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Desalination Plant at Tseung Kwan O - Feasibility Study

Executive Summary

8901/B&V/0055 (Issue 2) - Final

Report Authorized For Issue By:

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1 INTRODUCTION

1.1 Background

1.1.1 Our water source is facing various challenges, including increasing local water demand arising from population and economic growth, occurrence of extreme weather and severe drought as a result of climate change, as well as competition for water resource due to the rapid economic development in the Pearl Delta Area. In this connection, WSD has been implementing the "Total Water Management (TWM) Strategy" since 2008 to better prepare Hong Kong for uncertainties such as acute climate changes and low rainfall. Under the TWM strategy, Hong Kong should broaden its strategic investment in advanced water treatment such as the reverse osmosis (RO) technology for desalination plant which is unaffected by climate change.

1.1.2 With fresh water shortages in the world in recent years, the desalination technology grew rapidly and demonstrated a decreasing trend in production costs. According to the International Desalination Association (IDA) data, currently there are over 17,000 desalination facilities around the world with daily output of 80 million cubic meters and about 60% of the installed capacity adopted reverse osmosis desalination technology (see attached Annex 2A and 2B) and the construction of the reverse osmosis desalination facilities has continued to grow. The technology will continue to mature in the coming future and become the global trend for freshwater supply source.

1.1.3 In view of the above, Water Supplies Department (WSD) conducted a feasibility study and a pilot plant study on the development of desalination facilities in Hong Kong in 2002 and 2007 respectively. The studies confirmed the technical feasibility of desalination using reverse osmosis under local conditions to produce potable water complying with the World Health Organization (WHO) standards.

1.1.4 In the previous studies, 13 potential sites for the desalination facilities were identified for preliminary evaluation. Subsequently, four short-listed sites were identified for further evaluation in the suitability for Reverse Osmosis (RO) technology. They included Siu Ho Wan, Area 38 Tuen Mun, Tsang Tsui Ash Lagoon, and Tseung Kwan O (TKO) Area 137. A set of criteria was established for the evaluation of these sites. These criteria were grouped into four categories, namely technical, cost, environmental impacts, and regulatory and social impacts. TKO Area 137 was the highest ranked site from the perspective of functional and technical issues. It was hence selected for this study for validation of its suitability in the development of RO desalination facilities.

1.1.5 The proposed desalination plant in TKO, with a water production capacity of 135 million litres per day (MLD) expandable to 270 MLD is a pioneer fresh water production plant. It will provide a new water resource for Hong Kong (about 5% to 10% of the total fresh water demand). It will also allow WSD to acquire practical experience and skills in the application of advanced water treatment technology such as desalination by means of reverse osmosis.

1.1.6 Black & Veatch Hong Kong Limited (B&V) was commissioned by WSD in December 2012 to study the feasibility and cost effectiveness of constructing a seawater reverse osmosis (SWRO) desalination plant at TKO Area 137, together with associated fresh water transfer facilities to the existing Tseung Kwan O Fresh Water Primary Service Reservoir (TKOFWPSR).

1.1.7 This Executive Summary serves to summarize the principal findings of this Feasibility Study

2 IMPLEMENTATION PROGRAMME

"The original content of this section is not shown as it is under review and being revised during the design stage."

3 WATER QUALITY

3.1 Seawater Quality

3.1.1 The following are key source water quality parameters for the design of pre-treatment systems and RO system for a desalination plant with a submerged open intake:

- Turbidity and total suspended solids
- Total organic carbon (TOC)
- Algal cell loading measured as chlorophyll-a and algal cell counts
- Temperature and pH
- Salinity / Total dissolved solids (TDS)
- Individual salts that impact design and operation of the RO system (primarily chloride, bromide, and boron)

3.1.2 Seasonal variations were observed during sampling. The water quality in the sampling locations are typically characterised by low concentrations of turbidity, suspended solids, chlorophyll-a and TOC. In summer season, from June to September, chlorophyll-a and TOC measurements are both noticeably higher than the rest of the year.

3.1.3 The pre-treatment processes were formulated with reference to the findings of water sampling in particular the following water quality control parameters:-

- Turbidity;
- Total Organic Carbon;
- Total Dissolved Solids; and
- Algae.

3.1.4 The treatment process design is further discussed in Section 3 of the Report.

3.2 Treated Water Quality Objectives

3.2.1 In addition to WSD's water quality (WQ) objectives and WHO guidelines, additional WQ objectives/goals for TKO desalination facility are required to ensure that product water is comparable or better than the supply from the existing WSD's Water Treatment Works.

Table 3-1 shows the design goals for treated water quality which are adopted for the proposed TKO desalination facility. Alkalinity, hardness, boron, total dissolved solids (TDS) and bromide are the additional parameters in the final water quality objective for the desalination plant.

Parameter	Unit	Design Goal
pH	pH unit	8.2-8.8
Alkalinity	mg/L as $CaCO_3$	30-75
Hardness	mg/L as $CaCO_3$	>40
Colour	Hazen units	≤5
Turbidity	NTU	≤1.0 NTU, and ≤0.3 NTU in 95% of daily samples in any month (prior to pH adjustment)
Iron as Fe	mg/L	≤ 0.1
Manganese as Mn	mg/L	≤0.05
Aluminium as Al	mg/L	≤0.10
Free residual chlorine	mg/L	0.5 – 1.5
Fluoride as F	mg/L	±10% of nominal level (current 0.5 mg/L)
Taste and odour	TON	Unobjectionable
Total Coliforms & E. coli	no./100mL	Absent
Viruses	Log removal in %	4-log (99.99%) reduction or inactivation
Cryptosporidium oocysts (C)	Log removal in %	4-log (99.99%) reduction or inactivation
Giardia cysts (G)	Log removal in %	4-log (99.99%) reduction or inactivation
Boron(1)	mg/L	≤1.0
Total Dissolved Solids(1)	mg/L	≤250
Bromide(1)	mg/L	<0.2
Note (1): Guideline values not specified by WHO.		

