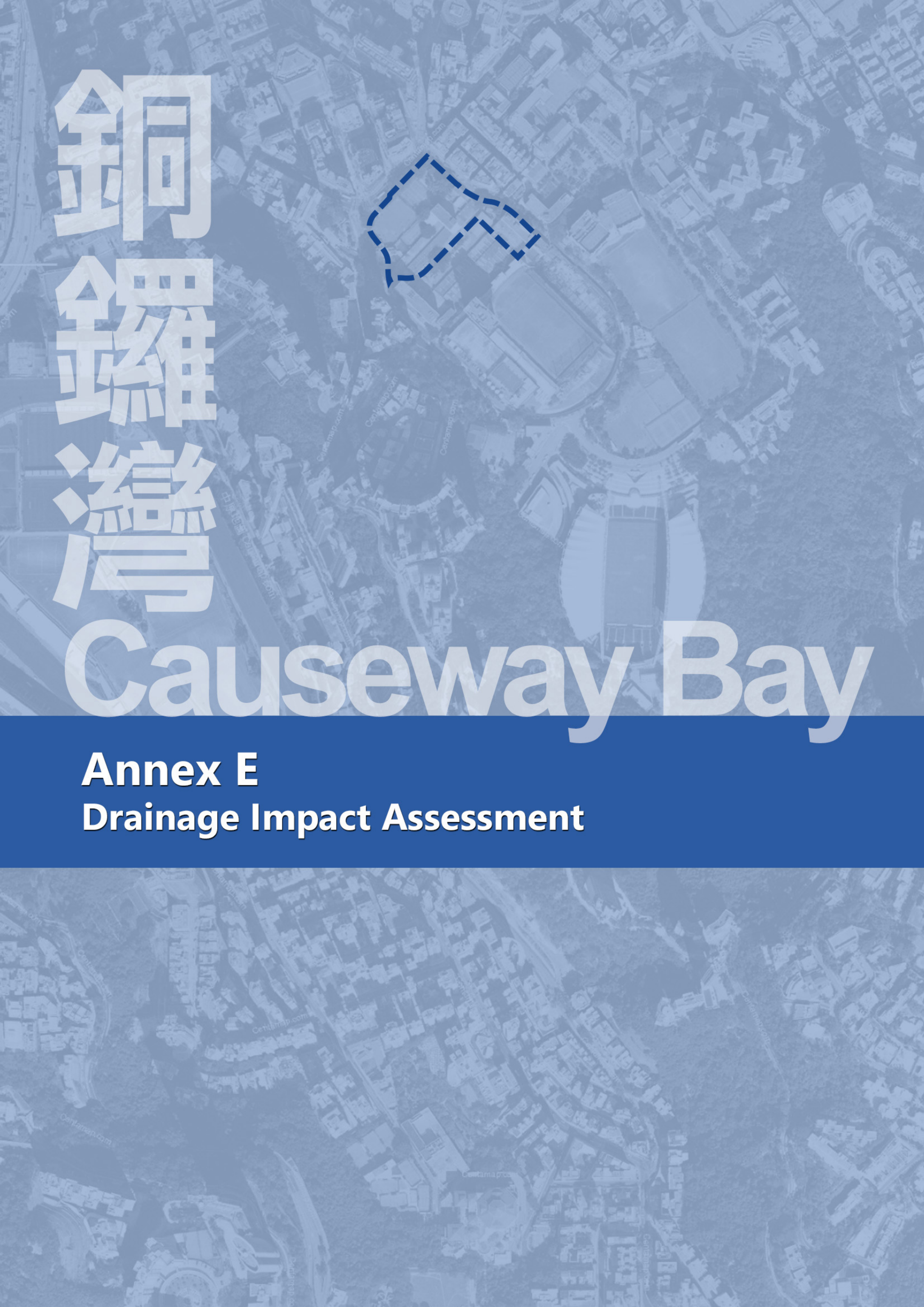

銅鑼灣
Causeway Bay

Annex E
Drainage Impact Assessment

Proposed Redevelopment at Caroline Hill Road, Causeway Bay

Drainage Impact Assessment (DIA)

Report Ref

04 | 13 August 2025

Job number 247866

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ARUP

Contents

1 Introduction

1.1 General

This revised DIA had been submitted to support the Fresh S16 Planning Application with the revised layout plan submission. The recommendation established in the previously approved DIA remains unchanged.

2 The Development

The subject site is located at Causeway Bay at the junction of Caroline Hill Road and Leighton Road. The subject site area covers approx. 14,800m^2. It was occupied by the ex-Electrical and Mechanical Services Department (EMSD) Headquarters, the ex-Civil Aid Service Headquarters, the ex-Post Office Recreation Club and the PCCW Recreation Club.

Below is an aerial photograph of the subject site.

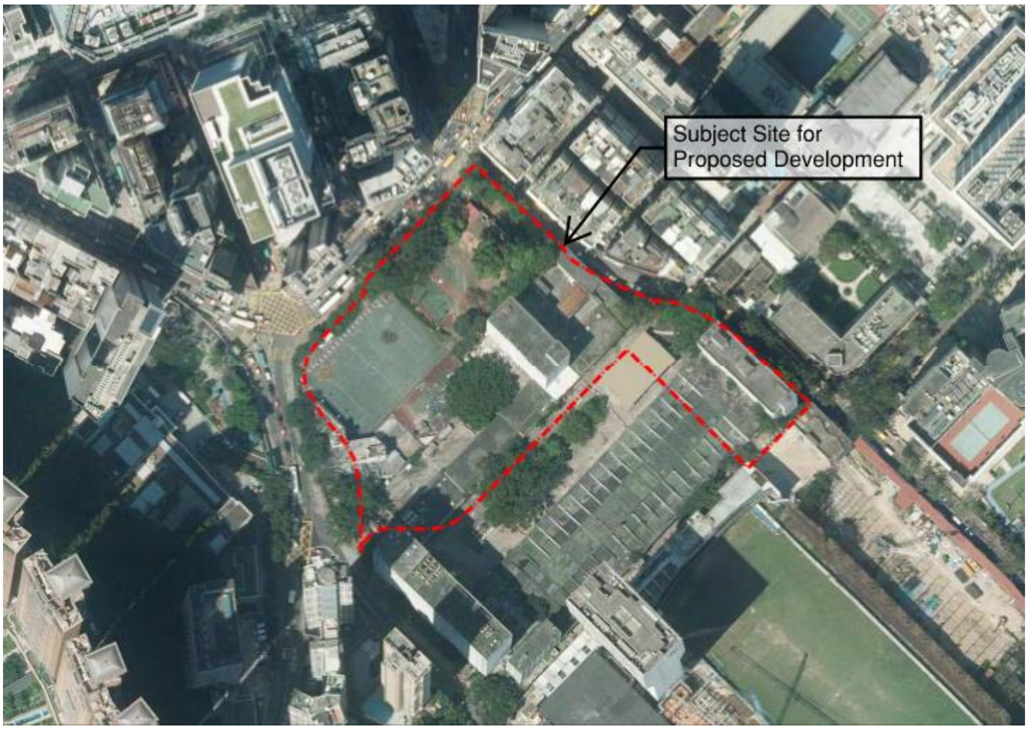


Figure 1 - Location of Subject Site

For the general arrangement in subject site, two office towers are separated by the future public road as shown in below proposed ground floor plan. Two existing Old and Valuable Trees (OVT) are observed in the subject site. One OVT (OVT No. HKP WCH/1) is located at the North of the subject site and next to Leighton Road. Another OVT (OVT No. EMSD WCH/1) is located at the South of the subject site and next to the Future Public Road.

