Stormwater Drainage Manual

CORRIGENDUM No. 1/2022

(a)	CONTENTS	**Add the following sections:** Section 6.9 Flood Resilience Measures and Emergency Preparedness Appendix 1 – Reference Extreme Sea Levels with Consideration of Historical Storm Surge Records before 1954 (in mPD) Appendix 2 – Design Allowance in Mid 21st Century
(b)	Section 1.3.2 Design Structures	**Replace "**(e.g. box culverts, manholes, floodwater pumping stations, etc.)" **with "**(e.g. box culverts, manholes, floodwater pumping stations, stormwater storage tanks, drainage tunnels, engineering channels, etc.)" **in the third sentence.** **Add the following design standard:**

Design Elements/Loads	Design Standards
Seismic Load (only applicable for drainage structures that are susceptible to seismic effects)	● BS EN 1990:2002+A1:2005: Eurocode – Basic of Structural Design ● BS EN 1998 Eurocode 8: Design of Structures for Earthquake Resistance - BS EN 1998-1:2004+A1:2013 "Part 1: General Rules Seismic Actions and Rules for Buildings" and UK NA to BS EN 1998-1:2004+A1:2014. - BS EN 1998-4:2006 "Part 4: Silos, Tanks and Pipelines" and UK NA to BS EN 1998-4:2006 - BS EN 1998-5:2004 "Part 5: Foundations, Retaining Structures and Geotechnical Aspects" and UK NA to BS EN 1998-5:2004

(c) Section 3.2.4 Detailed Considerations

Add the following bullet:

(e) For projects on new development area, the project proponent and designer should take the opportunity to upgrade the flood protection levels of the area to the levels recommended in this Manual.

(d) Section 5.3.2 Design Extreme Sea Levels

Replace the Section with the following:

Table 8 shows the design extreme sea levels at North Point/Quarry Bay, Tai Po Kau, Tsim Bei Tsui and Tai O, based on frequency analysis using the Generalized Extreme Value (GEV) distribution model, with the parameters estimated by the Method of L-moments. In general, for tide stations with sufficient data history, frequency analysis was conducted based on instrumental data up to 2019. For tide stations with insufficient data history, frequency analysis was conducted based on instrumental data and correlated data from North Point/ Quarry Bay for an extended data set of 66 years (from 1954 to 2019). In comparison to frequency analysis only based on instrumental data with relatively short history, analysis results based on the extended data set are considered more reliable for deriving extreme sea levels at high return period.

The Mean Higher High Water (MHHW) levels for the 4 tide stations are shown in Table 9. The data have been converted to mPD for easy application.

(e) Section 6.8 Design Considerations of Rainfall and Sea Level Due to Climate Change

Replace the Section with the following:

In Hong Kong, rainfall is projected to increase and extreme sea level mainly comprising mean sea level and storm surge component is projected to rise under climate change. Excess rainfall will overload the stormwater drainage system. Extreme sea level rise will increase the flood risk in low-lying and coastal areas.

To consider the effect of climate change in the drainage design, the projection of rainfall increase and extreme sea level rise as well as corresponding design allowance should be added to the respective design rainfall intensities/synthetic rainstorm profiles and design extreme sea levels given in the corresponding figures and tables in this manual as described below.

The rainfall increase, mean sea level rise and storm surge increase due to climate change under intermediate greenhouse gas emissions scenario [SSP2-4.5] are given in Table 28, Table 29 and Table 30 respectively. Rainfall increase refers to the increase in annual maximum daily rainfall with reference to the Sixth Assessment Report (AR6) by the Intergovernmental Panel on Climate Change (IPCC). Mean sea level rise refers to the projection at Quarry Bay by the IPCC AR6 Sea-Level Projection Tool. Storm surge increase due to climate change is projected based on the projected increase in intensity of tropical cyclones considering climate change effect under IPCC AR6. In calculating the extreme sea level rise due to climate change in mid 21st century and end of 21st century, the mean sea level rise in mid 21st century and end of 21st century as shown in Table 29 should be added to the storm surge increase in Tables 30a and 30b respectively.

Considering the uncertainties in the range of possible future climate change development and global actions among nations on reducing carbon emissions, design allowance to cater for the projection difference between very high greenhouse gas emissions scenario [SSP5-8.5] and intermediate greenhouse gas emissions scenario [SSP2-4.5] in end 21st century, as given in Table 31 should be considered for both rainfall increase and extreme sea level rise to further enhance resilience of infrastructure against possible higher greenhouse gases emissions scenarios.

In general, drainage provision in new development areas should consider the climate change effects up to end of 21st century plus design allowance. For drainage design that can be upgraded progressively at later stage, design for drainage provision can firstly consider the projection of rainfall increase and extreme sea level rise in the mid 21st century. Adequate site area/relevant provisions should then be reserved/provided to facilitate future upgrading works taking into account the projection of rainfall increase and extreme sea level rise plus design allowance in end of 21st century and project office should draw up a long-term enhancement plan detailing the roadmap for these future upgrading works. For drainage design that could hardly be upgraded progressively at later stage (e.g. setting of design outfall level under extreme sea level rise for a stand-alone drainage system to prevent backwater effect), design for drainage provision should consider the projection of rainfall increase and extreme sea level rise plus design allowance in end of 21st century at the first place.

