Territory-wide Implementation Study of Water-cooled Air Conditioning Systems in Hong Kong

Executive Summary to Strategic Environmental Assessment

May 2005

Contents

1. INTRODUCTION

1.1. Background

The Strategic Environmental Assessment Report documents the Strategic Environmental Assessment (SEA) for the "Territory-wide Implementation Study for Water-cooled Air Conditioning Systems (WACS) in Hong Kong", which examines the potential environmental benefits and impacts of various schemes of WACS.

1.2. Key objectives

1.2.1. To reap full benefits of WACS, and to realize the strategic implementation of various WACS schemes in prospective geographic areas of Hong Kong.

1.2.2. To examine the comparative environmental benefits and impacts of various WACS schemes, to recommend practicable technologies, infrastructure, and measures for resolving constraints and for preventing or mitigating impacts, and to evaluate prospective geographic areas for implementation of the schemes.

1.3. Key scopes

(a) Identify and describe elements of the community and environment likely to be affected by the proposed WACS schemes, and / or likely to cause impacts upon the proposed works.
(b) Identify and quantify potential sources of environmental impact and determine the significance of impacts on sensitive receivers and potential affected areas.
(c) Propose infrastructure or mitigation measures to be provided to minimize pollution, environmental disturbance and nuisance arising from the construction and operation of the proposed works.
(d) Identify, predict and evaluate the residual environmental impacts and cumulative effects expected to arise during construction, operation of the proposed works in relation to the sensitive receivers and potential affected uses.
(e) Conduct an Environmental Review (ER) for each prospective geographic area where WACS schemes are proposed, evaluating and comparing the respective environmental issues of each type of WACS scheme.
(f) Describe the strategic assessment with respect to the key assumptions, evaluation method of SEA, environmental considerations in water supply and wastewater discharge, cumulative impacts and environmental benefits up to 2020, key features

of mitigation measures, and ER of each prospective areas of the Study.

(g) Design and specify the framework of strategic environmental monitoring and audit (SEM&A) requirements necessary to ensure effective implementation of the environmental protection and pollution control measures recommended.

2. KEY ENVIRONMENTAL AND HEALTH ISSUES IDENTIFIED

2.1. Water quality issues

2.1.1. Two fundamental forms of heat rejection for WACS are direct once-through type, which uses cooling water to transfer heat to an aquatic heat sink, and evaporative cooling tower type, which rejects heat to the atmosphere through evaporation of recirculating cooling water and discharge a small amount of cooling water for maintaining water quality of the system.

2.1.2. An important aspect of the operation of cooling water systems is the control of the quality of water with respect to corrosion, fouling, scaling and bacterial growth.

2.1.3. Chemical methods are commonly used in WACS in Hong Kong to control water quality. The discharge of cooling water containing residual chemicals to the receiving water may undermine the sewage plant, and also pose impacts to the environment. The location of such discharge, and the assimilation capacity of the aquatic body need to be considered.

2.1.4. The discharge data of 99 existing direct once-through seawater cooling system collected by the Environmental Protection Department were used as the baseline condition. The cumulative impacts from the discharges of existing and future WACS proposed were examined by using a water quality model.

2.1.5. The water quality of cooling towers was obtained by carrying out sampling to 50 existing cooling towers and the collected data was also used as the baseline condition. The potential impacts from the discharge of existing and future cooling towers on the sewerage system were evaluated.

2.2. Air quality issues

2.2.1. Potential reduction of air-borne emissions associated with the generation of electricity at fossil fuel power stations due to the wider adoption of WACS is the most significant benefit.

2.2.2. Potential environmental impacts may result from the construction of WACS plant and the release of ozone-depleting refrigerant during operation, maintenance, commissioning and decommissioning of air conditioning systems.

2.3. Noise issues

2.3.1. Construction noise and operation noise of the WACS plant may cause impact to adjacent sensitive receivers.

2.4. Health issues

2.4.1. It was not currently feasible to conduct a quantitative risk assessment of Legionnaires' disease (LD) for the wider use of fresh water cooling towers as there still existed a large degree of scientific uncertainly on the question of infection of LD associated with cooling tower systems.

2.4.2. While wider adoption of fresh water cooling towers could achieve energy saving objective, proper control on the installation, operation and maintenance of cooling towers is also vital in order to minimise the risk of LD and maintain its occurrence at a level not worse than the present situation.

2.5. Other potential issues

2.5.1. Other potential issues, such as ecological impact, waste management, heritage resources, landscape and visual, are also assessed in general.

3. ENVIRONMENTAL ASSESSMENT OF VARIOUS ENVIRONMENTAL AND HEALTH ISSUES

3.1. Water quality issues

3.1.1. The key cumulative environmental impacts on water quality issues are expected to be those on marine water quality and ecology arising from the combined effects of future WACS adopting once-through seawater cooling and existing cooling water discharges. The two most significant factors are the potential thermal effects to the sea and the quantities of residual chemicals and reaction by-products being discharged in the effluent.

