Appendix D

Revised Drainage Impact Assessment

ARUP

Application for Planning Permission Under Section 16 of the Town Planning Ordinance (Cap. 131) for Proposed Residential Development in Area Shown as 'Road', Various Lots in D.D. 221 and Adjoining Government Land, Sha Ha, Sai Kung

Drainage Impact Assessment Report

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Job number 292635

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1. Introduction

1.1 Project Background

1.1.1 The Application is to seek approval from the Town Planning Board (TPB) under Section 16 of the Town Planning Ordinance (Cap. 131) for the proposed residential development at various lots in D.D. 221 and adjoining Government Land, Sha Ha, Sai Kung.

1.1.2 The Application Site is a strip of land falling within area shown as 'Road' in the Approved Sai Kung Town Outline Zoning Plan ("OZP") No. S/SK-SKT/6. To its north is Tai Mong Tsai Road which will be widened under the planned Hiram's Highway Improvement Stage 2 project, while to its south is the "Comprehensive Development Area (1)" ("CDA(1)") which is subject to a Section 16 planning application No. A/SK-SKT/28 approved with conditions by TPB on 14 January 2022. Currently, the Application Site is partly used for temporary open storage and partly vacant with unmanaged vegetation.

1.1.3 The Application Site, with an area of about 9,038 m^2, includes the Development Site (about 7,614m^2) and the empty area within the limit of works area of the planned Hiram's Highway Improvement Stage 2 adjoining the Development Site for better rationalisation of boundary. The key development parameters are summarised in **Table 1-1** below:

Table 1-1 Key development Parameters

Parameter	Proposed Scheme
District Location	Sai Kung
Site Location	Sha Ha
Application Site Area (1)	About 9,038m^2
Development Site Area	About 7,614m^2
Plot Ratio (2)	About 1.5
Domestic Gross Floor Area (GFA)	About 11,421m^2
Building Height (No. of Storeys) (3)	10 storeys
Site Coverage	Not more than 42%
No. of Residential Blocks	3
No. of Units (about)	280
Average Unit Size	About 40.79m^2
Anticipated Population (4)	About 756
Local Open Space	Not less than 756m^2
Target Completion Year	2032
Residents' Clubhouse (5)	GFA of about 571m^2

(1) The Application Site includes the Development Site and empty area within the limit of works area of the planned Hiram's Highway Improvement Stage 2 adjoining the Development Site for better rationalisation of boundary.

(2) Plot ratio calculation is based on the area of Development Site.

(3) The number of storeys excludes l-storey basement carpark.

(4) Person per flat (PPF) ratio of 2.7 is assumed, with reference to the average household size in the District Council Constituency Area Q01 Sai Kung Central in 2021 Population Census.

(5) According to APP-104, a maximum 5% of total Domestic GFA can be applied for GFA concession for a development with Domestic GFA up to 25,000m^2. The clubhouse GFA is proposed to be exempted from GFA calculation.

1.2 Purpose of the Report

1.2.1 This **Drainage Impact Assessment ("DIA")**, appended to the Supporting Planning Statement, is prepared in support of the Application for the proposed residential development.

1.2.2 The DIA Report includes relevant information to assess current flooding conditions, and flood risks after the proposed works including:

- Outline the current flooding susceptibility and proposed drainage;
- Outline the changes to the drainage characteristics and potential drainage impacts with might arise from the proposed project;
- Details of any proposed drainage impact mitigation measure and any further drainage impact implications; and
- Details of any proposed monitoring requirements.

1.2.3 The DIA Report outlines the existing drainage network in the vicinity of the Site; studies the proposed development; defines the potential impacts that may arise; and proposed mitigation measures where necessary.

1.2.4 The Report is structured as follows:

- **Section 1** introduces the project background, objectives and scope of the Project;
- **Section 2** presents the methodology and design criteria;
- **Section 3** describes the existing drainage system and its performance;
- **Section 4** describes the proposed drainage system and its performance;
- **Section 5** presents the potential drainage impacts and drainage mitigation measures; and
- **Section 6** summarises the conclusion.

2. Assessment Methodology

2.1 Overview

2.1.1 This chapter describes the methodology to assess the drainage network performance under both existing and proposed conditions.

2.2 Design Standards and Guidelines

2.2.1 The DIA has been prepared in accordance with the following design manuals and information have been adopted:

- DSD's Advice Note No. 1 – Application of the Drainage Impact Assessment Process to Private Sector Projects;
- Stormwater Drainage Manual (SDM) Fifth Edition, January 2018;
- Stormwater Drainage Manual – Corrigendum No. 1/2022;
- Stormwater Drainage Manual – Corrigendum No. 1/2024;
- Stormwater Drainage Manual – Corrigendum No. 2/2024 (SDM 2024);
- CEDD GEO – Technical Guidance Note No. 39 (TGN 39) "*Guidelines for Estimation of surface Runoff from Natural Terrain Catchments for Drainage Design Purposes*";
- Drainage Record Plans obtained from the GeoInfo[1] Map services of the Lands Department.

2.3 Design Criteria

2.3.1 The SDM 2024 recommends a range of different flood protection standards for various land uses, as shown in **Table 2-1** below.

Table 2-1 Design Flood Protection Standards

Land Use and Drainage Type	Return Period
Intensively used Agricultural Land	2-5 years
Village Drainage including Internal Drainage System under a Polder Scheme	10 years[1]
Main Rural Catchment Drainage Channels	50 years[2]
Urban Drainage Trunk Systems	200 years

[1] https://www.map.gov.hk/gm/

Land Use and Drainage Type	Return Period
Urban Drainage Branch Systems	50 years
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	

2.3.2 For low lying area or those in congested urban locations, the recommended standards may not be suitable or achievable. In such cases, consistent with SDM 2024, a pragmatic approach should be considered.

2.3.3 Where catchments are tidally influenced, the SDM 2024 recommends that for a T-year flood, peak flood levels are taken as the higher of the flood levels resulting from the following two cases:

Case A : a T-year sea level in conjunction with a X-year rainfall; and

Case B : a X-year sea level in conjunction with a T-year rainfall.

In the above rule,

X = 10 when T = 50, 100 or 200; and

X = 2 when T = 2, 5 or 10.

2.3.4 The proposed drainage network consists of Branch drains; the adopted design return period is 50years. A sensitivity analysis has been conducted under 200 year storm event.

2.4 Method of Analysis

Drainage Network Performance

2.4.1 The performance the stormwater drainage network has been assessed as per SDM 2024 Section 8.3 and Table 12. Underground stormwater network has been assessed through Colebrook-White formula.

Catchment Runoff

2.4.2 The catchment runoff has been assessed through the adoption of the Rational Method as specified in section 7.5.2 of SDM.

2.4.3 The inlet time, or time of concentration of a natural catchment has been assessed with Brandsby William's Equation as per SDM section 7.5.2. The inlet time for urbanised catchments has been set to 5 minutes.

2.5 Design Parameters

Design Roughness

2.5.1 The adopted roughness coefficients are consistent with SDM Table 13 and Table 14; and are summarised in **Table 2-2**.

Table 2-2 Adopted Roughness Coefficients

Drainage Network Element	Colebrook Roughness [mm]
Existing Drainage Pipes	0.6
Proposed Drainage Pipes	0.6
Existing Drainage Box Culverts	1.5

Design Siltation Allowance

2.5.2 To cater for capacity reduction due to materials deposited within stormwater network, siltation allowance has been adopted in accordance with SDM Section 9.3 and summarised below:

(a) 5% reduction in flow area if the gradient is greater than 1 in 25.

(b) 10% reduction in flow area in other cases.

Design Runoff Coefficients

2.5.3 The adopted runoff coefficients are summarised in **Table 2-3** and are consistent with SDM section 7.5 and GEO TGN 39.

