土木工程拓展署
Civil Engineering and Development Department

Agreement No. CE 63/2016 (EP)

Environmental Monitoring and Audit for Disposal Facility to the East of Sha Chau (2017-2020) – Investigation

Quarterly EM&A Report for Contaminated Mud Pits to the East of Sha Chau and the South of The Brothers – October to December 2019

Revision 0

February 2020

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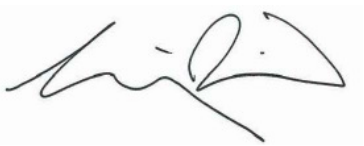
Client:	Project No:
Civil Engineering and Development Department (CEDD)	0400720
Summary: This document presents the Quarterly EM&A Report for *Environmental Monitoring and Audit for Disposal Facility to the East of Sha Chau and the South of The Brothers*.	Date: 17 February 2020 Approved by:  Craig A. Reid *Partner*

Revision	Description	By	Checked	Approved	Date
v0	Quarterly EM&A Report for ESC CMPs and SB CMPs	GS	RC	CAR	17/2/20

Distribution

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Dredging, Management and Capping of Contaminated Sediment Disposal Facility at Sha Chau

Environmental Certification Sheet
EP-312/2008/A

Reference Document/Plan

Document/~~Plan~~ to be ~~Certified~~/ Verified:	Quarterly EM&A Report for Contaminated Mud Pits to the East of Sha Chau – October to December 2019
Date of Report:	17 February 2020
Date prepared by ET:	17 February 2020
Date received by IA:	17 February 2020

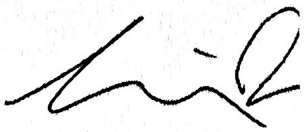
Reference EP Condition

Environmental Permit Condition:

Condition 3.1 of EP-312/2008/A
The EM&A programme shall be implemented in accordance with the procedures and requirements in the EM&A Manual. Any changes to the monitoring and audit requirements shall be justified by the ET leader and verified by the Independent Auditor as conforming to the requirements set out in the EM&A Manual, and shall seek the prior approval from the Director before implementation.

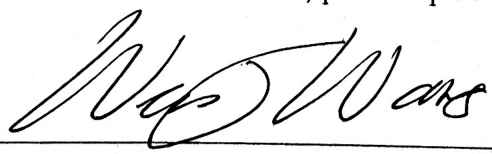
ET Certification

I hereby certify that the above referenced document/~~plan~~ complies with the above referenced condition of EP-312/2008/A.

Craig A. Reid,
Environmental Team Leader:  Date: 17/2/2020

IA Verification

I hereby verify that the above referenced document/~~plan~~ complies with the above referenced condition of EP-312/2008/A.

Dr Wang Wen Xiong,
Independent Auditor:  Date: 17/2/2020

CONTENTS

Agreement No. CE 63/2016 (EP)
Environmental Monitoring and Audit
for Disposal Facility to the East of Sha Chau (2017-2020) - Investigation

Quarterly Environmental Monitoring and Audit (EM&A) Report for October to December 2019

EXECUTIVE SUMMARY

Impact Water Quality Monitoring during Dredging Operations, Water Column Profiling, Routine Water Quality Monitoring, Pit Specific Sediment Chemistry and *Cumulative Impact Sediment Chemistry* were carried out for the Contaminated Mud Pits (CMPs) to the East of Sha Chau (ESC) during the quarterly period of October to December 2019. This report presents the results of these monitoring activities to identify whether the dredging and disposal operations at ESC CMP V are causing any unacceptable impact(s) to the surrounding aquatic environment or to those marine organisms that utilize these habitats.

Water Quality Monitoring for ESC CMPs

Impact Water Quality Monitoring during Dredging Operations of ESC CMP Vb

Dredging activities for ESC CMP Vb were conducted between 11 November and 5 December 2019 and Impact Water Quality Monitoring during Dredging Operations for ESC CMP Vb was conducted three times per week during the reporting period between 11 November and 4 December 2019. Monitoring results showed that levels of DO, Turbidity and SS complied with the Action and Limit Levels at all stations. The results indicated that the dredging operations at ESC CMP Vb did not appear to cause any unacceptable deterioration in water quality during this quarterly period.

Water Column Profiling of ESC CMP Vd – October to December 2019

Results indicated that levels of Salinity, pH and Dissolved Oxygen (DO) complied with the Water Quality Objectives (WQOs) at both Upstream and Downstream stations. Levels of DO, Turbidity and Suspended Solids (SS) complied with the Action and Limit Levels at all stations. Overall, the results indicated that the mud disposal operation at ESC CMP Vd did not appear to cause any unacceptable impact in water quality during this quarterly period.

Routine Water Quality Monitoring of ESC CMPs – October and November 2019

Results of Routine Water Quality Monitoring conducted in October and November 2019 showed that levels of DO, Salinity and pH complied with the WQOs at all stations. Levels of DO, Turbidity and SS complied with the Action and Limit Levels at all stations.

From the monitoring results and statistical analysis, there were no trends indicating any increase in the concentrations of contaminants with proximity to the pit or with time. Thus, it appears that mud disposal operations at

CMP Vd have not caused any unacceptable impact in water quality during the reporting period.

Sediment Quality Monitoring for ESC CMPs

Pit Specific Sediment Chemistry of ESC CMP Vd – October to December 2019

Monitoring results showed that the concentrations of inorganic contaminants were generally below the Lower Chemical Exceedance Levels (LCELs) at most monitoring stations. Statistical analysis indicated that there did not appear any trend of increasing sediment contaminants' concentrations with proximity to the pit or with time. Thus, it appears that mud disposal operation at ESC CMP Vd have not caused any unacceptable impact in sediment quality during the reporting period.

Cumulative Impact Sediment Chemistry of ESC CMPs – December 2019

Monitoring results showed that the concentrations of inorganic contaminants were generally below the LCELs at all monitoring stations. Statistical analysis indicated that there did not appear to be any significant trend of increasing concentrations of contaminants with proximity to the pit or with time. Thus, it is considered that mud disposal operations at ESC CMP Vd have not caused any unacceptable impact in sediment quality during the reporting period.

合約編號 第CE 63/2016（EP）號

沙洲以東海泥卸置設施的環境監察及審核（2017–2020）–勘查研究

環境監察及審核季度報告（二零一九年十月至十二月）

行政摘要

在2019年10月至12月的季度報告期內，環境小組在沙洲以東海泥卸置設施進行了挖掘期間水質監察、水層質量監察、例行水質監察、指定污泥坑沉積物化學監察及沉積物化學累積性影響監察。本報告詳述以上的環境監察結果，從而分析在沙洲以東海泥卸置設施CMP V的挖掘及卸置作業有否對鄰近水體環境及利用這水體為棲身地的海洋生物造成不可接受的環境影響。

沙洲以東海泥卸置設施 (ESC CMPs)之水質監察

沙洲以東海泥卸置設施(ESC CMP Vb)挖掘期間水質監察

沙洲以東海泥卸置設施(ESC CMP Vb)的挖掘活動在2019年11月11日至12月5日期間進行，而水質監察則在11月11日至12月4日期間每星期進行3次。監察結果顯示，所有監測站的溶解氧含量、混濁度及懸浮固體含量也符合行動及極限水平。總體而言，沒有證據顯示在報告期內沙洲以東海泥挖掘活動對周邊水體環境產生任何不可接受的水質影響。

水層質量監察–2019年10月至12月

監察結果顯示上游及下游監測站的鹽度、酸鹼值及溶解氧含量均符合海水水質指標。上游及下游監測站的溶解氧含量、混濁度及懸浮固體含量也符合行動及極限水平。總體而言，水層質量監察結果表明報告期內沙洲以東海泥卸置設施CMP Vd的污泥卸置活動沒有引致任何不可接受的水質影響。

例行水質監察 –2019年10月和11月

2019年10月和11月的例行水質監察結果顯示受影響監測站、中距離監測站及參考監測站的溶解氧含量、鹽度及酸鹼值均符合海水水質指標。所有監測站的溶解氧含量、混濁度及懸浮固體含量也符合行動及極限水平。從監察數據和統計結果顯示，海水的污染物濃度沒有因越接近泥坑而趨向增加，亦沒有隨著時間而增加。總體而言，沒有證據顯示在報告期內沙洲以東海泥卸置運作對周邊水體環境產生任何不可接受的水質影響。

