Prepared for

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PROPOSED PUBLIC RESIDENTIAL HOUSING / STARTER HOMES DEVELOPMENT AT UDWYT LOT 14RP AND ADJOINING GOVERNMENT LAND (SITE A) & PROPOSED PRIVATE RESIDENTIAL DEVELOPMENT AT UDWYT LOT 11 RP AND ADJOINING GOVERNMENT LAND (SITE B), WONG YUE TAN, TAI PO

DRAINAGE IMPACT ASSESSMENT

Date	**February 2025**
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CHAPTERS

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APPENDICES

1. INTRODUCTION

1.1 Project Background

1.1.1 Referring to the Lands Sharing Pilot Scheme ("LSPS") application at Lo Fai Road/ Ting Kok Road with application no. LSPS/001 on 19 July 2021, the applicant has revised the submission.

1.1.2 The application involves two private lots, namely Lot 14 RP and Lot 11 RP in Unsurveyed District at Wong Yue Tan ("UDWYT") and adjoining Government Lands ("GL"). Lot 14 RP and adjoining Government Land (Site A) would be designated for public housing / Starter Homes Housing development, whereas Lot 11 RP and adjoining Government Land (Site B) would be designated for proposed private residential development.

1.1.3 As per request from Drainage Services Department (DSD) (dated 1 September 2021) and LSO, Drainage Impact Assessment (DIA) with calculation on drainage provisions is submitted herewith for further information.

1.1.4 Ramboll Hong Kong Limited has been commissioned by the Applicant to provide environmental consultancy services for the DIA for the Proposed Development at Site A and Site B.

1.2 Site A and Site B and its Environ

1.2.1 Site A and Site B are located at Ting Kok Road in Tai Po with residential developments and Tai Po Industrial Estate nearby. The existing use of the sites is vacant.

1.2.2 Site A is bounded by Ting Kok Road to the south, and Lo Fai Road to the west. The area to the north to east is vegetated slope area zoned Green Belt.

1.2.3 Site B is bounded by Ting Kok Road to the south. The area to the south to east is vegetated slope area zoned Green Belt.

1.2.4 The location and its environs are shown in **Figure 1**.

1.3 Proposed Development

1.3.1 Site A will consist of public residential housing / SH housing while Site B will have private residential tower. In addition, GIC uses such as residential care home for elderly (RCHE) and retail facilities will be included in Site A as well. Greenery portion which amounts to 20% of site area is assumed and applied to both Site A and Site B for assessment purpose, and is subject to detailed design and with reference to PNAP APP-152 Sustainable Building Design Guidelines. The expected year for completion of the Proposed Development is 2030 tentatively. Yet, it may take extra time to design and complete the development so that the project may be completed as late as by 2033.

2. DRAINAGE IMPACT ASSESSMENT

2.1 Scope of Work

2.1.1 The aim of this DIA is to assess whether the capacity of the existing drainage network serving Site A and Site B is sufficient to cope with the stormwater runoff from the proposed development. Drainage Record Plans was obtained from Drainage Services Department (DSD) for the purpose of this DIA.

2.2 Assessment Criteria and Methodology

2.2.1 The assessment standard complies with DSD Stormwater Drainage Manual (SDM) (2018 Edition), Corrigendum No. 1/2022 and Corrigendum No. 1/2024. Site A and Site B are situated in an area served by urban drainage trunk system, therefore, a 1 in 50 year return storm has been adopted for the DIA.

2.2.2 The catchment runoff has been calculated using the "Rational Method", as outlined in the DSD SDM:

$$Q = 0.278\ C\ i\ A$$

Where Q = peak runoff in m^3/s
C = runoff coefficient (dimensionless)
i = rainfall intensity in mm/hr
A = catchment area in km

2.2.3 Site A and Site B before the development was covered by steep vegetated land with runoff coefficient 0.35 adopted.

2.2.4 The proposed development will be mainly for residential use. Runoff coefficients of 0.95 and 0.15 (which is for grassland (sandy soil) – flat) are adopted for the future paved and unpaved areas respectively.

2.2.5 The rainfall intensity parameter "i" is dependent on the return period, rainfall duration and the time of concentration of the catchment under consideration. For the future upstream catchment containing the Site, there is no significant change to the flow path and the same time of concentration has been adopted as for the existing scenario. Runoff calculations are included in **Appendix 1**.

2.3 Existing Drainage System

2.3.1 For Site A, there are existing Ø 1650 mm stormwater drains along Lo Fai Road to the west. The pipe is then enlarged to Ø 1800 mm pipe along Ting Kok Road and then connects to a 4000 × 2700 mm box culvert (see **Figure 2**). Stormwater runoff collected eventually discharges to Tolo Harbour over 1.1 km to the south near Tai Po Waterfront Park.

2.3.2 For Site B, there are existing stormwater drains running across Ting Kok Road located to the east. The pipe connects to a 525 mm width stepped channel that discharges the collected runoff to Tolo Harbour over 200 m to the southeast near Fortune Garden (see **Figure 2**).

2.4 Proposed Drainage System

2.4.1 After development, both Site A and Site B would have 20% greenery assumed. A flat platform will be formed for the sites. Stormwater flow from Site A and Site B will be conveyed to the proposed terminal manholes (TA and TB) and then connected to the existing drainage system. For both Site A and B, peripheral channels with adequate capacity for both sites would provide and submit the design during detailed design

stage to DSD and seek for the DSD's comment. For Site A, a Ø 900 mm pipeline is proposed to connect manhole TA to existing manhole D1 (SMH1007476) at Lo Fai Road. Also, the peripheral channel will be proposed along the site boundary to divert the runoff from outside site. The proposed drainage system for Lot 14 RP is shown in **Figure 4**. For Site B, there are two options of proposed drainage system.

2.4.2 For Site B option 1, a Ø 600 mm pipe is proposed to connect terminal manhole TB to new manhole B1, then a new Ø 750 mm pipes will be constructed along Ting Kok Road to existing manhole E1 (SMH1042722). Existing drainage segment from manhole E1 to E2 will be upgraded to Ø 1200 mm and E2 to E3 will be upgraded to Ø 1350 mm. The invert level of the existing 525 mm width stepped channel (segment manhole E3 to E4) is unknown in Geoinfo Map, invert level adjustment work is proposed and subject to investigation at later stage. The proposed drainage system for Site B option 1 is shown in **Figure 5**.

2.4.3 For Site B option 2, a proposed Ø 600 mm drain will cross Ting Kok Road first (manhole TB to BC2) and then a proposed Ø 900 mm eastward to connect to the existing drain manhole E3. The stepped channel (segment from manhole E3 to E4) will be upgraded to 1350 mm width. The proposed drainage system for Site B option 2 is shown in **Figure 6**.

2.4.4 The proposed drainage pipeline location is shown in **Figure 7** and **Figure 8**. Detail pipeline alignment, invert level and size are tentative and will be subject to the detailed design stage. In all circumstances, the proposed drain pipes and manholes should not be constructed in planting areas and will be followed in detailed design stage.

2.4.5 Peripheral channel will be proposed for collect the surface runoff from the uphill catchment. Detail size, gradient, and layout will be subject to detailed design stage and included in drainage plan submission.

2.4.6 As Ting Kok Road is of considerable traffic, trenchless method not to disturb traffic (such as pipe jacking) is considered required for a section of pipeline crossing road for Site B. Total closure of road is not expected for the construction of the drainage system.

2.4.7 The surface runoff of the Site A and Site B upon completion of the Proposed Development is summarized in **Table 1**.

Table 1 Summary of Surface Runoff under Proposed Conditions

Catchment	Area (m^2)	Runoff (m^3/s) under 1 in 50 years scenario
SA	20,291	1.06
SB	5,696	0.29
Total	**25,987**	**1.36**

2.5 Discussion

2.5.1 The estimated surface runoff from the Proposed Development and surrounding catchment areas has been compared with the capacity of the existing drainage system. Detailed calculations are shown in **Appendix 1**. Catchment area in the vicinity of Site A and Site B is shown in **Figure 2**. Based on the assessment, it is found that the existing and proposed drainage system (including both options for Site B) with upgrading works should have sufficient capacity to cater the stormwater generated from the proposed development and related existing catchment areas (see **Appendix 1**). The exact alignment is subject to detailed design and feasibility is to be verified after underground utility survey. All new and updated drainage system except those directly connecting from the terminal manhole will be handed over to the Government after implementation.

2.6 Temporary Drainage Impact and Mitigation Measures During Construction Stage

2.6.1 During the construction period, sediments and building debris may be mixed with the surface runoff and block the entering location of existing stormwater drains.

2.6.2 For the permanent post-construction case, the surface channels within the subject site may be blocked by debris or illegal dumping. This could lead to flooding of the local area in the development site. The owner should take up the routine maintenance of surface channels and underground drainage pipes within the estate. Desilting the terminal manholes should also be carried out routinely.