Table 2-3 Adopted Runoff Coefficients

Surface	Runoff Coefficients
Paved Area	0.9
Unpaved Area	0.3

Design Rainfall

2.5.4 The synthetic rainfall designed in SDM section 4.3 has been adopted in this assessment. A uniformly distributed rainfall with an intensity determined by the Intensity-Duration-Frequency (IDF) relationship has been used.

2.5.5 The assessed catchments fall within SDM defined rainfall zone "HKO Headquarters"; the adopted rainfall parameters are obtained from SDM Table 3a and summarised in **Table 2-4**.

Table 2-4 Adopted Rainfall IDF Parameters

Parameter	Return Period: 50 years	Return Period: 200 years
a	505.5	508.8
b	3.29	3.46
c	0.355	0.322

2.5.6 The assessed catchment areas are less than 25km^2, hence no aerial reduction factor has been applied.

Design Sea Level

2.5.7 The synthetic design sea levels defined in SDM section 5.3 has been adopted in this assessment. The Site is located in Sai Kung, the nearest design sea level gauging station of "*North Point/Quarry Bay*" has been adopted.

Design Climate Change Scenario

2.5.8 With a conservative approach the Climate Change conditions defined in SDM section 6.8 for End of 21st Century have been adopted.

2.5.9 The adopted rainfall increase and design allowance as stipulated in SDM are summarised in **Table 2-5**.

Table 2-5 Adopted Rainfall Increase

Scenario	Rainfall Increase	Design Allowance	Adopted Total Increase
End 21st Century	16.0%	12.1%	28.1%

2.5.10 The adopted sea levels together with their increase and design allowance stipulated in SDM are summarised in **Table 2-6**.

Table 2-6 Adopted Sea Levels

Return Period	North Point / Quarry Bay [mPD]	Scenario	Mean Sea Level Rise [m]	Stom Surge [m]	Design Allowance [m]	Adopted Total Sea Levels [mPD]
10	3.20	End 21st Century	0.47	0.10	0.22	3.99
50	3.66			0.14	0.24	4.51

3. Existing Conditions

3.1 Overview

3.1.1 This chapter describes the existing drainage network and the existing catchments. The design runoff flows are defined and the performance of the existing drainage network in such conditions is assessed.

3.2 Existing Drainage Network

3.2.1 The site is located south of Tai Mong Tsai Road; existing ground levels vary between 6.8mPD and 8.3mPD degrading from north to south.

3.2.2 The main drainage network in the vicinity of the site consists of a 3 cell 3m wide and 3m high box culvert in the north. A schematic is shown in **Figure 3.1**.

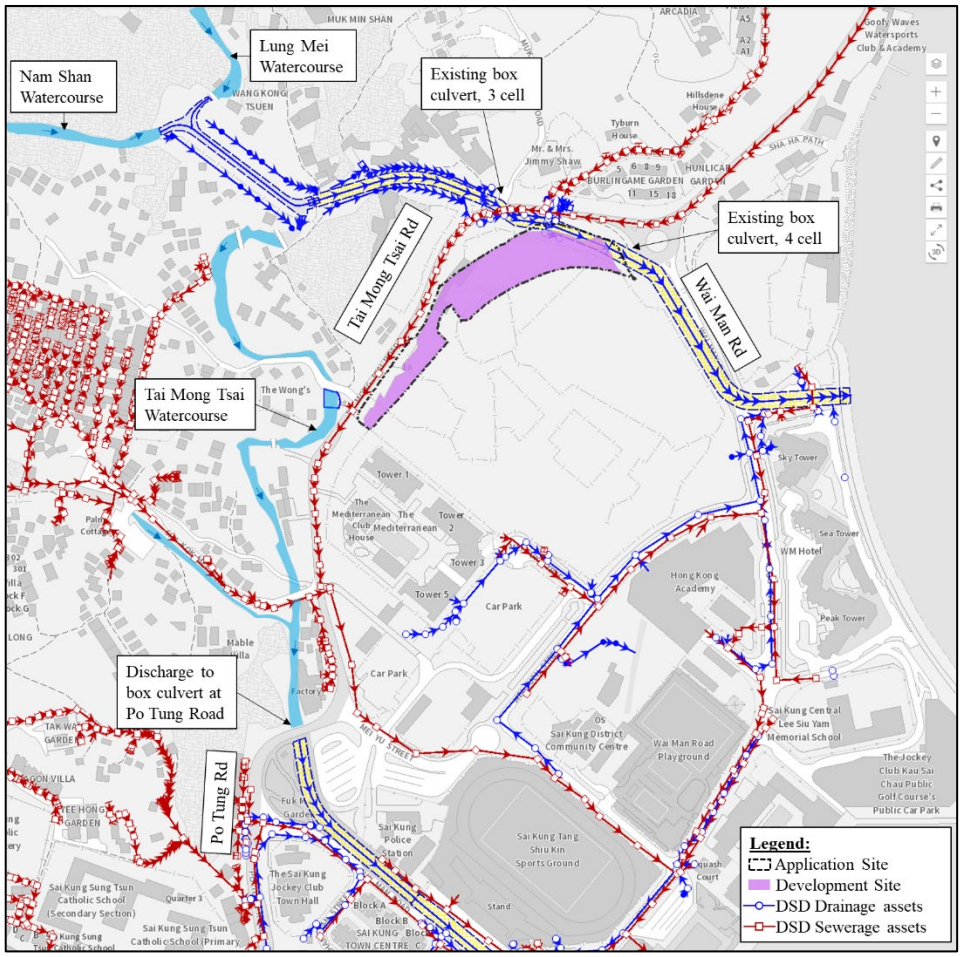


Figure 3.1 – Existing drainage network schematic

3.2.3 The incoming flows from the upstream catchments are collected by Nam Shan watercourse and Lung Mei Watercourse. After the confluence of the two watercourses discharge to the existing 3 cell box culvert with 3m wide and 3m high cells; the box culvert collects flow from tributary drainage and catchments, including the Site. The box culvert extends, downstream of the Site, to a 4 cell box culvert having same cell size as upstream, and finally to the sea.

3.2.4 The runoff from the Site is collected by unmapped minor drainage infrastructures and discharges to the existing 1,200mm diameter drain and consequently to the existing 3 cell box culvert. The Site overlaps on the eastern edge with the existing 1,200 mm diameter drain and the box culvert.

Existing Flooding Records

3.2.5 Available flooding records have been reviewed; the Site is not classified as Flooding Blackspots according to DSD website[2].

3.2.6 A flooding incident was reported on 4 May 2024. No further incidents have been identified.

Ecological Sensitive Streams

3.2.7 The presence of Ecologically Important Streams/Rivers (EIS) as per ETWB TCW No. 5/2005 and associated website[3] has been scrutinised. There are no EIS that will be affected by proposed works.

3.3 Existing Catchments and Runoffs

3.3.1 The Site is shown as "*Road*" area in the Sai Kung Town OZP No. S/SK-SKT/6 and is currently used as open storage. The land use zoning in the surroundings "*Recreation*" ("REC"). This land use has been conservatively considered as fully paved. The existing catchments to be assessed are provided in **Appendix A**.

3.3.2 The existing catchments discharge locations and the assessed existing runoff for the design storm event are summarised in **Table 3-1** and further detailed in **Appendix B**.

