6. WATER QUALITY IMPACT

6.1 Introduction

6.1.1 This chapter presents the assessment of potential water quality impacts which may arise during the construction and operation phase of the proposed third golf course. Construction phase impacts to water quality sensitive receivers could arise from silty water run-off from works areas as well as the various construction works associated with the proposed third golf course. Operation phase impacts to water quality sensitive receivers could arise from chemical-contaminated run-off from managed turfgrass areas, salinized discharge from the desalination plant and additional discharge load from the existing sewage treatment works.

6.1.2 As specified in the EIA Study Brief, the assessment area for water quality impact assessment shall cover the Project area, plus any stream courses and associated water systems in the vicinity which may be affected by the Project. A water quality monitoring programme will be devised to build on the earlier monitoring work and provide important data for feedback into the Turfgrass Management Plan (TMP), monitor pollution effects at sensitive sites in terms of potential water quality impacts, and monitor long term trends of water quality during the operation phase of the golf course.

6.2 Environmental Legislation, Policies, Standards and Criteria

6.2.1 The following relevant legislation and associated guidelines are applicable to the evaluation of water quality impacts associated with the construction and operation of the Project:

- Environmental Impact Assessment Ordinance (Cap. 499. S.16), Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM), Annexes 6 and 14;
- Water Pollution Control Ordinance (WPCO);
- Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (WPCO, Cap. 358, S.21);
- Hong Kong Planning Standards and Guidelines (HKPSG); and
- Practice Note for Professional Persons (ProPECC), Construction Site Drainage (PN1/94).

6.2.2 The Water Pollution Control Ordinance (WPCO, Cap 358) provides the major statutory framework for the protection and control of water quality (WQ) in Hong Kong. According to the Ordinance and its subsidiary legislation, the whole of the Hong Kong waters are divided into ten Water Control Zones (WCZs) and four supplementary WCZs. Water Quality Objectives (WQOs) were established to protect the beneficial uses of WQ in the WCZs. The proposed third Golf Course at Kau Sai Chau lies within the Port Shelter WCZ and the water quality sensitive receivers (WSRs) which may be affected by the Project works are located with the same WCZ. The WQOs for the Port Shelter WCZ are used as the basis for assessment of water quality impacts in this EIA Report. Extracts of the corresponding WQOs for the Port Shelter WCZ are listed in Table 6.1.

Table 6.1 Water Quality Objectives for Port Shelter WCZ

Parameter	Objectives	Part or parts of Zone
Dissolved Oxygen (DO)	(a) 2m of seabed: $\geq$ 2 mg/L (b) Depth-averaged: $\geq$ 4 mg/L	Marine waters excepting Fish Culture Subzones
	(c) 2m of seabed: $\geq$ 2 mg/L (d) Depth-averaged: $\geq$ 5 mg/L	Fish Culture Subzones
	$\geq$ 4.0 mg/L	Inland water
Bacteria	Annual geometric mean for depth-averaged *E. coli* $\leq$ 610cfu/100mL	Secondary Contact Recreation Subzone and Fish Culture Subzones
Salinity	Change of ambient salinity level $\leq$ 10%	Whole zone
Suspended Solid (SS)	Rise in ambient SS level: < 30% Not give rise to accumulation of SS which may adversely affect aquatic communities	Marine water
	Annual median $\leq$ 25 mg/L	Inland water
Unionized Ammonia	$\leq$ 0.021 mg/L	Whole zone
Temperature	Change of natural daily temperature range $\leq$ 2°C	Whole zone
pH	In range of 6.5 - 8.5 units, change of natural pH range $\leq$ 0.2 units	Marine water except Bathing Beach Subzones

	In range of 6.0 – 9.0 units, change of natural pH range ≤ 0.5 units	Bathing Beach Subzones
Nutrients	Annual mean depth-averaged inorganic nitrogen ≤ 0.1 mg/L	Marine waters
	Not cause excessive or nuisance growth of algae or other aquatic plants	Marine waters
BOD_5	≤ 5 mg/L	Inland waters
COD	≤ 30 mg/L	Inland waters
Turbidity	No changes in turbidity or other factors arising from water discharges shall reduce light transmission substantially from the normal level	Bathing Beach Subzones
Dangerous substances	Not attain the levels as to produce significant toxic effects in humans, fish or any other aquatic organisms with due regard to biologically cumulative effects in food chains and to toxicant interactions with each other.	Whole zone
	Not cause a risk to any beneficial use of the aquatic environmental.	Whole zone
Colour	≤ 50 Hazen units	Inland waters
Visible foam, oil scum, litter	Not to be present	Whole zone
Odour	Not cause objectionable odours	Whole zone
Phenol	Not be present in such quantities as to produce a specific odour, or in concentrations ≥ 0.05 mg/L as C_6H_5OH	Bathing Beach Subzones

Note: the specified limits are concerning the change due to the waste discharge.

6.2.3 To determine the criteria for water quality assessment in this EIA, relevant water quality parameters were selected for review in this study. These selected parameters cover a broad spectrum of stressor which are important in the EIA context, including SS, DO, Salinity, Ammonia Nitrogen (NH_3-N), Total Inorganic Nitrogen (TIN), Nitrite Nitrogen (NO_2-N), Nitrate Nitrogen (NO_3-N), Total Kjeldah Nitrogen (TKN), Total Phosphate (TP), Ortho-phosphate (Ortho-P), Chlorophyll-a and Pesticides. Details of the review are presented in the Section 6.4.

6.3 Summary of Turfgrass Management Plan (TMP)

6.3.1 The use of turfgrass chemicals (fertilizers and pesticides) will be a key environmental issue for the Project. Generally, operation of the new golf course is not expected to have any significant impact on the marine environment. This is borne out by the proposed duplication of active wastewater and run-off reuserun-off, as operated on the existing courses, and the closed system being operated in relation to run-off. Turfgrass has been demonstrated to be an effective filter, and virtually eliminates erosion run-off (Appendix A6.2). The existing course monitoring programme has been designed accounting for the fact that run-off is likely to be minimal, and the same approach to monitoring will be adopted in the proposed third golf course. Consequently, impacts are not expected in open areas of water around Kau Sai Chau. The performance of the TMP will be assessed in terms of the quality of turf produced in line with the stated objectives of water and nutrient conservation and chemical minimisation.

6.3.2 Four chemicals are used for existing golf courses. These are nitrogenous fertilizers, herbicides, fungicides and insecticides. The approach should be to minimise application of fertilizers, and is also driven by economic requirements to minimise recurrent costs (A case where environmental protection and economic expediency work together).

6.3.3 The two existing courses are planted with bermuda grass, a grass species popular for golf courses. Bermuda grass must be irrigated using fresh water. To reduce fresh water consumption on the proposed third golf course, Paspalum "Sea Isle 2000" for greens and *Paspalum Vaginatum* for fairways and tees are selected. Paspalum is a perennial, warm season, sod forming grass. It is also a halophytic (salt tolerant) grass with salinity tolerance ranges among the highest of turfgrass species. Seashore paspalum has a much lower fertilizer and water requirement than Bermuda grasses. This turf is well suited to handle difficult growing conditions between January and April in Hong Kong. All turf planted on greens, tees and fairways will be certified and tested for purity to minimise management control efforts in the long term.

6.3.4 Healthy growth rates are achieved when the grass is not over fertilized or over watered. A balanced programme allows the grass to stand up to wear and develop disease resistance. As with the existing golf courses, the use of sub-surface drainage systems can ensure all soils are free-draining and avoid accumulation of surplus surface water. It can also greatly reduce the associated turf maintenance problems in the future.

6.3.5 Nutrient status in soil will be monitored 3 times per year, which helps to determine the optimum nutrient provisions for turf grass. In addition, slow release fertilizer will be used, together with spoon feeding through foliar applications, to minimise the potential for nutrient leaching. Paspalum has a relatively low nitrogen requirement compared with Bermuda. To minimize the potential for nitrogen run-off, applications will not be made if heavy rain is forecastrun-off.

[t1]

6.3.6 All pesticides used on the proposed third golf course must be registered under the Pesticide Ordinance. The following pesticide inventory has been identified for more regular use on the proposed third golf course and will be stored at the golf course maintenance workshop:[t2]

a) Fungicides, including Iprodione (Rovral), Chlorothalonil (Daconil), Manocozeb and Fosetyl Aluminium (Alliete)*.
b) Herbicides, including Oxadiazon (Ronstar)*, Imazaquin (Image), Glyphosate (Roundup) and 2,4-D/Mecoprop (2,4-D/MCPP)*;
c) Insecticides, including Chlorpyrifos, Fipronil (Chipco Choice) and Imidacloprid (Merit).
d) Biopesticides products include *Bacillus thuringiensis**.

Note: * - Pesticide is not included in the current pesticides list at the existing golf courses but will be applied in the proposed third golf course.

Disease control and fungicides

6.3.7 [t3]Seashore Paspalum does not have the wide variety of pathogen problems which tend to affect other warn season grasses, probably due to the fact that it evolved in a wet, humid ecosystem with multiple disease exposure, where surviving ecotypres have developed resistance.

6.3.8 The Paspalum grasses chosen for the proposed third golf course at Kau Sai Chau are noted as some of the most disease resistant varieties available that are adaptable to the Hong Kong environment. Hong Kong's weather is conducive to fungal attacks at certain times of the year. Disease prevention through a balanced nutritional programme in association with cultural methods and a well-developed maintenance regime will provide conditions which limit grass susceptibility to fungal attack. Conditions on the proposed third golf course will be open with low vegetation and good air movement. This air movement will reduce the amount of moisture surrounding the leaf surface thereby discouraging dew formation which is one of the major causes of fungal infection.

6.3.9 Saturated soil profiles have been proven to contribute to disease outbreaks. With the United State Golf Association (U.S.G.A.). Method of Putting Green Construction and free draining sand fairways, the soil profiles are not expected to become saturated.

6.3.10 Thus both the two major contributors to turf grass diseases in Hong Kong can be minimized by the use of a widely accepted construction method and a well ventilated location. Disease attacks should therefore be minimal and easily contained. Disease resistance can be controlled in most cases through a balanced nutritional programme in association with cultural and irrigation practices and the minimal use of fungicides. The use of salt water will also be explored as a bio-control for disease treatment.

6.3.11 The degradation of Aliette (newly proposed fungicide at the proposed third golf course) proceeds through the hydrolysis of the ester bond, resulting in the formation of phosphorous acid and ethanol. The ethanol is further degraded into carbon dioxide. The potential for groundwater and/or surface water contamination by fosetyl-Al and its degradates is expected to be very low, due to the rapid degradation (half life is less than 2 days) of the compound in soil to non-toxic degradates under both aerobic and anaerobic conditions. No adverse effects to groundwater/surface water are anticipated.

Weed Control and herbicide requirements

6.3.12 Close Paspalum mowing heights provides a tight dense canopy that deters aggressive growth in most weeds. With good cultural mowing practices, it is estimated that 90% of the weed species would be smothered by the dense Paspalum grass covering. Grass density is created through a close and frequent mowing schedule. All turf supplied for planting of the proposed third golf course will be certified and tested. Tight quality control measures will ensure a mono-stand of pure turf from the beginning, reducing any requirement for Herbicide control on an ongoing basis.

6.3.13 Mechanical methods (hand pulling) of removing turfgrass weeds will be the primary means of control. Broad leaved weeds will be removed mechanically by the course maintenance staff. Paspalum has been used widely on salt-affected sites due to its high tolerance for saline water. In such cases most weeds are suppressed or eradicated by the high salinity. The localized use of salt water will be explored as a means of weed control through spot spraying which should be sufficient to eradicate most annual grass and broadleaf weed problems. An additional weed control strategy will be the use of rock salt in the form of spot application to problem weeds, followed by light irrigation (too much water will dilute the salt-enhanced stress and diminish weed control effectiveness).

6.3.14 Herbicides will only be used under extreme cases when persistent weeds need to be removed. These will be controlled by means of chemical applications. One application or at most a second light application will normally suffice in removing unwanted weeds. Herbicides will only be applied in select areas on dry days with very little air movement to reduce the risk of spray drift to non-targeted areas. It should be the objectives of the Golf Course Superintendent (GCS) to avoid establishment of weeds through good management and cultural practices and to avoid the use of herbicides wherever possible.

6.3.15 A single application of pre-emergent herbicide Ronstar (newly proposed herbicide) would be made at the time of planting (establishment) only. This application is unavoidable and necessary as the main aim is to reduce infestation of weeds to the planted Paspalum during establishment period and to maintain the monoculture of planted turf, and it can greatly reduce the long-term weed control requirements during the operation phase of the golf course. Herbicides will only be applied in the form of spot applications where cultural maintenance, mowing practices, and salty water treatments have failed.

6.3.16 [t4]Oxadiazon, which is the active ingredient of Ronstar, (newly proposed herbicide) has low environmental mobility which is bound strongly by soil colloids and humus. With the short half-life (less than 2 days), low migration or leaching potential are expected. 2,4-D/Mecoprop is applied post emergence and is used on sports turf for selective control of creeping broadleaf weeds. It has a relatively short half-life and is rather immobile in the soil. Its average half-life in soils ranged from 13 days to 21 days. The average half-life in grass was 6.1 days and 6.9 days in thatch. It is considered a biodegradable compound. Under normal conditions, the residues are not persistent in soil, water, or vegetation.

Insect control and insecticide applications

6.3.17 [t5]The most common invertebrate pests likely to be found on Kau Sai Chau are Armyworm, Cut Worms and Sod Webworm, Mole Crickets, and White Grubs (family *Scarabaeidae*). White Grubs and Army Worms are usually detected by the feeding habits of the local Magpie (Pica pica). Mole Crickets push mounds of soil above the turf and destroy roots and tear plants from their growing places. Insect invasions will be most prevalent during the turf establishment stage when the roots and stems of the plant are at a young and immature stage. Whilst chemical control is considered an important component in controlling insect populations, it forms only part of an integrated pest management approach and will only be used as a last resort. By understanding the lifecycle of insects, the most sensitive point in their life cycle when they can be effectively controlled can be determined.

6.3.18 [t6]*Bacillus thuringiensis* (newly proposed bio-pesticides) produces crystal proteins their effect on the host by causing lysis of midgut epithelial cells, which leads to gut paralysis. The insect stops feeding and if it does not recover eventually dies. From the Bt crystal protein's mode of action, it can be inferred that at least four parameters are involved in crystal protein function:1) effectiveness of solubilization, 2) efficiency of protoxin-toxin conversion, 3) specific membrane receptor binding, and 4) specificity of a crystal protein (insecticidal spectrum). The short half-life of Bt is mainly due to ultraviolet inactivation when topically applied on site. Changes in soil productivity and fertility due to Bt are not likely because Bt's natural occurrence in soil, lack of accumulation, and relatively short persistence.

6.3.19 An important benefit of microbial control agents is that they can be used to replace, at least in part, some chemical pest control agents. It is not necessary to guarantee replacing all of the chemical pesticides with microbial agents would have fewer environmental risks. Bio-pesticides will be used on first detection of pests or when seasonal conditions indicated pest outbreaks are probable at Hole 5 and part of Hole 6. It gives an opportunity to test biological products on a limited scale and in a highly controlled manner. Biological products that are proven to be effective and safe could then be considered for wider application across all three courses. The point of using the bio-pesticides is to try to prevent threshold levels being reached at early stage.

Environmental fate for proposed pesticides frequently used at the proposed third golf course

6.3.20 Pesticides concentrations (selected representative for the existing golf courses monitoring) measured at all marine and freshwater locations are well below the pesticides reporting limit (0.5 µg/L) over 9 years at the existing golf courses.

6.3.21 The proposed third golf course is an extension (to the southeast side of the Kai Sai Chau Island) from the existing golf courses and the whole proposed third golf course is within the Kau Sai Chau Island. Types of the diseases, weeds and pests found at the proposed third golf course in future are expected to be fairly similar to the existing golf courses. The usage of pesticides at the proposed third golf course in terms of application frequency will, therefore, similar to the existing golf courses practices.

6.3.22 Similar approach of the specific turfgrass management plan will extend from the existing golf courses to the proposed third golf course. Physical soil characteristics, soil moisture, pH and soil temperature (which may have an effect on the pesticides degradation rate/pathway) at the new proposed third golf course have the same soil type and turfgrass management approach and control as the existing golf courses. Therefore, pesticides degradation rate/pathway (for those have been applied at the existing golf courses over the past 10 years) at the proposed third golf course should be no significant change in future third golf course operation when it compares with the existing golf courses.

6.3.23 Pesticides apply to the existing golf courses which will also apply to the proposed third golf course. In addition, environmental friendly pesticides will also introduce to the proposed third golf course turfgrass management plan. The characteristics of the newly proposed pesticides at the proposed third golf course are as follows:

(i) Shorter half-life than the pesticides use at the existing golf courses – non-persistence in nature (the average length of time to reach one-half of the originally applied dosage is much shorter);

(ii) Bio-pesticides (such as *Bacillus thuringiensis*) will be applied at the Hole 5 and part of Hole 6 – less chemical application is expected at the proposed third golf course; and

(iii) New turfgrass (Seashore paspalum) is selected at the proposed third golf course which is more disease resistance and higher salt tolerance than the turfgrass at the existing golf courses (Bermuda grass), lower pesticides application frequency is expected at the proposed third golf course. In addition, localized use of salt water application can be an alternative of weed control than chemical.

6.3.24 Mode of pesticides actions and their environmental fates in soil and water for proposed pesticides will be frequently used at the proposed third golf course is shown in Appendix A6.2. In summary, all of the proposed pesticides for the third golf course have a low leaching potential to environment. For those newly recommended pesticides, they are more environmentally friendly due to their short half life which can further minimize the leaching concern during the operation phase of the third golf course. With the proposed closed low flow drainage system, filter system (nutrient and pesticides removal) and biopesticides application at Hole 5 and part of Hole 6, no significant impact on the water quality during the operation phase of the proposed third golf course is expected. With the incorporation of intensive EM&A monitoring on water quality during the construction and operation phases of the proposed third golf course (in addition to the existing golf courses ecology and water quality monitoring), water quality should be within an acceptable WQO standards of Port Shelter in future.

Fertilizer requirement

6.3.25 [t7]The objective of the TMP with respect to fertilization is to minimize application. At certain times of a year, nitrogenous fertilizers will be applied to a programme suited to Paspalum turf and the prevailing soil conditions that will be determined through soil testing. Relative to other turf grass, Paspalum has a lower requirement for Nitrogenous fertilizer. Paspalum fertilization requirements differ substantially from Bermuda grass requirements with a Nitrogen to Potassium ratio of 1:2 or 1:3, depending on prevalent soil conditions. Iron applications will also be made since this will increase chlorophyll content and also harden plant cells increasing resistance to trampling. Micro nutrients will only be applied if soil test results indicate deficiencies. None of the Nitrogen, Phosphate, and Potassium (NPK) based fertilizers will contain trace elements as this can lead to an imbalance in nutrients.

6.3.26 Paspalum grass requires its own specialized management techniques. Healthier growth rates are achieved when the grass is not over fertilized or over watered. A balanced fertilizer and watering programme would allow the grass to stand up to wear and develop disease resistance.

6.3.27 Nutrient status will be monitored every three months of the year through soil testing to determine the nutrient status and overall health of the soil. This helps integrate into the nutritional programmes for the grass with the nutrient requirements found to be necessary through the laboratory tests. Tests help determine the optimum nutrient provisions for turf grass. To help maintain an even balance of nutrient supply that is not greatly affected by environmental conditions, slow release fertilizers will be used, together with spoon feeding through foliar applications. This practice will ensure that there would be no nutrient loading within the soil and efficient turf nutrient uptake, minimizing potential for nutrient loss from the soil.

6.3.28 Major organic products used on the existing golf courses at the proposed third golf course are as follows:

- Terralift TX-10 NPK 4:2:8(greens grade);
- Terralift Outfield NPK 6:2:4 (fairway grade);
- Terralift (Rocastem, Java, Plantmax, and soil max products) = microbial feeds; and
- Sustain NPK 5:2:10 (greens grad and fairway grade);

6.3.29 The above products would be used as part of an overall program in conjunction with inorganic slow release NPK fertilizers which would vary depending on soil tests (organic fertilizers would account for between 30-50% of total fertilizer used).

