2 CONSIDERATION OF ALTERNATIVES

In accordance with *Clause 3.3* in the EIA Study Brief (*ESB-266/2013*), the following section presents a consideration of the alternatives for the Project. The section has been divided into a discussion of the following:

- Need of the Project;
- Consideration of Alternative Sites;
- Consideration of Alternative Development Options; and
- Consideration of Alternative Construction Methods and Sequences of Works.

Based on the above considerations, the Environmental Impact Assessment (EIA) of the preferred alternative is presented in the subsequent sections.

2.1 Need of the Project

Water shortage is a general phenomenon throughout the world. Many places have shortage of freshwater for supporting the developments. Without exception, Hong Kong is also facing this potential risk which is exaggerated with the particular situation that the main freshwater supply is covered by a single source of Dongjiang Water. Although under the Dongjiang Water Supply Agreement, the Government of Guangdong Province agrees to supply up to an ultimate annual quantity of 1,100 million m^3 of freshwater to Hong Kong, in extreme drought condition, the water supply from this single source may be affected which will have a direct impact to Hong Kong society.

In this case, it is of paramount importance to have a secure water supply to sustain Hong Kong's development. To better prepare Hong Kong for the sudden unforeseeable uncertainties in this aspect, the Total Water Management (TWM) strategy has been promulgated by the Hong Kong SAR Government in 2008. The target of the TWM strategy is to diversify the freshwater resources to minimize the impact on the society caused by the shortage of a particular source.

Taking into account both the major source from Dongjiang water and the past records of the local yield collected in water gathering grounds, the Water Supply Department (WSD) has conducted a risk assessment of freshwater resource adequacy in Hong Kong. The analysis shows that due to the increase in water demand, a potential deficit of our freshwater resources of maximum 39 million m^3 per year is predicted.

To address the identified potential freshwater shortage, in the TWM strategy, two alternative new water resources were identified and evaluated, namely expansion of water gathering ground and reservoir storage and implementation of desalination. The expansion of water gathering ground will entail high land costs and undermine the conservation importance and development potential of the areas concerned for protection of the water quality. With this serious drawback, the TWM study concludes that the option of expanding water gathering ground and reservoir is of very low priority for Hong Kong. The TWM strategy was also presented in the 151st Meeting of the Advisory Council on the Environment (ACE) held on 14 April 2008 which also agreed that the expansion of water gathering ground might have negative impact on the environment, in particular the ecology of some sensitive downstream resources.

To this end, WSD has kept abreast of the latest developments in desalination technology and prepared for the related planning and studies so that other water sources can be tapped into in good time in case of water shortage. A Feasibility Study (CE 71/2000 (WS)) and a Pilot Plant Study (CE 97/2002 (WS)) on developing desalination facilities in Hong Kong had been conducted in 2002 and 2007 respectively. Both studies confirmed the technical feasibility of using desalination technologies as a reliable freshwater source to produce potable water in compliance with the World Health Organisation (WHO) standards. Furthermore, WSD has assessed the technical feasibility and economic viability of building a medium-sized desalination plant in Hong Kong, at a designated site in Tseung Kwan O (Area 137) to cope with the risk of potential freshwater shortage. All the previous studies show that constructing a desalination plant to provide potable water would be an appropriate solution to alleviate the shortage of our freshwater resources.

2.1.1 Consideration of Project Alternatives

As summarized above in the TWM Strategy, two alterative options for increasing the freshwater supply to Hong Kong were considered:

- Expansion of water gathering ground and reservoir storage; and,
- Seawater Desalination.

The evaluation of the identified options is detailed in ***Table 2.1***. Overall, the major concern for the development is land requirement, in which seawater desalination plant would be preferred as it is easy to operate with small footprint (10 ha in the current project), whilst the expansion of water gathering ground would have much larger land requirement (about 64km^2 to deliver the same capacity of freshwater resources), potentially affecting sites of recognized conservation importance (e.g. Country Parks), and sensitive habitats and associated wildlife in lowland areas. Desalination is therefore deemed as a sustainable and preferred solution to provide potable water and alternative freshwater resource to Hong Kong.

Table 2.1 Comparison between Water Ground Gathering Reservoir and Desalination Plant

Aspect	**Water Ground Gathering Reservoir**	**Desalination Plant**
Land Requirement	In Hong Kong about one-third of the land serves as water gathering grounds. There are limited additional land resources of Hong Kong for such use and it would be difficult to find suitable sites for additional impounding reservoirs. Development of such additional sites would require encroachment into environmentally sensitive areas such as country parks and lowland natural habitats. It is considered not possible to expand the water ground gathering reservoir without increasing the water gathering ground. This is also keen competition of land for other uses.	A typical desalination plant requires limited land (about 10 ha) and can easily be situated in less sensitive areas such as reserved land for industrial use.

Aspect	Water Ground Gathering Reservoir	Desalination Plant
Cost	Entail high cost for land resumption.	High capital costs and high level of electricity consumption. Energy efficiency measures can be incorporated into project design to reduce operational cost.
Environmental benefits/ disbenefits	Expansion of water gathering ground and reservoir storage will give rise to negative impacts on ecology of sensitive downstream resources. Encroachment into country park may occur with loss of trees and associated wildlife during the construction of the catchwater in water gathering ground and reservoir.	RO desalination plant is easy to operate with small footprint. Although hypersaline brine will be discharged as a by-product of the desalination process, the brine will be rapidly diluted to the salinity of ambient level. As RO desalination would not have boiler, therefore no air emissions (e,g, NOx, SOx, etc.) would be generated. Also, all noisy plants during operation phase will be enclosed in building structure and this noise, if any, is minimized.
Supply stability	The yield in water gathering ground is highly dependent on rainfall, this option is not capable of dealing with climate change and is thus still susceptible to rainfall variation which imposed impact to the water supply reliability.	Seawater resource is inexhaustible, it can accommodate different levels of demand and provide alternative stable water resources
Conclusion	Very low priority option for Hong Kong and thus is not considered as viable option	Proven technology and several reverse osmosis desalination was built worldwide and thus is considered as viable option

2.1.2 Public Consultation

Public consultation/engagement activities were held to gather comments and recommendation from the public on this Project. The Sai Kung District Council (SKDC) and Advisory Committee on Water Resource and Quality of Water Supplies (ACRQWS) were consulted during the Project. ***Table 2.2*** summarizes the activities and the comments during the public consultation process.

Table 2.2 Consultations and Comments on the Desalination Plant

Consulted Party and Meeting Date	Key Comments
Advisory Committee on Water Resource and Quality of Water Supplies Meeting dated on 21 November 2014	• Generally supported the construction of desalination plant • The brine generated from the desalination plant shall be properly managed during operation • Understand that alternative methods proposed for brine management cannot significantly reduce the volume of brine discharge from the plant • The feasibility of installing demonstrative scale of alternative brine management for education purpose shall be further assessed
Sai Kung District Council Meeting dated on 6 January 2015	• Generally supported the construction of desalination plant • To ensure the produced water from desalination is safe for drinking • To ensure cost effectiveness and sustainability of the project • To address the environmental impact, in particular implication on marine ecology and fisheries of surrounding water bodies

Based on the above consultations, the community shows general support on the Project with positive advice. The advice has been taken into consideration of the design of the Project. In particular, the environmental concerns received via public consultation and engagements are considered in the environmental impact assessment.