3.1.2. Based on a conservative approach for assessing cumulative environmental impacts with all potential WACS-DCS zones identified (20 zones) adopting direct once-through seawater cooling systems, the total discharge rate of cooling water of these potential WACS-DCS zones will be about 315 m^3/s. This discharge rate will be added to the discharge rate of 99 existing direct once-through systems to make an assessment.

3.1.3. The Delft3D[1] was used to assess the impacts of temperature, chlorine and biocide discharges from the direct once-through WACS for dry and wet seasons. The modelled scenario was the worst scenario with all air-cooled systems within the potential zones converted to WACS-DCS and all WACS-DCS plants adopting direct once-through seawater cooling. The results represented a conservative view of future situation.

3.1.4. Three local area models were used to assess the impacts, namely Victoria Harbour Model, the Fine Grid Model (for Victoria Harbour and the western waters) and the Tolo Harbour Model. The models were set up to represent the 2020 time horizon.

3.1.5. To assess the effects of the existing and future WACS discharges, the excess temperature, the chlorine concentration and the generic biocide concentration were computed in wet and dry seasons.

Victoria Harbour Model

3.1.6. The results from the simulation showed that the temperature rise near the surface in major part of the region during wet season is about 0.4ºC. At places where the flow velocities were low and the discharge rates were relatively high, the excess temperature above 1ºC was encountered. These places were South East Kowloon Development, Kowloon Bay, Cheung Sha Wan and Tsuen Wan. However, the excess temperatures of more than 1ºC occurred only in very small areas. The increase in temperature near the bed was hardly exceeded 0.5ºC. The computational results in dry season had less impact than in wet season due to the fact that the total WACS discharge rate in wet season was higher and large amount of heat was accumulated in the top layer of the sea. The Table A3.1 in Appendix A showed the area of excess temperature in Victoria Harbour.

3.1.7. In wet season, the computed chlorine concentration, averaged over the 14 days spring

[1] Delft3D is a model system, which can simulate the time and space variations of hydrodynamics, waves, water quality, morphology, sediment transport and ecology, and their interconnections. The decay rates of chlorine and generic biocide used in this simulation were 24/day and 0.1/day respectively. Their concentrations at the discharge were both assumed to be 0.3 ppm.

neap cycle, near the surface was mostly less than 0.005 ppm. The chlorine concentration near the bed was negligible. The spatial distribution of chlorine in dry season was similar to wet season results and the concentrations were somewhat lower due to low WACS discharge rates. The Table 3.2 in Appendix A showed the area with chlorine concentration exceeding the ambient condition in Victoria Harbour.

3.1.8. The computed biocide concentration near the surface during wet season in major part of Victoria Harbour was up to 0.04 ppm. At places where the flow velocities were low, such as Kowloon Bay, Cheung Sha Wan and Tsuen Wan, the biocide concentration above 0.06 ppm was encountered. The highest biocide concentrations of more than 0.06 ppm occurred in very small areas. The biocide concentration near the bed during wet season was less pronounced than near the surface and hardly exceeded 0.03 ppm. The results obtained in dry season had less impact than in wet season with respect to the area concerned. The Table 3.3 in Appendix A showed the area with biocide concentration exceeding the ambient condition in Victoria Harbour.

Tolo Harbour Model

3.1.9. The computational results of Tolo Harbour in wet season showed that the excess temperature of 0.5ºC or higher in large area and in particular the excess temperature at Shing Mun River Channel was found exceeding 1.5ºC. In the vicinity of Pak Shek Kok and Tai Po, the excess temperature near the bed was about 1ºC higher than that of the surface in wet season. In dry season, an area of 5.4 km^2, in particular Pak Shek Kok and Tai Po, were found with an excess temperature of 1ºC at the surface. The Table 3.4 in Appendix A showed the area of excess temperature in Tolo Harbour.

3.1.10. The spatial distribution of chlorine concentration in wet and dry seasons showed that the impact at surface was restricted to a small area in the proximity of the discharge locations. However, the chlorine concentration was relatively high at the bed near Pak Shek Kok and Tai Po. The Table 3.5 in Appendix A showed the area with chlorine concentration exceeding the ambient condition in Tolo Harbour.

3.1.11. The computed distribution of the average biocide concentration near the free surface revealed that the biocide concentration had a level 0.03 ppm higher than the ambient condition in a large area, especially in Tolo Harbour. This is caused by the restricted mixing of the effluent in Tolo Harbour due to mild hydrodynamic conditions. The impact was significant in Pak Shek Kok, discharge sites at Tai Po area and Shing Mun River Channel. The Table 3.6 in Appendix A showed the area with biocide concentration exceeding the ambient condition in Tolo Harbour.

Fine Grid Model

3.1.12. The computational results were found significant at the discharge locations in Yuen Long and Tuen Mun, where the maximum excess temperature exceeded 1.5ºC near the free surface in wet season and the same value was also found near the bed. The excess temperature near the free surface and the bed at Yuen Long in dry season was found to be about 3.5ºC and 1.9ºC respectively. The Table 3.7 in Appendix A showed the area of excess temperature determined by the Fine Grid Model.

