Removal of Sediment in Lo Tik Wan, Sok Kwu Wan and Cheung Sha Wan Fish Culture Zones

Project Profile

August 1998

Agriculture & Fisheries Department

1. Introduction

Bottom sediment under the Lo Tik Wan, Sok Kwu Wan and Cheung Sha Wan fish culture zones (FCZs) contain a large amount of organic matter accumulated over the years. This is largely the result of the traditional practice of using trash fish as fish feed in the past decades. The organic sediment would adversely affect the surrounding marine habitats, the associated marine life and the productivity of the FCZs.

To reduce the problem of bottom sedimentation, AFD introduced in 1994 a new pellet feed formulation in place of trash fish. Better fish growth and good environmental benefits of less water pollution and a cleaner sea bottom were observed in some farms in Lo Tik Wan FCZ. The improvement of sea bottom conditions through the promotion of the environmental-friendly pellet feed alone could likely be a slow process. To achieve quick improvements in the marine environment, the Director of Agriculture and Fisheries hence proposes the removal of bottom sediment at FCZs by dredging. There are several localized benefits in this project in both fisheries and ecological views. They include:

- Improvement of the local water quality and sediment condition to be more suitable for fish culture and for benthic colonization;
- Removal of the anoxic sediments to enable fast recovery of the bottom environment within weeks rather than years through decomposition by natural process;
- Removal of the bulk of nutrient trapped in the sediment in the FCZs can help to reduce the risks of local red tide;
- Minimising fish kills due to the upwelling of anoxic and toxic gas; and,
- Removal of trapped nutrient which may be released gradually, affecting the water quality at fish culture zones and the surrounding environment.

The Federation of Hong Kong Aquaculture Associations (comprising representatives of various fish culture zones) has requested Government assistance in the removal of sediment under fish culture zones in April and May 1998. The Federation is also supportive of the proposal to conduct a pilot project in the selected fish culture zones. Some members of the Provisional Legislative Council also supported Government action to remove sediment in fish culture zones. The Federation and the fish farmers in the three fish culture zones concerned will be

closely liaised with, to exchange views and to ensure the smooth progress of the dredging process.

Despite the obvious benefits of removing bottom sediment in fish culture zones, there is a lack of experience in sediment dredging in fish culture zones. The practical way forward is to conduct dredging in a few fish culture zones on a trial basis in order to gain experience in such dredging operations and to monitor its effectiveness. This sediment removal exercise at the three FCZs is a pilot study in Hong Kong and will provide valuable experience and information on the technical feasibility and environmental acceptability for future dredging in other FCZs.

2. Basic Information

2.1 Project Title

Removal of Sediment in Lo Tik Wan, Sok Kwu Wan and Cheung Sha Wan Fish Culture Zones.

2.2 Purpose and Nature of the Project

To remove the enriched sediment at the seabed of the three selected Fish Culture Zones by grab dredging so as to improve the environmental conditions.

2.3 Name of the Project Proponent

Agriculture & Fisheries Department.

2.4 Location & Scale of Project

The proposed areas are beneath the gazetted zone areas of the three FCZs, Sok Kwu Wan (Figure 2.4a), Lo Tik Wan (Figure 2.4b) and Cheung Sha Wan (Figure 2.4c). The boundaries of areas to be dredged will be extended out 5m for areas 1 & 2 and 8m for area 3 of Sok Kwu Wan, whilst a 8m and 5m edge extension will be subjected to Lo Tik Wan and Cheung Sha Wan respectively. The boundaries are extended based on the fact that organic pollutants (excessive trash fish feed) may deposit the zone areas and the widths of the extension is estimated by the water depth from the respective zone edges to the sea bottom. Depths of sediment to be dredged range from 0.5-1m and in no circumstance, greater than 1 m depth (Fig. 2.4a-c of Appendix II EM & A Manual). The gazetted zone areas, the proposed dredged areas and sediment volume of the three FCZs are summarized in Table 2.4a. Approximately 456,000 m^3 of in situ sediment will be removed in the Project. The corresponding coordinates of the three FCZs is shown in Table 2.4b.

Table 2.4a The proposed sediment volume to be dredged and the zone area of the three subjected Fish Culture Zones

Fish Culture Zone	Zone Area (m^2)	Dredged Area (m^2)	Proposed Sediment Volume (m^3)
Sok Kwu Wan	141,200	160,000	171,000
Lo Tik Wan	109,200	138,000	138,000
Cheung Sha Wan	214,200	228,000	147,000

Table 2.4b The coordinates of the three Fish Culture Zones

	Northing	Easting		Northing	Easting
Sok Kwu Wan			**Lo Tik Wan**		
SKW 1	807687.000	831235.000	LTW 1	809272.634	831102.000
SKW 2	807724.355	831359.517	LTW 2	809272.395	831487.000
SKW 3	807444.833	831443.373	LTW 3	809139.395	831620.000
SKW 4	807414.000	831530.000	LTW 4	808876.000	831.463.000
SKW 5	807295.000	831458.000	LTW 5	809014.593	831324.407
SKW 6	807337.000	831340.000	LTW 6	809153.000	831186.000
SKW 7	807818.288	831677.603			
SKW 8	807810.000	831798.000	**Cheung Sha Wan**		
SKW 9	807566.000	831607.500	CSW 1	811184.672	818495.106
SKW 10	807627.539	831526.678	CSW 2	810924.019	819108.670
SKW 11	807875.000	831930.000	CSW 3	810785.960	819050.020
SKW 12	807930.000	832300.000	CSW 4	810637.290	818783.360
SKW 13A	807958.534	832491.956	CSW 5	810758.500	818498.039
SKW 14A	807884.349	832502.983	CSW 6	811088.031	818454.051
SKW 15	807855.815	832311.027			
SKW 16	807800.815	831941.027			

2.5 Number and Type of Designated Projects

Dredging of sediment in the gazetted zone areas of the three FCZs is an operation which is less than 500m from the nearest boundary of an existing fish culture zone and is classified as a designated project under C.12 of Schedule 2 of the Environmental Impact Assessment Ordinance.

