4 WATER QAULITY MONITORING

Introduction

4.1 In this section, the requirements, methodology, equipment, monitoring locations, criteria and protocols for the monitoring and audit of water quality impacts during the construction phase and operational phase of the Project are presented. The construction phase monitoring and audit is required if open trench method is used for outfall construction.

Water Quality Parameters

4.2 Dissolved oxygen (DO), turbidity, suspended solids (SS), and ammonia nitrogen levels shall be monitored at designated marine water quality monitoring stations during the construction phase and operation phase. DO and turbidity should be measured in-situ whereas SS and ammonia nitrogen concentrations should be determined by laboratory. In addition, other relevant parameters including *E.coli*, temperature, pH, and salinity shall also be measured.

4.3 The water quality impact assessment undertaken in the EIA study concluded that the ambient level of total inorganic nitrogen (TIN) were generally high and close to or even exceeds the limit level 0.1 mg/L as stipulated by the WQO. The monitoring of the TIN level is therefore considered necessary during the first year after the commissioning of the STW.

4.4 A sample data record sheet is shown in Appendix B for reference.

Monitoring Equipment

Dissolved Oxygen and Temperature Measuring Equipment

4.5 The instrument should be a portable and weatherproof dissolved oxygen (DO) measuring instrument complete with cable and sensor, and use a DC power source. The equipment should be capable of measuring:

(a) a DO level in the range of 0 – 20 mg /L and 0 – 200% saturation; and

(b) a temperature of 0 – 45 degree Celsius.

4.6 The instrument should have a membrane electrode with automatic temperature compensation complete with a cable. Sufficient stocks of spare electrodes and cables shall be available for replacement where necessary. (For example, YSI model 59 meter, YSI 5739 probe, YSI 5795A submersible stirrer with reel and cable or an approved similar instrument).

4.7 Should salinity compensation not be built-in to the DO equipment, in-situ salinity should be measured to calibrate the DO equipment prior to each DO measurement.

Turbidity Measurement Instrument

4.8 The instrument should be a portable, weatherproof turbidity-measuring instrument complete with comprehensive operation manual. The equipment should use a DC power source. It should have a photoelectric sensor capable of measuring turbidity between 0-1000 NTU and be complete with a cable (e.g. Hach model 2100P or an approved similar instrument).

Sampler

4.9 A water sampler comprises a transparent PVC cylinder, with a capacity of not less than 2 litres, and can be effectively sealed with latex cups at both ends. The sampler should have a positive latching system to keep it open and prevent premature closure until released by a messenger when the sampler is at the selected water depth (e.g. Kahlsico Water Sampler or an approved similar instrument).

4.10 Water samples for suspended solids measurement should be collected in high density polythene bottles, packed in ice (cooled to 4°C without being frozen), and delivered to the laboratory as soon as possible after collection.

Water Depth Detector

4.11 A portable, battery-operated echo sounder should be used for the determination of water depth at each designated monitoring station. This unit can either be hand held or affixed to the bottom of the work boat, if the same vessel is to be used throughout the monitoring programme.

Salinity

4.12 A portable salinometer capable of measuring salinity in the range of 0 – 40 parts per thousand (ppt) should be provided for measuring salinity of the water at each monitoring location.

Sample Containers and Storage

4.13 Water samples for SS and TIN determinations should be stored in high density polythene bottles with no preservative added, packed in ice (cooled to 4°C without being frozen) and delivered to HOKLAS accredited laboratory for analysis as soon as possible after collection. Sufficient volume of samples should be collected to achieve the detection limit stated in **Table 4-1**.

Monitoring Position Equipment

4.14 A hand-held or boat-fixed type digital Differential Global Positioning System (DGPS) with way point bearing indication or other instrument of similar accuracy, should be provided and used during marine water quality monitoring to ensure the monitoring vessel is at the correct location before taking measurements.

Monitoring Methodology

4.15 All in-situ monitoring instruments should be checked, calibrated and certified by a laboratory accredited under HOKLAS or any other international accreditation scheme before use, and subsequently re-calibrated at 3 monthly intervals throughout all stages of the water quality monitoring programme. Responses of sensors and electrodes should be checked with certified standard solutions before each use. Wet bulb calibration for a DO meter should be carried out before measurement at each monitoring location.