[2] Flooding blackspot DSD website, inspected on 16/04/2024
https://www.dsd.gov.hk/EN/Flood_Prevention/Our_Flooding_Situation/Flooding_Blackspots/index.html

[3] Ecologically Important Streams AFCD website, inspected on 16/04/2024
https://www.afcd.gov.hk/english/conservation/con_wet/streams_rivers_hk/Con_NSR/Ecologically_Important_Streams.html

Table 3-1 Existing Catchments and Runoff for 50 year End 21st Century rainfall event

Catchment	Discharges to	Area [ha]	Paved %	Design runoff [m^3/s]
CA_04_S	Box culvert Inlet	1.03	100%	0.79
CA_05_road	SMH4081225	0.22	100%	0.16
CA_02	Box culvert Inlet	199.10	30%	44.20
CA_03	Box culvert Inlet	22.10	30%	5.98
CA_06	N4627226693	0.55	60%	0.29
CA_07	SMH4081225	2.26	60%	1.03
CA_01	SMH4081226	1.37	100%	1.05

3.4 Performance of Existing Network

3.4.1 The existing ground levels are of around 11mPD which is over 6m higher than the adopted extreme design sea levels for the Case B 50year design storm event. The area is not affected by sea level flooding or backwater effect from high sea levels as it is over 6m higher than the extreme design tide under Case B storm combination; the drainage network performance is determined by rainfall intensity as the network is not subject to sea level backwater. The design rainfall intensity for Case B storm combination adopts 10year rainfall return period which is lower than the design rainfall adopted under Case A storm combination. The worst case for the drainage network performance will therefore be Case A storm combination; the drainage network performance will be assessed against severe rainfall storm events.

3.4.2 The design flow in the existing 3 cell box culvert is below the assessed capacity as shown in **Table 3-2**, detailed calculations are provided in **Appendix B**.

Table 3-2 Existing Network Performance

Design return period	Network element	Capacity [m^3/s]	Design flow [m^3/s]	Utilisation %
50 years - End 21st Century	Existing 3 cell box culvert between N4627226693 and SGJ4026100	233.6	53.2	23%
Sensitivity under 200 years - End 21st Century			60.7	26%

4. Proposed Conditions

4.1 Overview

4.1.1 This chapter describes the proposed development and the assesses the changes in land use and runoff characteristics as well flood storage. The proposed network is then described, and its performance assessed.

4.2 Proposed Works

4.2.1 The proposed development will convert the Site from current open storage to residential, a preliminary layout is shown in **Figure 4.1**.

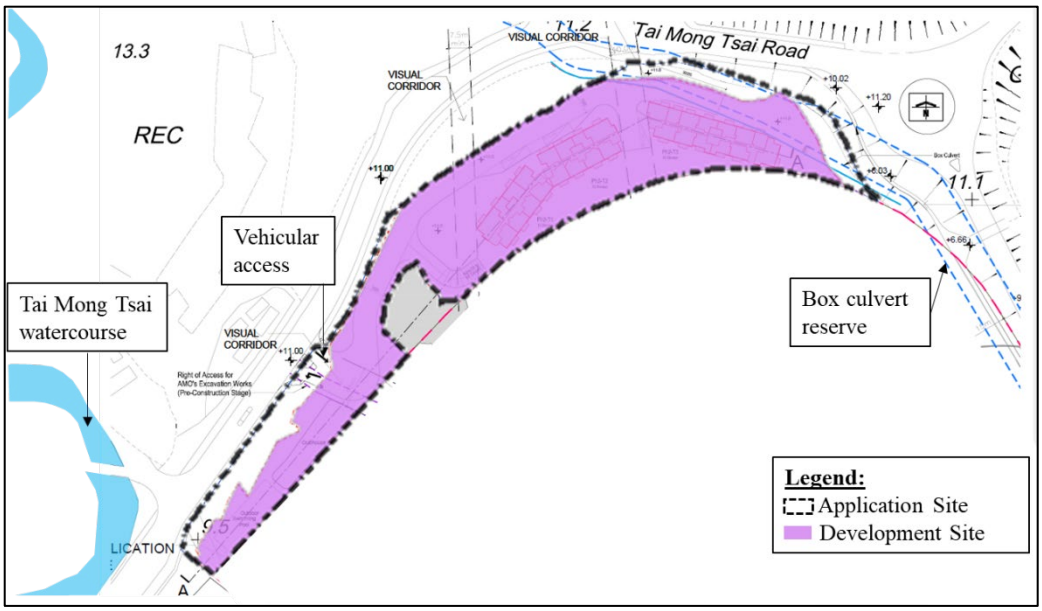


Figure 4.1 – Proposed development preliminary layout

4.2.2 The formation levels of the proposed development have been preliminarily identified in around 11mPD.

4.2.3 The proposed development will respect the drainage reserve of the existing box culvert at its northern edge. The proposed drainage network will discharge to a new terminal manhole within the Site, from there a new 825mm diameter drain will convey the flows to the existing stormwater manhole SMH4081226 and consequently to the downstream existing 1,200mm diameter pipe. The proposed development will not conflict with the drainage reserve of the existing box culvert.

4.3 Changes in Land Use and Runoff

4.3.1 The proposed development will include not less than 756m^2 of Local Open Space. With a conservative approach, the Site has been considered as fully paved.

4.3.2 The existing conditions have been assessed as fully paved, no change in runoff flows magnitude has been identified. Runoff discharge location is not modified; the receiver is still the existing 1,200mm drain.

4.4 Changes in Flood Storage

4.4.1 There is no flood storage within the site and no flood volume is accumulated during severe storm events. The proposed development will be fully drained by the proposed drainage network and does not include flood storage infrastructure. No change in flood storage has been identified.

4.5 Proposed Drainage Network

4.5.1 A new drainage network is proposed to serve the development. To facilitate maintenance, the terminal manhole has been preliminarily located in proximity of the proposed internal road.

4.5.2 The proposed drainage network will convey runoff flows from the Site to the existing 1,200mm diameter drain, a layout plan is provided in **Appendix A**. The proposed drainage network will consist in an 825mm diameter concrete pipe.

4.6 Proposed Extension and Diversion of Existing Drainage Network

4.6.1 The proposed drainage network will discharge to the existing stormwater manhole SMH4081226. The proposed development will not conflict with the drainage reserve of the existing box culvert.

4.6.2 No main drainage diversion works or drainage extension works have been identified.

4.7 Performance of Proposed Drainage Network

4.7.1 The proposed formation level will be higher than the existing ones and above design sea levels; the proposed network performance will therefore be dominated by extreme rainfalls and network capacity.

4.7.2 The proposed drain has sufficient capacity to convey the design flows as summarised in **Table 4-1** and further detailed in **Appendix B**.

Table 4-1 Proposed Network Performance

Design return period	Network element	Capacity [m^3/s]	Design flow [m^3/s]	Utilisation %
50 years - End 21st Century	Proposed 825mm pipe from TM_01 to SMH4081226	1.43	1.05	74%

4.8 Maintenance Responsibility

4.8.1 The management and maintenance responsibilities for the proposed drainage network inside the Application Site and upstream of the proposed terminal manhole TM_01 will be maintained by the developer or the management of the development after completion. The proposed drainage system downstream of the proposed terminal manhole TM_01 will be handed over to DSD upon completion of the construction works.

5. Potential Drainage Impacts and Mitigation Measures

5.1 Overview

5.1.1 In this chapter the identified drainage impacts and associated mitigation measures are discussed.

5.2 Potential Drainage Impacts

5.2.1 The runoff from the Site under baseline conditions is discharged to the existing drainage network downstream of existing manhole SMH4081226. Under proposed conditions the Site will discharge to the proposed terminal manhole TM_01 connected to existing stormwater manhole SMH4081226. The performance of existing drainage network downstream of existing manhole SMH4081226 under existing and proposed conditions have been assessed.

5.2.2 The existing 1,200mm diameter stormwater drain design flows under proposed conditions have been compared against the existing capacity. As shown in **Table 5-1** the existing 1,200mm diameter stormwater drain has sufficient capacity to convey the design flows under proposed conditions; assessment of further drainage pipes is provided in **Appendix B**.