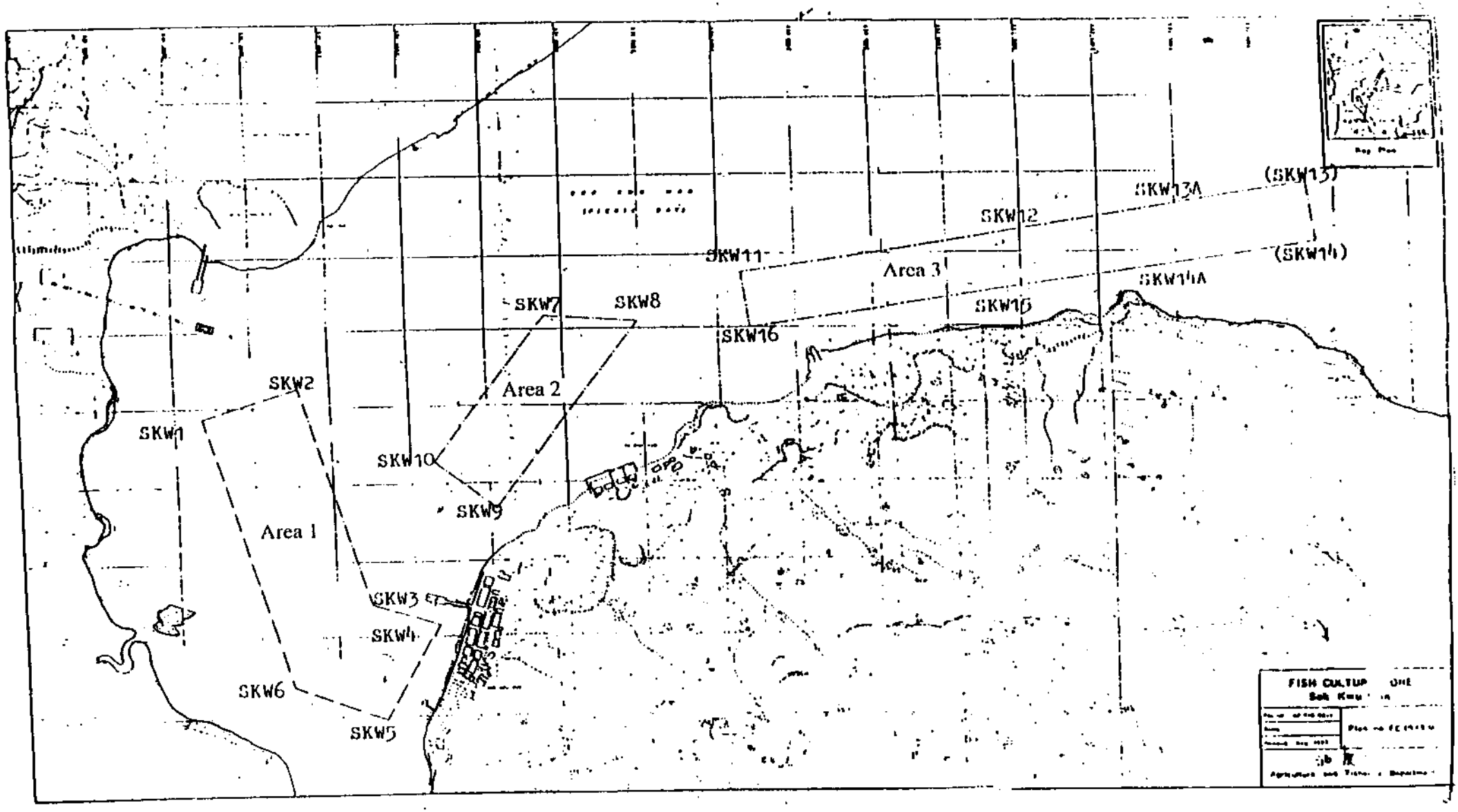


Figure 2.4a Sok Kwu Wan Fish Culture Zone

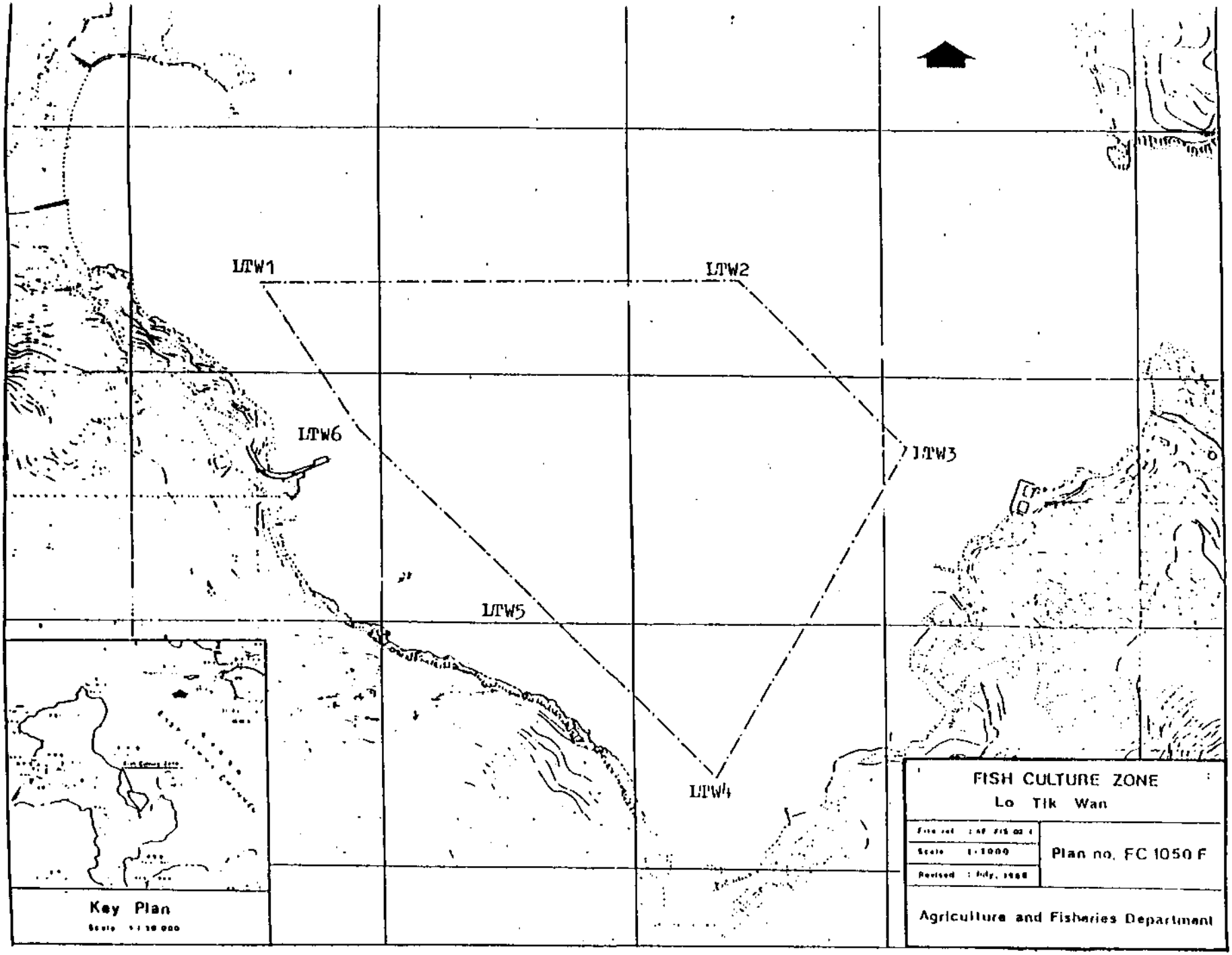


Figure 2.4b Lo Tik Wan Fish Culture Zone

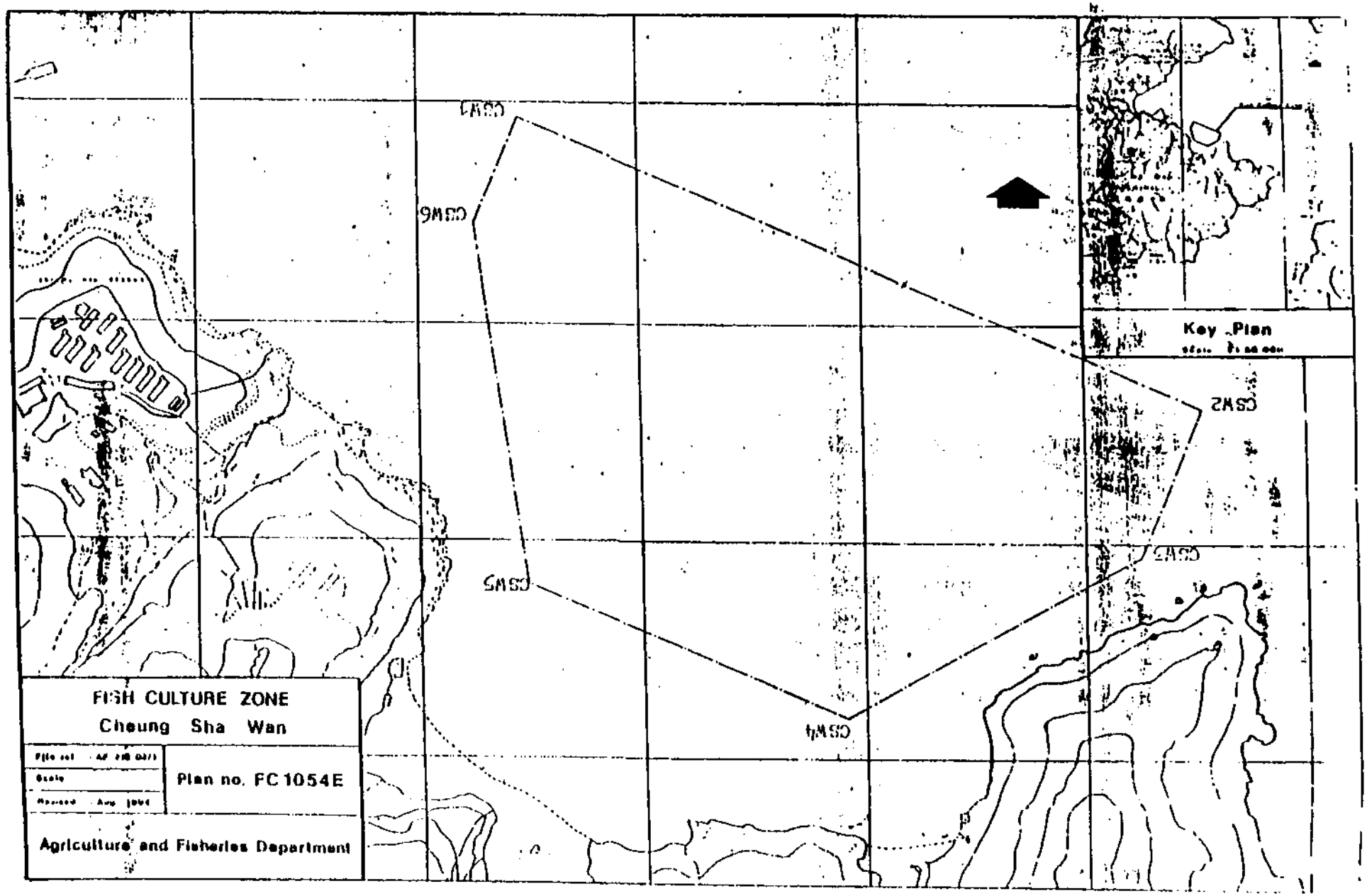


Figure 2.4c Cheung Sha Wan Fish Culture Zone

3. Planning and Implementation Programme

3.1 Planning and Implementation

The whole project will be planned and implemented by Agriculture and Fisheries Department (AFD) in collaboration with Civil Engineering Department (CED). Dredging will be carried out by contractors appointed by CED.

3.2 Project Programme

To shorten the period of disturbance to the FCZs and the environment during dredging, it is important that the dredging operation should be carried out within shortest possible time. Hence, 3 grab dredgers will be deployed by CED's contractor and each FCZ will start dredging simultaneously with one dredger operating. Working sequence and the average dredging rate in each FCZ are presented in Fig. 3.2a-c. By the end of the 8th week, the dredger at Lo Tik Wan will transfer to Sok Kwu Wan. Then the two dredgers will operate together to acelerate the dredging process.

The whole dredging process will be finished within two and a half months (10 weeks) for the 3 FCZs. The timing may vary slightly depending on the zone areas and the weather condition during dredging (Table 3.2a). The programme is prepared based on the assumption the dredging will proceed between 0700-1900 everyday, including general holidays and Sunday. Prior to and after the dredging procedure, a period of 4 weeks will be assigned for the baseline and post-project water quality monitoring (WQM). The work, including the water quality monitoring, is scheduled to start in September 1998, after the typhoon season, and be finished by January 1999.

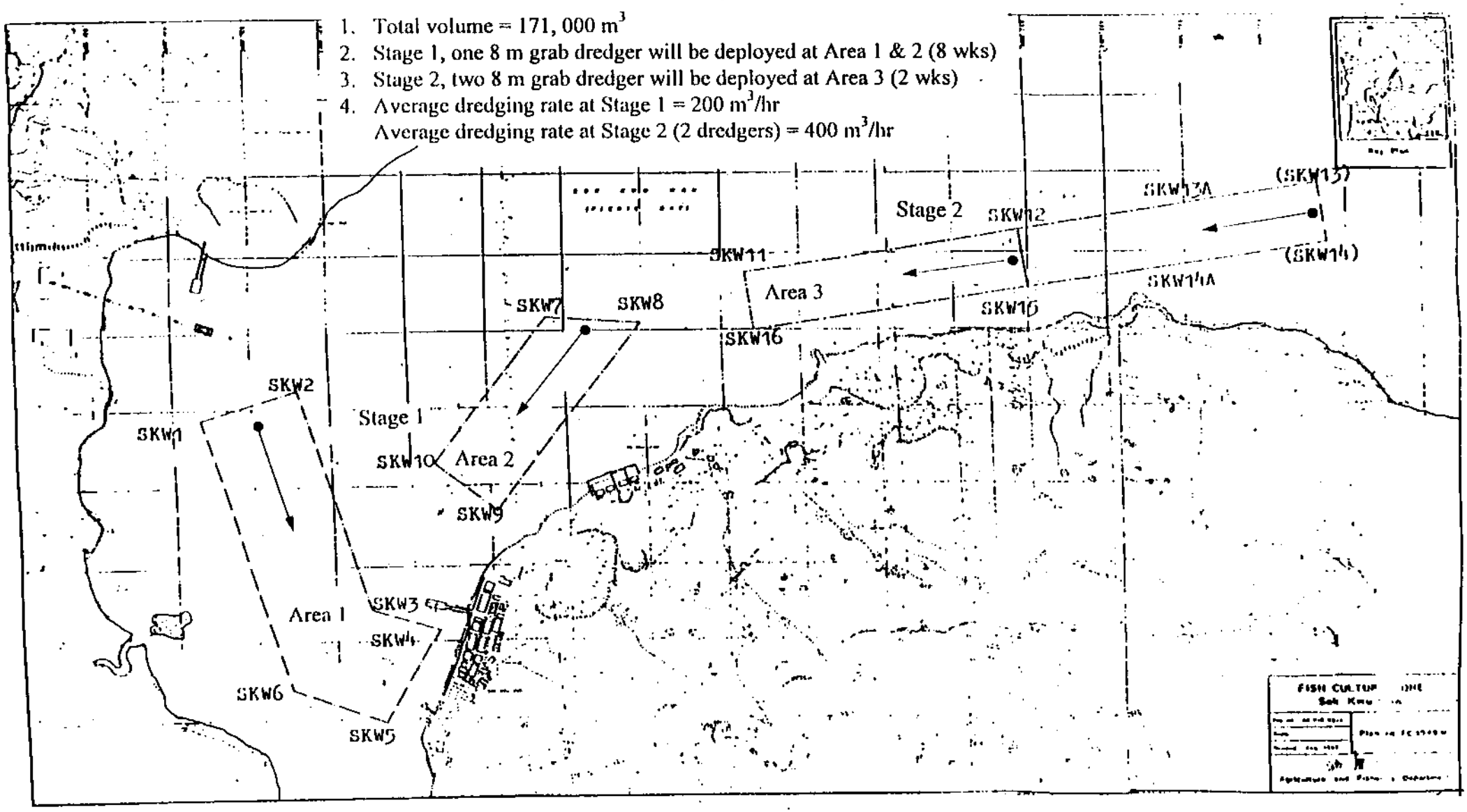


Figure 3.2a Working sequence at Sok Kwu Wan Fish Culture Zone

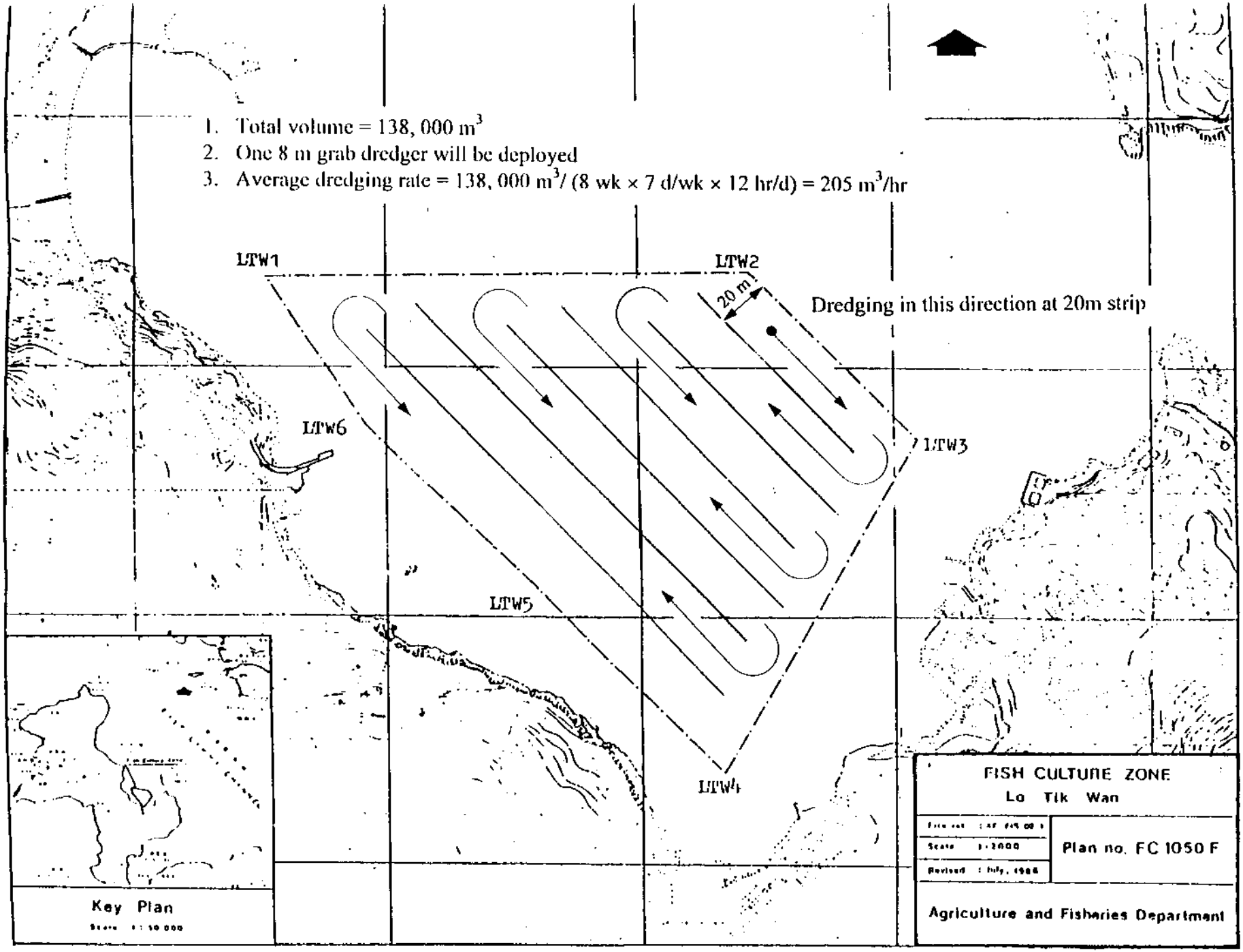


Figure 3.2b Working sequence at Lo Tik Wan Fish Culture Zone

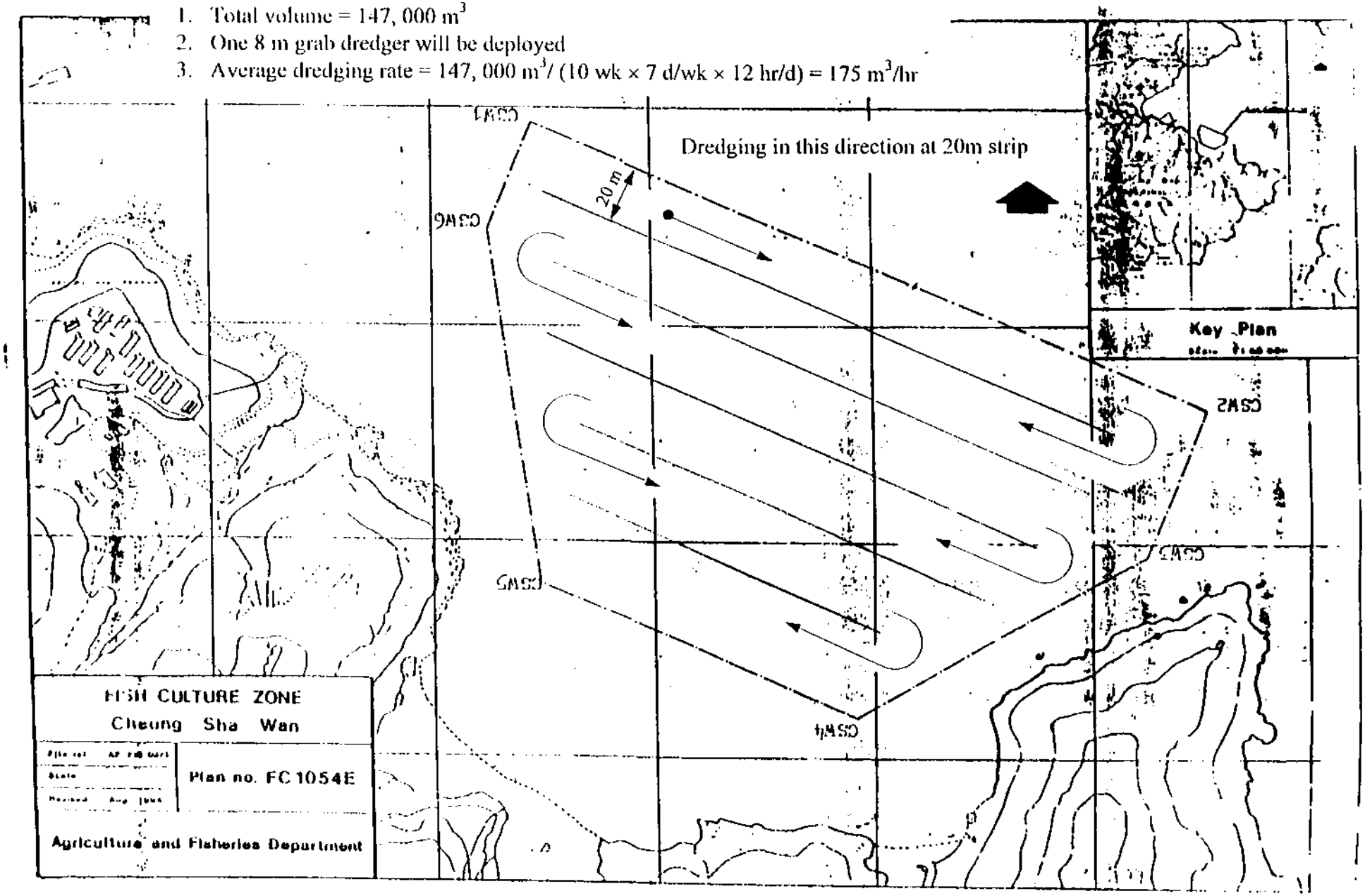


Figure 3.2c Working sequence at Cheung Sha Wan Fish Culture Zone

Table 3.2a Provisional project and water quality monitoring (WQM) program (Two dredgers will be deployed at Sok Kwu Wan by the end of the 8th week)