Table 3-1: Fresh Water Quality Objectives

4 DESIGN OF TREATMENT WORKS

4.1 Introduction

4.1.1 Various intake, pre-treatment, RO process and RO concentrate disposal options have been evaluated in detail. In summary, the recommended process train is illustrated in Figure 4-1

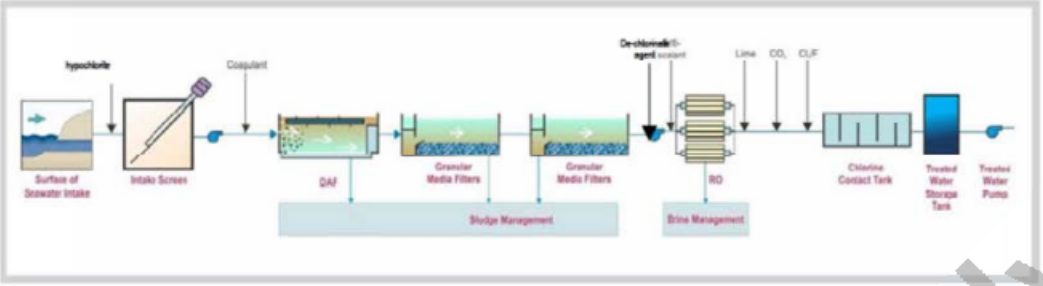

Figure 4-1 – Preliminary Treatment Process Flow Diagram

4.1.2 The following desalination processes are recommended for the Desalination Plant at Tseung Kwan O :-

- Seawater Intake – Seawater extraction
- Pre-chlorination – Control of bio-fouling at downstream process equipment
- Clarification by dissolved air flotation (DAF) – Algae, oil & grease and suspended solid removal
- Two-stage media filtration – Turbidity improvement
- Cartridge filters – Polishing the seawater prior to entering the RO system
- Two-pass reverse osmosis (RO) – Desalination Process
- Addition of chlorine gas - Final disinfection;
- Addition of hydrated lime, carbon dioxide and sodium hydroxide dosing – Remineralisation/corrosion control
- Fluoridation – Dental protection
- Submarine outfall with diffuser system – RO concentrate disposal
- Gravity thickening – Sludge thickening of filter backwash waste and clarifier sludge
- Membrane filter presses – Sludge dewatering

4.1.3 The cleaning chemicals for RO include sodium hydroxide, citric acid, and hydrochloric acid. Chemical cleaning of RO membranes are typically carried out when permeability of the membranes drops below specific set points. Such cleaning waste will be neutralized before disposal to sewer. Supernatants from residual processes will be recycled to the intake at controlled flowrates.

4.2 Seawater Intake

4.2.1 The proposed intake system consists of one submerged intake pipe which extends to about 250m away from the shore with submerged intake point at about 10m below sea level. Sodium hypochlorite system will also be provided for bio-fouling control.

4.2.2 The coarse intake screens located at the end of the intake pipe will be of bar type with bar spacing of 20mm and shall be made of stainless steel at least Grade 316 for marine environments.

4.2.3 The fine traveling band screens are proposed at the downstream of coarse bar screens. The size of opening for the screen will be 3 mm and two (2) nos of screen are proposed with one duty and one standby configuration.

4.3 Pre-treatment

4.3.1 Coagulant Mixing

4.3.1.1 Coagulant mixing will be the first unit process in the pre-treatment. Under normal operating conditions, ferric chloride with dose ranging from 10mg/l to 40mg/l will be added to the raw seawater prior to passing through the downstream Dissolved Air Flotation (DAF) and media filtration processes.

4.3.2 Dissolved Air Flotation (DAF)

4.3.2.1 Two stages of flocculation are anticipated at the immediate downstream of rapid mixing. Polyelectrolyte provision will be made, to deal with adverse raw water quality conditions at the upstream of the flocculation tank before enters the dissolved air flotation section of the unit..

4.3.2.2 As floated floc particles accumulate on the surface of the DAF unit, a thick sludge layer is formed. Periodic removal of the sludge layer is required and may be carried out by hydraulic or mechanical methods. Desludging is carried out hydraulically by raising the water level in the unit causes the overflow of the sludge blanket into the sludge collection trough. This is accomplished by raising an automatic effluent weir plate on a prescribed frequency and duration. Alternatively, mechanical scrapers can be used to remove the sludge from the top of the flotation zone. Mechanical method can offer thicker sludge concentrations upto 2%.

4.3.2.3 Flexibility is allowed to bypass the DAF unit as a cost saving feature for reducing chemical and energy usages when conditions warrant.

4.3.3 Two-Stage Media Filtration

4.3.3.1 Clarified water from the DAF units will flow to the two-stage media filters downstream by gravity which can provides consistent and effective pre-treatment. In seawater applications, use of dual media filters are widely adopted after having been proven in several full scale desalination plants. Two-stage dual media filtration is therefore recommended for TKO to provide additional protection to the SWRO membrane.

4.3.4 Cartridge Filters

4.3.4.1 The cartridge filters will remove suspended particles that may accumulate downstream of the filtration process. Cartridge filters serve as the final barrier in all RO systems prior to the high pressure RO feed pumps.