4.16 For the on site calibration of field equipment, the BS 127:1993, "Guide to Field and on-site test methods for the analysis of waters" should be observed.

4.17 Sufficient stocks of spare parts should be maintained for replacements when necessary. Backup monitoring equipment should also be made available so that monitoring can proceed uninterrupted even when some equipment is under maintenance, calibration, etc.

Laboratory Measurement/Analysis

4.18 Duplicate samples from each independent sampling event are required by EPD for all parameters. Analysis of suspended solids, TIN, ammonia nitrogen, and *E.coli* should be carried out in a HOKLAS or other international accredited laboratory. Sufficient water samples should be collected at the monitoring stations for carrying out the laboratory SS, TIN, ammonia nitrogen, and *E.coli* determinations, with detection limits of each parameter shown in **Table 4-1**. The determination works should start within 24 hours after collection of the water samples. The analysis should follow the standard methods according to Table 4-1 and as described in American Public Health Association (APHA) *Standard Methods for the Examination of Water and Wastewater*, 19th edition, unless otherwise specified.

Table 4-1 Analytical Methods to be applied to Marine Water Quality Samples

Determinant	Standard Method	Detection Limit
Suspended solids (mg /L)	APHA 2540 D	0.5 mg /L
Total Inorganic Nitrogen (mg /L)	APHA 4500-N_{org} or equivalent methods subject to approval of EPD	0.01 mg /L
Ammonia Nitrogen (mg /L)	ASTM D3590-89 B (FIA)	0.005 mg /L
E.coli	In house method, membrane filtration with CHROMagar Liquid *E.coli-coliform culture*	1 cfu / 100 mL

4.19 For each of the testing methods details shall be submitted to the EPD for approval prior to commencement of the monitoring programme. The submitted information should include pre-treatment procedures, instruments use, Quality Assurance/Quality Control (QA/QC) details (such as blank, spike recovery, number of duplicate samples per batch, etc.), detection limit and accuracy. The QA/QC details should be in accordance with the requirements of HOKLAS or international accredited scheme. The QA/QC results should be reported. EPD may

also request the laboratory to carry out analysis of known standards provided by EPD for quality assurance. Additional duplicate samples may be required by EPD for inter laboratory calibration. Remaining samples after analysis shall be kept by the laboratory for 3 months in case repeat analysis is required. If in-house or non-standard methods are proposed, details of the method verification may also be required to submit to EPD. In any circumstance, the sample testing should have comprehensive quality assurance and quality control programmes. The laboratory should be prepared to demonstrate the quality control programme to EPD or his representatives if and when required.

Monitoring Locations

4.20 The marine water quality monitoring stations during the construction works are shown in **Figure 4-1**. These stations were chosen based on the following criteria:

(a) At locations close to and preferably at the boundary of the mixing zone of the major site activities as indicated in the EIA report, which are likely to have water quality impacts;

(b) Close to the sensitive receptors which are directly or likely to be affected;

(c) For monitoring locations located in the vicinity of the sensitive receptors, care should be taken to cause minimal disturbance during monitoring;

(d) At two or more control stations which shall be at locations representative of the project site in its undisturbed condition. Control stations should be located, as far as is practicable, both upstream and down stream of the works area.

Control stations are necessary to compare the water quality from potentially impacted sites with the ambient water quality. Control stations shall be located within the same body of water as the impact monitoring stations but should be outside the area of influence of the works and, as far as practicable, not affected by any other works. Measurements shall be taken at 3 water depths, namely, 1m below water surface, mid-depth and 1m above sea bed, except where the water depth less than 6m, the mid-depth station may be omitted. Should the water depth be less than 3m, only the mid-depth station will be monitored. The ET Leader shall seek approval from the IC(E) and DEP on all the monitoring stations.

