7. Sewerage and Sewage Treatment Implications

7.1 Introduction

This section presents the assessment of impacts on the existing public sewerage facilities associated with the Project, according to the requirements as specified in section 3.4.7 and Appendix D2 of the Study Brief (ESB-261/2013).

Additional sewage is expected to be generated by the Project. This section is to assess the sewage impacts to the existing sewerage system in Tai Shue Wan including the sewerage catchments of Aberdeen Preliminary Treatment Works (APTW) due to the additional sewage flow arising from the Project, and to recommend appropriate mitigation measures to the sewerage system, if any, as a result of the Project.

7.2 Methodology of Sewerage Impact Assessment

7.2.1 Assessment Approach and Methodology

The assessment has been undertaken in accordance with the criteria and guidelines for evaluating and assessing impacts on the downstream public sewerage, sewage treatment and disposal facilities which would convey and collect the sewage flow from the Project as stated in Section 6.5 in Annex 14 of the EIAO Technical Memorandum. The following approach and methodology have been adopted to assess the impact on the existing / planned public sewerage system and sewage treatment capacity arising from the Project:

- Collect relevant information for the assessment;
- Investigate and review the capacity of the existing public sewerage networks and sewage treatment facilities in Aberdeen;
- Assess the impact of discharging sewage arising from the Project to the existing public sewerage systems within the sewerage catchment of APTW; and
- Formulate measures to mitigate any forecasted shortfalls in the sewerage system as a result of the Project and provide recommendations on the design, operation and maintenance requirements for the proposed sewerage system.

7.2.2 Design Reference

A desktop study was carried out to collect the relevant background information for the assessment as summarised below:

- Drainage Record Plans within the vicinity of the Tai Shue Wan from Drainage Services Department (DSD);
- Sewage flow generated from the Project;
- Proposed Development Layout Plan of the Project;
- EIA Report under the Repositioning project; and
- The Technical Note on the Compilation of 2011-based Territorial Population and Employment Data Matrix (TPEDM).

7.2.3 Design Standard Guideline

The assessment of the existing/planned downstream public sewerage networks and sewage treatment facilities in Aberdeen Sewerage Catchment have been carried out based on the following standards, guidelines, manuals and reports:

- The Guidelines for Estimating Sewage Flows for Sewage Infrastructure Planning Version 1.0 published by EPD (GESF)

7.3 Existing and Planned Sewerage Condition

7.3.1 Existing Sewage Collection for Ocean Park

The Project is located at Tai Shue Wan, and it is within the Aberdeen Sewerage Catchment, which also embodies South Bay, Repulse Bay, the eastern part of the Ocean Park area, Wong Chuk Hang, Aberdeen, Tin Wan and Chi Fu Fa Yuen. Sewage generated within this catchment is conveyed to the Aberdeen Preliminary Treatment Works (APTW) for treatment.

There are four main public sewage pipelines collecting sewage discharged from Ocean Park. Three sewers are located at Shum Wan Road, one connection, and Nam Long Shan Road, two connection, for the Tai Shue Wan side of Ocean Park, and other is located at Wong Chuk Hang Road.

The sewage generated from the Tai Sue Wan side of Ocean Park is connected to the three existing sewers at one connection on Shum Wan Road and two connections on Nam Long Shan Road. Part of the sewage generated at Tai Shue Wan discharges to the 300mm diameter gravity sewer along Shum Wan Road and then the pumping station located at Shum Wan Road. The sewage is then pumped to a rising main and discharged to a sewer located along Nam Long Shan Road and finally conveyed to the APTW. The Shum Wan Road sewer serves the sewage generated from Ocean Park with a discharge of 162m^3/day as per the discharge license issued by EPD.

Another existing sewerage connection at Nam Long Shan Area is to the 225mm diameter sewer and 450mm diameter at Nam Long Shan Road to collect the part of the sewage from the Tai Shue Wan. The 225mm diameter sewer currently collects sewage generated from the existing Ocean Park's facilities of Marine World with a discharge limit of 850m^3/day as per the discharge licence issued by EPD. The 450mm diameter sewer currently collects sewage generated from the new summit area of Ocean Park including Funicular Building, Rainforest, Thrill Mountain and Polar and the seawater usage for flushing and backwashing of the pools for animals with approximately 1,062m^3/day. The sewage was estimated based on the actual water bill (709m^3/day of fresh water) and in-house seawater daily pumping record (353m^3/day of seawater). Taking into account the proposed change of opening hours of the existing Ocean Park from "10:00hrs to 22:00hrs" to "09:00hrs to 23:00hrs", it is estimated that the sewage generated would be increased to approximately 1,239m^3/day.

