1. Drainage Proposal

1.1 Site Particulars

1.1.1 The application site is abutting a local vehicular access leading to Kong Nga Po Road. possesses an area of approximately 1,763m^2.

1.1.2 There is an existing streamcourse to the South of the application site, and works have been done to widen the streamcourse and concrete blocks were place along the streamcourse to ensure capacity and flooding susceptibility of the adjoining areas would not be adversely affected. Photos of current condition of the streamcourse are shown in Figures 6.1 to 6.4. Figure 5 depicts the location of the camera and the direction of the photo.

1.1.3 Calculations have been made comparing the capacity of the original stream course and the channel after the completed works.

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

1.2.1 The application site is mostly paved, an area of approximately 1,763m^2. The paved area will have a gradient sloping from North to South from about +26.6mPD to +26.5mPD.

1.2.2 In order to follow the topography of the application site, the proposed surface channel will be constructed following the gradient of the site. As demonstrated in the calculations in Paragraph 3 and 4 hereunder, a 300mm surface U-channel and 375mm stepped channel will be capable to drain the surface runoff accrued at the subject site.

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

1.3.1 For the internal catchment, with an area of approximately 1,763m^2, a 300mm surface U-Channel along the site peripheral is proposed to intercept the run-off of the site.

1.3.2 The intercepted stormwater from the site will then be discharged to the existing open streamcourse to the Northwest of the Site via a proposed 375mm stepped channel.

1.3.3 It is noted that the land to the North, South, and East command a lower level. Although a portion of the land towards the South Western border commands a slightly higher, the majority of the land to the West commands a lower level. It is also noted that the land to the West is occupied by an open storage site that is completely fenced off with corrugated metal. Therefore, we assume overland flow from adjacent land to be minimal.

2 Runoff Estimation and Proposed Drainage Facilities

2.1 Proposed Drainage Facilities

2.1.1 Subject to the below calculations, it is determined that 300mm surface U-channel which is made of concrete along the site periphery is adequate to intercept storm water generated at the application site.

2.1.2 The intercepted stormwater from the site will then be discharged to the existing streamcourse to the South of the application site as shown in Figure 1.

2.1.3 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), and Design Chart for Standard Sized Stepped Channel, the capacity estimation are included below.

2.1.4 The calculations below shows that the proposed 300mm U-channel and 375mm stepped channel has adequate capacity to cater for the surface runoff generated at the application site.

2.1.5 A next set of calculations checks and confirms that the downstream watercourse has the capacity for the surface runoff generated at the application site and external catchment.

2.1.6 All the proposed drainage facilities, including the section of stepped 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 and stepped channel will be cleaned at regular interval to avoid the accumulation of rubbish/debris which would affect the dissipation of storm water.

2.1.7 The provision of the proposed surface U-channel will follow the gradient of the application site. All the proposed drainage facilities will be constructed and maintained at the expense of the applicant.

2.1.8 The applicant will move the concrete blocks back away from the stream course, to create and maintain a buffer area, at +23.0mPD, at a minimum 3m from the top of the bank. All of the concrete blocks will be placed outside this 3m wide buffer area, and no proposed works will be done within this buffer area after the construction.

3 Calculation 1: 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 from the application site is about 1,763 m^2;

II. Approximately 1,763 m^2 is hard paved, and therefore the value of run-off co-efficient (k) is taken as 0.95.

Difference in Land Datum	=	26.6m –26.5m = 0.1m
L	=	50.6m
Average fall	=	0.2m 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	=	$0.14465[50.6/(0.2^{0.2}\times 1{,}763^{0.1})]$
t_c	=	4.78 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

$i = 474.6/[4.78+2.90]^{0.371}$
$i = 222.7\text{mm/hr}$

By Rational Method, $Q = 0.95\times 222.7\text{mm/hr} \times 1{,}763/3600$
$Q = 104\text{l/s} = 0.104\text{m}^3\text{/s} = 6{,}218\text{ l/min}$

In accordance with the Chart of the Rapid Design of Channels in "Geotechnical Manual for Slopes", 300mm surface U-channel in 1:100 gradient is considered adequate to dissipate all the stormwater accrued by the application site, as shown in Figure 2. The intercepted stormwater will then be discharged to the existing natural stream to the South of the application site by 375mm stepped channel, as shown in Figure 1. A 375mm stepped channel, with α = 45 degrees, is considered adequate to dissipate all the stormwater accrued by the application site as shown in Figure 3

4 Calculation 2: Runoff Calculations of the Entire Catchment

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:

III. The total catchment area of the application and its surrounding is estimated to be about 679,773 m^2;
IV. An area of approximately 97,280m^2 are developments with mostly hard paved surfaces, and therefore the value of run-off co-efficient (k) is taken as 0.8. And the rest of the catchment area, 582,493m^2, is steep grassland and therefore the value of run-off co-efficient (k) is taken as 0.25.

