec \times 10.4m^2$$

$$\mathbf{Q_{Max} = 15.99m^3/sec}$$

$$\mathbf{15.99m^3/sec > 0.058m^3/sec}$$

$$\mathbf{Q_{Max} > Q}$$

The 10cm gapping is more than adequate to receive the overland flow from the external catchment.

10 Conclusion

10.1 The applicant will be responsible for the construction and ongoing maintenance of the drainage facilities.

10.2 Potential drainage impacts that may arise from the Site after construction of the Proposed Development have been assessed. Thus, existing stormwater system will have sufficient capacity to receive stormwater runoff from the Proposed Development and surrounding catchments.

10.3 Adequate measures are provided at the resources of the applicant to prevent the site from being eroded and flooded

10.4 External catchment is taken into account such that flooding susceptibility of the adjoining areas would not be adversely affected by the proposed development.

Appendix I: Chart of the Rapid Design of Channels (Entire site, 450U-Channel, 1:100 Gradient)

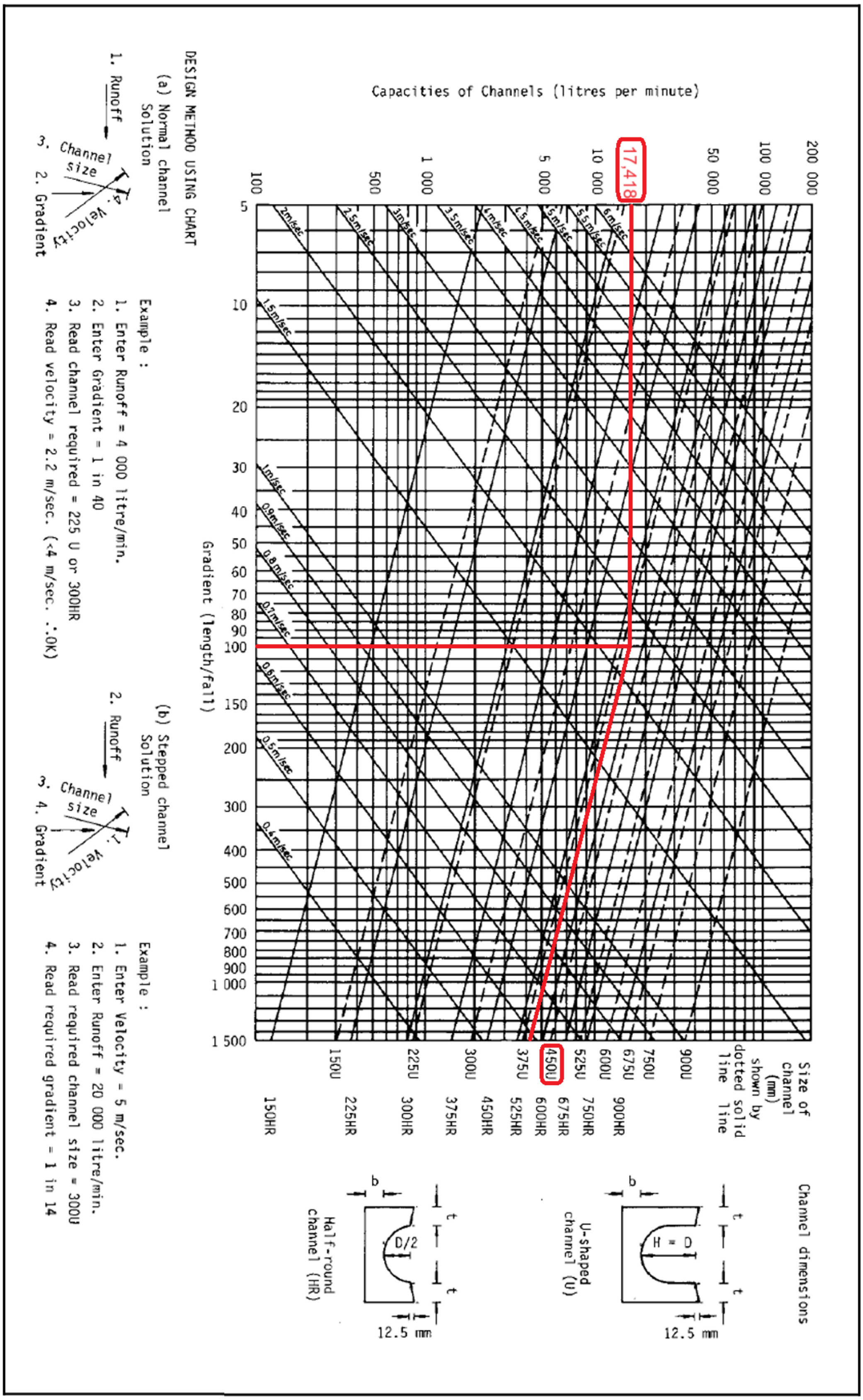


Chart for the Rapid Design of Channels in the Geotechnical Manual for Slopes (Second Edition) (GCO, 1984)