4.4 RO System

4.4.1 The RO section of the desalination plant consists of high pressure pumps, RO membrane trains, booster pumps, concentrate valves, piping and energy recovery system. The first pass of the RO system in Stage 1 has 10 trains including 1 standby unit, each with a production capacity of approximately 700 m^3/hr. There are 10 high pressure pumps and 10 energy recovery devices in the first-pass of the RO system (i.e. one HPP/ERD per RO train). The SWRO design for Phase 2 Desalination Plant will be identical to Phase 1.

4.4.2 Figure 4-2 illustrates the proposed RO membrane configuration. RO feed water, filtered seawater from the filters will be pumped via the transfer pumps to the seawater RO process. The filtered feed water will first pass through cartridge filter vessels to safeguard the suspended particles in an acceptable level.

4.4.3 The pressurized stream is split, with half of the flow going to the high pressure pumps (one dedicated for each RO unit) and the other half to the energy recovery devices (one dedicated for each RO unit). Flow entering the energy recovery device (ERD) is pressurised by hydraulic energy recovered from the concentrate and by a booster pump to combine with the other half of the flow entering the RO skids. High pressure RO feed pumps and ERD booster pumps will be equipped with variable speed drives. The high-pressure RO feed pumps vary the RO feed pressure to produce the required permeate flow in response to changes in operating conditions such as water quality (salinity and temperature).

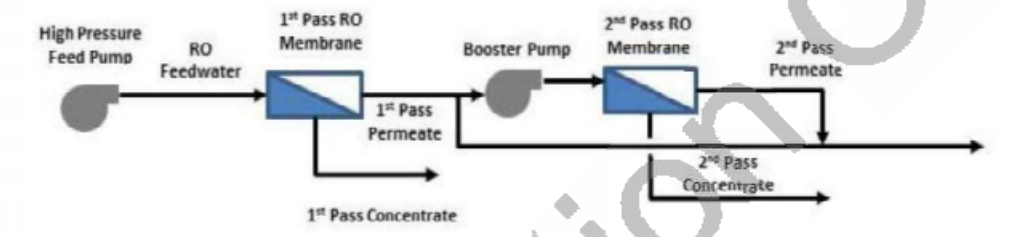

Figure 4-2: RO Membrane Configuration

4.5 Concentrate Disposal

4.5.1 With a recovery rate 40-50% the TKO desalination plant will treat all seawater to drinking water standards. The remaining 50 to 60 percent that will be rejected by the SWRO membranes (commonly referred to as RO concentrate) will be returned to the sea via the proposed 1500mm diameter outfall. Sufficient pressure shall be provided, either by gravity or pump for the concentrate to discharge via the design outfall.

4.6 Post-Treatment

4.6.1 Desalination process will produce high quality water with very low alkalinity and Total Dissolve Solid (TDS). To eliminate potential taste and corrosion problems resulting from this aggressive water, post-treatment is necessary to stablise the SWRO permeate. Post-treatment including remineralisation and corrosion control by addition of carbon dioxide, hydrated lime, fluoridation for dental protection, and disinfection by chlorine are recommended.

4.7 Treated Water Storage and Delivery

4.7.1 A proposed DN1200 water main approximate 9km long shall be provided for delivering treated water from the desalination plant to the existing Tseung Kwan O Fresh Water Primary Service Reservoir (TKOFWPSR). The new water main is proposed to be connected to the existing inlet chamber at the northern side of TKOFWPSR. The water main shall be buried pipeline made of steel complying with ISO 10224:2002.

4.7.2 The proposed water main will be laid along the carriageway of Wan Po Road, Po Hong Road, Tsui Lam Road and finally towards TKOFWPSR. The pipe laying works will be carried out mainly by open-cut method with trenchless method in some of the critical junctions along Wan Po Road and Po Lam Road.

5 ENVIRONMENTAL IMPACT ASSESSMENT

5.1 Air Quality Impact

5.1.1 Construction Phase

5.1.1.1 Potential dust generating activities, including excavation and filling, materials handling, truck movements on unpaved roads and wind erosion of temporary stockpile of dusty materials have the potential to cause adverse fugitive dust impacts to the nearby air sensitive receivers (ASRs) if not properly managed. As the site has been formed, only minor excavation from the foundation and piling works are required. No fugitive dust emission is anticipated from the building construction and civil works. The worksite of submerged intake and outfall pipes and also slope stabilization works are located more than 250 m from the nearest ASR. Therefore, fugitive dust emission is minor. With the implementation of the recommended dust control measures and adoption of good construction site practices, no adverse fugitive dust impact is anticipated. The fresh water mains will be laid in small sections using open-cut method and small-scale excavation works will be required. Since the excavated materials generated will be relatively small and the worksite is small, no adverse fugitive dust impact is envisaged provided that the recommended dust control measures are properly implemented. No cumulative impact is anticipated during the construction phase of the Project.

5.1.1.2 To ensure proper implementation of the recommended dust mitigation measures and good construction site practices during the construction phase, environmental site audits on weekly basis is recommended throughout the construction period.

5.1.2 Operation Phase

5.1.2.1 By reviewing the process flow, no gaseous emission during operation is anticipated. Potential gaseous emission from the standby generator within the desalination plant is infrequent and transient. Hence, no adverse air quality impact is anticipated. Sludge produced from the desalination process is chemical sludge and the potential to cause odour nuisance is low. With the implementation of proper odour control measures and good management practices, no adverse odour impact is anticipated during the operation of the desalination plant. As no adverse air quality or odour impact is anticipated during the operation of the desalination plant, therefore, no air quality or odour monitoring is considered necessary.