Location	Activities	1st Month	2nd Month	3rd Month	4th Month	5th Month
Cheung Sha Wan	WQM (Baseline)					
	WQM (Impact)					
	WQM (Post-project)					
	Execution of Works					
Lo Tik Wan	WQM (Baseline)					
	WQM (Impact)					
	WQM (Post-project)					
	Execution of Works					
Sok Kwu Wan	WQM (Baseline)					
	WQM (Impact)					
	WQM (Post-project)					
	Execution of Works				2 dredgers	

4. Possible Impact on the Environment

4.1 Sediment Condition

Wu et al (1994) showed that mariculture activities in four FCZs in Hong Kong (Ma Wan, Sok Kwu Wan, Yung Shue Au & Tap Mun) using trash fish for feeding generated a very high organic and nutrient loading and caused severe but localised organic pollution to the marine environment. High organic enrichment of the bottom sediment was indicated by the relative high value of sediment oxygen demand, hydrogen sulphide concentration, total organic matter and total organic nitrogen compared with the control areas. The diversity of benthic animals areas which serves as a good indicator for organic pollution is also reduced in the study.

A sediment quality study has been performed in the project to classify the sediment grade for disposal purpose and to determine the appropriate water quality parameters to be monitored in the environmental monitoring and audit (EM & A) programme. The concentration in mg/kg (dry weight) of cadmium, chromium, copper, mercury, nickel, lead and zinc were determined to satisfy the requirements specified by EPD under the Dumping at Sea Ordinance. Analysis for total inorganic nitrogen (TIN, μg-N/L), total kjeldahl nitrogen (TKN, μg-N/L), ammoniacal nitrogen (NH_3-N, μg-N/L), sediment oxygen demand (SOD, $mgO_2/hr/m^2$), electrochemical potential (mV), total phosphate (TP, μg-P/L), total sulphide (TS, μg-S/L), total organic carbon (% w/w) and particle size distribution were also determined for the bottom sediment. Results are presented in Appendix I Sediment Quality Test Results.

In summary, sediment from Area 1 and 2 of Sok Kwu Wan FCZ was classified as contaminated sediment due to the marginal exceedance of Zn. The sediment from all three FCZs were found to be highly organic-enriched based on the measurement of TKN and Total P, as well as in a reducing and anaerobic condition, indicated by the negative values of electrochemical potential and high chemical oxygen demand.

4.2 Dredging and Disposal Procedure

4.2.1 Water Quality

During the dredging process, the main environmental impact will be the resuspension of the organic enriched sediment. The anoxic gas hydrogen sulphide may occasionally be released from the bottom sediment. There will also be a short-termed drop of dissolved oxygen within the dredged area. The impacts will be transient.

4.2.2 Ecological & Fisheries Impact

The cultured fish and benthic organisms are vulnerable to the possible deterioration in water quality, e.g. decrease in ambient dissolved oxygen and increase in suspended solid. Coral communities at Luk Chau, in vicinity to Lo Tik Wan FCZ may also be impacted by the suspended sediments.

4.2.3 Noise Impact

Noise impact during the dredging process will, if any, be minimal. Assessment in accordance with the Technical Memorandum on 'Noise from Construction Work other than Percussive Piling' revealed that noise levels at sensitive receivers during unrestricted hours (0700-1900 hours on any day not being a general holiday) would not exceed the guildlines contained in the Technical memorandum on 'Environmental Impact Assessment Process'.

4.2.4 Transport and Disposal of Contaminated Sediment (for Sok Kwu Wan FCZ only)

The dredged sediment will be carried by Hopper Barges and transported via Tug Boats for disposal at approved areas. Disposal of dredged materials will follow requirements specified by EPD under the Dumping at Sea Ordinance.

4.3 Other Impact

No operational and decommissioning impacts are identified.

5. Surrounding Environment

5.1 Existing and Planned Sensitive Receivers

(a) Fish Culture Zones

The dredged areas will be located beneath the zone areas of the three FCZs. The main sensitive receivers in this project are those fishes reared in the stated FCZs. Mariculturists have been consulted and they agreed that they would take into account of the dredging operation including relocating their rafts to areas with minimal impacts (at least 1 km from the dredging sites) and within reasonable reach. To find the most suitable relocation areas for the various FCZs, a liaison meeting will be arranged with representatives from fishermen's organisations, AFD, CED and Marine Department before the commencement of the work. No fish culture activities will be allowed within the FCZs during dredging.

(b) Coral Community

Qualitative and quantitative underwater surveys have been conducted on the eastern and western shores of Luk Chau, the island about 500m from Lo Tik Wan FCZ (BCL, 1995). Both hard and soft corals are recorded.

(c) Benthic Communities

Due to the highly organic-enriched sediment in the FCZs, the diversity of benthic animals is very low. By removing the anoxic sediment, it will provide the opportunity for the benthic organisms to recolonize the defaunated seabed.

6. Environmental Protection Measures and Further Environmental Implications

6.1 Water Quality Impact

To minimize the short term impacts on the surrounding environment during dredging and disposal of removed sediment at appropriate dumping grounds directed by Environmental Protection Department, standard pollution control clauses will be incorporated in the work contracts. Water quality monitoring and audit program during dredging will be conducted to ensure compliance with the relevant Water Quality Objectives.

A detailed Environmental Monitoring & Auditing (EM & A) Manual is presented in Appendix II. Action/ event plans are proposed in the EM & A manual to confirm compliance with the Water Quality Objectives and acceptability of the impacts.

The Contractor shall prevent adverse impacts from operations on water quality. To achieve these requirements the Contractor shall design and implement methods of work that:

- Minimise disturbance to the seabed while dredging;
- Minimise leakage of dredged material during lifting;
- Minimise loss of material during transportation of dredged materials;
- Prevent unacceptable reduction, due to the work, of the dissolved oxygen content of the waters adjacent to the work;
- Prevent excess suspended solids from being present in the water within and adjacent to the work; and,
- Prevent avoidable deterioration in water quality that may cause adverse effects on the marine life in the FCZs.

Pollution avoidance measures during the dredging process shall include but not be limited to the following:

- Mechanical grabs shall be designed and maintained to avoid spillage and to seal tightly while being lifted;

- All vessels shall be sized such that adequate clearance is maintained between vessels and the seabed at all states of the tide to ensure that undue turbidity is not generated by turbulence from vessel movement or propeller wash;
- Marine works shall cause no visible foam, oil, grease, scum, litter or other objectionable matter to be present on the waters within the Site or dumping grounds;
- Barges and grab dredgers shall be fitted with tight-fitting seals to their bottom openings to prevent leakage of material;
- Excess materials shall be cleaned from the decks and exposed fittings of barges and grab dredgers before the vessel departs;
- Loading of barges and grabs shall be controlled to prevent splashing of dredged materials into the surrounding waters, and barges or grabs shall not be filled to a level that will cause overflowing of materials or polluted water during loading or transportation; and,
- Adequate freeboard shall be maintained on barges to ensure that decks are not washed by wave action.

Seabed surveys have been carried out in the sediment quality study and the results are presented in Table 4.1 of Appendix I. Only garbages like fish bones, scales and shell fragments were obtained and these will not interfere with the closure of the grab.

6.2 Ecological and Fisheries Impact

No fish culture will be allowed in the FCZs during the dredging operation. The main sensitive receiver, the cultured fishes, will not be impacted by the work. Impacts to the benthic fauna will be minimal as the diversity and abundance of the benthos are already low in the FCZs. Silt curtains will be installed to minimise the impact on the coral communities at Luk Chau. Water quality will also be monitored near the coral communities to ensure there is no exceedance of the water quality parameters. A station will be located near the coral communities in order to monitor the water quality during the dredging process. Locations of the silt curtain and monitoring locations are indicated in Fig. 2.4b of Appendix II EM & A manual.

6.3 Noise Impact

Noise sensitive receivers are identified nearby the subject sites. Operations are restricted during daytime to reduce the potential effect of noise. To allow working during daytimes on Sundays and public holidays, site measurement of noise levels will be conducted. If necessary, noise abatement measures such as erecting acoustic barriers on board of the dredgers will be implemented. In addition, construction activities during restricted hours (between 1900 and 0700 hours on weekdays and at any time on general holidays including Sundays) will require a Construction Noise Permit (CNP) under the Noise Control Ordinance, Cap. 400. Since the proposed dredging works have planned to proceed between 0700 to 1900 on Sundays and public holidays, the application for a CNP will be made.

6.4 Transport and Disposal of Contaminated Sediment

Impacts are unlikely to be significant as the process will strictly followed the established requirements of DEP on the disposal of the contaminated sediment. The bulk of sediment dredged will be disposed of at the South Cheung Chau dumping ground. Contaminated sediment for Area 1 and 2 of Sok Kwu Wan will be disposed of at the mud pit at East Sha Chau.

6.5 Possible Severity, Distribution and Duration of Environmental Effects

Environmental impacts would be transient and minimal. No fish culture activities will be allowed within the FCZs during dredging. Since the dredging areas are only within the FCZs with small dredged volume and the work will be finished within 10 weeks, the environmental impacts caused by the project should be short-termed and localized.

By removal of the bottom sediment, water quality and benthic habitat will be improved. This will consequently improve the mariculture environment and enhance the re-establishment of the benthic communities.

6.6 Further Implication

The study will provide valuable information for assessment of proposals for sediment removal in other FCZs in future.

7. Reference

Binnie Consultants Limited (1995). Report on Underwater Dive Surveys (Oct 1991-Nov 1994). Fill Management Study. Phase IV. Investigation and Development of Marine Borrow Areas for Civil Engineering Department, Geotechnical Engineering Office.

Wu, R.S.S., K.S. Lam, D. W. MacKay, T. C. Lau, V. Yam (1994). Impact of Marine Fish Farming on Water Quality and Bottom Sediment: A Case Study in the Sub-tropical Environment. Marine Environmental Research 38:115-145.

Appendix I

Sediment Quality Test Results

Appendix I Sediment Quality Test Result

1. Introduction

Marine bottom sediment to be dredged will adversely affect the water quality of the surrounding water bodies. Assessment of the sediment quality has therefore been considered necessary in order to determine the existing conditions in the vicinity of the FCZs and the potential sensitivity of each FCZ.

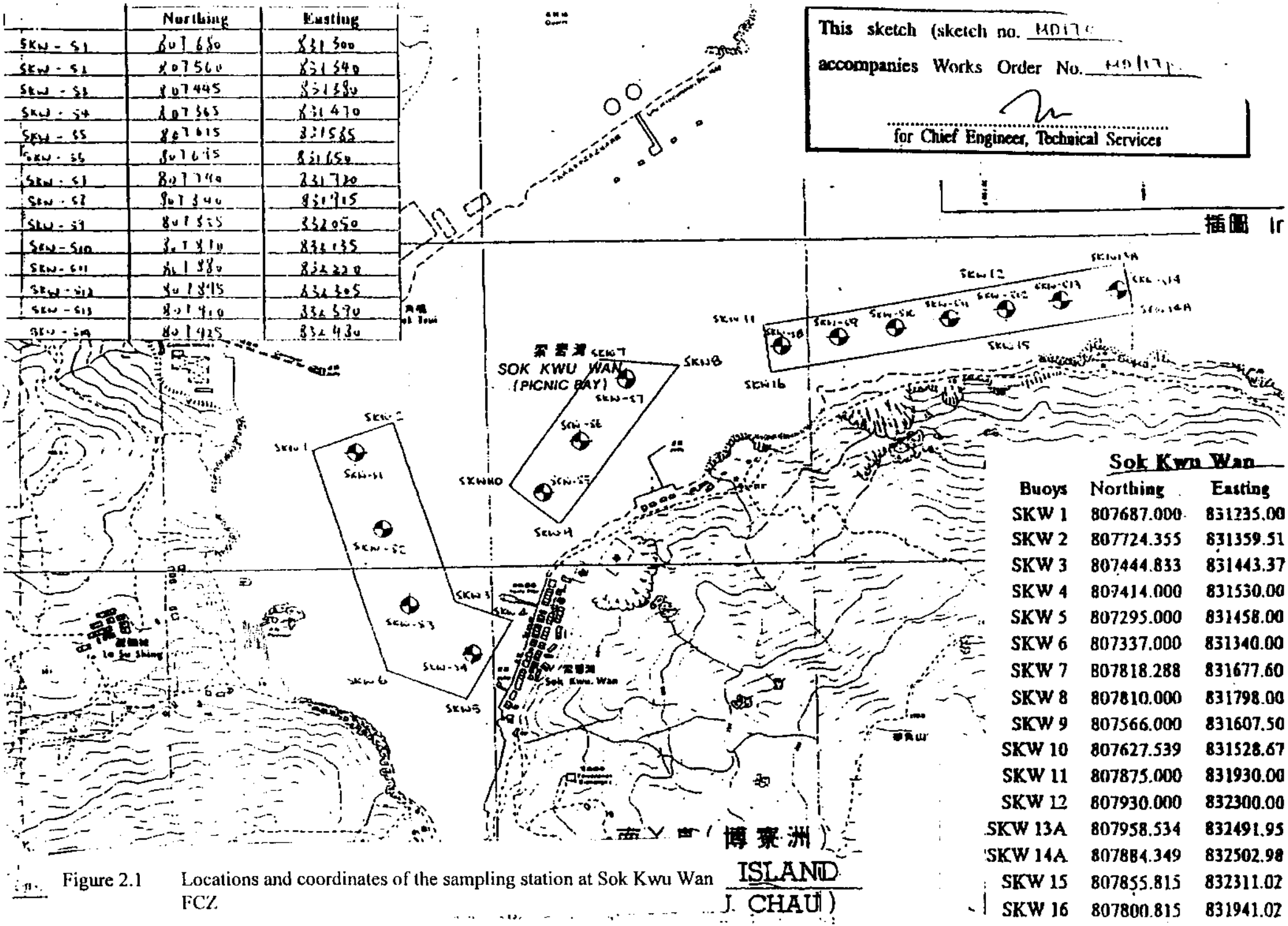
The main aims of the sediment test are:

a) Classifying of the bottom sediment such that appropriate disposal procedure will be established; and
b) Selecting relevent water quality parameters for the environmental monitoring and audit programme.