Difference in Land Datum	=	139m –22.4m = 116.6m
L	=	1,090m
Average fall	=	10.7m 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	=	$0.14465[1,090/(116.6^{0.2}\times 679,773^{0.1})]$
t_c	=	25.34 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	=	$474.6/[25.35+2.90]^{0.371}$
i	=	137.4mm/hr

By Rational Method, Q	=	0.8× 137.4mm/hr × 97,280m2/3600 +0.25 x 137.4mm/hr x 582,493m2/3600
Q	=	7,418l/s = $7.418m^3/s$

5 Checking the Capacity of the Original Streamcourse

Manning Equation

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

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

L	=	1.9m
D	=	0.6m
R	=	[1.9×0.7]/[2×0.7+1.9]
R	=	0.40m
n	=	0.035 $s/m^{1/3}$

		(Table 13 of Stormwater Drainage Manual, Natural Stream channel, with weeds, fair)
V	=	$[0.40^{2/3}]\times[0.01^{0.5}]/0.035$
V	=	2.07m/sec

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

A	=	L × D
A	=	1.9 × 0.7
A	=	$1.33m^2$
Q_{Max}	=	$1.53m/sec \times 1.33m^2$
Q_{Max}	=	$2.07m^3/sec$
$2.07m^3/sec$	<	$7.418m^3/sec$
Q_{Max}	<	Q

The original streamcourse's capacity was not sufficient for the entire catchment area

6 Checking the Capacity of the Widened Streamcourse

Manning Equation

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

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

L	=	2.2m
D	=	0.7m
R	=	$[2.2\times0.7]/[2\times0.7+2.2]$
R	=	0.43m
n	=	$0.014\ s/m^{1/3}$
		(Table 13 of Stormwater Drainage Manual, concrete lined channels)
V	=	$[0.43^{2/3}]\times[0.01^{0.5}]/0.014$
V	=	4.06m/sec

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

A	=	L × D
A	=	2.2 × 0.7
A	=	$1.54m^2$
Q_{Max}	=	$4.06m/sec \times 1.54m^2$
Q_{Max}	=	$6.25m^3/sec$
$6.25m^3/sec$	<	$7.418m^3/sec$
Q_{Max}	<	Q

After the work done on the drainage streamcourse, the capacity has increased significantly from $2.07m^3/sec$ to $6.25m^3/sec$, however it is still not sufficient for the entire catchment area. The applicant proposes to further improve on the streamcourse, by further widening the streamcourse to 2.6m wide and also deepen the streamcourse to 0.9m deep.

7 Checking the Capacity of the Proposed streamcourse

Manning Equation

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

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

L	=	2.6m
D	=	0.9m
R	=	[2.6×0.9]/[2×0.9+2.6]
R	=	0.53m
n	=	0.014 $s/m^{1/3}$ (Table 13 of Stormwater Drainage Manual, concrete lined channels)
V	=	$[0.53^{2/3}]\times[0.01^{0.5}]/0.014$
V	=	4.69m/sec

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

A	=	L × D
A	=	2.6 × 0.9
A	=	$2.34m^2$
Q_{Max}	=	$4.69m/sec \times 2.34m^2$
Q_{Max}	=	$10.97m^3/sec$
$10.97m^3/sec$	>	$7.418m^3/sec$
Q_{Max}	>	Q

The proposed work on the streamcourse will further increase the capacity and will be sufficient to receive the runoff from the entire catchment.

8 Conclusion

8.1 The emergency works that the applicant has performed has increased the streamcourse's capacity significantly, however it is still insufficient to receive runoff from the entire catchment area.

8.2 The applicant proposes to further widen and deepen the streamcourse to increase the capacity so that it would be sufficient to receive runoff from the entire catchment.

8.3 The increased runoff from the proposed development is minimal compared to the increased capacity of the streamcourse, and will not have any adverse impact on the surrounding areas.