4.21 The proposed water quality monitoring stations for the Project are provided in **Table 4-2**.

Table 4-2 Proposed Marine Water Quality Monitoring Stations

Station	Description	Easting	Northing
W1	Predicted Dredging Non-Impact Zone	821279.0	816452.1
W2	Live Coral Area	821573.2	816769.7
C1	Control Station	821919.0	817155.0
C2	Control Station	821443.2	816257.4

4.22 Control stations (C1 – C2) shown in Figure 4-1 and Table 4-2 are indicative and subject to further review before construction phase. The revised station sittings should be submitted 4 weeks before commencement of baseline monitoring for EPD and AFCD approval.

4.23 Two proposed monitoring stations (W1 – W2) are located within the secondary contact recreation subzone and are in the vicinity of coral community. These locations are proposed to monitor the impacts from the construction of the submarine and emergency overflow outfall as well as the effluent discharge from the proposed STW on water quality.

4.24 The status and locations of water sensitive receivers and the marine activities may change after issuing this Manual. If such cases exist, the ET Leader should propose with justification for changes to monitoring locations or other requirements of the EM&A programme, and seek approval from the IC(E) , EPD and AFCD.

Baseline Monitoring

4.25 Baseline conditions for water quality shall be established and agreed with DEP prior to the commencement of marine works. The purposes of the baseline monitoring are to establish ambient conditions prior to the commencement of the works and to demonstrate the suitability of the proposed impact, control and reference monitoring stations. The baseline conditions shall normally be established by measuring the water quality parameters specified in Section 4.2. The measurements shall be taken at all designated monitoring stations including control stations, 3 days per week, at mid-flood and mid-ebb tides, for four weeks prior to the commencement of marine works. Baseline monitoring schedules shall be faxed to EPD one week prior to the commencement of baseline monitoring. The interval between two sets of monitoring shall not be less than thirty-six hours.

4.26 There shall not be any marine construction activities in the vicinity of the stations during the baseline monitoring. In the EIA Report, the marine works of the Project are scheduled to start at least 4 weeks after the completion of dredging and reclamation of Peng Chau Helipad to avoid any cumulative water quality impact.

4.27 In exceptional case when insufficient baseline monitoring data or questionable results are obtained, the ET Leader shall seek approval from DEP on an appropriate set of data to be used as baseline reference.

4.28 Duplicate in-situ measurements and samples collected from each independent sampling event shall be collected to ensure a robust statistically interpretable database. **Table 4-3** summarises the baseline monitoring programme for each water quality parameter.

Table 4-3 Summary of Baseline Monitoring Programme for Marine Water Quality

Parameter	Stations	Frequency	Duration
DO, temperature, turbidity, pH, salinity, SS, Ammonia nitrogen, and *E.coli*	All	3 days per week, at mid-ebb and mid-flood	1 month
TIN	All	3 days per week, at mid-ebb and mid-flood tides	1 month

4.29 Other relevant data shall also be recorded including monitoring location/position, time, water depth, tidal stages, weather conditions and any special phenomena underway near the monitoring station. There shall not be any marine construction activities in the vicinity of the stations during the baseline monitoring.

Impact Monitoring

4.30 During the course of marine works, monitoring shall be undertaken three days per week, at mid-flood and mid-ebb tides, with sampling/measurement at the designated monitoring stations. Duplicate in-situ measurements and samples collected from each independent sampling event shall be collected to ensure a robust statistically interpretable database. The interval between two sets of monitoring shall not be less than thirty-six hours except where there are exceedances of Action and/or Limit levels, in which case the monitoring frequency will be increased.

4.31 Two consecutive measures of DO concentration, DO saturation and turbidity will be taken in situ at 1 m below the surface, mid-depth and 1 m above the seabed at each location. If the water depth is less than 6 m, the mid-depth measurement may be omitted subject to the approval of the ER. It the depth is less than 3 m, only the mid-depth measurements need to be taken subject to the approval of the ER. The monitoring probes shall be retrieved out of water after the first measurement and then redeployed for the second measurement. Where the difference in value between the first and second readings of DO or turbidity parameters is more than 25% of the value of the first reading, the reading shall be discarded and further readings shall be taken. Duplicate water samples for SS and TIN shall be collected at the same three depths.