2. Sampling Information

The locations and coordinates of the sampling stations are shown in Figures 2.1-2.3. The sampling commenced on 7 .5 .98.

Samples were confined to surface sediment (0m) and at 0.5m depth only and collected by divers using specially made sampling tubes of 65 mm in diameter. The locations of sampling stations were determined by DGPS. Approximately 1 kg of sediment sample was collected at each station, and immediately stored in plastic bag. Each bag was labelled to indicate the respective sample location. The samples were transported to MateriaLab on the same day after collection. After arrival, the samples were divided, stored, composed and chilled if necessary, according to the test requirements.



	Northing	Easting
SKW - S1	807650	831300
SKW - S2	807560	831540
SKW - S3	807445	831580
SKW - S4	807365	831470
SKW - S5	807615	831585
SKW - S6	807615	831650
SKW - S7	807740	831720
SKW - S8	807840	831915
SKW - S9	807555	832050
SKW - S10	807810	832135
SKW - S11	807880	832220
SKW - S12	807815	832305
SKW - S13	807910	832370
SKW - S14	807925	832430

Sok Kwu Wan

Buoys	Northing	Easting
SKW 1	807687.000	831235.00
SKW 2	807724.355	831359.51
SKW 3	807444.833	831443.37
SKW 4	807414.000	831530.00
SKW 5	807295.000	831458.00
SKW 6	807337.000	831340.00
SKW 7	807818.288	831677.60
SKW 8	807810.000	831798.00
SKW 9	807566.000	831607.50
SKW 10	807627.539	831528.67
SKW 11	807875.000	831930.00
SKW 12	807930.000	832300.00
SKW 13A	807958.534	832491.95
SKW 14A	807884.349	832502.98
SKW 15	807855.815	832311.02
SKW 16	807800.815	831941.02

Figure 2.1 Locations and coordinates of the sampling station at Sok Kwu Wan FCZ

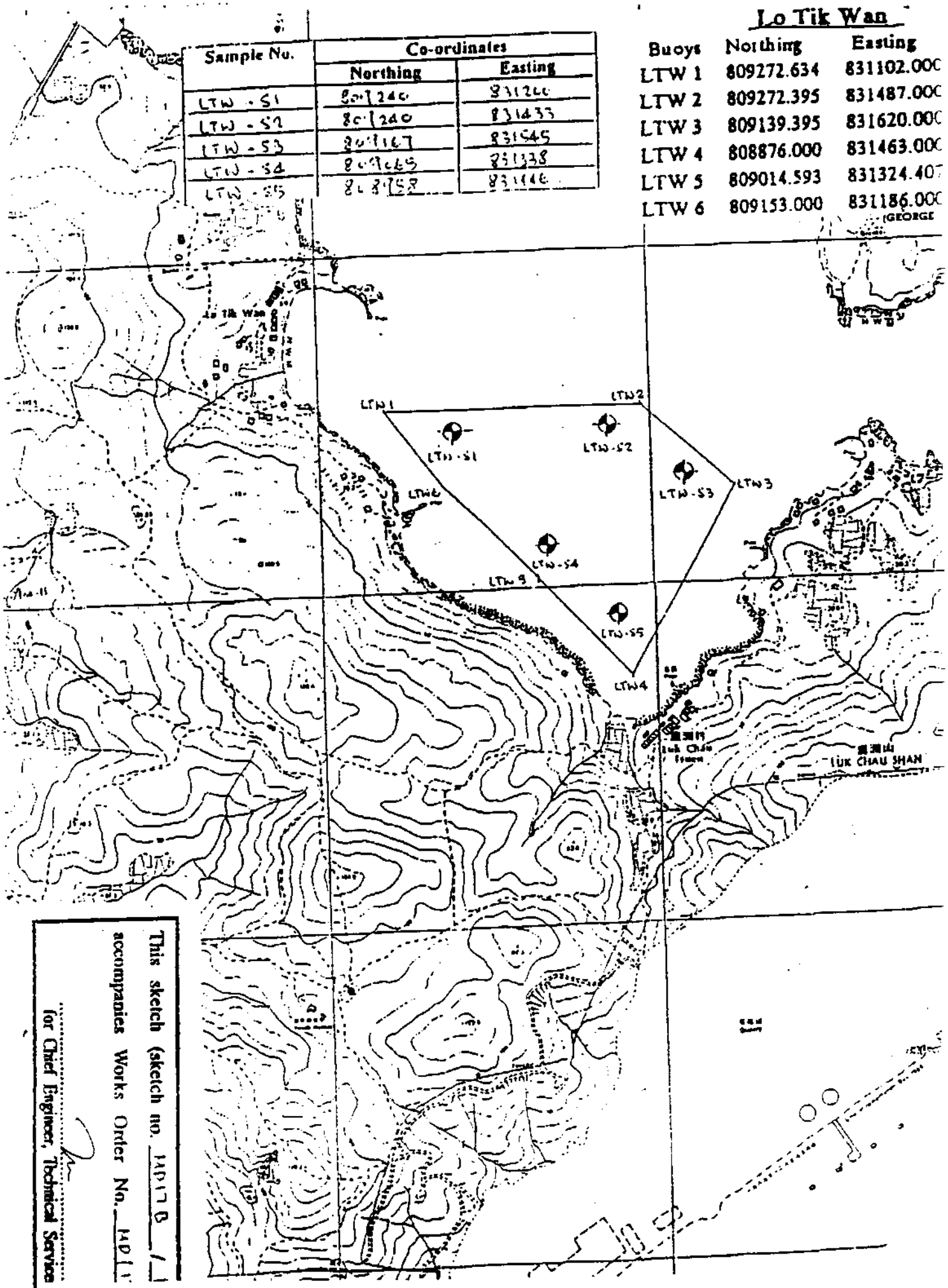


Figure 2.2 Locations and coordinates of the sampling station at Lo Tik Wan FCZ

Buoys	Northing	Easting
CSW 1	811184.672	818495.106
CSW 2	810924.019	819108.670
CSW 3	810785.960	819050.020
CSW 4	810637.290	818783.360
CSW 5	810758.500	818498.039
CSW 6	811088.031	818454.051

accompanies Works Order No. MP 17187

for Chief Engineer, Technical Services

Sample No.	Co-ordinates	
	Northing	Easting
CSW - S1	811132	818530
CSW - S2	810883	818666
CSW - S3	810665	818815
CSW - S4	810641	819000
CSW - S5	810432	818575
CSW - S6	810875	818710
CSW - S7	810315	818900
CSW - S8	810145	818555
CSW - S9	810018	818750

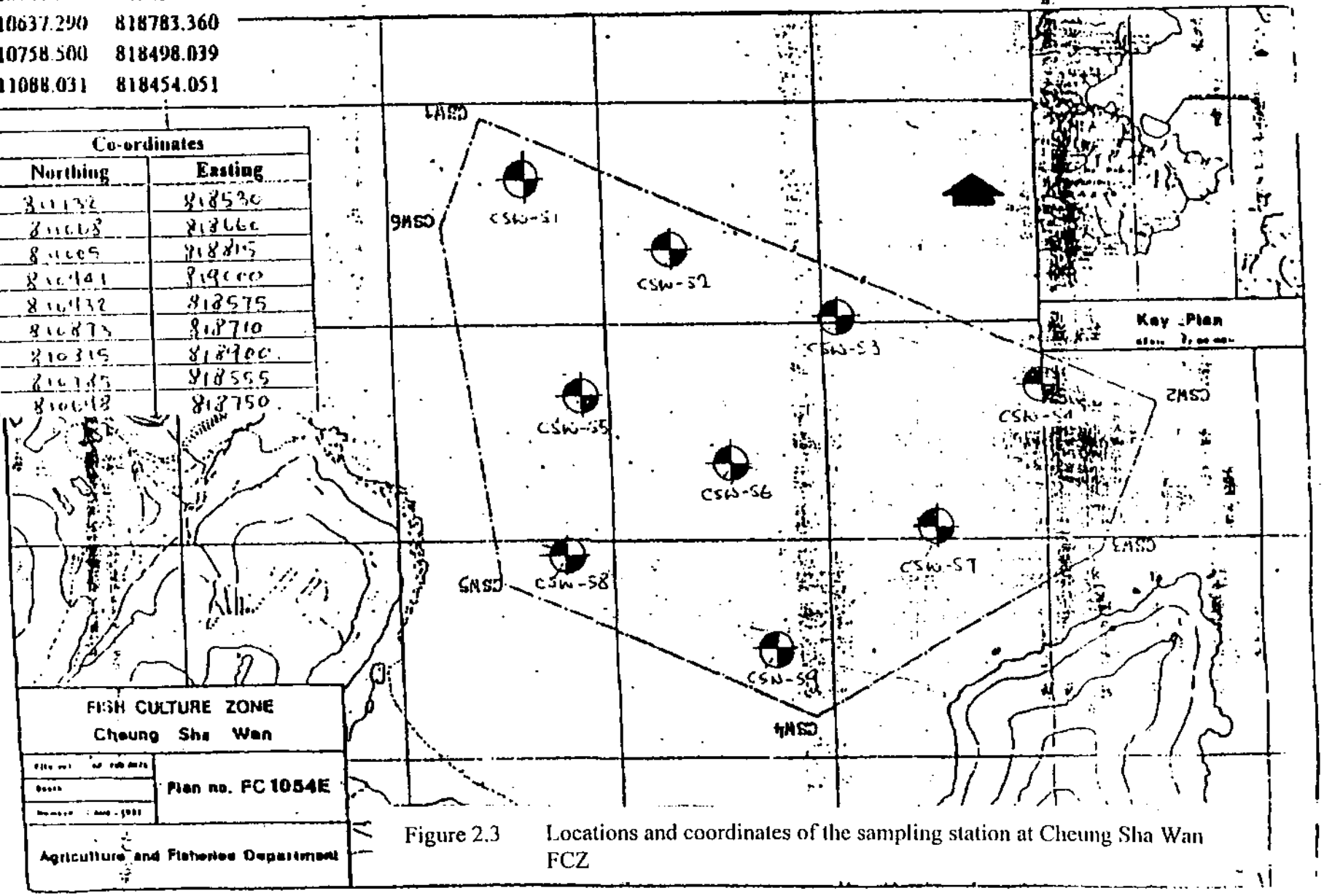


Figure 2.3 Locations and coordinates of the sampling station at Cheung Sha Wan FCZ

3. Testing Information

Tested parameters were listed in Table 3.1.

Table 3.1 Tested parameters

Testing Items	**Sampling Depth**	
	0m	**0.5m**
Chromium (mg/ kg)	✓	
Cadium (mg/ kg)	✓	
Copper (mg/ kg)	✓	
Lead (mg/ kg)	✓	
Zinc (mg/ kg)	✓	
Nickel (mg/ kg)	✓	
Mercury (mg/ kg)	✓	
Total Inorganic Nitrogen (mg N/ kg)	✓	✓
Total P (mg P/ kg)	✓	✓
Total TKN (mg N/ kg)	✓	
Sediment Oxygen Demand $_{1260}$ (mg O_2/ L)	✓	✓
Electrochemical Potential (mV)	✓	
NH_3-N (mg N/ kg)	✓	
Sulphide (mg S^{2-} / kg)	✓	
Particle Size Distribution (PSD)	Samples of 0.5 m only were mixed to form one composite sample each for Cheung Sha Wan, Lo Tik Wan and 3 areas of Sok Kwu Wan	
Chemical Oxygen Demand (mg O_2/ kg)	✓	
Total Organic Carbon (mg C /kg)	✓	

Testing methodologies and quality control measures of the above parameters have been approved by EPD.

4. Results

A general description of the physical natures of the bottom sediment are shown in Table 4.1.

Table 4.1 The physical natures of the sediment

Sample	Silty/ Sandy	Colour	Odour	Remarks
		Cheung Sha Wan		
CSW-S1	very silty mud	yellowish grey	nil	stiff
CSW-S2	very silty mud	yellowish grey	nil	stiff
CSW-S3	very silty mud	yellowish grey	nil	relatively stiff
CSW-S4	very silty mud	yellowish grey	nil	relatively stiff
CSW-S5	very silty mud	yellowish grey	slight odour	relatively stiff
CSW-S6	very silty mud	yellowish grey	slight odour	relatively stiff
CSW-S7	very silty mud	yellowish grey	slight odour	stiff with shell and rubbish like fish bone
CSW-S8	very silty mud	yellowish grey	nil	relatively stiff
CSW-S9	very silty mud	yellowish grey	nil	stiff
		Lo Tik Wan		
LTW-S1	very silty mud	yellowish grey	nil	with rubbish like fish bone
LTW-S2	sandy silt	yellowish grey	nil	with rubbish like fish bone
LTW-S3	sandy silt	yellowish grey	slight	with a lot of rubbish and shell fragments
LTW-S4	very silty mud	grey	nil	stiff
LTW-S5	very silty mud	yellowish grey	nil	relatively stiff with rubbish like fish bone
		Sok Kwu Wan		
SKW-S1	sand	yellowish grey	nil	with shell fragments
SKW-S2	very silty mud	dark grey	nil	with rubbish like fish bone
SKW-S3	very silty mud	dark grey	nil	with rubbish like fish bone
SKW-S4	sandy silt	yellowish grey	nil	with shell fragments
SKW-S5	very silty mud	dark grey	nil	not stiff, with rubbish like fish bone
SKW-S6	very silty mud	very dark grey	nil	not stiff
SKW-S7	very silty mud	yellowish grey	nil	stiff
SKW-S8	very silty mud	yellowish grey	nil	stiff
SKW-S9	sandy silt	yellowish grey	slight odour	relatively stiff
SKW-S10	sandy silt	yellowish grey	nil	relatively stiff with rubbish like fish bone
SKW-S11	very silty mud	yellowish grey	nil	relatively stiff
SKW-S12	very silty mud	yellowish grey	nil	stiff
SKW-S13	very silty mud	yellowish grey	nil	stiff with rubbish like fish bone
SKW-S14	sandy silt	yellowish grey	nil	relatively stiff with rubbish like fish bone

The sediment test results were shown in Table 4.2.