5.2 Noise Impact

5.2.1 Construction Phase

5.2.1.1 A construction noise assessment has been undertaken to predict the noise levels at the representative noise sensitive receivers (NSRs) due to the construction of the Project. Practicable mitigation measures, including use of quiet construction plant, movable noise barriers, noise insulation sheets, scheduling of construction activities and noise enclosures, have been recommended. No adverse noise impacts are anticipated with the implementation of the practical mitigation measures and noise levels at all NSRs are predicted comply with the EIAO requirements.

5.2.2 Operation Phase

5.2.2.1 All equipment will be accommodated inside the plant rooms and hence fully enclosed. Operational noise from the pumping station is assumed to be emitted through louvres. No

adverse noise impacts are anticipated at the representative NSRs during the operational phase due to the Project because of the large horizontal separation.

5.3 Water Quality

5.3.1 Construction Phase

5.3.1.1 Computational modelling has been conducted to predict various potential water quality impacts from the proposed marine dredging operation under this Project, including suspended solid (SS) elevation, sedimentation, DO depletion, release of nutrient, heavy metal and trace organic pollutants. Full compliance is predicted at all identified water sensitive receivers (WSRs) for all parameters in both seasons, with the exception of exceedances in SS elevation predicted at four coral WSRs. With the implementation of silt curtain around grab dredger and reduced dredging rate at seawater intake, the predicted SS elevation at these WSRs would be significantly reduced and would be in compliance to the water quality objective (WQO) criteria for SS. To ensure environmental compliance, marine water monitoring for the marine dredging works is recommended.

5.3.1.2 Other potential water quality impacts from marine and land-based construction were also addressed. Appropriate preventive and mitigation measures are recommended to minimize the potential water quality impact from these works. Environmental monitoring and audit is recommended to ensure the proper implementation of these measures.

5.3.2 Operation Phase

5.3.2.1 The discharge of RO concentrate from the desalination process is the main environmental concern for the Project operation. The potential change in hydrodynamic and water quality from Project operation was assessed in detail using a combination of near field (CORMIX) and far field (Delft3D) modelling tools. The change in salinity, elevation in SS (and sedimentation flux), anti-scalant, total inorganic nitrogen (TIN) and Fe during normal operation, as well as the discharge of total residual chlorine (TRC) and sodium metabisulphite (SMBS) during bio-growth control works, were all assessed using the near field and far field modelling tools specified above. The effluent plume of the RO concentration is predicted to be highly localized in both seasons. The elevation in salinity and other chemicals are predicted to be diluted soon after leaving the submarine outfall. No observable mixing zone is predicted for most discharge scenarios for most chemicals constituents. Where mixing zone is predicted, it would be closely confined near the submarine outfall and would not encroach to any nearby WSRs. No adverse water quality impact from the discharge of RO concentrate would be expected. To ensure environmental compliance, monitoring of discharge effluent quality and marine water quality at nearby selected WSRs are recommended.

5.3.2.2 Other potential water quality impact from regular chemical clean, sewage effluent and chemical spillage has been addressed. Appropriate measures are recommended to minimize any potential water quality impact associated with the daily operation of the Project. No adverse water quality impact from the daily operation of the Project is expected.

5.4 Sewerage Impact and Sewage Treatment Works Implication

5.4.1 The proposed strategy, discharge of sewage directly via a sewerage system to the Tseung Kwan O PTWs, is considered feasible in terms of regional sewerage strategy, land, environmental impact and construction considerations. The proposed plant is considered sustainable in terms of sewerage.

5.4.2 The configuration and alignment of the proposed new sewerage system will be confirmed in the detail design stage of this project, while the infrastructure design especially the road alignment and sewerage system of TKO Area 137 is proposed. Gravity sewer is a preferable option in term of cost-benefit consideration by constructing the sewer from the plant to connect the existing manhole.

5.4.3 Based on the above, there is no unacceptable sewerage impact would be anticipated to the existing sewerage system arising from the proposed Desalination Plant.

5.5 Waste Management & Land Contamination

5.5.1 Construction Phase

5.5.1.1 It is estimated that a total of about 227,696 m^3 of excavated materials will be generated from the construction of the seawater intake and outfall, basement/ foundation and piling works of the desalination plant and the mains laying works, of which 26,913 m^3 of the excavated materials will be reused on-site for general filling. A surplus of about 196,656 m^3 of the excavated materials (inert C&D) will be disposed off-site to the public fill reception facilities; 3,112 m^3 of the excavated materials (non-inert C&D) will be disposed of at SENT Landfill or its extension (if implemented) or NENT Landfill; and 1,016 m^3 of the excavated materials will be reused on-site as fill material after cement stabilization far as practicable or will be disposed as dredged marine sediments *(ETWB TC(W) No. 34/2002)* in case cement stabilization is not a practical treatment. With reference to *ETWB TC(W) No. 33/2002*, a C&DMMP for the Project has been prepared. With the inclusion of marine sediments generated from excavation (1,016 m^3), it is estimated that a total of 7,346 m^3 of marine sediments will be generated from the construction of seawater intake and outfall and desalination plant (including slope mitigation works). The marine sediments (with the contamination level of Category 'L') will disposed of at specific open sea area in accordance with *ETWB TC(W) No. 34/2002*. The project proponent will implement the project in accordance with the Dump at Sea Ordinance (DASO) and the requirements as stipulated in *ETWB TC(W) No. 34/2002*, prior to the application and allocation of space for dredging and disposal of sediment arising from the project.