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

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

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

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

Figure 1 Drainage Plan

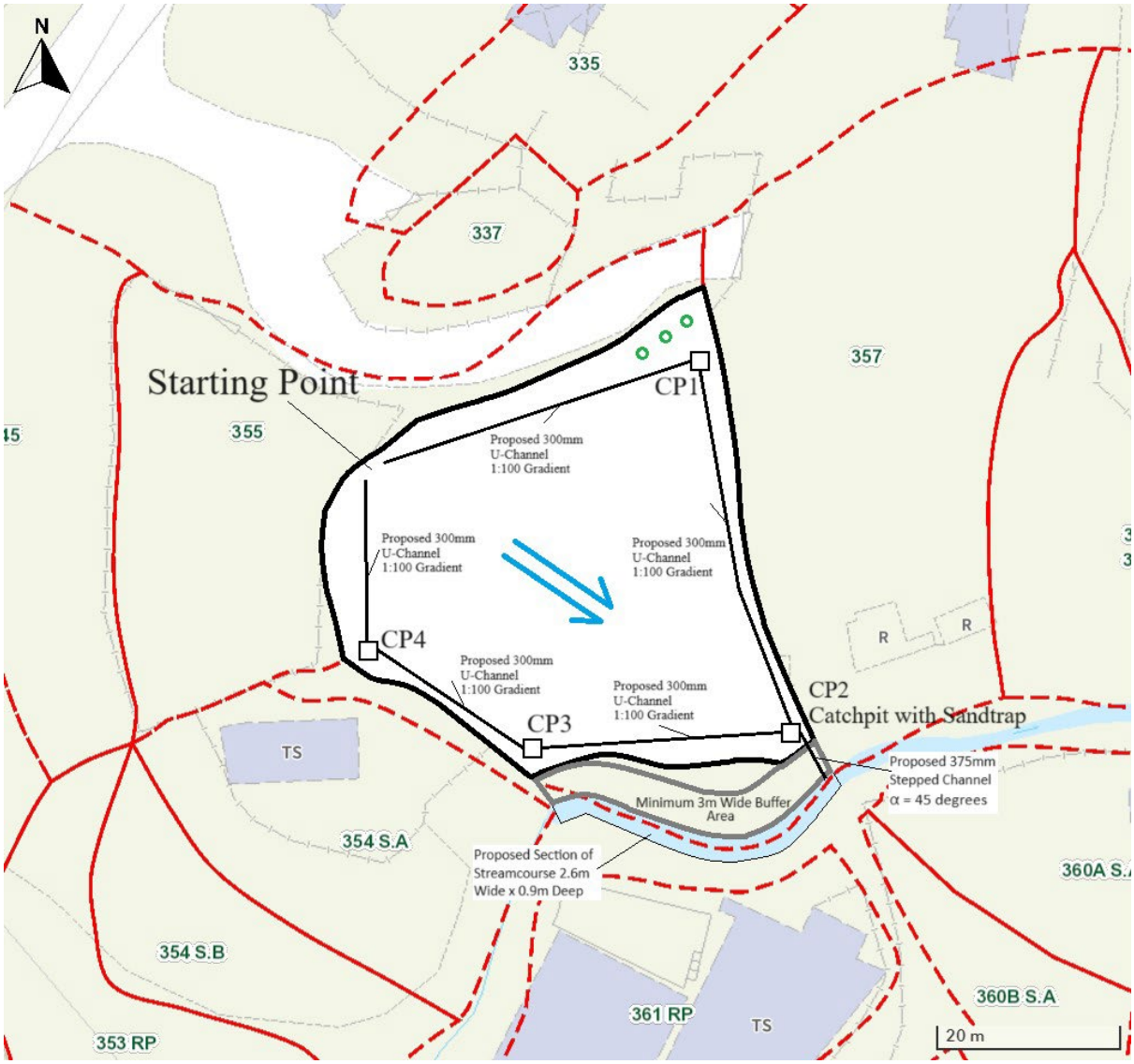

Figure 2 Cross Section of Streamcourse and Buffer Area

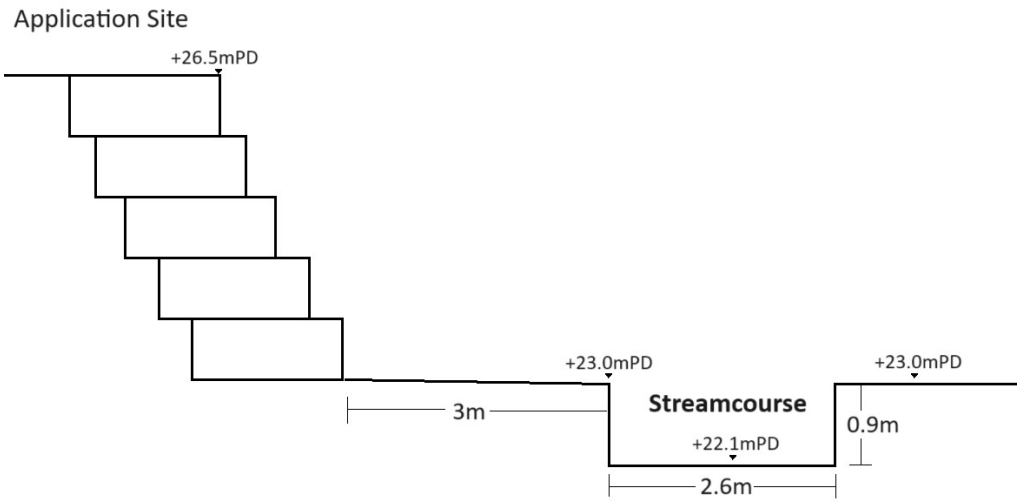

Figure 3 Chart for the Rapid Designs of Channels (Application Site)