2.1.3 Scenarios With and Without Project

Without Project

According to Hong Kong Observatory's study report, climate change will, in some instances, bring about more frequent extremely dry weather and increase the likelihood of occurrence of consecutive droughts. This will not only affect the local yield collected in Hong Kong, but also impact on the water resources in Dongjiang which contributes 70 – 80% of the freshwater demand in Hong Kong. Without the proposed Project, Hong Kong lacks an alternative of freshwater resources and will be subject to water shortage arising from severe droughts which impact the water supply reliability in Hong Kong.

With Project

With the implementation of the Project, part of the freshwater supply will be based on a guaranteed quantity from desalination which can release the water stress on Dongjiang. The purpose and objective of this Project is to present an appropriate solution to provide alternative potable water source and alleviate the shortage of freshwater resources due to climate change and subsequent adverse weather.

The proposed desalination plant can produce 135 million liter per day (Mld) of freshwater, which is equivalent to 22% of the mean gross yield collected from water gathering grounds over the past decade. After the expansion of the desalination plant to 270 Mld, this capacity will be equivalent to 44% of mean gross yield collected from water gathering grounds over the past decades. The proposed desalination plant can provide approximate 5% and 10% of contribution to the total freshwater demand in Hong Kong. The proposed desalination plant is thus of paramount importance in supplementing the fresh water resources in Hong Kong.

2.2 Consideration of Alternative Sites – Site Selection

Prior to the Project, various studies had been conducted for investigating the technical and economic viability of desalination. In particular, the Study *Agreement No. CE71/2000 – Feasibility Study on Development of Desalination Facilities in Hong Kong* (the "Feasibility Study") completed in 2002 identified various potential locations for the desalination plant and assessed the suitability.

In the Feasibility Study, several locations are shortlisted for constructing a new desalination facility in Hong Kong, including Siu Ho Wan, Tuen Mun Area 38, Tsang Tsui Ash Lagoon and Tseung Kwan O Area 137. The shortlisted locations were assessed based on functionality, cost, environmental benefits/ disbenefits and regulatory/ social issues. Locations of these sites are depicted in ***Figure 2.1***.

The site selection criteria were further elaborated and confirmed in the Study *Agreement No. CE97/2002(WS) – Pilot Plant Study on Development of Desalination Facilities in Hong Kong* (the "Pilot Plant Study") completed in 2007 which included a more detailed investigation in the technical and financial viability of desalination using reverse osmosis technology.

Findings from the Pilot Plant Study showed that the western waters of Hong Kong is typically more turbid and has higher suspended solid (SS) levels compared to that in the eastern side, due to influence of the Pearl River tidal flows. On the other hand, the eastern waters of Hong Kong is oceanic in nature with less turbidity and lower SS levels, and is remote from the influence of the Pearl River flows. Since the eastern waters in Hong Kong is relatively consistent in quality with relatively less variation in salinity, which is beneficial to the operations of the desalination plant and should be put in a higher priority for the development of desalination plant. In terms of constructability and feasibility, Tseung Kwan O Area 137 is thus selected as the preferred location for the development of the desalination plant. In 2012, a site of about 10 ha at Tseung Kwan O Area 137 has been earmarked for the construction of a desalination plant with an output capacity of 135Mld with provisions for future expansion to 270 Mld.

A summary description and evaluation of each short-listed location is provided in ***Table 2.3***.

Table 2.3 Potential Desalination Plant Location and Evaluation Outcomes

	A) Siu Ho Wan	**B) Tuen Mun Area 38**	**C) Tsang Tsui Ash Lagoon**	**D) Tseung Kwan O Area 137**
Description	The site is located on the northwest coast of Lantau Island.	The site is located in western New Territories and it is a reclaimed land.	The site is located within the existing Tsang Tsui Ash Lagoon.	The site is located at the southern tip of the TKO Area 137 and it is a reclaimed land.
Functionality	Have less desirable quality of seawater, but able to integrate with existing water supply system.	Have less desirable quality of seawater and not easy to integrate to water supply system.	Have less desirable quality of seawater and not easy to integrate to water supply system.	Have acceptable quality of seawater can integrate with existing water supply system.
Cost	Low opportunity and capital cost as the land is owned by the government and the site is flat which give rise to minor cost of building demolition.	Low capital cost as the land has already been formed but land use competition with other industries may increase the opportunity cost.	Low capital cost as the land has already been formed but land use competition with other industries may increase the opportunity cost.	Low capital cost as the land has already been formed but land use competition with other industries may increase the opportunity cost.
Environmental benefits/ disbenefits	The site is surrounded by residential area with noise and water sensitive receivers and potential chlorine hazard. The site does not involve habitat removal and thus the ecological impacts are also minimal. However, potential visual impact may arise due to the new town	The site is situated in industrial area and no or low noise impact, potential chlorine hazard and ecological impact. Potential visual impact is identified as it is located by seafront and can be viewed from sea. Across the Urmston Road Channel to the northwest of the site Sha Chau and Lung Kwu Chau marine park and Chinese White	Receiving water body is considered to be topographically constrained with limited dispersive capacity. The site is also in the vicinity of an oyster culture zone.	The site has minimal impact on landscape. As the land has been formed, extensive earthworks are not required and thus further reduce the impacts on the surrounding environment. The site is close to the sea and water distribution networks (Tseung Kwan O Primary Fresh Water Service Reservoir) and

	A) Siu Ho Wan	B) Tuen Mun Area 38	C) Tsang Tsui Ash Lagoon	D) Tseung Kwan O Area 137
	development in North Lantau area overlooking the site.	Dolphin feeding area is found and defined as water sensitive receiver.		to consumers to minimize construction and land-use of pipelines and pumping efforts for water distribution.
Regulatory/ Social	Government and occupied by government department	Government owned land and no occupants. But it is close to river trade terminal, the development may have impact on marine traffic.	Land is owned by utility and required land resumption	A reclaimed land owned by Government.

Based on the evaluation in ***Table 2.3***, Tseung Kwan O Area 137 was selected as the most preferable site due to functionality aspect and relatively fewer environmental disbenefits among the short-listed sites.

2.3 Consideration of Alternative Development Options

2.3.1 Extent of the Project

a) Footprint of the Desalination Plant

A 10 hectares (ha) land has been allocated for the Project at Tseung Kwan O Area 137, and three options for the development of desalination plant are considered:

Option 1 - Adopting the allocated land;

Option 2 – Locating the plant in rock cavern; and,

Option 3 - Shifting the footprint of plant site towards south west.

The area required for Option 1 to 3 is shown in ***Figure 2.2***.

For Option 1, the allocated land is reclaimed land and currently occupied by Civil Engineering and Development Department (CEDD) as public fill bank which has been formed to an appropriate level. As such, extensive site formation, which induces extensive fugitive dust and construction waste generation, is not anticipated for the Project. In addition, the 10 ha allocated land is located outside the boundary of Clear Water Bay Country Park. However, the natural slope mitigation works would encroach into the Clear Water Bay Country Park.