With consideration of the congested environment and other social impact considerations in well-developed areas, different site/technical constraints might be encountered when developing design for new drainage provision. Hence, it may be more practical to consider the projection of rainfall increase and extreme sea level rise in the mid 21^{st} century. However, unless there are practically unsolvable site/technical constraints, projection year up to the end of 21^{st} century for rainfall increase and extreme sea level rise plus design allowance should be considered as far as practicable.

Under some critical circumstances such as the case as mentioned in Section 6.9, the combination of structural measures and resilience measures / emergency preparedness may be considered to fulfill the design requirements or as mitigation measures.

The projection of rainfall increase and sea level rise comes up from a number of variables and research technology available at the time of assessment and it will be regularly reviewed based upon the latest IPCC Assessment Report or other relevant studies. The designer should make reference to the latest findings of climate change assessment promulgated by relevant authorities and, appropriately follow the prevailing design standards and guidelines.

(f) Section 6.9 Flood Resilience Measures and Emergency Preparedness

Add the following section:

6.9 FLOOD RESILIENCE MEASURES AND EMERGENCY PREPAREDNESS

There may be occasions that extreme sea levels may become higher than the levels of drainage system outfalls and the areas of low topography. If structural measures such as pipeline upgrading, stormwater diversion, storage scheme, and pumping scheme are found technically infeasible or not cost effective due to various constraints (e.g. no available area for provision of new pumping scheme), impact of flooding could be alleviated with provision of adequate resilience measures / emergency preparedness especially during passage of tropical cyclone or heavy rainstorm which should be proposed for DSD’s acceptance.

(g)	Section 12.7.2 Desilting Opening	**Delete** "900 mm x 750 mm and" **in the third and the last sentences of the first paragraph.**

Replace the fourth sentence of the second paragraph with the following:

Where space is available, off-road desilting opening should be provided as far as possible.

Add after the last sentence of the second paragraph with the following:

When the desilting access into box culvert is off-road, alternatives such as access ramps and desilting openings covered with precast slabs or whatsoever covers can be considered to suit the access into the box culvert/adjoining areas. The design of off-road desilting openings should ensure that sufficient working space will be available for the plants and equipment during future desilting operations to minimize disturbance to the public.

(h)	LIST OF TABLES	**Replace the following table:**

Table No.	
28	Rainfall Increase due to Climate Change

Add the following tables:

Table No.	
29	Mean Sea Level Rise due to Climate Change
30a	Storm Surge Increase in Mid 21st Century
30b	Storm Surge Increase in End of 21st Century
31	Design Allowance in End of 21st Century

(i) Table 8 Design Extreme Sea Levels (in mPD)

Replace the table with the following:

Table 8 – Design Extreme Sea Levels (in mPD)

Return Period (Years)	**North Point/ Quarry Bay (1954-2019)**	**Tai Po Kau (1962-2019)**	**Tsim Bei Tsui (1954-2019)**	**Tai O (1954-2019)**
2	2.82	2.97	3.07	2.87
5	3.03	3.27	3.31	3.16
10	3.20	3.54	3.52	3.36
20	3.38	3.86	3.74	3.57
50	3.66	4.41	4.09	3.84
100	3.91	4.93	4.41	4.06
200	4.19	5.59	4.78	4.28

Note:

1. The extreme sea levels at Tsim Bei Tsui and Tai O were based on the frequency analysis of instrumental data and correlated data from North Point/ Quarry Bay for an extended data set of 66 years (from 1954 to 2019).
2. For facilities which are vulnerable and sensitive to sea water level, e.g. E&M installations, where more stringent design is desirable, designers can make reference to the extreme sea levels as shown in Appendix 1. These extreme sea levels were derived with inclusion of significant storm surge events in Hong Kong before 1954.

(j) Table 9 Mean Higher High Water (MHHW) Levels (in mPD)

Replace the table with the following:

Table 9 – Mean Higher High Water (MHHW) Levels (in mPD)

North Point/ Quarry Bay (1954-2019)	**Tai Po Kau (1963-2019)**	**Tsim Bei Tsui (1974-2019)**	**Tai O (1985-2019)**
2.01	2.02	2.32	2.13

Notes: Data period for analysis at Tai O tide station does not cover 1998-2010 inclusive.

(k) Table 28 Rainfall Increase due to Climate Change

Replace the table with the following:

Table 28 – Rainfall Increase due to Climate Change

	Rainfall Increase
Mid 21st Century	11.1%
End of 21st Century	16.0%

Notes:
1. The rainfall increase is relative to the average of 1995-2014.
2. Mean projection values are adopted in the table.
3. Mid 21st century refers to years 2041 – 2060; end of 21st century refers to years 2081 – 2100.