5.5.1.2 During the construction of civil structures and buildings within the Site, it is estimated that a total of about 4,556 m^3 of public fill and 1,139 m^3 of construction waste will be generated. The public fill and the construction waste will be disposed of at TKO Area 137 Fill Bank (if it is still in operation), or other public fill reception facilities and landfill, respectively.

5.5.1.3 With respect to the scale of the construction activities, it is anticipated that the quantity of chemical waste to be generated will be small. It is also estimated that about 104 kg of general refuse will be generated per day by the construction workers. With the implementation of general good construction site practices, the construction of the Project will not cause adverse waste management, traffic or environmental impacts (including potential hazard, air and odour emissions, noise and water quality).

5.5.2 Operation Phase

5.5.2.1 It is estimated that about 27 tonnes per day (tpd) and 55 tpd of dewatered sludge (with a minimum dry solid content of 30%) will be generated from the desalination plant with the production capacity of 135 MLD and 270 MLD, respectively. The dewatered sludge will be transferred to landfill by trucks.

5.5.2.2 Similar to the construction phase, chemical waste arises from operation activities of the plant is expected to be small. It is estimated that a total of approximately 65 kg of general

refuse will be generated from the operation of the plant on a daily basis. To facilitate waste avoidance and minimisation, recyclable materials will be sorted on-site with the use of recycling bins. The non-recyclable refuses will be delivered to West Kowloon Transfer Station/ Sha Tin Transfer Station.

5.5.2.3 With good site practices and proper operation and maintenance of the facilities, the potential environmental impacts (including potential hazard, air and odour emissions, noise and water quality) associated with the storage, handling, collection, transport and disposal of waste arising from the operation of the Project will meet the criteria specified in the *EIAO-TM* and no adverse waste management impacts are anticipated.

5.5.3 Land Contamination

5.5.3.1 A land contamination assessment has been conducted for the Project. The Project comprised the construction of a desalination plant (the Plant Area); a trunk feed system (the Feed Area) connecting the plant to the TKOPFWSR and other associate supporting facilities as well as the slope mitigation work (the Slope Area) at part of the Clear Water Bay Country Park. Based on a review of historical information, only the area covered by the Temporary Magazine Storage (TMS) Site was identified with low risk of potential land contamination.

5.5.3.2 The TMS Site was part of the sea prior to 2000 and was left vacant after the completion of reclamation until 2012. It was then used as a magazine storage facility. A site reconnaissance was conducted on 7 August 2014 and potential land contaminating risks were identified at the generator room and the waste chemical drum storage at the side of the vehicle access road.

5.5.3.3 Before the hand-over of the TMS Site to WSD for further development, the owner of TMS Site and its contractor shall ensure the TMS site is properly cleaned up before handover to CEDD. After the TMS Site is handed over to WSD and before the commencement of any construction work, the contractor of WSD shall prepare a Contamination Assessment Plan (CAP) for EPD endorsement prior to the commencement of site investigation. A Contamination Assessment Report (CAR) shall be prepared to summarise the results of the site investigation. If land contamination is identified, a Remediation Action Plan (RAP) shall be prepared to identify feasible remediation methods and a Remediation Report (RR) shall be prepared to demonstrate completion of remedial actions for EPD endorsement

5.5.3.4 With the above mitigation measures in place, the overall impact due to land contamination, if identified, of the Site is considered to be insignificant after the site investigation and remediation (if necessary). No contamination causing insurmountable impacts to the environment is expected.

5.6 Ecology

5.6.1 A total of 11 habitat types were identified within the Study Area. They are terrestrial habitats (i.e. mixed woodland, plantation, shrubland-grassland, agricultural land, wasteland, watercourse and urbanised/disturbed area) and coastal habitats (i.e. rocky shore, sandy shore, subtidal hard and soft bottom habitats and artificial seawall habitat). All of the habitats are of very low or low ecological value, except for mixed woodland and shrubland/grassland and subtidal hard and soft bottom (marine water) of low to moderate ecological value. Apart from this, the Clear Water Bay Country Park is the recognized ecologically important / sensitive sites are located within the Study Area.

5.6.2 Regarding to species of conservation interest, nine flora species, one mammal species, 14 bird species, 5 butterfly species, one aquatic fauna, amphioxus from subtidal soft bottom

habitat and hard corals from the subtidal hard bottom habitat were recorded during the field baseline surveys. Except for the flora species *Marsdenia lachnostoma* was recorded within the slope mitigation works area, none of the other species were found residing within the Project Site. Mitigation measures are recommended to avoid and minimize potential impact on the aforementioned flora species of conservation interest in the slope mitigation works area. Although bird species of conservation interest and an unoccupied bird nest were recorded within the Project Site and slope mitigation works area, these species have high level of mobility and no sign of nursery or breeding activites of these species were found within the Project Site area, thus no direct impact on these species of conservation interest is anticipated.

5.6.3 During the construction phase, construction activities may cause direct ecological impacts including habitat loss and vegetation removal, whereas indirect impacts on wildlife include disturbances and changes in water quality. Potential impacts of increased human activities and other disturbances due to the Project construction would not be significant provided that regular checks on construction site practices and boundaries will be conducted. In addition, in the view of the availability of surrounding similar habitats, the potential impact on wildlife especially on the species of conservation interest as a result of habitat fragmentation and isolation is considered to be minimal.

5.6.4 For marine ecological impact, habitat loss of subtidal soft bottom habitat which is of low to moderate ecological value (within the Project footprint) will also arise from minor marine dredging activity for installing the submarine facilities and there will be potential burial of benthic organisms. Intertidal and subtidal habitat (including corals) will be impacted temporarily due to the deterioration of water quality arising from minor marine dredging works.