3.1.13. The maximum chlorine concentration was found to be 0.001 ppm above the ambient condition in the vicinity outside Victoria Harbour. The results in wet and dry seasons were similar. The Table 3.8 in Appendix A showed the area with chlorine concentration exceeding the ambient condition determined by the Fine Grid Model.

3.1.14. The spatial distribution of biocide concentration showed that the impacts at the discharge locations in Yuen Long and Tuen Mun were significant, with the concentration of 0.1 ppm above the ambient condition in wet and dry seasons. The Table 3.9 in Appendix A showed the area with biocide concentration exceeding the ambient condition determined by the Fine Grid Model.

3.1.15. The modelled scenario represented the worst case (assuming that all WACS-DCS adopting once-through seawater cooling). A general observation regarding the effects of the WACS discharges was that the effects of the discharges were only significant in areas with little mixing with surrounding waters, i.e. semi-enclosed waters. In particular, the discharges in Tolo Harbour and Deep Bay were particularly sensitive.

3.1.16. The increase in the chorine and biocide concentration appeared to be mainly limited to less than 0.01 ppm and 0.1 ppm respectively, and only a small area was affected. In the affected areas, the dosing of chemicals should be kept to a minimum.

3.2. Air quality issues

3.2.1. The assessment of air quality aimed to explore the impacts arising from construction, operation and demolishment of proposed WACS in the identified zones in the territory. Due to expected savings in electricity consumed, the gaseous emissions from fossil power stations would be reduced. In addition, if the adoption of ammonia as refrigerant was promulgated and the recycling and recovery of refrigerants were strictly observed, WACS related release of refrigerants and the associated ozone layer depletion would be minimal.

3.2.2. The principal source of air quality impact is fugitive dust, which arises from the construction phase of WACS. As the construction work of WACS would only cause short-term dust impact to the surrounding, the mitigation measures, such as watering the exposed areas, should be adequate.

3.2.3. Other source of air quality impact is the emission of drift and / heated air from cooling tower type WACS. If salt water cooling tower is used, the saline air emission will induce corrosion problem to the nearby buildings.

3.2.4. The major potential cumulative benefit that can be achieved through the territory-wide implementation of WACS is the reduction of green house gas emission from power plants resulted from electricity saving of WACS. Based on estimated electricity saving of 1,360 millions kWh per year[2], the anticipated reductions of green house gas emissions will be 950,000 tonne by the year 2020.

3.3. Noise issues

3.3.1. The principal noise sources arising from WACS are the noise from operating WACS equipment and construction activities of WACS. Three types of noise sensitive receivers (NSR) were selected for the assessment.

3.3.2. All three types of WACS schemes would involve laying underground piping network; in particular the central seawater type and district cooling type WACS schemes. The assessment was undertaken by assuming that all construction equipment would be located on a single notional noise source point and all would be operated simultaneously at that point to simulate the worst scenario. The unmitigated construction noise levels were found 17 to 27 dB(A) above the noise criteria (65 to 75 dB(A) depending on the receiver) at a distance of 10 m from the source, which exceeded the day-time standards of all NSRs. Thus, suitable mitigation measures are required to alleviate the impacts. The results are shown in Table 3.10 of Appendix A.

3.3.3. For the operational noise impact of various schemes of WACS, the cooling tower type

[2] The estimation assumes 90% penetration of DCS in 10 newly developed DCS zones, 35% penetration of DCS pulus 15% penetration of Cooling Tower Scheme in 5 existing DCS zones and 50% penetration of Cooling Tower Scheme in the remaining zones with adequate fresh water supply capacity.

WACS would emit some low frequency air flow noises, some splashing water sound and some squealing noise from mechanical equipment. In central seawater type and district cooling type WACS, the noises would be mainly from the central pumping facilities and chiller plant via the ventilation outlet of the plant rooms. In order to meet the acceptable noise level at a distance of 10 m from the source, the maximum allowable sound power level (SPL) of plants should be between 86 dB(A) and 96 dB(A) (depending on the area sensitivity rating). The results of maximum allowable SPL were shown in the Table 3.11 of Appendix A.

3.4. Health issues

3.4.1. Fresh water cooling towers are known to be a potential source of Legionella. The local annual occurrence of Legionnaires' disease per million of population is relatively low comparing to other overseas countries. In case of a relaxation of freshwater supplies for air conditioning purposes on a territory-wide scale, the present scenario may be altered. In this regard, proven, cost-effective and environmentally benign technologies of water treatment are recommended to control such risks.

3.4.2. Legionella cannot survive in seawater cooling towers.

3.4.3. A survey was carried out to fifty existing cooling towers in Hong Kong. The information of their operating conditions and water treatment methods were collected. The results of temperature, pH, BOD_5, COD and TSS[3] of the cooling water were found within the requirements laid down in the EPD's Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems. The detailed results were shown in Table 3.12.