For Option 2, the proposed cavern development for the desalination plant is located within the natural slope in the Clear Water Bay Country Park next to the allocated land **(*Figure 2.2*)**. Since cavern development involves blasting and vibratory construction method, air-borne and ground-borne noise as well as construction waste surplus would be anticipated. Furthermore, the area requires for the same design capacity of the plant in cavern would be about 11 ha (i.e. larger than that for Option 1) as part of the plant components, particularly chemical storage, would have to be situated outside the cavern for safety purpose and thus lead to a larger project footprint. The above ground structures, such as portals and ventilation shafts, may also involve construction in the Clear Water Bay Country Park and thus lead to a larger project footprint.

For Option 3, the footprint of the proposed desalination plant is set back towards south west by 60-80m from the adjoining slope area to avoid the need of slope stabilization work at the nature slope within the country parks area (***Figure 2.2***). The option would require the same area of land as that for Option 1. However, the 10 ha site for the proposed desalination plant as mentioned in Option 1 was reserved according to the Preferred Land Use Plan endorsed by Committee on Planning and Land Development (CPLD) in 2006. The shifting of the site boundary of the desalination plant would adversely affect the planned land uses for the adjoining areas and CPLD's endorsement of the proposal would be required. Unless the required slope mitigation works will involve irreversible damages to the landscape and rare species of wildlife/flora in the Country Park, the alternative of shifting the site boundary, to avoid any slope mitigation works to be carried out in the country park area is not supported from land utilization of view.

The summary of three options is shown in ***Table 2.4***.

Table 2.4 Comparison of Plant Footprint

Characteristics	**Option 1** **Adopting the Allocated Land**	**Option 2** **Cavern Development**	**Option 3** **Shifting the plant footprint towards south west**
Land Requirement	~10ha	~ 11ha (7ha – cavern development, 4 ha – Tseung Kwan O Area 137)	~ 10 ha
Environmental benefits/ disbenefits	• Plant site does not encroach into the Clear Water Bay Country Park • Nuisances due to site formation is not anticipated as the land has been formed by the existing fill bank	• Air-borne and ground-borne noise in the Clear Water Bay Country Park area during blasting and vibratory construction • Creates additional C&D surplus • The above ground structures, such as portals and ventilation shafts, may also involve construction in the Clear Water Bay Country Park.	• Plant site does not encroach into the Clear Water Bay Country Park • Nuisances due to site formation is not anticipated as the land has been formed by the existing fill bank • No slope stabilisation work within the country park is required.
Other issue	Natural slope mitigation works would encroach into the Clear Water Bay Country Park.	Chemical storage required outside the cavern because of safety consideration and leads to larger project footprint.	The earmarked site for the desalination plant is reserved according to the Preferred Land Use Plan endorsed by CPLD in 2006. The shifting of the site boundary of the Plant would adversely affect the planned land uses for the adjoining areas.
Conclusion	With minimum land requirement and	Not viable option and thus not considered.	Not viable option from land utilization point of view.

Characteristics	Option 1 Adopting the Allocated Land	Option 2 Cavern Development	Option 3 Shifting the plant footprint towards south west
	construction within the country park area is avoided, thus it is a preferred option.		

In view of the above, Option 1 – adopting the allocated land is the preferred plant extent in terms of environmental benefits/ disbenefits and land utilization.

b) Slope Mitigation Works

In accordance with the findings of the natural terrain hazard assessment carried out in accordance with GEO Report No. 138, the natural slope adjoining the plant area on the east side is deemed to impose landslide risk on the development in the site. In order to provide a safe environment for the development, landslide hazard mitigation measures are proposed to alleviate the landslide risks. The recommended works are based on consideration of four options:

Option 1: Set back proposed plant outside the influence zone of potential landslides and rock falls from the natural slope

Option 2: Construct passive measures such as barriers within the influence zone to contain potential landslides

Option 3: Adopt active protection measures for stabilization works, including soil nailing and rock stabilization works, in the natural slope area identified with risk of landslides and rock falls

Option 4: Adopt mixed use of active and passive protection measures, such that debris and rock barriers and localized rock stabilization of large unstable rocks and boulders and soil nailing at steep portions above rock cliff

Option 1 is to set back the plant and the ancillary infrastructures outside the influence zone of the natural terrain. It will avoid slope mitigation works on the natural hillside within the country park area. In accordance with the guidance given in GEO Report No.138, this option requires approximately 60 to 80m set back throughout the entire length of the plant site adjoining the slope area, and thus sterilizing 4 ha of land along the toe of the natural slopes. The required area of set back is shown in ***Figure 2.3a***.

Option 2 is to construct passive defense measures, such as flexible barriers, within the influence zone and at a distance of about 15m from the toe of the natural slope to catch landslide debris, boulders and rock falls from the natural hillside and thus avoiding slope mitigation works within the country park area. The required area of set back is shown in ***Figure 2.3b.***

Option 3 is to adopt active stabilization measures by stabilizing the natural hillside slope areas with potential landslide and rock fall hazards. The slope mitigation works will include installing soil nails on the soil slopes and installing rock stabilization works at the steep rock portions of the hillside in areas with risks for landslides and rock falls throughout the natural slope. The areas of these works are depicted in ***Figure 2.3c***.

Option 4 is to adopt a mixed use of active and passive stabilization measures by stabilizing the localized natural hillside slope areas with large scale potential landslide hazards, stabilizing the boulders with large scale rock fall hazards, and providing flexible debris barriers to stop small scale rock fall hazards. This option minimizes the use of soil nails and rock stabilization works on the slope area while protecting plant buildings from small rock falls and debris run-out from potential landslides. The flexible debris barriers will be installed in the lower portion of the slope but where it is effective, they will also be installed within the influence zone in the plant site to minimise the extent of works within the country park area. The extent of the proposed option is demonstrated in ***Figure 2.3d***.

An evaluation of the above options has been undertaken and the findings are summarized in ***Table 2.5***.

Table 2.5 Description of Potential Natural Terrain Slope Mitigation Works and Evaluation Outcomes

Evaluation Criteria	**Option 1 – Set back outside impact zone**	**Option 2 – Passive protection with partial set back**	**Option 3 – Active Protection**	**Option 4 – Mixed use of active and passive protection measures**
Safety Protection from Landslide and Rock Fall Hazards	Effective safety protection	Incomplete protection, large landslides and some boulder and rock falls on the upper portions of the natural hill may still impact the development within original landslide impact zone by overshooting the steep rock cliffs, and result in unacceptable residual risk of landslides.	Effective safety protection.	Effective safety protection.
Land Utilization	A strip of land (4 ha, equivalent to 40% of the earmarked site area) shall be reserved as no entry zone.	A strip of land (0.8 ha, equivalent to 8% of the earmarked site area) shall be reserved as no entry zone.	No set back is required.	Two strips of land (total 0.02 ha, less than 1% of site area) shall be reserved as no entry zone.