5.6.5 With the implementation of the proposed mitigation measures, no adverse residual impact due to the land-based and marine-based construction of proposed desalination plant, slope mitigation works, freshwater rising main and submarine intake and outfall pipelines is anticipated.

5.7 Fisheries

5.7.1 A literature review of baseline information on commercial fisheries resources and fishing operations surrounding the waters of the proposed Project has been undertaken. Results from the review indicate that fisheries importance of the Project Area and its vicinity is low when compared to other waters of Hong Kong. Sensitive receivers including spawning ground, nursery ground, artificial reefs and Fish Culture Zone area have been identified; however, the assessment of water quality impacts demonstrated that these areas will not be affected.

5.7.2 During construction of the Project, direct impacts arising from the proposed marine works include loss of approximately 0.11 ha of seabed fisheries habitat due to seabed dredging. Given the small size of the fishing ground and temporal nature of the marine works, no significant direct impacts on fishing operations are expected to occur. Indirect impacts to fisheries resources related to perturbations to key water quality parameters are also expected to be insignificant as the predicted changes in water quality are short term and localised to immediate vicinity of the works area. Marine construction works have been designed to reduce potential impacts on the water quality which will, in turn, reduce impacts on fisheries resources. No fisheries-specific mitigation measures are required during construction.

5.7.3 No significant operational phase impacts to fisheries resources, habitat and fishing operations are expected to occur. Impingement and entrainment of fisheries resources will be mitigated through the appropriate design of the intake screens. Unacceptable impacts from discharges of RO concentrate are not anticipated to occur as the effects from these discharges will be localised to the lower layers of the water column in direct vicinity of the outfall. Compliance with the relevant discharge standards to control water quality impacts to within acceptable levels is also expected to control impacts to fisheries resources. No additional fisheries-specific mitigation measures are required during operation.

5.7.4 All of the potential construction and operational fisheries impacts identified are deemed acceptable.

5.8 Landscape and Visual Impact

5.8.1 Landscape Impact

5.8.1.1 The majority of the Project Site falls within the existing fill bank at Fat Tong Chau which is currently landscape of low quality with little valuable vegetation or amenity value and therefore in general the Project at construction and operation is considered to have little landscape impact.

5.8.1.2 The periphery of the main Project Site may affect some of the lower adjoining hillside and its associated vegetation, however, and as such Grass & shrubs east of TKO Area 137 and Mixed Woodland along lower hillside of Tin Ha Shan and Clear Water Bay Peninsular Coastal Uplands may be slightly or moderately affected at construction and with the loss of the block greening provided by Shrub and Trees of TKO Area 137 is also moderate affected prior to mitigation. Slope mitigation works have been carefully considered to ensure there is minimal disturbance to the landscape, where various alternatives have been reviewed.

5.8.1.3 The option to use localized slope stabilization, localized boulder stabilization, and localized flexible debris barriers in the lower portion of the natural slope and in the plant site is presented as the most suitable. Notably there will be no tree felling as a result of the slope mitigation. In addition for any trees that do require felling, these will be compensated for with direct compensatory planting as well as the optimization of greening opportunities within the project boundary, with the proposed creation of new landscape resources using green roof, vertical greening, shrub planting and raised planters. In addition, to soften and screen the flexible barrier for slope mitigation works, climber planting will also be considered.

5.8.1.4 It is considered that given the compensatory tree planting and the proposed careful greening of the Project Site landscape, the overall residual impact on existing trees and greenery would be reduced to an acceptable level. It is therefore considered that by year 10 of operation all landscape impacts on Landscape Resources (LRs) and Landscape Character Areas (LCAs) will be insignificant, with the exception of Shrubs and Trees of TKO Area 137 and Drainage Channel which due to the loss of block greening and the Drainage Channel respectively will remain 'slight', and Fill Area and Fat Tong O Reclamation which at operation are considered to be slightly beneficially affected since the wasteland fill area will have been transformed into a working plant with a more amenable landscape.

5.8.2 Visual Impact

5.8.2.1 The Project includes buildings up to a maximum of 20 m height and is situated in an area that is naturally shielded by topography to the north east and separated by at least 2 km from viewers across the Tathong Channel on Hong Kong Island to the south east. All

residential Visual Sensitive Receivers (VSRs) identified are at least 2 km from the Project Site and those VSRs that are close are all workers or recreational VSRs which represent low numbers of viewers.

5.8.2.2 The Project will also blend with existing character of the area, given it is located in an area that is currently being used as a fill area with ongoing earthworks and is near the TKO Industrial area and the SENT Landfill. Given these factors the general assumption is that the Project will have limited visual impact. The Visual Impact Assessment confirms that overall the majority of VSRs will experience small or insignificant visual impacts due to the construction and operation of the Project without mitigation.

5.8.2.3 Seven (7) Visual Sensitive Receivers are considered to experience moderate visual impacts prior to mitigation (at construction, operation or both): five residential VSRs (Residents in LOHAS Park, Residents in the TKO Area 85, Residents in Island Resort, Siu Sai Wan, Residents in Chai Wan Area, Residents in Heung Fa Chuen Area), one occupational VSR at operation only (Future workers in TKO Area 137) and one recreational VSR (Hikers/ Campers on Tung Lung Chau).

5.8.2.4 With mitigation measures centered around the principles of careful detailed design of the facilities to blend with the existing landscape, conserving existing greenery and providing some soft landscaping (e.g. roadside planting, etc), all visual impacts are considered to be slight or insignificant by year 10 of operation.