6.3.30 Fertilizers provide nutrients to plants for healthy growth and development. Fertilizers are classified into two groups: organic and inorganic. Organic fertilizers come directly from plant or animal sources while inorganic fertilizers come from naturally occurring petroleum or mineral deposits.

6.3.31 The advantage of organic fertilizers is that they improve the structure of the soil. It will retain more of their nutrients and water, have superior aeration for strong root development, require less chemical fertilizers, require less watering and become easier to cultivate.

6.3.32 The advantage of inorganic chemical fertilizers is that they contain much higher concentrations of nutrients. Thus, much less fertilizer in terms of quantity needs to be applied. In addition, their nutrients are immediately available to plants. In contrast, organic products must be decomposed by soil microbes before nutrients become available to plants. This decomposition process may not rapid enough to satisfy the needs of a rapidly growing plant, causing a nutrient deficiency.

6.3.33 The main reason for not relying on a completely organic program in the existing and proposed third golf courses is that a balance needs to be established to maintain a healthy soil profile. If the only means of fertilization is organic, this will lead to organic layering in the sand soil profile as the organic matter continues to build quicker than it can be broken down. This layer is easily compressed and non-porous to air and water resulting in saturation just below the surface. The restricted flow of air to the root system which begins forming black layer and root death because of anaerobic conditions. The combination of organic and inorganic fertilizers for the golf courses is the best practices to ensure the turf health, soil health and reduce the chances of leaching occur.

Records

6.3.34 At the existing Jockey Club Kai Sai Chau golf course, all applications of fertilizer and pesticide are well documented including the following details:

- Location of applications;
- Type of fertilizer applied;
- Amount applied in kg per hectare;
- Date of applications; and
- Product applied.

Buffer Zones and No spray areas

6.3.35 Buffer zones have been identified at all sensitive stream areas (Figure 6.6b). No spraying of fertilizer and pesticides will be allowed within these designated buffer zones during operation phase of the proposed golf course. Vegetative buffer zones of 5 meters have been established and designated as no-spray area (fertilizer and pesticides) around all of the new lakes in the proposed third golf course.

[t8]

6.3.36 Details for nutrients and pesticides application for the proposed third golf course have been incorporated into the turfgrass management guideline (Appendix A6.4).

6.4 Review of Existing Water Quality

Marine Water

6.4.1 The Environmental Protection Department routinely measures water quality to ensure compliance with statutory WQOs. Any development with a potential to degrade water quality must show that the associated activities will not affect the water quality adversely. The study area, comprising the marine waters which may be affected by the construction and operation of the new golf course, is within the Port Shelter WCZ, all of which is designated for secondary contact recreation and, as such, has an WOQ for *E.coli*, which needs to be met. The construction and operation of the proposed third golf course may also raise suspended solids level, increase nutrients (fertiliser) and introduce toxic substances (pesticides).

6.4.2 The characteristics and the baseline water quality conditions of the Port Shelter WCZ that may be affected by the Project have been reviewed in this section. At present, the Routine Monitoring Programme conducted by EPD provides the most comprehensive spatial and temporal marine water quality data, and these data may be used to represent the baseline water quality conditions.

6.4.3 The marine baseline water quality conditions were determined from the integrated data collected between 1998 and 2003 from all monitoring stations (i.e. PM1, 2, 3, 4, 6, 7, 8, 9 & 11) within the Port Shelter.

6.4.4 The water quality in the Port Shelter WCZ is among the best in the territory, with high dissolved oxygen (DO) and low turbidity, nutrients, and *E. coli* bacteria. The water quality at various monitoring stations near the existing and proposed third golf courses in the Port Shelter WCZ is fairly uniform. Yearly water quality monitoring data (1998-2003) at all Port Shelter monitoring locations are presented in Figures 6.1a and 6.1b.

6.4.5 The suspended levels at all marine monitoring locations are low (1.4 – 4.3 mg/L) in 1998-2003. In general, surface water has a lower concentration of suspended solids than the water at bottom level. Same trend has been recorded for the turbidity level in average value of 9.4 mg/L (0.4 mg/L – 23.9 mg/L). The pH values was ranging from 6.7 to 8.8 (95^{th} percentile = 8.4) in 1998-2003.

6.4.6 Marine monitoring data shows that all marine monitoring locations comply with Total Inorganic Nitrogen (95^{th} percentile = 0.087 mg/L; < 0.1 mg/L), unionized ammonia (95^{th} percentile = 0.004 mg/L; < 0.021 mg/L) and E. coli (95^{th} percentile = 35.5 cfu/100mL; < 610 cfu/100mL) WQOs for the Port Shelter WCZ throughout the years from 1998-2003. Low level for the Total Phosphate was also recorded at all monitoring locations (95^{th} percentile = 0.024 mg/L). The range of the Chlorophyll-a was 1.7 to 3.2 µg/L in 1998-2003.

6.4.7 Similar to other Hong Kong waters, the Port shelter WCZ experienced a moderate decrease of DO by 0.6 mg/L (10%) in 2003. The annual mean DO levels at nine monitoring stations ranged from 5.8 mg/L to 6.0 mg/L. Nevertheless, the DO levels at depth-averaged and surface at all locations comply with the WQOs for the Port Shelter WCZ from 1999-2003 (Figure 6.1c).

6.4.8 Based on the Marine Water Quality Report (2003), a notable decrease in nitrogen (NH_4-N, TKN, TN) was observed at all stations in 2003. The Port Shelter WCZ had the best WQO compliance amongst all the WCZs in 2003, and fully achieved its WQO between 1999 and 2003. There is a decreasing trend in total nitrogen, total phosphorus and *E. coli* at the inner bay (stations PM2 and PM5). This could be attributed to the upgrading of Sai Kung Sewage Treatment Works and provision of sewerage infrastructure to the villages.

Existing Golf Courses

6.4.9 Prior to construction of the existing golf courses, a baseline monitoring exercise was carried out to establish the existing conditions at the time. During construction phase monitoring, the only activity having a potential to impact on marine water quality was the dam construction. Regular monitoring was carried out with a proviso that it would become more frequent if there were indications that water quality was deteriorating.

6.4.10 The monitoring exercise was then extended to the operation phase and is currently still being carried out regularly on a quarterly basis. Table 6.2 shows marine water quality during the operation phase of the existing North and South course (1995-2004). The marine and freshwater monitoring locations are shown in Figures 6.2 and 6.3.

6.4.11 The potential discharge points at the existing golf course during heavy storm events are at the existing reservoir and the outlet of the existing marsh, with Marine C and Marine B being the nearest marine monitoring locations respectively. For inland water monitoring locations, location A and D are the final receptors for the existing reservoir and the existing marsh respectively.

Table 6.2 Marine Water Quality Monitoring Result (1995 to 2004) for Existing Golf Course

Station	Year	DO (mg/L)	Temp (ºC)	pH	Turbidity (NTU)	Salinity (ppt)							
Marine A	1997	7.81	19.0	8.17	2	30.1							
		Ammonia Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	TIN (mg/L)	TKN (mg/L)	Unionized Ammonia (mg/L)	Total PO_4 (mg/L)	Ortho PO_4 (mg/L)	Chl a (μg/L)	Chlorpyrifos (μg/L)	Diazinon (μg/L)	Iprodione (μg/L)	Mancozeb (μg/L)
	1996	<0.05	<0.005	0.03	0.09	0.10	0.002	<0.005	<0.005	10	<0.5	<0.5	<0.5	-
	1997	<0.05	<0.005	0.03	0.09	0.37	0.003	0.05	<0.005	7	<0.5	<0.5	-	<0.5
	1998	<0.05	<0.005	0.01	0.06	0.30	0.003	0.02	<0.005	<5	-	<0.5	-	<0.5
	1999	<0.05	<0.005	0.01	0.06	0.13	0.002	0.02	<0.005	<5	<0.5	<0.5	-	<0.5
	2000	-	-	0.01	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2001	-	-	0.01	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2002	-	-	0.04	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2003	-	-	0.01	-	-	-	<0.1	-	-	--	<0.5	--	<0.5
	2004	-	-	0.01	-	-	-	<0.1	-	-	--	<0.5	--	<0.5
Station	Year	DO (mg/L)	Temp (ºC)	pH	Turbidity (NTU)	Salinity (ppt)							
Marine B	1997	6.81	28.7	7.95	4	30.2							
		Ammonia Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	TIN (mg/L)	TKN (mg/L)	Unionized Ammonia (mg/L)	Total PO_4 (mg/L)	Ortho PO_4 (mg/L)	Ch a (μg/L)	Chlorpyrifos (μg/L)	Diazinon (μg/L)	Iprodione (μg/L)	Mancozeb (μg/L)
	1996	<0.05	<0.005	0.03	0.09	0.20	0.001	<0.005	<0.005	<5	<0.5	<0.5	<0.5	-
	1997	<0.05	<0.005	0.05	0.10	0.38	0.003	0.06	<0.005	8	<0.5	<0.5	-	<0.5
	1998	<0.05	<0.005	0.01	0.06	0.22	0.002	0.02	<0.005	<5	-	<0.5	-	<0.5
	1999	<0.05	<0.005	<0.01	0.06	0.23	0.002	0.09	<0.005	<5	<0.5	<0.5	-	<0.5
	2000	-	-	0.02	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2001	-	-	0.02	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2002	-	-	0.05	-	-	-	<0.1	-	-	-	<0.5	-	<0.5

	2003	-	-	0.04	-	-	-	<0.1	-	-	--	<0.5	--	<0.5
	2004	-	-	0.01	-	-	-	<0.1	-	-	--	<0.5	--	<0.5
Station	**Year**	DO (mg/L)	Temp (°C)	pH	Turbidity (NTU)	Salinity (ppt)								
Marine C	1997	6.44	27.9	7.97	2	30.4								
		Ammonia Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	TIN (mg/L)	TKN (mg/L)	Unionized Ammonia (mg/L)	Total PO_4 (mg/L)	Ortho PO_4 (mg/L)	Ch a (μ g/L)	Chlorpyrifos (μ g/L)	Diazinon (μ g/L)	Iprodione (μ g/L)	Mancozeb (μ g/L)
	1996	<0.05	<0.005	**0.31**	**0.37**	0.50	0.002	<0.005	<0.005	<5	<0.5	<0.5	<0.5	-
	1997	<0.05	<0.005	0.03	0.08	0.34	0.002	0.07	<0.005	<5	<0.5	<0.5	<0.5	-
	1998	<0.05	<0.005	0.02	0.08	0.22	0.002	0.09	<0.005	<5	<0.5	<0.5	-	<0.5
	1999	<0.05	<0.005	0.01	0.07	0.43	0.002	0.06	<0.005	<5	-	<0.5	-	<0.5
	2000	-	-	0.01	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2001	-	-	0.01	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2002	-	-	0.04	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2003	-	-	0.02	-	-	-	<0.1	-	-	--	<0.5	--	<0.5
	2004	-	-	0.02	-	-	-	<0.1	-	-	--	<0.5	--	<0.5

Station	**Year**	DO (mg/L)	Temp (°C)	pH	Turbidity (NTU)	Salinity (ppt)								
Tai Tau Chau	1997	6.84	28.4	8.10	3	30.1								
		Ammonia Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	TIN (mg/L)	TKN (mg/L)	Unionized Ammonia (mg/L)	Total PO_4 (mg/L)	Ortho PO_4 (mg/L)	Ch a (μ g/L)	Chlorpyrifos (μ g/L)	Diazinon (μ g/L)	Iprodione (μ g/L)	Mancozeb (μ g/L)
	1996	<0.05	<0.005	0.01	0.06	0.40	0.002	0.06	<0.005	<5				
	1997	<0.05	<0.005	0.02	0.07	0.33	0.002	0.05	<0.005	<5	<0.5	<0.5	<0.5	-
	1998	<0.05	<0.005	0.01	0.06	0.26	0.001	0.04	<0.005	<5	<0.5	<0.5	-	<0.5
	1999	<0.05	<0.005	0.01	0.06	0.20	0.002	0.05	<0.005	<5	-	<0.5	-	<0.5
	2000	-	-	0.03	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2001	-	-	0.02	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2002	-	-	0.03	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2003	-	-	0.04	-	-	-	<0.1	-	-	--	<0.5	--	<0.5
	2004	-	-	0.02	-	-	-	<0.1	-	-	--	<0.5	--	<0.5
Station	**Year**	DO (mg/L)	Temp (°C)	pH	Turbidity (NTU)	Salinity (ppt)								
Kai Lung Wan	1997	8.26	29.9	8.18	1	29.8								
		Ammonia Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	TIN (mg/L)	TKN (mg/L)	Unionized Ammonia (mg/L)	Total PO_4 (mg/L)	Ortho PO_4 (mg/L)	Ch a (μ g/L)	Chlorpyrifos (μ g/L)	Diazinon (μ g/L)	Iprodione (μ g/L)	Mancozeb (μ g/L)
	1996	<0.05	<0.005	0.01	0.06	0.40	0.002	0.06	<0.005	<5				
	1997	<0.05	<0.005	0.01	0.06	0.39	0.001	0.07	<0.005	<5	<0.5	<0.5	<0.5	-
	1998	<0.05	<0.005	0.01	0.06	0.24	0.001	0.06	<0.005	<5	<0.5	<0.5	-	<0.5
	1999	<0.05	<0.005	0.01	0.06	0.29	0.002	0.05	<0.005	<5	-	<0.5	-	<0.5
	2000	-	-	0.04	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2001	-	-	0.02	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2002	-	-	0.04	-	-	-	<0.1	-	-	-	<0.5	-	<0.5
	2003	-	-	0.02	-	-	-	<0.1	-	-	--	<0.5	--	<0.5
	2004	-	-	0.02	-	-	-	<0.1	-	-	--	<0.5	--	<0.5

Remarks:

All pesticides are measured below the reporting limit (0.5 µg/L) over 9 years of monitoring results at the existing golf courses. Therefore, <0.5 µg/L is used as the worst case scenario for concentration of pesticides at the proposed third golf course.

Bold : Exceedance to Table 6.4 guideline value

When value is has the < sign, it is smaller than reporting limit.

Unioinzed ammonia (calculated value).

Inland Water

6.4.12 No EPD river water quality data are available for the identified streams within the study area. Site visits during the dry season revealed that the majority of the streams had extremely low flow at upstream areas. The vicinity of the proposed third golf course has never been developed and there is no evidence of direct discharge of run-off to the streams in the area. A heavily silted stream (Stream A) is identified within the proposed third golf course boundary (please refer to Chapter 8 Terrestrial Ecology Chapter for further details), mainly resulting from silty run-off from the eroded slopes over the years.

Existing Golf Course

6.4.13 During the operation of the existing golf courses, continuous monitoring of water quality at the irrigation reservoir, lake 1, lake 15/29 and pond after marsh have been carried out since July 1995. A summary of inland water monitoring results from 1996 to 2004 are presented in Table 6.3. Some areas of the courses have been subject to periodic chemical treatment to ensure suitable playing conditions, and the focus of the monitoring programme was to monitor potential impacts of the Turfgrass Management Plan (TMP) i.e. pesticides and fertilizer products migrating off-site. Water quality results are reviewed in conjunction with data (such as soil tests) obtained directly by the Golf Course Superintendent (GCS) to initiate changes to fertilizer and chemical applications as appropriate.

Table 6.3 Inland Water Quality Monitoring Result (1995 to 2004) for Existing Golf Course

Station	Year	DO (mg/L)	Temp (ºC)	pH	Turbidity (NTU)	Salinity (ppt)								
Lake 1	1997	9.55	29.3	6.83	57	0								
		Ammonia Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	TIN (mg/L)	TKN (mg/L)	Unionized ammonia (mg/L)	Total PO_4 (mg/L)	Ortho PO_4 (mg/L)	Chl a (μg/L)	Chlorpyrifos (μg/L)	Diazinon (μg/L)	Iprodione (μg/L)	Mancozeb (μg/L)
	1996	**0.62**	**0.31**	**3.22**	**4.1**	**1.4**	0.003	**0.16**	0.05	**25**	<0.5	<0.5	<0.5	-
	1997	**0.53**	0.13	**1.72**	**2.3**	**1.3**	0.003	**0.17**	0.08	**40**	<0.5	<0.5	-	<0.5
	1998	**0.21**	0.05	**1.56**	**1.8**	1.1	0.001	**0.15**	0.04	**42**	-	<0.5	-	<0.5
	1999	**0.11**	0.05	**4.90**	**5.1**	0.9	0.001	0.04	<0.005	**25**	<0.5	<0.5	-	<0.5
	2000	-	-	**0.79**	-	-	-	<0.005	-	**10**	-	<0.5	-	<0.5
	2001	-	-	**0.98**	-	-	-	<0.005	-	<5	-	<0.5	-	<0.5
	2002	-	-	**1.08**	-	-	-	**0.22**	-	**9**	-	<0.5	-	<0.5
	2003	-	-	**0.60**	-	-	-	0.10	-	**13**	-	<0.5	-	<0.5
	2004	-	-	**0.56**	-	-	-	**0.25**	-	**38**	-	<0.5	-	<0.5
Station	Year	DO (mg/L)	Temp (ºC)	pH	Turbidity (NTU)	Salinity (ppt)								
	1997	5.98	29.6	7.10	5	0								

Station	Year	Ammonia Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	TIN (mg/L)	TKN (mg/L)	Unionized ammonia (mg/L)	Total PO_4 (mg/L)	Ortho PO_4 (mg/L)	Chl a (μ g/L)	Chlorpyrifos (μ g/L)	Diazinon (μ g/L)	Iprodione (μ g/L)	Mancozeb (μ g/L)
	1996	0.13	0.06	**0.83**	0.8	1.1	0.004	<0.005	0.11	**59**	<0.5	<0.5	<0.5	-
Reservoir	1997	0.16	0.02	**0.34**	0.5	0.5	0.001	0.03	<0.005	**16**	<0.5	<0.5	-	<0.5
	1998	0.32	0.01	**0.30**	0.4	0.6	0.003	0.03	<0.005	**10**	-	<0.5	-	<0.5
	1999	0.11	0.01	**0.35**	0.5	0.6	0.001	0.02	<0.005	<5	<0.5	<0.5	-	<0.5
	2000	-	-	**0.22**	-	-	-	**0.12**	-	**20**	-	<0.5	-	<0.5
	2001	-	-	**0.30**	-	-	-	<0.005	-	**19**	-	<0.5	-	<0.5
	2002	-	-	0.20	-	-	-	<0.005	-	**19**	-	<0.5	-	<0.5
	2003	-	-	0.13	-	-	-	<0.005	-	**14**	-	<0.5	-	<0.5
	2004	-	-	0.14	-	-	-	<0.005	-	**8**	-	<0.5	-	<0.5
Station	Year	DO (mg/L)	Temp (°C)	pH	Turbidity (NTU)	Salinity (ppt)								
	1997	6.91	26.5	6.41	9	0								
		Ammonia Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	TIN (mg/L)	TKN (mg/L)	Unionized ammonia (mg/L)	Total PO_4 (mg/L)	Ortho PO_4 (mg/L)	Chl a (μ g/L)	Chlorpyrifos (μ g/L)	Diazinon (μ g/L)	Iprodione (μ g/L)	Mancozeb (μ g/L)
	1996	0.25	0.03	**1.60**	**1.8**	1.1	0.001	0.08	0.07	**12**	-	-	-	-
	1997	0.28	0.04	**0.56**	0.8	0.5	0.002	0.03	<0.005	**7**	<0.5	<0.5	-	<0.5
Lake 15/19	1998	0.11	0.02	**0.29**	0.5	0.7	0.001	0.07	<0.005	**8**	-	<0.5	-	<0.5
	1999	0.33	0.01	0.02	0.3	0.3	0.001	0.01	<0.005	<5	<0.5	<0.5	-	<0.5
	2000	-	-	0.03	-	-	-	0.02	-	**15**	-	<0.5	-	<0.5
	2001	-	-	0.01	-	-	-	0.01	-	**20**	-	<0.5	-	<0.5
	2002	-	-	0.08	-	-	-	0.01	-	**16**	-	<0.5	-	<0.5
	2003	-	-	0.02	-	-	-	0.02	-	<5	-	<0.5	-	<0.5
	2004	-	-	0.02	-	-	-	0.01	-	<5	-	<0.5	-	<0.5

Station	Year	DO (mg/L)	Temp (°C)	pH	Turbidity (NTU)	Salinity (ppt)								
	1997	8.06	28.8	6.47	13	0								
		Ammonia Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	TIN (mg/L)	TKN (mg/L)	Unionized ammonia (mg/L)	Total PO_4 (mg/L)	Ortho PO_4 (mg/L)	Chl a (μ g/L)	Chlorpyrifos (μ g/L)	Diazinon (μ g/L)	Iprodione (μ g/L)	Mancozeb (μ g/L)
	1996	0.59	0.04	**1.14**	**1.7**	0.1	0.002	0.01	0.07	<5	-	-	-	-
	1997	0.17	0.03	**0.62**	0.8	<0.05	0.001	0.03	0.02	**6**	<0.5	<0.5	-	<0.5
Pond after Marsh	1998	0.14	0.01	0.20	0.3	0.1	0.001	0.01	<0.005	<5	-	<0.5	-	<0.5
	1999	0.18	0.01	0.04	0.2	<0.05	0.001	0.01	<0.005	<5	<0.5	<0.5	-	<0.5
	2000	-	-	0.05	-	-	-	0.01	-	<5	-	<0.5	-	<0.5
	2001	-	-	0.02	-	-	-	0.01	-	**7**	-	<0.5	-	<0.5
	2002	-	-	0.12	-	-	-	0.01	-	<5	-	<0.5	-	<0.5
	2003	-	-	0.02	-	-	-	0.01	-	**11**	-	<0.5	-	<0.5
	2004	-	-	0.03	-	-	-	0.01	-	<5	-	<0.5	-	<0.5

Remarks:

All pesticides are measured below the reporting limit (0.5 μg/L) over 9 years of monitoring result at the existing golf courses. Therefore, <0.5 μg/L is used as the worst case scenario for concentration of pesticides at the proposed third golf course.