4.1 Heavy Metals

Two samples (SKW-S2 &S3) from Area 1 and one (SKW-S5) from Area 2 of Sok Kwu Wan were classified as contaminated mud (Class C) due to the marginal exceedance of Zn concentration. For all the other samples from Lo Tik Wan, Cheung Sha Wan and Area 3 of Sok Kwu Wan, they were all classified as uncontaminated mud (Class A & B).

4.2 Total Carbon

Comparing with the EPD 1996 sediment quality data (from Marine Water Quality in Hong Kong for 1996), the total carbon content from all the stations in FCZs were on average <0.3 % w/w which was lower than most stations within the Southern Water Control Zone of 0.5-0.8 % w/w.

4.3 Nutrients

The total Kjeldahl nitrogen (on average >1000 mg N/kg) and total phosphorus content (on average >400 mg P/kg) on average of the FCZ sediments were well above the sediment concentration in other benthic stations monitored by EPD in Hong Kong (TKN <600 mg N/kg & Total P <200 mg P/kg; from Marine Water Quality in Hong Kong for 1996). For ammoniacal nitrogen, the data was comparable (~10 mg N/kg) with those within the Southern Water Control Zone.

4.4 Sulphide

The sulphide content at Sok Kwu Wan (on average >200 mg S/kg) was much higher than those at Lok Tik Wan and Cheung Sha Wan (<1 mg S/kg). Also, the sulphide content from Sok Kwu Wan was much higher than the sediment stations within the Southern Water Quality Control Zone (<67 mg S/kg).

4.5 Oxygen Demand

CODs (>20000 mg O_2/kg) of the FCZs bottom sediment were much higher than the average reading at the Southern Water Quality Control Zone (7700-18000 mg O_2/kg, data from EPD).

4.6 Particle Size Distribution

Marine sediment can be grouped into two fractions according to its particle size distribution (PDS):

- Coarse fraction (sand and coarse material equal to or greater than 63 μm in diameter); and,
- Fine fraction (silts and clays less than 63 μm in diameter).

The results showed that sediment from FCZ is mainly composed of silty mud. Only at Area 1 of Sok Kwu Wan, the % of particles <63μm was less than 50 and only 2 % of the particles from Cheung Sha Wan was composed of coarse particles.

4.7 Electrochemical Potential

Electrochemical potential is a measure of the reduction-oxidation (redox) status of sediment. A positive potential value usually indicates an aerobic environment while a negative value indicates an anaerobic situation.

Nearly all readings from the 3 FCZs were negative, indicating an anaerobic environment.

Table 4.2 Sediment test results from the three Fish Culture Zones: Lo Tik Wan, Cheung Sha Wan and Sok Kwu Wan.

Lo Tik Wan

	Testing Items	Sampling Depths 0 m					
	Sample No	LTW-S1	LTW-S2	LTW-S3	LTW-S4	LTW-S5	Mean ± SD
1	Chromium (mg/ kg)	34	21	17	41	37	30 ± 10.44
2	Cadium (mg/ kg)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
3	Copper (mg/ kg)	37	20	23	54	43	35.4 ± 14.12
4	Lead (mg/ kg)	33	20	22	39	36	30 ± 8.51
5	Zinc (mg/ kg)	150	75	68	180	150	124.6 ± 50.06
6	Nickel (mg/ kg)	19	13	9	23	20	16.8 ± 5.67
7	Mercury (mg/ kg)	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
	Classification of Contamination Level	**B**	**A**	**A**	**B**	**B**	
8	Total Inorganic Nitrogen (mg N/ kg)	<0.1	0.2	<0.1	<0.1	<0.1	
9	Total P (mg P/ kg)	6500	650	550	980	960	1928 ± 2562.77
10	Total TKN (mg N/ kg)	2900	460	420	1100	1200	1216 ± 1005.82
11	Sediment Oxygen Demand $_{1260}$ (mg O_2/ L)	0	0	0.016	0	0	0.0032 ± 0.0072
12	Electrochemical Potential (mV)	-120	-250	-60	-390	-150	
13	NH_3-N (mg N/ kg)	8	8	4	21	10	10.2 ± 6.42
14	Sulphide (mg S^{2-} / kg)	<1	<1	<1	<1	<1	<1
15	PSD	Gravel%: Sand%: Silt%: Clay%:	13 24 38 25				%Particle size <63μm : 63
16	Chemical Oxygen Demand (mg/ kg)	39000	22000	12000	48000	48000	33800 ± 16161.68
17	Total Organic Carbon (% w/w)	0.62	0.075	0.06	0.23	0.26	0.25 ± 0.23

	Testing Items	Sampling Depths 0.5 m					
		LTW-S1	LTW-S2	LTW-S3	LTW-S4	LTW-S5	
8	Total Inorganic Nitrogen (mg N/ kg)	0.3	<0.1	0.2	<0.1	<0.1	
9	Total P (mg P/ kg)	9400	9200	620	830	890	4188 ± 4668.21
11	Sediment Oxygen Demand $_{1260}$	0	0	0	0	0	0

Table 4.2 Continued **Cheung Sha Wan**

	Testing Items	Sampling Depths 0 m									
	Sample No	CSW-S1	CSW-S2	CSW-S3	CSW-S4	CSW-S5	CSW-S6	CSW-S7	CSW-S8	CSW-S9	Mean± S D
1	Chromium (mg/ kg)	39	39	39	40	37	35	35	37	40	37.89±1.96
2	Cadium (mg/ kg)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
3	Copper (mg/ kg)	44	43	42	43	41	36	40	41	50	42.22±3.73
4	Lead (mg/ kg)	44	45	60	45	41	38	39	40	45	44.11±6.57
5	Zinc (mg/ kg)	130	130	130	130	130	130	130	140	160	134.44±10.14
6	Nickel (mg/ kg)	21	21	20	21	20	18	20	19	22	20.22±1.20
7	Mercury (mg/ kg)	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
	Classification of Contamination Level	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**B**	
8	Total Inorganic Nitrogen (mg N/ kg)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
9	Total P (mg P/ kg)	530	580	520	520	1300	1200	1100	840	1000	843.33±316.78
10	Total TKN (mg N/ kg)	1400	1300	1000	1300	1300	1600	1300	1900	1800	1433.33±282.84
11	Sediment Oxygen Demand $_{1260}$	0	0	0	0	0	0	0	0	0	0
12	Electrochemical potential (mV)	-140	-90	-50	-50	20	-260	20	-60	-400	
13	NH_3-N (mg N/ kg)	19	17	11	12	24	34	15	18	20	18.89±6.94
14	Sulphide (mg S^{2-} / kg)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
15	PSD	Gravel%: 0 Sand%: 2 Silt%: 61 Clay%: 37									%Particle size <63μm : 98
16	Chemical Oxygen Demand (mg/ kg)	44000	45000	39000	40000	44000	45000	45000	46000	53000	44555.56± 3972.13
17	Total Organic Carbon (% w/w)	0.23	0.26	0.2	0.24	0.24	0.25	0.24	0.23	0.29	0.24±0.024

	Testing Items	Sampling Depths 0.5 m									
	Sample No	CSW-S1	CSW-S2	CSW-S3	CSW-S4	CSW-S5	CSW-S6	CSW-S7	CSW-S7	CSW-S9	Mean± S D
8	Total Inorganic Nitrogen (mg N/ kg)	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	
9	Total P (mg P/ kg)	600	540	690	520	1100	1700	1500	760	950	928.89±427.59
11	Sediment Oxygen Demand $_{1260}$	0	0	0	0	0	0	0	0	0	0

Table 4.2 Continued **Sok Kwu Wan Area 1 & 2**

	Testing Items	Sampling Depths 0 m									
		Area 1					Area 2				
	Sample No	SKW-S1	SKW-S2	SKW-S3	SKW-S4	Mean±SD	SKW-S5	SKW-S6	SKW-S7	SKW-S8	Mean±SD
1	Chromium (mg/ kg)	9	32	33	27	25.25±11.15	36	33	33	34	34±1.41
2	Cadium (mg/ kg)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
3	Copper (mg/ kg)	10	54	57	54	43.75±22.54	46	45	31	31	38.25±8.38
4	Lead (mg/ kg)	<15	48	47	45		49	49	37	37	43±6.93
5	Zinc (mg/ kg)	58	220	230	160	167±78.97	210	190	130	120	162.5±44.25
6	Nickel (mg/ kg)	<6	17	18	13	16±2.65	19	18	17	17	17.75±0.96
7	Mercury (mg/ kg)	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
	Classification of Contamination Level	**A**	**C**	**C**	**B**		**C**	**B**	**A**	**A**	
8	Total Inorganic Nitrogen (mg N/ kg)	0.7	1.6	0.9	1.4	1.15±0.42	1.3	0.4	0.2	0.9	0.7±0.50
9	Total P (mg P/ kg)	100	850	560	710	555±325.63	740	2400	590	490	1055±902.53
10	Total TKN (mg N/ kg)	390	2300	2200	1300	1547.5±893.14	1500	1800	1200	1100	1400±316.23
11	Sediment Oxygen Demand $_{1260}$	0.287	0	0	0	0.072±0.14	0	0	0	0.032	0.008±0.016
12	Electrochemical Potential (mV)	-20	-110	-270	-150		-200	-50	-80	-60	
13	NH_3-N (mg N/ kg)	6	13	13	8	10±3.56	11	20	6	6	10.75±6.60
14	Sulphide (mg S^{2-} / kg)	4	600	490	390	371±259.26	1600	690	140	70	625±706.66
15	PSD	Gravel%:		8		%Particle size	Gravel%:		1		%Particle size
		Sand %:		53		<63μm : 39	Sand %:		10		<63μm : 89
		Silt %:		24			Silt %:		60		
		Clay %:		15			Clay %:		29		
16	Chemical Oxygen Demand (mg/ kg)	51000	50000	49000	44000	48500±3109.13	54000	50000	38000	35000	44250±9178.78
17	Total Organic Carbon (% w/w)	0.029	0.34	0.38	0.19	0.23±0.15	0.27	0.39	0.22	0.19	0.27±0.088
	Testing Items	Sampling Depths 0.5 m									
		Area 1					Area 2				
	Sample No	SKW-S1	SKW-S2	SKW-S3	SKW-S4	Mean±SD	SKW-S5	SKW-S6	SKW-S7	SKW-S8	Mean±SD
8	Total Inorganic Nitrogen (mg N/ kg)	0.3	0.2	0.2	0.3	0.25±0.06	<0.1	<0.1	<0.1	0.2	
9	Total P (mg P/ kg)	100	790	660	450	500±301.22	650	1400	710	720	870±354.683
11	Sediment Oxygen Demand $_{1260}$	0.166	0	0	0	0.04±0.08	0	0	0.02	0.076	0.024±0.036

Table 4.2 Continued **Sok Kwu Wan Area 3**

	Testing Items	Sampling Depths 0 m						
		Area 3						
	Sample No	SKW-S9	SKW-S10	SKW-S11	SKW-S12	SKW-S13	SKW-S14	Mean± S D
1	Chromium (mg/ kg)	30	30	30	32	25	23	28.33±3.50
2	Cadium (mg/ kg)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
3	Copper (mg/ kg)	27	27	28	28	10	10	21.67±9.05
4	Lead (mg/ kg)	34	37	35	35	25	25	31.83±5.38
5	Zinc (mg/ kg)	110	110	110	120	83	86	103.17±15.00
6	Nickel (mg/ kg)	15	16	16	17	12	12	14.67±2.16
7	Mercury (mg/ kg)	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
	Classification of Contamination Level	**A**	**A**	**A**	**A**	**A**	**A**	
8	Total Inorganic Nitrogen (mg N/ kg)	1.2	0.6	0.3	0.2	0.3	<0.1	
9	Total P (mg P/ kg)	350	580	460	420	390	250	408.33±110.53
10	Total TKN (mg N/ kg)	1000	1000	1100	1100	1100	1000	1050±54.77
11	Sediment Oxygen Demand $_{1260}$	0	0	0	0.004	0	0	0
12	Electrochemical Potential (mV)	-150	-110	-70	-70	-350	-120	
13	NH_3-N (mg N/ kg)	13	10	8	10	10	11	10.33±1.63
14	Sulphide (mg S^{2-} / kg)	190	280	210	160	240	190	211.67±42.62
15	PSD	Gravel%: 2 Sand %: 14 Silt %: 61 Clay %: 23						%Particle size <63μm : 84
16	Chemical Oxygen Demand (mg/ kg)	33000	32000	34000	32000	21000	20000	28666.67± 6377.04
17	Total Organic Carbon (% w/w)	0.16	0.36	0.16	0.15	0.48	0.11	0.24±0.15
	Testing Items	Sampling Depths 0.5 m						
		Area 3						
	Sample No	SKW-S9	SKW-S10	SKW-S11	SKW-S12	SKW-S13	SKW-S14	Mean± S D
8	Total Inorganic Nitrogen (mg N/ kg)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
9	Total P (mg P/ kg)	460	730	580	610	270	400	508.33±164.61
11	Sediment Oxygen Demand $_{1260}$	0	0	0	0	0	0	0

5. Conclusion

With reference to the water quality measurements of EPD (Marine Water Quality in Hong Kong for 1996), the following water quality parameters (Table 5.1) were selected for the EM&A procedure.

All sediments were essentially uncontaminated except Area 1 & 2 of Sok Kwu Wan FCZ where marginal exceedance of Zn level was detected. In view of the small quality of the sediment in Area 1 & 2 and the possible dilution effect in the hopper barges prior to dumping, it is proposed, subject to EPD's approval, that all sediment will be dumped to open ground.

Table 5.1 EM&A monitoring parameters in the three FCZs.

Monitoring Parameters	Lo Tik Wan	Cheung Sha Wan	Sok Kwu Wan
Dissolved oxygen	✓	✓	✓
Suspended Solid	✓	✓	✓
Turbidity	✓	✓	✓
Total Phosphorus	✓	✓	✓
TKN	✓	✓	✓
NH_3-N	✓	✓	✓
BOD_5	✓	✓	✓
Zn			✓

Appendix II

Environmental Monitoring & Audit Manual

Appendix II Environmental Monitoring & Audit Manual

1. Introduction

1.1 Purpose of the Manual

The purpose of this Environmental Monitoring and Audit (EM&A) Manual is guide the setup of an EM&A programme to monitor the water quality, to assess the effectiveness of the recommended mitigation measures and to identify the further need for additional mitigation measures or remedial actions. This manual outlines the monitoring and audit programme to be undertaken for the dredging of bottom sediment at three Fish Culture Zones (FCZs): Sok Kwu Wan, Lo Tik Wan and Cheung Sha Wan. It aims to provide systematic procedures for monitoring, auditing and minimising the environmental impacts associated with the dredging and disposing off works.