Post-construction Monitoring

4.32 Upon completion of all marine based construction activities, a post-construction monitoring exercise on water quality shall be carried out for four weeks in the same manner as the impact monitoring. Duplicate in-situ measurements and samples collected from each independent sampling event shall be collected to ensure a robust statistically interpretable database.

Event and Action Plan

4.33 Marine water quality criteria, namely Action and Limit levels, are shown in **Table 4-4**. These criteria should be applied to ensure that any deteriorating water quality could be readily detected. When the monitoring results of the water quality parameters at any designated monitoring stations exceed the water quality criteria, the actions in accordance with the Event and Action Plan in **Table 4-5** shall be carried out.

Table 4-4 Action and Limit Levels for Marine Water Quality

Parameters	Action	Limit
DO in mg/ L (Surface, Middle & Bottom)	Surface & Middle 5 percentile of baseline data for surface and middle layer Bottom 5 percentile of baseline data for bottom layer	Surface & Middle 4 mg/L or 1 percentile of baseline data for surface and middle layer Bottom 2 mg/L or 1 percentile of baseline data for bottom layer
SS in mg/ L (depth-averaged)	95 percentile of baseline data or 120% of upstream control station's SS at the same tide of the same day	99 percentile of baseline data or 130% of upstream control station's SS at the same tide of the same day
Unionised Ammonia in mg /L (depth-averaged)	95 percentile of baseline data or 0.021 mg/ L	99 percentile of baseline data or 0.021 mg /L
E.coli (depth-average)	95 percentile of baseline data	99 percentile of baseline or 610 cfu/100mL as geometric mean
Turbidity in NTU (depth-averaged)	95 percentile of baseline data or 120% of upstream control station's turbidity at the same tide of the same day	99 percentile of baseline or 130% of upstream control station's turbidity at the same tide of the same day
TIN in mg/ L (depth-averaged)	95 percentile of baseline data	99 percentile of baseline data

Notes: 1. "depth-averaged" is calculated by taking the arithmetic means of reading of all three depths.
2. For DO, non-compliance of the water quality limits occurs when monitoring result is lower than the limits.
3. For turbidity, SS and TIN, non-compliance of the water quality limits occurs when monitoring result is higher than the limits.
4. All the figures given in the table are used for reference only and the EPD may amend the figures whenever it is considered as necessary.

Table 4-5 Event and Action Plan for Marine Water Quality

Event	Action			
	ET Leader	**IC(E)**	**ER**	**Contractor**
Action level being exceeded by one sampling	1. Repeat in-situ measurement on next day of exceedance to confirm findings; 2. Identify source(s) of impact; 3. Inform IC(E), Contractor and ER; 4. Check monitoring data, all plant, equipment and Contractor's working methods.	1. Check monitoring data submitted by ET and Contractor's working methods.	1. Confirm receipt of notification of non-compliance in writing; 2. Notify Contractor.	1. Inform the ER and confirm notification of the non-compliance in writing; 2. Rectify unacceptable practice; 3. Amend working methods if appropriate.
Action level being exceeded by two or more consecutive sampling days	1. Repeat measurement on next day of exceedance to confirm findings; 2. Identify source(s) of impact; 3. Inform IC(E), Contractor, ER, EPD, and AFCD; 4. Check monitoring data, all plant, equipment and Contractor's working methods; 5. Discuss mitigation measures with IC(E), ER and Contractor; 6. Ensure mitigation measures are implemented; 7. Increase the monitoring frequency to daily until no exceedance of Action level.	1. Check monitoring data submitted by ET and Contractor's working method; 2. Discuss with ET and Contractor on possible remedial actions; 3. Review the proposed mitigation measures submitted by Contractor and advise the ER accordingly; 4. Supervise the implementation of mitigation measures.	1. Discuss with IC(E) on the proposed mitigation measures; 2. Ensure mitigation measures are properly implemented; 3. Assess the effectiveness of the implemented mitigation measures.	1. Inform the Engineer and confirm notification of the non-compliance in writing; 2. Rectify unacceptable practice; 3. Check all plant and equipment and consider changes of working methods; 4. Submit proposal of additional mitigation measures to ER within 3 working days of notification and discuss with ET, IC(E) and ER; 5. Implement the agreed mitigation measures.