The existing sewerage connection at Wong Chuk Hang Road allows sewage from the existing Lowland area to the 300mm gravity sewer across the Wong Chuk Hang Road towards the APTW.

7.3.2 Planned Sewerage Collection for Project

The sewage generated from the Project and the existing facilities of Ocean Park at Tai Shue Wan will be connected by a network within the Project area to a pump room within the proposed Water Park building.

Sewage will be temporarily collected in a sump pit with a minimum size of 12m^3 and then conveyed by twin rising main, 2 x 150mm diameter, up the hillside. Then it will be discharged ultimately to the existing 450mm diameter sewer via the government sewerage manhole: FMH7056262 at Nam Long Shan Area. The existing 450mm diameter sewer and the proposed discharge location are shown in **Figure 7.1**.

According to the latest planning, the chiller tank will be cleaned annually that a very little amount of discharge with residual chlorine level at 5mg/L will be conveyed to the sewerage system and diverted to APTW for treatment. Thus, it is considered that the impact to the downstream sewerage system is minimal.

Moreover, a continuous release of 1.6L/s of spent cooling water will be generated during the Ocean Park opening hours (0900 to 2300). The spent cooling water generated will be reused on site for flushing purposes. Under the current design, a total amount of 573.13 m^3/day of flushing water is required for the Project, which will fully utilise the 69.12 m^3 spent cooling water generated daily. The spent cooling water for re-use will be treated in accordance with the NSF 350 Standard in the 2012 USEPA Guidelines for Water Reuse standard which is along with the EMSD water quality objectives for re-use of spent cooling water as flushing supply and summarised in **Section 6.6**. Hence, no spent cooling water will be directly discharged, and no impact to the existing sewerage system is anticipated due the release of spent cooling water.

The planned sewerage system will be designed in accordance with all the relevant standards and guidelines published by DSD. The planned and existing sewerage network are maintained and operated by Ocean Park in accordance with the Sewerage Manual published by DSD. The planned sewage pumping system is being designed in accordance with the sewerage manual published by DSD, the requirement on self-cleaning velocity will be achieved and the maximum retention time of the planned pumping station will not be more than 2 hours to avoid the septic and odour problems.

7.3.3 Existing and Planned Sewerage Treatment Facilities

Sewage collected from the Ocean Park is conveyed by the existing sewerage systems to the APTW for treatment. The treated effluent is ultimately discharged to sea for disposal.

APTW is located at Tin Wan Praya Road. The design capacity (Peak Flow) is 3.06m^3/s. Capacities of the individual treatment units are shown in **Table 7.1**. At the time of preparing this Section, no further upgrading work for APTW is confirmed.

Table 7.1: Existing Facilities of the APTW

Treatment Unit	No. of Unit	Capacity of Each Treatment Unit (m^3/s)
Pump Capacity	3 Duty + 1 Standby	3.06
Fine Screen	2 Duty + 1 Standby	3.06
Grit Trap	1 Duty + 1 Standby	3.06

7.4 Assumptions and Parameters Adopted for Assessment

7.4.1 Assessment Scenarios

The assessment of impacts due to the Project on the public sewerage system in APTW sewerage catchment has been carried out for both baseline condition and ultimate condition of the Project as summarised in **Table 7.2**.

Table 7.2: Assessment Scenarios

Scenario Year	Description
2013	Baseline Condition
2021	Ultimate Condition for the Project

7.4.2 Global Unit Flow Factors (GUFF) – Sewage Treatment Works & Pumping Station

Estimation of the sewage flow to the affected sewage treatment works and pumping station in Aberdeen sewerage catchment has been undertaken according to the methodology as specified in GESF. Appropriate GUFF for domestic, commercial, industrial and institutional activities have been selected in accordance with GESF, as shown in **Table 7.3**.