It is envisaged that the EM & A Manual will be reviewed during the final detailed design and periodically throughout the project implementation to ensure that it remains relevant and effective in respect of changing site conditions.

1.2 Background

The Contractor, Nishimatsu Construction Company Limited has been awarded a contract by the Government of Hong Kong Special Administrative Region , Civil Engineering Department (CED), Contract No. CV/97/05, for the Maintenance Dredging during the period of 1998-1999.

Under this term contract, the contractor is designated to carry out a maintenance dredging for the Fish Culture Zones of Sok Kwu Wan, Lo Tik Wan and Cheung Sha Wan.

The works mainly include dredging of designated amount of marine sediment from each of the three Fish Culture Zones by Grab Dredgers. The dredged sediment will be carried by Hopper Barges and transported via Tug Boats for disposal at approved area.

After preliminary study on the quality of sediments being taken from the FCZs, it is recommended that water quality monitoring on various parameters shall be undertaken during dredging at the mentioned FCZs.

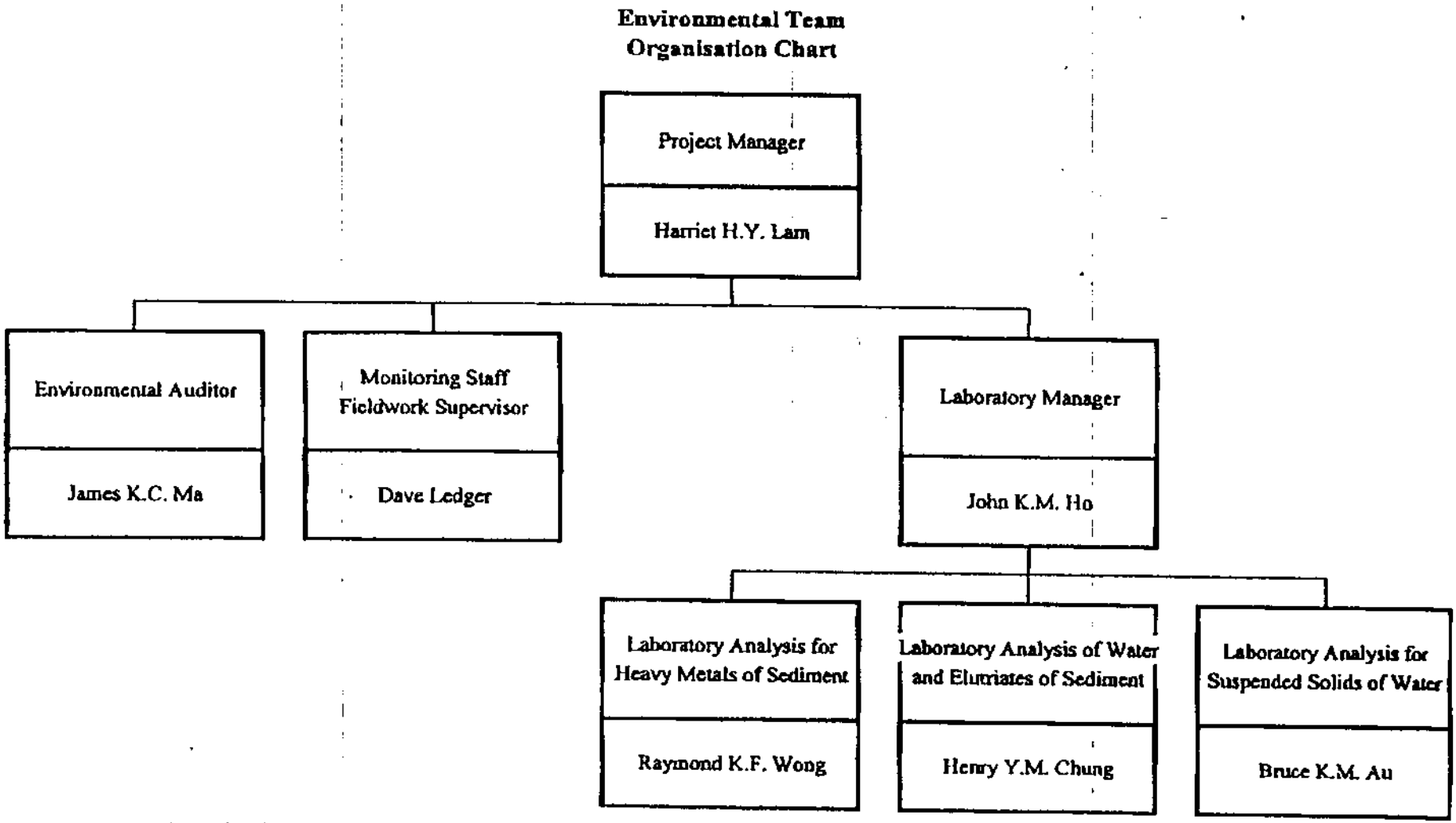


Figure 1.4a Organization Chart of the Environmental Team

2. Water Quality

2.1 Water Quality Parameter

Monitoring of turbidity in NTU, dissolved oxygen (DO) in mg/L and suspended solids (SS) in mg/L shall be carried out by the Environmental Team to ensure that any deteriorating water quality could be readily detected and timely action be taken to rectify the situation. The first two parameters are to be measured in situ whilst the suspended solids are to be determined in the laboratory.

Based on the sediment quality results, additional parameters are included for the monitoring. They are Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), Ammoniacal Nitrogen (NH_3-N), BOD_5 and Zinc (Zn, only for Sok Kwu Wan FCZ). These parameters shall be determined in the laboratory.

Table 2.1 showed the parameters to be monitored in the three FCZs.

Table 2.1 EM&A monitoring parameters in the three FCZs.

Monitoring Parameters	Lo Tik Wan	Cheung Sha Wan	Sok Kwu Wan
General:			
Dissolved oxygen	✓	✓	✓
Suspended Solid	✓	✓	✓
Turbidity	✓	✓	✓
Additional:			
Total Phosphorus	✓	✓	✓
TKN	✓	✓	✓
NH_3-N	✓	✓	✓
BOD_5	✓	✓	✓
Zn			✓

In association with the water quality parameters, some relevant data shall also be measured, such as monitoring location/ position, time, water depth, water temperature, salinity, DO saturation, weather conditions, tidal state, and any special phenomena and work underway at the Project site etc.

2.2 Monitoring Equipment

2.2.1 Dissolved Oxygen and temperature Measuring Equipment

a) The instrument should be a portable, weatherproof dissolved oxygen measuring instrument complete with cable, sensor, comprehensive operation manuals, and use a DC power source. It should be capable of measuring:

- a dissolved oxygen level in the range of 0-20mg/L and 0-200% saturation; and,
- a temperature of 0-45 °C

b) It should have a membrane electrode with automatic temperature compensation complete with a cable. Sufficient stocks of spare electrodes and cables should be available for replacement where necessary.

2.2.2 Turbidity Measurement Instrument

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.

2.2.3 Suspended Solids

a) A water sampler should have a transparent PVC cylinder, with a capacity of not less then 2 L, and can be effectively sealed with latex cups at both ends. The sampler should be a positive latching system to keep it open and prevent premature closure until released by a messager when the sampler is at the selected water depth.

b) Water samples for suspended solids measurement should be collected in high density polythene bottles, packed in ice and delivered to the laboratory as soon as possible after collection.

2.2.4 Salinity

A portable salinometer capable of measuring salinity in the range of 0-40 g/L should be used for measuring salinity of the water at each monitoring location.

2.2.5 Water Depth Detector

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 handheld or affixed to the bottom of the work boat, if the same vessel is to be used throughout the monitoring program.

2.2.6 Location of Monitoring Site

A hand-held or boat-fixed type digital Global Positioning System (GPS) or other equivalent instrument of similar accuracy shall be provided and used during monitoring to ensure the monitoring vessel is at the correct location before taking measurements. After the positions are set out, locationing of boat can be by use of buoys or with reference to landmarks.

2.2.7 Ambient Temperature

A standard calibrated thermometer should be used for ambient temperature measurement. This thermometer is to be calibrated at 6 months intervals.

All in-situ monitoring instrument should be checked, calibrated and certified by HOKLAS accredited laboratory before use and subsequently re-calibrated at 3 months intervals throughout all stages of the water quality monitoring. 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.

The water quality monitoring equipments used for the project are listed in Table 2.2.

Table 2.2 Water Quality Monitoring Equipments

Equipment	Model	Parameters Measured	Calibration Frequency
Turbidity meter	HACH 2100P	Turbidity	3 months
Dissolved oxygen meter	YSI 58 with stirrer	Dissolved oxygen, Dissolved oxygen saturation and Water temperature	3 months
Echo sounder	Seafarer 901	Water depth	-
Water sampler	Kahlsico 3 litre with messenger	Water sampling	-
GPS receiver	Magellan 5000	Locating the monitoring boat	-
Buoys	-	Locating the monitoring boat	-
Thermometer	Standard calibrated thermometer	Ambient temperature	6 months
Salinity meter	YSI 30/33	Salinity	3 months

2.3 Monitoring Methodology

2.3.1 Fieldwork

Measurements are to be taken at 3 water depths, namely 1 m below water surface, mid-water and 1 m above seabed at both mid-flood and mid-ebb tides, except where the water depth is less than 6 m, the mid-depth station may be omitted. Should the water depth be less than 3 m, only mid-depth will be monitored. The Environmental Team should agree with the Engineer on all the monitoring stations.

Two measurements of turbidity, DO, DOS and temperature at each depth of each station are to be taken. The probes must be removed from water after the first measurement and then redeployed for the second measurement. If there is a significant difference between the first and second measurements, the readings should be discarded and further measurements should be made. One sample of suspended solids measurement should be taken at each depth and at each water quality monitoring/control station. Only if the preceding turbidity field tests show a marked difference between the two corresponding samples, duplicate samples for suspended solid measurement would be commenced. The samples should be kept in chilled condition during delivery to laboratory and before commencement of the analysis. For the purpose of evaluating the water quality, all values for SS and turbidity should be depth-averaged.

Water samples for the additional parameters are to be taken at 3 water depths at each location and a composite sample will be formed

from the samples at three different depths in equal proportions. Measurement of the additional parameters will be conducted on the composite samples.

2.3.2 Laboratory Measurement/ Analysis

Suspended solids (SS)

Analysis of suspended solids should be carried out in a HOKLAS accredited laboratory. Water samples of about 1 litre should be collected at the monitoring stations for the laboratory SS determination. The SS determination work should start within 24 hours after collection of water samples.

Samples should be well mixed and filtered (with a vacuum of less than 381 mm of Hg) through pre-weighed Millipore matched pair filters (at < 5 mg/L) or pre-weighed Whatman GF/C filters (at > 5 mg/L). A Millipore or equivalent filtration assembly (with vacuum of less than 381 mm of Hg) should be used to filter the water samples. Particulates collected on the filter papers should be dried in a drying oven at 103°C until a constant weight is reached and cooled to room temperature in a dessicator prior to weighing. An accurate electronic balance should be used to attain a precision level of 0.1 mg.

Total Phosphorus

Total phosphorus in sample is determined colorimetrically by ascorbic acid method.

Total Kjeldahl Nitrogen (TKN)

Sample is digested with mercuric sulphate and sulphuric acid mixture followed by distillation. Ammonia is trapped and determined by colorimetric method using salicylate reagent.

Ammoniacal Nitrogen (NH_3-N)

Ammonia in sample reacts with reagent added. Color complex formed is determined colorimetrically by spectrophotometer.

Biochemical Oxygen Demand (BOD_5)

The biochemical oxygen demand of a water sample is determined through measurement by dissolved oxygen meter (YSI model 58) before and after sample incubation at 20°C for five days.

Total Zn, µg/L level

A homogenized sample is digested and filtered. The filtrate is analyzed for zinc content by atomic absorption spectrophotometry with graphite tube atomizer.

2.4 Monitoring Locations

Four monitoring stations and two control stations are designated for Lo Tik Wan and five monitoring with two control stations are sited for Cheung Sha Wan. At Sok Kwu Wan FCZ, eight monitoring stations and two control stations are designated, as shown in Figures 2.4a-2.4c. Coordinates of the monitoring stations and control stations are shown in Table 2.4.