Event	Action			
	ET Leader	**IC(E)**	**ER**	**Contractor**
Limit level being exceeded by one sampling day	1. Repeat measurement on next day of exceedance to confirm findings; 2. Identify source(s) of impact; 3. Inform IC(E), Contractor, ER, EPD, and AFCD; 4. Check monitoring data, all plant, equipment and Contractor's working methods; 5. Discuss mitigation measures with IC(E), ER and Contractor.	1. Check monitoring data submitted by ET and Contractor's working method; 2. Discuss with ET and Contractor on possible remedial actions; 3. Review the proposed mitigation measures submitted by Contractor and advise the ER accordingly.	1. Confirm receipt of notification of failure in writing; 2. Discuss with IC(E), ET and Contractor on the proposed mitigation measures; 3. Request Contractor to review the working methods.	1. Inform the ER and confirm notification of the non-compliance in writing; 2. Rectify unacceptable practice; 3. Check all plant and equipment and consider changes of working methods; 4. Submit proposal of mitigation measures to ER within 3 working days of notification and discuss with ET, IC(E) and ER.
Limit level being exceeded by two or more consecutive sampling days	1. Repeat measurement on next day of exceedance to confirm findings; 2. Identify source(s) of impact; 3. Inform IC(E), Contractor, ER, EPD, AFCD; 4. Check monitoring data, all plant, equipment and Contractor's working methods; 5. Discuss mitigation measures with IC(E), ER and Contractor; 6. Ensure mitigation measures are implemented; 7. Increase the monitoring frequency to daily until no exceedance of Limit level for two consecutive days.	1. Check monitoring data submitted by ET and Contractor's working method; 2. Discuss with ET and Contractor on possible remedial actions; 3. Review the Contractor's mitigation measures whenever necessary to assure their effectiveness and advise the ER accordingly; 4. Supervise the implementation of mitigation measures.	1. Discuss with IC(E), ET and Contractor on the proposed mitigation measures; 2. Request Contractor to critically review the working methods; 3. Make agreement on the mitigation measures to be implemented; 4. Ensure mitigation measures are properly implemented; 5. Consider and instruct, if necessary, the Contractor to slow down or to stop all or part of the construction activities until no exceedance of Limit level.	1. Take immediate action to avoid further exceedance; 2. Submit proposal of mitigation measures to ER within 3 working days of notification and discuss with ET, IC(E) and ER; 3. Implement the agreed mitigation measures; 4. Resubmit proposals of mitigation measures if problem still not under control; 5. As directed by the Engineer, to slow down or to stop all or part of the construction activities until no exceedance of Limit level.

4.34 It is recommended that if monitoring results indicate that the marine works have caused an adverse impact on water quality at the sensitive receivers, additional mitigation measures should be recommended to rectify the non-compliance or the construction programme should be carefully reviewed to slow down the rate of dredging such that the water quality at the sensitive receivers is in compliance with criteria. The working schedule and the mitigation measures should be reviewed by the Contractor, the IC(E), the ET Leader and the ER, and if necessary, works should be slowed down or suspended until such impact is reduced to an acceptable level.

4.35 The ET Leader should assess the effectiveness and efficiency of the proposed mitigation measures and/or remedial actions for the on-going construction activities. Due to the relatively short dredging period, the performance of the environmental management system (that is, of the overall EM&A programme) should be reviewed by the ET Leader on a weekly basis. The findings of this review should be included in the relevant monthly EM&A and quarterly summary reports, together with any recommendations to improve the performance of the EM&A programme.