Table 5-1 Existing Network Performance under Proposed Conditions

Design return period	Network element	Capacity [m^3/s]	Design flow [m^3/s]	Utilisation %
50 years - End 21st Century	Existing 1,200mm drain between SMH4081226 and SMH4081227	9.8	2.2	23%

5.3 Drainage Mitigation Measures

5.3.1 The existing drainage network has sufficient capacity to convey the design flows; mitigation measures have not been identified necessary.

5.4 Blue-Green Infrastructure

5.4.1 The assessment has considered the Site as fully paved, hence under proposed conditions a conservative runoff scenario has been attained. The design runoff flow can be further reduced by adopting blue green infrastructure within the Site; these will remove part of the design flow by infiltration (e.g. porous pavements) or by localised storage (e.g. raingardens).

5.4.2 The assessment has considered the worst-case scenario to facilitate development flexibility and provide a conservative assessment. The feasibility of adopting of blue-green infrastructure within the Site shall be considered in detailed design stage.

6. Conclusion

6.1.1 The proposed residential development is located at various lots in D.D. 221 and adjoining government land in Sha Ha, Sai Kung. The Site is currently used as open storage.

6.1.2 This DIA has assessed the impacts of the proposed development in accordance with DSD's Advice Note No. 1 "*Application of the Drainage Impact Assessment Process to Private Sector Projects*" and DSD SDM.

6.1.3 According to the assessment of this report, the existing drainage network has sufficient capacity to convey the existing runoff flows.

6.1.4 The proposed development will be served by a dedicated 825mm diameter stormwater pipe. The flows form the site will be discharged to a new terminal manhole and from there to the existing stormwater manhole SMH4081226; the existing 1,200mm stormwater drain will convey flows from such manhole to the existing 3 cell box culvert.

6.1.5 The proposed drainage network has sufficient capacity to cater for the design runoff flows from the proposed development.

6.1.6 The existing drainage network has sufficient capacity to convey the design flows; mitigation measures have not been identified necessary.

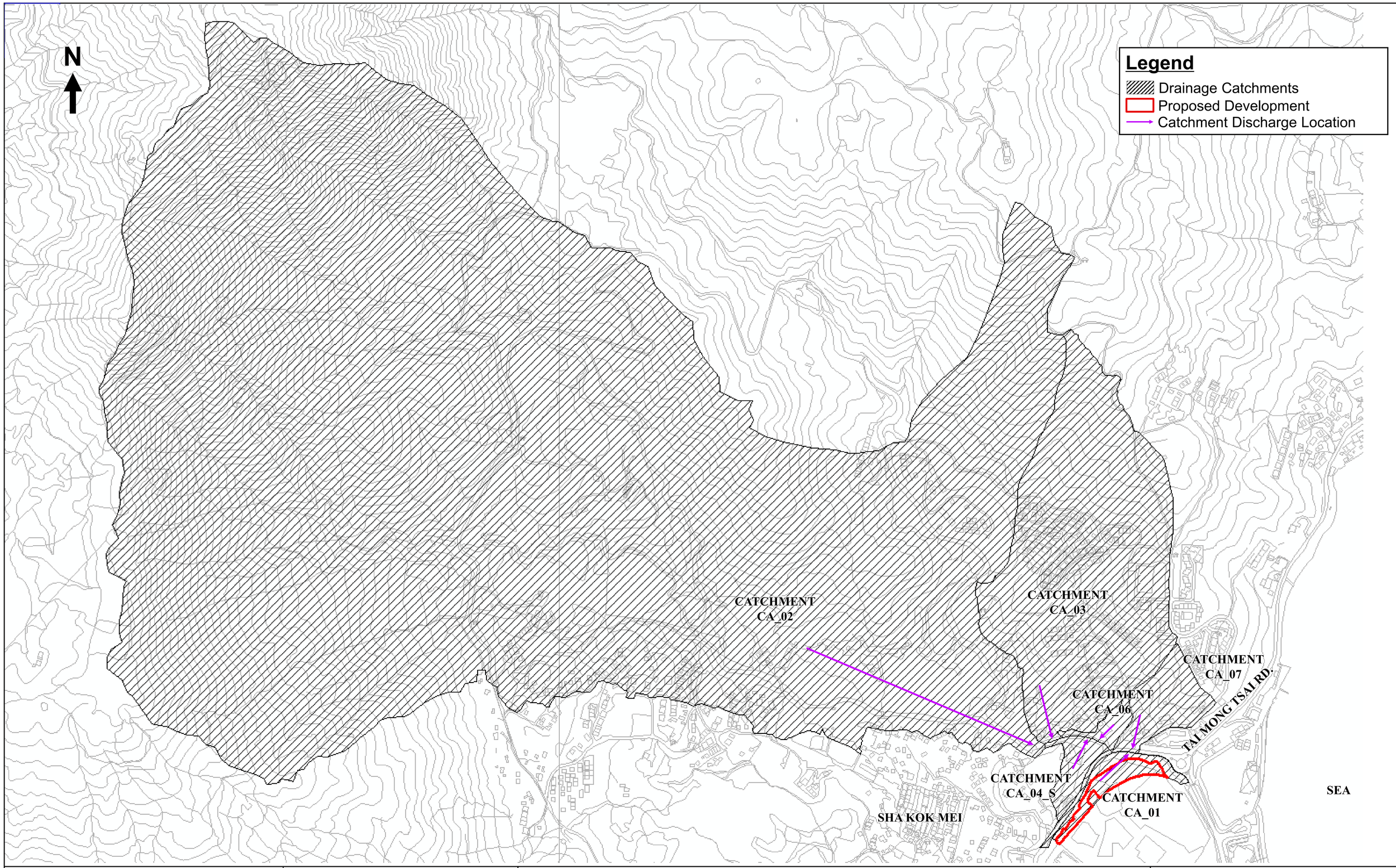
6.1.7 The drainage impact assessment carried out demonstrated that with the implementation of the proposed drainage network the proposed development will not cause any adverse drainage impact to existing public drainage infrastructure in the vicinity of the site.

Abbreviation List

Abbreviation	Definition
Arup	Ove Arup and Partners Hong Kong Limited
CDA(1)	Comprehensive Development Area (1)
CEDD	Civil Engineering and Development Department
DIA	Drainage Impact Assessment
DSD	Drainage Services Department
EIS	Ecologically Important Streams/Rivers
ETWB	Environment, Transport and Works Bureau
GEO	Geotechnical Engineering Office
GFA	Gross Floor Area
ha	hectares
HKO	Hong Kong Observatory
IDF	Intensity-Duration-Frequency
mPD	Meters above Principal Datum
OZP	Outline Zoning Plan
PPF	Person per flat
SDM	Stormwater Design Manual
SL	Sea Level
TCW	Technical Circular Works
TGN	Technical Guidance Note

Appendix A

Drawings



Job Title

Application for Planning Permission Under Section 16 of the Town Planning Ordinance (Cap. 131) for Proposed Residential Development in Area Shown as "Road", Various Lots in D.D. 221 and Adjoining Government Land, Sha Ha, Sai Kung