2.6.3 The following summarizes the rating of potential impacts and mitigation measures.

Table 2 Potential Drainage Impacts and Mitigation Measures

Potential Impacts	Description	Rating of Impacts (H=High, M=Medium, L=Low)	Proposed Mitigation Measures
Flooding within development site and adjacent areas	Flooding may occur during severe rainstorm.	L	- Formation levels shall have adequate gradients for gravitational discharge runoff. - Regular inspection of drainage facilities e.g.: U-channels, catchpits, underground drainage pipes and manholes.
Obstruction of sediment and debris during the construction period	Generating the sedimentation materials during the construction period and/or debris wash-off from stockpiled materials which may cause obstruction to the downstream drainage system.	M	- Regular inspection of drainage system. - Catchpits with desilting traps shall be constructed in the drainage system.
Obstruction of sediments and debris post-construction and during operation	Blockage of U-channels within the subject site due to runoff debris and illegal dumping.	M	- Routine maintenance of the drainage system. - Desilting of the drainage facilities, e.g.: surface channels, underground drainage pipes and manholes routinely. - Petrol interceptors and catchpits should be provided in the drainage system. - Petrol interceptors will be located within the lot and maintained by the lot owners.

Mitigation Measures

Sediment deposition during the construction period

2.6.4 Blockage of U-channels within the subject site due to runoff debris and illegal dumping is a common problem during operation and post-construction. Routine maintenance of the drainage system and desilting the drainage facilities, such as surface channels, underground drainage pipes and manholes, frequently, is recommended. Petrol interceptors and catchpits should be provided in the drainage system to ensure that

the drainage facilities function properly without obstruction especially in the wet season.

Sediment deposition post-construction and during operation

2.6.5 When the proposed pipes are under construction, the flow direction of the surface runoff follows the natural drain path or the temporary surface channels from the site formation drainage plan. All of the surface runoffs will pass through catchpits and terminal manholes with desilting traps where the sediment is screened before being discharged into the existing DSD drainage network system. Routine inspection of existing and temporary drainage works is recommended to be carried out during the construction period to ensure that the drainage facilities function properly without obstruction especially during the wet season.

3. OVERALL CONCLUSION

3.1 Conclusion

3.1.1 The potential drainage impact arisen from the Proposed Development has been assessed. Tentative connection to collect surface runoff from slope area has been proposed.

3.1.2 Based on the drainage impact assessment results, the existing and proposed drainage system with upgrading works will have adequate capacity to cater for stormwater generated from the proposed development and related existing catchment areas.

3.1.3 The proponent will be responsible for the upgrading work and associated monitoring programme during the construction stage for the purpose to ensure that the projects' expected drainage performance is achieved.

Figures

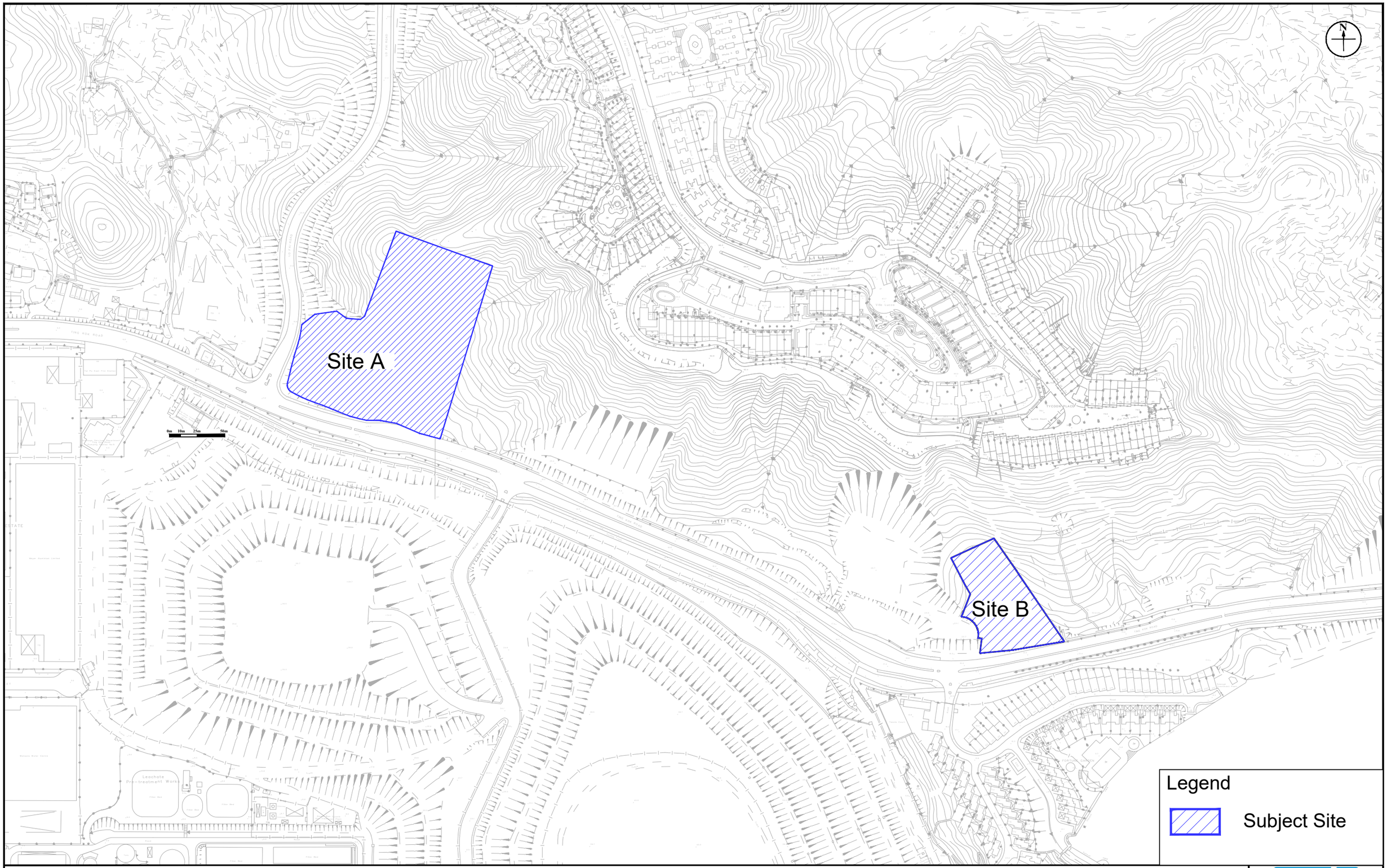

Figure: 1

Title: Location of the Subject Site and its Environ

Project: Proposed Public Residential Housing / Starter Homes Development at UDWYT Lot 14RP (Site A) & UDWYT Lot 11 RP (Site B), Wong Yue Tan, Tai Po

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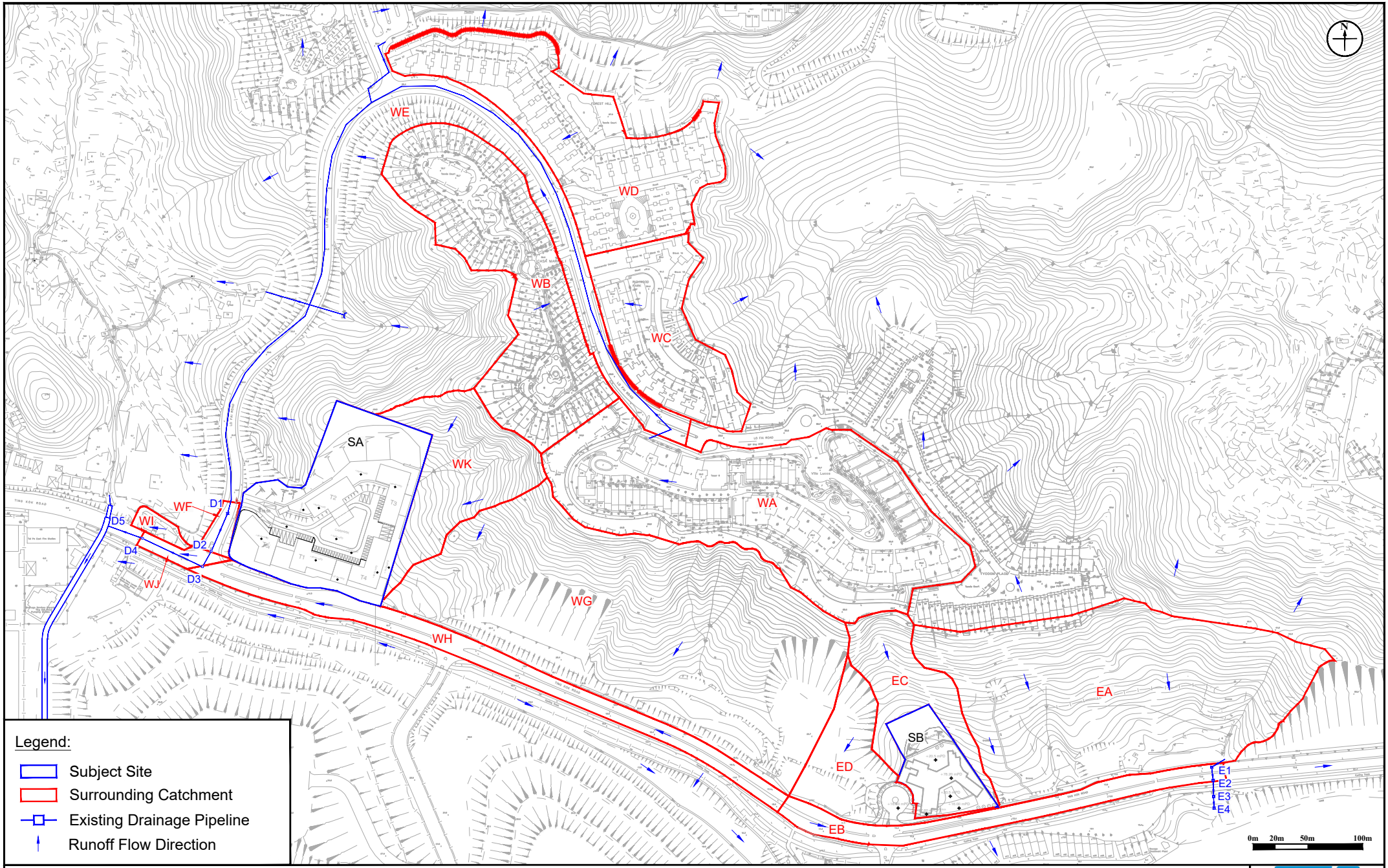