Evaluation Criteria	Option 1 – Set back outside impact zone	Option 2 – Passive protection with partial set back	Option 3 – Active Protection	Option 4 – Mixed use of active and passive protection measures
Potential Stabilization Area on the Hillside	No stabilization works on the slope. Future maintenance works and repair works (usually soil nail and rock stabilization works) will be needed when landslides occurs.	No stabilization works on the slope. Future maintenance works and repair works (usually soil nail and rock stabilization works) will be needed when failure occurs.	Soil nailing and rock slope stabilization covers approximately 3.3 ha of the hillside.	Soil nailing and rock slope stabilization barriers covers approximately 0.5 ha of the hillside.
Encroachment of country park footprint	0 ha	0 ha	3.3 ha	0.49 ha
Environmental Benefits/ Disbenefits to Clear Water Bay Country Park	No environmental disbenefits by the proposed slope works. But future maintenance/ repair works would lead to extensive disturbance to the natural habitats in the Clear Water Bay Country Park when landslides and/or rock-falls occur.	No environmental disbenefits by the proposed slope works. But future maintenance/ repair works would lead to extensive disturbance to the natural habitats in the Clear Water Bay Country Park when landslides and/or rock-falls occur.	Relatively large areas of clearance of vegetation on slope area will be required by the slope mitigation works	i) The slope works are localized to areas at the lower portion of the slope and at the identified unstable boulders. Area with foundations of flexible debris barriers will also be disturbed by the slope mitigation works ii) Tree-felling can be avoided by careful designs of works around trees. Vegetation clearance can be reduced where practicable. iii) No extensive earthworks are required. iv) Catering for alignment changes
Construction Cost	N/A	Moderate	High	Moderate
Maintenance /running cost	Low	Low	Moderate	Low

Based on the findings above, Option 1 would result in an extensive loss of usable land for implementation of the project. The remaining area is not sufficient for the development of the desalination plant at the Phase 1 design capacity of 135 Mld and the future expansion to 270 Mld. As discussed in ***Section 2.3.1 (a)***, the shifting of the site boundary to southwest is considered not viable based on land utilization point of view. The extension beyond the earmarked site is not feasible due to planning and land zoning considerations. Consequently, Option 1 is considered not viable.

Under Option 2, there is a residual risk on the desalination plant caused by the overshooting of landslide and boulder falls originated on the upper portions of the natural hillside and is considered as an ineffective protection for the desalination plant (refer to overshooting scenario in ***Figure 2.3b***). Hence, Option 2 is not feasible due to the unacceptable residual risk on the desalination plant and its operators from major landslides and boulder fall hazards.

For both Options 1 and 2, without stabilization, the condition of the slope will deteriorate. Landslides will occur during adverse weather conditions in future. Maintenance and repair works will be required and provided as necessary. There are still potential disturbance to natural habitats within Country Park area due to maintenance and repair works of future landslides.

Option 3 employs blanket slope stabilization works, including soil nailing and rock stabilization works, will be required on the steep portions of the natural slope covering 3.3 ha of the slope area. Extensive disturbance to natural habitat within Country Park would be unavoidable and thus this option is not considered due to the environmental drawback.

Option 4 consists of localized slope stabilization, localized boulder stabilization, and localized flexible debris barriers. The lengths of barriers on the natural slope have been optimized such that these are located to contain potential landslides and boulder falls that may overshoot the cliff tops. Lengths of barriers are provided beyond the toe of the natural slope outside the Country Park where there is no overlooking cliffs. The works will provide effective safety protection from major landslides and rock fall hazards. The localized stabilization works on the slope area will be optimized to avoid the impact to the existing vegetation and to minimize the impact to the Country Park as much as practicable. Localized clearance of vegetation to allow construction of the slope stabilization works will be minimized, and no tree will be felled. The extent is significantly less than that required in Option 3.

In view of the less environmental disturbance and the effectiveness on safety protection, Option 4 is recommended. In addition, the above options for the natural terrain slope mitigation works were reviewed by Civil Engineering Development Department under the Natural Terrain Hazard Study (NTHS) Report for the Project. The rationale of selecting the most appropriate option for slope mitigation works were agreed by CEDD and the exact extent of the required mitigation works would be subject to the detailed design. The hazard mitigation works of Option 4 are demonstrated in ***Figure 2.4***.

2.3.2 Layout of the Project

a) Chlorine Storage

Because of the shape of land earmarked for desalination plant, the 10 ha site shall be optimized by the selection of treatment process and associated layout design based on the technical requirement, design flow and flexibility of future expansion. In addition, the scale and size of above-ground structure of the Desalination Plant are optimized by housing suitable facilities underground (i.e. intake / treated water pumps, storage facilities, clarification basins and filtration facilities) to achieve a better plant hydraulic and minimize the energy use in pumping and reduce potential environmental impacts.

A chlorine store shall be provided in the desalination plant for disinfection process. However, chlorine storage within the Plant is categorized as a Potentially Hazard Installation (PHI) under the Hong Kong Planning Standards and Guidelines and will induce hazard to life to the surrounding citizen. The location of the chlorine store shall be carefully designed in order to reduce the impact to the surrounding environment.

Three locations of the chlorine store were assessed, including:

Option 1 is locating the chlorine store near the northern boundary;

Option 2 is locating at around the center of the site; and,

Option 3 is locating at the southern boundary of the site.

The proposed locations for chlorine store are shown in the ***Figure 2.5*** and the evaluation is demonstrated in ***Table 2.6***.

Table 2.6 Comparison of Chlorine Store Location within Desalination Plant

	Option 1 **Northern Boundary**	**Option 2** **Around Centre of the Site**	**Option 3** **Southern Boundary of the Site**
Distance away from explosive offloading pier	585m	360m	60m
Distance away from Existing offsite population (Assuming TKO industrial estate)	915m	1140m	1440m

Options 1 and 2 are located away from the CEDD explosive offloading pier and this is found to have advantage over Option 3, as the explosive offloading pier may impose external risk to the chlorine store building, for example leakage of chlorine drum or structural damage to the chlorine store building.

Option 1, however, has a shorter separation distance between the chlorine store and surrounding environment than Option 2. It is preferable to site hazardous installation away from surrounding population to minimize potential hazards, and so Option 2 was duly selected as the preferred chlorine store location.

b) Alignment and Location of Submarine Intake and Outfall

Intake

Two intake options, namely Option 1 Offshore Open Intake in the western side of Kwun Tsai, and; Option 2 – Subsurface Intake System in Joss House Bay, were considered and they are illustrated in ***Figure 2.6***. Evaluation outcomes are summarized in ***Table 2.7***.

Table 2.7 Comparison of Alignment options for Submarine Intake

Characteristics	**Option 1 – Offshore Open Intake**	**Option 2 – Subsurface Intake System**
Engineering	The location of intake structure and pipeline is selected such that the intake is adequately submerged at low tide, protected from the damaging wave motion of storm, due to silt sediment. This option also ensures stable feed water for desalination and subsequently freshwater supply.	Subsurface intake system requires to lay larger number of perorated pipe under the seabed or vertical well along the shoreline to ensure the water quality is good and stable. This method is highly dependent on the geological characteristic of the local subsurface media, However, based on the information available from geological testing and conditions from the site, the transmissivity is expected to be very low and a number of wells should be required which incur the spatial problem for implementation.
Environmental benefits/ disbenefits	To minimize the impingement and entrainment of planktonic organisms, the intake is located 200-250m offshore where the productivity is relatively low. Also, the backwash water from the desalination plant serves as cooling water which further reduces the intake water volume. The intake pipe with corresponding intake structures will be constructed for serving ultimate capacity which avoids the construction at seabed during expansion in future. The diameter of intake pipes shall be sized to maintain sufficient cleaning velocity, whilst maintaining a low intake velocity to avoid infringement of the marine ecology.	Extensive excavation of vertical well or dredging under the seabed is required and subsequently generates extensive excavated materials and increase of suspended solid level onshore during dredging of seabed, which is anticipated to have higher coverage than that at offshore. Also, the vertical wells require adequate spacing apart such that yield/capacity is not impacted which leads to a larger project footprint. Since the system is difficult to maintain, additional well or infiltration gallery will be required during operation and this implies an extended construction duration (e.g. maintenance dredging).
Safety	Sufficient depth (at least 10m) of the intake structure is required to avoid any obstruction to normal marine traffic.	This option is onshore construction, thus impact of marine traffic is avoided.
Conclusion	Intake is designed to located 200-250m away from the shore. The location is considered viable options in terms of constructability and minimal impacts on marine ecology and fisheries.	Extensive construction works on seabed or along the shoreline is required and the system may be blocked by particle in the sea and difficult to maintain and required additional dredging. Therefore, the option is not preferred.