Appendix II: Chart of the Rapid Design of Channels (Catchment Areas b and c)

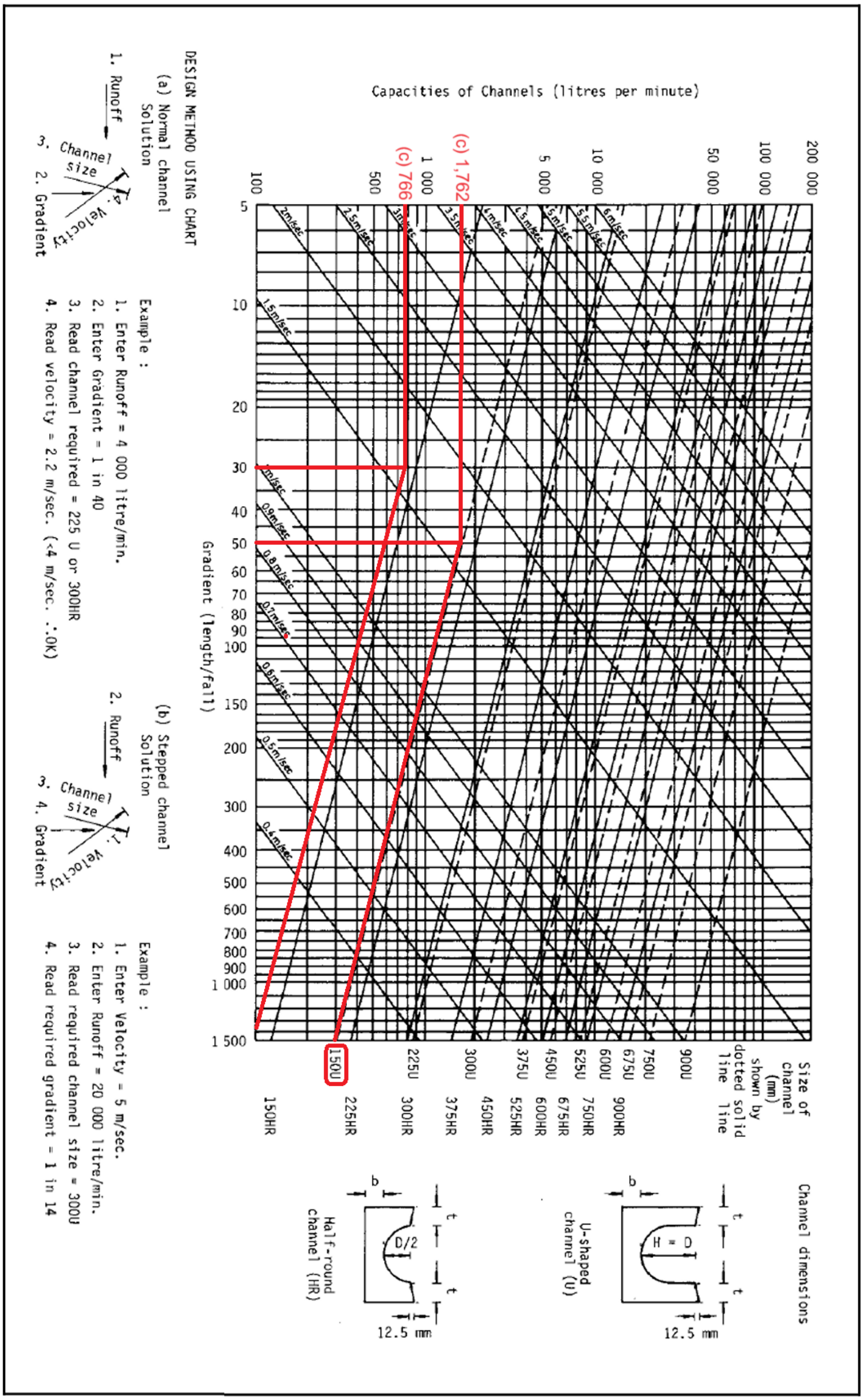


Chart for the Rapid Design of Channels in the Geotechnical Manual for Slopes (Second Edition) (GCO, 1984)