Figure: 2

Title: Existing Drainage System and Catchment Area in the Vicinity of the Subject Site

Project: Proposed Public Residential Housing / Starter Homes Development at UDWYT Lot 14RP and Adjoining Government Land (Site A) & Proposed Private Residential Development at UDWYT Lot 11 RP and Adjoining Government Land (Site B), Wong Yue Tan, Tai Po

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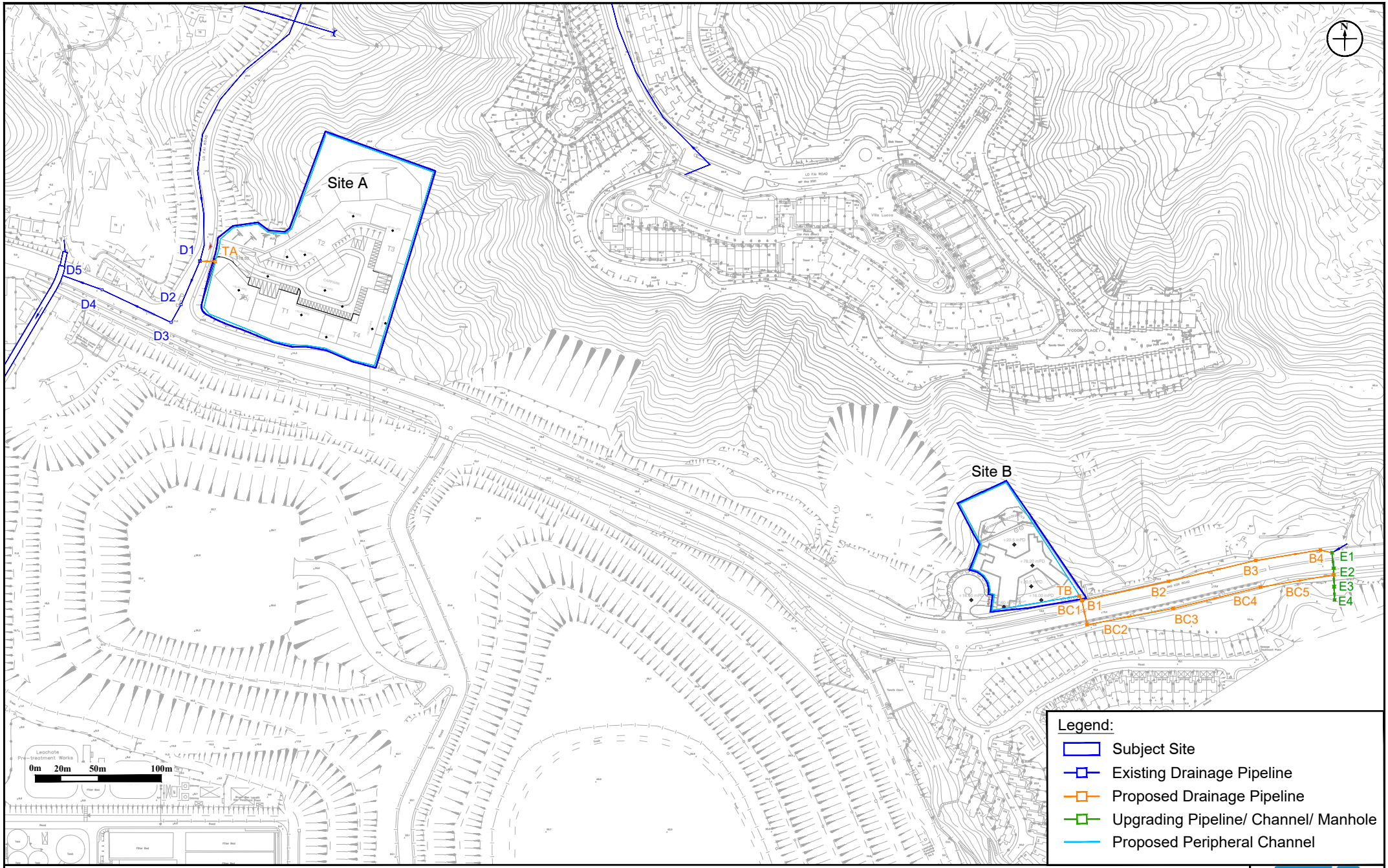

Figure: 3

Title: Existing Drainage System in the Vicinity of the Subject Site and Proposed Drainage Pipeline

Project: Proposed Public Residential Housing / Starter Homes Development at UDWYT Lot 14RP (Site A) & UDWYT Lot 11 RP (Site B), Wong Yue Tan, Tai Po

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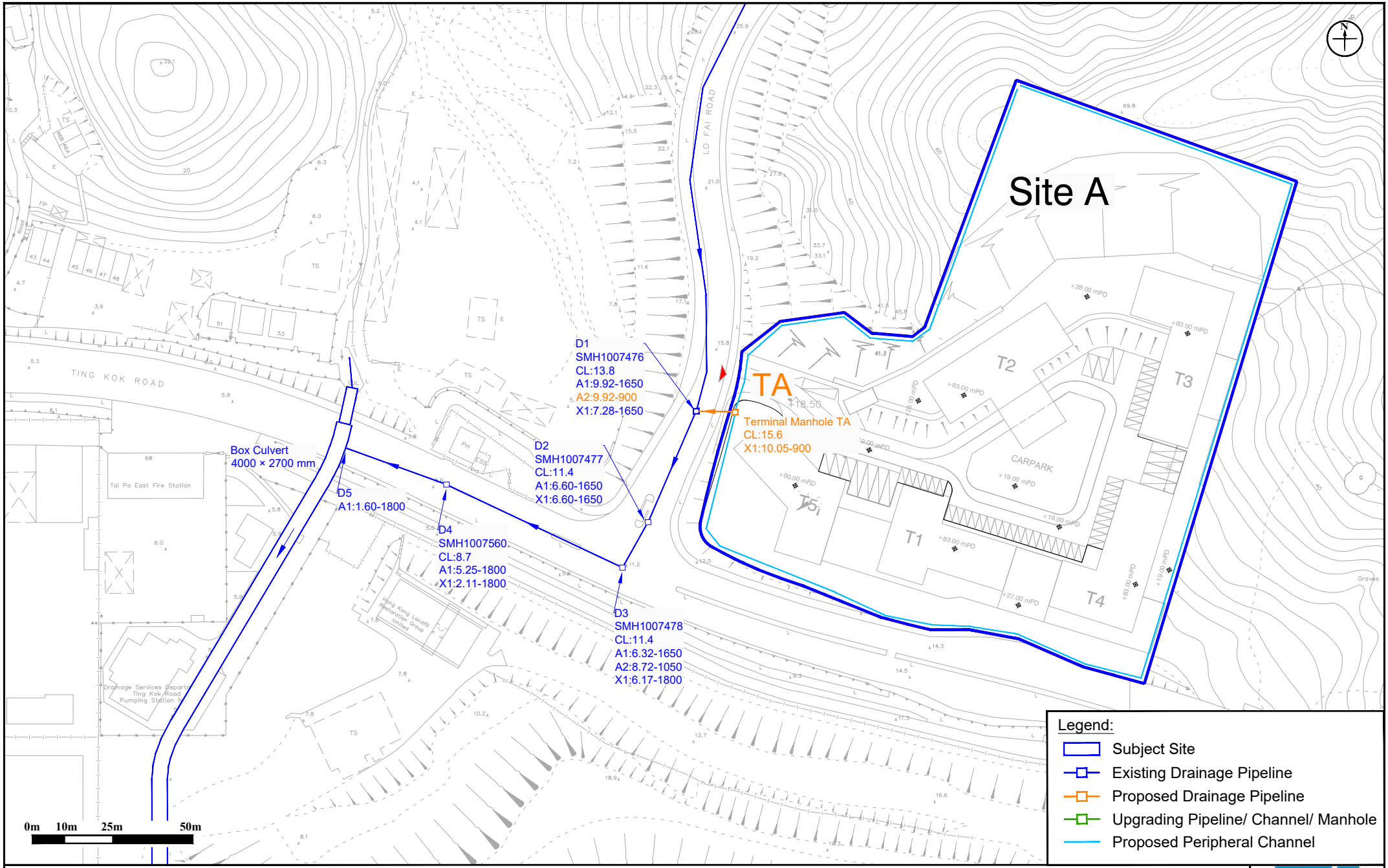