3.4.4. The bleed-off water from cooling towers were found suitable for reuse as flushing water and discharge into foul sewers leading into Government sewage plants as the water quality complied with the existing Water Quality Requirements for Flushing Water and Standards for effluents discharged into foul sewers leading into Government sewage plants of the EPD Technical Memorandum.

3.4.5. Automatic dosing of water treatment chemicals to cooling towers should be able to maintain the target chemical concentration accurately and to control the water quality

[3] BOD_5, COD and TSS stand for 5-day biochemical oxygen demand, chemical oxygen demand and total suspended solids respectively. These parameters are widely used characteristics for water and wastewater.

effectively.

3.4.6. The water quality of the cooling water was found less satisfactory in the hottest months, i.e. June to September.

3.5. Other potential issues

3.5.1. Potential ecological impact from the prospective WACS schemes depends on the likely water quality impact within the potential zones. Victoria Harbour has the lowest impact on aquatic life species, while Junk Bay is second to Victoria Harbour. The most sensitive area lies within the North-western waters of the Territory.

3.5.2. The volume of excavated materials for the associated infrastructures of all WACS potential zones during construction was found to be 1.45M m^3. It should however be noted that the construction periods may not be simultaneous. The volume only represents the waste generated within a certain period.

3.5.3. There were 72 locations of declared monuments located within the WACS zones. When specific WACS development for an area was eventually selected, detailed heritage assessment would need to be carried out accordingly.

3.5.4. Landscape and visual impacts arising from the WACS were likely the removal of existing vegetation due the construction of underground plant rooms and the above-ground structure for plant room ventilation purposes. When specific WACS development for an area was eventually selected, detailed landscape and visual impact assessment would need to be carried out accordingly.

4. MITIGATION MEASURES

4.1. Water quality issues

4.1.1. The following strategies for mitigating potential water quality impacts are recommended.

(a) Select the rapidly biodegradable chemicals (with a half life less than 16 days) and optimise the use of chemicals for water treatment.
(b) Adopt alternative water quality control methods other than dosing water treatment chemicals, such as UV, ozone, peroxide, cathodic protection, on-line cleaning, coating and painting, etc.

(c) Maintain the cycles of concentration[4] in cooling towers between 3 and 8, such that the dissolved solids in the cooling water can be kept at a level not affecting the system operation and the make-up water can also be conserved.
(d) Select intake and discharge locations away from sensitive marine areas.

4.1.2. In addition to the above strategies, the following specific efforts could also be promulgated.

(a) Substitute the use of chemical treatment methods with non-polluting physical means, such as side-stream filtration, application of UV, and mechanical scrubbing;
(b) Improve the engineering designs of the cooling system, such as the use of corrosion resistant materials, and continuous bleeding; and
(c) Regulate the use of water treatment chemicals.

4.2. Air quality issues

4.2.1. The following strategies for mitigating the air quality impact during construction of WACS should be considered.

(a) Regular watering of the construction sites to minimise fugitive dust emissions.
(b) Provision of wheel washing facilities at the exit of the construction sites.
(c) Limit the vehicle speed limit and confine the vehicles to designated roadways in construction sites.
(d) Provision of an enclosure when transferring dusty materials from a conveying system or earth moving equipment to a vehicle.

4.2.2. Since the principal potential air quality impact arising from the operation of WACS is the drift generated from cooling towers, they should be considered to be installed at locations where the occupants of the nearby buildings are not subject to this nuisance. Installation of high efficiency drift eliminators to cooling towers can minimise the emission of drift, but maintaining adequate buffer distance between the cooling tower to the nearby buildings or wind channels should be the most appropriate measure. The potential corrosive effect caused by the drift from seawater cooling towers is much higher than that from fresh water cooling towers. The latter is more suitable for the local environment.

[4] The cycle of concentration of a cooling tower system is the ratio between the concentration of selected parameter in cooling water and the concentration of the same parameter in make-up water.

4.3. Noise issues

4.3.1. The following strategies of mitigating the potential noise impact during construction should be considered.

(a) Site the noisy construction equipment away from the noise sensitive receivers. Prolonged operation of equipment close to dwellings and schools should be avoided.
(b) Schedule the noisy activities at times coinciding with periods of high background noises.
(c) Select construction equipment with acoustic enclosure and low noise output.
(d) Maintain the construction equipment properly.
(e) Erect stockpiles, noise barriers and other structures to screen noise generated from construction activities.

4.3.2. The following strategies of mitigating the potential noise impact during operation should be considered.

(a) Install acoustic enclosure and / or silencer with proper adoption of orientation and configuration of the ventilation vent.
(b) Reduce structure-borne noise caused by the equipment operation by installing acoustic enclosure and vibration isolator.

4.4. Health issues

4.4.1. It is recommended that special attention be paid to the water quality control of cooling towers during the hottest seasons.