Below is the proposed development plan which is presented in **Appendix A.**

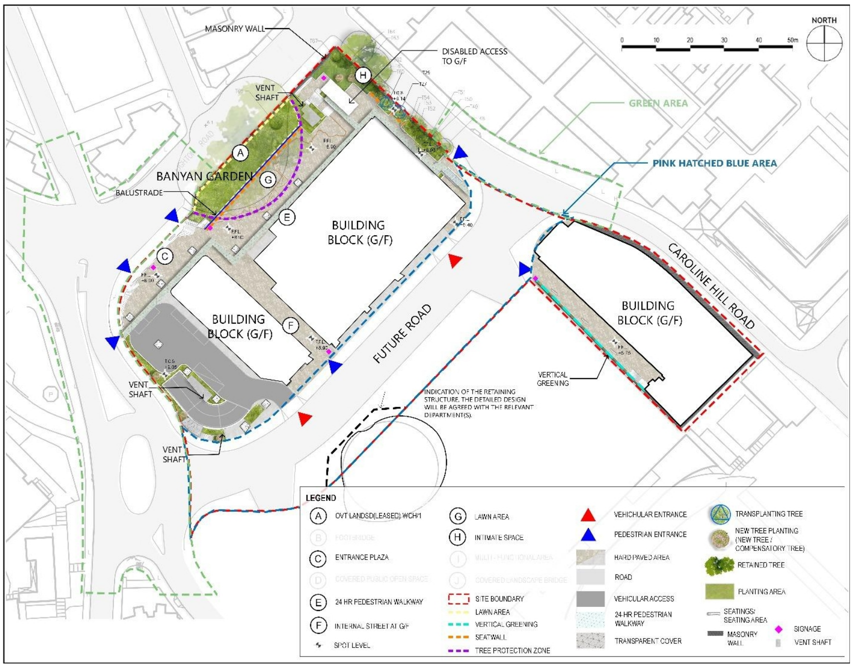


Figure 2 - Proposed Development Plan

Below is the layout plan for two old and valuable trees which is presented in **Appendix B.**

Figure 3 - OVT layout Plan

3 Methodology and Technical Approach

3.1 Assessment Approach

The DIA is following the standards set out in the Stormwater Drainage Manual (Fifth Edition) issued by *Drainage Services Department in January 2018 (DSD SDM*) and the Corrigendum No. 1/2022, 1/2024 and 2/2024.

3.1.1 Runoff Estimation

Flood Protection Level

The design standard for a drainage system shall be able to accommodate a flood event with a predefined return period, which the return period depends on the area and type of drainage system.

The design flood protection level is determined in accordance with *Table 10 of the DSD SDM*, which is reproduced in **Table 3.1**.

Table 3.1 – Recommended Design Return Periods based on Flood Levels

Category	Return Period
Intensively Used Agricultural Land	2-5 years
Village Drainage including Internal Drainage System under a Polder Scheme	10 years [1,3]
Main Rural Catchment Drainage Channels	50 years [2,3]
Urban Drainage trunk systems	200 years [4]
Urban drainage branch systems	50 years [4]

Notes:
1. The impact of a 50-year event should be assessed in each village to check whether a higher standard than 10 years can be justified.
2. Embanked channels must be capable of passing a 200-year flood within banks.
3. ‘Village Drainage’ refers to the local stormwater drainage system within a village. A stormwater drain conveying stormwater runoff from an upstream catchment but happens to pass through a village may need to be considered as either a ‘Main Rural Catchment Drainage Channel’ or ‘Village Drainage’, depending on the nature and size of the upstream catchment (refer to Section 6.6.1 of the DSD SDM.)
4. An ‘Urban Drainage Branch System’ is defined as a group or network of connecting drains collecting runoff from the urban area and conveying stormwater to a trunk drain, river or sea (refer to *Section 6.6.2 of the DSD SDM).*
5. An ‘Urban Drainage Trunk System’ collects stormwater from branch drains and/or river inlets, and conveys the flow to outfalls in river or sea (refer to *Section 6.6.2 of the DSD SDM).*

To assess the hydraulic performance of the proposed drainage system, a flood protection level with a return period of 50 years for “Urban Drainage Branch Systems” is used in this DIA.

Peak Runoff

The peak runoff is estimated using the Rational Method in accordance with *Section 7.5.2 of the DSD SDM* with the following equation:

$$Q = 0.278CiA$$

where, Q = peak runoff in m^3/s
C = runoff coefficient
i = rainfall intensity in mm/hr
A = catchment area in km^2

Runoff coefficient

The runoff coefficients, *C*, for different surface characteristic to be adopted in this DIA for the peak runoff estimation are referenced to *Section 7.5.2 (b) of the DSD SDM* and listed in **Table 3.2**.

Table 3.2 – Runoff Coefficient

Surface Characteristics	Runoff Coefficient, C[1]
Asphalt	0.70 – 0.95
Concrete	0.80 – 0.95
Brick	0.70 – 0.85
Grassland (heavy soil[2]) - Flat - Steep	 0.13 – 0.25 0.25 – 0.35
Grassland (sandy soil) - Flat - Steep	 0.05 – 0.15 0.15 – 0 20

Notes:
1. For steep natural slopes or areas where a shallow soil surface is underlain by an impervious rock layer, a higher C value of 0.4 – 0.9 may be applicable.
2. Heavy soil refers to fine grain soil composed largely of silt and clay.

Referring to the equation for peak runoff estimation, a greater value of *C* implies a greater peak runoff. Considering that the effect of soaking in unpaved area may not be as high as grassland, to be conservative, the runoff coefficient for the unpaved area is assumed to be 0.35; and the runoff coefficient for the paved area is assumed to be 0.9.

Rainfall Intensity

The rainfall intensity is determined by the following equation with reference to *Section 4.3.3 of the DSD SDM*:

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

where, i = rainfall intensity in mm/hr
td = duration in minutes
a, b, c = storm constants

The storm constants, i.e. *a*, *b*, and *c*, under *Table 3a "Storm Constants for Different Return Period of HKO Headquarters" of the DSD SDM*, which are recommended for general application, are adopted in this DIA.

According to *Section 6.8 of the DSD SDM*, the rainfall in Hong Kong is projected to increase under climate change. Considering the effect of climate change, 11.1% rainfall increase for mid-21st century (2041 –2060) as given in *Table 28 of the DSD SDM* has been included in calculating the rainfall intensity. Therefore, the equation becomes:

$$i = \frac{a}{(t_d+b)^c} \times (1 + 11.1\%)$$

where, *i* = rainfall intensity in mm/hr
td = duration in minutes
a, b, c = storm constants

Time of Concentration

The duration of minutes, *td*, is referred to the time for a drop of water to flow from the remotest point in the catchment to its outlet, i.e. the time of concentration, *tc*.

3.1.2 System Capacity

The capacity of the existing drainage system is checked by using the continuity equation, assuming full-bore flow condition:

$$Q = VA$$

where, *Q* = peak runoff in m^3/s
V = cross-sectional mean velocity in m/s
A= cross-sectional area of the pipe/channel in m^2

The cross-section mean velocity, *V*, is estimated using the Colebrook White equation:

$$\bar{V} = -\sqrt{32gRS_f}\,\log\left[\frac{k_s}{14.8R} + \frac{1.255\nu}{R\sqrt{32gRS_f}}\right]$$

where, $\bar{V}$ = cross-sectional mean velocity (m/s)
S_f = friction gradient (dimensionless)
g = acceleration due to gravity (m/s^2)
R = hydraulic radius (m)
ks = surface roughness (m)
ν = kinematic viscosity (m^2/s)

Referring to the equation for cross-section mean velocity estimation, a greater value of ks implies a smaller velocity of the drainage system. To be conservative, the surface roughness is assumed to be 0.6 mm for precast concrete pipe and 0.03mm for PE pipes with reference to *Table 14 - Recommended Roughness Values ks of the DSD SDM*, considering the reduced hydraulic performance in future due to degradation of material.

3.1.3 Sub-Catchment area

The catchment plan for existing case, the Approval Scheme and the Proposed Scheme are attached in **Appendix D**. The changes in the planting area around the OVT are summarized in below table for easy reference.