Figure: 4

Title: Existing Drainage System in the Vicinity of Site A and Proposed Drainage Pipeline

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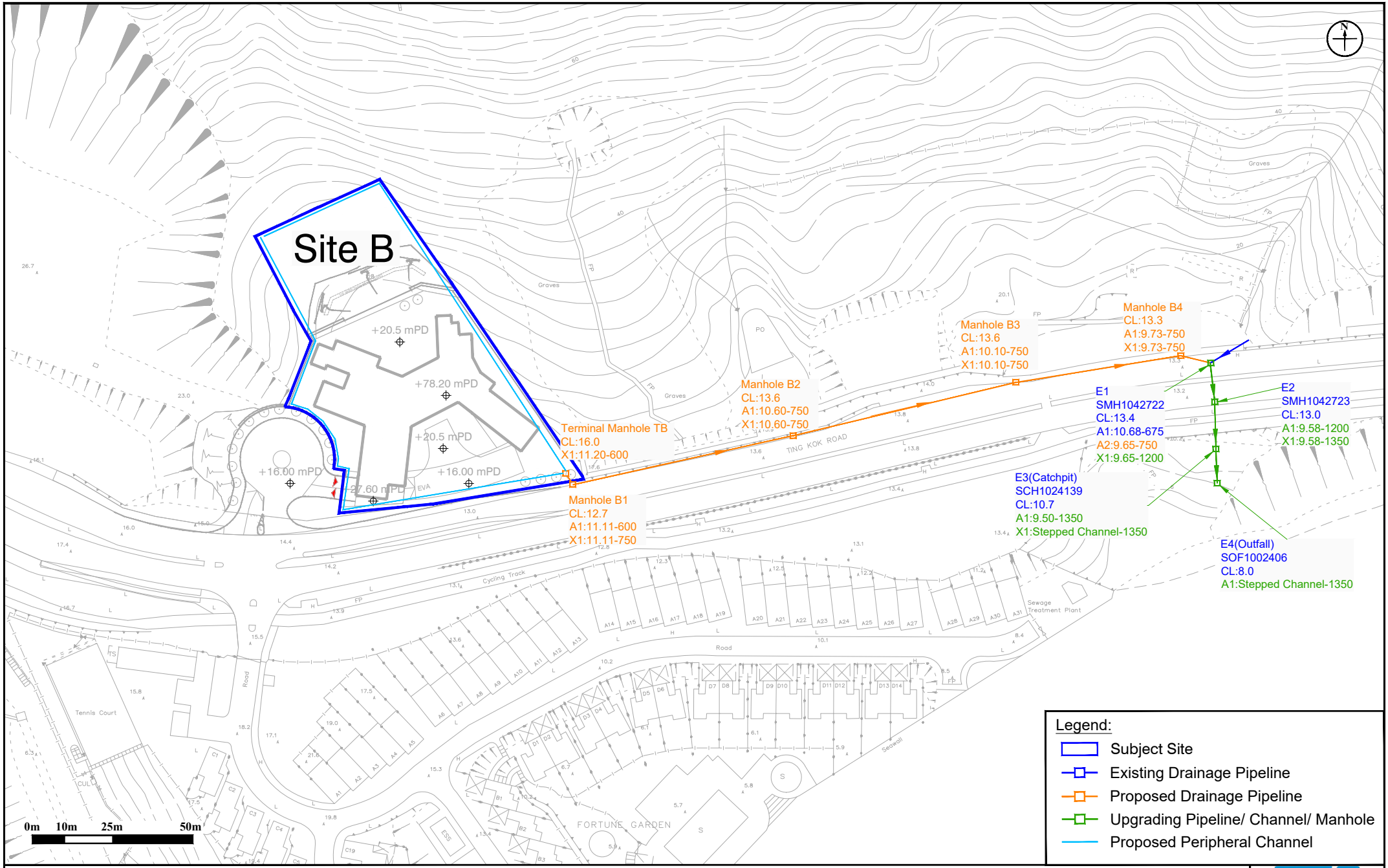

Figure: 5

Title: Existing Drainage System in the Vicinity of Site B and Proposed Drainage Pipeline – Option 1

Project: Proposed Public Residential Housing / Starter Homes Development at UDWYT Lot 14RP and Adjoining Government Land (Site A) & Proposed Private Residential Development at UDWYT Lot 11 RP and Adjoining Government Land (Site B), Wong Yue Tan, Tai Po

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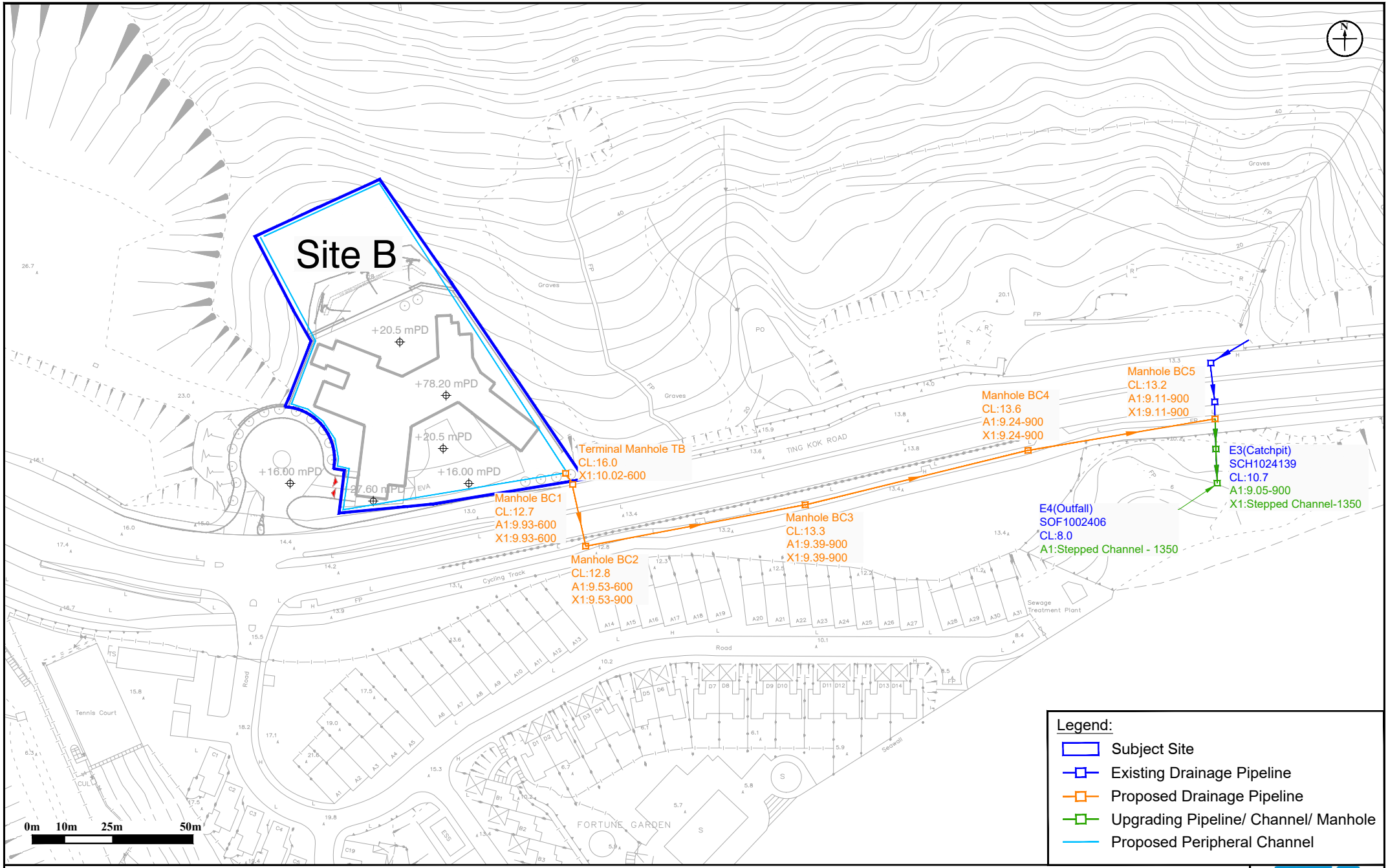