Base on the evaluation above, Option 1 – Offshore Open Intake at Joss House Bay is preferred due to constructability and minimum environmental impacts.

Outfall

Two options for the outfall alignment were evaluated. Option 1 is discharging to Tathong Channel and Option 2 is discharging to Joss House Bay. Both options are designed to discharge as close to the tidal current as possible to enhance dispersion process. The proposed alignment of both options is provided in ***Figure 2.7***. The evaluation outcome of different outfall alignment options is presented in ***Table 2.8***.

Table 2.8 Comparison of Alignment options for Submarine Outfall

Characteristics	**Option 1– Tathong Channel**	**Option 2 – Joss House Bay**
Engineering	The length and depth of the submarine outfall with designed with due considerations on the discharge standards of the marine waters of the Junk Bay, Eastern Buffer, Port Shelter, Mirs Bay and Southern Water Control Zones (WCZs). The discharge location shall take into account the water depth, outlet velocity of the currents and movement of water to allow sufficient mixing and dilution upon discharge.	The location of outfall structure is selected such that the outfall is adequately submerged at low tide, to protect from the damaging wave motion of storm. Also this outfall alignment is close to tidal current to allow sufficient mixing and dilution upon discharge.
Environmental benefits/ disbenefits	Located at Tathong Channel can provide better tidal current for diluting the discharge. However, the proposed location required longer outfall pipeline than option 2, this induced more C&D waste surplus.	Joss House Bay has relatively low fisheries productivity, and the tidal current is sufficient to dilute the discharge. The outfall pipeline in Joss House Bay would be shorter and thus require less excavation works and minimize the waste generation.
Safety	Located at Tathong Channel where is the main channel of marine traffic in Hong Kong, the construction and operation of the outfall would disrupt the marine traffic.	In comparison with Tathong Channel, Joss House Bay is less busy in terms of marine traffic, and thus minimize the obstruction to normal marine traffics.
Conclusion	This option is not preferred in terms of marine traffic obstruction and the extensiveness of excavation works.	Outfall designed to located 300-350m away from the shore in Joss House Bay is considered viable option in terms of constructability and minimal impacts on surrounding environment.

By comparing the dispersion efficiency of the concentrate and the associated environmental benefits of both options, Option 1 is relatively better than Option 2 as it is closer to the tidal current. However, the proposed site location is not next to the shoreline along the Tathong Channel, and a longer outfall pipe will be required for Option 1 which results in more C&D waste surplus during construction stage. Also, the Tathong Channel is the main channel of the marine traffic in Hong Kong, the construction and operation and maintenance of the outfall may cause disruption to marine traffic. Based on above evaluation, Option 2 is the preferred option for the outfall.

c) Trunk Feed System

Two options of the trunk feed alignment were studied and illustrated in ***Figure 2.8***.

In Option 1, the alignment of new pipe will be laid along Wan Po Road, Po Hong Road Po Lam Road North and Tsui Lam Road. In this option, whole trunk main is proposed to be laid under the carriageway.

In Option 2, the proposed alignment runs from Wan Po Road and Chun Wang Street and across Junk Bay to King Ling Road, Tong Yin Street, Po Shun Road, Po Hong Road, Po Lam Road North and Tsui Lam Road. In this option, submarine pipeline is required to be built for crossing Junk Bay from Chun Wang Street to King Ling Road.

The options were evaluated by the length of pipe, traffic impact, and environmental impact and tabulated in ***Table 2.9***.

Table 2.9 Description of Potential Trunk Feed Alignment and Evaluation Outcomes

Characteristic	**Option 1**	**Option 2**
Pipe Length	9.3km	9 km
Traffic Impact	Moderate	Low
Environmental benefits/ disbenefits	Although there will be some obstruction along the existing Wan Po Road during construction, this option only requires land-based construction in area of relatively low ecological value. This avoids disturbance to marine ecological environment and water quality. With the adoption of trenchless method, the air and noise impacts associated with this option are largely minimized. In addition, a treated water pumping station will be provided within the TKO site for the desalination plant and no booster pumping station is anticipated along the product water delivery pipeline alignment. This further reduces the footprint of the project.	This option would construct a shorter truck feed system. However, about 2.2 km of pipeline required to be constructed and potentially damage to the marine ecology and affect the water quality in the surrounding region. In addition, operation and maintenance of the submarine pipeline is relatively difficult. The laying of submarine pipe would be longer than land-based underground pipe of the same length. Thus, environmental impact for laying submarine pipe should be longer than that of the land-based pipeline laying of the same length.

Although Option 2 can have a relative shorter pipe length and less traffic impact on Wan Po Road, Option 1 is chosen as the preferred option for the trunk main due to the drawbacks on marine ecology and water quality from Option 2.

2.3.3 Design of the Project

a) Desalination Technology

All the-state-of-the-art desalination technologies were considered in the Project. Broadly speaking, two major desalination processes are commonly used in large scale desalination applications around the world including seawater reverse osmosis and multi-stage flash desalination.

Seawater Reverse Osmosis (SWRO)

Seawater will be drawn from the seawater intake system for the desalination process. Chlorine is dosed periodically into the intake seawater for control of microbial growth at the intake and the associated screening system.

Seawater will be delivered to the pre-treatment system for pre-treatment by clarification followed by filtration prior to the Seawater Reverse Osmosis (SWRO) process. Coagulant/polymer will be added to feed water for coagulation and flocculation. Residual chlorine left over from the intake chlorination will be removed by dechlorination process. Process waste streams will be generated from the pre-treatment processes. The process waste streams will include sludge from clarifiers and backwash waste from filters (also known as residual streams).

High pressure feed pumps will drive the seawater through the RO system. The pressurized seawater will be split into two streams, a low pressure permeate stream (product stream) and a high pressure concentrate stream (RO concentrate or waste stream) which is the rejected flow from the RO membranes and required to be discharged. The permeate produced in the RO system will be passed into the post-treatment system prior to pumping into the distribution system for potable water uses. The RO membranes will require cleaning with chemicals (i.e. clean-inplace or CIP) on periodic basis. The waste generated from the RO cleaning process is neutralized before disposal to public sewer.

Post-treatment processes will include disinfection using chlorine and fluoridation, pH correction and stabilization via hydrated lime and carbon dioxide dosing.

Multi-stage flash desalination (MSF)

In the MSF process, seawater is heated in a vessel called the brine heater. This is generally done by condensing steam on a bank of tubes that carrying seawater and passing through the vessel. This heated seawater then flows into another vessel, called a stage, where the ambient pressure is lower, causing the water to boil.