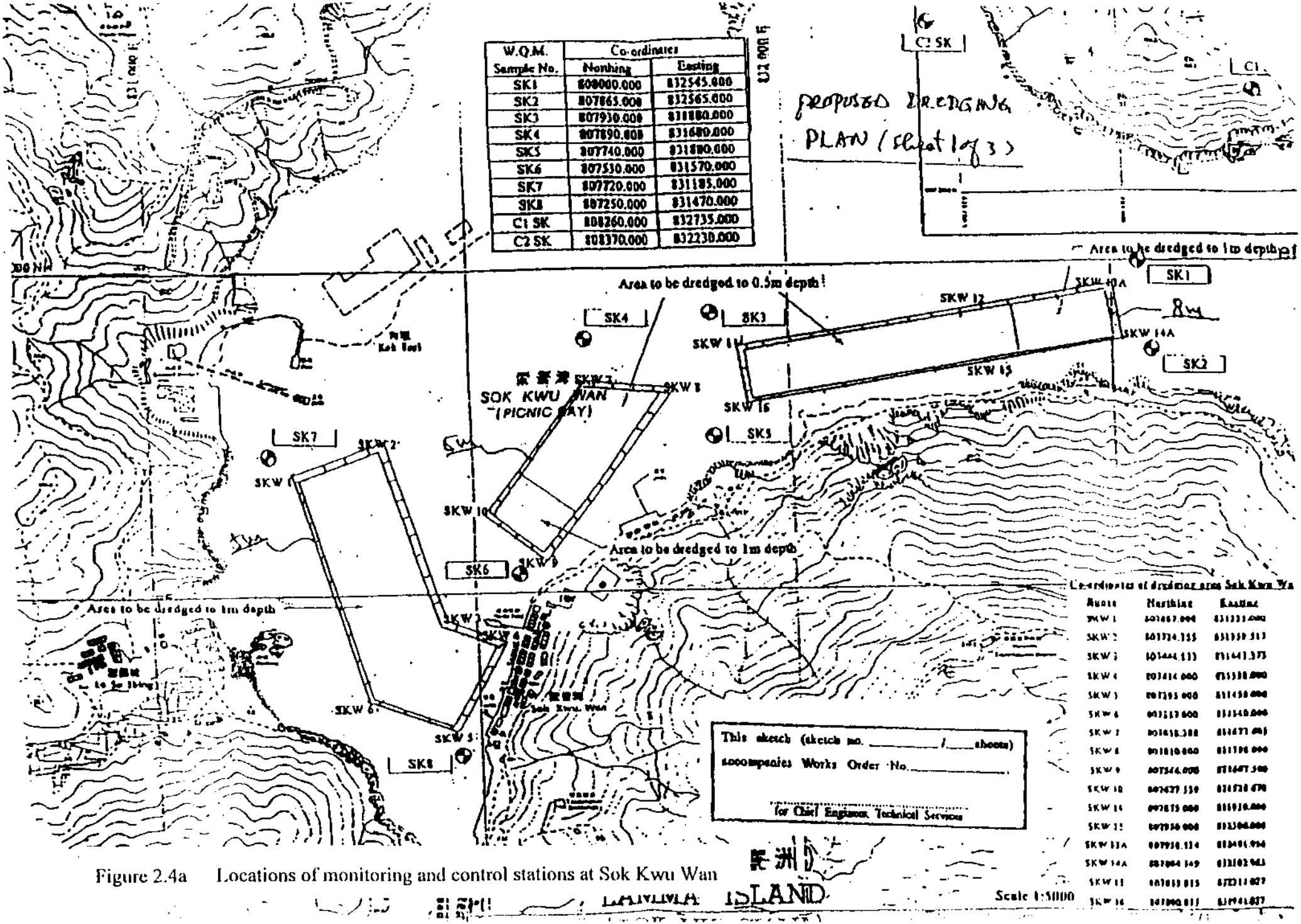


Figure 2.4a Locations of monitoring and control stations at Sok Kwu Wan

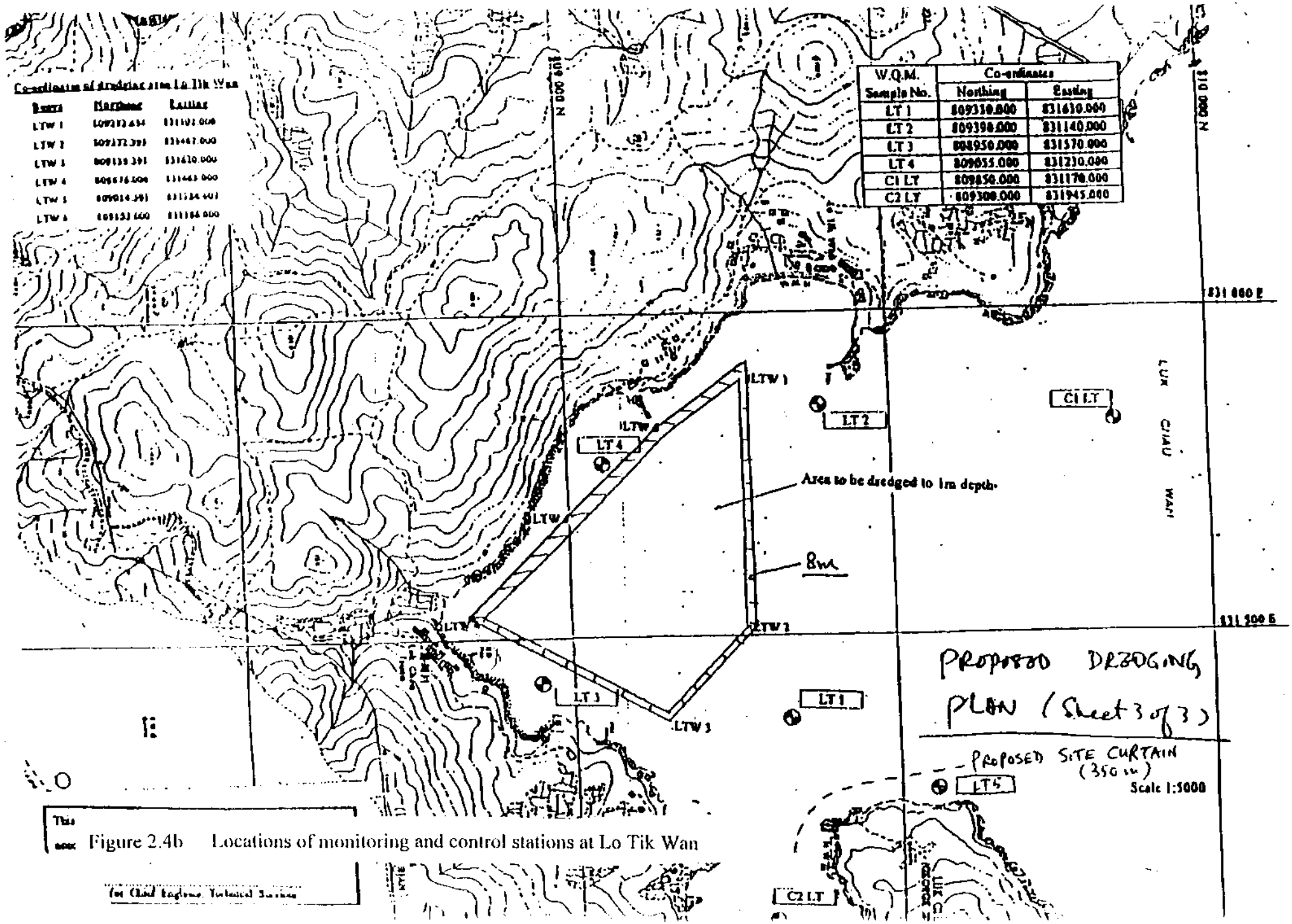


Figure 2.4b Locations of monitoring and control stations at Lo Tik Wan

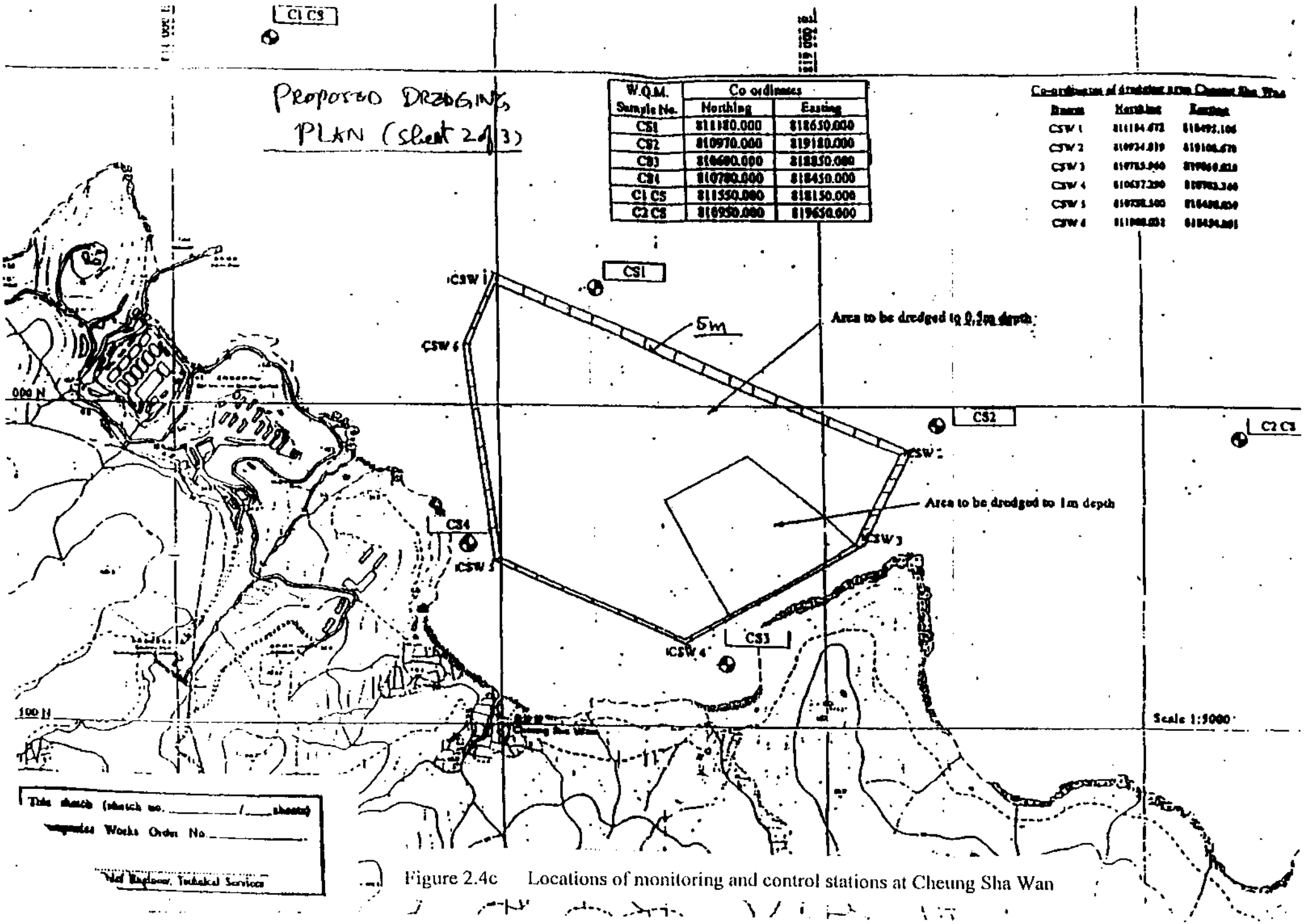


Figure 2.4c Locations of monitoring and control stations at Cheung Sha Wan

Table 2.4 Coordinates of Monitoring and Control Stations

Station No	Coordinates	
	Northing	Easting
Lok Tik Wan FCZ		
Monitoring Stations		
LT1	809330	831630
LT2	809390	831140
LT3	808950	831570
LT4	809055	831230
LT5	Exact location will be determined on site after the installation of the site curtain near Luk Chau	
Control Stations		
C1LT	809850	831170
C2LT	809300	831945
Cheung Sha Wan		
Monitoring Stations		
CS1	811180	818650
CS2	810970	819180
CS3	810600	818850
CS4	810780	818450
Control Stations		
C1Cs	811550	818150
C2Cs	810950	819650
Sok Kwu Wan		
Monitoring Stations		
SK1	808000	832545
SK2	807865	832565
SK3	807930	831880
SK4	807890	831680
SK5	807740	831880
SK6	807530	831570
SK7	807720	831185
SK8	807250	831470
Control Stations		
C1SK	808260	832735
C2SK	808370	832230

2.5 Monitoring Regime

2.5.1 Monitoring Stations

During the monitoring period (Baseline, Impact and Post-Project monitorings), all general parameters including suspended solids, dissolved oxygen, turbidity, salinity and water temperature are to be monitored. Additional water quality parameters, including Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), Ammoniacal Nitrogen (NH_3-N), BOD_5 and Zinc (Zn, only for Sok Kwu Wan Area 1 & 2) are to be monitored at the same number of stations.

The overall monitoring regime is shown in Table 2.5.

Table 2.5 Montoring Regime

Location	Activities	1st Month	2nd Month	3rd Month	4th Month	5th Month
Cheung	WQM (Baseline)					
Sha Wan	WQM (Impact)					
	WQM (Post-project)					
	Execution of Works					
Lo Tik	WQM (Baseline)					
Wan	WQM (Impact)					
	WQM (Post-project)					
	Execution of Works					
Sok	WQM (Baseline)					
Kwu	WQM (Impact)					
Wan	WQM (Post-project)					
	Execution of Works				2 dredgers	

2.5.2 Baseline Monitoring

Baseline conditions for the various water quality parameters are to be established. The baseline conditions should be established by measuring the parameters specified in Section 2.5.1 at all designated stations, 3 days per week, at mid-flood and mid-ebb tides, for four consecutive weeks prior to the commencement of marine works. By using the results from baseline monitoring, the AL levels are to be formulated and submitted to DEP through the Engineer for approval prior to commencement of marine works.

2.5.3 Impact Monitoring

General parameters

During the course of the works, monitoring frequency of all the general parameters (DO, SS & Turbidity) should be three days per week, with sampling/ measurement at all designated monitoring stations specified in Section 2.5.1. The interval between two each series (mid-ebb and mid-flood) of sampling/ measurement should normally be not less than 36 hours except there are exceedances of Action and/or Limit levels in which the monitoring frequency will be increased according to the Action/ Event Plan.

Additional parameters

During the impact monitoring period, the sampling of marine water for determination of the additional parameters (Total P, TKN, NH_3-N, BOD_5 and Zn) is to be carried out once per week at both mid-flood and mib-ebb tides at all the stations.

Should the monitoring results of the water quality parameters at any designated monitoring stations indicate that the AL levels are not complied with, immediate actions should be taken in accordance with the Action/Event Plan.

2.5.4 Post Project Monitoring

Upon completion of all the maintenance dredging, the post project monitoring for all general parameters is to be conducted for a continuous period of four weeks in the same manner as described in Impact Monitoring at all designated stations specified in Section 2.5.1.

2.6 Action and Limit Levels

The Action and Limit (AL) levels are to be formulated based on the baseline monitoring data. A framework of AL levels is illustrated in Table 2.6.

Table 2.6 Action and Limit Levels (Baseline and Control Stations Approach)

Parameters	Action	Limit
DO in mg/L (Surface, Middle & Bottom)	Surface & Middle 5%-ile of baseline data for surface and middle layer. Bottom 5%-ile of baseline data for bottom layer.	Surface & Middle 4mg/L except 5mg/L for FCZ or 1%-ile of baseline data for surface and middle layer Bottom 2mg/L or 1%-ile of baseline data for bottom layer
SS in mg/L (depth-averaged)	95%-ile of baseline data or 120% of upstream control station's SS at the same tide of the same day.	99%-ile of baseline or 130% of upstream control station's SS at the same tide of the same day and specific sensitive receiver water quality requirements.
Turbidity (Tby) in NTU (depth-averaged)	95%-ile of baseline data or 120% of upstream control station's Tby at the same tide of the same day.	99%-ile of baseline or 130% of upstream control station's Tby at the same tide of the same day

Notes:

- For DO, non-compliance of the water quality limits occurs when monitoring result is lower than the limits.
- For SS and Tby, non-compliance of the water quality limits occurs when monitoring result is higher than the limits.

2.7 Action/ Event Plan

Should the monitoring results of the water quality parameters at any designated monitoring stations indicate that the water quality criteria are not compiled with, the actions in accordance with the Action Plan in Table 2.7 are to be carried out.