4.4.2. The bacterial growth should be controlled by means of chemicals or biocides, however, other more environmentally friendly measures, such as UV, ozone, peroxide technologies, should also be considered to adopt.

4.4.3. A high efficiency drift eliminator for cooling towers should be adopted to reduce the drift emitting from the cooling towers. Proper operation and maintenance to cooling towers should also be promulgated.

4.5. Other potential issues

4.5.1. The following mitigating measures for waste generated during construction of WACS should be considered.

(a) Avoid and minimise the waste generation from good practice of design.
(b) Sort all construction waste into inert and non-inert components. Reuse non-inert materials where possible.
(c) Select reusable materials during construction.
(d) Prepare a Waste Management Plan and ensure that all site operations comply with the Plan.
(e) Chemical wastes should be properly stored, labelled, packaged and collected in accordance with the relevant regulations.

4.5.2. If Declared Monuments, Deemed Monuments and other heritage resources were involved in the WACS projects, detailed heritage assessment on should be carried out during the design phase of WACS projects.

4.5.3. All WACS related facilities should be installed underground as far as possible. Any above ground structures should be integrated with the landscape, such as planting vegetation and use of background-compatible colouring. Detailed landscape and visual impact assessment may be required.

4.5.4. In order to minimise the impacts of WACS intakes and discharges on the marine environment, the following criteria to mitigate the ecological impacts should be considered.

(a) Avoid locating the sites at important spawning grounds, fish culture zones, shellfish beds, any location where a particular concentration of aquatic life is present, or any location with ecological interest.
(b) Adopt Best Available Technologies, such as the application of ozone and UV for water treatment as alternatives to chemically treat the cooling water.
(c) Locate intake and outfall to high current area for carrying the aquatic life past the intake and for effective dissipation of thermal plume respectively.
(d) Avoid locating the intake from a poor water quality region or area with frequent algal blooms.

5. STRATEGIC ENVIRONMENTAL MONITORING AND AUDIT FRAMEWORK

5.1. Introduction

5.1.1. In order to ensure that the required environmental protection measures are instituted and that the predicted outcomes are not exceeded, a strategic environmental monitoring and audit (SEM&A) is required to be conducted to confirm and assess the validity and level of environmental benefits achievable by the implementation of WACS.

5.2. SEM&A Framework

5.2.1. The aim of the SEM&A framework is to provide a clear direction on the SEM&A for all stages of the WACS implementation from completion of the Strategic Environmental Assessment (SEA). To achieve this aim the SEM&A framework provides a listing of the environmental elements and actions to be taken which are considered imperative to ensure WACS's coherent and satisfactory environmental performance.

5.3. SEA Assumptions

5.3.1. The SEA assumptions include the following major points.

(a) There will be zero net additional wastewater drainage loading form the cooling tower.
(b) No chemicals with unacceptable environmental impact will be used for controlling quality of cooling water.
(c) The thermal effect of discharge from seawater cooling systems and the decay of residual chemicals in the discharge are accepted on the basis of a 30% penetration[5] on a territory-wide basis.

5.4. Environmental Mitigation Measures

5.4.1. The following environmental protection measures are required to be enforced / taken.

(a) All bleed-off water from the cooling towers shall be reused for toilet flushing. In exceptional case that direct discharge to sewerage system is required, special permission will be required and such discharge can only be made at off-peak period.
(b) Proven technologies should be employed for the control of water quality. The chemicals to be used should be environmentally acceptable. Where use of chlorine is involved, the total residual chlorine discharge concentration should be limited to

[5] EPD recommends constant monitoring and audit to territory-wide WACS(DCS) adopting once-through seawater cooling when the take-up rate is 30% or below for future scenario. In case of exceeding 30% in future, the environmental review on WACS implementation will be triggered for decision and remediation.

0.3 ppm.

(c) A register of chemicals acceptable for use should be maintained. The use of any chemicals not in the register should only be permitted subject to a satisfactory environmental assessment.

(d) Where the 30% penetration of projected substitution on a territory-wide basis of WACS (once-through seawater cooling) is anticipated to be exceeded, a review on the SEA for discharge of seawater cooling systems should be conducted.

(e) Other mitigation measures on noise and air pollution should be taken where necessary.

5.5. Environmental Benefits

5.5.1. The potential cumulative benefits that can be achieved through successful territory-wide implementation of WACS are the reduction in the gaseous emissions from power plants, and hence the green house effect can be alleviated.

5.5.2. The estimated reduction of green house gas emission resulting from the implementation of WACS is 950,000 tonne per year by the year of 2020.

5.5.3. The extent and amount of the potential cumulative benefits arising from the territory-wide implementation of WACS should be confirmed and verified the validity in the SEM&A. The SEM&A schedules are shown in the Appendix B.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Assuming that the territory-wide penetration of cooling tower scheme is 50%and the territory-wide penetrations of district cooling scheme are 35% for existing developed areas and 90% for newly developed areas, the estimated saving of electricity will be 1,360 millions kWh and the total reduction in greenhouse gas emissions will be 950,000 tonne per year by the year 2020.