The sudden introduction of the heated water into the chamber causes it to boil rapidly, almost exploding or flashing into steam. Generally, only a small percentage of this water is converted to steam (water vapour), depending on the pressure maintained in this stage, since boiling will continue only until the water cools (furnishing the heat of vaporisation) to the boiling point.

The vapour steam generated by flashing is converted to fresh water by being condensed on tubes of heat exchangers that run through each stage. The tubes are cooled by the incoming feed water going to the brine heater. This, in turn, warms up the feed water so that the amount of thermal energy needed in the brine heater to raise the temperature of the seawater is reduced.

An MSF unit uses a series of stages set at increasingly lower atmospheric pressures. The feed water could pass from one stage to another and be boiled repeatedly without adding more heat. Typically, a MSF plant can contain from 15 to 25 stages.

Evaluation of environmental benefits/ disbenefits and feasibility of SWRO and MSF is presented in ***Table 2.10***.

Table 2.10 Description of Potential Desalination Technologies and Evaluation Outcomes

Characteristics	**Seawater Reverse Osmosis (SWRO)**	**Multistage Flash (MSF)**
Land Requirement	Modular (10 ha for this Study)	Large
Energy Consumption	Moderate, 2.5-4.0 kWh/m^3 (1.75 to 2.8 kg of CO_2/m^3)	High, 12.7-15.0 kWh/m^3 (8.9 to 10.5kg of CO_2/m^3)
Engineering	High pressure feed pumps will drive the seawater through the RO system. The pressurized seawater will be split into two streams, a low pressure permeate stream (product stream) and a high pressure concentrate stream (RO concentrate or waste stream) which is the rejected flow from the RO membranes and required to be discharged. The permeate produced in the RO system will be passed into the post-treatment system prior to pumping into the distribution system for potable water uses. It has high recovery of about 30% to 90%, i.e. more effective in producing freshwater.	Seawater is heated in a vessel called the brine heater. This is generally done by condensing steam on a bank of tubes that carrying seawater and passing through the vessel. MSF required high energy input for boiling and poor recovery of 10% to 25%.
Environmental benefits/ disbenefits	Although the brine discharge would affect the water quality of surrounding water bodies, the easy operation, small footprint, relatively lower energy consumption (~30% to 70% lower than MSF) and high recovery would promote the use of this technology and this also reduce the impacts to surrounding habitats. Also, as no boiling is required, impact of air quality would be minimized. The small footprint also implies that the construction of the plant is not extensive, and thus reduces the extent and duration of construction impacts.	Due to boiling of water, generation of on-site air pollution by burning fossil fuel is anticipated. Also, heated and concentrated seawater will affect the water quality of surrounding water bodies when discharging

The evaluation outcomes revealed that MSF technology requires high power consumption, including electricity and fuel consumption. For fuel burning, local emission of carbon dioxide, nitrogen oxides are anticipated which impose environmental impact to the surrounding. Also MSF technology was applied in the decommissioned Lok On Pai Desalination Plant which was closed because of high power consumption of the operational method. In this case, MSF should incur a relatively higher carbon footprint and induce a higher environmental impact.

Compared with MSF, SWRO technology has definite advantages of less energy consumption, no local emission of fossil fuel consumption and relatively economic viable. Seawater Reverse Osmosis (SWRO) is thus adopted as the preferred method for desalination process.

b) Disinfection Process

In the desalination processes, disinfection is required in two locations, including intake pipe for bio-fouling control and final disinfection of the treated water prior to distribution. The following disinfection technologies were considered and evaluated:

- Chlorination
- Ozonation
- UV Radiation

The disinfection process for freshwater, residual disinfectant is required to safeguard against the risk of subsequent microbial contamination during distribution. For ozonation and UV disinfection, they are not capable to provide residual disinfectant and chlorination, with lower dosage, is still required. Thus chlorination is the preferred option for disinfection in the Plant.

In the market, there are several ways of achieving chlorination including direct addition of chlorine gas or hypochlorite. The hypochlorite can be provided by bulk purchase of the sodium hypochlorite or onsite generation by electricity. The evaluation of different chlorination methods are demonstrated in the following.

Chlorine Gas Addition

It is a common practice adopted by WSD for disinfection, the chlorine is added into treated water by vaporizing the gas from liquefied chlorine storage drum. However, chlorine gas leakage will impose hazard to life to surrounding environment. The volume of on-site storage shall be minimized to reduce the risk to the surrounding environment. The hazard to life assessment shall be conducted when adopting this option.

Bulk Delivered Liquid Hypochlorite

Liquid sodium hypochlorite has been used extensively as a disinfectant because of less hazardous when accidently leaked, and is typically provided at between 12.5 and 15 "trade percent" concentration. Each sodium hypochlorite molecule possesses one hypochlorite ion (OCl^-), which is equivalent to one chlorine molecule (Cl_2). However, bulk sodium hypochlorite will degrade or decay over time, which results in aged solutions that are weaker and less effective.

The primary byproduct of sodium hypochlorite degradation is chlorate. Although chlorate is currently unregulated, it is anticipated that it may be regulated in the future. WHO has a provisional guideline value of 0.7 mg/L. Limiting the amount of total chlorite and chlorate applied to the process water should therefore be a consideration in a bulk sodium hypochlorite feed system design. Therefore, it is not preferred to use in the final disinfection process.

Onsite Generation by Electricity

The on-site sodium hypochlorite generation can be produced by using equipment that applying DC power to brine solution generated from concentrate stream of desalination process or dissolving NaCl or salt in softened water. Chlorine evolves at the anode surface, while hydrogen evolves at the cathode surface. Ultimately, chlorine reacts with sodium and the hydroxyl ion (OH^-) in the solution to produce sodium hypochlorite and hydrogen gas. The low concentration sodium hypochlorite solution that is produced is approximately a 0.8% solution, which large area is required for storage and production. High energy consumption is required for the process and the evolved hydrogen gas will impose explosion risk to the plant when hydrogen dilution is not sufficient

Besides, chlorate and bromate are formed in the side reactions of the process. In practice, bromate formed in the electrolysis is found to be less than 1.0 µg per 1 mg of Chlorine produced as sodium hypochlorite. The Chlorine dose applied would have to be in excess 10 mg/L to cause an exceedance of the WHO Guideline value of 10 µg/L. Additional by-products will be generated during the process, including hydrogen gas and waste brine from the water softening equipment regeneration process.

The volume of concentrate generated from desalination under design capacity is large and the reduction of brine discharge by the process is considered as negligible.

The summary of the three options for chlorination are summarized in ***Table 2.11***.

Table 2.11 Comparison of Chlorination Option for Desalination Plant and Evaluation Outcome

	Option 1 **Chlorine Gas**	**Option 2** **Bulk Delivered Liquid Hypochlorite**	**Option 3** **Onsite Generation**
Energy Consumption	Low	Low	Moderate
Environmental benefits/ disbenefits	Chlorine gas leaks need to be dealt with scrubber system.	Chlorine gas will be formed during the accidental mix with acid	Hydrogen gas is one of the by-products and mitigation measures need to be in place.
Source supply/reliability	Used currently in all WSD WTWs. 90 days storage is typical, except in SWPS	Not currently used in WSD WTWs, except in SWPS. Storage limited to 30 days due to deterioration/by-product formation	Availability of high purity salt with low bromide content is critical to minimize bromate formation
Other issues	N/A	Chlorate: Decay due to storage. Maximum chlorine dose limited due to formation of above byproducts. The quality of sodium hypochlorite depends on the manufacturer	Chlorate and bromate: Side reaction of the generation process. Maximum chlorine dose limited due to formation of above byproducts.