5.8.3 Overall Landscape and Visual Impact

5.8.3.1 Overall, it is considered with reference to Annex 10 of the EIAO-TM, the landscape and visual impacts of the Project are acceptable with mitigation measures.

5.9 Landfill Gas Hazard

5.9.1 Qualitative assessment on potential landfill gas hazards posed by the SENT landfill, SENT Landfill Extension, TKO Stage II/III Restored Landfill and TKO Stage I Restored Landfill to the Project. The source-pathway-target analysis shows that landfill gas hazard posed to the Project Site by the aforementioned landfills range from low to medium for various identified targets during both construction and operation phases (such as the fresh water main and structures fall within the Landfills Consultation Zones)of the Project

5.9.2 Provided that all the recommended precautionary and protection measures (including landfill gas monitoring, staff training, gas seal) are implemented properly, the safety of all personnel presence at the Project Site during the construction and operation phases would be safeguarded. Thus, there would be no adverse impact anticipated on the feasibility of the Project.

5.10 Hazard to Life

5.10.1 A Hazard Assessment of the risks associated with the use, storage and transport of chlorine and DGs at the proposed Desalination Plant has been conducted for the operational phase (Year 2036) of the Project. The cumulative risk assessment of the Project, through interaction or in combination with other existing, committed and planned developments involving DGs in the vicinity of the Project has also assessed.

5.10.2 The assessment methodology and assumptions were based on previous assessments having similar issues, namely Shatin to Central Link, In-situ Reprovisioning of Sha Tin Water Treatment Works, Harbour Area Treatment Scheme (HATS) Stage 2A Environmental Impact

Assessment and Construction of an International Theme Park. The list of major assumptions refers to the Environmental Impact Assessment Report of the Project.

5.10.3 In all cases, the Individual Risk complies with the Hong Kong Risk Guidelines and the Societal Risk lies in the acceptable region. The societal risk expressed in the form of FN curves, lies in the acceptable region of the HKRG for the use, transport and storage of chlorine at the Desalination Plant.

5.10.4 Therefore, the operation of the Desalination Plant is acceptable in terms of both individual risk and societal risk as stipulated in Annex 4 of the TM. Safeguard measures are recommended to ensure the risk associated with the use, storage, and transport of chlorine and DGs at the proposed Desalination Plant complies with the Hong Kong Risk Guidelines and stays in "Acceptable" region.

6 GROUND INVESTIGATION

6.1.1 Site specific ground investigation (GI) works and laboratory testing on sample retrieved are proposed to determine and confirm the ground materials, sub-soil profile, groundwater regime, bedrock level, shear strength parameters and other engineering properties of ground materials.

6.1.2 Land base GI works were covered the area at MTRCL separation zone of temporary explosive magazine, fill bank and natural terrain within the Clear Water Bay Country Park. Marine base GI works were covered the proposed alignment of the intake and outfall pipe..

6.1.3 In this feasibility study, limited number of GI works is conducted to get the general understanding of the proposed site area in geotechnical aspects. Additional site investigation works in the site area shall be conducted in detailed design stage to have a comprehensive view of the geological information in the site.

7 ARCHITECTURAL AND LANDSCAPE DESIGN

7.1.1 The landscape and visual impact assessment was conducted under the EIA of the project. In order to minimize the visual impact, the aesthetic and landscape design principle and mitigation measures may be adopted during detailed design stage without compromising the functionality and operability of the facility.

8 TRAFFIC IMPACT ASSESSMENT

8.1.1 The traffic impact assessment was conducted under this Study and involves a study of traffic implication while undertaking the proposed construction of a dedicated trunk feed system for transferring of fresh water output from the desalination plant in TKO Area 137 to TKOFWPSR in Tsui Lam Road. This proposed water main is a 9.5 km of 1200 mm diameter pipeline, the alignment of which starts from the northbound carriageway of Wan Po Road via Po Hong Road, Po Lam Road North and terminates at TKOFWPSR in Tsui Lam Road. The proposed commencement and completion of construction works are scheduled for Q2 2016 and Q3 2020 respectively.

8.1.2 Operational assessments for the concerned sections of carriageways were carried out under the existing traffic conditions and during construction for AM and PM Peaks in 2020.

According to the results of operational assessment, proper implementation schedule was recommended for different road section and junctions.

8.1.3 The results of the traffic impact assessment reveal that the carriageways should be operating at satisfactory level during construction. In addition it is also acceptable to allow works areas between junctions among Wan Po Road, Po Yap Road, Po Hong Road, Po Lam Road North and Tsui Lam Road to be occupied for 24 hours without causing any adverse traffic impact. Work station at Tsui Lam Road is proposed to be implemented with one lane closure either by 2-phase temporary traffic control for the road section without access or 3-phase temporary traffic control for the portion with an access. It is therefore reasonable to adapt the off peak period (10:00-16:00) to minimise the traffic impacts during construction.

8.1.4 The junctions of Wan Po Road/Wan O Road, Wan Po Road/Landfill Site, Wan Po Road/Shek Kok Road, Wan Po Road/Pak Shing Kok and Tsui Lam Road/Po Lam Road would experience some degree of traffic impact during construction. It is suggested to adopt either the trenchless method or decking during the peak periods in order to minimise the potential traffic impact to an acceptable level.

9 LAND REQUIREMENTS

9.1.1 The proposed site is about 10 ha and has been reserved for the desalination plant.

9.1.2 The site falls within an area zoned "Other Specified Uses" annotated "Deep Waterfront Industry" ("OU(DWI)") on the draft Tseung Kwan O Outline Zoning Plan No. S/TKO/19 (the OZP). As desalination is not a specific use in the Outline Zoning Plan, an amendment will need to be submitted to revise the "OU(DWI)" zoning to "OU(Desalination Plant)" under the Town Planning Ordinance.