Drawing Title

Drainage Catchments Overview

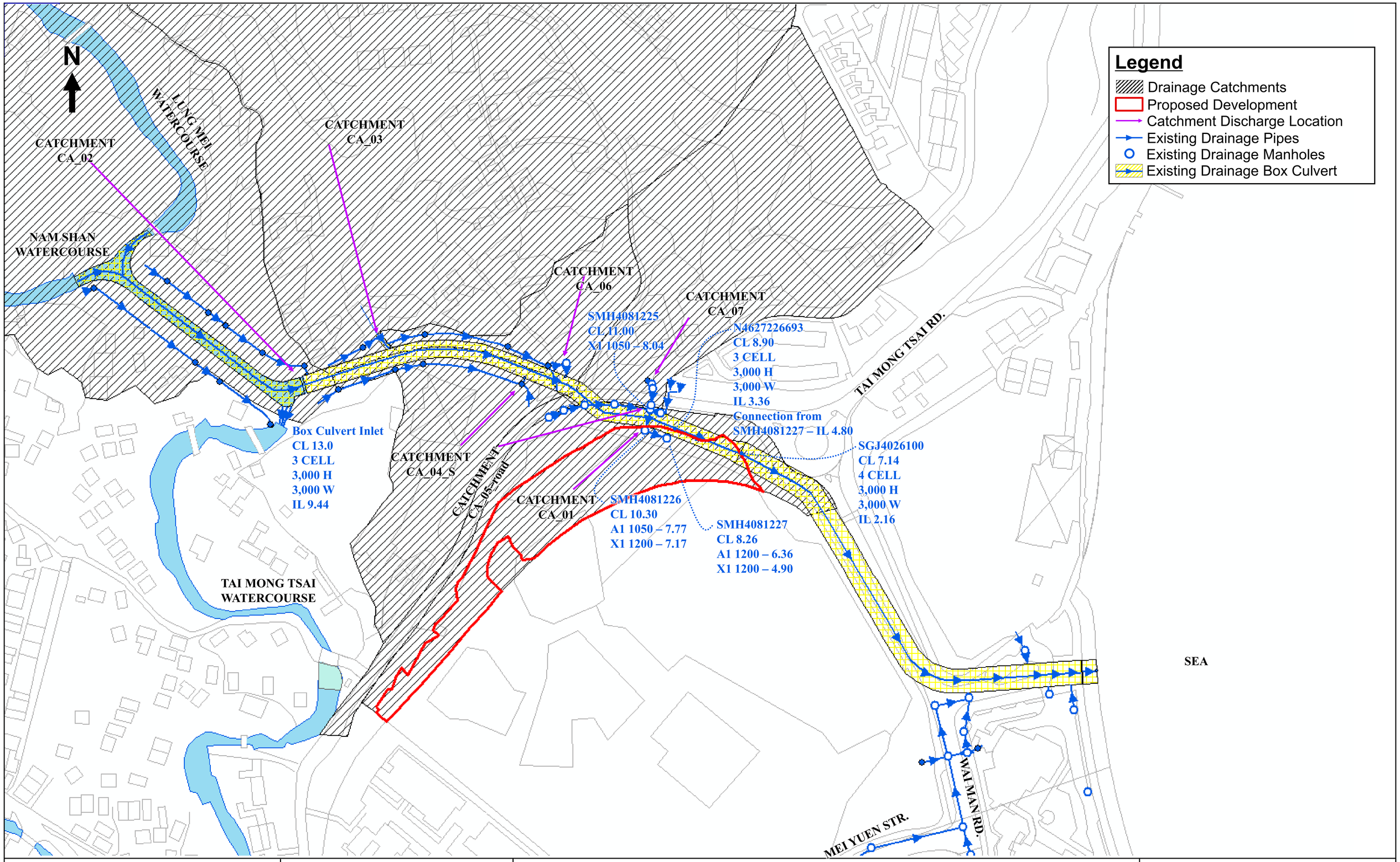
ARUP

Scale: N.T.S.

Drawn: NP Date: 05/2025 Checked: NP Approved: NP

Job No.

Drawing No. DRA_CATCH_01



Job Title

Application for Planning Permission Under Section 16 of the Town Planning Ordinance (Cap. 131) for Proposed Residential Development in Area Shown as "Road", Various Lots in D.D. 221 and Adjoining Government Land, Sha Ha, Sai Kung

Drawing Title

Drainage Catchments

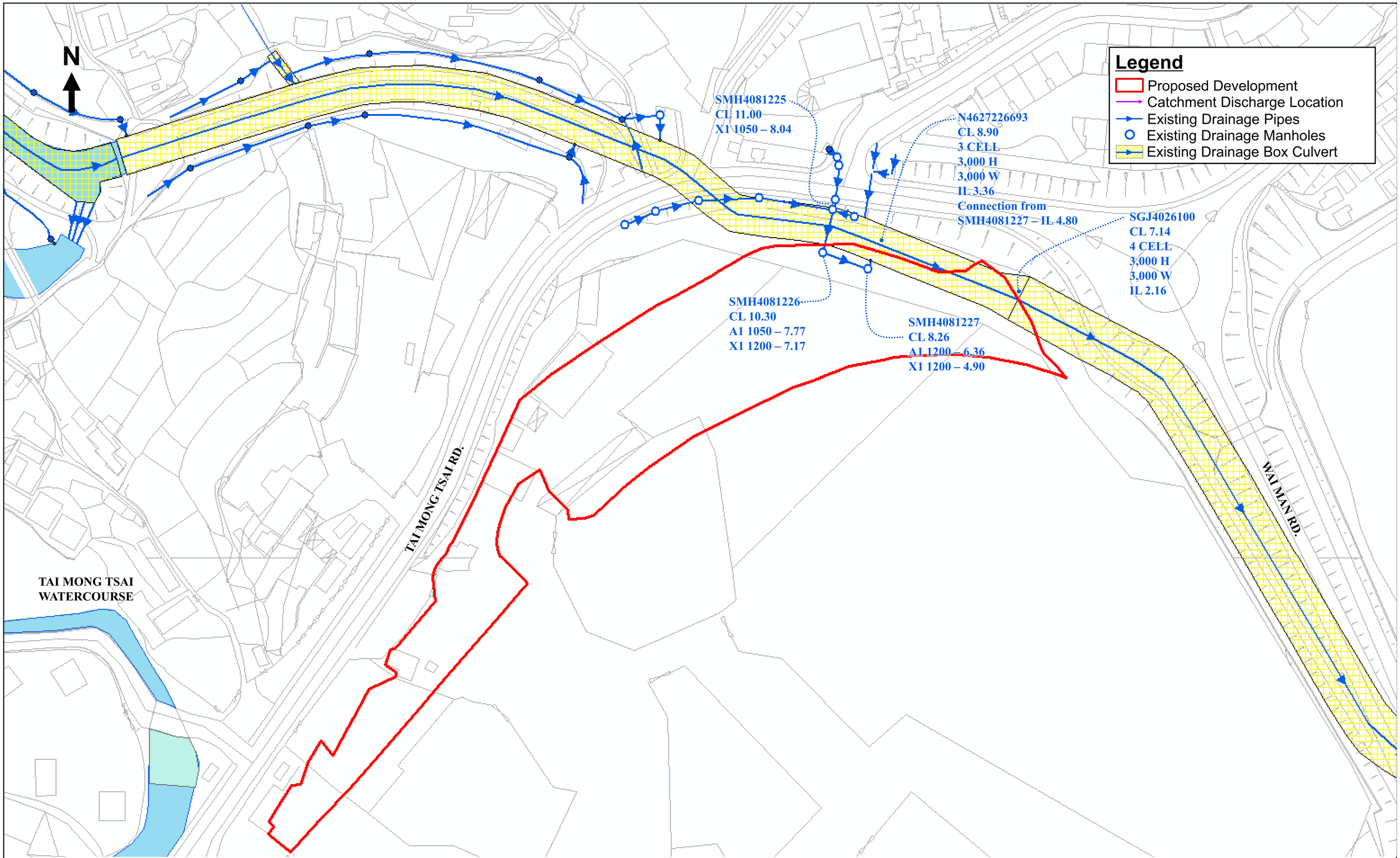
ARUP

Scale: N.T.S.

Drawn: NP Date: 05/2025 Checked: NP Approved: NP

Job No.