沙洲以東海泥卸置設施 (ESC CMPs)之沉積物監察

指定污泥坑沉積物化學監察–2019年10月至12月

監察結果顯示，大部分監測站的無機污染物含量均大致低於化學物質低量值。從統計結果顯示，沉積物的污染物濃度沒有因越接近泥坑而趨向增加，亦沒有隨著時間而增加。總體而言，沒有證據顯示在報告期內沙洲以東海泥卸置運作對沉積物質素造成任何不可接受的影響。

沉積物化學累積性影響監察–2019年12月

監察結果顯示，所有監測站的無機污染物含量均大致低於化學物質低量值。從統計結果顯示，沉積物的污染物濃度沒有因越接近泥坑而趨向增加，亦沒有隨著時間而增加。總體而言，沒有證據顯示在報告期內沙洲以東海泥卸置運作對沉積物質素造成任何不可接受的影響。

1 INTRODUCTION

1.1 PROJECT DESCRIPTION

1.1.1 The Civil Engineering and Development Department (CEDD) is managing a number of marine disposal facilities in Hong Kong waters, including the Contaminated Mud Pits (CMPs) to the South of The Brothers (SB) and to the East of Sha Chau (ESC) for the disposal of contaminated sediment, and open-sea disposal grounds located to the South of Cheung Chau (SCC), East of Tung Lung Chau (ETLC) and East of Ninepins (ENP) for the disposal of uncontaminated sediment. Two Environmental Permits (EPs), EP-312/2008/A and EP-427/2011/A, were issued by the Environmental Protection Department (EPD) to the CEDD, the Permit Holder, on 28 November 2008 and 23 December 2011 for the Dredging, Management and Capping of Contaminated Sediment Disposal Facilities at ESC CMP V and SB CMPs, respectively.

1.1.2 Under the requirements of the two EPs for ESC CMP V and SB CMPs, Environmental Monitoring and Audit (EM&A) programmes which encompass water and sediment chemistry, fisheries assessment, tissue and whole body analysis, sediment toxicity and benthic recolonisation studies as set out in the EM&A Manuals are required to be implemented. EM&A programmes have been continuously carried out during the operation of the CMPs at ESC and SB. A review of the collection and analysis of such environmental data from the monitoring programme demonstrated that there had not been any adverse environmental impacts resulting from disposal activities [1][2]. The current programme will assess the impacts resulting from dredging, disposal and capping operations of CMP V as well as capping operations of SB CMPs.

1.1.3 The present EM&A programme under *Agreement No. CE 63/2016 (EP)* ("the Study") covers the dredging, disposal and capping operations of the ESC CMP V as well as the capping operations of the SB CMPs (see *Annex A* for the EM&A programme). The scheduled EM&A programme for SB CMPs was completed in December 2018.

1.2 ACTIVITIES CONDUCTED DURING THE REPORTING PERIOD

1.2.1 Detailed works schedule for ESC CMP V is shown in *Figure 1.1*. During the reporting period of October to December 2019, the following works were being undertaken at the CMPs:

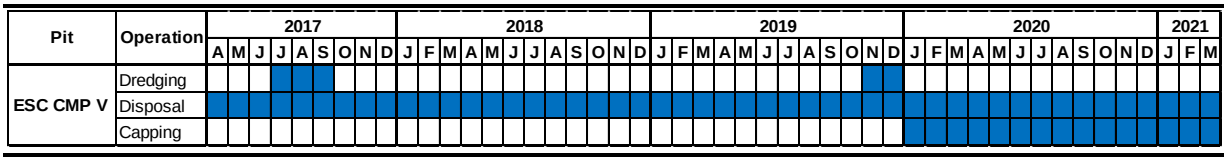
- Dredging of accumulated natural deposits at ESC CMP Vb; and

(1) ERM (2013). Environmental Monitoring and Audit for Contaminated Mud Pit V at East of Sha Chau. Final Report. For CEDD.

(2) ERM (2017). Environmental Monitoring and Audit for Contaminated Mud Pit V at East of Sha Chau (2012 - 2017). Final Report. For CEDD.

- Disposal of contaminated mud at ESC CMP Vd.

Figure 1.1 Works Schedule for ESC CMPs



1.2.2 The records for dredging of accumulated natural deposits at ESC CMP Vb and contaminated mud disposal at ESC CMP Vd during the reporting period are presented in *Annex B*.

1.3 OBJECTIVES OF THE MONITORING AND AUDIT PROGRAMME

1.3.1 The objectives of the EM&A programme are as follows:

1) To monitor and report on the environmental impacts of the dredging operations associated with the construction of the disposal pits;

2) To monitor and report on the environmental impacts due to capping operations of the exhausted pits;

3) To monitor and report on the environmental impacts of the disposal of contaminated marine sediments in the active pits and specifically to determine:

   a. changes/trends caused by disposal activities in the concentrations of contaminants in sediments adjacent to the pits;

   b. changes/trends caused by disposal activities in the toxicity of sediment adjacent to the pits;

   c. changes/trends caused by disposal activities in the concentrations of contaminants in tissues of demersal marine life adjacent to and remote from the pits;

   d. impacts on water quality and benthic ecology caused by the disposal activities; and

   e. the risks to human health and dolphin of eating seafood taken in the marine area around the active pits.

4) To monitor and report on the environmental impacts of the disposal operation and specifically to determine whether the methods of disposal are effective in reducing the risks of unacceptable environmental impacts.

5) To monitor and report on the benthic recolonisation of the capped pits and specifically to determine the difference in infauna between the capped pits and adjacent sites.

6) To assess the impact of a major storm (Typhoon Signal No. 8 or above) on the containment of any uncapped or partially capped pits.

7) To design and continually review the operation and monitoring programme and:

   a. to make recommendations for changes to the operation that will rectify any unacceptable environmental impacts; and

   b. to make recommendations for changes to the monitoring programme that will improve the ability to cost effectively detect environmental changes caused by the disposal activities.

8) To establish numerical decision criteria for defining impacts for each monitoring component.

9) To provide supervision on the field works and laboratory works to be carried out by contractors/laboratories.

1.3.2 The purpose of this *Quarterly EM&A Report for October to December 2019* is to provide information regarding the findings in the quarterly reporting period of October to December 2019 on the environmental impacts resulting from dredging operation at ESC CMP Vb and backfilling operation at ESC CMP Vd. Although the EM&A programme has been conducted since 1997, this report presents the analytical and statistical results of the quarterly reporting period. Results from previous monitoring will be presented and discussed in the Annual Review Report. Readers are referred to the *Monthly EM&A Reports* for this Study for graphical and tabular presentations of the monitoring results.

1.3.3 The objectives of this report are to:

- Confirm that all activities, tests, analyses, assessments etc. have been carried out as stated in the *EM&A Manual*; and,

- Report on any trend resulting from disposal, backfilling and capping operations at the CMPs.

2 ENVIRONMENTAL MONITORING & AUDITING PROGRAMME

2.1 ENVIRONMENTAL MONITORING & AUDITING TASKS

2.1.1 Six key elements were designed for the EM&A Programme for assessing whether key environmental parameters are being affected by dredging, backfilling and capping operations at CMPs. Key tasks are as follows:

- Sediment Quality Monitoring;
- Sediment Toxicity Testing;
- Trawling & Tissue/ Whole Body Contaminant Testing;
- Water Quality Monitoring;
- Human Health and Ecological Risk Assessment; and
- Benthic Recolonisation.

2.2 EM&A SAMPLING AND ANALYSES

2.2.1 Details regarding the methodologies for the field sampling and laboratory analyses of the monitoring tasks listed in *Section 2.1* are presented in the *EM&A Manuals* (1) as well as in *Contract No. CV/2017/04 (Sediment Disposal Facilities to the East of Sha Chau and East of Tung Lung Chau – Sampling (2018-2022))* and *Contract No. CV/2017/05 (Sediment Disposal Facilities to the East of Sha Chau and East of Tung Lung Chau – Testing (2018-2022)).* Lam Geotechnics Limited and Wellab Limited were responsible for sampling under *Contract No. CV/2017/04* and laboratory analyses under *Contract No. CV/2017/05*, respectively, during the quarterly period.