Formerly EMSD development (the Existing Case)	
Paved	15,490.5m^2
Unpaved	133.5m^2
Approval Scheme	
Paved	14,050m^2
Unpaved	750m^2
Proposed Scheme	
Paved	14,133.5m^2
Unpaved	666.5m^2

Compared with the existing site, both the Approval Scheme and Proposed Scheme will have the landscape area increase from the existing case of 133.5m^2 by enlarging the area of OVT zone to 750m^2 for the Approval Scheme and 666.5m^2 for the Proposed Scheme.

3.2 Existing Drainage System

Based on the latest underground utility survey record, there are totally 10 existing drainage connection points inside the site boundary as shown in below figure, including three 150⌀, seven 225⌀ and one 375⌀ drainage pipes.

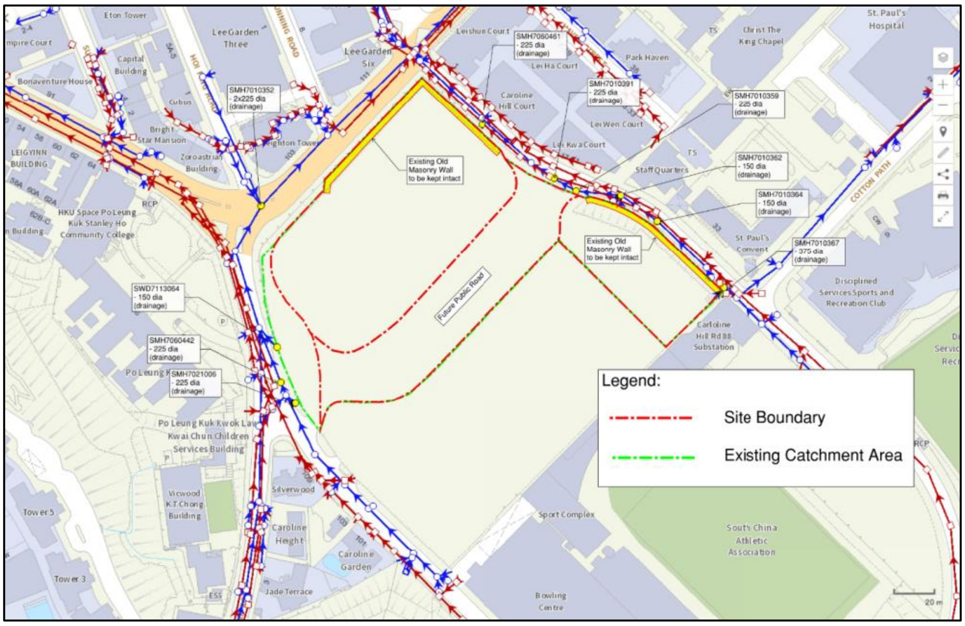


Figure 5 - Location of existing connection points inside the site boundary

Thus, total catchment area of 15,624m^2 in subject site is assumed to discharge to the nearest existing drainage system, which is located on the running southwest to northeast across the Tong Lo Wan Road. 15,490.5m^2 and 133.5m^2 are considered as paved and unpaved area respectively. The catchment area plan is presented in **Appendix D**.

The surface runoff is discharged to an existing 2250mm (w) x 2150mm (h) box culvert (SBP7001145), which is running along Tung Lo Wan Road. And then, the stormwater is discharge to Victoria Harbour, combining the surface runoff with road gullies and catchment from the upstream of Causeway Bay.

3.3 Proposed Drainage System

Proposed drainage discharge points are developed by keeping the similar catchment distribution as existing. The layout plan of existing and proposed drainage discharge points is presented in **Appendix C**.

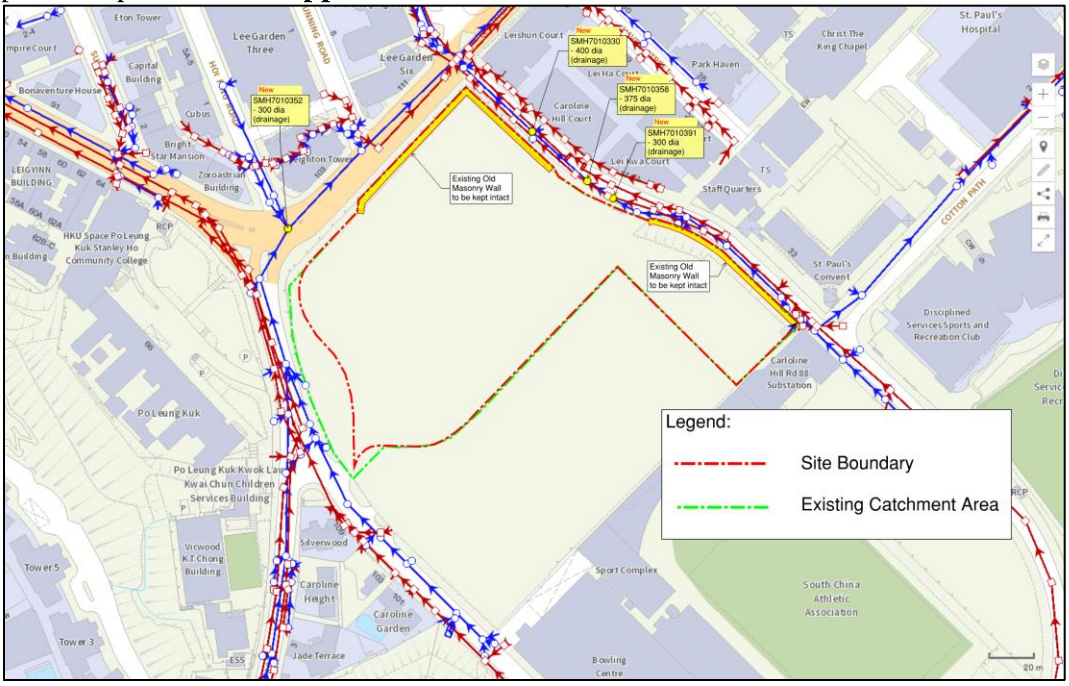


Figure 5 - Location of proposed connection points of subject site

Thus, for proposed development, total catchment area of 14,800m^2 within the subject site is assumed to discharge to the nearest existing drainage system, which is located on the running southwest to northeast across the Tong Lo Wan Road. 14,133.5m^2 and 666.5m^2 are considered as paved area and unpaved area. The catchment area plan is presented in **Appendix D**.

3.4 Potential Drainage Impacts

Currently, the surface runoff of subject site is discharged by the existing drainage discharge points, diverting to the existing 900⌀ drainage pipe along Leighton Road which is further diverted to the existing box culvert at Tung Lo Wan Road.

For the characteristic of the existing catchment, the paved and unpaved area are 15,490.5m^2 and 133.5m^2 respectively. For the characteristic of the catchment for proposed development, the unpaved area would be increased to 666.5m^2 by enlarging the area of OVT zone. Therefore, the total surface runoff from the site would be reduced. The surface runoff from the subject site would be then discharged to the proposed drainage discharge points. The peak runoff to the existing branch of drainage pipe along Leighton Road should be reduced. Thus, there is no drainage impact to the existing drainage system as a result of the proposed redevelopment.

The summary table for the catchment of drainage connections is shown below.