Bold : Exceedance to Table 6.4 guideline values

When value is has the < sign, it is smaller than reporting limit.

Unioinzed ammonia (calculated value).

Monitoring standards and guidelines for existing golf course

6.4.14 All monitoring guidelines and other relevant standards for physio-chemical parameters which are used to undertake a water quality assessment are shown in Table 6.4. Guidelines values are mainly derived from the 90th percentile of operation phase monitoring data, and have been agreed with EPD in 1998. All monitoring data is presented in the Appendix A6.2.

6.4.15 The exceedance of any one of the guideline values was considered as exceedance of the Trigger Level. Under such circumstances, the GCS would be notified and requested to reduce levels of chemical applications incrementally to reach a balance at which environmental impacts are deemed insignificant while turfgrass management remains undisrupted.

Table 6.4 Water Quality Monitoring Standards and Guidelines

Parameters	Guideline values	
	Freshwater	Marine Water
pH	6.0-9.0 (1)	6.5-8.5 (1)
Turbidity (NTU)	-	18 (1)
Dissolved oxygen	>4 (1)	>4 (1)
Chlorophyll a (µg/L)	<5 (1)	<20 (1)
Ammonia Nitrogen (mg/L)	0.50 (1)	0.050 (2)
Nitrite Nitrogen (mg/L)	0.20 (1)	0.005 (2)
Nitrate Nitrogen (mg/L)	0.20 (1)	0.090 (2)
Total Kjeldahl Nitrogen (mg/L)	1.2 (1)	0.500 (2)
Total Phosphate (mg/L)	0.10 (1)	0.090 (2)
Ortho-phosphate (mg/L)	0.05 (1)	0.010 (2)
Conductivity (µS/cm)	<1000 (1)	-

Source: HKJC EM&A Report (1998)
Note:

(1) These values are based on professional judgement and knowledge
(2) Based on 90th percentile of operation phase monitoring data

6.4.16 The key monitoring parameters used were Nitrate Nitrogen, Nitrite Nitrogen, Ammonia Nitrogen, Phosphate, Conductivity, Dissolved oxygen, Turbidity, pH, Chlorophyll-a and Pesticides. The monitoring parameters were reduced starting from 1998, though only monitoring parameters for Nitrate Nitrogen, Total Phosphate, Chlorophyll-a and specific pesticides were reduced. The chemicals chosen for analysis varied depending on the turfgrass management practices in operation at the time. Sampling was timed to coincide with specific chemical applications.

6.4.17 Selected pesticides were examined in freshwater and marine water quality locations. The main aim of the monitoring programme was to monitor the impact on water quality by the actual type of pesticides applied at the existing golf courses during the sampling period. The monitoring criteria of the selected pesticides for freshwater and marine water monitoring are focus on the application frequency and method over the past 9 years. Insecticides (Chlorpyrifos and Diazinon) and Fungicides (Iprodione and Mancozeb) are the four most frequently used products at the existing golf course throughout the past 9 years as the representative pesticides selected to be monitored during the operation phase of the existing golf course. The recommended pesticide applications followed the turfgrass management guideline for the existing golf courses. All of the pesticide concentrations were well below the level of reporting limit (0.5 ug/L) for all freshwater and marine monitoring locations. This supported the conclusion that there was no adverse effect on the broader aquatic environment due to proper chemical management and application during the monitoring period. A specific turfgrass management guideline has been established for the proposed third golf course and is presented in the Appendix A6.4 of this Report.

6.4.18 By comparing the concentrations of total inorganic nitrogen and nitrate nitrogen with the WQO, no exceedance was found at any of the marine monitoring locations. Only one exceptional case of exceedance was record at marine water control station (Marine C) but no exceedance was found at all other impact monitoring locations (Marine Stations A and B and Fish Culture Zones – Tai Tau Chau and Kai Lung Wan) in 1996. There was no any exceedance found in any of the marine monitoring locations for the Nitrite Nitrogen, Ammoniacal Nitrogen, Total Kjeldahl Nitrogen, Total Phosphate and Orthophosphate parameters by comparing the monitoring results in Table 6.2 with Table 6.4 from 1996 to 2004.

6.4.19 For freshwater water quality monitoring locations, the highest turbidity was found in Lake 1 and the lowest DO concentration was found in the reservoir. In general, water quality monitoring results showed that the exceedance mainly occurred at the Lake 1, as it is the first point of treat effluent discharge from the sewage treatment works (uneven mixing/flushing). The water continued to flow to the existing reservoir through the primary catchment of the existing golf courses. Other freshwater monitoring locations showed an improving trend for the water quality and most of the monitoring parameters complied with the guideline values from 1999 onwards.

6.4.20 Exceedances of Chlorophyll-a (guideline value for the existing golf course are shown in Table 6.4) in the reservoir, which occurred between 1996 to 1999, were likely related to an increase in ambient temperature coupled with reservoir stratification from low wind periods. There were decreasing trends for nitrate nitrogen and chlorophyll at the existing reservoir from 1996 to 1999. Concentrations of chlorophyll-a were relatively constant from 2000 to 2004 (approximate < 20 µg/L).

Bathing Beaches

6.4.21 There are two gazetted beaches (Kiu Tsui and Hap Mun Bay) in the Port Shelter WQZ, on the western side of Sharp Island. Both of these beaches are remote from the proposed third golf course. There are two non-gazetted beaches on the southwestern edge (Pak Sha Tsui and Kau Sai Wan) of the Island which can be accessed only by boat. They are popular at weekends during the bathing season but are remote from the proposed Project area.

6.4.22 To protect public health and to assess whether the Water Quality Objective is met, a comprehensive beach monitoring programme has been implemented by the EPD. Gazetted beaches are monitored during the bathing season, and are graded Good, Fair, Poor and Very Poor with respect to water quality. A grading of Poor or worse is equivalent to non-compliance with the WQOs. The annual grading for the closest gazetted beaches from 2000 to 2004 (annual beach water quality report, EPD) are summarised in Table 6.5. The monitoring of beach water quality is based on the measurement of *E. coli* density which is the microbiological parameter stipulated in the WQO and is also an internationally acceptable indicator.

Table 6.5 Water Quality at Gazetted Beaches on Sharp Island (2000-2004)

Beach	Grade 2004	Grade 2003	Grade 2002	Grade 2001	Grade 2000
Kiu Tsui	Good	Good	Good	Good	Good
Hap Mun Bay	Good	Good	Good	Good	Good

6.4.23 Beaches close to Kau Sai Chau have therefore met the WQOs for bathing beach sub-zones from 2000 to 2004, indicating that water quality is high.

6.4.24 The gazette beaches, Kiu Tsui and Hap Mun Bay, have routine water quality monitoring by EPD. As the non-gazetted beaches are far from the proposed project (shortest distance to the desalination plant are 1125 m) and not susceptible to have impact by the desalination plant in future. No water quality monitoring is required during the operation phase of the proposed third golf course.

6.5 Proposed closed low flow drainage system at the proposed third golf course

6.5.1 To provide sufficient freshwater for irrigation on the first two courses, a reservoir was formed at the northern end of the island by constructing a rockfill dam across the Kwat Tau Tam inlet. The overall design for the water management and quality control was based on the concept of self containment and effluent re-cycling, both to conserve water and to minimise potential environmental impacts on marine and mariculture areas around the Island. Consequently, the irrigation and drainage systems, together with the golf course lakes, reservoir, and associated catchments, were designed as far as practicable as a closed water management system to optimise re-cycling of irrigation run-off within the Project area. Treated wastewater and sewage effluent from the clubhouse and maintenance areas are also re-cycled into this closed system. This approach is considered to be successful, and will be adopted for the proposed third golf course.

6.5.2 To prevent the surface run-off from the proposed third golf course from entering existing streams and marine water, a closed low flow drainage system is proposed to capture surface water from the proposed third golf course and pump it back to the existing reservoir for reuse as irrigation for the golf courses (Figure 6.4). The drainage system design and conceptual approach for the proposed third golf course is similar to the existing golf courses to minimize impact to nearby sensitive receivers. With the closed drainage system for golf course run-off, the same approach in turfgrass management practices as the existing golf courses, and comprehensive monitoring programme at the proposed third golf course, water quality impacts are not expected.

6.5.3 The three main components for the closed low flow drainage system are:

- underground tanks/surface lakes with pumping stations;

- irrigation buffer Lake 1D (first temporary collection of surface run-off from proposed third golf course); and
- existing reservoir (storage for irrigation purpose).

6.5.4 Detailed descriptions of these components are as follows:

- The closed low flow drainage system involves interception of run-off by sub-surface drainage from the greens, fairways and tees for all holes except Hole 5 and part of Hole 6, and re-circulating the flow through the irrigation system. Run-off from Hole 5 and part of Hole 6 would discharge into the existing marsh area.
- A total of 10 pumping stations, coupled with either lake or tank storage, would intercept run-off from the golf course and direct it to the irrigation buffer lake (Lake 1D). Overflow from Lake 1D would be channelled to the existing reservoir where the run-off would be re-circulated through the irrigation system.
- The interception system has been designed to retain a design flow of a 1 in 2-year event.
- The irrigation buffer, Lake 1D, will not receive run-off from undistributed native areas to the golf course. It will serve as the first point of discharge prior to overflow to the existing reservoir for storage and irrigation.
- Under this option irrigation water to the proposed third golf course will be supplied via the buffer lake (Lake 1D) supplemented by the desalination plant during dry periods.

6.5.5 Run-off from greens, tees and fairways will be collected by catchpits or the perforated sub-soil drainage system, from where it will be conveyed along pipes to the underground storage tanks or open storage ponds. Each storage pond and tank will have a set of pumps operated automatically by level control, which will pump the run-off to the irrigation buffer reservoir. The storage volume between the pumps on and off levels and their pumping rate has been determined such that overflow shall only occur on rainstorm events greater than a 1 in 2-year return period. When the irrigation buffer reservoir is full it will overflow to the existing reservoir at Kau Sai Chau.

6.5.6 The permanent drainage system for the proposed third golf course comprises comprehensive networks of drains, lakes and low flow storage tanks/pumping stations, with the following major objectives:

- To avoid flooding of the proposed third golf course and to remove water from the playing areas as soon as possible;
- To collect and convey run-off from the proposed third golf course to the existing reservoir for irrigation and recycle purpose;
- To prevent low-flow run-off from discharging directly the streams and marine waters; and
- To maintain flows through existing streams.

6.5.7 The layout design of the proposed third golf course has given due consideration to the protection of all identified water quality sensitive receivers as follows:

- There is no alteration of watercourses in the latest design layout - buffer zones will be provided for all sensitive streams to reduce disturbance during the construction and operation phase;
- There is no development near existing wetlands (marsh);
- Disturbance to stream beds during the construction phase of the permanent bridges is avoided (pre-cast unit of the bridge segments will either be transported by barge or constructed on-site and installed at the proposed locations);
- Streams are protected from contamination by keeping maintenance areas, i.e. tees, greens and fairways, to a minimum; and
- The new lakes are designed to serve as temporary storage points for run-off.

6.5.8 Generally, the monitoring programme for the existing golf courses will be adopted for the proposed third golf course. A comprehensive monitoring manual and programme will be designed to ensure cost effective monitoring.

6.5.9 A key factor of the proposed third golf course is the need for irrigation water. Preliminary design includes utilization of dead storage within the existing irrigation reservoir, an irrigation buffer lake, and a desalination plant to provide freshwater to the proposed third golf course.

6.5.10 The design for the proposed closed low flow drainage system at the third golf course will protect all of the identified water sensitive receivers. No potential water quality impact along the east coast, including coral, mangroves, and abandoned fish culture zone (FCZ) in Tiu Cham Wan, is expected during the operation phase of the proposed third golf course. All potential run-off (except Hole 5 and part of Hole 6 which will drain into the existing marsh) from the proposed third golf course will be directed back into the main drainage system and ultimately to the existing reservoir.

6.6 Assessment Methodology & Criteria

6.6.1 The assessment area for the purpose of this water quality impact assessment is the Project area, and includes any stream courses and associated water systems in the vicinity which may be affected by the Project. The water quality sensitive receivers which may be affected by the construction and operational activities for the proposed third golf course have been identified, and potential sources of water quality impact which may arise during the construction and operation phase of the Project are described. All identified sources of potential water quality impact are then evaluated to determine their impact significance.

6.7 Identification of Water Sensitive Receivers

6.7.1 Beneficial uses were defined in accordance with the requirements of the Hong Kong Planning Standards and Guidelines (HKPSG), which have been transposed into the EIA-TM.

6.7.2 Several potentially important water quality sensitive receivers (WSRs) which may be affected by the construction and operation of the proposed third golf course were identified (Figure 6.5). These WSRs include:

- Freshwater streams;
- Fish Culture Zones - Tai Tau Chau, Tiu Cham Wan (inactive), Kai Lung Wan & Kau Sai;
- Non-gazette beaches - Pak Sha Tsui, Kau Sai Wan;
- Sandy beaches - Kau Chung Wan and Kau Tung Wan;
- [t9]Coral Sites and Mangroves; and
- Seagrass – located about 200m to the south of existing jetty at Kai Sai Chau

6.7.3 The existing approach of Turfgrass management on fertilizer and pesticides application will be extended and used in the proposed third golf course, and the same soil type used in the existing golf courses will be used at the proposed third golf course. The sand cap thickness of the existing golf course will be increased from 150 mm 200mm sand cap.

6.7.4 Ground water is not considered to be a sensitive receiver within the Project area for the following reasons:

- The golf course shall be formed with a sand layer on the subsoil over cut rock or clay-typed sub-soil. Sub-soil is made of Complete Decomposed Volcanic fill with minimum thickness of 300 mm beneath the sand capping layer (200 mm). The clay-typed sub-soil material is sufficient impermeable layer enabling the water flow towards to the subsoil drainage pipes rather downwards.

- The relatively thicker sand cap layer that will be used in the proposed third golf course can increase the retention time in the soil layer and provide a larger surface for micro-organisms to breakdown nutrients and pesticides more effectively. In addition, KSC Island is mainly composed of volcanic rock with low permeability, further reducing the leaching potential of pollutants into the ground water.

- Literature review indicates that trace chemicals applied to golf courses are less likely to be detected in groundwater due to the high microbial activities for the breakdown of nutrients and pesticides in soil layers of turf areas, minimum chemical application rate and specific physical properties of the chemicals applied such as short half-lives (Appendix A6.2).

Desalination Plant discharge to the water sensitive receivers

6.7.5 The shortest distances (as measured by travel distance by the pollutant) from the nearest pollution source (desalination plant discharge) to the WSRs are summarized in Table 6.6.

Table 6.6 Shortest Distance from the Nearest Pollution Source to the WSRs

Sensitive Receivers	Shortest Distance (m)	Nearest Pollution Source
Fish Culture Zone at Kai Lung Wan	450	Desalination Plant
Fish Culture Zone at Kau Sai	2000	Desalination Plant
Kau Sai Wan Beach	2020	Desalination Plant
Pak Sha Tsui Beach	1125	Desalination Plant
Sharp Island	750	Desalination Plant
Coral site at Sharp Island	760	Desalination Plant
Mangrove at Western part of KSC (MG1)	500	Desalination Plant
Seagrass to the south of the pier	200	Desalination Plant
Corals located near the tip of intake pipeline	40	Desalination Plant
Corals on bedrock to the south of the pier	80	Desalination Plant[t10]

Fish Culture Zones

6.7.6 On the existing golf courses, most of the run-off have been directed to the reservoir and no pesticides residues have been detected. For the proposed third golf course, the drainage system is designed to retain most of the water which will be recycled at the existing reservoir system. Operational water quality impact is not expected. The shortest distance from the desalination plant is approximately 450m (Kai Lung Wan FCZ) (Table 6.6).

Beaches

6.7.7 There are no gazetted beaches on Kau Sai Chau, and there are only two non-gazetted beaches at Pak Sha Tsui and Kau Sai Wan on Kau Sai Chau, though these are not considered to be susceptible to impact from the Project as they are at a substantial distance from the desalination plant discharge. The shortest distance from the desalination plant is greater than 1000 m, as shown in Table 6.6.

Fresh Water Streams

6.7.8 There are three identified sensitive streams at Kau Sai Chau. By providing sufficient buffer zones on both side of the streams and leaving the stream beds unaffected, they are not considered to be susceptible to impact from the Project and the desalination plant.

Sandy Beaches

6.7.9 There are two sandy bays located at southeast side of the Kai Sai Chau Island and far away from the desalination plant (shortest distance > 2000m). These are not considered to be susceptible to impact from the desalination plant.

Corals

6.7.10 Five potential sites (B1, B2, D1, D2 & D3) were surveyed and considered for optimum locations for the desalination plant and temporary barging point. Two sites (D1 and D3) were found of higher ecological values and therefore, being excluded. For the remaining three sites, all of them had low coral coverage (less than 5%) and ecological importance, but two of them had the corals (B1 and B2) concentrated within a narrow strip close to the shore, and some corals are not transplantable. Installing pipelines in these two sites would cause inevitable direct loss of corals, so they were also excluded. While the last site is dominated by muddy sandy bottom (D2) and therefore recommended as the preferred site. The proposed desalination plant intake and outfall pipelines (D2) are adjacent to the existing pier with coral coverage was lower than 5%. Most of the D2 site has a sandy and muddy-sandy substrate, with the sandy substrate at the shallower part and the muddy-sandy substrate further seaward. Low density and small corals (60% $\leq$ 10cm) only 6 corals $\geq$ 20 cm) are scattered on isolated boulders.

6.7.11 All coral colonies find in D2 were small and common to dominant in Hong Kong. No uncommon or rare species was found. Coral colonies were located within the silt curtain area would require transplantation to 80m away south to the existing pier and other mitigation measures to reduce the impacts (Please refers to Chapter 9, A9.1 and A9.2 for details). EM&A on water and coral monitoring during the construction and operation phases of desalination plant are recommended to ensure the water quality and successful rate of the coral being transplanted.

6.7.12 The next closest coral site, located to the south of the existing pier at Kau Sai Chau, is 80m away and located on bedrock, though only scattered corals were found. Hard corals and seagrass where found in the southern part of the proposed the desalination plant intake and discharge pipelines location which is distant (at least 80m away for the nearest coral site and were un-transplantable) from the existing pier.

6.7.13 The distances from the desalination plant to the corals at Sharp Island and the eastern side of Kau Sai Chau, both of higher coral coverage, are more than 700m. They are not considered to be susceptible to impact from the desalination plant.