(1) ERM (2017). Updated EM&A Manual for ESC CMP V. Environmental Monitoring and Audit for Disposal Facility to the East of Sha Chau (2017-2020) – Investigation. Agreement No. CE 63/2016 (EP).

3 MONITORING & AUDITING RESULTS

3.1 OVERVIEW OF THE MONITORING & AUDITING ACTIVITIES

3.1.1 Sampling & Laboratory Analysis

3.1.2 Schedules of the EM&A programme are presented in *Annex A*. The samplings, *in-situ* measurements and analyses of samples were conducted in accordance with the *EM&A Manual* during this reporting period. The samplings conducted as well as the monitoring results received from the Contractors for this reporting period are shown in *Table 3.1*.

Table 3.1 Samplings Conducted and Monitoring Results Received from the Contractors for the Reporting Period of October to December 2019

Key Task	Date of Sampling & *in-situ* Measurement	Date of Results Received from the Contractors
ESC CMPs		
Impact Monitoring for Dredging of ESC CMP Vb	11, 13, 15, 18, 20, 22, 25, 27 & 29 November 2019 2 & 4 December 2019	6 December 2019 7 January 2020
Water Column Profiling of ESC CMP Vd	10 October 2019 6 November 2019 12 December 2019	31 October 2019 6 December 2019 31 December 2019
Routine Water Quality Monitoring of ESC CMPs	9 October 2019 7 November 2019	31 October 2019 6 December 2019
Pit Specific Sediment Chemistry of ESC CMP Vd	8 October 2019 5 November 2019 16 December 2019	31 October 2019 6 December 2019 31 December 2019
Cumulative Impact Sediment Chemistry of ESC CMPs	3 & 5 December 2019	7 January 2020

3.1.3 The monitoring results of the above environmental monitoring components for ESC CMPs have been presented in the respective *Monthly EM&A Reports* for this Study. The statistical analyses of these environmental monitoring components, where applicable, are presented in the following sections to report any trends caused by disposal activities at ESC CMPs during the reporting period. It should be noted that statistical analysis was not conducted for *Water Column Profiling for ESC CMP Vd* as the monitoring stations were mobile depending on the location of backfilling operation during the monitoring event. In addition, there was no action / limit level exceedances for the levels of Dissolved Oxygen (DO), Turbidity and Suspended Solids (SS) for the impact water quality monitoring during dredging operation of ESC CMP Vb conducted in November and December 2019 and thus there did not appear to have any unacceptable deterioration in water quality due to the dredging operation. As such, statistical analysis was not conducted for *Impact Monitoring for Dredging of ESC CMP Vb*.

3.2 SUMMARY OF MONITORING RESULTS AND STATISTICAL ANALYSES FOR ESC CMPS

3.2.1 *Impact Water Quality Monitoring during Dredging Operations of ESC CMP Vb*

3.2.2 Dredging activities for ESC CMP Vb were conducted between 11 November and 5 December 2019 and *Impact Water Quality Monitoring during Dredging Operations* for ESC CMP Vb was conducted three times per week during the reporting period between 11 November and 4 December 2019 as presented in *Table 3.1*. During each survey day, monitoring was conducted during both mid-ebb and mid-flood tides at two Reference (Upstream) stations and five Impact (Downstream) stations around the dredging operations at ESC CMP Vb. Monitoring was also conducted at one Sensitive Receiver station situated in Ma Wan. A total of eight (8) stations were monitored and locations of the sampling stations are shown in *Figure 3.1*. The dredged volume during the reporting period is detailed in *Table B1* of *Annex B*. The monitoring results indicated that levels of DO, Turbidity and SS complied with the Action and Limit Levels at all stations.

3.2.3 Overall, the results indicated that the dredging operations at ESC CMP Vb did not appear to cause any unacceptable deterioration in water quality during this quarterly period.

3.2.4 *Water Column Profiling of ESC CMP Vd*

3.2.5 *Water Column Profiling* for ESC CMP Vd was conducted once every month from October to December 2019 as presented in *Table 3.1*. A total of two (2) stations were sampled, one located 100 m Upstream and one located 100 m Downstream of the disposal area. The monitoring results indicated that levels of Salinity, pH and DO complied with the Water Quality Objectives (WQOs) at both Upstream and Downstream stations in October, November and December 2019. Levels of DO, Turbidity and SS also complied with the Action and Limit Levels at all stations during the quarterly period.

3.2.6 Overall, the results indicated that the mud disposal operation at ESC CMP Vd did not appear to cause any unacceptable deterioration in water quality during this quarterly period.

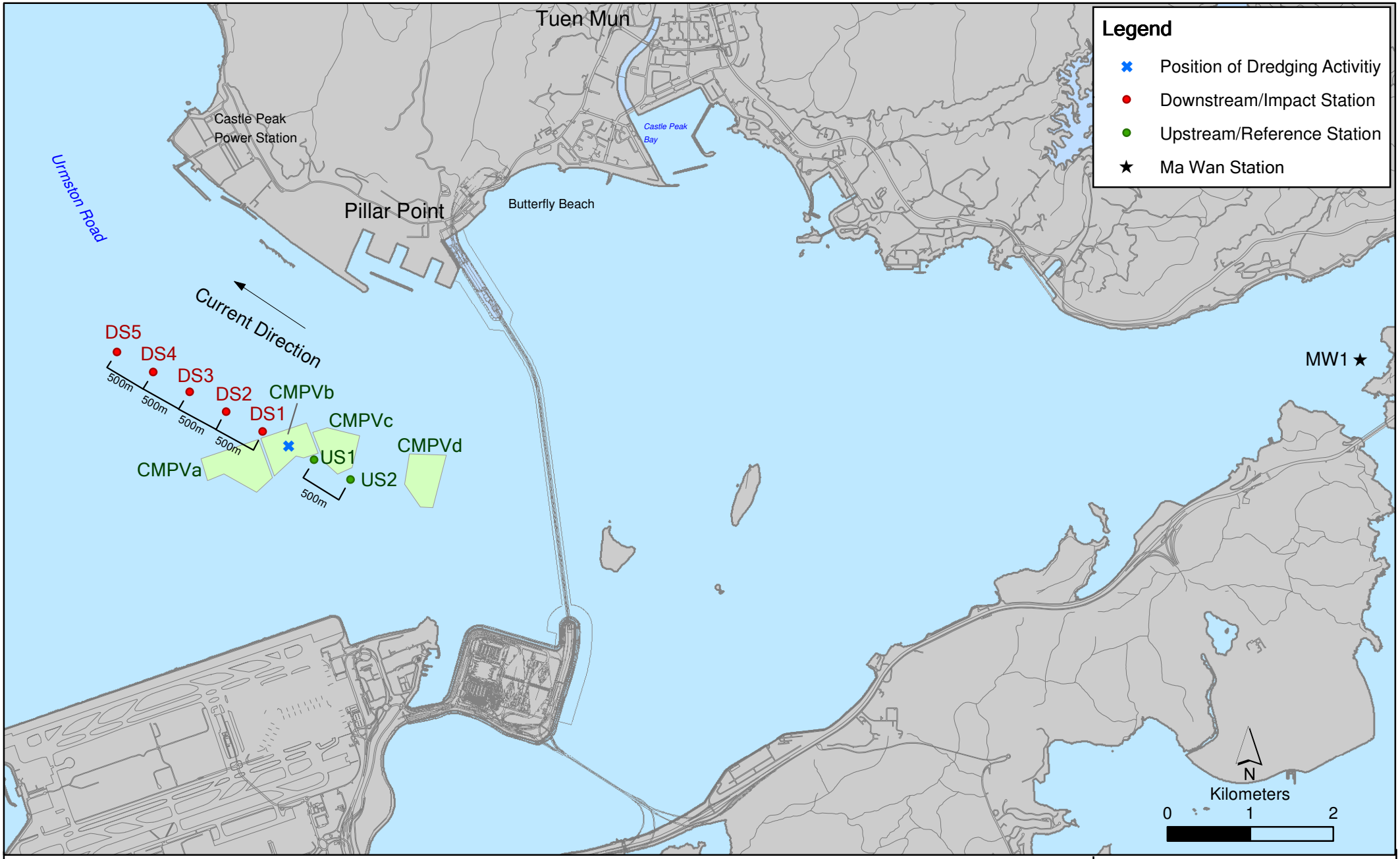


Figure 3.1

Indicative Dredging Impact Sampling Stations for CMPV

Note: The locations of sampling stations will be determined on site based on current direction and position of dredging activities.