Figure: 6

Title: Existing Drainage System in the Vicinity of Site B and Proposed Drainage Pipeline - Option 2

Project: Proposed Public Residential Housing / Starter Homes Development at UDWYT Lot 14RP and Adjoining Government Land (Site A) & Proposed Private Residential Development at UDWYT Lot 11 RP and Adjoining Government Land (Site B), Wong Yue Tan, Tai Po

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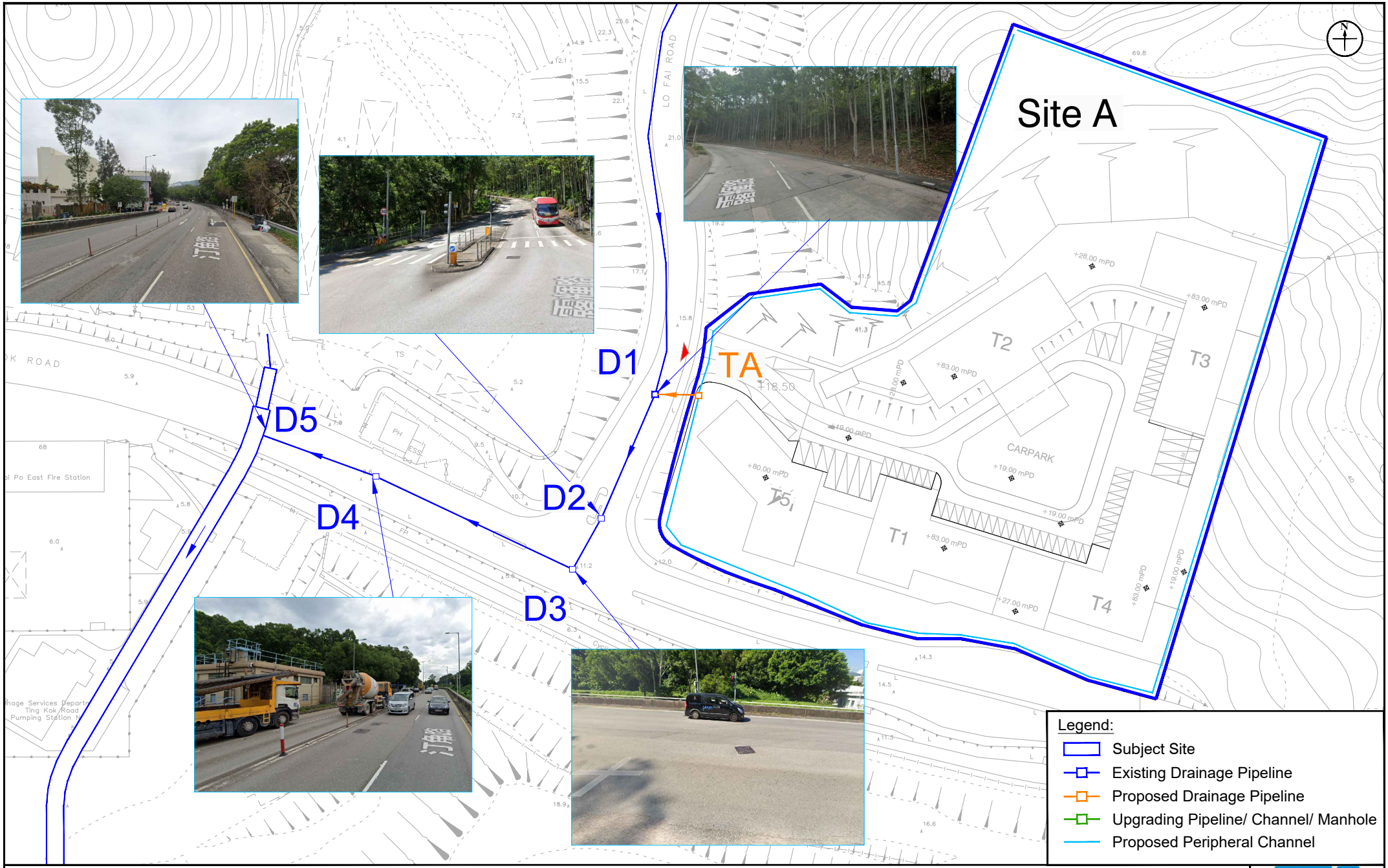

Figure: 7

Title: Proposed Drainage Pipeline Location (Site A)

Project: Proposed Public Residential Housing / Starter Homes Development at UDWYT Lot 14RP and Adjoining Government Land (Site A) & Proposed Private Residential Development at UDWYT Lot 11 RP and Adjoining Government Land (Site B), Wong Yue Tan, Tai Po

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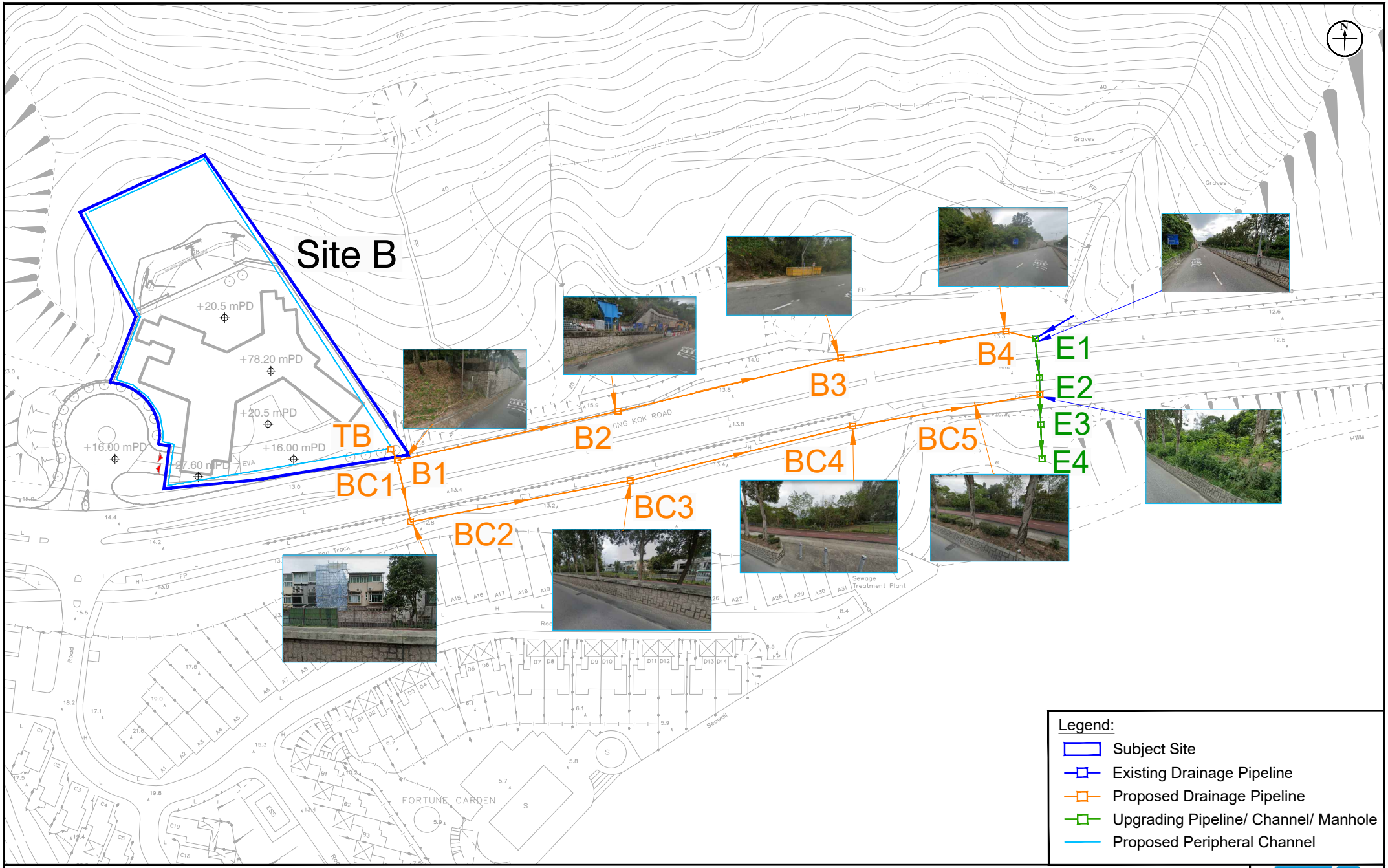

Figure:	8
Title:	Proposed Drainage Pipeline Location (Site B)
Project:	Proposed Public Residential Housing / Starter Homes Development at UDWYT Lot 14RP and Adjoining Government Land (Site A) & Proposed Private Residential Development at UDWYT Lot 11 RP and Adjoining Government Land (Site B), Wong Yue Tan, Tai Po