Table 2.7 Action/Event Plan

Event	Environmental Team (ET)	Engineer (ER)	Contractor
Action level being exceeded by one sampling day	• Repeat in-situ measurement to confirm findings; • Identify source(s) of impact; • Inform EPD and Contractor; • Check monitoring data, all plant, equipment and Contractor's working methods; • Discuss mitigation measures with ER and Contractor; • Repeat measurement on next day of exceedance.	• Discuss with ET and Contractor on the proposed mitigation; • Make agreement on the mitigation measures to be implemented; • Assess the effectiveness of the implemented mitigation measures.	• Inform the ER and confirm notification of the non-compliance in writing; • Rectify unacceptable practice; • Check all plant and equipment; • Consider changes of working methods; • Discuss with ET and ER and propose mitigation measures to ER; • Implement the agreed mitigation measures.
Action level being exceeded by more than one consecutive sampling days	• Repeat in-situ measurement to confirm findings; • Identify source(s) of impact; • Inform EPD and Contractor; • Check monitoring data, all plant, equipment and Contractor's working methods; • Discuss mitigation measures with ER and Contractor; • Ensure mitigation measures are implemented; • Prepare to increase the monitoring frequency to daily; • Repeat measurement on next day of exceedance.	• Discuss with ET and Contractor on the proposed mitigation; • Make agreement on the mitigation measures to be implemented; • Assess the effectiveness of the implemented mitigation measures.	• Inform the ER and confirm notification of the non-compliance in writing; • Rectify unacceptable practice; • Check all plant and equipment; • Consider changes of working methods; • Discuss with ET and ER and propose mitigation measures to ER within 3 working days; • Implement the agreed mitigation measures.
Limit level being exceeded by one sampling day	• Repeat in-situ measurement to confirm findings; • Identify source(s) of impact; • Inform EPD and Contractor; • Check monitoring data, all plant, equipment and Contractor's working methods; • Discuss mitigation measures with ER and Contractor; • Ensure mitigation measures are implemented; • Increase the monitoring frequency to daily until no exceedance of Limit level.	• Discuss with ET and Contractor on the proposed mitigation; • Request Contractor to critically review the working methods; • Make agreement on the mitigation measures to be implemented; • Assess the effectiveness of the implemented mitigation measures.	• Inform the ER and confirm notification of the non-compliance in writing; • Rectify unacceptable practice; • Check all plant and equipment; • Consider changes of working methods; • Discuss with ET and ER and propose mitigation measures to ER within 3 working days; • Implement the agreed mitigation measures.
Limit level being exceeded by more than one consecutive sampling days	• Repeat in-situ measurement to confirm findings; • Identify source(s) of impact; • Inform EPD and Contractor; • Check monitoring data, all plant, equipment and Contractor's working methods; • Discuss mitigation measures with ER and Contractor; • Ensure mitigation measures are implemented; • Increase the monitoring frequency to daily until no exceedance of Limit level. for two consecutive days.	• Discuss with ET and Contractor on the proposed mitigation; • Request Contractor to critically review the working methods; • Make agreement on the mitigation measures to be implemented; • Assess the effectiveness of the implemented mitigation measures; • Consider and instruct, if necessary, the Contractor to slow down or to stop all or part of the marine work until no exceedance of Limit level.	• Inform the ER and confirm notification of the non-compliance in writing; • Rectify unacceptable practice; • Check all plant and equipment; • Consider changes of working methods; • Discuss with ET and ER and propose mitigation measures to ER within 3 working days; • Implement the agreed mitigation measures; • As directed by the Engineer, to slow down or to stop all or part of the marine work or construction activities.

2.8 Mitigation Measures

The Project Environmental Assessment has recommended water quality control and mitigation measures. The Contractor is to be responsible for the design and implementation of these measures.

2.8.1 Water Quality

The Contractor should minimize the risk of sediments or other pollutants being released into the water column and deposited in the seabed other than designated locations.

Pollution avoidance measures shall include but not be limited to the followings:

- Mechanical grabs shall be designed and maintained to avoid spillage and innovatively seal tightly while being lifted;
- All vessels shall be sized such that adequate clearance is maintained between vessels and the seabed 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 are to be repaired promptly and plant is not to be operated with leaking pipes;
- Marine works shall cause no visible foam, oil, grease, scum, litter or other objectionable matter to be present on the water within the Site or dumping grounds;
- Barges and grab dredgers shall be fitted with thigh-fitting seals to their bottom openings to prevent leakage of material;
- Excess material shall be cleaned from the decks and exposed fittings of barges and grab dredgers before the vessel is moved;
- Loading of barges and grabs shall be controlled to prevent splashing of dredged material into the surrounding water, and barges or grabs shall not be filled to a level that will cause overflowing of material or polluted water during loading or transportation; and,
- Adequate freeboard shall be maintained on barges to ensure that decks are not washed by wave action.

If the above measures are not sufficient to restore the water quality to acceptable levels, upon the advice of the Environmental Team, the Contractor, after liaison with the Environmental Team, is to propose other mitigation measures to the Engineer for approval, and carry out the mitigation measures.

2.8.2 Coral Communities

Silt curtains will be installed to minimise the impact to the coral communities at Luk Chau. Water quality will also be monitored near to the coral community to ensure there is no exceedance of the water quality parameters.

3. Reporting

The Environmental Team is to prepare and submit Baseline Monitoring Report, First Monthly EM & A Report, Subsequent Monthly EM & A Report and Final EM & A Summary Report to DEP for comment via the Engineer.

The ET Leader will prepare and submit a Baseline Environmental Monitoring Report with 10 days of completion of the baseline monitoring. Copies of the Baseline Environmental Monitoring Report will be submitted to each of the three parties: the Contractor, the ER and The EPD. The ET Leader shall liaise with the relevant parties on the exact number of copies they want. The form and content of the report, and the representation of baseline monitoring data will be in a format to the satisfaction of EPD and include, but not be limited to the following:

a) up to half a page executive summary;

b) brief project background information;

c) drawings showing locations of the baseline monitoring stations;

d) an updated construction programme with milestones of environmental protection/mitigation activities annotated;

e) monitoring results (in both hard and diskette copies) together with the following information:
   - monitoring methodology;
   - name of laboratory and types of equipment used and calibration details;
   - parameters monitored;
   - monitoring locations (and depth);
   - monitoring date, time, frequency and duration;
   - QA/QC results and detection limits.

f) details on influencing factors, including:
   - major activities, if any, being carried out on the Site during the period;
   - weather conditions during the period;
   - other factors which might affect the results.

g) determination of the Action and Limit Levels (AL levels) for each monitoring parameter and statistical analysis of the baseline data, the analysis shall conclude if there is any significant difference between control and impact stations for parameters monitored;

h) revisions for inclusion in the EM&A Manual; and

i) comments and conclusions.

EM&A Reports

The results and findings of all EM&A work required in the Manual shall be recorded in the monthly EM&A reports prepared by the ET Leader. The EM&A report shall be prepared by A/ER and submitted within 10 working days of the end of each reporting months, with the first report due in the month after construction commences. A maximum of 4 copies of each monthly EM&A report shall be submitted to each of the three parties: the Contractor, the ER and the EPD. Before submission of the first EM&A report, the ET Leader shall liaise with the parties on the exact number of copies and format of the monthly reports in both hard copy and electronic medium requirement.

First Monthly EM&A Report

The first monthly EM&A report shall include at least but not be limited to the following:

a) Executive Summary (1-2 pages)
   - Breaches of AL levels;
   - Complaint Log
   - Notifications of any summons and successful prosecution;
   - Reporting Changes;
   - Future key issues.

b) Basic Project Information
   - Project organisation including key personnel contact names and telephone numbers;
   - Construction Programme with fine tuning of construction activities showing the interrelationship with environmental protection/ mitigation measures for the month;
   - Management structure; and
   - Works undertaken during the month.

c) Environmental Status
   - Works undertaking during the month with illustrations (such as location of works, daily dredging rates); and
   - Drawing showing the project area, any environmental sensitive receivers and the locations of the monitoring and control stations.

d) Summary of EM&A requirements

   - all monitoring parameters;
   - Environmental quality performance limits (Action and Limit levels);
   - Event-Action Plans;
   - Environmental mitigation measures, as recommended in the project EIA study final report;

- Environmental requirements in contract documents.

e) Implication Status

Advice on the implementation status of environmental protection and pollution control/mitigation measures including measures for ecological and visual impacts, as recommended in the project profile, summarized in the implementation schedule.

f) Monitoring results

To provide monitoring results (in both hard and diskette copies) together with the following information:

- monitoring methodology;
- name of laboratory and types of equipment used and calibration details;
- parameters monitored;
- monitoring locations (and depth);
- monitoring date, time, frequency and duration;
- Weather conditions during the period;
- graphical plots of the monitoring parameters in the month annotated against;
- the major activities being carried out on site during the period;
- weather conditions that may affect the results;
- any other factors which might affect the monitoring results; and
- QA/QC results and detection limits.

g) Report on Non-compliance, Complaints, Notifications of Summons and Successful Prosecutions

- record of all non-compliance (exceedances) of the environmental quality performance limits (Action and Limit levels);
- record of all complaints received (written or verbal) for each media, including locations and nature of complaints investigation, liaison and consultation undertaken, actions and follow-up procedure taken, results and summary;
- record of all notifications of summons and successful prosecutions for breaches of the current environmental protection/pollution control legislations, including locations and nature of the breaches, investigation, follow-up actions taken, results and summary;
- review of the reasons for and the implications of non-compliance, complaints, summons and prosecutions including review of pollution sources and working procedures; and
- description of the actions taken in the event of noncompliance and deficiency reporting and any follow-up procedures related to earlier noncompliance.

h) Others

- an account of the future key issues as reviewed from the works programme and work method statements;
- advice on the solid and liquid waste management status; and
- submission of implementation status proforma, proactive environmental protection proforma, regulatory compliance proforma, site inspection proforma, data recovery schedule and complaint log summarizing the EM&A of the period.

Subsequent Monthly EM&A Reports

The subsequent monthly EM&A reports shall include the following:

a) Executive Summary (1-2 pages)

- Breaches of AL levels;
- Complaint Log
- Notifications of any summons and successful prosecution;
- Reporting Changes;
- Future key issues.

b) Environmental Status

- Construction Programme with the fine tuning of construction activities showing the inter-relationship with environmental protection/mitigation measures for the month;
- Works undertaken during the month with illustrations including key personnel contact names and telephone numbers; and
- Drawing showing the project area, any environmental sensitive receivers and the locations of the monitoring and control stations.

c) Implementation Status

Advice on the implementation status of environmental protection and pollution control/mitigation measures including measures for ecological and visual impacts, as recommended in the project profile, summarized in the implementation schedule.

d) Monitoring results

To provide monitoring results (in both hard and diskette copies) together with the following information:

- monitoring methodology;
- name of laboratory and types of equipment used and calibration details;
- parameters monitored;

- monitoring locations (and depth);
- monitoring date, time, frequency and duration;
- Weather conditions during the period;
- graphical plots of the monitoring parameters in the month annotated against;
- the major activities being carried out on site during the period;
- weather conditions that may affect the results;
- any other factors which might affect the monitoring results; and
- QA/QC results and detection limits.

e) Report on Non-compliance, Complaints, Notifications of Summons and Successful Prosecutions

- record of all non-compliance (exceedances) of the environmental quality performance limits (Action and Limit levels);
- record of all complaints received (written or verbal) for each media, including locations and nature of complaints investigation, liaison and consultation undertaken, actions and follow-up procedure taken, results and summary;
- record of all notifications of summons and successful prosecutions for breaches of the current environmental protection/pollution control legislations, including locations and nature of the breaches, investigation, follow-up actions taken, results and summary;
- review of the reasons for and the implications of non-compliance, complaints, summons and prosecutions including review of pollution sources and working procedures; and
- description of the actions taken in the event of noncompliance and deficiency reporting and any follow-up procedures related to earlier noncompliance.

f) Others

- an account of the future key issues as reviewed from the works programme and work method statements; and
- advice on the solid and liquid waste management status.

g) Appendix

- AL levels;
- Graphical plots of trends of monitored parameters at key stations over the past four reporting periods for representative monitoring stations annotated against the following:

I. major activities being carried out on Site during the period;
II. weather conditions during the period; and
III. any other factors which might affect the monitoring results

- Monitoring schedule for the present and next reporting period

- Cumulative statistics on complaints, notifications of summons and successful prosecutions
- Outstanding issues and deficiencies

Final EM&A Summary Report

The termination of EM&A programme shall be determined on the following basis:

a) completion of construction activities and insignificant environmental impacts of the remaining outstanding construction works;
b) trends analysis to demonstrate the narrow down of monitoring exceedances due to construction activities and the return of ambient environmental conditions in comparison with baseline data; and
c) no environmental complaint and prosecution involved.

The proposed termination may be required to consult related local community such as village representative/committee and/or District Board and the proposal should be endorsed by the A/ER and the project proponent prior to final approval from the Director of Environmental Protection.

The final EM&A summary report shall include, inter alia, the following:

a) an executive summary;

b) basic project information including a synopsis of the project organisation, programme, contacts of key management, and a synopsis of work undertaken during the entire construction period;

c) a brief summary of EM&A requirements including:
    - monitoring parameters;
    - environmental quality performance limits (Action and Limit levels); and
    - environmental mitigation measures, as recommended in the project profile.

d) advice on the implementation status of environmental protection and pollution control/mitigation measures, as recommended in the project profile, summarised in the updated implementation status proformas;

e) drawings showing the project area, any environmental sensitive receivers and the locations of the monitoring and control stations;

f) graphical plots of the trends of monitored parameters over the construction period for representative monitoring stations annotated against:

    - the major activities being carried out on Site during the period;

- weather conditions during the period;
- any other factors which might affect the monitoring results: and
- the return of ambient environmental conditions in comparison with baseline data.

g) compare and contrast the EM&A data with the project profile predictions and annotate with explanation for any discrepancies;

h) provide clear-cut decisions on the environmental acceptability of the project with reference to the specific impact hypothesis;

i) a summary of noncompliance (exceedances) of the environmental quality performance limits (Action and Limit levels);

j) a brief review of the reasons for and the implications of non-compliance including review of pollution sources and working procedures;

k) a summary description of the actions taken in the event of non-compliance and any follow-up procedures related to earlier non-compliance;

l) a summary record of all complaints received (written or verbal) for each media, liaison and consultation undertaken, actions and follow-up procedures taken;

m) review the monitoring methodology adopted and with the benefit of hindsight, comment on its effectiveness (including cost effectiveness);

n) a summary record of notifications of summons and successful prosecutions for breaches of the current environmental protection/pollution control legislations, locations and nature of the breaches, investigation, follow-up actions taken and results;

o) review the practicality and effectiveness of the dredging process and EM&A programme (e.g. effectiveness and efficiency of the mitigation measures), recommend and improvement in the EM&A programme; and

p) a conclusion to state the return of ambient and/or the predicted scenario as per the project profile.