6.7.14 A proposed temporary barging point will be of floating-pontoon form with 20m (wide) x 40m (long) platform with no supporting structure on-shore, no sub-tidal filling works would be required for the barging point. As the coral colonies at Sites B2 area concentrated within the first 15 m seaward from the coastline, all anchoring points/structures of the floating pier could be located on the shore and/or to deeper water to avoid the coral. No direct impact on corals is anticipated.

Mangroves

6.7.15 Three mangroves sites were identified at Kau Sai Chau. The closest site, MG1, is 500m from the desalination plant. Sites MG2 and MG3 are located near the existing reservoir and the eastern part (south centre) of Kau Sai Chau, and are not considered to be susceptible to impact from the desalination plant.

Seagrass

6.7.16 A seagrass site located to the south of the existing pier at Kau Sai Chau (identified in 2005 sub-tidal survey) is the nearest important sensitive receivers to the desalination plant, and is 200 m from the desalination plant.

Water Quality Criteria

6.7.17 For the purpose of this assessment, the ambient value of suspended solids (SS) and salinity was represented by 90th percentile of the reported concentrations. EPD routine monitoring data (1998–2003) at monitoring stations PM1, PM2, PM3, PM4, PM6, PM7, PM8, PM9 and PM11 (depth-averaged) were used as the data source of the reported concentrations. The ambient values and allowable increases in SS concentration under the WQO for the identified sensitive receivers are given in Table 6.7.

Table 6.7 Background SS Concentrations and Tolerance Elevation at Sensitive Receivers

Sensitive Receiver	Ambient 90th percentile (mg/L)	WQO Tolerance elevation (mg/L)
Suspended Solids		
Coral / Seagrass/Fish Culture Zone#	4.95	1.485
Salinity		
Coral / Seagrass / Fish culture Zone#	34.1	3.41

Note:
For Dissolved oxygen, WQO for all sites of ecological interest is $\geq$ 4 mg/L.
WQO for Suspended solids at Port Shelter;
All values are depth-averaged

6.8 Identification of Potential Environmental Impacts

6.8.1 Potential sources of water quality impact associated with the construction of the proposed third golf course have been identified. These include:

- silty run-off from the construction site of the proposed 18-hole golf course;
- chemical-contaminated run-off during turf establishment and before completion of the proposed closed low flow drainage system;
- muddy and waste water generated during permanent bridge construction;
- temporary barging point at Kau Sai Chau;
- fine sediment to suspension during dredging for the construction of desalination plant's intake and outfall;
- general construction activities;
- sewage effluent generated by on-site workforce; and
- operation of concrete batching plant during construction.

6.8.2 Potential sources of water quality impact associated with the operation phase of the proposed third golf course have been identified. These include:

- desalination plant water discharge; and
- chemicals and pesticides run-off from the proposed 18-hole golf course.

6.9 Evaluation of Impact during the Construction Phase of Proposed Third Golf Course

18-hole Golf Course Construction – Run-off and Drainage

6.9.1 There will only be minimal disturbance to the watercourses by providing buffer zones at both sides of the streams (Figure 6.6a). Only limited, localized and short-term elevation in suspended solids concentration during the diversion works are expected. Moreover, the small portions of streams which are channelized are located at the very upstream end which is dry for most of the year. There is therefore unlikely to be any unacceptable water quality impacts on the water body.

6.9.2 Sediment control practices will be implemented to reduce sediment loads from site run-off during excavation. Certain principles will be adopted during the construction phase of the proposed third golf course including scheduling earthworks appropriately, minimizing the disturbed areas, protecting exposed soil surfaces from runoff and stabilizing disturbed areas. With the implementation of proposed mitigation measures, minimal impact is expected at the identified sensitive receivers. As an additional level of protection, water quality monitoring and audit during construction stage is recommended (EM&A manual Section 3 for details).

6.9.3 A buffer zone will be set up to ensure that the streams are not affected during construction and operation phase of the proposed third golf course. Figure 6.6b shows the buffer zones at all identified streams and proposed permanent bridges locations.

6.9.4 The tentative construction programme for all earthworks that will start from February 2006 to February 2007. Major earthworks will be carried out separately in three groups: **Group**

A includes Hole 11, 12, 13, 14, 15 and 16 (early Mar 06 to early Jul 06). **Group B** includes Hole 3, 4, 5, 6, 7, 8 and 9 (early Jul 06 to late Oct 06). **Group C** includes Hole 1, 2, 10, 17 and 18 (late Oct 06 to Mar 07). There is no overlapping of the major earth/slope construction between the three groups. The approximate earthworks time of Group A, Group B and Group C is approximately 100 days, 106 days and 108 days respectively. For the cut-and-fill operations, maximum two holes will be worked simultaneously for each group. The average concurrent working area for cut-and-fill operation in Group A, Group B and Group C is 1370 m^2/day, 1472 m^2/day and 1926 m^2/day respectively. The earthwork will be constructed in a progressive way throughout a year.

6.9.5 Construction run-off and drainage could cause physical, chemical and biological impact on the water bodies in the vicinity of the Project. If mitigation measures (Section 6.11) such as temporary drainage system, good site practices etc during the construction phase are followed strictly to prevent run-off and drainage water with high levels of suspended solids from entering the adjacent water bodies, unacceptable impacts are not expected.

Run-off during turf establishment period

6.9.6 The turf areas will be completed progressively throughout the construction period. With more of the new holes covered by turf as construction of the proposed golf course progress, potential impact from silty run-off from the construction site would gradually decrease. The potential impacts of nutrient and pesticides run-off may occur before the completion of the proposed closed low flow drainage system. If mitigation measures such as those identified in Section 6.11 are followed strictly to prevent such run-off from entering the adjacent water bodies. With these approaches, unacceptable impacts are not expected.

Temporary and permanent bridge construction

6.9.7 Prior to construction of the permanent bridges, different parts of the site will be separated by existing streams (Figure 6.6a). Temporary steel bridges will first be erected adjacent to the locations of permanent bridges to provide access over the stream and the remaining site area. Steel bridges have the advantages that they can be erected and demolished easily and quickly, are able to withstand heavy traffic loading and require only temporary mass concrete footing.

6.9.8 It is unavoidable to construct permanent bridges for accessibility and playability of the proposed third golf course, To minimize the potential water quality impacts on streams, permanent bridges in the proposed third golf course are designed with pre-cast concrete decks and earth-retaining bridge abutments. Pre-cast deck units will either be manufactured off-site and delivered to site by barge, or constructed inside a designated, covered area within the construction works boundary at Kau Sai Chau but remaining outside the designated stream buffer zone. Minimal impact to the identified sensitive streams is expected. Measures to avoid spillage of turbid water and waste water into the watercourses will be implemented to minimize impacts on water quality and associated ecology. A discharge licence needs to be applied from EPD for discharging effluent from the construction site. The discharge quality is required to meet the requirements specified in the discharge licence. All the wastewater generated from the works area should be collected and diverted to a wastewater treatment system for removal of suspended solids and to adjust pH prior to final discharge. With the implementation of the mitigation measures in Section 6.11, it is anticipated that unacceptable water quality would not arise at the identified water quality sensitive receivers during works close to the identified streams.

Temporary Barging Point at Kau Sai Chau

6.9.9 A piled pier was originally proposed as the construction method for the temporary barging point at Kau Sai Chau, but wastewater generated from the works areas may pose significant impacts on marine water quality if not handled properly. A floating pontoon is therefore proposed as an alternative to minimize the potential water quality impacts. The proposed location of the temporary barging point is shown in Figure 6.7. The estimated construction duration for the temporary barging point is less than 1 week, and it will be decommissioned once construction of the proposed third golf course has been completed.

6.9.10 The barging loading point to be used at the site will be secured by means of anchors. The only works required onshore would be a small temporary platform made of pre-cast concrete sea wall blocks with rock filling behind. The barge itself will be secured by at least four anchors, and a hinged ram provided for transferring plant and materials either directly from the barge, or with the barge acting as a floating transfer platform for others vessels lying alongside. A small portion of the seabed will be required for anchor points and can be easily relocated. Those anchor points will be lowered to the seabed precisely to the designed position with the aid of divers. With the small construction works areas, unacceptable impact is not expected. A schematic diagram of floating pontoon is shown in Figure 6.7a.

Dredging during Construction of Desalination Plant's Intake and Outfall

6.9.11 Dredging will be carried out for the construction of desalination plant intake and outfall proposed location of the desalination plant. The proposed construction period for the dredging works is approximate 2 months, and the estimated total quantity of dredged material is approximately 1,500 m^3. The SS loss rate is proportional to the dredged volume, which is calculated by the volumetric rate times the stoichiometric coefficient (S-factor). Table 6.8 shows the S-factor for grab dredgers.

Table 6.8 Stoichiometric Coefficient

[t11]

Dredger	S-factor	Source
Grab (Open, no silt screen)	12 – 25 kg/m^3	Kirby and Land (1991)
Grab (Closed, no silt screen)	11 – 20 kg/m^3	
Grab (Closed, with silt screen)	2 – 5 kg/m^3	
Backhoe (No silt screen)	12 – 25 kg/m^3	
Backhoe (With silt screen)	5 – 10 kg/m^3	

6.9.12 Water is shallow (less than 2 m) along the shoreline makes access by small dredgers impossible, therefore dredging using the closed grab method, or backhoes on pontoon combined with silt curtains are proposed and assessed.

6.9.13 Backhoe at locations with water depths of less than 2m and use closed grab dredger for works at locations water depths of more than 2m are for the proposed dredging works of the desalination plant's intake and outfall pipelines. The estimated dredging works is about 50m long (where backhoe should be used for locations with water less than 2m deep) and 70m long (where closed grab dredger should be used for locations with water more than 2m deep). Only one dredging method is allowed at any one time.

6.9.14 The estimated total dredging volumes by closed grab and backhoe are approximate 900m^3 and 600m^3 respectively. For a construction period of 20 days and 8 hours a day for closed grab method, the dredging volume will be 900/20 = 45m^3/day. For a construction period of 30 days and 8 hours a day for backhoe method, the dredging volume will be 600/30 = 20m^3/day.

6.9.15 The 90th percentile of suspended solids (1998-2003) at Port Shelter WCZ is 4.95 mg/L, with the minimum and maximum values at 0.5 mg/L and 26 mg/L respectively. The net increases of predicted suspended solids at the nearest sensitive receiver (Corals) range from 1.078 mg/L to 1.094 mg/L (Table 6.9). The impact due to dredging is within the natural variation of suspended solid at Port Shelter WCZ. The suspended solids levels at all sensitive receivers will be at an acceptable level.

Table 6.9 Summary prediction on the SS elevation at the nearest sensitive receiver (coral on 80m bedrock) when dredging by closed grab and backhoe methods[t12]

	Closed Grab dredging with silt curtain for deeper seawater level (water depth-averaged 7m)	Backhoe excavation with silt curtain for shallow water depth (water depth-averaged 2m)
Dredging rate	45 m^3/d	20 m^3/d
Working hrs	8 hrs	8 hrs
Construction period	20 days	30 days
Stoichiometric Coefficient	5 kg/m^3 (Table 6.9)	10 kg/m^3 (Table 6.9)
SS release rate	45m^3/d x 5kg/m^3÷8hrs÷60mins÷60s = 0.078 kg/s	20m^3/d x 10kg/m^3÷8hrs÷60mins÷60s = 0.069 kg/s
Initial concentration [A]	[0.0078kg/s÷(7mx40mx0.02m/s)]x1000 = 1.393 mg/L	[0.0069kg/s÷(2mx40mx0.02m/s)]x1000 = 4.312 mg/L
SS settlement time [B]	7m÷0.0005m/s = 14000s	2m÷0.0005m/s = 4000s
Total distance traveled required for full settlement	14000s x 0.02m/s = 280m	4000s x 0.02m/s = 80m
SS elevation concentration at the nearest WSR[C]	1.393mg/L x [1 – (60m÷280m)] = 1.094 mg/L	4.312 mg/L x [1 – (60m÷80m)] = 1.078 mg/L
WQO SS tolerance elevation[D]	4.95 mg/L x 30% = 1.485 mg/L	
Compliance with WQO	Yes	Yes
Daily deposition rate[E]	0.0005m/s x 1.094mg/L x 86400s ÷1000 = 0.047 kg/m^2/day	0.0005m/s x 1.078mg/L x 86400s ÷1000 = 0.046 kg/m^2/day
Sedimentation rate guideline[F]	0.1 kg/m^2/day	
Compliance	Yes	Yes
DO depletion[G]	1.094 mg/L x 0.23 x 16732/10^6 = 0.00421 mg/L	1.078 mg/L x 0.23 x 16732/10^6 = 0.00417 mg/L
Compliance	Yes-Undetectable	Yes-Undetectable

Remarks:

A - Assuming SS release is over the entire water column with a silt curtain diameter of 40m with maximum current velocity of 0.02m/s (Hyder, 1999). The current velocity is the dominant factor for the seasonal factor. The calculation on the initial concentration has been taken into account of the seasonal factor by applying the maximum current velocity value._Average water depth for closed grab method is 7m and 2m for backhoe excavation.

B - According to WAHMO studies, the minimum settling rate of SS during dredging works is 0.001 m/s. However, as the sediment settles onto the sea bed, concentration will gradually decrease. To account for this reduced concentration, the settling rate is then halved, which gives a value of 0.0005 m/s.

C - The nearest WSR is 60m (away from the silt curtain).

D - The 90th percentile tile baseline concentration of SS (1998-2003) is 4.95 mg/L.

E - The rate of deposition due to sediment plumes from the dredging can be determined by the multiplication of SS concentration and daily settling rate (Scott & ERM, 2000). According to WAHMO studies, the minimum settling rate of SS during dredging works is 0.001 m/s. However, as the sediment settles onto the sea bed concentration will gradually decrease. To account for this reduced concentration the settling rate is then halved which gives a value of 0.0005 m/s.

F - According to the ERM (2001), 0.1 kg/m^2/day was proposed as the assessment criterion for protecting coral and benthics and therefore the predicted impacts due to sediment deposition from dredging are considered to be acceptable.

G - The degree of oxygen depletion exerted by sediment plume is a function of the oxygen demand of the sediment, its concentration in the water column and the rate of oxygen replenishment. The oxygen demand of the sediment (16,732 mg/kg) is the average chemical oxygen demand of the sediment quality at Port Shelter (1998-2003). According to Mouchel (2002), the impact of the oxygen demand on DO concentration has been calculated based on the multiplication of SS concentration, Oxygen Demand and Daily Oxygen Uptake Factor (set as 0.23 in ERM, 1997).

Desalination intake, outfall pipelines and pumping station alignment consideration

6.9.16 The proposed intake pipe requires to be constructed at a low enough level such that it can supply seawater to the desalination under all tide conditions. Further it requires to be constructed with its a sufficient height above the seabed such that it does not become silted up. Based on these constraints and the seabed topography at KSC pier the intake pipe requires to be 100m long. The intake and outfall pipes both require rock armour protection to prevent wave action washing the pipelines away and prevent damage from boat anchors.

6.9.17 The 50 m separate distance between the sea water intake and return water outfall is a minimum distance, based on engineering practice for this size of desalination, to prevent return water short circuiting back into the sea water intake, which would adversely affect the desalination plant operation. The outfall length is determined such that discharge should be below low tide level.

6.9.18 Due to these technical constraints the intake and outfall pipe cannot be located where boats and barges dock as the pipes and their armour block the passage of boats. Therefore, if the intake and outfall pipes are located on the north side of KSC pier the existing barge delivery point would require to be relocated. This would require identification of a new site and require a new coastline reclamation to provide a new permanent barging point.

6.9.19 Similarly if the intake and outfall were moved further from the existing pier away from the existing barging point. Reclamation and site formation on the natural coastline would be required to enable construction of the intake and outfall.

6.9.20 In view of the above constructing the intake and outfall pipe directly adjacent to the existing pier are least impact arrangements. The proposed footprint of the pipelines follows the site that was previously disturbed by construction of the existing pier.

6.9.21 Reasons for not laying the intake pipeline and pumping station to the north of the pier is also due to the following reasons. (i) There is steep natural terrain to the north of the Pier. Extensive slope cutting and reclamation works will be required for the site formation. This will be destructive to the natural coastline and (ii) The water quality on the north side of the pier is poorer than the south side and not suitable as feed water to the desalination plant. The poorer quality is as a result of the enclosed bay and greater volume marine traffic (Figure 6.7b).

6.9.22 Swapping the intake and outfall pipelines is not considered as a mitigation measures because there will also be inevitably indirect impact on corals for those located within the silt curtain when dredging even though the direct impact on coral has been minimized. Degrading of water quality (SS elevation and sedimentation rate) on corals within the silt curtain area during dredging is expected.

Silt curtain arrangement

6.9.23 Based on the above justification on proposed pipelines location, the proposed intake and outfall pipelines are considered the best available feasible option (engineering feasible and least ecological value). Corals which are within the silt curtain could be affected by the elevation of suspended solids and sedimentation rate during dredging. In order to minimize the number of corals being transplanted within the silt curtain, three scenarios by the different silt curtain arrangement during the dredging have been assessed and evaluated. Schematic diagrams for the three scenarios are shown in Appendix A6.6. Either closed-grab or backhoe method should be carried out in any one time. The results are summarized as following Table 6.10.

Table 6.10 Summary on the SS elevation, sedimentation rate and DO depletion for all three scenarios

	Coral within the silt curtain	Compliance with WQO / relevant standards	80m coral on bedrock	Compliance with WQO / relevant standards
Scenario 1 - One single silt curtain for closed-grab and backhoe area				
SS elevation (closed grab)	5.6 mg/L	No	1.094 mg/L	Yes
SS elevation (backhoe)	10.9 mg/L	No	1.078 mg/L	Yes
Deposition rate (closed grab)	0.241 kg/m²/d	No	0.047 kg/m²/d	Yes
Deposition rate (backhoe)	0.469 kg/m²/d	No	0.046 kg/m²/d	Yes
DO depletion (closed grab)	0.02 mg/L	Undetectable	0.0042 mg/L	Undetectable
DO depletion (backhoe)	0.04 mg/L	Undetectable	0.0041 mg/L	Undetectable
Scenario 2 – Double silt curtain at backhoe area only				
SS elevation (closed grab)	-	-	4.382 mg/L	No
SS elevation (backhoe)	-	-	0.434 mg/L	Yes
Deposition rate (closed grab)	-	-	0.189 kg/m²/d	No
Deposition rate (backhoe)	-	-	0.019 kg/m²/d	Yes
DO depletion (closed grab)	-	-	0.0169 mg/L	Undetectable
DO depletion (backhoe)	-	-	0.0017 mg/L	Undetectable
Scenario 3 – Double silt curtain at closed-grab area and single silt curtain at backhoe area				
SS elevation (closed grab)	2.8 mg/L	No	0.274 mg/L	Yes
SS elevation (backhoe)	3.9 mg/L	No	1.085 mg/L	Yes
Deposition rate (closed grab)	0.12 kg/m²/d	No	0.012 kg/m²/d	Yes
Deposition rate (backhoe)	0.17 kg/m²/d	No	0.047 kg/m²/d	Yes
DO depletion (closed grab)	0.010 mg/L	Undetectable	0.0011 mg/L	Undetectable
DO depletion (backhoe)	0.014 mg/L	Undetectable	0.0042 mg/L	Undetectable

6.9.24 The SS elevation and sedimentation rate to the corals within the silt curtain exceed the WQO standards (1.485 mg/L) and sedimentation guideline value (0.1 kg/m²/day) for Scenarios 1 and 3. For Scenario 2, no coral are within the silt curtain area at the backhoe region but the dredging activities by the close-grab method (without the silt curtain protection) in deeper water region will cause significant impacts (WQO exceedance on SS and sedimentation rate) to coral either for those next to the dredging are or on bedrock 80m away. This option is therefore not to be considered feasible. Transplantation of all corals within the silt curtain is, therefore, recommended.

General Construction Activities

6.9.25 General construction activities are unlikely to have impacts on water quality provided that the site is well maintained and good construction practices are well implemented.