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Appendix 1 Detailed Drainage Impact Assessment Calculations

Proposed Public Residential Housing / Starter Homes Development at UDWYT Lot 14RP and Adjoining Government Land (Site A) & Proposed Private Residential Development at UDWYT Lot 11 RP and Adjoining Government Land (Site B). Wong Yue Tan. Tai Po
Table 1 - Proposed Catchment Areas and Run-off (1 in-50 year)

$$Q_p = 0.278\ C\ i\ A$$

where Q_p = peak runoff in m^3/s
C = runoff coefficient (dimensionless)
i = rainfall intensity in mm/hr
A = catchment area in km^2

Surface Characteristics	*Runoff coefficient, C***
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 - 0.20

Notes:
Site Area: 25,987 m^2 (Site A 20.291 m^2 & Site B 5.696 m^2)

Future Site Development will include Paved Areas, C = 0.95, with Soft Landscaping, C = 0.15
Catchments are small, so Rational Method is appropriate

1 in 50-year (according to Table 3 of DSD Manual)
a= 505.5
b= 3.29
c= 0.355

	Catchment	Discharge Manhole	Paved	Unpaved	Run-off at	Area	Levels (mPD)		Fall	Overland, L	Fall, H	Overland t_i	t_0	Total t_f[3]	Total t_c[2]	Intensity	Weighted Runoff Coefficient	Run-off
						(m^2)	Upstream	Downstream	(m)	(m)	(m/100m)	(min)	(min)	(min)	(min)	(mm/h)		(m^3/s)
Site A related Catchment																		
Surrounding Catchment	WA	D1	70%	30%	D1	41,722								9.9	9.9	202	0.71	1.67
					D2									0.2	10.1	201	0.71	1.66
					D3									0.7	10.7	198	0.71	1.63
					D4									0.4	11.1	196	0.71	1.62
					D5									0.0	11.1	196	0.71	1.62
	WB	D1	80%	20%	D1	26,186								7.9	7.9	214	0.79	1.23
					D2									0.2	8.1	213	0.79	1.23
					D3									0.7	8.7	209	0.79	1.20
					D4									0.4	9.1	207	0.79	1.19
					D5									0.0	9.1	207	0.79	1.19
	WC	D1	90%	10%	D1	14,504								7.9	7.9	215	0.87	0.75
					D2									0.2	8.0	213	0.87	0.75
					D3									0.7	8.7	209	0.87	0.73
					D4									0.4	9.1	207	0.87	0.73
					D5									0.0	9.1	207	0.87	0.73
	WD	D1	80%	20%	D1	25,441								7.1	7.1	220	0.79	1.23
					D2									0.2	7.3	219	0.79	1.22
					D3									0.7	7.9	214	0.79	1.20
					D4									0.4	8.3	212	0.79	1.18
					D5									0.0	8.3	212	0.79	1.18
	WE	D1	40%	60%	D1	34,957	89.0	15.3	73.7	895.3	8.2	29.8	29.8	0.4	30.2	145	0.59	0.83
					D2									0.2	30.4	145	0.59	0.83
					D3									0.7	31.1	144	0.59	0.83
					D4									0.4	31.4	144	0.59	0.82
					D5									0.0	31.4	144	0.59	0.82
	WF	D2	100%	0%	D2	1,046	15.3	11.4	3.9	47.7	8.2	2.3	2.3	0.2	2.4	272	0.95	0.08
					D3									0.7	3.1	262	0.95	0.07
					D4									0.4	2.8	267	0.95	0.07
					D5									0.0	2.8	267	0.95	0.07
	WG	D3	0%	100%	D3	60,185	91.3	18.5	72.8	649.2	11.2	19.3	19.3	0.7	19.9	166	0.35	0.97
					D4									0.4	20.3	165	0.35	0.96
					D5									0.0	19.9	166	0.35	0.97
	WH	D3	100%	0%	D3	10,733	18.0	11.4	6.6	579.0	1.1	32.3	32.3	0.7	32.9	141	0.95	0.40
					D4									0.4	33.3	141	0.95	0.40
					D5									0.0	33.3	141	0.95	0.40
	WI	D4	90%	10%	D4	921	10.7	8.7	2.0	47.4	4.2	2.6	2.6	0.4	3.0	264	0.87	0.06
					D5									0.0	3.0	264	0.87	0.06
	WJ	D4	100%	0%	D4	1,158	12.0	8.7	3.3	81.0	4.1	4.4	4.4	0.4	4.7	241	0.95	0.07
					D5									0.0	4.7	241	0.95	0.07
	WK	TA	0%	100%	TA	12,560	96.2	15.9	80.3	115	70.1	2.8	2.8	0.0	2.8	267	0.15	0.14
					D1									0.4	3.2	261	0.15	0.14
					D2									0.2	3.3	259	0.15	0.14
					D3									0.7	4.0	250	0.15	0.13
					D4									0.4	4.3	246	0.15	0.13
					D5									0.0	4.3	246	0.15	0.13
					Overall	**229,413**												**7.43**
After Development	SA	TA	80%	20%	TA	20,291								5.0	5.0	239	0.79	1.06
					D1									0.1	5.1	237	0.79	1.06
					D2									0.2	5.3	236	0.79	1.05
					D3									0.7	5.9	230	0.79	1.02
					D4									0.4	6.3	227	0.79	1.01
					D5									0.0	6.3	227	0.79	1.01
Site B related Catchment																		
Surrounding Catchment	EA	E1	0%	100%	E1	45,302	83.7	13.4	70.3	370.2	19.0	10.2	10.2	0.2	10.3	200	0.35	0.88
					E2									0.1	10.5	199	0.35	0.88
					E3									0.2	10.6	198	0.35	0.87
					E4									0.1	10.7	198	0.35	0.87
	EB	E2	100%	0%	E2	7,339	18.0	13.0	5.0	406.1	1.2	23.1	23.1	0.0	23.1	158	0.95	0.31
					E3									0.2	23.3	158	0.95	0.31
					E4									0.1	23.4	158	0.95	0.31
	EC	TB	0%	100%	TB	8,200	83.7	13.1	70.6	214.8	32.9	6.3	6.3	0.0	6.3	227	0.35	0.18
					B1									0.05	6.3	226	0.35	0.18
					B2									0.8	7.1	220	0.35	0.18
					B3									0.8	7.9	214	0.35	0.17
					B4									0.6	8.5	211	0.35	0.17
					E1									0.1	8.6	210	0.35	0.17
					E2									0.1	8.7	209	0.35	0.17
					E3									0.2	8.9	208	0.35	0.17
					E4									0.1	9.0	207	0.35	0.17
	ED	E2	80%	20%	E2	8,886	60.0	13.0	47.0	463.5	10.1	17.0	17.0	0.0	17.0	174	0.83	0.36
					E3									0.2	17.2	173	0.83	0.36
					E4									0.1	17.3	173	0.83	0.35
					Overall	**69,727**												**1.73**
After Development	SB	TB	80%	20%	TB	5,696								5.0	5.0	239	0.79	0.30
					B1									0.05	5.0	238	0.79	0.30
					B2									0.8	5.8	231	0.79	0.29
					B3									0.8	6.6	224	0.79	0.28
					B4									0.6	7.2	219	0.79	0.27
					E1									0.1	7.3	219	0.79	0.27
					E2									0.1	7.4	218	0.79	0.27
					E3									0.2	7.6	216	0.79	0.27
					E4									0.1	7.7	216	0.79	0.27

Remarks:
1. Assumed Time of Concentration through stream flow
2. Assumed Time of Concentration
3. The Brandsby William's Equation is adopted for t0. For total tf, pipe length / pipe velocity / 60 is adopted to calculate the pipe flow rate. 1.5m/s of pipe velocity is adopted for a normal assumption. Total time of concentration is t0 plus tf.
4. Streamflow time (tf) is meaning the pipe flow time and the pipe length / pipe velocity / 60 is adopted in the calculation. For the proposed development, 5 mins as the minimum times of concentration is adopted

Proposed Public Residential Housing / Starter Homes Development at UDWYT Lot 14RP and Adjoining Government Land (Site A) & Proposed Private Residential Development at UDWYT Lot 11 RP and Adjoining Government Land (Site B), Wong Yue Tan, Tai Po
Hydraulic Calculations of Existing and Proposed Drainage System

Table 2a - 1 in 50-year Runoff of Future Site A related Catchments (m3/s)

Runoff at	Catchment												Total
	WA	WB	WC	WD	WE	WF	WG	WH	WI	WJ	WK	SA	
TA											0.14	1.06	**1.20**
D1	1.67	1.23	0.75	1.23	0.83						0.14	1.06	**6.91**
D2	1.66	1.23	0.75	1.22	0.83	0.08					0.14	1.05	**6.95**
D3	1.63	1.20	0.73	1.20	0.83	0.07	0.97	0.40			0.13	1.02	**8.19**
D4	1.62	1.19	0.73	1.18	0.82	0.07	0.96	0.40	0.06	0.07	0.13	1.01	**8.25**
D5	1.62	1.19	0.73	1.18	0.82	0.07	0.97	0.40	0.06	0.07	0.13	1.01	**8.25**