In order to reduce the total volume of liquid chlorine to be stored on site, the bulk sodium hypochlorite is preferred for bio-fouling control and based on the above evaluation, addition of chlorine gas for final disinfection is preferred due to the following reasons:

- ***Common WSD practices*** – In all the water treatment plant, chlorine gas is used for the disinfection which become a common practice for WSD. To this the operators should be familiar with the transportation, storage and handling and uses of chlorine gas.

- ***No residues*** – Unlike on-site generation, no residue will be generated in the use of chlorine gas. For on-site generation, only part of the seawater will be converted to hypochlorite whilst the remaining residual will be discharged back to the sea which may still incur environmental impact.

- ***Quality assurance*** – In the use of sodium hypochlorite, the quality of disinfection depends on the producers/suppliers which may not be fully guaranteed. If gas chlorine is used, WSD can ensure the gas quality based on their established QA procedures.

2.4 Consideration of Alternative Construction Methods

2.4.1 Alternative Installation Techniques for the Submarine Pipelines, Intake and Outfall Structure

For marine pipeline construction, there are typically constructed by dredging or trenchless method.

Based on the geological profile along the intake and outfall alignments, the rock head at the shores along and in the vicinity of the proposed intake and outfall pipes alignments are exposed at or close to the seabed, substantial dredging /rock breaking and backfilling is necessary to restore the affected area to the original bathometry. The dredging operation will give rise to considerable environmental impact to the water quality and considered as not feasible. The dredging extent for the option is demonstrated in ***Figure 2.9***.

Trenchless method has been considered for the construction of the proposed submarine outfall with a view to reduce potential impacts of the marine dredging works on water quality, marine ecology and fisheries of the Joss House Bay. The submarine outfall will be constructed by trenchless method, i.e. Micro-tunneling or Horizontal Directional Drilling (HDD) method subject to the final designed diameter of the conveyance pipe for intake and outfall. For HDD method, it involves drilling a pilot hole and then progressively enlarging the hole using reaming tools in steps until the required diameter is achieved. Reaming is either done in the reverse direction to the pilot boring or in the same direction (forward reaming). Once the reamed hole has been fully formed, the pipeline is pulled and/or pushed into the reamed hole. Micro-tunneling is a process remotely controlled Micro-Tunnel Boring Machine (MTBM) combined with the pipe jacking system to directly install product pipelines underground in a single pass. Jacking and reception shaft at the opposite drive for retrieving the MTBM. The process is applicable to tunnel diameter to about 2 to 3 meters.

The use of Micro-tunneling and HDD method is particularly suitable for construction of the proposed submarine intake and outfall because marine dredging and excavation would be minimal comparing with conventional submarine pipeline installation methods by forming a trench in seabed along the entire alignment of the proposed submarine pipe and backfilling after pipe laying. Minor dredging of the seabed over a much smaller area at the end of the intake and outfall pipe will, however, be required for constructing the reception shaft of the MTBM and the installation of the intake structure and diffuser. With the use of trenchless method, the extent of dredging will be limited to ~ 50m for intake structure and ~ 150 m for the diffuser, and the dredging extents are thus reduced considerably. The extent of dredging for trenchless method is also demonstrated in ***Figure 2.9***. This will effectively reduce the dredging volume by more than half (reduced from ~ 18,000 m^3 to ~ 6,330 m^3) and greatly minimize the potential impacts on water quality, marine ecology and fisheries associated with dredging activities. Therefore, trenchless method with localized dredging is the preferred option for the installation of submarine pipelines, intake and outfall. Evaluation of submarine installation method is presented in ***Table 2.12*** below.

Table 2.12 Comparison of Construction Method for Submarine Pipelines, Intake and Outfall

Characteristics	**Option 1 – Conventional Dredging**	**Option 2 – Trenchless method with localized dredging**
Engineering	Based on the geological profile along the intake and outfall alignment, the rock head at the shores along and in the vicinity of the proposed intake and outfall alignments are exposed at or close to the seabed, substantial dredging /rock breaking and backfilling is needed to restore the affected area to the original bathymetry.	Horizontal Directional Drilling (HDD) method involves drilling a pilot hole and then progressively enlarging the hole using reaming tools in steps until the required diameter is achieved. Reaming is either done in the reverse direction to the pilot boring or in the same direction (forward reaming). Once the reamed hole has been fully formed, the pipeline is pulled and/or pushed into the reamed hole. Micro-tunneling is a process remotely controlled Micro-Tunnel Boring Machine (MTBM) combined with the pipe jacking system to directly install product pipelines underground in a single pass. Jacking and reception shaft at the opposite drive for retrieving the MTBM. The process is applicable to tunnel diameter to about 2 to 3 m.
Environmental benefits/ disbenefits	By adopting solely conventional dredging for submarine installations, considerable impact to water quality and generation of a significant amount of dredged materials would be anticipated.	The trenchless method can reduce the dredging volume by more than half (reduced from ~ 18,000 m^3 to ~ 6,330 m^3) and greatly minimize the potential impacts on water quality, marine ecology and fisheries associated with dredging activities.
Conclusion	Not preferred in terms of environmental drawbacks.	Reduction in dredging extent would reduce the potential impact on water quality due to submarine installations. Therefore, this option is preferred.

In addition, suitable rock fill material will be used to backfill the standing platform of the intake structure and outfall diffuser. Rock fill is considered as the most suitable material as it offers sufficient support and protection to the systems, and has low fines content which reduces potential impacts on water quality, marine ecology and fisheries during marine backfilling activities.

2.4.2 Alternative Construction Method for Land-based Works

a) Alternative Installation Techniques for the Trunk Feed System

Since the freshwater rising mains will be constructed along the carriageway to the TKOFWPSR, most of the delivery pipes will be constructed by cut-and-cover method. Cut-and-cover method is a common construction method for pipe laying by excavating the ground and backfill after laying the pipe. The maximum trench depth for cut and cover will be about 3 m.

Cut-and-cover method is not feasible at several road junctions along the alignment because of heavy traffic. Trenchless method will be adopted at the designated locations. Pipe jacking and micro-tunnelling are the two most preferable and effective trenchless methods for the proposed works.

A comparison of the environmental benefits and disbenefits of the cut-and cover method and trenchless method is summarized in ***Table 2.13*** below.