	Existing Case					**Approved Scheme**				
	Downstream Manhole	Pipe dia. (mm)	Sub-Catchment ref.	Paved catchment (m^2)	Unpaved catchment (m^2)	Downstream Manhole	Pipe dia. (mm)	Sub-Catchment ref.	Paved catchment (m^2)	Unpaved catchment (m^2)
South of subject site	SMH7021006	225	A4, A5, 50%A7	751.6	0					
	SMH7060442	225	A2, A6	1352	0					
	SWD7113064	150	50%A7	349	0					
Total area of the South			A2, A4-A7	2,452.6	0					
North of subject site	SMH7010352	825	A2-A8, A10	5,610.3	133.5	SMH7010352	825	B2, B3, B4	4,500	750
Total area of the North			A2-A8, A10	5,610.3	133.5			B2, B3, B4	4,500	750
East of subject site	SMH7060461	225	A9, A11, A12	2,122	0	SMH7010330	400	B5, B6	3,400	0
	SMH7010391	225	A1, A13	4,937.7	0	SMH7010358	375	B1, B7	3,550	0
	SMH7010362	150	50%A14, 50%A15	1,410.3	0	SMH7010391	300	B8	2,600	0
	SMH7010364	150	50%A14, 50%A15	1,410.3	0					
Total area of the East			A1, A9, A11, A12, A13, A14, A15	9,880.2	0			B1, B5-B8	9,550	0
Total area of the site			A1-A15	15,490.5	133.5			B1-B8	14,050	750

	Proposed Scheme				
	Downstream Manhole	Pipe dia. (mm)	Sub-Catchment ref.	Paved catchment (m^2)	Unpaved catchment (m^2)
South of subject site					
Total area of the South					
North of subject site	SMH7010352	825	B2, B3, B4	4,824.0	426.0
Total area of the North			B2, B3, B4	4,824.0	426.0
East of subject site	SMH7010330	400	B5, B6	3,159.5	240.5
	SMH7010358	375	B1, B7	3,550	0
	SMH7010391	300	B8	2,600	0
Total area of the East			B1, B5-B8	9,309.5	240.5
Total area of the site			B1-B8	14,133.5	666.5

The summary table for the peak runoff of drainage connections is shown below.

	Existing Case					**Approved Scheme**				
	Sub-Catchment ref.	Paved catchment (m^2)	Unpaved catchment (m^2)	Peak Runoff (m^3/s)	Remark	Sub-Catchment ref.	Paved catchment (m^2)	Unpaved catchment (m^2)	Peak Runoff (m^3/s)	% change
South of subject site	A2, A4-A7	2452.6	0	0.146	-	-	-	-	-	-
North of subject site	A2-A8, A10,	5610.3	133.5	0.336	-	B2, B3, B4	4500	750	0.275	-18.06%
East of subject site	A1, A9, A11, A12, A13, A14, A15	9880.2	0	0.589	-	B1, B5-B8	9550	0	0.570	-3.34%
Total Peak Runoff	A1-A15	15,490.5	133.5	0.925	-	B1-B8	14050	750	0.845	-8.68%

	Proposed Scheme				
	Sub-Catchment ref.	Paved catchment (m^2)	Unpaved catchment (m^2)	Peak Runoff (m^3/s)	% change
South of subject site	-	-	-	-	-
North of subject site	B2, B3, B4	4,824.0	426.0	0.292	-13.18%
East of subject site	B1, B5-B8	9,309.5	240.5	0.557	-5.41%
Total Peak Runoff	B1-B8	14,133.5	666.5	0.849	-8.22%

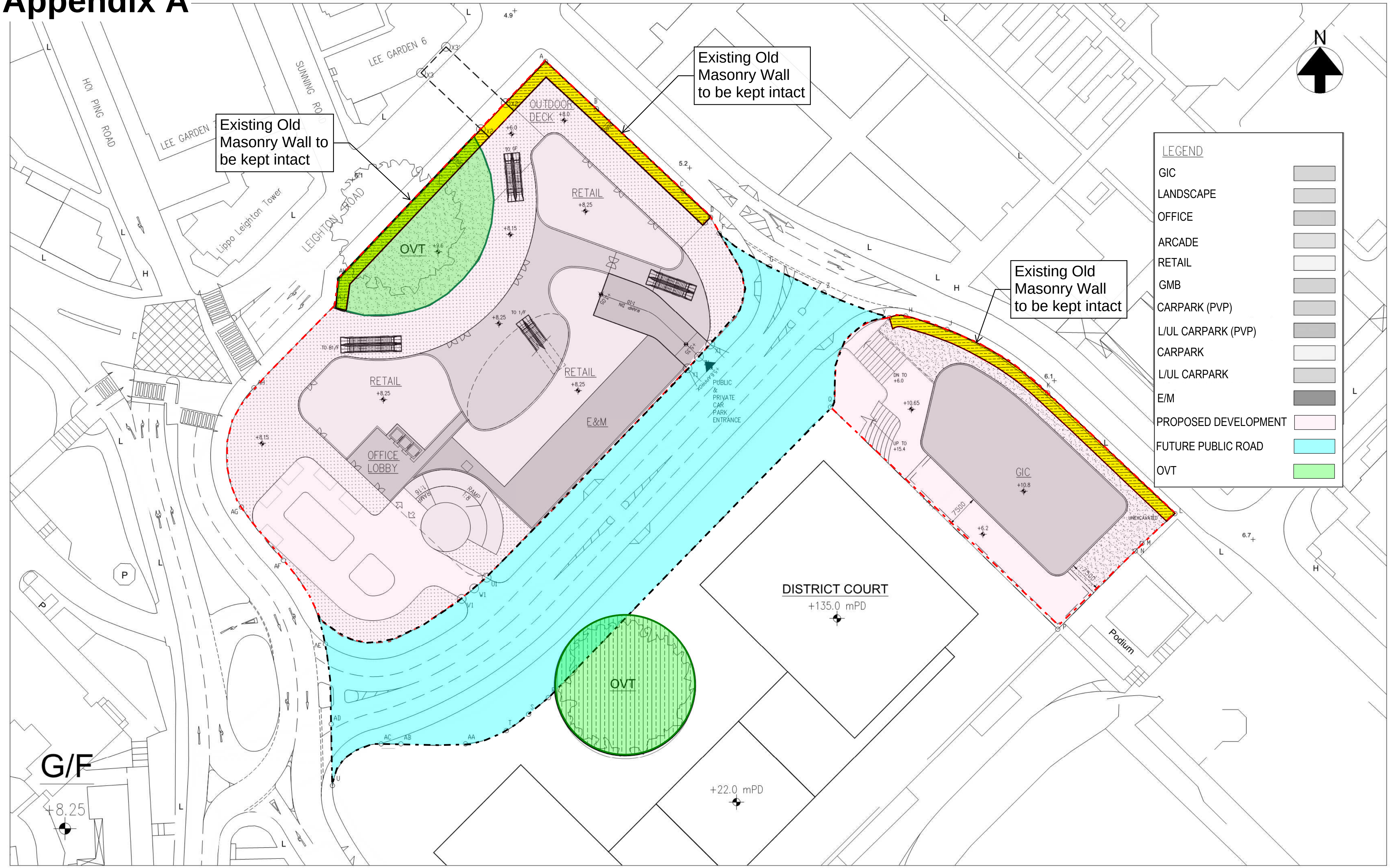
4 Conclusion

Since the total surface runoff for the proposed scheme will be reduced with enlarged landscape area when compared with the existing case, the peak runoff to the existing branch of drainage pipe along Leighton Road should also be reduced and should be beneficial to the existing drainage system. Therefore, it is concluded that there would be no impact to the existing drainage system as a result of the proposed scheme.