Table 2b - 1 in 50-year Runoff of Future Site B related Catchments (m3/s)

Runoff at	Catchment					Total
	EA	EB	EC	ED	SB	
TB			0.18		0.30	**0.48**
B1			0.18		0.30	**0.48**
B2			0.18		0.29	**0.46**
B3			0.17		0.28	**0.45**
B4			0.17		0.27	**0.44**
E1	0.88		0.17		0.27	**1.32**
E2	0.88	0.31	0.17	0.36	0.27	**1.98**
E3	0.87	0.31	0.17	0.36	0.27	**1.97**
E4	0.87	0.31	0.17	0.35	0.27	**1.97**

Table 3a - Hydraulic Capacities for Existing Drainage System (Site A)

Manhole ID	Manhole ID	Manhole Reference	Manhole Reference	Type of Channel	Pipe Dia.	Pipe Length	Invert Level 1	Invert Level 2	g	k_s	s	Gradient	v	V	Area	Q	Q_{allt} [1]
					mm	m	mPD	mPD	m/s^2	m		1 in	m^2/s	m/s	m^2	m^3/s	m^3/s
D1	D2	SMH1007476	SMH1007477	Circular	1650	36.1	7.28	6.60	9.81	0.0030	0.019	53	0.000001	5.18	2.14	11.08	9.97
D2	D3	SMH1007477	SMH1007478	Circular	1650	14.6	6.60	6.32	9.81	0.0030	0.019	53	0.000001	5.18	2.14	11.08	9.97
D3	D4	SMH1007478	SMH1007560	Circular	1800	59.1	6.17	5.25	9.81	0.0030	0.016	64	0.000001	4.96	2.54	12.62	11.36
D4	D5	SMH1007560	-	Circular	1800	31.8	2.11	1.60	9.81	0.0030	0.016	62	0.000001	5.03	2.54	12.81	11.53

Table 3b - Hydraulic Capacities for Proposed Drainage System (Site A)

Manhole ID	Manhole ID	Manhole Reference	Manhole Reference	Type of Channel	Pipe Dia.	Pipe Length	Invert Level 1	Invert Level 2	g	k_s	s	Gradient	v	V	Area	Q	Q_{allt} [1]
					mm	m	mPD	mPD	m/s^2	m		1 in	m^2/s	m/s	m^2	m^3/s	m^3/s
TA	D1	-	SMH1007476	Circular	900	10.1	10.05	9.92	9.81	0.0030	0.013	77	0.000001	2.91	0.64	1.85	1.67

Table 3c - Comparison of Runoff from Proposed Catchments and Hydraulic Capcities of Existing Drainage System (Site A)

Manhole ID	Manhole ID	Pipe Dia.	Q_{allt} [1]	Catchment Involved	Runoff	Occupancy	Sufficient Capacity?	Runoff [2]	Occupancy	Sufficient Capacity?	Runoff [3]	Occupancy	Sufficient Capacity?	Runoff [4]	Occupancy	Sufficient Capacity?
		mm	m^3/s		m^3/s			m^3/s			m^3/s			m^3/s		
D1	D2	1650	9.97	WA-WE. SA. WK	6.91	69.3%	YES	7.67	76.9%	YES	8.01	80.4%	YES	8.85	88.8%	YES
D2	D3	1650	9.97	WA-WE. SA. WK	6.95	69.7%	YES	7.71	77.4%	YES	8.06	80.9%	YES	8.90	89.3%	YES
D3	D4	1800	11.36	WA-WF. SA. WK	8.19	72.1%	YES	9.09	80.0%	YES	9.50	83.6%	YES	10.49	92.3%	YES
D4	D5	1800	11.53	WA-WK. SA	8.25	71.5%	YES	9.16	79.4%	YES	9.57	83.0%	YES	10.57	91.6%	YES

Table 3d - Comparison of Runoff from Proposed Catchments and Hydraulic Capcities of Proposed Drainage System (Site A)

Manhole ID	Manhole ID	Pipe Dia.	Q_{allt} [1]	Catchment Involved	Runoff	Occupancy	Sufficient Capacity?	Runoff [2]	Occupancy	Sufficient Capacity?	Runoff [3]	Occupancy	Sufficient Capacity?	Runoff [4]	Occupancy	Sufficient Capacity?
		mm	m^3/s		m^3/s			m^3/s			m^3/s			m^3/s		
TA	D1	900	1.67	SA	1.20	72.2%	YES	1.34	80.2%	YES	1.40	83.8%	YES	1.54	92.5%	YES

Table 4a - Hydraulic Capacities for Existing Stepped Channel (Site B)

Segment	Inlet	Outlet	Type of Channel	Design Gradient	Length	Depth	Width	C_e	x	f_e	Y_{90}	d_o	D_H	V_o	Q	Q_{silt} [1]
				α°	m	mm	mm				m	m	m	m/s	m^3/s	m^3/s
E3 - E4	E3	E4	Stepped Channel	20.0	10.7	615	525	0.31	0.60	0.77	0.58	0.40	0.63	2.36	0.49	0.47

Table 4b - Hydraulic Capacities for Proposed Drainage System (Site B - Option 1)

Manhole ID	Manhole ID	Manhole Reference	Manhole Reference	Type of Channel	Pipe Dia.	Pipe Length	Invert Level 1	Invert Level 2	g	k_s	s	Gradient	v	V	Area	Q	Q_{silt} [1]
					mm	m	mPD	mPD	m/s^2	m		1 in	m^2/s	m/s	m^2	m^3/s	m^3/s
TB	B1	-	-	Circular	600	4.1	11.20	11.11	9.81	0.0030	0.022	46	0.000001	2.91	0.28	0.82	0.74
B1	B2	-	-	Circular	750	70.5	11.11	10.60	9.81	0.0030	0.007	138	0.000001	1.93	0.44	0.85	0.77
B2	B3	-	-	Circular	750	71.7	10.60	10.10	9.81	0.0030	0.007	143	0.000001	1.90	0.44	0.84	0.75
B3	B4	-	-	Circular	750	52.2	10.10	9.73	9.81	0.0030	0.007	141	0.000001	1.91	0.44	0.85	0.76
B4	E1	-	SMH1042723	Circular	750	9.4	9.73	9.65	9.81	0.0030	0.009	118	0.000001	2.10	0.44	0.93	0.83

Table 4c - Hydraulic Capacities for Proposed Upgrading Workings (Site B - Option 1)

Manhole ID	Manhole ID	Manhole Reference	Manhole Reference	Type of Channel	Pipe Dia.	Pipe Length	Invert Level 1	Invert Level 2	g	k_s	s	Gradient	v	V	Area	Q	Q_{silt} [1]
					mm	m	mPD	mPD	m/s^2	m		1 in	m^2/s	m/s	m^2	m^3/s	m^3/s
E1	E2	SMH1042722	SMH1042723	Circular	1200	12.3	9.65	9.58	9.81	0.0030	0.006	176	0.000001	2.32	1.13	2.62	2.36
E2	E3	SMH1042723	SCH1024139	Circular	1350	14.7	9.58	9.50	9.81	0.0030	0.005	184	0.000001	2.44	1.43	3.50	3.15

Table 4d - Hydraulic Capacities for Upgrading Stepped Channel (Site B - Option 1)

Segment	Inlet	Outlet	Type of Channel	Design Gradient	Length	Depth	Width	C_e	x	f_e	Y_{90}	d_o	D_H	V_o	Q	Q_{silt} [1]	qw	dc	*h*	*l*	(dc)onset	qw<=2 m^2/s?	dc >= (dc)onset?	acceptable?
				α°	m	mm	mm				m	m	m	m/s	m^3/s	m^3/s	m^2/s							
E3 - E4	E3	E4	Stepped Channel	20.0	10.7	950	1350	0.31	0.60	0.77	0.89	0.62	1.29	3.36	2.80	2.66	1.97	0.73	109	300	0.10	TRUE	TRUE	TRUE

Table 4e - Comparison of Runoff from Proposed Catchments and Hydraulic Capcities of Existing Drainage System (Site B) (SC)

Manhole ID	Manhole ID	Pipe Dia.	Q_{silt} [1]	Catchment Involved	Runoff	Occupancy	Sufficient Capacity?	Runoff [2]	Occupancy	Sufficient Capacity?	Runoff [3]	Occupancy	Sufficient Capacity?	Runoff [4]	Occupancy	Sufficient Capacity?
		mm	m^3/s		m^3/s			m^3/s			m^3/s			m^3/s		
E3	E4	525	0.47	EA-ED, SB	1.97	419.9%	NO	2.19	466.0%	NO	2.29	487.0%	NO	2.53	537.8%	NO

Table 4f - Comparison of Runoff from Proposed Catchments and Hydraulic Capcities of Proposed Drainage System (Site B - Option 1)