Sewage Effluents

6.9.26 Based on the Sewerage Manual, Part I, 1995 of the Drainage Services Department (DSD), the sewage production rate for construction workers is estimated at 0.35 m^3 per worker per day. Assuming a upper bound of about 500 construction workers working simultaneously at the construction site, about 175m^3 of sewage would be generated per day. The sewage must not be allowed to discharge directly into the surrounding water body without treatment. All sewage discharge is subject to control, and illegal discharge of untreated sewage is prohibited and would affect the water quality in the area. Provision of suitable sewage collection and treatment facilities on site will avoid the sewage pollution problem, and, if so provided, it is unlikely that sewage generated from the site would have a significant impact on water quality.

6.9.27 For any wastewater generated with the construction site, a discharge licence should be obtained from EPD under the WPCO before making the discharge. Wastewater treatment facilities should be provided on site to treat the effluent to meet the required water quality standards before discharge.

Concrete batching plant

6.9.28 As the proposed site for the concrete batching plant is located inland, near the proposed temporary pier (Figure 6.8), there is unlikely to be any potential impact arising (sediment run-off) to marine water and nearby stream courses. Potential sources of water pollution include release of cement materials with rain wash, wash water from dust suppression sprays, and fuel, oil and other lubricants from maintenance of construction vehicles and mechanical equipment.

6.9.29 With the implementation of adequate construction site drainage and the provision of sediment removal facilities (Section 6.11), unacceptable water quality impact on the coastal waters is not expected to arise.

6.10 Evaluation of Impact during the Operation phase of the Proposed Third Golf Course

Desalination Plant Discharge

6.10.1 The desalination plant will be located south of the existing pier of the Kau Sai Chau golf courses. A diagram of the associated intakes and return routes is shown in Figure 6.7c.

6.10.2 The desalination plant will consist of the following components:

- seawater intake pump house, incorporating seawater pumps;
- pretreatment facilities including flocculation and media filters;
- pretreatment containers;
- reverse osmosis desalination plant;
- chemical dosing treatment tanks including caustic soda, sodium meta bisulphate, sodium hypochlorite, anti-scalant and coagulant;
- production water pumping station;
- seawater intake pipeline; and
- seawater return pipeline.

Reverse Osmosis (RO) process, inputs and outputs

6.10.3 The RO process involves the pre-treatment of seawater and then pushing it through a membrane, so that freshwater is driven through while higher salinity water is left behind. This saline is then directed back to the sea (referred to as return flow). Figure 6.9 shows the flow diagram for the desalination plant for this Project.

6.10.4 Pre-treatment is essential and involves the following components:

- chlorination;
- addition of coagulant polymer (iron chloride) as a coagulant for seawater filters; and
- removal of suspended solids.

6.10.5 The filtration system will require backwashing with chlorine scavenger before the backwash is returned to the sea. Chlorine and sodium metabisulphite are dosed, but they will revert back into sodium and chloride ions in the process before being discharged into the marine water, so as to ensure there is no free chlorine is in the return water.

6.10.6 Following the pre-treatment of solids, an anti-scalant (Prema Treat ® PC-191) will be added to the feedwater in the RO plant to prevent precipitation (scales) on the membranes. Anti-scalant substance will eventually be found in low concentration in the return seawater. Chlorine scavenger (sodium metabisulphite) will also be added to the feedwater in this process stage to remove all chlorine residues before discharge to marine water. Bio-fouling of the membrane system is controlled by shock dosing of sodium hypochlorite, which will be removed prior to discharge to the marine environment.

6.10.7 The pressure needed to enable the water to pass through the membranes and have the salt rejected will be supplied by high-pressure pumps.

Product Water

6.10.8 An RO system produces water with a pH of around 6. Product water may be treated to provide the required pH for irrigation of the proposed third golf course.

Water quality modelling

6.10.9 The proposed desalination plant can provide 1,450 m^3/d of irrigation water to the proposed third golf course during the dry seasons (Nov–Mar) with an average seawater intake will be around 3,816m^3/d. The desalination plant will only operate occasionally during the wet seasons in case of contingency, mainly for maintenance reasons. To cope with the irrigation needs of the proposed third golf course, maximum salinated discharge flow rate will be 1,450 m^3 per day with the plant operating on a 24-hour basis. The average water discharge flow rate will be

0.0168 m^3/s.

6.10.10 At full production, 3,816 m^3/d of seawater can be pumped to the desalination plant with 2,366 m^3/d of seawater will be returned together with backwash from pre-treatment, based on a membrane recovery of 38%. The plant will return concentrated seawater at +/- 1 ^oC of ambient seawater temperature.

6.10.11 To predict the mixing zone and affected area due to the seawater discharge, a mathematical model, CORMIX, was used to evaluate the salinity impact arising from the discharge. Details on the CORMIX model are presented in Appendix A6.1.

6.10.12 The 300 mm outfall extends 40m from the seashore and will have a discharge velocity of 0.0168/0.3/0.3/0.25/3.1416 = 0.24 m/s. The densities for ambient sea water and salinated discharge are 1024 kg/m^3 and 1040 kg/m^3 respectively. Taking the ambient current from the discharge to the nearest WSR (Seagrass) as a worst case scenario, the horizontal angle between discharge and ambient current will be 75^o (Appendix A6.1). The dilution factors relative to downstream distances are calculated and summarized in Table 6.11.

Table 6.11 Dilution Factor versus Downstream Distance

Downstream Distance (m)	Dilution	Remarks
0 m	1.00	Just outside the outfall
3.93 m	6.67	Criterion boundary of salinity
5.06 m	8.6	End of near field region
10 m	14.6	-
20 m	16.9	-
50 m	17.9	Plume is attached the left bank
100 m	19.1	-
200 m	20.6	-
500 m	23.9	-

Impact assessment of salinated water discharge

6.10.13 Discharge of salinated water will be the main concern during the operation phase of the desalination plant, as, by volume, 40% of the seawater will be extracted as fresh water. Since the 90^{th} percentile ambient salinity is 34.1 ppt, the salinity discharge will be 34.1/(1-40%) = 56.833 ppt. Therefore, the net impact on salinity from the discharge will be 56.833-34.1 = 22.733 ppt. The salinity concentration at the edge of near field region will be 22.733/8.6 = 2.643 ppt. Since the nearest WSR (Coral) is located 80 m away from the discharge, the net impact on salinity at this WSR (Coral) will be 22.733/18.5 = 1.228 ppt which is negligible compared with the criterion of 34.1x10% = 3.41 ppt. Minimal salinity impact on the marine water quality is therefore expected during the operation phase of the desalination plant.

6.10.14 Table 6.12 summarizes the predicted salinity concentration at identified sensitive receivers. All the predicted results are well below the WQO standard. No salinity impact to any sensitive receiver is expected during the operation phase of the desalination plant. The 90^{th} percentile of salinity (1998-2003) at Port Shelter WCZ is 34.1 ppt, and the minimum and maximum values are 22.4 ppt and 35.2 ppt respectively. The net increase in predicted salinity (1.228 ppt) at the nearest sensitive receiver (corals) is within the natural variation of salinity at Port Shelter WCZ, and the expected change of salinity concentration at all sensitive receivers during the operation phase of the desalination plant is considered insignificant. The nearest WSR (Coral - 80 m away from the discharge) will be selected as coral translocation site before the desalination plant intake and outfall pipelines construction.

Table 6.12 Summary of Salinity Impact to the Marine Sensitive Receivers[t13]

Sensitive Receivers	Shortest Distance to the desalination plant discharge (m)	Net impact on salinity (ppt)	WQO Tolerance elevation (mg/L)
Corals on bedrock to the south of the pier	80	1.228	3.41
Seagrass at the Southern part of the pier	200	1.103	3.41
Fish Culture Zone at Kai Lung Wan	450	1.033	3.41
Mangrove at Western part of KSC	500	0.951	3.41
Sharp Island	750	< 0.951	3.41

Coral Sites at Sharp Island	760	< 0.951	3.41
Pak Sha Tsui Beach	1125	< 0.951	3.41
Fish Culture Zone at Kau Sai	2000	< 0.951	3.41
Kau Sai Wan Beach	2020	< 0.951	3.41

Impact assessment of backwash discharge

6.10.15 The total volume of backwash water from 5 backwash filter units is 75m³ per 24 hours. Each filter unit backwash is in time sequence, so that only one filter unit will be backwashed at one time within 24 hours. Each of the filter should be backwash once within 24 hours. The discharge SS concentration will be 321.5 mg per second per filter unit in 10 minutes. The maximum volume of backwash water from each filter unit is 15 m³. The discharge water will not immediately be discharged into the marine water, but will be diverted backed into a 20m³ backwash water holding tank which holds all of the backwash water. The calculated SS concentration in the holding tank is (321.5 mg/s x 10 mins x 60s)/(15 m³ x 1000) = 192,900 / 15000 = 12.86 mg/L. The backwash water will then be slowly discharged into the marine water over a 4.5-hour period. The maximum allowable backwash discharge time from the backwash water holding tank (discharging the backwash water per filter unit) to marine water should be no longer than 4.5 hrs (4.5 hrs x 5 filters = 22.5 hrs) to avoid the cumulative impacts of SS from the filter units.

6.10.16 The washwater discharge flowrate will be $15m^3/4.5$ hr = $0.000926m^3/s$ (Holding tank volume at 20 m^3). Compared with the salinated water discharge of $0.0168m^3/s$, the additional momentum and salinity dilution due to backwashing will be negligible. Ignoring the settling effect, the modeling results in Table 6.11 are also applicable to suspended solids. SS concentration prior to the discharge is expected to be 12.86 mg/L. The dilution factor at the nearest water sensitive receivers (80m) (corals) will be 18.5 times less than the discharge, i.e. 0.695 mg/L. As this calculation did not consider the settling of suspended solids, and the actual concentration at sensitive receivers should be even lower. Since the 90^{th} percentile ambient suspended solid is 4.95 mg/L, the tolerant elevation of SS is 1.485 mg/L (4.95 mg/L x 30%). The net SS concentration from the backwash water increase (0.695 mg/L) at the nearest sensitive receiver (corals) is below the tolerance elevation of 1.485 mg/L, and is therefore well within the SS WQO standards. No SS impact on the marine water quality from the desalination plant on SS during the operation phase is therefore expected.

6.10.17 Table 6.13 summarizes the predicted suspended solids (SS) concentrations at the identified sensitive receivers. The predictions show that SS concentrations at all the locations are well below the WQO standard. No suspended solid impact to any sensitive receivers during operation phase of the desalination plant is expected.

Table 6.13 Summary of Suspended Solids Impact to the Marine Sensitive Receivers

Sensitive Receivers	Shortest Distance to the desalination plant discharge (m)	Net impact on SS (mg/L)	WQO Tolerance elevation (mg/L)
Corals on bedrock to the south of the pier	80	0.695	1.485
Seagrass at the Southern part of the pier	200	0.624	1.485
Fish Culture Zone at Kai Lung Wan	450	0.585	1.485
Mangrove at Western part of KSC	500	0.538	1.485
Sharp Island	750	< 0.538	1.485
Coral Sites at Sharp Island	760	< 0.538	1.485
Pak Sha Tsui Beach	1125	< 0.538	1.485
Fish Culture Zone at Kau Sai	2000	< 0.538	1.485
Kau Sai Wan Beach	2020	< 0.538	1.485

6.10.18 The 90^{th} percentile of suspended solids (1998-2003) at Port Shelter WCZ is 4.95 mg/L, with the minimum and maximum values at 0.5 mg/L and 26 mg/L respectively. The net increase of predicted suspended solids (0.695 mg/L) at the nearest sensitive receiver (corals) is within the natural variation of salinity at Port Shelter WCZ, and therefore the suspended solids levels at all sensitive receivers during the operation phase of the desalination plant will not be affected.

6.10.19 Using the same calculation approach as the impact assessment for dredging during construction phase, the sediment deposition rate at the nearest sensitive receiver (corals) (at 80m) will be 0.0005m/s x 0.695 g/m^3 x 60s x 60min x 24hr / 1000 g/kg = 0.030 $kg/m^2/day$. According to the ERM (2001), 0.1 $kg/m^2/day$ was proposed as the assessment criterion for protecting corals and benthics, the predicted SS impacts due to sediment deposition from backwash water are therefore considered acceptable. The degree of oxygen depletion exerted by sediment plume is a function of the oxygen demand of the sediment, its concentration in the water column and the rate of oxygen replenishment. The average value of chemical oxygen demand of the sediment at Port Shelter (1998-2003) is 16,732 mg/kg. According to Mouchel (2002), the impact of the oxygen demand on DO concentration has been calculated based on the multiplication of SS concentration, Oxygen Demand and Daily Oxygen Uptake Factor (set as 0.23 in ERM, 1997). Oxygen depletion exerted by backwash discharge will be 0.695 g/m^3 x 0.23 x

16732/1000/1000 = 0.0027 mg/L which is undetectable.
[t14]
Anti-scalant

6.10.20 The active ingredient in the anti-scalant proposed for use in the RO system is PermaTreat® PC-191. It does not contain heavy metals or hazardous substances. None of the substances in this product are listed as carcinogens by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP) or the American Conference of Governmental Industrial Hygienists (ACGIH). The potential toxicity to human is therefore low. Anti-scalant concentration prior to discharge is expected to be 3 mg/L. The dilution factor at the nearest WSR (80m) (Seagrass) will be 18.5 times less than the discharge, i.e. 0.162 mg/L. According to the ecotoxicology result from at Material Safety Data Sheet of the anti-scalant PermaTreat® PC-191, the 96-hr LC_{50} for fish are range from > 300 to 1212 mg/L. The 96-hr LC_{50} for invertebrates is > 1000 mg/L. The 96-hr EC_{50} for green algae is 20 mg/L. The predicted anti-scalant concentration (0.162 mg/L) at the nearest WSR is 123 times lower than the 96-hrs EC_{50} for the green algae. With reference to the ecotoxicology data of the anti-scalant, it is not likely to be harmful to aquatic biota given the low toxicity and low initial concentration (Appendix A6.3).

Summary for marine water quality impact from the desalination plant

6.10.21 For the purpose of water quality modelling assessment on (i) suspended solids and sedimentation rate during dredging and (ii) operational impact of the proposed desalination plant. The ambient values of suspended sediments and salinity were represented by the 90th percentile values of the reported concentrations. EPD routine monitoring data (1998–2003) at monitoring stations PM1, PM2, PM3, PM4, PM6, PM7, PM8, PM9 and PM11 (depth-averaged) were used as the data source of the reported concentrations. Ambient values and allowable tolerance elevation for SS and salinity concentrations under the WQO for the identified sensitive receivers are given in Table 6.8.

During construction

6.10.22 Since the sediment testing results showed that marine sediments to be dredged for the proposed submarine intake and discharge were classified as Category L and no exceedance of the respective LCELs were recorded (please refer to Chapter 7 for details), the potential impact of contaminants released from the sediments would be minimal. In other words, the potential release of metals and organics from sediment into the water column would not result in any adverse impact on water quality during the dredging works.

6.10.23 The predicted suspended solids to the corals (nearest sensitive receivers) would be well below the WQO during the construction phase (dredging activities) of the desalination plant intake and outfall pipelines (The net increase of predicted suspended solids at the nearest sensitive receiver (Corals) by using backhoe method and closed grab method are 1.078 mg/L and 1.094 mg/L respectively). For dissolved oxygen, the DO depletion rate due to dredging is 0.0042 mg/L which is under the detectable limit. No impact for DO depletion is therefore expected during dredging. For the sedimentation rate, the daily deposition rate to corals will be 0.047 kg/m²/day (closed grab) and 0.046 kg/m²/day (backhoe). According to another approved EIA study (ERM, 2001), the adopted allowable sedimentation rate for Hong Kong eastern water coral is 0.1 kg/m²/day for the corals in the Hong Kong eastern waters. No impact due to sedimentation of suspended solids to corals (80m) is expected during the construction phase. The choice of sedimentation rate can also apply to seagrass as a conservative value for the desalination plant. As corals are filter feeders, they are considered to be more susceptible to smothering effect by sediment than seagrass.

During Operation

6.10.24 The predicted suspended solids (net increase due to the desalination plant discharge is 0.695 mg/L which is well below the WQO standard of 1.485 mg/L) and salinity (net increase due to the desalination plant discharge is 1.228 ppt which is well below the WQO standard of 3.41 ppt) impacts to the corals are well within the WQO standards during the operation phase of the desalination plant. For dissolved oxygen, the DO depletion rate due to desalination plant discharge is 0.0027 mg/L which is under the detectable limit. No impact in the form of DO depletion is expected during operation phase of the desalination plant. For the sedimentation rate (backwash water from the desalination plant), the daily deposition rate to corals will be 0.03 kg/m²/day. No adverse water quality impact in relation to suspended solid, salinity, and DO, are expected during the construction and operation phase of the desalination plant.

Chemicals and Pesticides Run-off

Testing and analysis

6.10.25 The proven Turfgrass Management Plan for the existing golf courses will be applied to the third golf course. The rational is to minimize the use of chemicals and pesticides. The chemicals chosen for analysis will vary depending on the turfgrass management practices in operation at the time. For example, if there is a specific pest problem requiring chemical treatment, water quality monitoring will be undertaken to trace the environmental fate of the chemical. Sampling should be timed to coincide with specific chemical applications.

Increased Nutrient Loading (Red Tides)

6.10.26 There is potential for eutrophication caused by natural processes and contamination from fertiliser application monitoring of reservoir water quality is a requirement of WSD. The main concern is the use of nitrogen for fertilisation and its eventual fate. To a smaller extent, leaching of phosphorus is also a concern. The nitrogen source used should be in slow release form. The conjugated forms of urea that will be used are Methyl Urea and Polymer Sulfur-coated Urea. Phosphorus is unlikely to have significant run-off following fertilizer applications because it is rapidly adsorbed into the soil, and any run-off can be controlled by irrigation practices and an understanding of rain patterns. With the correct management practices, loss of nitrogenous fertilizer will be minimal. Based on the monitoring records at the existing golf courses past 9 years, the nitrogen and phosphorus absorption by turf area are as high as 98 % and 99% respectively.

Run-off from Land Drainage System

6.10.27 To conserve water and to minimise potential environmental impacts on marine and mariculture areas around the island, the overall water management and land drainage for the existing golf course is based on the concept of self-containment and effluent re-cycling. This approach is operation successfully at the existing golf courses, and will be adopted for the proposed third golf course. The same turfgrass management practice approach (specific to the new turf – *Seashore paspalum* – Appendix A6.4) together with the closed low flow land drainage system will ensure freshwater and marine water qualities are within acceptable levels.

6.10.28 Water quality at the proposed third golf course is assessed using the past 9 year's comprehensive water quality monitoring data from the existing golf course. Moreover, rainfall data for the past 10 years are also included for the estimation. The hydrological prediction approach and assumptions are as follows:

(a) Summarize the freshwater and marine water quality data at all monitoring locations at the existing golf course over past 9 years.
(b) Present the preliminary design of the proposed closed drainage system and 18-hole turf area.
(c) Summarize fertilizer applications load to the primary catchment at the existing golf courses.
(d) Summarize residual fertilizer load at the existing reservoir from the primary catchment.
(e) Calculate nutrient absorption load per unit turf area at the existing golf courses.
(f) Predict leaching concentrations to the new lakes of the proposed third golf course (based on rainfall data over the past 10 years).
(g) Predict existing reservoir water quality with additional run-off load from the proposed third golf course (based on rainfall data the past 10 years).
(h) Estimate frequency of the overflow events at the proposed third golf course (based on the rainfall data over the past 10 years).

6.10.29 All monitored pesticides concentrations at all monitoring locations are below the reporting limit (< 0.5 µg/L) over 9 years of monitoring at the existing golf courses. Therefore, with the same approach to turfgrass management, pesticides concentration should be below the detection limit at the proposed third golf course, and no water quality impact is expected. Moreover, less frequent use of pesticides and nutrients is expected during the operation phase of proposed third golf course than on the existing golf courses due to the higher drought and disease tolerance of the proposed new turf *Seashore paspalum*.

Water quality at proposed new lakes during rainstorm event

6.10.30 This section presents the result for the water quality impact assessment on nutrients applied to the proposed third golf course with respect to the closed low flow land drainage system during the operation phase of the proposed golf course. Detailed calculations are shown in Appendix A6.2.