Operation Phase Monitoring

4.36 During operation phase, monitoring locations (W1 and W2) and control stations (C1 and C2) should be monitored on a quarterly basis for TIN, DO, turbidity, temperature, pH, salinity, SS, ammonia nitrogen and *E. coli*, following the same analytical methods as stated from S4.5 to S4.19. Water quality samples should be collected at 1 m below the surface and 1 m above the seabed at each location. Monitoring should be undertaken once every quarter (3 months) during first year after the commissioning of the STW at mid-ebb and mid-flood tide during each survey. The post commissioning monitoring will be terminated after the 1 year of STW upgrade commissioning as long as the water quality around Peng Chau do not deteriorate. In order to verify the assumptions adopted by the near-field model, initial dilution measurement, effluent characterization and plume tracking survey are required. The surveys are scheduled to commence after commissioning of the Peng Chau STW outfall and last for 12 months. DSD would arrange funding for the surveys and will check and confirm with EPD on the detailed arrangements of the surveys beforehand.

Mitigation Measures

Construction Phase

4.37 During the dredging works, the Contractor should be responsible for the design and implementation of the following mitigation measures.

(a) Dredging should be undertaken using closed grab dredgers with a total production rate of 55 m^3/hr;

(b) Deployment of silt curtain with minimum solid reduction efficiency of 75% from the dredging area while dredging works are in progress;

(c) All vessels should be sized such that adequate clearance (i.e. minimum clearance of 0.6m) 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;

(d) All pipe leakages should be repaired promptly and plant shall not be operated with leaking pipes;

(e) Excess material should be cleaned from the decks and exposed fittings of barges before the vessel is moved;

(f) Adequate freeboard should be maintained on barges to ensure that decks are not washed by wave action;

(g) All barges should be fitted with tight fitting seals to their bottom openings to prevent leakage of material;

(h) Loading of barges and hoppers should be controlled to prevent splashing of dredged material to the surrounding water, and barges and hoppers should not be filled to a level which would cause the overflow of materials or sediment laden water during loading or transportation; and

(i) The decks of all vessels should be tidy and free of oil or other substances that might be accidentally or otherwise washed overboard.

Construction Run-off and Drainage

4.38 The Contractor should observe and comply with the Water Pollution Control Ordinance and the subsidiary regulations. The Contractor should follow the practices, and be responsible for the design, construction, operation and maintenance of all the mitigation measures as specified in ProPECC PN 1/94 "Construction Site Drainage". The design of the mitigation measures should be submitted by the Contractor to the Engineer for approval. These mitigation measures should include the following practices to minimise site surface runoff and the chance of erosion, and also to retain and reduce any suspended solids prior to discharge:

(a) Provision of perimeter channels to intercept storm-runoff from outside the site. These should be constructed in advance of site formation works and earthworks.

(b) Works programmes should be designed to minimize works areas at any one time, thus minimising exposed soil areas and reducing the potential for increased siltation and runoff.

(c) Sand/silt removal facilities such as sand traps, silt traps and sediment basins should be provided to remove the sand/silt particles from run-off. These facilities should be properly and regularly maintained. These facilities shall be carefully planned to ensure that they would be installed at appropriate locations to capture all surface water generated on site.

(d) Careful programming of the works to minimise soil excavation works during rainy seasons.

(e) Trench excavation should be avoided in the wet season, and if necessary, these should be excavated and backfilled in short sections.

(f) Open stockpiles of construction materials on site should be covered with tarpaulin or similar fabric.

General Construction Activities

4.39 Debris and rubbish generated on-site should be collected, handled and disposed of properly to avoid entering the nearby coastal waters and stormwater drains. All fuel tanks and storage areas should be provided with locks and be sited on sealed areas, within bunds of a capacity equal to 110% of the storage capacity of the largest tank. Open drainage channels near the works areas should be covered to block the entrance of large debris and refuse.

Wastewater Arising from Workforce

4.40 No interruption of the Peng Chau STW would be anticipated during construction phase. Wastewater from workforce should be properly collected and discharged to STW for proper treatment.