Drawing No. DRA_CATCH_02



	Job Title **Application for Planning Permission Under Section 16 of the Town Planning Ordinance (Cap. 131) for Proposed Residential Development in Area Shown as "Road", Various Lots in D.D. 221 and Adjoining Government Land, Sha Ha, Sai Kung**	Drawing Title **Existing Drainage Network**	ARUP Scale: N.T.S. Drawn: NP Date: 05/2025 Checked: NP Approved: NP Job No. Drawing No. DRA_EXIST_00

N

Legend

- Proposed Development
- Catchment Discharge Location
- Existing Drainage Pipes
- Existing Drainage Manholes
- Existing Drainage Box Culvert
- Existing Drainage Reserve
- Proposed Drainage Pipes
- Proposed Drainage Manholes
- Proposed Internal Road Layout (for Information only)

SMH4081225
CL 11.00
X1 1050 – 8.04

N4627226693
CL 8.90
3 CELL
3,000 H
3,000 W
IL 3.36
Connection from
SMH4081227 – IL 4.80

SGJ4026100
CL 7.14
4 CELL
3,000 H
3,000 W
IL 2.16

TM_01
CL 11.00
X1 825 – 7. 57

SMH4081227
CL 8.26
A1 1200 – 6.36
X1 1200 – 4.90

SMH4081226
CL 10.30
A1 1050 – 7.77
X1 1200 – 7.17
X2 825 – 7.50

DRAINAGE RESERVE

TAI MONG TSAI RD.

WAI MAN RD.

TAI MONG TSAI WATERCOURSE

	Job Title **Application for Planning Permission Under Section 16 of the Town Planning Ordinance (Cap. 131) for Proposed Residential Development in Area Shown as "Road", Various Lots in D.D. 221 and Adjoining Government Land, Sha Ha, Sai Kung**	Drawing Title **Proposed Drainage Network**	ARUP Scale: N.T.S. Drawn: NP Date: 05/2025 Checked: NP Approved: NP Job No. Drawing No. DRA_PROP_00

Appendix B

Calculations

Table A - Hydraulic Checking of the existing drainage system after completion of the Proposed Development

A) Design Parameters :

Runoff

Runoff Coeff., C = 0.90 (Paved)
= 0.30 (Unpaved)

Return Period = 50 years Urban Drainage Branch System

Inlet Time, T_o = minutes 5.00 Urban Drainage
Time of Flow is conservatively assumed = 0 min

Rainfall Intensity, $I = a / (Tc + b)^c$ 50-year (Gumbel solution)
where : a = 505.5 (Table 3a, Stormwater Drainage Manual Corridendum 1/24)
b = 3.29
c = 0.355

Peak Runoff ,Q_p = 0.278 C I A

Rainfall Increase due to Climate Change = 28.1% (End 21st Century, Table 28 &31 Corrigendum 1/22)

B) Existing Catchment Runoff:

Catchment		Characteristics		Time			Catchment						Runoff Flows	
Name	Type	Total catchment area	Catchment slope	Inlet, t_o	Flow, t_f	Concentration, t_c	Catchment area (hard pavement)	Catchment area (grassland)	Paved effective Area	Unpaved effective Area	Effective area (Sum of C x A)		Peak Runoff	Towards
	Rural / Urban	[ha]	[m / 100m]	[min]	[min]	[min]	[%]	[%]	[ha]	[ha]	[ha]	[km^2]	[m^3/s]	
CA_04_S	Urban	1.03	1	5.0	0.0	5.0	100%	0%	0.93	0.00	0.9288	0.009288	0.79	Box culvert Inlet
CA_05_road	Urban	0.22	1	5.0	0.0	5.0	100%	0%	0.19	0.00	0.19413	0.0019413	0.16	SMH4081225
CA_02	Rural	199.10	24	41.7	1.0	42.7	30%	70%	53.76	41.81	95.568	0.95568	44.20	Box culvert Inlet
CA_03	Rural	22.10	16	21.1	2.0	23.1	30%	70%	5.97	4.64	10.608	0.10608	5.98	Box culvert Inlet
CA_06	Rural	0.55	20	3.7	3.0	6.7	60%	40%	0.30	0.07	0.365574	0.0036557	0.29	N4627226693
CA_07	Rural	2.26	19	7.7	4.0	11.7	60%	40%	1.22	0.27	1.49424	0.0149424	1.03	SMH4081225
CA_01	Urban	1.37	1	5.0	0.0	5.0	100%	0	1.23	0.00	1.2348	0.012348	1.05	SMH4081226

C) Proposed Catchment Runoff:

Catchment		Characteristics		Time			Catchment						Runoff Flows	
Name	Type	Total catchment area	Catchment slope	Inlet, t_o	Flow, t_f	Concentration, t_c	Catchment area (hard pavement)	Catchment area (grassland)	Paved effective Area	Unpaved effective Area	Effective area (Sum of C x A)		Peak Runoff	Towards
	Rural / Urban	[ha]	[m / 100m]	[min]	[min]	[min]	[%]	[%]	[ha]	[ha]	[ha]	[km^2]	[m^3/s]	
CA_01	Urban	1.37	1	5.0	0.0	5.0	100%	0	1.23	0.00	1.2348	0.012348	1.05	TM_01

(C) Total Runoff to Proposed network 1.05

Note: Total catchment area under proposed conditions is conservatively assumed as existing catchement.

Table - Capacity Performance of Existing Drain

Notes:
Calculated by Colebrook-White Equation $\overline{V} = -\sqrt{32gRS_f}\,\log\left[\frac{k_s}{14.8R} + \frac{1.255\nu}{R\sqrt{32gRS_f}}\right]$

ν is kinematic viscosity of fluid = 1.14 x 10-6 m2/s and g is the gravity = 9.81m/s2
V is the velocity, D is the diameter of the sewer and S is the gradient of the sewer.

Assumed data

Pipe Materal	Roughness ks (mm)
MC	1.5
PC	0.6

Siltation
S< 1 in 25 10%
S> 1 in 25 5%

Existing Network

Manhole						Existing Pipe Parameter																		
UP_MAN No.	DN_MAN No.	Catchment inflow	Runoff flows (m^3/s)	Upstream flows (m^3/s)	Design Flow (m^3/s)	DIA (D) (mm)	DIA (D) (m)	Area (m2)	Perimeter (m)	Hydr Radius (m)	LEN (m)	UP_GL (mPD)	DN_GL (mPD)	UP_INV (mPD)	DN_INV (mPD)	Gradient (S)	Pipe Materal	Roughness Used ks (mm)	Pipe Materal ks (mm)	VEL (m/s)	CAP full bore (m^3/s)	Siltation (%)	CAP w. Silt. (m^3/s)	F/C (%)	Adequate Capacity?
Box culvert Inlet	N4627226693		50.96	0.00	50.96	3 Cell BC 3H*3W		27.000	36.000	0.750	233.0	13.00	8.90	9.44	3.36	38	MC	1.50	MC, ks=1.5 mm	9.58	258.78	10%	232.90	21.9%	YES
N4627226693	SGJ4026100		0.29	53.21	53.50	3 Cell BC 3H*3W		27.000	36.000	0.750	45.7	8.90	7.14	3.36	2.16	38	MC	1.50	MC, ks=1.5 mm	9.61	259.59	10%	233.63	22.9%	YES
SGJ4026100	SGJ4020186			53.50	53.50	4 Cell BC 3H*3W		36.000	48.000	0.750	48.4	7.14	8.87	2.16	1.93	210	MC	1.50	MC, ks=1.5 mm	4.09	147.12	10%	132.40	40.4%	YES
SMH4081225	SMH4081226		1.19	0.00	1.19	1,050	1.05	0.865	3.297	0.263	12.0	11.00	10.30	8.04	7.77	44	PC	0.60	PC, ks=0.6 mm	5.17	4.48	10%	4.03	29.6%	YES
SMH4081226	SMH4081227		1.05	1.19	2.24	1,200	1.2	1.130	3.768	0.300	13.6	10.30	8.25	7.17	6.36	17	PC	0.60	PC, ks=0.6 mm	9.15	10.34	5%	9.82	22.8%	YES
SMH4081227	N4627226693			2.24	2.24	1,200	1.2	1.130	3.768	0.300	2.2	8.25	8.90	4.90	4.80	22	PC	0.60	PC, ks=0.6 mm	7.99	9.03	5%	8.58	26.1%	YES