(l) Table 29 Mean Sea Level Rise due to Climate Change

Add the following table:

Table 29 – Mean Sea Level Rise due to Climate Change

	Mean Sea Level Rise
Mid 21st Century	0.20 m
End of 21st Century	0.47 m

Notes:
1. The mean sea level rise is relative to the average of 1995-2014.
2. Median projection values are adopted in the table.
3. Mid 21st century refers to period around 2050; end of 21st century refers to period around 2090.

(m) Table 30 Storm Surge Increase due to Climate Change

Add the following table:

Table 30 –Storm Surge Increase due to Climate Change

Table 30a Storm Surge Increase in Mid 21st Century

Return Period (Years)	**North Point/ Quarry Bay (m)**	**Tai Po Kau (m)**	**Tsim Bei Tsui (m)**	**Tai O (m)**
2	0.04	0.05	0.05	0.03
5	0.05	0.07	0.06	0.05
10	0.06	0.08	0.08	0.05
20	0.07	0.10	0.09	0.06
50	0.08	0.13	0.11	0.08
100	0.09	0.15	0.12	0.09
200	0.10	0.17	0.13	0.10

Notes: Mid 21st century refers to period around 2050.

Table 30b Storm Surge Increase in End of 21st Century

Return Period (Years)	North Point/ Quarry Bay (m)	Tai Po Kau (m)	Tsim Bei Tsui (m)	Tai O (m)
2	0.06	0.09	0.09	0.06
5	0.09	0.14	0.12	0.09
10	0.10	0.17	0.15	0.10
20	0.12	0.20	0.17	0.12
50	0.14	0.25	0.20	0.14
100	0.16	0.29	0.23	0.16
200	0.18	0.34	0.26	0.18

Notes: End of 21st century refers to period around 2090.

(n) Table 31 Design Allowance

Add the following table:

Table 31 Design Allowance in End of 21st Century

Rainfall Increase	Extreme Sea Level Rise (Sum of Mean Sea Level Rise and Storm Surge Increase)				
	Return Period (Years)	North Point/ Quarry Bay (m)	Tai Po Kau (m)	Tsim Bei Tsui (m)	Tai O (m)
12.1%	2	0.20	0.22	0.20	0.19
	5	0.21	0.24	0.22	0.20
	10	0.22	0.25	0.23	0.21
	20	0.22	0.27	0.23	0.22
	50	0.24	0.29	0.25	0.22
	100	0.24	0.31	0.26	0.23
	200	0.25	0.34	0.27	0.24

Note:

1. End of 21st century refers to period around 2090.
2. Design allowance was derived from the projection difference (median values) between very high greenhouse gas emissions scenario [SSP5-8.5] and intermediate greenhouse gas emissions scenario [SSP2-4.5]. For design allowance in mid 21st century, designers can make reference to the table as shown in Appendix 2.

(o) Appendices 1 and 2

Add Appendices 1 and 2 in the following pages:

Appendix 1 – Reference Extreme Sea Levels with Consideration of Historical Storm Surge Records before 1954 (in mPD)

Return Period (Years)	North Point/Quarry Bay (1874-2019)			Tai Po Kau (1874-2019)		
	Reference Extreme Sea Level	95% Confidence Interval		Reference Extreme Sea Level	95% Confidence Interval	
		Lower	Upper		Lower	Upper
2	2.81	2.78	2.85	2.96	2.92	3.00
5	3.03	2.96	3.09	3.26	3.17	3.36
10	3.20	3.09	3.31	3.55	3.37	3.75
20	3.41	3.22	3.59	3.93	3.58	4.28
50	3.74	3.40	4.09	4.62	3.89	5.32
100	4.05	3.54	4.59	5.34	4.16	6.48
200	4.42	3.69	5.25	6.30	4.45	8.12

Note:
Significant storm surge events in 1874, 1923, 1936, 1937, 1949 and 1951 were considered in the analysis for the above table. Data for storm surge event in 1874 was based on reconstructed model simulation results. Other events were based on observation data documented in various literature such as government internal memos, correspondence to government and Hong Kong Observatory publications. For facilities which are vulnerable and sensitive to sea water level, e.g. E&M installations, where more stringent design is desirable, designers can make reference to the extreme sea levels as shown in the above table.

Appendix 2 – Design Allowance in Mid 21st Century

Rainfall Increase	Extreme Sea Level Rise (Sum of Mean Sea Level Rise and Storm Surge Increase)				
	Return Period (Years)	**North Point/ Quarry Bay (m)**	**Tai Po Kau (m)**	**Tsim Bei Tsui (m)**	**Tai O (m)**
0 %	2	0.04	0.05	0.05	0.04
	5	0.04	0.06	0.05	0.04
	10	0.04	0.07	0.06	0.05
	20	0.04	0.07	0.06	0.05
	50	0.05	0.08	0.06	0.05
	100	0.05	0.09	0.07	0.06
	200	0.05	0.10	0.07	0.06

Notes:

1. Mid 21st century refers to period around 2050.
2. Design allowance for rainfall increase has been included in Table 28.