6.2. Wider adoption of physical water treatment methods, such as side stream filtration, UV, and environmentally friendly chemicals, such as ozone, peroxides, should be promoted. Effective measures should be implemented to control the bacterial growth in fresh water cooling towers.

6.3. The impacts of the discharges from the once-through seawater systems were only significant in areas with little mixing with surrounding waters, such as Tolo Harbour and

Deep Bay. Therefore,

(a) The intakes and outfalls of the seawater systems should be located away from sites with high ecological interest, important spawning grounds, fish culture zones, shellfish beds or any location where a particular concentration of aquatic life is present.

(b) Best Available Technologies, such as the application of ozone and UV for water treatment, should be adopted as alternatives to chemicals to treat the cooling water. If the use of Chlorine is inevitable, the total residual chlorine in the cooling water must be controlled below 0.3 ppm.

6.4. The bleed-off from fresh water cooling towers should be reused as flushing water. Therefore, there is no net increase in the overall quantity of the sewage to the receiving sewerage infrastructure. In case when the quantity of bleed-off exceeds the flushing water demand in a building, permission for direct discharge to the sewerage system can be granted, but such discharge should only be made within off-peak period.

6.5. In view of the potential savings in electricity, gaseous emissions from fossil fuel power stations will be reduced, leading to benefits in terms of air quality.

6.6. The major temporary air pollution from construction of WACS facilities is dust, which can be suppressed by enclosing and watering the sites. Given the limited scale of the works involved, no adverse air quality impact is expected.

6.7. The potential source affecting the air quality during the operation of WACS facilities is the drift and heated air emissions. Cooling towers should be well designed and suitably located to minimise the nuisance caused by heated air. For seawater type cooling towers, the saline air emission would induce corrosion problem to nearby buildings. In this regard, fresh water cooling tower is more suitable for the local environment.

6.8. The noise impacts arising from the construction activities of WACS facilities could be brought under control without much difficulty; therefore, no adverse construction noise impact is expected.

6.9. The operation noise of WACS facilities is mainly from the mechanical parts of the plant. These noises can also be treated directly; therefore, no adverse operation noise impact is expected.

6.10. Proven, cost-effective and environmentally benign technologies, coupled with the use of high efficiency drift eliminators for cooling towers should be promulgated to minimise the spread of Legionella bacteria.

6.11. The impacts arising from the construction waste, chemical waste, and the landscape and visual impacts can be tackled under the existing regulation; therefore, no adverse impact on these issues is expected.

Appendix A

Table A3.1 – The area of excess temperature in Victoria Harbour

Excess Temperature	**Wet Season**		**Dry season**	
	Surface	**Bed**	**Surface**	**Bed**
1ºC	1.08 km^2	0.00 km^2	0.92 km^2	0.00 km^2
2ºC	0.19 km^2	0.00 km^2	0.13 km^2	0.00 km^2
3ºC	0.05 km^2	0.00 km^2	0.01 km^2	0.00 km^2

Table 3.2 – The area of excess chlorine level in Victoria Harbour

Chlorine Level Exceeding	**Wet Season**		**Dry season**	
	Surface	**Bed**	**Surface**	**Bed**
0.0005 ppm	17.6 km^2	0.6 km^2	12.7 km^2	0.0 km^2
0.001 ppm	8.3 km^2	0.2 km^2	6.8 km^2	0.0 km^2
0.005 ppm	2.9 km^2	0.0 km^2	2.6 km^2	0.0 km^2
0.01 ppm	1.6 km^2	0.0 km^2	1.4 km^2	0.0 km^2
0.05 ppm	0.2 km^2	0.0 km^2	0.2 km^2	0.0 km^2

Table 3.3 – The area of excess biocide concentration in Victoria Harbour

Biocide Concentration Exceeding	**Wet Season**		**Dry season**	
	Surface	**Bed**	**Surface**	**Bed**
0.06 ppm	1.0 km^2	0.0 km^2	1.0 km^2	0.0 km^2
0.12 ppm	0.2 km^2	0.0 km^2	0.1 km^2	0.0 km^2
0.18 ppm	0.1 km^2	0.0 km^2	0.01 km^2	0.0 km^2

Table 3.4 – The area of excess temperature in Tolo Harbour

Excess Temperature	Wet Season		Dry season	
	Surface	Bed	Surface	Bed
1ºC	4.17 km^2	8.00 km^2	5.30 km^2	0.60 km^2
2ºC	0.09 km^2	2.30 km^2	1.40 km^2	0.40 km^2
3ºC	0.00 km^2	0.67 km^2	0.40 km^2	0.00 km^2

Table 3.5 – The area with of excess chlorine level in Tolo Harbour

Chlorine Level Exceeding	Wet Season		Dry season	
	Surface	Bed	Surface	Bed
0.0005 ppm	1.9 km^2	0.7 km^2	2.5 km^2	0.0 km^2
0.001 ppm	1.0 km^2	0.6 km^2	2.1 km^2	0.0 km^2
0.005 ppm	0.8 km^2	0.2 km^2	1.1 km^2	0.0 km^2
0.01 ppm	0.6 km^2	0.2 km^2	0.8 km^2	0.0 km^2
0.05 ppm	0.2 km^2	0.0 km^2	0.1 km^2	0.0 km^2

Table 3.6 – The area of excess biocide concentration in Tolo Harbour.