Abbreviation:

UP_MAN	Upstream Manhole
DN_MAN	Downstream Manhole
DIA	Diameter
LEN	Length
UP_GL	Upstream Ground Level
DN_GL	Downstream Ground Level
UP_INV	Upstream Invert Level
DN_INV	Downstream Invert Level
VEL	Peak Pipe Velocity
CAP	Peak Pipe Capacity
F/C	Peak Flow/Capacity
PC	Precast Concrete Pipe
MC	Monolithic Concrete
GRP	Factory manufactured GRP
PE	Polyethilene, uPVC

Table - Capacity Performance of Drainage Network After Development

Notes:
Calculated by Colebrook-White Equation $\overline{V} = -\sqrt{32gRS_f}\,\log\left[\frac{k_s}{14.8R} + \frac{1.255\nu}{R\sqrt{32gRS_f}}\right]$

ν is kinematic viscosity of fluid = 1.14 x 10-6 m2/s and g is the gravity = 9.81m/s2
V is the velocity, D is the diameter of the sewer and S is the gradient of the sewer.

Assumed data

Pipe Materal	Roughness ks (mm)
MC	1.5
PC	0.6

Siltation
S< 1 in 25 10%
S> 1 in 25 5%

Network after Development

Manhole						Existing Pipe Parameter																	
UP_MAN No.	DN_MAN No.	Catchment inflow	Runoff flows (m^3/s)	Upstream flows (m^3/s)	Design Flow (m^3/s)	DIA (D) (mm)	DIA (D) (m)	Area (m2)	Perimeter (m)	Hydr Radius (m)	LEN (m)	UP_GL (mPD)	DN_GL (mPD)	UP_INV (mPD)	DN_INV (mPD)	Gradient (S)	Pipe Materal	Roughness Used ks (mm)	Pipe Materal ks (mm)	VEL (m/s)	CAP full bore (m^3/s)	Siltation (%)	CAP w. Silt. (m^3/s)	F/C (%)	Adequate Capacity?
Box culvert Inlet	N4627226693		50.96	0.00	50.96	3 Cell BC 3H*3W		27.000	36.000	0.750	233.0	13.00	8.90	9.44	3.36	38	MC	1.50	MC, ks=1.5 mm	9.58	258.78	10%	232.90	21.9%	YES
N4627226693	SGJ4026100		0.29	53.21	53.50	3 Cell BC 3H*3W		27.000	36.000	0.750	45.7	8.90	7.14	3.36	2.16	38	MC	1.50	MC, ks=1.5 mm	9.61	259.59	10%	233.63	22.9%	YES
SGJ4026100	SGJ4020186			53.50	53.50	4 Cell BC 3H*3W		36.000	48.000	0.750	48.4	7.14	8.87	2.16	1.93	210	MC	1.50	MC, ks=1.5 mm	4.09	147.12	10%	132.40	40.4%	YES
SMH4081225	SMH4081226		1.19	0.00	1.19	1,050	1.05	0.865	3.297	0.263	12.0	11.00	10.30	8.04	7.77	44	PC	0.60	PC, ks=0.6 mm	5.17	4.48	10%	4.03	29.6%	YES
SMH4081226	SMH4081227			2.24	2.24	1,200	1.2	1.130	3.768	0.300	13.6	10.30	8.25	7.17	6.36	17	PC	0.60	PC, ks=0.6 mm	9.15	10.34	5%	9.82	22.8%	YES
SMH4081227	N4627226693			2.24	2.24	1,200	1.2	1.130	3.768	0.300	2.2	8.25	8.90	4.90	4.80	22	PC	0.60	PC, ks=0.6 mm	7.99	9.03	5%	8.58	26.1%	YES
TM_01	SMH4081226		1.05	0.00	1.05	825	0.825	0.534	2.591	0.206	7.0	11.00	10.30	7.57	7.50	100	PC	0.60	PC, ks=0.6 mm	2.97	1.59	10%	1.43	73.5%	YES

Abbreviation:

UP_MAN	Upstream Manhole
DN_MAN	Downstream Manhole
DIA	Diameter
LEN	Length
UP_GL	Upstream Ground Level
DN_GL	Downstream Ground Level
UP_INV	Upstream Invert Level
DN_INV	Downstream Invert Level
VEL	Peak Pipe Velocity
CAP	Peak Pipe Capacity
F/C	Peak Flow/Capacity
PC	Precast Concrete Pipe
MC	Monolithic Concrete
GRP	Factory manufactured GRP
PE	Polyethilene, uPVC

Sensitivity Under 200yr Storm - Hydraulic Checking of the existing drainage system after completion of the Proposed Development

A) Design Parameters :

Runoff

Runoff Coeff., C = 0.90 (Paved)
= 0.30 (Unpaved)

Return Period = 200 years Urban Drainage Branch System (box culvert)

Inlet Time, T_o = minutes 5.00 Urban Drainage
Time of Flow is conservatively assumed = 0 min

Rainfall Intensity, $I = a / (Tc + b)^c$ 200-year (Gumbel solution)
where : a = 508.8 (Table 3a, Stormwater Drainage Manual Corridendum 1/24)
b = 3.46
c = 0.322

Peak Runoff ,Q_p = 0.278 C I A

Rainfall Increase due to Climate Change = 28.1% (End 21st Century, Table 28 &31 Corrigendum 1/22)

B) Existing Catchment Runoff:

Catchment		Characteristics		Time			Catchment						Runoff Flows	
Name	Type	Total catchment area	Catchment slope	Inlet, t_o	Flow, t_f	Concentration, t_c	Catchment area (hard pavement)	Catchment area (grassland)	Paved effective Area	Unpaved effective Area	Effective area (Sum of C x A)		Peak Runoff	Towards
	Rural / Urban	[ha]	[m / 100m]	[min]	[min]	[min]	[%]	[%]	[ha]	[ha]	[ha]	[km^2]	[m^3/s]	
CA_04_S	Urban	1.03	1	5.0	0.0	5.0	100%	0%	0.93	0.00	0.9288	0.009288	0.85	Box culvert Inlet
CA_05_road	Urban	0.22	1	5.0	0.0	5.0	100%	0%	0.19	0.00	0.19413	0.0019413	0.18	SMH4081225
CA_02	Rural	199.10	24	41.7	1.0	42.7	30%	70%	53.76	41.81	95.568	0.95568	50.42	Box culvert Inlet
CA_03	Rural	22.10	16	21.1	2.0	23.1	30%	70%	5.97	4.64	10.608	0.10608	6.69	Box culvert Inlet
CA_06	Rural	0.55	20	3.7	3.0	6.7	60%	40%	0.30	0.07	0.365574	0.0036557	0.31	N4627226693
CA_07	Rural	2.26	19	7.7	4.0	11.7	60%	40%	1.22	0.27	1.49424	0.0149424	1.13	SMH4081225
CA_01_existing	Urban	1.37	1	5.0	0.0	5.0	100%	0	1.23	0.00	1.2348	0.012348	1.12	SMH4081226

C) Proposed Catchment Runoff:

Catchment		Characteristics		Time			Catchment						Runoff Flows	
Name	Type	Total catchment area	Catchment slope	Inlet, t_o	Flow, t_f	Concentration, t_c	Catchment area (hard pavement)	Catchment area (grassland)	Paved effective Area	Unpaved effective Area	Effective area (Sum of C x A)		Peak Runoff	Towards
	Rural / Urban	[ha]	[m / 100m]	[min]	[min]	[min]	[%]	[%]	[ha]	[ha]	[ha]	[km^2]	[m^3/s]	
CA_01_Proposed	Urban	1.37	1	5.0	0.0	5.0	100%	0	1.23	0.00	1.2348	0.012348	1.12	TM_01

(C) Total Runoff to Proposed network 1.12

Note: Total catchment area under proposed conditions is conservatively assumed as existing catchement.