Appendix A

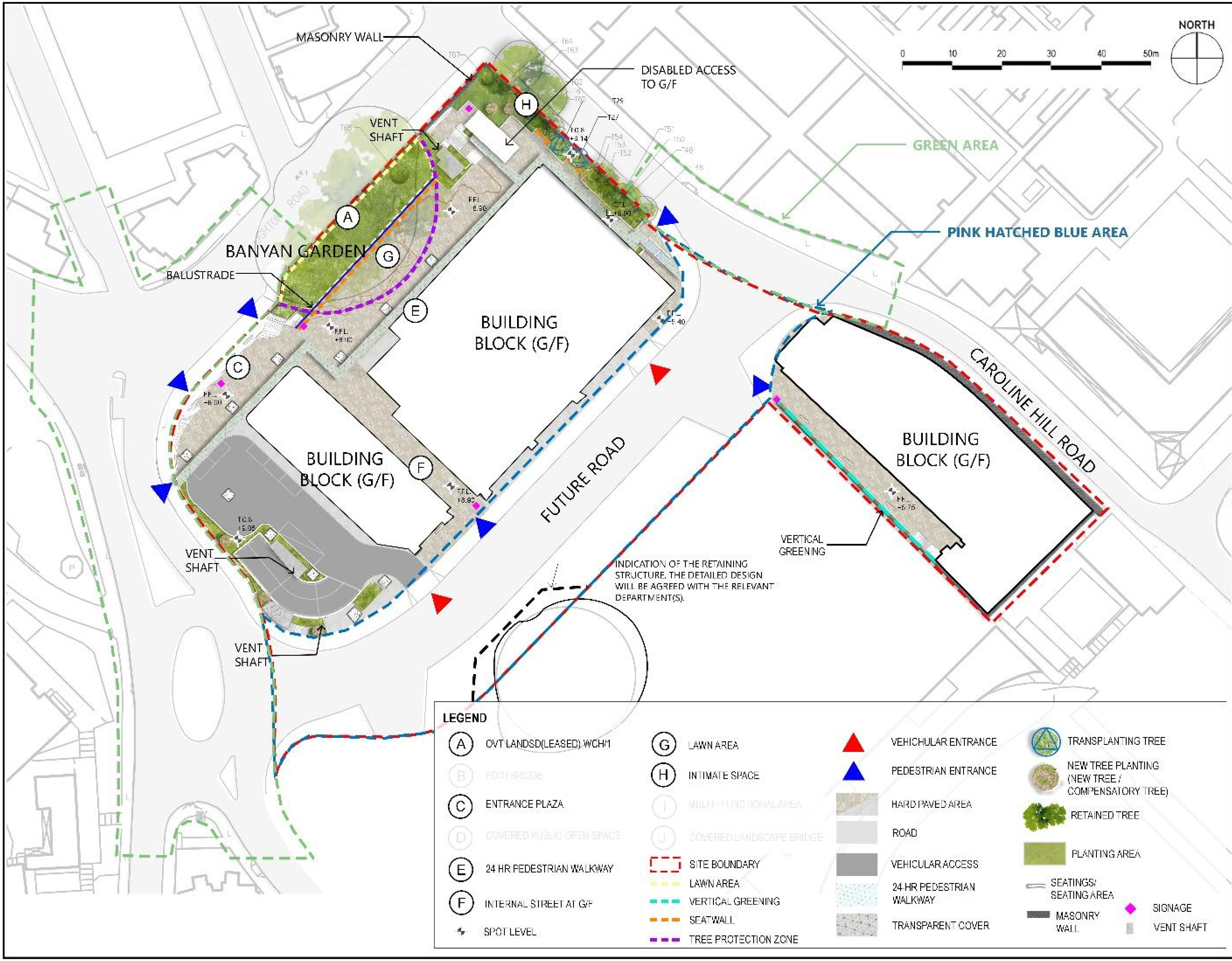
Layout Plan of Caroline Hill Road Development

Appendix A



Layout Plan of Caroline Hill Road Development

(Approved Layout Plan)



REV	DATE	DESCRIPTION
-		

otherland

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CLIENT:
PATCHWAY HOLDINGS (HK) LIMITED

PROJECT:
CAROLINE HILL ROAD

TITLE:
APPENDIX C2 -
LANDSCAPE MASTER PLAN (G/F)

SCALE:	1:750@A3
DRAWN BY:	OY
CHECKED BY:	PC
APPROVED BY:	PC
DRAWING DATE:	AUG 2025
PROJECT No:	HYSAN02
SHEET No: HYSAN02-LMP-C2-2	REV: -