Manhole ID	Manhole ID	Pipe Dia.	Q_{silt} [1]	Catchment Involved	Runoff	Occupancy	Sufficient Capacity?	Runoff [2]	Occupancy	Sufficient Capacity?	Runoff [3]	Occupancy	Sufficient Capacity?	Runoff [4]	Occupancy	Sufficient Capacity?
		mm	m^3/s		m^3/s			m^3/s			m^3/s			m^3/s		
TB	B1	600	0.74	EC, SB	0.48	64.6%	YES	0.53	71.7%	YES	0.56	75.0%	YES	0.61	82.8%	YES
B1	B2	750	0.77	EC, SB	0.48	62.4%	YES	0.53	69.2%	YES	0.56	72.4%	YES	0.61	79.9%	YES
B2	B3	750	0.75	EC, SB	0.48	63.5%	YES	0.53	70.5%	YES	0.56	73.7%	YES	0.61	81.4%	YES
B3	B4	750	0.76	EC, SB	0.48	63.0%	YES	0.53	70.0%	YES	0.56	73.1%	YES	0.61	80.7%	YES
B4	E1	750	0.83	EC, SB	0.48	57.5%	YES	0.53	63.9%	YES	0.56	66.7%	YES	0.61	73.7%	YES
E1	E2	1200	2.36	EA, EC, SB	1.32	56.1%	YES	1.47	62.2%	YES	1.53	65.0%	YES	1.69	71.8%	YES
E2	E3	1350	3.15	EA-ED, SB	1.98	62.9%	YES	2.20	69.8%	YES	2.30	73.0%	YES	2.54	80.6%	YES
E3	E4	525	3.33	EA-ED, SB	1.97	59.2%	YES	2.19	65.7%	YES	2.29	68.7%	YES	2.53	75.8%	YES

Table 4g - Comparison of Runoff from Proposed Catchments and Hydraulic Capcities of Proposed Drainage System (Site B - Option 1) (SC)

Manhole ID	Manhole ID	Pipe Dia.	Q_{silt} [1]	Catchment Involved	Runoff	Occupancy	Sufficient Capacity?	Runoff [2]	Occupancy	Sufficient Capacity?	Runoff [3]	Occupancy	Sufficient Capacity?	Runoff [4]	Occupancy	Sufficient Capacity?
		mm	m^3/s		m^3/s			m^3/s			m^3/s			m^3/s		
E3	E4	1350	2.66	EA-ED, SB	1.97	74.1%	YES	2.19	82.2%	YES	2.29	85.9%	YES	2.57	96.3%	YES

Table 5a - Hydraulic Capacities for Proposed Drainage System (Site B - Option 2)

Manhole ID	Manhole ID	Manhole Reference	Manhole Reference	Type of Channel	Pipe Dia.	Pipe Length	Invert Level 1	Invert Level 2	g	k_s	s	Gradient	v	V	Area	Q	Q_{silt} [1]
					mm	m	mPD	mPD	m/s^2	m		1 in	m^2/s	m/s	m^2	m^3/s	m^3/s
TB	BC1	-	-	Circular	600	4.1	10.02	9.93	9.81	0.003	0.022	46	0.000001	2.91	0.28	0.82	0.74
BC1	BC2	-	-	Circular	600	19.6	9.93	9.53	9.81	0.003	0.020	49	0.000001	2.81	0.28	0.79	0.72
BC2	BC3	-	-	Circular	900	69.8	9.53	9.39	9.81	0.003	0.002	487	0.000001	1.16	0.64	0.74	0.66
BC3	BC4	-	-	Circular	900	71.7	9.39	9.24	9.81	0.003	0.002	500	0.000001	1.14	0.64	0.73	0.65
BC4	BC5	-	-	Circular	900	59.3	9.24	9.11	9.81	0.003	0.002	445	0.000001	1.21	0.64	0.77	0.69
BC5	E3	-	SCH1024139	Circular	900	9.4	9.11	9.05	9.81	0.003	0.006	157	0.000001	2.04	0.64	1.30	1.17

Table 5b - Hydraulic Capacities for Upgrading Stepped Channel (Site B - Option 2)

Segment	Inlet	Outlet	Type of Channel	Design Gradient	Length	Depth	Width	C_e	x	f_e	Y_{90}	d_n	D_H	V_n	Q	Q_{silt} [1]	qw	dc	*h*	*l*	(dc)onset	qw<=2 m^2/s?	dc >= (dc)onset?	acceptable?
				α°	m	mm	mm				m	m	m	m/s	m^3/s	m^3/s	m^2/s							
E3 - E4	E3	E4	Stepped Channel	20.0	10.7	950	1350	0.31	0.60	0.77	0.89	0.62	1.29	3.36	2.80	2.66	1.97	0.73	109	300	0.10	TRUE	TRUE	TRUE

Table 5c - Comparison of Runoff from Proposed Catchments and Hydraulic Capcities of Proposed Drainage System (Site B - Option 2)

Manhole ID	Manhole ID	Pipe Dia.	Q_{silt} [1]	Catchment Involved	Runoff	Occupancy	Sufficient Capacity?	Runoff [2]	Occupancy	Sufficient Capacity?	Runoff [3]	Occupancy	Sufficient Capacity?	Runoff [4]	Occupancy	Sufficient Capacity?
		mm	m^3/s		m^3/s			m^3/s			m^3/s			m^3/s		
TB	BC1	600	0.74	EC, SB	0.48	64.6%	YES	0.53	71.7%	YES	0.56	75.0%	YES	0.61	82.8%	YES
BC1	BC2	600	0.72	EC, SB	0.48	67.0%	YES	0.53	74.4%	YES	0.56	77.8%	YES	0.61	85.9%	YES
BC2	BC3	900	0.66	EC, SB	0.48	72.4%	YES	0.53	80.3%	YES	0.56	83.9%	YES	0.61	92.7%	YES
BC3	BC4	900	0.65	EC, SB	0.48	73.3%	YES	0.53	81.4%	YES	0.56	85.1%	YES	0.61	93.9%	YES
BC4	BC5	900	0.69	EC, SB	0.48	69.1%	YES	0.53	76.8%	YES	0.56	80.2%	YES	0.61	88.6%	YES

Table 5d - Comparison of Runoff from Proposed Catchments and Hydraulic Capcities of Proposed Drainage System (Site B - Option 2) (SC)

Manhole ID	Manhole ID	Pipe Dia.	Q_{silt} [1]	Catchment Involved	Runoff	Occupancy	Sufficient Capacity?	Runoff [2]	Occupancy	Sufficient Capacity?	Runoff [3]	Occupancy	Sufficient Capacity?	Runoff [4]	Occupancy	Sufficient Capacity?
		mm	m^3/s		m^3/s			m^3/s			m^3/s			m^3/s		
E3	E4	1350	2.66	EA-ED, SB	1.97	74.1%	YES	2.19	82.2%	YES	2.29	85.9%	YES	2.53	94.9%	YES

Remarks:

1. Qsilt: 10% reduction in flow for gradient is not greater than 1 in 25, 5% reduction in flow for gradient greater than 1 in 25.
2. Cross Section Area of Circular Pipe: $D^2 \times PI / 4$
3. Perimeter of Circular Pipe: $(D \times 2 \times PI) / 2$
4. Cross Section Area of U-channel: $(D^2 \times PI) / 4 / 2 + (H \times D) / 2$
5. Perimeter of U-channel: $((D \times 2 \times PI) / 2 + H \times 2) / 2$
6. The value of k_s = 3mm is used for the calculation of slimed precast concrete for the drains, poor condition (based on Table 5: Recommended roughness values in Sewerage Manual)

Runoff [2] represents the situation in Mid 21st Century due to climate change with additional runoff of 11.1%
Runoff [3] represents the situation in Late 21st Century due to climate change with additional runoff of 16.0%
Runoff [4] represents the situation in Late 21st Century due to design allowance with additional runoff of 12.1%

Table 6 Freeboard between Pipe and Ground Level

Site B (Option 1)

Manhole	Invert Level	Pipe Dia. (mm)	Outside Dia. (mm)	Pipe Top Level	Ground Level	Difference (m)
TB	11.20	600	790	11.99	16	4.01
B1	11.11	750	950	12.06	13.6	1.54
B2	10.60	750	950	11.55	13.6	2.05
B3	10.10	750	950	11.05	13.6	2.55
B4	9.73	750	950	10.68	13.3	2.62

Site B (Option 2)

Manhole	Invert Level	Pipe Dia. (mm)	Outside Dia. (mm)	Pipe Top Level	Ground Level	Difference (m)
TB	10.02	600	790	10.81	16	5.19
BC1	9.93	600	790	10.72	12.7	1.98
BC2	9.53	900	1120	10.65	12.8	2.15
BC3	9.39	900	1120	10.51	13.3	2.79
BC4	9.24	900	1120	10.36	13.6	3.24
BC5	9.11	900	1120	10.23	13.2	2.97