9.1.3 Lands Department advised that the proposed desalination plant site has been allocated to CEDD as an existing temporary fill bank facility up to the end of 2018 with taking into account the Temporary Government Land Allocation (TGLA) Extension..

9.1.4 District Lands Officer (Sai Kung) advised that permanent land allocation is necessary for the proposed desalination plant and a 9 months' prior notice is required for processing the proposed land allocation.

9.1.5 Land resumption is not anticipated. Major land clearance will not be required.

9.1.6 The construction of the proposed submarine intake and outfalls works will be carried out below the high water mark, and hence gazetting of the proposed works under Foreshore & Seabed (Reclamation) Ordinance will be required.

10 RISK MANAGEMENT

10.1.1 The management of risks is a dynamic process. The importance of identified risks will change, and new risks will emerge, as the Project proceeds. As such, a systematic Risk Management Plan shall be developed and updated as a living document over the duration of the Project especially during Construction stage.

10.1.2 Risks (consequence and likelihood) and the effectiveness of control measures need to be monitored, as they will change with time. Furthermore, as the Project proceeds through design, tender and construction stages, new (or previously overlooked) risks will emerge. As such, ongoing review of the process and monitoring is essential to ensure that risks and their respective controls/treatments measures remain relevant and effective. The effectiveness of the risk management process will be measured by reference to performance indicators, which may change as the project advances through the different phases. The risk performance indicators may include, but not be limited to the followings:

- Reduction in number of accidents
- Reduction in cost of risks
- Reduction in occurrence of risk events
- Reduction in complaints received
- Reduction in delays to progress
- Reduction in claims
- Reduction in variation orders

10.1.3 In view of the above, a systematic Risk Management Plan that defines the following has been developed during the Investigation stage:

- A description of the risk management methodology to be adopted for the Project from inception to operation
- Details of the roles, responsibilities, processes and procedures, standards, tools and documentation to be utilized during the course of the Project in relation to documentation and management of risk
- Details of the various categories of risks and how they will be identified analysed, evaluated, mitigated, managed, monitored, and reported

10.1.4 A review of the Risk Management Plan concludes that the risk management methodology presented is consistent with the policy requirements and guidelines set out under the following Environment, Transport and Works Bureau (ETWB) documents:

- TCW 6/2005: Implementation of Systematic Risk Management in Public Works Projects
- ETWB Risk Management User Manual

10.1.5 While the Risk Register has summarized key outcomes of the initial risk assessment discussed above, and represented an understanding of the significant risks associated with the Project at the time, the Risk Register was reviewed on a regular basis during the Project.

10.1.6 It is recommended that another Risk Identification Workshop should be held in the Detailed Design Stage and Construction stage, preferably prior to the start of the Construction where

representatives of the successful contractor(s) could attend this workshop as they will be the primary owners of many of the risks relevant to the Construction stage. In addition, the Risk Register and the effectiveness of Risk Treatment Action Plans should be reviewed as an agenda item in regular Project Progress meetings or monthly progress meetings for reporting to WSD.

11 COST ESTIMATION

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Annex

List of Developed and Developing Desalination in Recent Year

Commissioned Plant

Commission Year	Plant	Country	Method	Capacity (MLD)
2014	Magtaa	Algeria	RO	500
2014	Al Ghubrah	Oman	RO	190
2014	Al Hamriya	UAE	RO	91
2013	Qingdao	China	RO	100
2013	Sorek	Israel	RO	624
2013	Tuaspring	Singapore	RO	319
2013	Binningup	Australia	RO	270
2013	Marsa Matrouh	Egypt	RO	24
2013	Nemmeli	India	RO	100
2013	Barka (additional capacity to existing)	Oman	RO	45
2012	Marina Baja	Spain	RO	50
2012	Victorian	Australia	RO	450
2012	Adelaide	Australia	RO	270
2012	Vladivostok	Russia	RO	10
2011	Al Dur	Bahrain	RO	218
2011	Curacao	Antilles AN	RO	25
2011	Az Zour	Kuwait	RO	136
2011	Fouka	Algeria	RO	120
2010	Sur	Oman	RO	80
2010	Hadera	Israel	RO	328
2010	Sydney	Australia	RO	250
2010	Chennai	India	RO	100
2010	Beckton	UK	RO	150

Under Construction and Planning

Status	Plant	Country	Method	Capacity (MLD)
Anticipated completion in 2015	Barka (additional capacity to existing)	Oman	RO	57
Anticipated completion in 2015	Nungua	Ghana	RO	60
Anticipated completion in 2015	Sadara	Saudi Arabia	RO	179
Anticipated completion in 2016	Changi	Singapore	RO	228
Anticipated completion in 2016	Basrah	Iraq	RO	199
Anticipated completion in 2016	El Salitral	Mexico	RO	21
Anticipated completion in 2017	Caleta Coloso	Chile	RO	220
Anticipated completion in 2017	Al Khafji	Saudi Arabia	RO	30
Anticipated completion in 2019	Carlsbad, California	USA	RO	189
Anticipated completion in 2019	Caofeidian	China	RO	1000
Contract award 2014	Mirfa	UAE	RO	136
Contract award 2014	Puerto Deseado	Argentina	RO	3
Contract award 2014	Agadir	Morocco	RO	100
Under planning	Nemmeli	India	RO	150
Under planning	Nemmeli	India	RO	200
Under planning	Daya Bay	China	RO	330
Under planning	Rosarito	Mexico	RO	378