Appendix B

Layout Plan of OVT

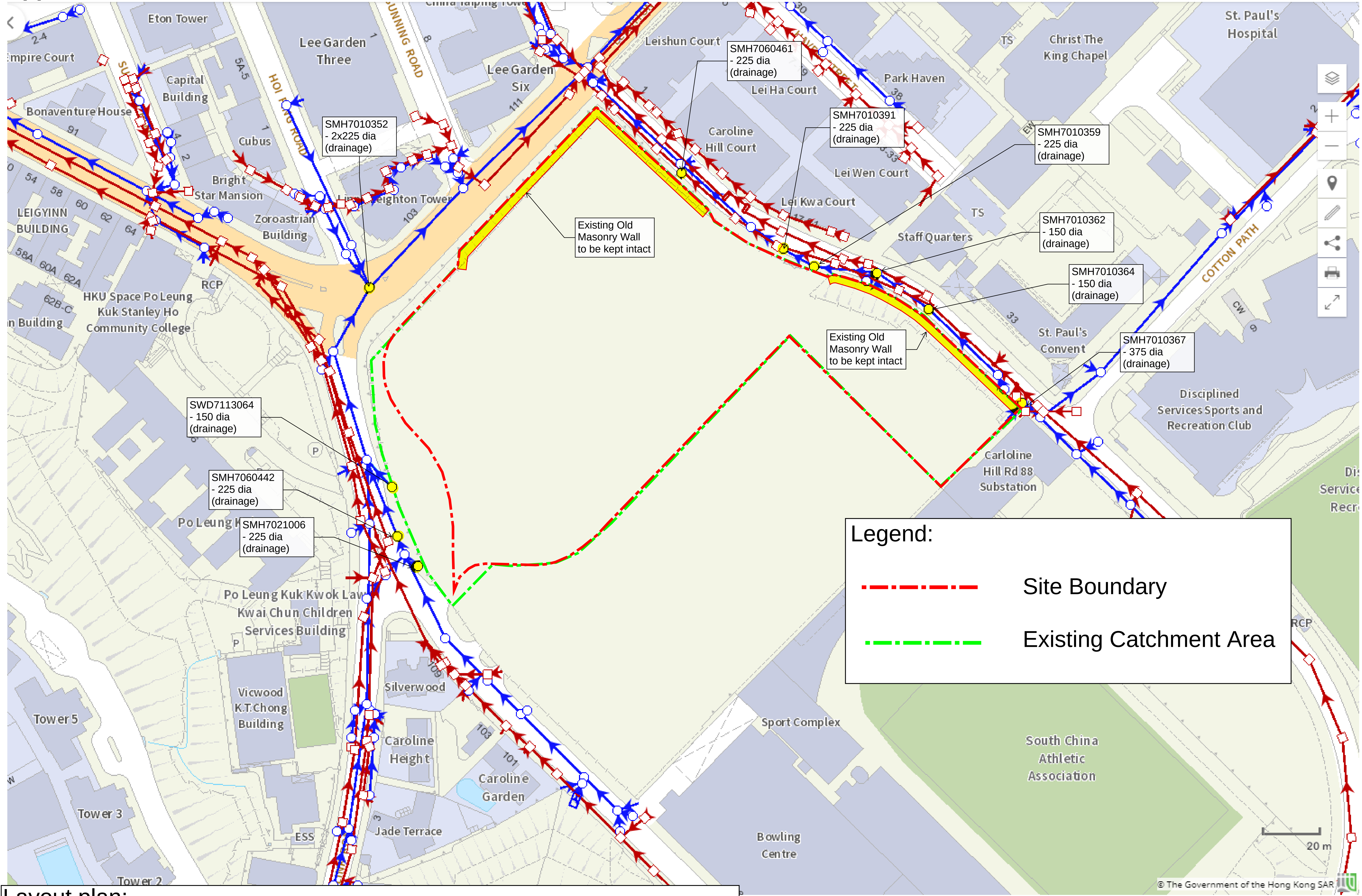
Appendix B

Location plan of OVT

Appendix C

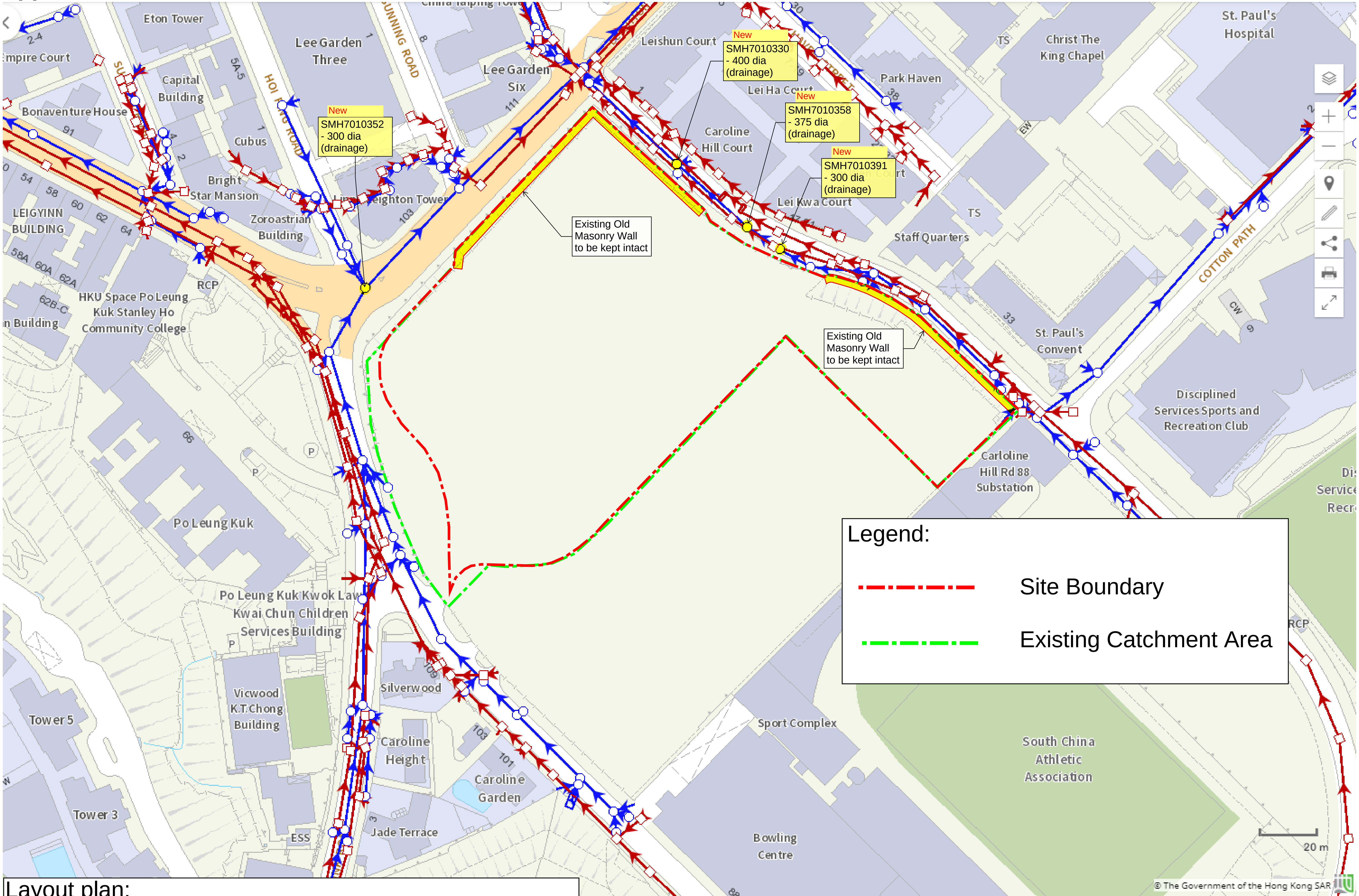
Drainage Layout plan for Caroline Hill Road Development

Appendix C



Layout plan:
Existing in-use drainage discharge points for formerly used development