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Date: 19/6/2017

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3.2.7 *Routine Water Quality Monitoring of ESC CMPs – October and November 2019*

Background

3.2.8 *Routine Water Quality Monitoring* for ESC CMPs was conducted in October and November 2019 as presented in *Table 3.1*. Sixteen (16) stations were sampled in October and November 2019, and locations of the monitoring stations are presented in *Figure 3.2*. The disposal volume during the reporting period is detailed in *Table B2* of *Annex B*. The monitoring results showed that levels of DO, Salinity and pH complied with the WQOs and the levels of DO, Turbidity and SS also complied with the Action and Limit Levels at all stations in October and November 2019.

Summary of Statistical Analyses

3.2.9 The aim of the statistical analysis is to reveal any trends of increasing concentration of contaminants with proximity to the pit or with time. Data obtained during this reporting period were statistically compared with data obtained since monitoring began at CMP V in February 2012. For most parameters, only low concentrations were measured from February 2012 to November 2019 and some parameters have majority of their recorded values below the limit of reporting. Statistical analysis was performed on parameters for which at least 60% of data were above the limit of reporting since monitoring of CMP V began in February 2012. Spatio-temporal differences in *in-situ* parameters, dissolved metal, inorganic and organic contaminant contents were then tested by three-factor partially-nested Analysis of Variance (ANOVA). Area, Period and Station were treated as fixed factors under investigation with Station nested within Area.

3.2.10 Should spatial or temporal trend of potential concern (i.e. increasing contaminant concentration with proximity to the pit or over time) be detected by ANOVA, linear regression analyses would be performed to examine the significance of the trend. Linear regression analysis makes assumptions of equal variance and normal distribution of data. Therefore, the significance level of the test was set at 1 % (i.e. $p = 0.01$) to reduce the chance of committing a Type 1 error. If a significant regression relationship was found between contaminant concentration and time (i.e. $p < 0.01$), r^2 value from the analysis would be further assessed. This value represents the proportion of the total variation in the dependent variable (i.e. contaminant concentration) that is accounted for by the fitted regression line and is referred to as the coefficient of determination. An r^2 value of 1 indicates a perfect relationship (or fit) whereas a value of 0 indicates that there is no relationship (or no fit) between the dependent and independent variables.

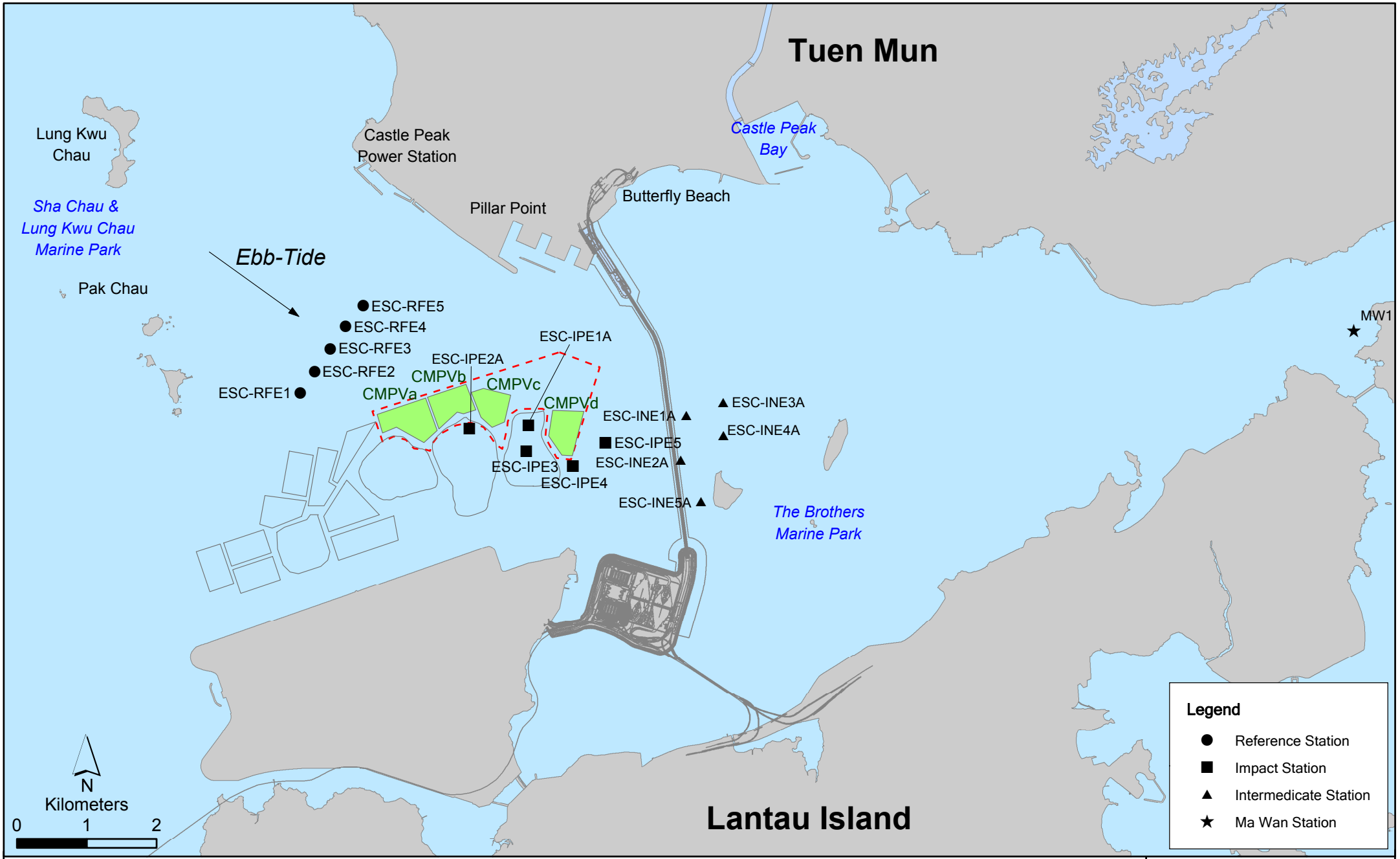

Figure 3.2

Routine & Capping Water Quality Sampling Stations (Ebb-Tide) for ESC CMPs

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Date: 19/4/2017

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3.2.11 As there are no specific criteria to indicate how meaningful an r^2 value is, for the purposes of this EM&A programme a value of 0.60 was adopted to indicate a meaningful regression. If $r^2 < 0.60$ then it was considered that there was a weak relationship between contaminant concentration and time or proximity to the pit, or none at all. If the regression analysis indicated $r^2 > 0.60$ then it had been interpreted that there was in fact a strong relationship between the dependent and independent variables (i.e. a strong temporal trend of increasing contaminant concentration with time or strong spatial trend of increasing contaminant concentration with proximity to the pit). Details regarding the statistical analyses results are presented in *Annex C*.

In-situ Measurement

Dissolved Oxygen (DO)

3.2.12 DO levels varied significantly with sampling periods and areas. There was no consistent spatial trend of decreasing concentrations of DO with proximity to the pit or consistent temporal trend of decreasing concentrations of DO over time. DO levels were the highest in February 2017 and were the lowest in July 2013, August 2016 and July 2019.

Turbidity

3.2.13 Turbidity levels varied significantly with sampling periods and areas. There was no consistent spatial trend of increasing concentrations of Turbidity with proximity to the pit or consistent temporal trend of increasing concentrations of Turbidity over time. Turbidity levels were the highest in November 2017 and were the lowest in February 2017.