Table 7.3: Adopted Global Unit Flow Factors (GUFF) for Sewage Treatment Works & Pumping Station

Category	Unit (per)	GUFF (m^3/day)	Data Source
Domestic (catchment specific)			
Private Housing and Public Housing	Person	0.23	GESF
Commercial			
Commercial Employee	employee	0.08	GESF
S1	employee	-	GESF – J7
S3	employee	0.25	GESF – J2
S4	employee	0.15	GESF – J9
S5	employee	-	GESF – J5
S6	employee	0.2	GESF – J4
S7	employee	0.2	GESF – J4
S8	employee	0.1	GESF – J3
S9	employee	1.5	GESF – J10
S10	employee	1.5	GESF – J10
S11	employee	0.1	GESF – J3
S12	employee	-	GESF – J6
S13	employee	-	GESF – J6
S14	employee	-	GESF – J6
S15	employee	-	GESF – J12
S16	employee	0.2	GESF – J11
S17	employee	0.2	GESF – J11
S18	employee	0.2	GESF – J11
S19	employee	0.2	GESF – J11
Industrial			
Industrial Employee	employee	0.08	GESF
S2	employee	0.55	GESF
Institutional			
School Student	person	0.04	GESF

7.4.3 Peaking Factors

According to GESF, a peaking factor should be applied in determining the peak flow. As the service condition of the existing sewerage systems within the study area is not clear, conservative approach using the peaking factors including stormwater allowance are adopted in this assessment. Based on GESF, the peaking factors adopted for determination of peak flows in sewers, sewage treatment works and pumping station are based on different population ranges as shown in **Table 7.4**:

Table 7.4: Peaking Factors

Population Range	Peaking Factor (including stormwater allowance) for Sewers
<1000	8
1,000 – 5,000	6
5,000 – 10,000	5
10,000 – 50,000	4
>50,000	$Max\left(\frac{7.3}{N^{0.15}}, 2.4\right)$ where: N = contributing population in thousands; and Contributing population = Calculated total average flow in m^3/day divided by 0.27 m^3/day

Population Range	Peaking Factor (including stormwater allowance) for Sewage Treatment, Preliminary Treatment Works and Pumping Stations
<1000	4
10,000 – 25,000	3.5
25,000 – 50,000	3
>50,000	$Max\left(\frac{3.9}{N^{0.065}}, 2.4\right)$ where: N = contributing population in thousands; and Contributing population = Calculated total average flow in m^3/day divided by 0.27 m^3/day

7.5 Sewage Flow Estimation

7.5.1 Sewage Generated by the Existing and Proposed Development

The total sewage flow generated for the entire existing and planned Project as well as the two future hotels that are under preliminary planning provided by the Ocean Park is summarised in **Table 7.5**. Detailed estimation is shown in **Appendix 7.4**.

Table 7.5: Estimated Sewage Flows from Ocean Park Adopted for Assessment

Source	Approximate Total ADWF (m^3/day)
Existing Ocean Park Facilities	70.5
Proposed Water Park Development (the Project)	710.0
Future Spa Hotel (under preliminary planning)	142.2
Future Fisherman's Wharf Hotel (under preliminary planning)	363.4
Total	1286.1

7.5.2 Existing and Projected Sewage Flow for Gravity Sewers along Nam Long Shan Road

Based on the aforementioned assumptions and drainage record plan, no planned sewage will be discharged to the existing 450mm diameter sewer along Nam Long Shan Road. The sewage flows in different catchment areas and the gravity sewers along Nam Long Shan Road have been estimated, as summarised in **Table 7.6** and **Table 7.7**. The 1,239m^3/day ADWF for existing facilities of Ocean Park has taken into account the proposed change of opening hours. The locations for individual discharges at the gravity sewers are shown in **Figures 7.3 to 7.5**. Details of the sewage flow calculation are given in **Appendix 7.3**.