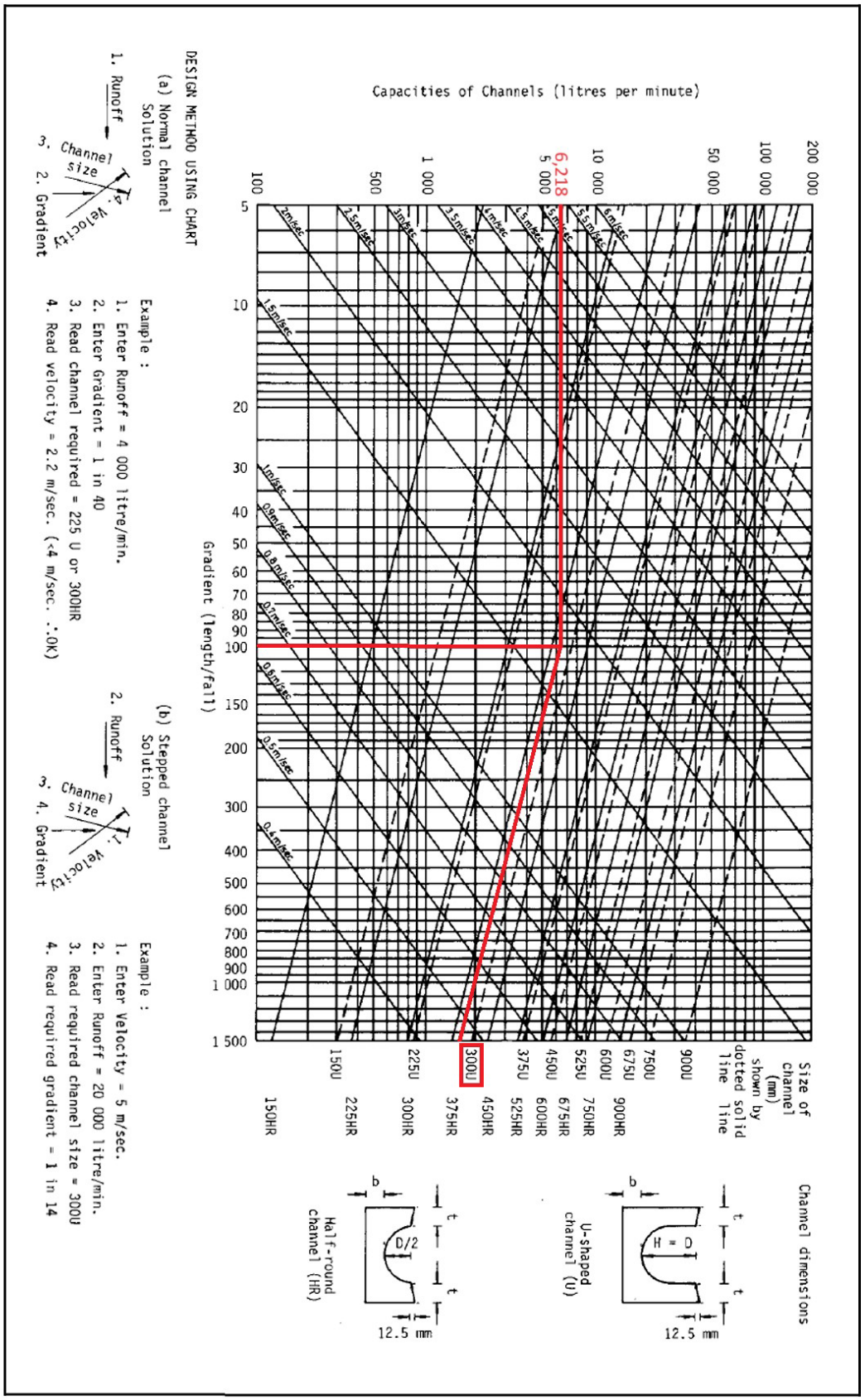

Chart for the Rapid Design of Channels in the Geotechnical Manual for Slopes (Second Edition) (GCO, 1984)