Metals and Metalloid

3.2.14 The majority of dissolved metals had high percentage of their values below the limit of reporting (i.e. > 60% of values were below the limit of reporting during February 2012 to November 2019). Copper, Nickel and Zinc were the exceptions, and all varied significantly over area and time as indicated by results of the ANOVA tests (*Annex C*), but without any consistent spatial or temporal trends.

Inorganic Contaminants

Ammonia Nitrogen (NH_3-N)

3.2.15 NH_3-N concentrations varied significantly with sampling periods and areas. There was no consistent spatial trend of increasing concentrations of NH_3-N with proximity to the pit or consistent temporal trend of increasing concentrations of NH_3-N over time.

Total Inorganic Nitrogen (TIN)

3.2.16 TIN concentrations varied significantly with sampling periods and areas. There was no consistent spatial trend of increasing concentrations of TIN with proximity to the pit or consistent temporal trend of increasing concentrations of TIN over time.

5-Day Biochemical Oxygen Demand (BOD_5)

3.2.17 Levels of BOD_5 varied significantly with sampling periods and areas. There was no consistent spatial trend of increasing concentrations of BOD_5 with proximity to the pit or consistent temporal trend of increasing concentrations of BOD_5 over time.

Suspended Solids (SS)

3.2.18 SS levels varied significantly with sampling periods and areas. There was no consistent temporal trend of increasing concentrations of SS over time. Subsequent regression analysis between SS levels and proximity to the pit (i.e. Area) indicated that there was significant spatial trend of increasing SS level with proximity to the pit ($p < 0.01$), but there was a weak relationship between SS level and proximity to the pit ($r^2 < 0.60$).

3.2.19 Overall, results of statistical analyses for the water quality data did not appear to provide any evidence of unacceptable water quality impacts caused by the mud disposal operations at CMP Vd of the ESC area.

3.2.20 *Pit Specific Sediment Chemistry of ESC CMP Vd*

Background

3.2.21 *Pit Specific Sediment Chemistry of ESC CMP Vd* was conducted once every month from October to December 2019 as presented in *Table 3.1*. ***A total of six (6) monitoring stations for ESC CMP Vd were sampled in each monitoring event and the monitoring locations are shown in*** **Figure 3.3.** ***The monitoring results showed that the concentrations of all inorganic contaminants were below the Lower Chemical Exceedance Levels (LCELs) at Pit-Edge and Near-Pit stations from October to December 2019, whilst the concentrations of some inorganic contaminants (e.g. Arsenic, Copper, Lead, Mercury, Silver and Zinc) were higher than LCEL / Upper Chemical Exceedance Level (UCEL) at Active Pit stations from October to December 2019.***

Summary of Statistical Analyses

3.2.22 Statistical analyses were performed for data obtained from *Pit Specific Sediment Chemistry of ESC CMP Vd* since March 2016. Statistical tests were run to examine the difference in contaminant concentrations amongst Active-Pit, Pit-Edge and Near-Pit stations and amongst sampling periods. ANOVA was employed as the statistical test, with Area, Period and Station as fixed factors and Station nested within Area.

3.2.23 Should spatial or temporal trend of potential concern (i.e. increasing contaminant concentration with proximity to the pit or over time) be detected by ANOVA, linear regression analyses would be performed to examine the significance of the trend. The assumptions of the linear regression analyses are discussed in *Sections 3.2.10* and *3.2.11*. Detailed results of statistical analyses are presented in *Annex C*.

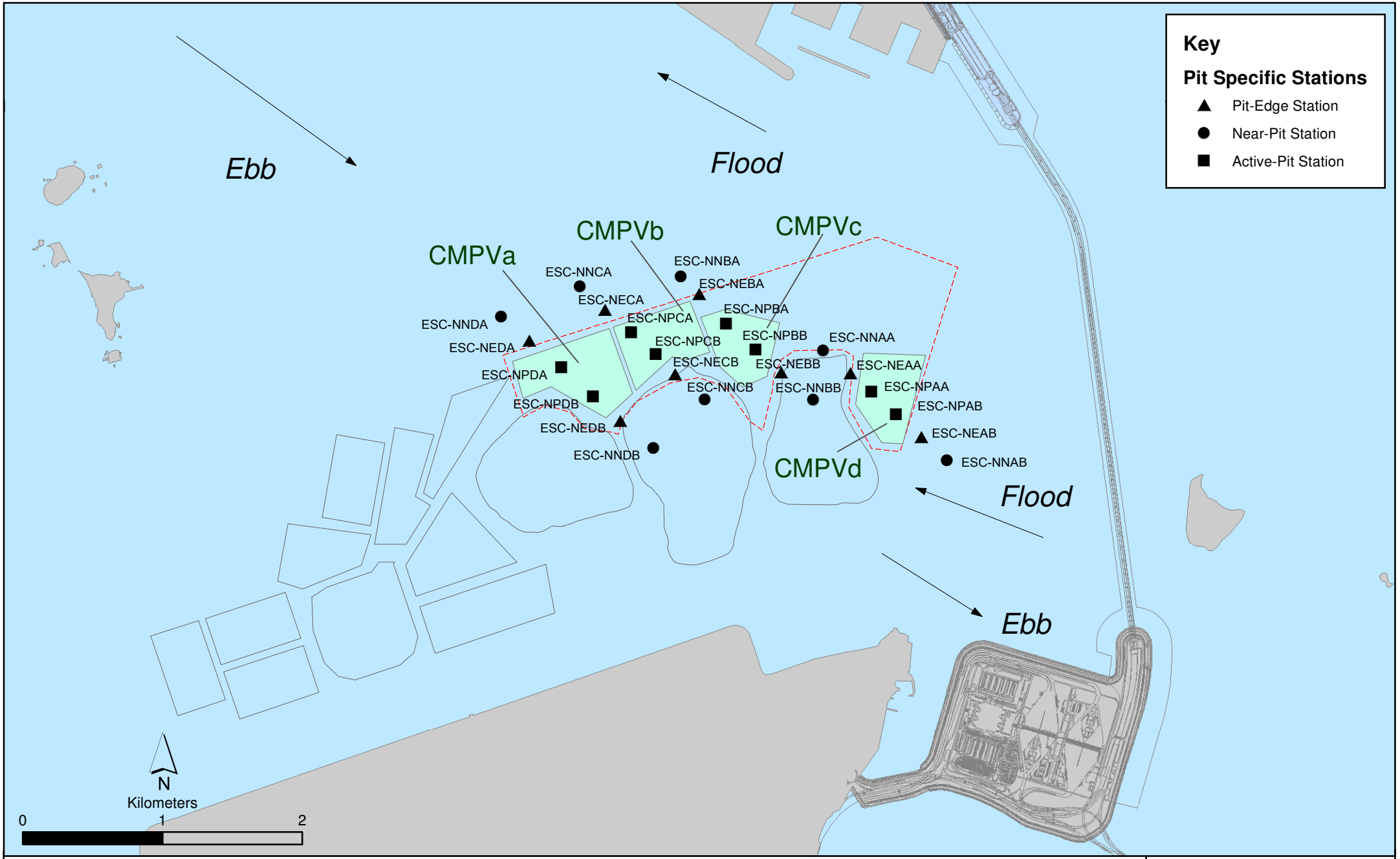

Figure 3.3

Pit Specific Sediment Quality Monitoring Stations for CMPV

File: T:\GIS\CONTRACT\0400720\Mxd\0400720_SQMS_pit specific.mxd
Date: 9/5/2017

Environmental Resources Management

ERM

Metals and Metalloids

3.2.24 There were significant spatial and temporal variations in the concentrations of all metal and metalloid contaminants (Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Mercury, Silver and Zinc). The concentrations of all measured metals and metalloids did not appear to increase over time. The concentrations of Cadmium, Chromium, Copper, Lead, Mercury, Nickel and Zinc were significantly higher at the Active Pit stations than at the Pit Edge stations than at Near Pit stations. Subsequent linear regression analysis for Cadmium, Chromium, Copper, Lead, Mercury, Nickel and Zinc levels and proximity to the pit (i.e. Area) indicated that there were significant spatial trends ($p < 0.01$), but there was a weak relationship between Cadmium, Chromium, Copper, Lead, Mercury, Nickel / Zinc levels and proximity to the pit ($r^2 < 0.60$).