Appendix C

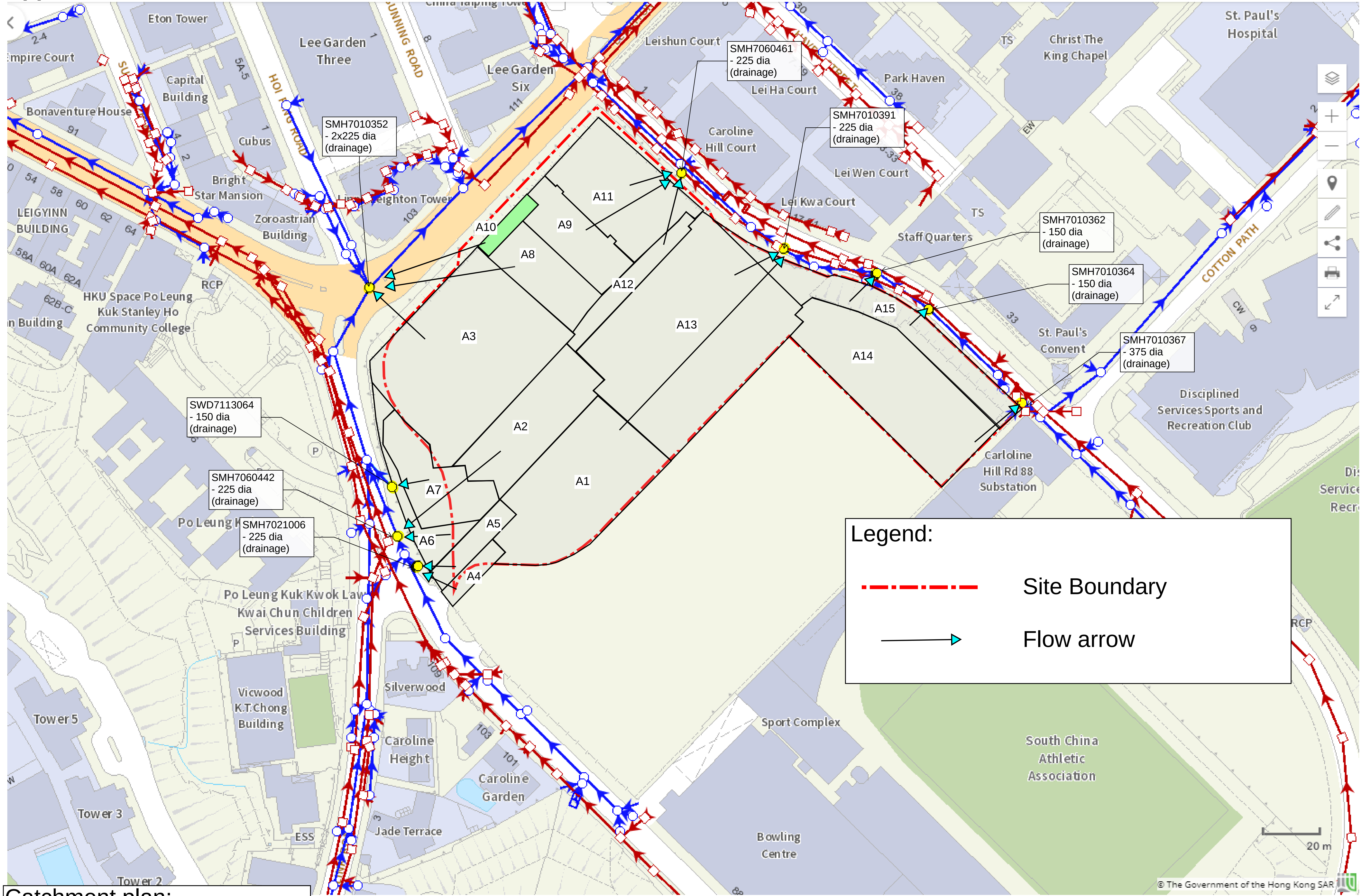


Layout plan:
Drainage discharge points for Proposed development

Appendix D

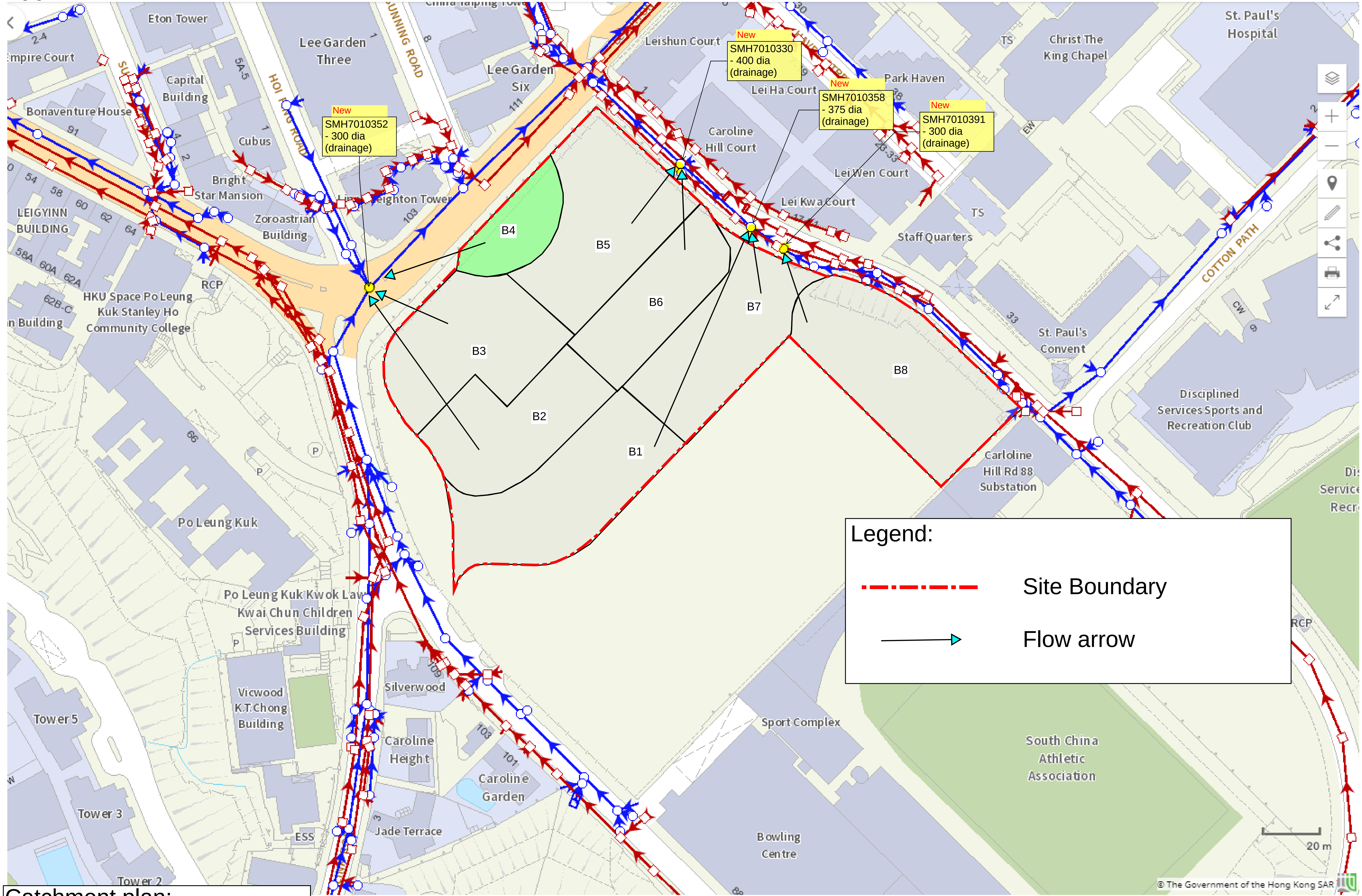
Catchment plan for Caroline Hill Road Development

Appendix D



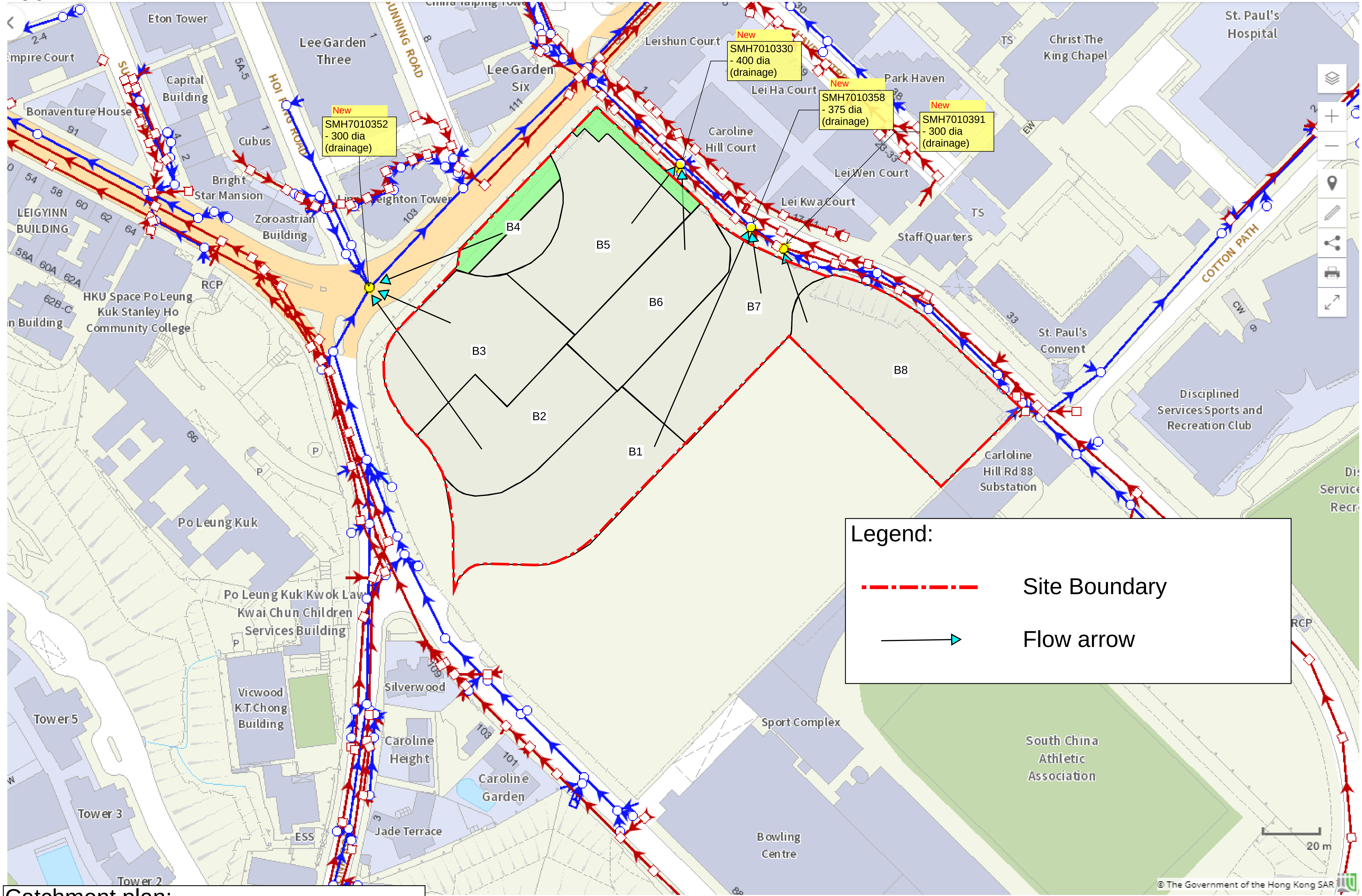
Catchment plan:
Formerly used development

Appendix D



Catchment plan:
Approval Layout Plan

Appendix D



Catchment plan:
Proposed Layout Plan

Appendix E

Pipe capacity check for Proposed Drainage discharge points

ARUP

Job No.	Sheet No.	Rev.
285077		B

Member/Location

Drg. Ref.