Figure 4 Design Chart for Standard Sized Stepped Channels

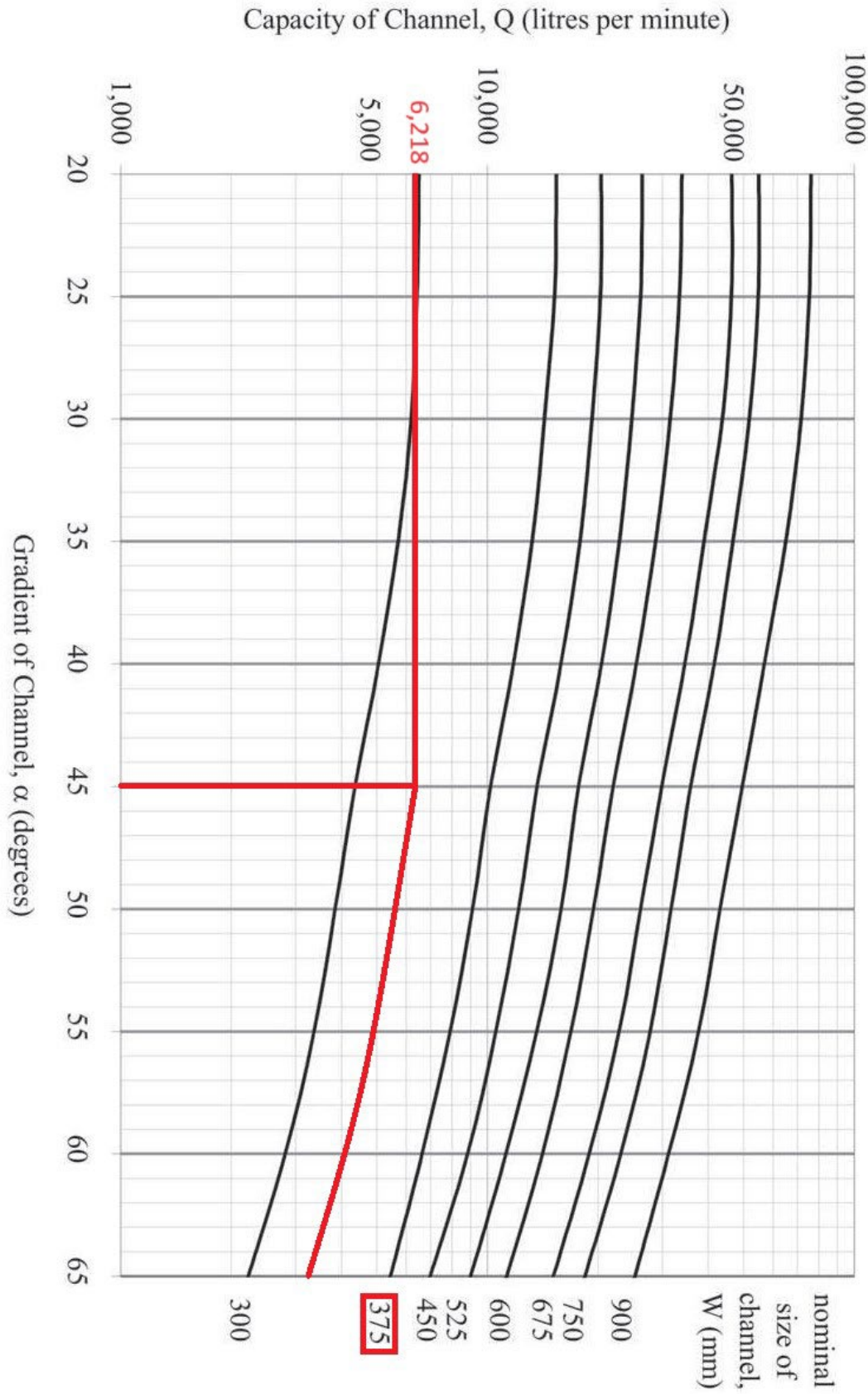

Figure 2 - Design Chart for Standard