Organic Contaminants

3.2.25 Concentrations of majority of organic contaminants were below their limits of reporting. Statistical analyses were only performed for contaminants for which 60% of data were over their limits of reporting.

3.2.26 In this reporting period, only Total Organic Carbon (TOC) concentrations were statistically analysed. Levels of TOC varied significantly with sampling area and time. It was significantly higher at the Active Pit stations than at the Pit Edge stations than at the Near Pit stations. Subsequent linear regression analysis for TOC levels and proximity to the pit (i.e. Area) indicated that there were significant spatial trends ($p < 0.01$), but there was a weak relationship between TOC levels and proximity to the pit ($r^2 < 0.60$). There was no consistent temporal trend of increasing concentrations of TOC over time.

3.2.27 From the results of the above statistical analyses, there did not appear to be any significant trend of increasing sediment contaminants' concentrations with proximity to the pit or with time. Therefore, there is no evidence indicating any unacceptable environmental impacts to sediment quality as a result of the contaminated mud disposal operations at ESC CMP Vd.

3.2.28 ***Cumulative Impact Sediment Chemistry of ESC CMPs***

Background

3.2.29 *Cumulative Impact Sediment Chemistry of ESC CMPs* was conducted in December 2019 as presented in *Table 3.1*. A total of nine (9) monitoring stations were sampled and the monitoring locations are shown in *Figure 3.4*. The monitoring results showed that the concentrations of all inorganic contaminants were generally below the LCELs at all monitoring stations in December 2019, except concentrations of Arsenic were higher than the LCEL at Near-field station ESC-RNB, Mid-field stations ESC-RMA and ESC-RMB, Far-field station ESC-RFB and Ma Wan station.

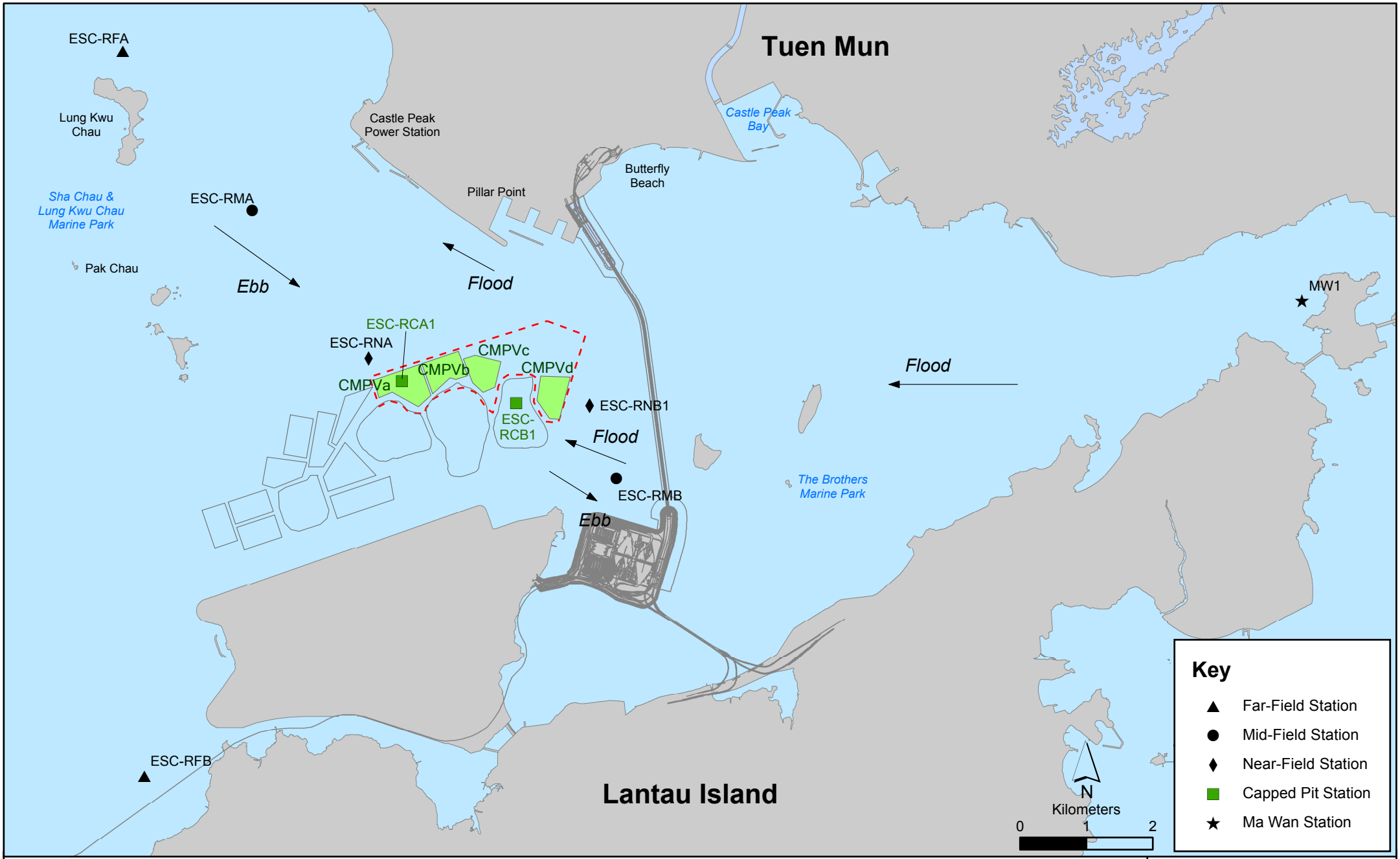

Figure 3.4

Cumulative Impacts Sediment Quality Monitoring Stations for ESC CMPs

File: T:\GIS\CONTRACT\0175086\Mxd\updated_20170419\0175086_SQMS_cum_impact.mxd
Date: 19/4/2017

Environmental Resources Management

ERM

Summary of Statistical Analysis

3.2.30 Data obtained during this reporting period were statistically compared with previous data obtained since monitoring began for ESC CMPs in June 2016. Statistical tests were run to examine the difference in contaminant concentrations amongst Near-Field, Mid-Field, Far-Field stations. ANOVA was employed as the statistical test, with Area and Station as fixed factors and Station nested within Area.

3.2.31 Should spatial or temporal trend of potential concern (i.e. increasing contaminant concentration with proximity to the pit or over time) be detected by ANOVA, linear regression analyses would be performed to examine the significance of the trend. The assumptions of the linear regression analyses are discussed in *Sections 3.2.10* and *3.2.11*. Detailed results of statistical analyses are presented in *Annex C*.

Metals and Metalloid

3.2.32 There were significant spatial variations in the concentrations of all metal and metalloid contaminants (Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Mercury, Silver and Zinc), but no consistent trend (i.e. Near-Field > Mid-Field > Far-Field) was observed. The concentrations of all measured metals and metalloids did not appear to increase over time.

Organic Contaminants

3.2.33 Concentrations of majority of organic contaminants were below their limits of reporting. Statistical analyses were only performed for contaminants for which 60% of data were over their limits of reporting.

3.2.34 In this reporting period, only TOC and Tributyltin (TBT) concentrations were statistically analysed. Levels of TOC and TBT varied significantly with sampling area and time. There was no consistent spatial trend of increasing concentrations of TOC/TBT with proximity to the pit or consistent temporal trend of increasing concentrations of TOC/TBT over time.

3.2.35 From the results of the above statistical analyses, there did not appear to be any significant trend of increasing sediment contaminants' concentrations with proximity to the pit or over time. Therefore, there is no evidence indicating any unacceptable environmental impacts to sediment quality as a result of the contaminated mud disposal operations at ESC CMP Vd during the quarterly period.