Biocide Concentration Exceeding	Wet Season		Dry season	
	Surface	Bed	Surface	Bed
0.06 ppm	4.0 km^2	8.0 km^2	5.0 km^2	0.6 km^2
0.12 ppm	0.1 km^2	2.0 km^2	1.5 km^2	0.4 km^2
0.18 ppm	0.0 km^2	0.5 km^2	0.5 km^2	0.0 km^2

Table 3.7 – The area of excess temperature determined by the Fine Grid model.

Excess Temperature	Wet Season		Dry season	
	Surface	Bed	Surface	Bed
1ºC	6.30 km^2	1.52 km^2	2.32 km^2	1.08 km^2
2ºC	1.53 km^2	0.11 km^2	0.46 km^2	0.00 km^2
3ºC	0.41 km^2	0.00 km^2	0.08 km^2	0.00 km^2

Table 3.8 – The area of excess chorine levels determined by the Fine Grid model.

Chlorine Level Exceeding	Wet Season		Dry season	
	Surface	Bed	Surface	Bed
0.0005 ppm	27.3 km^2	3.7 km^2	16.9 km^2	2.6 km^2
0.001 ppm	18.8 km^2	2.5 km^2	12.5 km^2	2.1 km^2
0.005 ppm	7.3 km^2	0.8 km^2	5.2 km^2	1.0 km^2
0.01 ppm	4.9 km^2	0.7 km^2	2.3 km^2	0.6 km^2
0.05 ppm	0.6 km^2	0.1 km^2	0.3 km^2	0.1 km^2

Table 3.9 – The area of excess biocide concentration determined by the Fine Grid model.

Biocide Concentration Exceeding	**Wet Season**		**Dry season**	
	Surface	**Bed**	**Surface**	**Bed**
0.06 ppm	6.0 km^2	1.5 km^2	2.0 km^2	1.0 km^2
0.12 ppm	1.5 km^2	0.1 km^2	0.5 km^2	0.0 km^2
0.18 ppm	0.4 km^2	0.0 km^2	0.1 km^2	0.0 km^2

Table 3.10 – The Predicted Noise Levels (PNL) (unmitigated and mitigated) at Possible NSRs

Type of NSR[1]	**Noise Criteria dB(A)[2]**	**Exceedance of Unmitigated PNL dB(A)**			**Exceedance of Mitigated PNL dB(A)[3]**		
		At 10 m	**At 50 m**	**At 100 m**	**At 10 m**	**At 50 m**	**At 100 m**
Site Formation / Clearance							
NSR1	75	17	3	N/A	10	N/A	N/A
NSR2	70	22	8	2	15	1	N/A
NSR3	65	27	13	7	20	6	N/A
Construction of Chiller Plant / Pumping Station							
NSR1	75	17	3	N/A	10	N/A	N/A
NSR2	70	22	8	2	15	1	N/A
NSR3	65	27	13	7	20	6	N/A
Construction of Infrastructure							
NSR1	75	17	3	N/A	10	N/A	N/A
NSR2	70	22	8	2	15	1	N/A
NSR3	65	27	13	7	20	6	N/A

Notes:

[1] NSR1 represents all domestic premises, temporary housing, hotels and hostels; NSR2 represents all education institutions and all others where unaided voice communication is needed; and NSR3 represents all education institutions (during examination).

[2] Daytime noise criteria: 75 dB(A) for residential premises; 70 dB(A) for educational institution (65dB(A) during examination).

[3] Mitigated by the use of “quiet” equipment.

Table 3.11 – The maximum allowable sound power level of plants that operated from 0700 hours to 2300 hours and 2300 hours to 0700 hours (the following day)

For operation from 0700 to 2300 hours						
ASR [1]	**ANL [2]**	**Maximum Allowable Sound Power Level for NSRs at Different Distance and Different ASR (dB(A))**				
		At 10 m	At 25 m	At 50 m	At 100 m	At 500 m
A	55	86	94	100	106	120
B	60	91	99	105	111	125
C	65	96	104	110	116	130
For operation from 2300 to 0700 hours						
ASR [1]	**ANL [2]**	**Maximum Allowable Sound Power Level for NSRs at Different Distance and Different ASR (dB(A))**				
		At 10 m	At 25 m	At 50 m	At 100 m	At 500 m
A	45	786	84	90	96	110
B	50	81	89	95	101	115
C	55	86	94	100	106	120

Notes:

[1] Area Sensitivity Rating

[2] Acceptable Noise Level in (dB(A)) is given in Table 2 of Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites (-5 dB(A) for planning purpose)

Table 3.12 – Summary of Results of Cooling Towers Water Quality Survey – Basin Water

Parameter	**No. of Samples**	**Maximum**	**Minimum**
Temperature (ºC)	374	41	21
pH	374	9.6	5.2
BOD5 (mg/L)	374	210	<4
COD (mg/L)	374	1500	<20
TSS (mg/L)	374	100	<3

Appendix B: SEM&A Schedule for Environmental Protection Measures - Environmental Impacts

SEA Report Ref.	Environmental Impacts	Environmental Protection Measures	Implementation Agent	Implementation Phase	Rationale/ Relevant Legislation/ Guidelines
	Water Quality / Ecology				
12.7.99-101	Corrosion, scaling and sediment fouling	Good treatment practice, in particular the use of proven technologies e.g. corrosion resistant materials, physical and environmentally friendly techniques. Use of approved chemicals approved by Regulator Office	Project Proponent Operator	Design, Construction & Operation	EMSD: Guidance of Pilot Scheme** Code of Practice for Prevention of Legionnaires' disease Recommendations of the WACS Study
	Biofouling and *Legionella*	Disinfection with environmentally friendly techniques including UV, Ozone and peroxide for fresh water cooling water Compliance with *Legionella* control requirements as recommended in Health Risk and Control Strategy Use of approved chemicals by Regulator Office. If chlorine based chemicals were used, the total residual chlorine concentration of the discharge should not exceed 0.3 mg/L		Design & Operation	
12.7.94 – 97	Discharge	Implementation of once-through seawater cooling system according to the prioritization of the prospective zones, in particular avoidance of the once-through seawater cooling system in ecologically sensitive zones e.g. Tolo Harbour, Deep Bay, etc. Compliance with the conditions of Consent of Discharge by Regulator Office for any surplus discharge to the existing sewerage system	Project Proponent Operator Regulator Office	Design, Construction & Operation	Recommendations of the WACS Study
	Air Quality				
12.2.15 – 18	Global warming and Ozone depletion refrigerants	Selecting appropriate refrigerants, in particular those with zero Ozone Depletion Potential (ODP) and Global Warming Potential (GWP); and code of practice for leakage prevention, recovery, re-use and recycle of the refrigerants	Project Proponent Contractor Regulator Office	Planning; Design; Construction; Operation & Decommissioning	
	Noise				
12.10.42 – 43	Operational noise	1. Use of acoustic enclosure and silencer 2. Proper orientation and configuration of vent	Project Proponent	Design & Operation	NCO, HKPSG, NQO*

Appendix B: SEM&A Schedule for Environmental Protection Measures - Environmental Impacts (continued)

SEA Report Ref.	Environmental Impacts	Environmental Protection Measures	Implementation Agent	Implementation Phase	Rationale/ Relevant Legislation/ Guidelines
	Heritage Resources				
12.12.4	Underground works	Carry out detailed heritage assessment to confirm the presence of heritage resources in the construction sites	Project Proponent	Planning; Design; Construction; Operation & Decommissioning	Antiquities and Monuments Ordinance
	Maintenance of underground facilities	AMO* guidelines for protection of heritage resources	Project Proponent	Design & Operation	AMO* guidelines
	Landscape & Visual				
12.13.1-3	Construction	1. Planning to install WACS facilities underground at seafront areas and inside existing urban parks to minimize inconvenience to the public 2. Avoidance of removal of existing vegetation 3. Installation of adequate hoarding to minimize visual effects	Project Proponent Contractor	Planning Design Construction Decommissioning	HKPSG, Section 10: Guidelines for Landscape and Visual Impact Assessment; Government General Regulation 740; TMEIAP*
12.13.4 - 5	Operation	Careful integration of the design of ventilation outlets of the underground plant room with the existing landscape, such as by planting vegetation around this structure, and by the use background-compatible colour	Project Proponent	Planning Design	

Notes

*	EIA	= Environmental Impact Assessment
	EIAO	= Environmental Impact Assessment Ordinance
	TMEIAP	= Technical Memorandum on Environmental Impact Assessment Process
	APCO	= Air Pollution Control Ordinance
	OLPO	= Ozone Layer Protection Ordinance
	AQO	= Air Quality Objectives
	NSRs	= Noise Sensitive Receivers
	NCO	= Noise Control Ordinance
	HKPSG	= Hong Kong Planning Standards and Guidelines
	WCPO	= Water Pollution Control Ordinance
	WDO	= Waste Disposal Ordinance
	AMO	= Antiquities and Monuments Office

**	CPSSCT	= Cooling Tower System
	DCS	= District Cooling System
	CSS	= Centralized Piped Seawater Supplies for Condenser Cooling or Central Seawater Scheme
	Pilot Scheme	= Pilot Scheme for Wider Use of Fresh Water in Evaporative Cooling Towers for Energy-efficient Air Conditioning Systems