6.10.31 The main low flow drainage system is a closed drainage system designed for storm events with a 1 in 2-year return period[1]. The sub-surface drainage system of the proposed third golf course drains and diverts surface run-off from the golf course to a system of underground storage tanks and two new lakes. Two proposed new lakes hold the surface run-off from the golf course temporarily. Run-off collected in the underground storage tanks and new lakes will be pumped to a proposed irrigation buffer, Lake 1D, from where overflow will be directed into the existing reservoir for irrigation purpose.

6.10.32 The proposed new lakes are :

- Lake near Hole 4 (Design volume = 1,870 m^3; Catchment area = 75,000 m^2)
- Lake near Hole 10 (Design volume = 9,880 m^3; Catchment area = 160,000 m^2)
- Irrigation Lake 1D (Design volume = 25,000 m^3)

6.10.33 The underground storage tanks and new lakes at Hole 4 and Hole 10 are the first points of collection for run-off from the proposed third golf course. Water from these collection points are then pumped back to Irrigation Lake 1D which acts as the first holding point for golf course run-off from the proposed third golf course. When Irrigation Lake 1D is full, water will overflow into the existing reservoir through underground pipe by gravity. Based on the proposed drainage design, overflow will occur when a storm event is greater than a 1 in 2-year return period storm event. For the worst case scenario in this study, 1 in 2-year storm event will be used to estimate the golf course run-off concentrations during overflow. It should be noted that no overflow from the new proposed lakes will occur during the operation phase of the proposed drainage design during a 1 in 2-year storm event. Table 6.14 summarizes the golf course run-off overflow concentrations of TIN and TP at the lakes near Hole 4 and Hole 10 during a 1 in 2-year rainstorm.

6.10.34 The estimation of the nutrient loading are based on the two main assumption:

(i) The organic fertilizer applied at the existing and proposed third golf courses is between 30 to 50% of total fertilizer (organic fertilizer with inorganic slow release fertilizer). For the worse case scenario, it is assume all of the organic nitrogen fertilizer will be available as nitrogen source as Total Inorganic Nitrogen (TIN) for the nitrogen load calculation.

(ii) It is assume all of the turfgrass area is applied at the same nitrogen and phosphate loading rate per unit area as green area for the worse case estimation. Total nitrogen application loads per unit area at greens and other turfgrass areas (tees and fairways) are 465 kg/ha/yr and 258 kg/ha/year respectively. While total phosphate application loads per unit area at greens and other turfgrass areas (tees and fairways) are 47 kg/ha/yr and 42 kg/ha/year.

Table 6.14 Estimated overflow run-off concentrations of TIN and TP at lakes near Hole 4 and Hole 10during 1 in 2-year rainstorm

Lake location	Timing	Predicted Concentration	
		TIN	TP
Lake near Hole 4	First Year : Turf establishment period (First 3 months) + 9 months of after establishment period	0.017 mg/L	0.003 mg/L
	Second Year : 12 months of Establishment period	0.013 mg/L	0.0004 mg/L
Lake near Hole 10	First Year : Turf establishment period (First 3 months) + 9 months of after establishment period	0.031 mg/L	0.005 mg/L
	Second Year : 12 months of Establishment period	0.023 mg/L	0.007 mg/L

Remarks: The 3-month turf establishment period has the highest nutrient requirement period among any other months during the operation phase for the proposed third golf course.

6.10.35 In conclusion, total inorganic nitrogen concentrations overflowing to the marine water from the lake near Hole 4 during 1 in 2-year rainstorm events comply with (i) Table 6.4 guideline values for the existing golf courses (TIN $\leq$ 0.145 mg/L) and (ii) WQO guideline value at Port Shelter WCZ ($\leq$ 0.1 mg/L) (Table 6.1). For total phosphate, there is no WQO guideline value at Port Shelter WCZ. The predicted total phosphate concentrations are in compliance with the Table 6.4 guideline values (TP $\leq$ 0.09 mg/L).

6.10.35 The golf course is shaped to collect all the surface runoff from the golf course to the catchpits which drains to the underground storage tanks and man made lakes. The storm drainage system including pipes and catchpits connecting to the underground storage tanks and man make lakes are designed to cater for 1 in 50 year rainfall runoff. Therefore, there will be no direct overflow from the course when there is severe rainstorm. The underground storage tanks, lakes and the existing reservoir are the controlled overflow points and shall discharge direct to the sea with no overflow to any natural stream course. The storage tanks and lakes are designed to contain events up to 1 in 2 year duration and shall capture the first flush on all events. Flows from the underground tanks and lakes shall be conveyed by gravity and pumping to the existing reservoir.

6.10.36 The proposed closed low flow drainage system design at the third golf course is a more conservative and preventive approach to collect, recycle and reuse the golf course runoff than the existing golf courses. Predicted water quality before the overflow event at the proposed man made lakes during 1 in 2 years storm event already complies with the Port Shelter WQO. The closed low flow drainage system design for 1 in 2 yrs at the proposed third golf course is, therefore, sufficient to protect the freshwater and marine water qualities in Port Shelter. Golf course runoff concentration during more severe rainstorms will be even lower due to larger flow and the fact that the first flush shall have been retained. Dilution of the golf course runoff (1 in 2 yrs) at the existing reservoir during 1 in 5 yrs, 1 in 10 yrs and 1 in 50 yrs overflow events are 1.4, 1.7 and 2.2. Thus, no water quality impact is expected for those storm events even larger than 1 in 2 years.

Hole 5 and part of Hole 6

6.10.36 Over the past 9 years of existing golf courses operation, run-off from holes N15, S1 to S9 (existing golf course) flowed to the existing marsh before overflowing into the marine water. With the proposed closed low flow drainage system for the proposed third golf course, the golf course run-off from the existing holes S1, S7 and S9 will be collected and diverted back to the existing reservoir rather than discharging directly to the marsh. The net golf course run-off load from the turfgrass to the marsh will be reduced when the proposed third golf course comes into operation. The golf course run-off from Hole 5 (mainly greens) and part of Hole 6 (fairway) will not be collected by the proposed closed low flow drainage system, but will be diverted to the existing marsh before discharge into the marine water. Ultimately, there will be an overall net decrease in golf course run-off flow to the marsh, and no adverse impact on water quality is expected from Hole 5 and part of Hole 6 during the operation phase of the proposed third golf course.

6.10.37 For the existing system, the golf course run-off from Holes N15, S1 to S9 flow into the marsh before overflowing into the marine water. The estimated flow to the marsh (1 in 2-year) from the existing system is 4,522 m^3. For Hole 5 and part of Hole 6, estimated flows (1 in 2-year) are 377 m^3 and 511 m^3 respectively. With the implementation of proposed closed drainage system, annual run-off from Holes S1, S7 and S9 (1,219 m^3) will be diverted back to the existing reservoir for irrigation rather than flowing into the existing marsh, and the net run-off flow volume into existing marsh will be reduced by 7.3%. In terms of turfgrass area, there is a net reduction of 6.6% with the proposed drainage system.

6.10.38 There is a pond as the final receptor located in the secondary catchment of the existing golf courses prior water overflow to the marine water. The pond is bound on the upstream by the marsh and has been efficiently acting as a sink for various nutrients, and on the downstream side by a concrete weir. Thus, in the dry season the pond is effectively an enclosed water body, but overflow to the sea occurs when water supply is adequate in heavy rain.

6.10.39 The predicted run-off concentration at Hole 5 and part of Hole 6 during the first 3-month establishment (worst case scenario) is extremely low. The predicted TIN and TP concentrations before discharge into the marsh are 0.08 mg/L and 0.014 mg/L respectively (Appendix A6.2). The water quality monitoring results at the marsh for TIN and TP ranged from 0.2-1.7 mg/L and 0.01-0.1 mg/L respectively. Total inorganic nitrogen concentrations from Hole 5 and part of Hole 6 during 1 in 2-year rainstorm events comply with (i) Table 6.4 guideline values for the existing golf course (TIN $\leq$ 0.145 mg/L) and (ii) WQO guideline value at Port Shelter WCZ ($\leq$ 0.1 mg/L) (Table 6.1). For total phosphate, there is no WQO guideline value at Port Shelter. The predicted concentrations of TP are in compliance with the Table 6.4 guideline values (TP $\leq$ 0.09 mg/L). Thus, no adverse impact on water quality is expected from Hole 5 and part of Hole 6 during the operation phase of the proposed third golf course.

6.10.40 In addition, monitoring results at Marine Station B (immediate discharge from pond after marsh) over the past 9 years show that all run-off are well below the WQOs standards at Port Shelter WCZ. With the 7.3% flow reduction to the marsh when the proposed third golf course comes into operation, no impact on the water quality is expected.

Overflow events

6.10.41 The predicted maximum frequency of overflow events (based on rainfall in Hong Kong over the past 10 years) at the proposed new lakes (lake near Hole 4 and lake near Hole 10) is 7 days per year only (storm event greater than 1 in 2-year return period), and it is considered to be low (1.91% per year). The TIN concentration from the new lakes during overflow is well within the WQO standard. No water quality impact is expected from the closed low flow land drainage system during the operation phase of the proposed third golf course.

Additional Sewage Discharge during Operation

6.10.42 During the operation phase, the increased amount of effluent generated will be directed to the licensed sewage treatment works (STP) on the site of the existing golf courses. The STP will need to be extended to accommodate the additional flows, with the maximum capacity increasing from 150m^3/day to 225 m^3/day.

6.10.43 The existing STP is based on the Rotating Biological Contactor (RBC) technology and includes for sludge dewatering (filter press). It is proposed to install a new STP adjacent to the existing plant to cater exclusively to the additional flow (75m^3/d) from the expansion of golf course to minimize the disruption to the existing STP. The two flows will be combined and use for irrigation and recycle purposes. The new STP can be installed prior to the completion of the clubhouse renovations such that part of the flow to the existing plant can be diverted to the new plant for the purpose of pre-commissioning the biological elements of the new plant.

6.10.44 After passing through the new STP, semi-treated wastewaters will be returned to the existing plant for treatment. In this way, biomass will steadily accumulate in the new plant to the point where the new plant was fully commissioned. At such time as the clubhouse expansion will be completed, the additional 75m^3/day of sewage generated will be fully treated from day one which provides a "seamless" transition. An additional benefit would be that, during the commissioning of the new STP, loads to the existing plant would be reduced thus enhancing its performance.

6.10.45 It is proposed that the 75m^3/day of sewage which will be generated in the extended clubhouse facilities will be combined with the 150 m^3/day of sewage currently generated in the clubhouse facilities. The combined flow will then be delivered to the influent bar screens at the existing sewage treatment plant. On passing through the bar screens, the combined sewage flow will be collected in the existing flow balance tank.

6.10.46 150 m^3/day of the combined flow collected in the balance tank will be treated in the existing plant as per the present day situation. The remaining 75m^3/day of the combined flow collected in the balance tank will be drawn off at a constant rate by new pumps installed in the existing balance tank. These pumps will be controlled by level sensors and a new control panel.

6.10.47 The 75m^3/day of sewage will be pumped to a new STP located adjacent to the existing STP. This new STP will operate totally independently of the existing plant other than for sludge handling. Sludge stored in the new STP will be periodically drawn off and dewatered in the existing sludge dewatering facilities.

6.10.48 To provide ensure the plant meets the *E.Coli* standard the existing UV disinfection lamps shall be replaced with larger units. In addition the existing micro-drum filters shall be replaced with larger units to ensure the suspended solid (SS) is maintained.

6.10.49 All discharges during the operation phase of the proposed extension of Sewage Treatment Works (STWs) located at the existing golf courses are required to comply with Technical Memorandum for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters issued under Section 21 of the WPCO. The existing effluent discharge standard for the STW include BOD (20 mg/L), COD (80 mg/L), SS (30 mg/L) and E. coli (100 cfu/100mL) and these shall be maintained. Application for a discharge licence variation for the proposed changes to the existing STWs should be made and consulted in advance to the Environmental Compliance Division of EPD before the operation of the STWs.

6.10.50 The STW plant extension will be subject to detailed design by the specialist plant suppliers employed by the main contractor and shall meet the requirements of the performance specification provided by the Engineer in the contract documents. The contractor shall be responsible to liaise with EPD and seek approval and agreement to modification of the discharge consent permit.

6.10.51 Treated Effluent from the STP will continue to be directed to the reservoir on the existing golf courses. Lake 1 at the existing golf courses is the first collection point, and the maximum total inorganic nitrogen and total phosphate concentrations recorded over the past 9 years were 6.06 mg/L and 0.42 mg/L respectively. The effluent water was diverted to a series of lakes at the existing golf courses and finally discharge to the existing reservoir for reuse and recycling as golf course irrigation over the past 9 years. The turfgrass at the primary catchment of the existing golf course acted as a filter system and can polish the treated effluent from the sewage treatment plant.

6.10.52 A net increase of TIN and TP loads of 0.42 kg/day and 0.03 kg/day from the STW is expected during the operation phase of the third golf course. The treated effluent from the sewage treatment works will also be using the same way through the same dischrage route (series of lakes and turfgrass area) before final storage in the existing reservoir for irrigation. The lowest nutrient absorption rates by the turf at the primary catchment for TIN and TP are 98 and 99% (please refer to Appendix A6.2 for details), and the expected TIN and TP concentrations before discharge to the existing reservoir are 0.084 kg/day and 0.003 kg/day. If the lowest reservoir volume (dead storage) is 56,503 m^3, both estimated TIN and TP concentrations are at undetectable levels. No cumulative impact on the water quality to the existing reservoir with the additional load from the sewage treatment work is expected.

6.11 Mitigation Measures

Key mitigation measures during Construction Phase

- Proposed 18-hole Golf Course Layout Design – buffer zone at streams;
- Run-off and Drainage Management – silty and turf establishment run-off;
- Concrete bridge construction;
- Dredging during construction of desalination plant’s intake and outfall;
- General construction activities;
- On-Site Sewage Effluents; and
- Concrete batching plant.

Key mitigation measures during Operation phase

- Chemicals and Pesticides Run-off (closed low flow drainage system); and
- Hole 5 and part of Hole 6 – Filter system and biopesticides.

Construction Phase

<u>Proposed 18-hole Golf Course Layout Design</u>

6.11.1 Three main sensitive streams (Stream A, B and C) were identified on the site of the proposed third golf course (Figure 6.6a). To avoid and minimize the water quality impacts on all identified sensitive streams during the construction phase, the proposed third golf course design layout has been carefully designed (mainly for Hole 10, 15, 16 and 17) to maintain the integrity of all sensitive streams.

6.11.2 Crossings would be required at the streams for access to fairways (greenskeeping equipment, golfers, golf buggies). Three permanent bridges are proposed, one at each stream course (Figure 6.5a). Two of these permanent bridges (at Streams A and C) would be supported by piers behind the stream banks and thus would not encroach onto the stream beds or stream banks. The bridge at Stream B would be a culvert bridge, with the stream passing beneath the bridge through a 450 mm diameter pipe. Two additional culvert crossings are proposed at the highest reach of tributary B1 of Stream B. In contrast to the underground pipe culvert at tributary A2, these culverts are only to enable passage of golfers and buggies, and are therefore much shorter (less than 2 m in length). They are also located at the highest and steepest stream reach of tributary B1. This reach of the stream would be dry during most of the year.

6.11.3 All sensitive streams are protected through the use of buffer zones along the length of the streams. For the golf course design of Holes 15/16, the whole length of Stream C is protected through the use of the buffer zones (20m on both sides) as conservative and precautionary measures. For Streams A and B, the smaller tributary of Stream A2 and an old tributary of

Stream B3 (relatively non-sensitive) will be partially turned into underground channels due to engineering design constraints and playability issues for the proposed third golf course. For the partly channeled portions at Streams A and B, water flow path will be maintained during the construction phase (temporary diversion if necessary) and the operation phase (underground pipes) of the proposed third golf course. The proposed underground pipe proposed is to ensure (i) no dehydration impact at the downstream location of the stream which can support fish species and other aquatic species and (ii) maintaining the water flow during the operation phase of the proposed third golf course.

6.11.4 Twenty-metre (20 m) buffer zones on both sides of the streams will be demarcated as a preventative mitigation measure to reduce disturbance during construction phase of the golf course, except for the portions of Streams A, which is of low ecological value, and an old tributary of Stream B. Details of the terrestrial ecological assessment are presented in Chapter 8. On one side of part of the Stream B, the buffer zone would be reduced to 5m, and this relatively small buffer zone is proposed due to space limitation and playability requirement of the golf course at the proposed Hole 10. The buffer zones are shown in Figure 6.6b.

6.11.5 For construction activities which must be carried out near natural streams (within the buffer zone), mainly the construction of crossings, preventative mitigation measures during the construction stage should be followed by the contractor. These are as follows:

- The proposed works site inside or in the proximity of natural streams should be temporarily isolated, by placement of sandbags or silt curtains and properly supported by props, to prevent adverse impacts on the stream water qualities;
- The natural bottom and existing flow in the stream should be preserved to avoid disturbance to the stream habitats;
- No direct or indirect discharge into the natural stream should be allowed from any construction activities;
- Stockpiling of construction material, if any, should be properly covered and located away from any natural streams;
- Monitor rain forecast closely and cover any exposed spoils when rainstorms are expected. Debris should be properly disposed of before rainstorms to avoid any being inadvertently washed into the stream; and
- Removal of existing vegetation alongside the stream should be avoided. When disturbance to vegetation is unavoidable, all disturbed areas should be hydroseeded or planted with suitable vegetation to blend in with the natural environmental upon completion of construction works.

6.11.6 With the implementation of the buffer zones and preventive mitigation measures, no significant impacts on water quality during construction phase of the golf course will be expected.

<u>Run-off and Drainage Management</u>

6.11.7 It is very critical to manage the stormwater run-off during the construction phase of the proposed golf course to ensure the impact of silty run-off is minimized effectively. The majority of the heavy construction works, the cut and fill earth works, would be conducted within the February 2006 – February 2007. Due to the tight construction programme, it is unavoidable to carry out earthworks during the wet season.

6.11.8 The golf holes will be constructed sequentially, with excavation and fill movements to the nearest-most point (to minimize the excavated mud movement within the construction site), with the first southernmost (Holes 11-16 – Group A) holes, then the northernmost (Holes 3-9 – Group B) holes and finally middle (Holes 1,2,10,17 and 18 – Group C) holes. For the cut-and-fill operations, maximum two holes will be worked simultaneously for each group.

6.11.9 With the proposed construction programme (major construction work will be carried out one group in a time with maximum two holes will be work simultaneously), the silty runoff will be controlled in a manageable way. With the proposed erosion control measures which will be accomplished through one or more several means, including (but not limit to): sedimentation tanks, silt fences, sand bags, porous pipe, hydroseeding; erosion control fabrics and mats; and temporary sedimentation basins, water quality impacts to the nearby streams and marine water is not anticipated. In addition, all sensitive streams will be protected by buffer zone during construction and operation phase of the proposed third golf course.

6.11.10 The golf holes will be completely individually, one-by-one and working first from the south toward to the center, then from the north toward the center and finally the center toward the temporary barging point.

6.11.11 A proposed temporary drainage system will fulfill the following purposes: (i) minimize the stormwater flow entering the works areas during construction; (ii) prevention of any polluted run-off to existing streams and marine waters; and (iii) recycle, reuse and recirculation of run-off for irrigation use.

6.11.12 The construction works will involve preparation of areas of earthworks, which will be vulnerable to stormwater. An effective and well-managed temporary drainage system should be provided as a physical barrier to reduce impact from run-off during the construction phase of the proposed third golf course. Treatment facilities should be provided to remove suspended solids and any pollutants that would be contained in the runoff before returning fro turf irrigation use.

6.11.13 The concepts and key elements (but not limit to) for the temporary drainage management (Appendix A6.5) are shown as follows:

(i) **Diversion of upstream flows around the works areas for stream crossings and underground pipes**: Minimize the impact of upstream run-off on the works areas by preventing storm flows from reaching the works areas. This will be done through provision of upstream cut-off drains to intercept the flows and divert them around the works area. The cut-off drains will convey flows to downstream stream courses or other elements of temporary drainage systems (such as storage facilities).

(ii) **Temporarily covering the works areas during severe storm events**: Severe storm events can be reasonably well forecast and, when heavy rain is predicted, mitigation measures should be implemented for vulnerable areas by using tarpaulins, plastic sheets or other temporary covering to protect the works areas and minimize damage and erosion. Covering of newly establishment grass areas is not recommended, and if this is unavoidable, it should only be done on a short term basis (less than 24 hours).