3.2.36

4 FINDINGS OF THE FIELD EVENTS AND LABORATORY TESTS AND ANALYSES BY THE INDEPENDENT AUDITOR

4.1.1 During the reporting period, the Independent Auditor (IA) conducted an inspection at the laboratory facility on 4 December 2019. The procedures of measurements of inorganic and organic contaminants of sediment samples were inspected. The IA was generally satisfied with the laboratory facilities, laboratory workers and the whole procedures of sample preparation and measurements. Overall, the IA satisfied with the monitoring procedures and confirmed that the requirements as stated in the EM&A Manual were followed.

5 ACTIVITIES SCHEDULED FOR THE NEXT REPORTING PERIOD

5.1.1 The monitoring activities to be conducted in the next quarterly period of January to March 2020 for ESC CMPs include:

- *Water Column Profiling of ESC CMP Vd* in January 2020;
- *Water Column Profiling of ESC CMP Vb* in February and March 2020;
- *Routine Water Quality Monitoring of ESC CMPs* in January and February 2020;
- *Water Quality Monitoring for Capping of ESC CMPs* in February 2020.
- *Pit Specific Sediment Chemistry of ESC CMP Vd* in January 2020;
- *Pit Specific Sediment Chemistry of ESC CMP Vb* in February and March 2020;
- *Cumulative Impact Sediment Chemistry of ESC CMPs* in February 2020;
- *Demersal Trawling for ESC CMPs* in January and February 2020; and
- *Sediment Toxicity Test of ESC CMPs* in February 2020.

5.1.2 The sampling schedule for ESC CMPs is presented in *Annex A*.

Annex A

Sampling Schedule

Annex A1 - East of Sha Chau Environmental Monitoring and Audit Sampling Schedule for CMP (April 2017 - March 2021)

			2017									2018												2019												2020												2021		
Pit Specific Sediment Chemistry	**Code**	**Frequency**	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Active-Pit																																																			
	ESC-NPAA	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	ESC-NPAB	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Pit-Edge																																																			
	ESC-NEAA	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	ESC-NEAB	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Near-Pit																																																			
	ESC-NNAA	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	ESC-NNAB	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Cumulative Impact Sediment Chemistry			A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Near-field Stations																																																			
	ESC-RNA	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
	ESC-RNB1	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
Mid-field Stations																																																			
	ESC-RMA	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
	ESC-RMB	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
Capped Pit Stations																																																			
	ESC-RCA1	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
	ESC-RCB1	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
Far-Field Stations																																																			
	ESC-RFA	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
	ESC-RFB	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
Ma Wan Station																																																			
	MW1	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	

Sediment Toxicity Tests			A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Near-Pit Stations																																																			
	ESC-TDA	2 times per year					5						5						5						5						5						5						5						5	
	ESC-TDB1	2 times per year					5						5						5						5						5						5						5						5	
Reference Stations																																																			
	ESC-TRA	2 times per year					5						5						5						5						5						5						5						5	
	ESC-TRB	2 times per year					5						5						5						5						5						5						5						5	
Ma Wan Station																																																			
	MW1	2 times per year					5						5						5						5						5						5						5						5	

Tissue/ Whole Body Sampling			A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Near-Pit Stations																																																			
	ESC-INA	2 times per year					*						*						*						*						*						*						*						*	
	ESC-INB	2 times per year					*						*						*						*						*						*						*						*	
Reference North																																																			
	TNA	2 times per year					*						*						*						*						*						*						*						*	
	TNB	2 times per year					*						*						*						*						*						*						*						*	
Reference South																																																			
	TSA	2 times per year					*						*						*						*						*						*						*						*	
	TSB	2 times per year					*						*						*						*						*						*						*						*	

Demersal Trawling			A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Near Pit Stations																																																			
	ESC-INA	4 times per year				5	5					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
	ESC-INB	4 times per year				5	5					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
Reference North																																																			
	TNA	4 times per year				5	5					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
	TNB	4 times per year				5	5					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
Reference South																																																			
	TSA	4 times per year				5	5					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
	TSB	4 times per year				5	5					5	5					5	5					5	5					5	5					5	5					5	5					5	5	

Capping			A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Ebb Tide																																																			
Impact Station Downcurrent																																																			
	ESC-IPE1A	4 times per year																																			3				3		3				3		3	
	ESC-IPE2A	4 times per year																																			3				3		3				3		3	
	ESC-IPE3	4 times per year																																			3				3		3				3		3	
	ESC-IPE4	4 times per year																																			3				3		3				3		3	
	ESC-IPE5	4 times per year																																			3				3		3				3		3	
Intermediate Station Downcurrent																																																			
	ESC-INE1A	4 times per year																																			3				3		3				3		3	
	ESC-INE2A	4 times per year																																			3				3		3				3		3	
	ESC-INE3A	4 times per year																																			3				3		3				3		3	
	ESC-INE4A	4 times per year																																			3				3		3				3		3	
	ESC-INE5A	4 times per year																																			3				3		3				3		3	
Reference Station Upcurrent																																																			
	ESC-RFE1	4 times per year																																			3				3		3				3		3	
	ESC-RFE2	4 times per year																																			3				3		3				3		3	
	ESC-RFE3	4 times per year																																			3				3		3				3		3	
	ESC-RFE4	4 times per year																																			3				3		3				3		3	
	ESC-RFE5	4 times per year																																			3				3		3				3		3	
Ma Wan Station																																																			
	MW1	4 times per year																																			3				3		3				3		3	
Flood Tide																																																			
Impact Station Downcurrent																																																			
	ESC-IPF1	4 times per year																																			3				3		3				3		3	
	ESC-IPF2	4 times per year																																			3				3		3				3		3	
	ESC-IPF3	4 times per year																																			3				3		3				3		3	
Intermediate Station Downcurrent																																																			
	ESC-INF1	4 times per year																																			3				3		3				3		3	
	ESC-INF2	4 times per year																																			3				3		3				3		3	
	ESC-INF3	4 times per year																																			3				3		3				3		3	
Reference Station Upcurrent																																																			
	ESC-RFF1A	4 times per year																																			3				3		3				3		3	
	ESC-RFF2A	4 times per year																																			3				3		3				3		3	
	ESC-RFF3	4 times per year																																			3				3		3				3		3	
Ma Wan Station																																																			
	MW1	4 times per year																																			3				3		3				3		3	

Routine Water Quality Monitoring			A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Ebb Tide																																																			
Impact Station Downcurrent																																																			
	ESC-IPE1A	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-IPE2A	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-IPE3	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-IPE4	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-IPE5	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
Intermediate Station Downcurrent																																																			
	ESC-INE1A	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-INE2A	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-INE3A	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-INE4A	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-INE5A	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
Reference Station Upcurrent																																																			
	ESC-RFE1	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-RFE2	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-RFE3	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-RFE4	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-RFE5	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
Ma Wan Station																																																			
	MW1	8 times per year	8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
Flood Tide																																																			
Impact Station Downcurrent																																																			
	ESC-IPF1	8 times per year	8	8		8	8		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-IPF2	8 times per year	8	8		8	8		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-IPF3	8 times per year	8	8		8	8		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
Intermediate Station Downcurrent																																																			
	ESC-INF1	8 times per year	8	8		8	8		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-INF2	8 times per year	8	8		8	8		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-INF3	8 times per year	8	8		8	8		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
Reference Station Upcurrent																																																			
	ESC-RFF1A	8 times per year	8	8		8	8		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-RFF2A	8 times per year	8	8		8	8		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
	ESC-RFF3	8 times per year	8	8		8	8		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	
Ma Wan Station																																																			
	MW1	8 times per year	8	8		8	8		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	

Water Column Profiling			A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Plume Stations	WCP1	Monthly	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	WCP2	Monthly	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Benthic Recolonisation Studies			A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Capped Stations at CMPV																																																			
	ESCV-CPA	2 times per year																																																	
	ESCV-CPB	2 times per year																																																	
	ESCV-CPC	2 times per year																																																	
	ESCV-CPD	2 times per year																																																	
Reference Stations																																																			
	RBA	2 times per year																																																	
	RBB	2 times per year																																																	
	RBC1	2 times per year																																																	

Impact Monitoring for Dredging			A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Upstream Stations																																																			
	US1	3 times per week				2	2	2																										2	2															
	US2	3 times per week				2	2	2																										2	2															
Downstream Stations																																																			
	DS1	3 times per week				2	2	2																										2	2															
	DS2	3 times per week				2	2	2																										2	2															
	DS3	3 times per week				2	2	2																										2	2															
	DS4	3 times per week				2	2	2																										2	2															
	DS5	3 times per week				2	2	2																										2	2															
Ma Wan Station																																																			
	MW1	3 times per week				2	2	2																										2	2															

Notes:
The number shown in each cell represents the numbers of replicates per monitoring station
Impact Monitoring for Dredging will be scheduled when dredging operations commence.
Benthic Recolonisation Studies for CMP V will be scheduled when capping operation for CMP V is completed.