Table 7.6: Estimated ADWF for the sewerage catchment

Catchment No.	ADWF (m^3/day)	Remark
S1 (Existing Facilities of Ocean Park with the proposed change of opening hours from "10:00hrs to 22:00hrs" to "09:00hrs to 23:00hrs")	1239.0	From Ocean Park
S2 (Project, existing Tai Shue Wan Facilities and the two future hotels)	1286.1	From design consultant of project
S3 (TWGHs David Trench Home for Elderly)	160.9	From DSD
S4 (Singapore International School)	110.6	-
S5 (Shue Yan Secondary School)	89.8	-

Table 7.7: Estimated ADWF and Peak flow for the gravity sewers

Contributing Catchment No.	Discharged Manhole	ADWF (m^3/d)	Contributing Population	Peaking Factor	Peak Flow (l/s)
S1	FMH7056267	1239.0	4589	6	86.1
S1 + S2	FMH7056262	2525.1	9353	5	146.2
S1 + S2 + S3	FMH7056229	2686.0	9949	5	155.5
S1 + S2 + S3 + S4 + S5	FMH7056213	2886.4	10691	5	167.1

7.5.3 Existing and Projected Sewage Flow in APTW

In order to assess the impact on APTW due to the Project, the future sewage flow handled by APTW is estimated according to the population forecast from the 2011-based TPEDM. The sewerage catchments represented by the Planning Data Zones (PDZ) system from the 2011-based TPEDM are shown in **Figure 7.2**. The sewerage catchments of APTW in terms of PDZ included 40, 41, 43, 44, 45, 46, 47, 49, 349, 50, 51.

Based on the estimated ADWF of the various PDZ within the sewerage catchment of APTW, the total ADWF discharged to APTW in 2013 and 2021 are calculated and summarised in **Table 7.8**. Details of the population in each Aberdeen Sewage Treatment Catchment and total sewage flow estimation for APTW in 2013 and 2021 are also given in **Appendix 7.2.**

Table 7.8: Estimated ADWF for the Relevant PDZs within the APTW sewerage catchment

Planning Data Zones	ADWF in 2013 (m^3/day)	ADWF in 2021 (m^3/day)
40	1,319	1,153
41	1,064	923
43*	211	290
44	4,825	5,070
45	2,310	2,191
46	5,805	5,914
47	16,343	16,302
49	8,497	12,038
349	2,258	2,783
50	1,486	1,456
51	3,268	3,614
Proposed Waterpark (Project)	0	780.5
Future Spa Hotel (under preliminary planning)	0	142.2
Future Fisherman's Wharf Hotel (under preliminary planning)	0	363.4

* For PDZ 43, only Category School and S16 are assumed to contribute to APTW catchment.

7.6 Assessment of Impact to Existing/Planned Sewerage and Sewage Treatment System

7.6.1 Overview

The Project will be in full-scale operation before 2021 and thus the sewage flow in 2021 will be the ultimate flow. This ultimate flow is used to assess the impacts on the following key components of the sewerage system and sewage treatment works:

- Gravity sewers along Nam Long Shan Road; and
- APTW.

7.6.2 Gravity Sewers along Nam Long Shan Road

It is proposed to connect the new development sewerage to the 450mm sewer along Nam Long Shan Road. The existing 450mm diameter along the Nam Long Shan Road has a capacity ranging from 0.17 m^3/s to 0.84 m^3/s. The utilization of the 450mm sewer for the catchments along Nam Long Shan Road including the project is ranging from 10% to 84%. It is considered that the existing 450mm diameter sewer capacity is sufficient to cater the sewage discharge arising from Project. The comparison of the proposed sewage flow against the capacity of the existing 450mm sewer along Nam Long Shan Road is shown in **Appendix 7.3**.

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7.6.3 Downstream Sewerage System

The sewage flows arising from the Project will be conveyed to APTW through approximate 2.5km long of 1500mm trunk sewer along Wong Chuk Hang Road. According to the assessment, the trunk sewer

generally has a capacity approximate 2.6 m^3/s. Thus, the sewage flow of 0.054 m^3/s from the Project only utilises approximately 2.1% of the trunk sewer. It is considered that no adverse impact to the trunk sewer.

The potential impacts arising from the re-use of spent cooling water for toilet flushing and the proposed disinfection system in terms of temperature effect and residual chlorine would be on the existing downstream sewerage system. It is expected that the spent cooling water will be at a temperature of 38°C. According to Table 1 of the Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters issued by EPD, it indicates the temperature standard 43°C for effluent discharged into foul sewers leading into Government sewage treatment plants. Temperature of the spent cooling water will be well below the regulated one for effluent discharged into foul sewers. The expected residual chlorine concentration at 5mg/l from annual cleaning process of the chiller tank to discharge the sewage system would be acceptable and infrequent of once per year. The potential impacts are therefore not anticipated to be significant.