(iii) **Silt traps and sedimentation tanks for main discharge routes from works area**: Sufficient and suitably sized silt traps and/or sedimentation tanks should be provided at the downstream ends of the systems to remove suspended solids prior to discharge. The discharge water quality shall comply with the *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* under the WPCO. The required volume of the sedimentation tanks will depend on the catchment area served. Multiple tanks in series may also be required where run-off are expected to be silty.

(iv) The design details of the temporary drainage system at turf establishment area follow the same principles of the permanent drainage system. However the component pipes, tanks, lakes and/or pumps may differ in size, shape, location, etc. from that of the permanent system, dependent upon the temporary runoff areas as compared with those of the permanent system. Additionally or alternatively, the temporary drainage system may consist of other methods to control soil erosion and/or to facilitate the collection of surface water runoff.

The temporary drainage system will function during the period of time in which the permanent system is not yet completed. This circumstance will arise from the fact that the golf holes, inclusive of the permanent drainage system, will be constructed individually. As a result, the permanent drainage system may not be completed in its entirety until connection is made from each respective golf hole area to the lake/reservoir. As the permanent drainage system is completed for each hole, the corresponding temporary system will be decommissioned and reused elsewhere.

The temporary drainage system will be in use until the permanent system is functional in a given area. Once the permanent system is functional in a given area, the temporary system will be decommissioned and, wherever possible, the components re-used in another temporary drainage system installed elsewhere. It is anticipated that the maximum duration of use for the temporary drainage system in any given area will be one-year.

The storage tanks and/or lakes will be designed to segregate suspended solids (or pollutants as may be the case in plant/equipment storage and refueling areas) as may be necessary by contract requirements and reuse.

(v) No irrigation, fertilizer and pesticide application to the turf should be permitted during rainstorm events or when heavy rainstorm is predicted within 24 hours of the application.

(vii) Run-off from materials storage areas, particularly fuel and chemicals storage area should be separated from the main drainage systems (bunded, if necessary) and provided with dedicated facilities, such as petrol interceptors, throughout the construction period.

6.11.14 The contractor should follow good site practices and be responsible for the design, construction, operation, and maintenance of all mitigation measures as specified in *ProPECC PN No. 1/94* on construction site drainage throughout the construction period. These practices include:

- Temporary ditches should be provided to facilitate run-off discharge into appropriate watercourses via a silt retention pond.
- All drainage facilities and erosion and sediment control structures should be inspected monthly and maintained to ensure proper and efficient operation at all times.
- For excavation of soil that cannot be avoided during the wet seasons, exposed surface or open stockpiles should be covered with tarpaulin or other means. Other measures that need to be implemented before, during and after rainstorms are summarized in *ProPECC PN No. 1/94*.
- Exposed soil areas should be minimized to reduce potential for increase siltation and contamination of run-off.
- Earthwork final surfaces should be well compacted and subsequent permanent work (turf establishment) should be performed immediately.
- The contractor should contain within the site all surface run-off generated from the construction works, concreting works, dust control and vehicle washing, etc.
- The contractor should arrange for other measures, such as provision of sand bags or temporary diversion systems, to prevent washing away of soil, silt or debris into any nearby natural streams. Any run-off should be diverted into appropriate sediment traps before discharging to the nearby drainage system. The discharge water quality should comply with the *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* under the WPCO.
- The contractor shall apply discharge licence from EPD for discharging effluent from the construction site before the commencement of construction work.
- The contractor should observe and comply with the Water Pollution Control Ordinance (WPCO) and its subsidiary regulations by implementing environmental protection measures (such as the use of silt traps) and preventing any point or non-point source of pollution.

Concrete bridge construction

6.11.15 No work is allowed to come into contact with the underlying stream bed during the concrete bridge construction. During construction of precast concrete bridge precaution measures should be taken where necessary to ensure that no potentially polluting liquid or solid wastes will fall into the stream. This is essential in avoiding water quality impacts to ecologically sensitive streams.

6.11.16 The contractor should follow good site practices, including, but no limited to:

- Construction work area for the precast concrete should be outside the designated stream buffer zone area;
- The designated work area for precast concrete work should be covered to minimize potential water run-off during rain from the construction area;
- It is recommended to install perimeter channels in the works area to intercept runoff at site boundary where practicable. Drainage channels are required to collect site runoff and to convey site runoff to sand/silt traps for removal of soil particles. Provision of regular cleaning and maintenance can ensure the normal operation of these facilities throughout the construction period. Sand bags should be provided control site runoff before a rainstorm occurs.
- All water used within the concrete work area should be collected, stored and recycled to reduce resource consumption. Stormwater run-off from the works areas for precast concreting works should drain by gravity towards a sedimentation basin. The overlying water from the sedimentation basin should be reused within the works area. The deposited sediment at the temporary sedimentation tank should be dewatered and disposed off-site. No water should be discharged outside the boundary of the precast concrete works area;
- Tarpaulin sheets or other means (water impermeable texture) should be placed beneath precast concrete beam level (must be above the stream bed level) to capture any falling object during installation of precast concrete bridge decks on the footings or abutments;
- Any direct and indirect discharge into the streams should be prohibited;
- The concrete bridge and footings of abutments must be completely above the high water mark;
- All equipment and machinery must be free of leaks or excess oil and grease;
- Equipment refueling or servicing or storage of fuel must be undertaken at a minimum of 30 meters from the stream;
- Soil and trash should be prevented from getting into the streams during construction by use of silt fence, fiber rolls, gravel bags and other effective means;
- All bare soil (abutment slope or temporary stockpile) must be covered with tarpaulin or other means before rain events which have been forecast;
- Concrete trucks or pumps should only be washed in designated washout pits;
- Wheel washing facilities should be provided at all site exits to ensure that earth, mud and debris would not be carried out of the works area by vehicles.
- Any run-off should be diverted into appropriate sediment traps before discharging to the nearby drainage system. The discharge water quality should comply with the *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* under the WPCO.
- The contractor shall apply discharge licence from EPD for discharging effluent from the construction site before the commencement of construction work.
- The contractor should observe and comply with the Water Pollution Control Ordinance (WPCO) and its subsidiary regulations by implementing environmental protection measures (such as the use of silt traps) and preventing any point or non-point source of pollution.

Dredging during Construction of Desalination Plant’s intake and outfall

6.11.17 The proposed dredging works require a very short time frame (around 2 months). The assessment of the water quality impact from marine dredging (taking into account for the season factor) indicated that construction works can proceed at the recommended working rates without causing unacceptable impacts to water quality sensitive receivers through either elevations of suspended sediment or deposition of sediment. Changes to other water quality parameters have been demonstrated to be minor, compliance with applicable standards and therefore not of concern.

6.11.18 Impacts to water quality sensitive receivers have largely been avoided during the design phase of the desalination plant due to:

- Alternative pipeline routes were studied during the design stage and the preferred alignment avoids direct impacts to sensitive receivers (detailed discussion at Chapter 9 Marine Ecology); and
- The length of intake and discharge outfall pipelines are selected with a minimum separation distance which ensures minimum dredging area is required.

6.11.19 The intake and outfall pipelines will be constructed by dredging the seabed to form a trench and backfilled with a layer of bedding material (quarry run stone) before putting the pipelines in place. Once in place, the pipelines are covered with layers of rock armour to protect the pipelines against damage by wave action. Rock excavated during site formation may be used as an alternative backfilling material if suitable.

6.11.20 The materials used for the backfilling at the intake and outfall pipelines are stone and rock armour only. Transfer of backfilling materials onto the seabed from barge should be conducted by careful grabbing and unloading to seabed (to minimize sediment migration), thereby minimize impacts on water quality to nearby water sensitive receivers. The expected backfilling duration is approximate 2 months. With the proposed unloading method of rock material within a short period of time, no water quality is anticipated during backfilling activity. As a preventative measure, silt curtain will also be required during the backfilling activities.

6.11.21 The Contractor shall use backhoe for dredging works at locations with water depths of less than 2m and use closed grab dredger for works at locations water depths of more than 2m. The estimated dredging works is about 50m long (where backhoe should be used for locations with water less than 2m deep) and 70m long (where closed grab dredger should be used for locations with water more than 2m deep). Only one dredging method should be used at any one time. The indicative location where the dredging methods are to be used is shown in Figure 6.7c.

6.11.22 To avoid pollution during dredging, transporting and dumping of marine mud, pollution avoidance measures should include but not be limited to the following:

- The maximum daily dredging rate for closed grab dredger should be $45m^3$/day;
- The maximum daily dredging rate for backhoe should be $20m^3$/day;
- Silt curtain should be installed for any dredging methods to protect the WSRs;
- Closed grabs or sealed grabs should only be used for locations with water depths $\geq$ 2m;
- Backhoe should only be used for locations with water depths $\leq$ 2m;
- All equipment should be designed and maintained to minimise the risk of silt and other contaminants being released into the water column or deposited in locations other than designated location;
- Mechanical grabs should be designed and maintained to avoid spillage and should seal tightly while being lifted;
- No trailing suction hopper dredgers would be deployed for the dredging of marine mud;
- All vessels should be sized such that adequate clearance is maintained between vessels and the sea bed at all states of the tide to ensure that undue turbidity is not generated by turbulence from vessel movement or propeller wash;
- All pipe leakages should be repaired promptly and plant shall not be operated with leaking pipes;
- Before moving the vessels which are used for transporting dredged materials excess material should be cleaned from the decks and exposed fittings of vessels and the excess materials should never be dumped into the sea except at the approved locations;
- Adequate freeboard should be maintained on barges to ensure that decks are not washed by wave action;
- The Contractor should monitor all vessels transporting material to ensure that no dumping outside the approved location takes place. The contractor should keep and produce logs and other records to demonstrate compliance and that journey times are consistent with designated locations and copies of such records should be submitted to the engineer;
- All bottom dumping vessels should be fitted with tight fitting seals to their bottom openings to prevent leakage of material;
- Loading of barges and hoppers should be controlled to prevent splashing of dredged material to the surrounding water, and vessels should not be filled to a level which will cause overflowing of material or polluted water during loading or transportation; and
- The engineer may monitor any or all vessels transporting material to check that no dumping outside the approved location nor loss of material during transportation takes place. The contractor should provide all reasonable assistance to the engineer for this purpose.

6.11.23 In addition, baseline water quality monitoring before commencement of the marine works should be carried out in the nearby waters to obtain baseline information for subsequent monitoring. Regular and frequent water quality monitoring should be carried out throughout the whole construction period to ensure the water quality during construction is well within the established environmental guidelines and standards (EM&A manual Section 3 for details).

[t15]Silt Curtain

6.11.24 To minimize impacts during the whole construction period of desalination plant’s intake and discharge outfalls, silt curtains should be utilized to minimize sediment migration. Indicative locations are shown in Figure 6.7c. The contractor should be responsible for the design, installation and maintenance of the silt curtains to minimize the impacts on the water quality and the protection of water sensitive receivers. The design and specification of the silt curtains should be submitted by the contractor to the engineer for approval. The area of works area enclosed by the silt curtain should be minimized to reduce the disturbance of ecological sensitive areas nearby.

6.11.25 A typical suspended solids reduction of 75% can be achieved with the incorporation of silt curtain. Two-layer silt curtains have generally been used for dredging projects of larger scale to further ensure this reduction. However, as the scale of proposed Project is considered small, the use of a single layer silt curtain which can achieve a minimum 75% suspended solids reduction is recommended.

6.11.26 Silt curtains should be formed from tough, abrasion resistant, permeable membranes, suitable for the purpose, supported on floating booms in such a way as to ensure that the sediment plume is restricted to within the limit of the works area.

6.11.27 The silt curtain should be formed and installed in such a way that tidal rise and fall are accommodated, with the silt curtains always extending from the surface to the bottom of the water column. The removal and reinstallation of such curtains during typhoon conditions should be as agreed with the Director of Marine Department.

6.11.28 The contractor should inspect the silt curtains regularly and check that they are moored and marked to avoid danger to marine traffic. Any damage to the silt curtain should be repaired by the contractor promptly and the works should be stopped until the repair is effected to the satisfaction of the engineer.

General Construction Activities

6.11.29 Debris and refuse generated on-site should be collected, handled and disposed of properly to avoid entering adjacent watercourse. Stockpiles of construction materials should be kept covered when not being used.

6.11.30 Oils and fuels should only be stored/handled in designated areas with pollution prevention facilities. Oil interceptors need to be regularly inspected and cleaned to avoid wash-out of oil during storm conditions.

6.11.31 The contractor should provide a safe storage area for chemicals on site. The contractor is required to register as a chemical waster producer if chemical wastes would be produced from the construction activities.

6.11.32 All fuel tanks should be provided with locks and be sited on sealed areas within bunds of capacity equal to 110% of the storage capacity of the largest tank.

6.11.33 Good housekeeping practices and staff training are required to minimize careless spillage and keep the work space in a tidy and clean conditions at all times. Accidental spillage of chemicals in the works area would directly affect the aquatic environment. It is recommended that the contractor should develop management procedures for chemical and implement an emergency plan to deal with chemical spillage in case of an accident.

6.11.34 Disposal of chemical wastes should be carried out in compliance with the Waste Disposal Ordinance. The chemical waste should be transported to a facility licensed to receive chemical waste, such as the Chemical Waste Treatment Facility at Tsing Yi. The Code of Practice on the Packaging, Labelling and Storage of Chemical Wastes details the requirements to deal with chemical wastes.

On-Site Sewage Effluents

6.11.35 To prevent sewage effluents affecting water courses, the following mitigation measures should be provided by the contractor:-

- Temporary sanitary facilities, such as portable chemical toilets, should be employed on-site to handle sewage from the workforce;
- The toilet facilities should be more than 30 m from any watercourse;
- Temporary storage tank should be provided to collect wastewater from kitchens or canteen, if any;
- A licensed waste collector should be deployed to clean the chemical toilets on a regular basis which will be and disposed of at government sewage treatment facilities;
- Regular environmental audit on the construction site can provide an effective control of any malpractices and can achieve continual improvement of environmental performance on site. It is anticipated that sewage generation during the construction phase of the Project will not cause water pollution problem once all required measures have been implemented; and
- Notices should be posted at conspicuous locations to remind the workers not to discharge any sewage or wastewater into the nearby environment during the construction phase of the Project.

Concrete batching plant

6.11.36 All water used within the concrete batching plant will be collected, stored and recycled to reduce resource consumption. This includes water used in the concrete batching process, truck cleaning, yard washing and dust suppression spraying. All spent dust suppression effluent will be collected and recycled. To minimize the potential water quality impacts that may generate from the concrete batching plant, a drainage system should be provided in this site. The batching plant area should be channelled to collect concrete washings for further treatment before reuse on-site and prevent concrete washings from directly entering the any stream or seawater. Site runoff should also be collected through the drainage system. To minimize the generation of contaminated site runoff from concrete production area, the concrete batching plant should be sheltered.

6.11.37 Concrete washings and site runoff should be pumped to a wastewater treatment system with a sedimentation unit for removal of suspended solids such as waste concrete particles, silt and grit in order to achieve the discharge standards. pH adjustment should also be applied if the pH value of the collected concrete washings and site runoff is higher than the pH range specified in the discharge licence. This can be achieved by adding neutralizing regents, i.e. acidic additive. A discharge licence should be applied from EPD for discharge of effluent from the site. Analysis of effluent quality may be required as one of the licensing conditions of the discharge licence. The Contractor should collect effluent samples at the final discharge point in accordance with the required sampling frequency to test the specified water quality parameters. The quality of the discharged effluent should comply with the discharge licence requirements. It is recommended to reuse the treated effluent for dust suppression and general cleaning on site, wherever possible.

6.11.38 The drainage system should be maintained on a regular basis to remove the deposits on the channels. The sedimentation and pH adjustment systems should also be checked and maintained by competent persons to ensure that the systems are functioning properly at all times.

6.11.39 The deposited sediment will be dewatered and the dry matter will require disposal off-site. The estimated maximum concentrate batching operation period during construction is 20 months.

6.11.40 Sand, gravel and other bulk materials will be delivered from the production area by conveyor boats or derrick barges to the temporary barging point, and the material will then be loaded onto dump trucks by loaders and delivered to the on-site storage areas.

6.11.41 Regular environmental inspections should be conducted to check the environmental performance of daily operation. These inspections will ensure proper installation and maintenance of pollution control measures, such as checking of sedimentation basin, wastewater recycling facility and enclosure of stockpiles, and the implementation of other mitigation measures.

Operation phase

Chemicals and Pesticides Run-off

6.11.42 Significant effort has been made to ensure that operation of the proposed third golf course will not cause unacceptable environmental impacts to the surrounding freshwater and marine environment. To mitigate the surface run-off from the proposed third golf course, a closed low flow drainage system (detailed design described in *Section 6.5*) is proposed to serve for this purpose.

6.11.43 Good water quality monitoring data over the past 9 years have demonstrated the effectiveness of the existing turfgrass management plan (*Section 6.3*). A similar turfgrass management plan adapted for use on *Seashore paspalum* will also be adopted for the proposed third golf course (Appendix A6.4). It is therefore expected that good water quality would be achieved within the proposed third golf course.

Hole 5 and part of Hole 6 – Filter system and biopesticides

6.11.44 A filter system (installed at the underground catchpits) and biopesticides for pest control are the proposed preventative mitigation measures for Hole 5 and part of Hole 6 of the proposed third golf course.

6.11.45 As mitigation for the open drainage of these locations to the existing marsh, a filter system is proposed to treat the surface run-off from Hole 5 and part of Hole 6. Table 6.15 shows the expected removal performance of the proposed filter system based on a designed maximum flow per filter unit (14L/s). The proposed filter systems will be installed at underground catchpits of Hole 5 and part of Hole 6 as preventive mitigation measures (Figure 6.10). Detailed design of the proposed filter system and proposed locations are shown in Appendix A6.2. Nutrients and pesticides can be absorbed by this filter system effectively as shown in the following table. Routine water quality monitoring of the filter system effluent water quality on nutrient and pesticides removal performance during the operation of the filter system will be required by the golf course operator to ensure the filter systems function properly (EM&A manual Section 3 for details).

Table 6.15 Performance of Filter System

Analysed components	Influent conc. (mg/L)	Effluent conc. (mg/L)	Removal rate (%)
TSS	295	9	96.95
TPH[@]	320	16	95.00
Zinc	0.45	0.06	86.67
BOD	250	26	89.60
COD	650	130	80.00

TN	54.4	17.7	67.46
TP	28.9	7.39	74.43

Remark: Data provided by manufacturer (http://www.ads-pipe.com/us/en/products/stormpure.shtml). Please refer to Appendix A6.2 for details.

@Total Petroleum Hydrocarbons (TPH) includes a broad family of several hundred chemical compounds and they are mixtures of chemicals basically made from hydrogen and carbon which represent between 50% and 98% of its composition. All of the pesticides used in KSC golf courses containing high percentages of carbon and hydrogen components. The proposed filter system should have the capacity to remove the pesticides, if present, from the run-off. It should be note that although pesticides have not been detected over the past 9 years of monitoring, it is a proposed preventive mitigation measure.

6.11.46 The proposed third golf course has a turfgrass management guideline, with an Integrated Pest Management plan (IPM). The management practice approach of the existing golf courses will be extended to the proposed third golf course.

6.11.47 The IPM is a management plan that uses a variety of control measures to keep turfgrass pest population below levels that are economically and aesthetically damaging, without creating a hazard to people and the environment. The basic components of IPM are control strategies including species and cultural selection, good mowing, irrigation practices, fertility and pH management, thatch control, rootzone management through good cultural practices such as aeration, wear and tear management, etc. Biological pest control and chemical pest control by developing a turf management plan encompass these features as best management practices. The emphasis is always on prevention: eliminating conditions that promote the establishment of the pest. If the pest becomes established, physical removal can be a viable option rather than chemical or biological control.

6.11.48 The goal of biological control is to use enemies (predators, parasites, and pathogens) to maintain populations of the species at a level that does not require further control measures. It is only one aspect of an overall strategy of IPM, which aims to control pest species using the most cost-effective, efficient, and environmentally-friendly methods available. Other aspects of IPM should include cultural and chemical method of control.