Job Title **Caroline Hill Road, Causeway Bay**

Calculation **Pipe Capacity Checking**

Made by IP | Date 7 Feb 2025 | Chd. CC

Notes

1 Runoff Coeff., C = 0.90 (Paved)

0.35 (Steep natural slope)

0.35 (unpaved)

Return Period = 50 years (Main Rural Catchment Drainage Channels)

(Table 10, Stormwater Drainage Manual)

Rainfall Intensity, $I = a / (T_c + b)^c$ (Gumbel solution)

where :

a =	505.5	Return Period = 50 years
b =	3.29	
c =	0.355	

(Table 3a, Stormwater Drainage Manual)
(Corrigendum No.1 2024 SDM)

2 Calculate by Colebrook-White Equation

$$\bar{V} = -\sqrt{32gRS_f}\,\log\left[\frac{k_s}{14.8R} + \frac{1.255v}{R\sqrt{32gRS_f}}\right]$$

v is kinematic viscosity of fluid = 1.14 x 10-6 m^2/s and g is the gravity = 9.81m/s^2
V is the velocity, R is the hydraulic radius and S is the gradient of the stormwater drain.

3 A 10% reduction in flow area is adopted to take into account the effects on flow capacity due to deposition of sediment in pipes.

4 Climate Change Factor (%) = 11.10%
(Table 28, Stormwater Drainage Manual, for rainfall increase at Mid 21st Century 2041 – 2060)

Catchment Area Distribution			
Catchment Area	Area (m2)		
	paved	natural slope	unpaved
B1	2235	0	0
B2	2200	0	0
B3	2300	0	0
B4	324	0	426
B5	1492	0	241
B6	1068	0	0
B7	1915	0	0
B8	2600	0	0
Total	14134	0	667

Runoff Calculation
Return period = 50 years

Location		Sub-	Catchment Area of the development					
US	DS	Catchment Reference	Paved		Steep Natural Slope		Unpaved	
			Sub-Catchment (m^2)	Accumulative Area (m^2)	Sub-Catchment (m^2)	Accumulative Area (m^2)	Sub-Catchment (m^2)	Accumulative Area (m^2)
New 300⌀	SMH7010352	B2, B3, B4	4,824.0	4,342	0	0	426.0	149
New 400⌀	SMH7010330	B5, B6	3,159.5	2,844	0	0	240.5	84
New 375⌀	SMH7010358	B1, B7	3,550.0	3,195	0	0	0.0	0
New 300⌀	SMH7010391	B8	2,600.0	2,340	0	0	0.0	0

Location	Drainage Character					Hydraulic parameter		Time of the development			(i) Extreme	Peak	Full bore	%	Full bore
US	Drainage Shape	Drainage size			Slope			t_e	t_f	t_c	mean intensity (1 in 50) with climate change	Runoff	Capacity		Velocity
		width/dia (mm)	height (mm)	length (m)	(S_f)	cross area (A) (m^2)	Hydraulic Diameter, D (m)	(min)	(min)	(min)	(mm/h)	(m^3/s)	(m^3/s)		(m/s)
New 300⌀	Circular PE Pipe	300	-	-	0.100	0.06	0.28	5.00	0.00	5.00	265.1	0.292	0.41	71	6.43
New 400⌀	Circular PE Pipe	400	-	-	0.010	0.11	0.37	5.00	0.00	5.00	265.1	0.191	0.26	73	2.31
New 375⌀	Circular Concrete Pipe	375	-	-	0.026	0.10	0.35	5.00	0.00	5.00	265.1	0.212	0.28	77	2.77
New 300⌀	Circular PE Pipe	300	-	-	0.020	0.06	0.28	5.00	0.00	5.00	265.1	0.155	0.18	88	2.78

ARUP	Job No. 285077	Sheet No.	Rev. B
	Member/Location		
Job Title: Caroline Hill Road, Causeway Bay	Drg. Ref.		
Calculation: Pipe Capacity Checking	Made by: IP	Date: 7 Feb 2025	Chd.: CC

Notes

1 Runoff Coeff., C = 0.90 (Paved)
0.35 (Steep natural slope)
0.35 (unpaved)

Return Period = 50 years (Main Rural Catchment Drainage Channels)

(Table 10, Stormwater Drainage Manual)

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$$\bar{V} = -\sqrt{32gRS_f}\,\log\left[\frac{k_s}{14.8R} + \frac{1.255v}{R\sqrt{32gRS_f}}\right]$$

v is kinematic viscosity of fluid = 1.14 x 10-6 m^2/s and *g* is the gravity = 9.81m/s^2
V is the velocity, *R* is the hydraulic radius and S is the gradient of the stormwater drain.

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(Table 28, Stormwater Drainage Manual, for rainfall increase at Mid 21st Century 2041 – 2060)

Rainfall Intensity, $I = a / (T_c + b)^c$ (Gumbel solution)

where :

a =	505.5
b =	3.29
c =	0.355

Return Period = 50 years **(Table 3a, Stormwater Drainage Manual)**
(Corrigendum No.1 2024 SDM)

Catchment Area Distribution			
Catchment Area	Area (m2)		
	paved	natural slope	unpaved
B1	2235	0	0
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B5	1492	0	241
B6	1068	0	0
B7	1915	0	0
B8	2600	0	0
Total	14134	0	667

Comparison between Total Peak Runoff
Return period = 50 years

Proposed Development

Location		Sub-	Catchment Area of the development						Drainage Character					Hydraulic parameter		Time of the development			(i) Extreme	Peak	Full bore	%	Full bore
US	DS	Catchment	Paved		Steep Natural Slope		Unpaved		Drainage	Drainage size			Slope			t_e	t_f	t_c	mean intensity	Runoff	Capacity		Velocity
		Reference	Sub-Catchment (m^2)	Accumulative Area (m^2)	Sub-Catchment (m^2)	Accumulative Area (m^2)	Sub-Catchment (m^2)	Accumulative Area (m^2)	Shape	width/dia (mm)	height (mm)	length (m)	(S_f)	cross area (A) (m^2)	Hydraulic Diameter, D (m)	(min)	(min)	(min)	(1 in 50) with climate change (mm/h)	(m^3/s)	(m^3/s)		(m/s)
	South of subject site	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	North of subject site	B2, B3, B4	4,824.0	4,342	0	0	426.0	149	Circular Concrete Pipe	-	-	-	-	-	-	5.00	0.00	5.00	265.1	0.292	-	-	-
-	East of subject site	B1, B5-B8	9,309.5	8,379	0	0	240.5	84	Circular Concrete Pipe	-	-	-	-	-	-	5.00	0.00	5.00	265.1	0.557	-	-	-
-	Total	B1-B8	14,133.5	12,720	0	0	666.5	233	Circular Concrete Pipe	-	-	-	-	-	-	5.00	0.00	5.00	265.1	0.849	-	-	-

Existing Development

Location		Sub-	Catchment Area of the development						Drainage Character					Hydraulic parameter		Time of the development			(i) Extreme	Peak	Full bore	%	Full bore
US	DS	Catchment	Paved		Steep Natural Slope		Unpaved		Drainage	Drainage size			Slope			t_e	t_f	t_c	mean intensity	Runoff	Capacity		Velocity
		Reference	Sub-Catchment (m^2)	Accumulative Area (m^2)	Sub-Catchment (m^2)	Accumulative Area (m^2)	Sub-Catchment (m^2)	Accumulative Area (m^2)	Shape	width/dia (mm)	height (mm)	length (m)	(S_f)	cross area (A) (m^2)	Hydraulic Diameter, D (m)	(min)	(min)	(min)	(1 in 50) with climate change (mm/h)	(m^3/s)	(m^3/s)		(m/s)
	South of subject site	A2, A4-A7	2452.6	2,207	0	0	0	0	Circular Concrete Pipe	-	-	-	-	-	-	5.00	0.00	5.00	265.1	0.146	-	-	-
-	North of subject site	A2-A8, A10	5610.3	5,049	0	0	133.5	47	Circular Concrete Pipe	-	-	-	-	-	-	5.00	0.00	5.00	265.1	0.336	-	-	-
-	East of subject site	A1, A9, A11, A12, A13, A14, A15	9880.2	8,892	0	0	0	0	Circular Concrete Pipe	-	-	-	-	-	-	5.00	0.00	5.00	265.1	0.589	-	-	-
-	Total	A1-A15	15490.5	13,941	0	0	133.5	47	Circular Concrete Pipe	-	-	-	-	-	-	5.00	0.00	5.00	265.1	0.925	-	-	-