Operational Phase

4.41 The Project Proponent should be responsible for the following measures:

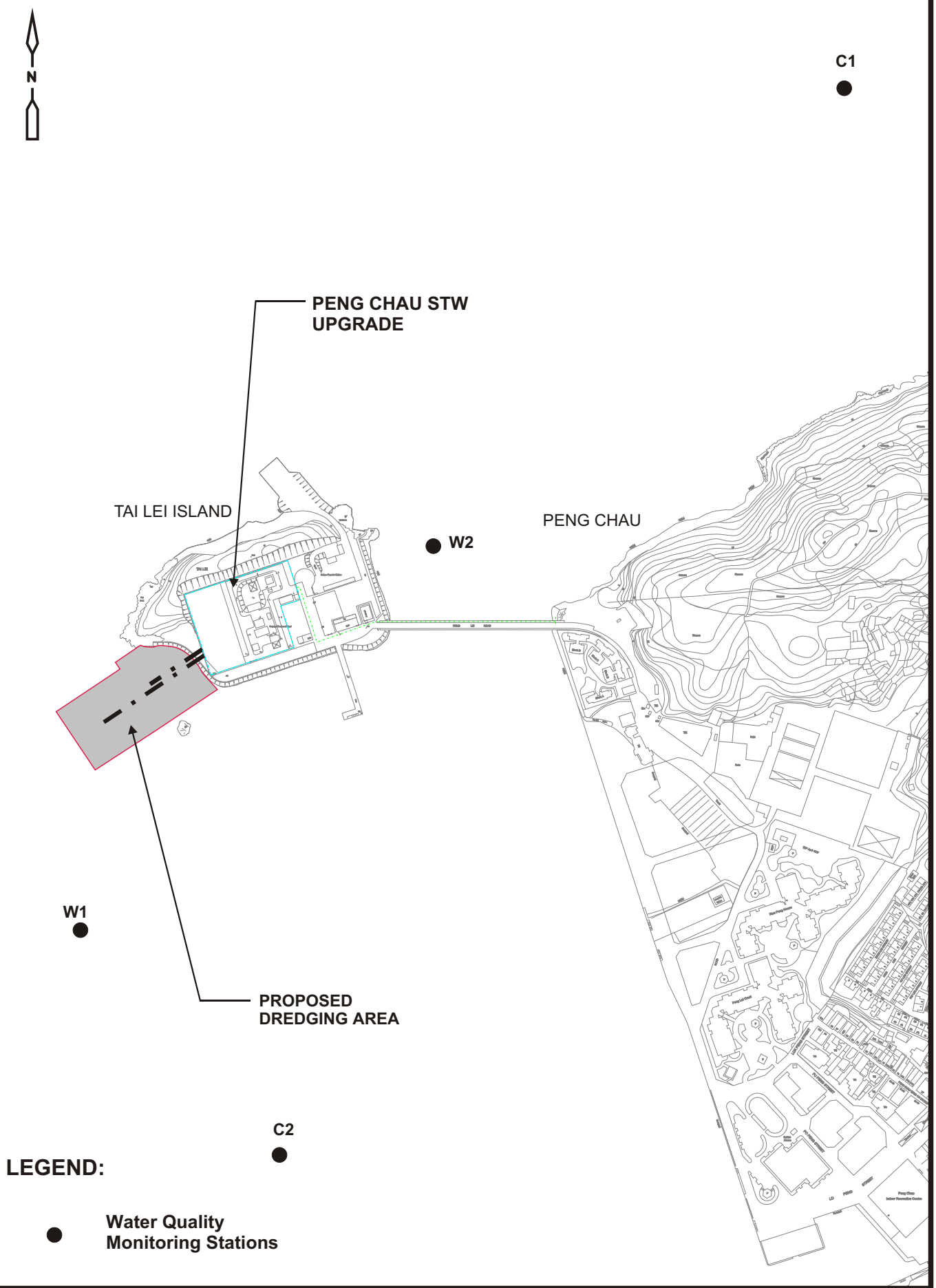
(a) Use of standby generator at the STW in case of interruption of electrical power supply;

(b) Construction of in-line and/or off-line equalization tanks to provide the buffer zone for influent and/or effluent storage; and

(c) In an extreme case where no electricity supply is available (including the failure of the standby generator, divert the inflow to the STW and by-pass the raw sewage through the submarine outfall for better dilution

4.42 The Project Proponent will also be responsible for the implementation of a full secondary level treatment works with denitrification and disinfection.

4.43 The implementation for the recommended water quality mitigation measures is presented in Appendix A.



CDM

Figure 4-1
Water Quality Monitoring Stations