Table - Capacity Performance of Existing Drain (200yr Sensitivity)

Notes:
Calculated by Colebrook-White Equation $\overline{V} = -\sqrt{32gRS_f}\,\log\left[\frac{k_s}{14.8R} + \frac{1.255\nu}{R\sqrt{32gRS_f}}\right]$

ν is kinematic viscosity of fluid = 1.14 x 10-6 m2/s and g is the gravity = 9.81m/s2
V is the velocity, D is the diameter of the sewer and S is the gradient of the sewer.

Assumed data

Pipe Materal	Roughness ks (mm)
MC	1.5
PC	0.6

Siltation
S< 1 in 25 10%
S> 1 in 25 5%

Existing Network

Manhole						Existing Pipe Parameter																		
UP_MAN No.	DN_MAN No.	Catchment inflow	Runoff flows (m^3/s)	Upstream flows (m^3/s)	Design Flow (m^3/s)	DIA (D) (mm)	DIA (D) (m)	Area (m2)	Perimeter (m)	Hydr Radius (m)	LEN (m)	UP_GL (mPD)	DN_GL (mPD)	UP_INV (mPD)	DN_INV (mPD)	Gradient (S)	Pipe Materal	Roughness Used ks (mm)	Pipe Materal ks (mm)	VEL (m/s)	CAP full bore (m^3/s)	Siltation (%)	CAP w. Silt. (m^3/s)	F/C (%)	Adequate Capacity?
Box culvert Inlet	N4627226693		57.95	0.00	57.95	3 Cell BC 3H*3W		27.000	36.000	0.750	233.0	13.00	8.90	9.44	3.36	38	MC	1.50	MC, ks=1.5 mm	9.58	258.78	10%	232.90	24.9%	YES
N4627226693	SGJ4026100		0.31	60.38	60.70	3 Cell BC 3H*3W		27.000	36.000	0.750	45.7	8.90	7.14	3.36	2.16	38	MC	1.50	MC, ks=1.5 mm	9.61	259.59	10%	233.63	26.0%	YES
SGJ4026100	SGJ4020186			60.70	60.70	4 Cell BC 3H*3W		36.000	48.000	0.750	48.4	7.14	8.87	2.16	1.93	210	MC	1.50	MC, ks=1.5 mm	4.09	147.12	10%	132.40	45.8%	YES
SMH4081225	SMH4081226		1.31	0.00	1.31	1,050	1.05	0.865	3.297	0.263	12.0	11.00	10.30	8.04	7.77	44	PC	0.60	PC, ks=0.6 mm	5.17	4.48	10%	4.03	32.4%	YES
SMH4081226	SMH4081227		1.12	1.31	2.43	1,200	1.2	1.130	3.768	0.300	13.6	10.30	8.25	7.17	6.36	17	PC	0.60	PC, ks=0.6 mm	9.15	10.34	5%	9.82	24.7%	YES
SMH4081227	N4627226693			2.43	2.43	1,200	1.2	1.130	3.768	0.300	2.2	8.25	8.90	4.90	4.80	22	PC	0.60	PC, ks=0.6 mm	7.99	9.03	5%	8.58	28.3%	YES

Abbreviation:

UP_MAN	Upstream Manhole
DN_MAN	Downstream Manhole
DIA	Diameter
LEN	Length
UP_GL	Upstream Ground Level
DN_GL	Downstream Ground Level
UP_INV	Upstream Invert Level
DN_INV	Downstream Invert Level
VEL	Peak Pipe Velocity
CAP	Peak Pipe Capacity
F/C	Peak Flow/Capacity
PC	Precast Concrete Pipe
MC	Monolithic Concrete
GRP	Factory manufactured GRP
PE	Polyethilene, uPVC

Table - Capacity Performance of Drainage Network After Development (200yr Sensitivity)

Notes:
Calculated by Colebrook-White Equation $\overline{V} = -\sqrt{32gRS_f}\,\log\left[\frac{k_s}{14.8R} + \frac{1.255\nu}{R\sqrt{32gRS_f}}\right]$

ν is kinematic viscosity of fluid = 1.14 x 10-6 m2/s and g is the gravity = 9.81m/s2
V is the velocity, D is the diameter of the sewer and S is the gradient of the sewer.

Assumed data

Pipe Materal	Roughness ks (mm)
MC	1.5
PC	0.6

Siltation
S< 1 in 25 10%
S> 1 in 25 5%

Network after Development

Manhole						Existing Pipe Parameter																	
UP_MAN No.	DN_MAN No.	Catchment inflow	Runoff flows (m^3/s)	Upstream flows (m^3/s)	Design Flow (m^3/s)	DIA (D) (mm)	DIA (D) (m)	Area (m2)	Perimeter (m)	Hydr Radius (m)	LEN (m)	UP_GL (mPD)	DN_GL (mPD)	UP_INV (mPD)	DN_INV (mPD)	Gradient (S)	Pipe Materal	Roughness Used ks (mm)	Pipe Materal ks (mm)	VEL (m/s)	CAP full bore (m^3/s)	Siltation (%)	CAP w. Silt. (m^3/s)	F/C (%)	Adequate Capacity?
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SGJ4026100	SGJ4020186			60.70	60.70	4 Cell BC 3H*3W		36.000	48.000	0.750	48.4	7.14	8.87	2.16	1.93	210	MC	1.50	MC, ks=1.5 mm	4.09	147.12	10%	132.40	45.8%	YES
SMH4081225	SMH4081226		1.31	0.00	1.31	1,050	1.05	0.865	3.297	0.263	12.0	11.00	10.30	8.04	7.77	44	PC	0.60	PC, ks=0.6 mm	5.17	4.48	10%	4.03	32.4%	YES
SMH4081226	SMH4081227			2.43	2.43	1,200	1.2	1.130	3.768	0.300	13.6	10.30	8.25	7.17	6.36	17	PC	0.60	PC, ks=0.6 mm	9.15	10.34	5%	9.82	24.7%	YES
SMH4081227	N4627226693			2.43	2.43	1,200	1.2	1.130	3.768	0.300	2.2	8.25	8.90	4.90	4.80	22	PC	0.60	PC, ks=0.6 mm	7.99	9.03	5%	8.58	28.3%	YES
TM_01	SMH4081226		1.12	0.00	1.12	825	0.825	0.534	2.591	0.206	7.0	11.00	10.30	7.57	7.50	100	PC	0.60	PC, ks=0.6 mm	2.97	1.59	10%	1.43	78.8%	YES

Abbreviation:

UP_MAN	Upstream Manhole
DN_MAN	Downstream Manhole
DIA	Diameter
LEN	Length
UP_GL	Upstream Ground Level
DN_GL	Downstream Ground Level
UP_INV	Upstream Invert Level
DN_INV	Downstream Invert Level
VEL	Peak Pipe Velocity
CAP	Peak Pipe Capacity
F/C	Peak Flow/Capacity
PC	Precast Concrete Pipe
MC	Monolithic Concrete
GRP	Factory manufactured GRP
PE	Polyethilene, uPVC