Sized Stepped Channels

Figure 5 Photo Location

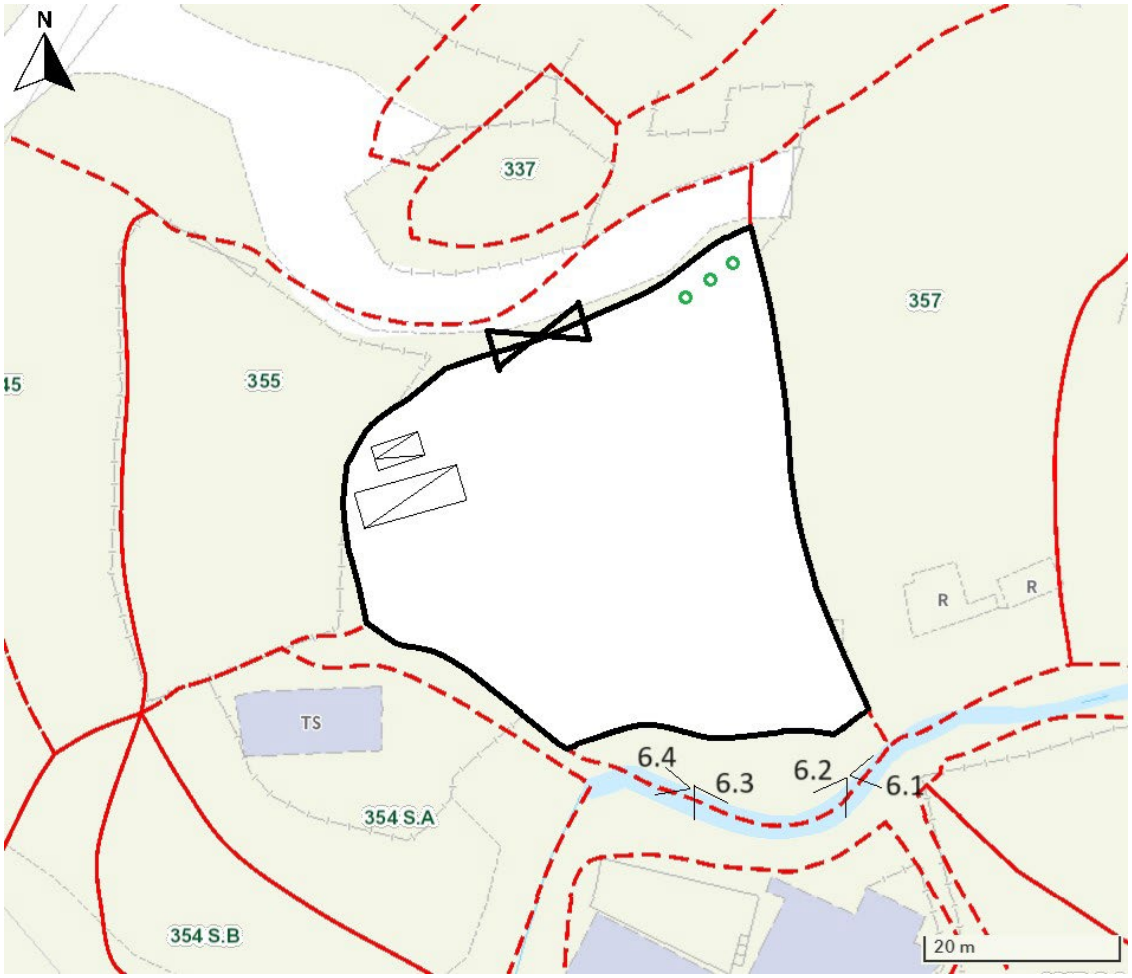

Figure 6.1

Figure 6.2

Figure 6.3

Figure 6.4