Table 2.13 Comparison of Construction Method for Trunk Feed System

Characteristics	**Cut- and-cover method**	**Trenchless method**
Environmental benefits	• Relatively quicker technique for short sections of trench. • Possibility to reuse excavated materials or surplus fills from other projects. • Catering for alignment changes.	• Surface works limited to the construction pits. Hence, reduced direct impacts on habitats and vegetation. • The works are underground in nature and thus minimizing the disturbance to sensitive receivers along the alignment. • Less PMEs is required with limited spoil to be disposed of compared with C&C method. • The underground works will not be visible to the public and hence reduced visual impacts.
Environmental disbenefits	• Works may affect habitats adjacent to the proposed alignment. • All sensitive receivers along the alignment have the potential to be affected. • More construction plant will be involved and this would generate relatively more noise and dust impacts. • Larger amount of material handling due to excavation and backfilling. • More potential for construction run off due to open excavation.	• Sensitive receivers nearby the construction pits will be subject to a longer period of environmental disturbance. • A wider pit is required compared to C&C method and sufficient area may not be available at congested site. • Requires treatment of surplus bentonite before disposal.

While trenchless method may be used at the selected locations where cut-and-cover method is not feasible, trenchless method is not suitable for wide-spread application because of its limitations. Trenchless method is generally adopted for straight pipe alignment. Construction of a working pit will be required at each end of a trenchless pipe. Construction of additional working pits is required for changing alignment direction. The length of a single trenchless pipe is restricted because of the limitation of jacking force. Linking up the pipe segments will require additional working pits. The working pits have to be located at selected locations where adequate space is available. Construction of working pits typically requires installation of temporary structural supports and extensive excavation. Sensitive receivers nearby the working pits will be subject to a longer period of environmental disturbance.

Based upon the above comparison, cut-and-cover method is proposed for the trunk main system because it is relatively more flexible in managing the construction duration and engineering constraint. Trenchless method will be considered in a particular location where the cut-and-cover method is considered not feasible, including the environmental impact imposed cannot be mitigated by the proper mitigation measures.

b) Construction Method for Desalination Plant

The construction works involved in the proposed Desalination Plant include Civil & Structural works, E&M works and Building Services works. For foundation, piling is required since the site is a reclamation area with deep level of rock head. Bore-piling is preferred since it is a non-displacement piling method, which produces less noise and ground vibration than the other displacement piling methods. There is no alternative viable construction method due to site constraint.

In order to suit with hydraulic requirement of the process, some facilities are required to be constructed below the ground level and therefore, excavation for underground structures like basements and pile caps is required. Tradition excavation and cast-in-situ concreting will be adopted for pile caps, basements and superstructures constructions.

For E&M and Building Services works, general fixing and installation of treatment plants and facilities such as SWRO skid, high pressure pumps and small sized utilities installations such as pipe-laying, ducting and cabling will be conducted. As such, apart from Civil & Structural works, all the works involved in the Desalination Plant are considered to create no adverse impact to the environment.

2.5 Consideration of Works Sequences

2.5.1 Sequences of Works

As the fresh water rising mains overlap with Wan Po Road, it shall be constructed in segments (approximately 40 m per workfront) with limited number of concurrent workfront to minimize disturbance to the local public and road users. In view of the potential noise impact, a total of not more than four workfronts working simultaneously would remarkably reduce the construction noise to the surrounding but at the same time be able to deliver the Project per programme. The construction of the Project is also planned to be implemented in multiple works packages to reduce concurrent construction activities, which is regarded as one of the effective approaches to reduce environmental impacts.

A comparison on sequence of works is presented in ***Table 2.14***.

Table 2.14 Comparison of Works Sequence

	Single workfront	Multiple package with concurrent workfronts
Environmental benefits	• Surface works limited to the 40m workfront, and hence minimize the disturbance to the local public and road users. • Less PMEs is required for single workfront. • Catering for alignment changes.	• Reduce the overall duration of construction works and thus which reduce the duration of potential environmental impacts to nearby sensitive receivers. • The construction of the Project is also planned to be implemented in multiple works packages to reduce concurrent construction activities, which is regarded as one of the effective approaches to reduce environmental impacts.
Environmental disbenefits	• Sensitive receivers nearby the construction pits will be subject to a longer period of environmental disturbance. • Longer overall project construction period with longer duration of environmental impacts.	• More construction plant will be involved and this would generate relatively more noise and dust impacts.

For the process building in the plant area will be constructed by cast in-situ method, all sub-structures and foundation will first be constructed and followed by erection of falsework and formwork for superstructure and concreting. The construction sequence will be repeated until all process buildings are constructed. No viable alternative is considered.

2.5.2 Construction Programme

The *EIAO-TM* specifies the priorities for addressing impacts is avoidance and minimization. This philosophy was referred to in designating the works construction programme by reducing the overall duration of construction works.

The construction for the project will be separated into two major contracts. Package A is for plant and other ancillary facilities and Package B is for mainlaying of the trunk feed. The Package A contract is scheduled to commence in Q3 2017 for completion of the construction in Q3 2020. The Package B contract is scheduled to commence in Q2 2016 for completion of the construction in Q4 2019. The major construction activities for the Project would comprise site formation, excavation and backfilling, erection of formwork and reinforcement, concreting, fabrication of steelwork, and testing and commissioning.

2.6 Selection of Preferred Scenario

Based on the review and consideration of project alternatives presented in the preceding sections, the preferred alternative to be taken forward to this EIA study is the provision of submarine pipelines for intake and outfall, desalination plant by Reverse Osmosis, mitigation works of 0.49 ha of natural slope within the Clear Water Bay Country Park by soil nailing, flexible barriers and rock stabilization, and construction of a 9 km rising mains along Wan Po Road. Both cut-and-cover method and trenchless construction method will be adopted for the construction of desalination plant and the truck feed system. The proposed submarine intake and outfall will be constructed by trenchless method with minor seabed dredging for the installation of the diffusers. Within the proposed Desalination Plant, bored piling and *in situ* concreting will be used for foundation and superstructure construction, respectively.

The selection of the preferred scenario is summarized in ***Table 2.15*** and construction method has brought about a series of environmental benefits to the Project, including:

- The provision of alternative potable water source and alleviate the shortage of freshwater resources due to climate change and subsequent adverse weather;
- The trunk feed system are proposed to be constructed underneath Wan PO Road to minimize disturbance to sensitive receivers and natural habitats;
- The mixed-use of soil nailing, flexible barrier and rock stabilization for slope mitigation is localized in nature and thus has minimized the disturbance to the natural habitats at the Clear Water Bay Country Park;
- The alignment and length of submarine utilities are at sufficient distances from sensitive receivers to reduce potential impacts on water quality, marine ecology and fisheries;
- The use of micro-tunnel boring machine for construction of the proposed submarine utilities reduces the extent of seabed dredging and dredging volume, thereby reducing the marine footprint of this project and the potential impacts on water quality, marine ecology and fisheries; and
- The recommended land-based construction methods are expected to avoid prolonged construction duration and hence reduce potential disturbance to the environment and the local public.

Table 2.15 Preferred Alternative for the Proposed Desalination Plant Development in this EIA Study

	Design	**Construction Method**
Desalination Plant		
Intake	Offshore Open Intake	Trenchless method and localized dredging
Pre-treatment	Two Stage Granular Media Filtration	-
Desalination	Reverse Seawater Osmosis	-
Treatment Building in Desalination Plant	-	Foundation: Bored pilling Superstructure: *in situ* concreting
Outfall	Submarine Outfall with Diffuser	Trenchless method and localized dredging
Natural Slope Mitigation		
Rock Slope	-	Mixed-use of flexible barrier, soil nail and rock stabilization.
Trunk Feed System		
Pipeline of the rising main	-	Cut & Cover and Pipejacking & Microtunneling (if necessary)