6.11.49 The threshold levels set in the Turfgrass management plan have been established with years of experience and would be applied universally across the golf courses (Table 6.16). Primary treatment (First detection of pests or when seasonal conditions indicated pest outbreaks were probable) of pest at Hole 5 & part of Hole 6 will be done through the use of biological treatments where products are available for specific pests. It is preferred to apply such products at an early stage of infestation to give the application the best chance of success. It is because bio-pesticides available and proposed are effective to pests in the immature stage only or take longer time to have an effect (mode of actions are less specific than chemical pesticides) on pest populations and actions. It is therefore not recommended to use at later stage or after the exceedance to the threshold level. Bio-pesticides use in Hole 5 and part of Hole 6 is a preventive approach to try to prevent threshold levels being reached. If there is an exceedance of the threshold level, it is not necessary to automatically trigger the use pesticides application. Golf Course Superintendent could then make decision on the type of treatment besides chemical pesticides application. There are many other factors have to taken into account prior to chemical application such as current weather, pest life cycle, other maintenance practices that could assists etc.

Table 6.16 Aesthetic and functional threshold table

Pest	Greens	Tees & Fairways	Roughs	Detection method
Diseases				
Helminthosporum	5%			
Pythium	5%	Untreated	Untreated	Visual inspection
Rhizoctonia	5%			/ Microscope
Dollar spot	10%			
Cuvulera	10%			
Insects				
White Grubs	2 nos. / sq. ft.	4 nos. / sq. ft.	6 nos. / sq. ft.	Visual + soil inspect
Mole Crickets	2 nos. / sq. ft.	3 nos. / sq. ft.	6 nos. / sq. ft.	Visual + soap flush
Sod Webworms	4 nos. / sq. ft.	8-10 nos. / sq. ft.	Not required	Visual + soap flush
Armyworms	Not required	4 nos. / sq. ft.	6 nos. / sq. ft.	Visual + soap flush
Cutworms	1 no. / sq. ft.	5 nos. / sq. ft.	Not required	Visual + soap flush

Weeds				
Nutsedge	Hand pulled	2 nos. / sq. ft.	6 nos. / sq. ft.	Visual inspection
Torpedograss	Hand pulled	2 nos. / sq. ft.	4 nos. / sq. ft.	
Broadleave weeds	Hand pulled	2 nos. / sq. ft.	6 nos. / sq. ft.	

Remarks: Threshold levels represent percent of area affected or number of insect/weeds per square feet required prior to any others treatment application**.**

6.11.50 [t16]All of the proposed biological products of insecticides and fungicides are microbial or plant extract and are non-toxic to non-target organism according to United States Environmental Pretection Agency (USEPA) information.

6.11.51 The reason for the use of bio-pesticides is not proposed beyond Hole 5 and part of Hole 6 is that these areas (remaining part of the proposed third golf courses) are already protected by the proposed closed low flow drainage system. The proposed use of bio pesticides at Holes 5 and part of Hole 6 represents a very small percentage of the entire proposed third golf course (Hole 5 and part of Hole 6 turfgrass area is 0.916 ha vs total turfgrass area is 19.2 ha) and is considered manageable despite the intensive maintenance requirements. Moreover, filter system will also be installed at catchpits to polish the golf course runoff from Hole 5 and part of Hole 6 before discharge to marine water. The use of biopesticides and filter system at hole 5 and part of hole 6 should be sufficient as a preventive mitigation measures.

6.11.52 The use of biopesticides on Holes 5 and part of Hole 6 will give the opportunity to test biological products on a limited scale and in a highly controlled manner. Biological products that are proven to be effective and safe can then be considered for wider application across all three courses in future. In addition, new turfgrass (Seashore paspalum) is selected for the proposed third golf course which is more disease resistance and higher salt tolerance than the turfgrass planted at the existing golf courses (Bermuda grass), lower pesticides application frequency is expected at the proposed third golf course. Moreover, localized use of salt water application can be an alternative of weed control than chemical.

6.11.53 Table 6.17 shows the list of insecticides and fungicides considered suitable for application to the proposed third golf course. *Bacillus thuringiensis* will be the used first as a bio-control for armyworm and sod webworm at Hole 5 and part of Hole 6. All of the proposed biological products are registered pesticides by AFCD under the Pesticides Ordinance.

Table 6.17 Proposed List of Biological Products apply at Hole 5 and part of Hole 6

	Target species	Biological products
Insects	Armyworms, sod webworms	Neem (AFCD Reg. No. 2P262), *Bacillus thuringiensis* (AFCD Reg. No. 2P12), *Spodoptera litura Nuclear* Polyhedrosis virus (AFCD Reg. No. 2P242)
	Mole crickets	*Beauveria bassiana* (AFCD Reg. No. 2P239)
Disease	Dollar spot	*Trichoderma harzianum* (AFCD Reg. No. 2P255)

6.12 Residual Impacts

Construction phase

6.12.1 The predicted net increase of suspended solids and suspended solids sedimentation rate to the nearest sensitive receiver are well within the WQO of Port Shelter during the construction of the proposed desalination plant intake and outfall pipelines. Oxygen depletion to the nearest sensitive receiver is undetectable.

Operation phase

6.12.2 The predicted net increase of suspended solids, salinity and suspended solids sedimentation rate to the nearest sensitive receiver are well within the WQO of Port Shelter during the operation phase of the desalination plant. Oxygen depletion to the nearest sensitive receiver is undetectable.

6.12.3 Predicted TIN concentrations at Lake near Hole 4 and Lake near Hole 10 before overflow to marine water are well within the WQO of Port Shelter. Predicted TP concentrations before overflow are also well within the guideline values for the existing golf courses.

6.12.4 For Hole 5 and Hole 6, predicted TIN concentrations before runoff to marsh are well within the WQO of Port Shelter. Predicted TP concentrations are also well within the guideline values for the existing golf courses.

6.12.5 Filter systems for nutrient and pesticides removal and the use of biopesticides at the Hole 5 and Hole 6 are proposed as a preventative mitigation measures.

6.12.6 With the implementation of the recommended mitigation measures, it is predicted that all potential impacts are minimized. Therefore, no significant residual impacts on the water quality the proposed 18-Hole third golf course.

6.13 Cumulative Impacts

6.13.1 There are no concurrent projects in and around Kau Sai Chau. The nearest likely concurrent project will be in Sai Kung Town (DSD' drainage improvement project in Sai Kung) which is separated by over 4 km of marine waters. Cumulative water quality impact during the construction phase is therefore not expected.

Existing reservoir

6.13.2 The expected TIN (0.814 mg/L during establishment and 0.813 mg/L after establishment) and TP (0.095 mg/L during establishment and 0.094 mg/L after establishment) after the addition of the run-off load from the proposed third golf course to the existing reservoir is well within the range of water quality at the existing reservoir over the past 9 years (TIN range from 0.4 to 0.86 mg/L; TP range from 0.02 to 0.1 mg/L). Therefore, no cumulative impact to the water quality at the existing reservoir during the operation phase of the third golf course is expected. The volume of the additional flow during 1 in 2-year storm events from the proposed third golf course only represents 4% of the lowest volume of the existing reservoir.

6.13.3 There is no available record for the previous overflow events at the existing reservoir. High frequency of overflow event is not expected as the existing reservoir is used for irrigation of the existing golf courses as well as the proposed third golf course. Water supply for irrigation of the existing golf courses is dependant on water from the existing reservoir, which is collected from the primary reservoir catchment. According to on site observations, overflow events during rainstorm would likely occur during wet seasons when the reservoir is full. The water levels at the existing reservoir will gradually decrease during the dry season (September to March) and will be replenished (water level gradually increase) by the increase of rainfall during the wet season (April to August). The excess amount of water available from the existing reservoir for irrigation depends on the inter-correlation between the irrigation usage from the existing reservoir, evapotranspiration rate of turf and replenishment through rainfall. Based on current estimation, the most likely overflow events may occur only in August. As the maximum number (past 10 years) of rainy days (greater than 1 in 2-year rainstorm) in August is 3 days, the overflow volume and frequency is considered extremely low (0.82% per year). Detailed estimation is provided in Appendix A6.2. It is recommended that overall events should be keep in record and conduct water quality monitoring at the nearby water quality sensitive receivers during the operation phase of the proposed third golf course.

6.13.4 A desalination plant will provide supplementary irrigation for the proposed third golf course during the dry season. To minimize the environmental impacts (construction of large inland reservoir and the related problem - streams dehydration due to changes in the original catchment area) of the proposed third golf course, desalination plant is proposed as a viable option to provide water for irrigation purpose. Based on the original design of the existing golf course, the water stored in the existing reservoir is only sufficient for the irrigation at existing golf courses. The proposed design includes utilization of dead storage (lower the invert level to increase the water availability from the existing reservoir), water can then be utilized by pumping to Irrigation Lake 1D, where it can be pumped through the irrigation system to the proposed third golf course. This increase in the water usage for the proposed third golf course during the wet season will further reduce the possibility of overflow events at the existing reservoir in future. To increase the size of the existing reservoir as addition water storage is considered not a feasible option due to the massive excavation which leads to degrade of the irrigation water quality in the reservoir and other environmental impacts. The huge disturbance during excavation works carrying out which could lead to close down the entire existing golf courses.

6.14 Summary

6.14.1 Table 6.18 summaries the overall water quality impact during the construction and operation phase of the proposed third golf course

Table 6.18 Summary of the predicted water quality impacts to the water quality receivers during the construction and operation phase of the proposed third golf course

Construction phase - Dredging of desalination plant intake and outfall pipelines			
SS net increase to the nearest WSR	WQO tolerance elevation	Compliance with WQO	Remarks
1.094 mg/L (closed grab) 1.078 mg/L (backhoe)	1.485 mg/L	Yes	-
SS sedimentation rate to the nearest WSR	Acceptable guideline level	Compliance with guideline	
0.047 kg/m²/day (closed grab) 0.046 kg/m²/day (closed grab)	0.1 kg/m²/day	Yes	Guideline value (EIA study) [R]
Oxygen depletion to the nearest WSR	WQO standard	Compliance with WQO	
0.00421 mg/L (closed grab) 0.00417 mg/L (backhoe)	$\geq$ 2 mg/L (2 m of seabed); $\geq$ 4 mg/L (depth average) – marine water except FCZs; $\geq$ 5 mg/L (depth average) - FCZs	Yes	DO depletion concentration is undetectable

Operation phase - Discharge from desalination plant			
Salinity net increase to the nearest WSR	WQO tolerance elevation	Compliance with WQO	
1.228 ppt	3.41 ppt	Yes	-
SS net increase to the nearest WSR	WQO tolerance elevation	Compliance with WQO	
0.695 mg/L	1.485 mg/L	Yes	-
SS sedimentation rate to the nearest WSR	Acceptable guideline level	Compliance with guideline	
0.030 kg/m²/day	0.1 kg/m²/day	Yes	Guideline value (EIA study) R
Oxygen depletion to the nearest WSR	WQO standard	Compliance with WQO	
0.0027 mg/L	$\geq$ 2 mg/L (2 m of seabed); $\geq$ 4 mg/L (depth average) – marine water except FCZs; $\geq$ 5 mg/L (depth average) - FCZs	Yes	DO depletion concentration is undetectable

Remark: R - ERM (2001). *Focused Cumulative Water Quality Impact Assessment of Sand Dredging at the West Poi Toi Marine Borrow Area*, Civil Engineering Department

Operation phase - Land Drainage System			
Lake near Hole 4	Predicted concentration during overflow	WQO standard / Relevant guideline*	Compliance with WQO / Relevant guideline*
Turf establishment (3 months)	TIN= 0.017; TP = 0.003 mg/L	TIN $\leq$ 0.1 mg/L (WQO); TP* $\leq$ 0.09 mg/L	Yes (marine water) Yes* (marine water)
After establishment (Operation phase)	TIN= 0.013; TP = 0.0004 mg/L	TIN $\leq$ 0.1 mg/L (WQO); TP* $\leq$ 0.09 mg/L	Yes (marine water) Yes* (marine water)
Lake near Hole 10	Predicted concentration during overflow	WQO standard / Relevant guideline*	Compliance with WQO / Relevant guideline*
Turf establishment (3 months)	TIN= 0.031; TP = 0.005 mg/L	TIN $\leq$ 0.1 mg/L (WQO); TP* $\leq$ 0.09 mg/L	Yes (marine water) Yes* (marine water)
After establishment (Operation phase)	TIN= 0.023; TP = 0.007 mg/L	TIN $\leq$ 0.1 mg/L (WQO); TP* $\leq$ 0.09 mg/L	Yes (marine water) Yes*(marine water)
Hole 5 and part of Hole 6	Predicted concentration run-off to marsh	WQO standard / Relevant guideline*	Compliance with WQO / Relevant guideline*
Turf establishment (3 months)	TIN= 0.08 mg/L#; TP = 0.014 mg/L#	TIN $\leq$ 0.1 mg/L (WQO); TP* $\leq$ 0.1 mg/L	Yes (marine water) Yes* (Inland water)
After establishment (Operation phase)	TIN= 0.06 mg/L#; TP = 0.002 mg/L#	TIN $\leq$ 0.1 mg/L (WQO); TP* $\leq$ 0.1 mg/L	Yes (marine water) Yes* (Inland water)
Proposed 18-hole turf area to existing reservoir	Predicted concentration	WQO standard / Relevant guideline*	Compliance with WQO / Relevant guideline*
Turf establishment (3 months)	TIN= 0.08 mg/L; TP = 0.014 mg/L	TIN $\leq$ 0.1 mg/L (WQO); TP* $\leq$ 0.1 mg/L	Yes (marine water) Yes* (Inland water)
After establishment (Operation phase)	TIN= 0.06 mg/L; TP = 0.002 mg/L	TIN $\leq$ 0.1 mg/L (WQO); TP* $\leq$ 0.1 mg/L	Yes (marine water) Yes* (Inland water)

Existing Reservoir	Predicted concentration during the operation phase of the proposed third golf course	WQO standard / Relevant guideline*	Compliance with WQO / Relevant guideline*
Turf establishment (3 months)	TIN= 0.814 mg/L; TP = 0.095 mg/L	TIN* $\leq$ 0.9 mg/L; TP* $\leq$ 0.1 mg/L	Yes* (Inland water guideline Table 6.4) Yes* (Inland water guideline Table 6.4)
After establishment (Operation phase)	TIN= 0.813 mg/L; TP = 0.095 mg/L	TIN* $\leq$ 0.9 mg/L; TP* $\leq$ 0.1 mg/L	Yes* (Inland water guideline Table 6.4) Yes* (Inland water guideline Table 6.4)

Remarks: * Relevant guideline, please refer to Table 6.4 for details; # predicted concentration has not take into account on the nutrient removal by the proposed filter (worst case scenario).

6.15 Environmental Monitoring & Audit (EM&A) Requirement

6.15.1 An EM&A programme focusing on those WSRs of particular concerns will be implemented to identify and rectify any problems. A recommended EM&A programme has been presented separately in the EM&A Manual (Section 3).

6.15.2 During the construction phase, marine monitoring stations include Tai Tau Chau Fish Culture Zone, Kai Lung Wan Fish Culture Zone, Kau Sai Fish Culture Zone, temporary barging point, nearest coral site to the dredging area of the desalination plant intake and outfall pipelines, coral site at eastern coastline, discharge point at existing marsh and control Stations. Inland monitoring stations include upstream and downstream of the Streams A, B and C and downstream at the existing marsh.

6.15.3 During the operation phase, marine monitoring stations include Tai Tau Chau Fish Culture Zone, Kai Lung Wan Fish Culture Zone, Kau Sai Fish Culture Zone, nearest coral site to the desalination plant, desalination plant mixing zone (between the Kai Lung Wan Fish Culture Zone and desalination plant), coral site at eastern coastline, discharge point at existing marsh and control Stations. Inland monitoring stations include downstream of the Streams A, B and C, irrigation lake 1D, existing reservoir, filter system (catchpits) effluent at Holes 5 and downstream at existing marsh.

6.15.4 Additional water quality parameters are required to monitor marine and stream water qualities when the permanent low flow drainage system is not yet completed but turf establishment has to be in place during construction phase, monitoring should be also be carried.

6.15.5 The water quality criteria, Action and Limit levels, should be applied to ensure that any deterioration of water quality is readily detected and timely rectifying action is taken. Should the water quality parameters monitoring results at any designated monitoring station exceed the water quality criteria, actions in accordance with the Event and Action Plan shall be carried out.

6.16 Conclusion

6.16.1 With the implementation of the appropriate mitigation measures, the impact on suspended solids concentration, dissolved oxygen depletion and daily deposition from minor dredging works during construction of desalination plant are within acceptable levels. Only one dredging method (closed grab dredger or backhoe) should be used at any one time. Installation of silt curtain should be used for both dredging method.

6.16.2 With the demarcation of buffer zones and other control along the streams, no adverse water quality impacts on the streams are expected. Other water quality impacts during construction can be mitigated by implementing proper site drainage and good housekeeping practices. Minor water quality impact would be associated with land-based construction. Impacts may result from surface run-off, chemical run-off and sewage from on-site construction workers. Impacts can be controlled and compliance with the WPCO standards achieved by implementing the recommended mitigation measures.

6.16.3 The impacts arising from increase of salinity, suspended solids and anti-scalant from desalination plant discharge to the nearest water sensitive receiver during the operation phase are negligible.

6.16.4 With the use of closed low flow drainage system at the proposed third golf course, no impacts from nutrients and pesticides due to surface run-off under heavy rainstorm condition are expected during the operation phase of the proposed third golf course. In addition, a reduction golf courses runoff from the existing golf courses to the existing marsh is facilitated by the closed low flow drainage system (diverting the golf courses runoff back to the existing reservoir).

6.16.5 Filter system and biopesticides control at Hole 5 and Hole 6 are the preventative mitigation measures for the golf course runoff before entering to the downstream of the existing marsh. No impacts from nutrients and pesticides are expected during the operation phase of the proposed third golf course.

6.16.6 No insurmountable residual and cumulative water quality impact are expected.

6.16.7 An EM&A programme will be implemented during the construction phase and operation phase, which would focus on those WSRs of particular concern to identify and rectify any problems.

Reference

AFCD (1998). *Artificial Reef Deployment Study, Draft Final Report*.
EPD (1998-2003). *Beach Water Quality in Hong Kong.*
EPD (1998-2003). *Marine Water Quality in Hong Kong*
EPD (1998-2003). *Fresh Water Quality in Hong Kong*
ERM (1997). *EIA Report for Disposal of Contaminated Mud in the East of Sha Chau Marine Borrow Pit*. Civil Engineering Department
ERM (2001). *Focused Cumulative Water Quality Impact Assessment of Sand Dredging at the West Poi Toi Marine Borrow Area*, Civil Engineering Department
Hyder Consulting Ltd (1999). *EIA Report for Hebe Haven Yacht Club Development Phase 2*.
Kirby, R. and Land, J.M. (1991). *The Impact of Dredging – A Comparison of Natural and Man-made Disturbances to Cohesive Sedimentary Regimes*. Proc. CEDA-PIANC Conference, Amsterdam. Central Dredging Association, The Netherlands.
Maunsell (2004). *Tai Po Sewage Treatement Work Stage V – EIA Study*.
Mouchel (2002). *EIA Report for Permanent Aviation Fuel Facility for Hong Kong International Airport*.
Scott in association with ERM (2000). *EIA Report for Construction of an International Theme Park in Penny's Bay of North Lantau and its Essential Associated Infrastructures*.

---

[1]

The low flow drainage system has been designed using HR Wallingford's HydroWorks software, an industry standard for drainage system design in Hong Kong and is used by both DSD and EPD. The HydroWorks software utilizes DSD storm design profiles as published in DSD's Stormwater Drainage Manual. The managed turf areas have been measured and incorporated in the drainage model to ensure the drainage system has sufficient capacity for events up to a 1 in 2-year return period.

[t1]New paragraph
[t2]Revised
[t3]Revised
[t4]Revised
[t5]Revised
[t6]Revised
[t7]Revised
[t8]New paragraph
[t9]Revised
[t10]New text
[t11]New text
[t12]New Table
[t13]New Table
[t14]New assessment on backwash water from filter – 6.10.15 to 6.10.19.
[t15]Section revised 6.11.13-6.11.19
[t16]New text and Table 6.16