7.6.4 Aberdeen Preliminary Treatment Works (APTW)

The potential impact on the APTW is assessed based on the estimated ultimate sewage flows arising from the Project as well as the population forecast from the 2011-based TPEDM within the catchment areas of the APTW (see **Table 7.9**). The estimated sewage flows handled by APTW are summarised in **Table 7.9** and details of the sewage flow estimation are given in **Appendix 7.1**.

Table 7.9: Estimated Sewage Flows Handled by APTW in 2013 and 2021

Scenario Year	Approxi-mate ADWF from Relevant PDZ (m^3/day)*	Approxi-mate ADWF from the Project and the two Future Hotels (m^3/day)*	Total ADWF (m^3/day)	Catch-ment Inflow Factor*	ADWF x Catchment Inflow Factor (m^3/day)	Contri-buting Population	Peaking Factor	Total Peak Flow (m^3/s)	Capacity of APTW Peak Flow (m^3/s)
2013	47,386	0	47,386	1.3	61,602	228,157	2.7	1.95	3.06
2021	51,733	1286.1	53,019	1.3	68,925	255,279	2.7	2.17	3.06

* For Catchment Inflow Factor, refer to the Table T-4 of the GESF,

It can be seen from **Table 7.9** that the estimated total ADWF and peak sewage flow, including that generated by the Project and the future two hotels (under preliminary planning), to be handled by APTW in 2021 would be approximately 68,925 m^3/day (ADWF) and 2.17 m^3/s (Peak Flow) respectively, which are within the capacity of the existing APTW. It is concluded that the APTW has adequate capacity to cater for the total flow generated by the Aberdeen sewerage catchment in Year 2021 including the proposed works under the Project.

7.7 Mitigation Measures

7.7.1 Septicity

Septicity is caused by increased retention time meaning the available dissolved oxygen and nitrate consumed by the biomass and the effluent. In order to control the septicity of sewage due to operation of sewage pumping facilities, the retention time of sewage should be minimised. Use of appropriate pump rate

should be considered for reducing the time of retention of sewage. Direct injection of chemicals could also be used to control septicity. The mitigation methods should be considered under detailed design stage.

In order to prevent septicity occurring in the sewage pump pit and rising mains, preventive measures will be adopted. These would include designing the bottom of the sewage pump pit inclined to minimise the likelihood of sludge accumulation and the sewage retention time in the pump pit not exceeding 30 minutes. Also, the rising main would be constructed from ductile iron pipes with epoxy internal linings complying with BS EN 598:1995 and the design minimum velocity within the rising mains would be 1m/s at full bore condition as suggested in the Sewerage Manual Part 1.

7.7.2 Gravity Sewers along Nam Long Shan Road

According to the above assessment, the existing gravity sewers along Nam Long Shan Road should be adequate for handling the sewage flows from the Project even if the two future hotels that are under preliminary planning have been taken into account. Hence, no upgrading of the sewers is required for the Project.

7.7.3 Aberdeen Preliminary Treatment Works (APTW)

It has been assessed that the capacity of existing APTW is sufficient to handle total flow generated by the Aberdeen sewerage catchment in Year 2021 even if the two future hotels that are under preliminary planning have been taken into account. Hence, no upgrading of the APTW is required for the Project.

7.8 Conclusion

The impact assessment has been carried out on the existing public sewerage network and treatment works to collect the sewage flow generated from the Project. The sewage flow from the Project is proposed to be discharged to the 450mm diameter sewer at Nam Long Shan Road and then conveyed to the APTW for treatment.

The hydraulic assessment results have revealed that the existing 450mm diameter gravity sewer along the Nam Long Shan Road should be able to handle all the sewage flows from the Project. Therefore, no adverse impact is anticipated on the existing 450mm diameter gravity sewers and the downstream sewerage system due to the Project.

In view of the assessment findings, it is considered that the design capacity of the existing APTW is sufficient to handle the estimated total ADWF and Peak Flow from the Project and the relevant PDZ during the ultimate scenario year of 2021. In conclusion, no adverse impact is anticipated on the existing APTW due to the Project.