Annex B

Dredging and Disposal Records

Table B1 Dredging Record at ESC CMP Vb

Date	Daily Dredging Volume (m^3)	Weekly Dredging Volume (m^3) (From Sunday to Saturday)
10-Nov-2019	0	8,500
11-Nov-2019	1,000	
12-Nov-2019	1,500	
13-Nov-2019	500	
14-Nov-2019	1,500	
15-Nov-2019	1,500	
16-Nov-2019	2,500	
17-Nov-2019	1,000	12,000
18-Nov-2019	3,000	
19-Nov-2019	3,000	
20-Nov-2019	2,500	
21-Nov-2019	500	
22-Nov-2019	1,000	
23-Nov-2019	1,000	
24-Nov-2019	1,500	12,500
25-Nov-2019	2,500	
26-Nov-2019	1,500	
27-Nov-2019	500	
28-Nov-2019	2,000	
29-Nov-2019	2,500	
30-Nov-2019	2,000	
01-Dec-2019	2,500	11,000
02-Dec-2019	2,500	
03-Dec-2019	2,000	
04-Dec-2019	2,000	
05-Dec-2019	2,000	
06-Dec-2019	0	
07-Dec-2019	0	

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
1-Oct-2019	0	1540657
2-Oct-2019	0	1540657
3-Oct-2019	550	1541207
4-Oct-2019	357	1541564
5-Oct-2019	356	1541920
6-Oct-2019	0	1541920
7-Oct-2019	0	1541920
8-Oct-2019	445	1542365
9-Oct-2019	219	1542584
10-Oct-2019	0	1542584
11-Oct-2019	500	1543084
12-Oct-2019	337	1543421
13-Oct-2019	1050	1544471
14-Oct-2019	628	1545099
15-Oct-2019	465	1545564
16-Oct-2019	819	1546383
17-Oct-2019	0	1546383
18-Oct-2019	2514	1548897
19-Oct-2019	200	1549097
20-Oct-2019	500	1549597
21-Oct-2019	1000	1550597
22-Oct-2019	954	1551551
23-Oct-2019	1582	1553133
24-Oct-2019	715	1553848
25-Oct-2019	500	1554348
26-Oct-2019	1954	1556302
27-Oct-2019	350	1556652
28-Oct-2019	700	1557352
29-Oct-2019	1365	1558717
30-Oct-2019	1109	1559826
31-Oct-2019	1906	1561732
1-Nov-2019	1289	1563021
2-Nov-2019	1831	1564852
3-Nov-2019	0	1564852
4-Nov-2019	500	1565352
5-Nov-2019	2411	1567763
6-Nov-2019	2365	1570128
7-Nov-2019	2240	1572368
8-Nov-2019	1897	1574265
9-Nov-2019	1859	1576124
10-Nov-2019	0	1576124
11-Nov-2019	1926	1578050
12-Nov-2019	1831	1579881
13-Nov-2019	1500	1581381
14-Nov-2019	1905	1583286
15-Nov-2019	1859	1585145
16-Nov-2019	1347	1586492
17-Nov-2019	0	1586492
18-Nov-2019	1859	1588351
19-Nov-2019	1388	1589739
20-Nov-2019	652	1590391
21-Nov-2019	1771	1592162
22-Nov-2019	1174	1593336

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
23-Nov-2019	1000	1594336
24-Nov-2019	0	1594336
25-Nov-2019	1500	1595836
26-Nov-2019	1000	1596836
27-Nov-2019	1500	1598336
28-Nov-2019	1500	1599836
29-Nov-2019	2500	1602336
30-Nov-2019	1916	1604252
1-Dec-2019	0	1604252
2-Dec-2019	1000	1605252
3-Dec-2019	2292	1607544
4-Dec-2019	1500	1609044
5-Dec-2019	2286	1611330
6-Dec-2019	1800	1613130
7-Dec-2019	2034	1615164
8-Dec-2019	700	1615864
9-Dec-2019	1500	1617364
10-Dec-2019	2000	1619364
11-Dec-2019	3522	1622886
12-Dec-2019	2700	1625586
13-Dec-2019	3300	1628886
14-Dec-2019	1500	1630386
15-Dec-2019	0	1630386
16-Dec-2019	3275	1633661
17-Dec-2019	1500	1635161
18-Dec-2019	2500	1637661
19-Dec-2019	2723	1640384
20-Dec-2019	2000	1642384
21-Dec-2019	2500	1644884
22-Dec-2019	0	1644884
23-Dec-2019	2500	1647384
24-Dec-2019	2000	1649384
25-Dec-2019	1400	1650784
26-Dec-2019	100	1650884
27-Dec-2019	2500	1653384
28-Dec-2019	3279	1656663
29-Dec-2019	594	1657257
30-Dec-2019	3091	1660348
31-Dec-2019	2610	1662958

Annex C

Statistical Analysis

Routine Water Quality Monitoring for ESC CMPs – Analysis of Variance and Linear Regression Analysis up to November 2019

Dissolved Oxygen

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	2783219.884	3	927739.961	17.765	**
Period	2269806541.467	42	54043012.892	1034.854	**
Area * Period	115417766.643	126	916014.021	17.540	**
Error	173275408.338	3318	52222.848		
Total	14175571273.500	3490			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Feb 17 ≥ Feb 13 ≥ Apr 16 ≥ Jan 17 > Feb 18 = Jan 13 > Jan 18 ≥ Feb 12 = Feb 19 ≥ Nov 18 > Jan 19 > Apr 13 = Apr 17 > Apr 18 = Nov 16= Apr 19 > Nov 17 = **Nov 19** > Apr 12 = May 13 > Nov 12 = May 19 = May 16 = May 18 > Oct 16 = Oct 12 > Jul 12 > May 17 ≥ May 12 = Jul 18 ≥ **Oct 19** > Jul 16 = Aug 17 = Oct 18 = Oct 17 > Aug 12 > Aug 13 = Aug 18 = Aug 19 ≥ Jul 17 ≥ Aug 16 = Jul 13 = Jul19
- Intermediate = Impact > Reference > Ma Wan Station

Turbidity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	107701398.465	3	35900466.155	144.109	**
Period	1422920755.607	42	33879065.610	135.995	**
Area * Period	375362206.943	126	2979065.134	11.958	**
Error	826580096.019	3318	249119.981		
Total	14175414712.000	3490			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Nov 17 > Oct 17 = Aug 13 ≥ Jan 19 ≥ Apr 17 = Aug 18 = Apr 12 = Aug 12 = May 19 = Nov 18 ≥ Nov 16 = Oct 16 ≥ Jul 18 = Nov 12 ≥ Jul 16 ≥ Jul 17 ≥ May 16 = Oct 18 = Aug 19 ≥ Apr 13 ≥ Feb 12 > **Oct 19** ≥ Apr 16 ≥ Jan 17 = Jul 19 ≥ May 18 ≥ Oct 12 = Apr 19 ≥ Jul 12 = Jan 18 = Aug 17 ≥ Aug 16 ≥ Feb 13 ≥ Feb 18 = May 12 ≥ Jan 13 ≥ Feb 19 = Apr 18 ≥ Jul 13 ≥ **Nov 19** ≥ May 17 = May 13 > Feb 17
- Impact = Reference > Intermediate > Ma Wan Station

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	4041010937.474	41	98561242.377	693.220	**
Area	19762885.306	3	6587628.435	46.333	**
Station(Area)	60300509.809	24	2512521.242	17.672	**
Period * Area	644039492.866	120	5366995.774	37.748	**
Period * Station(Area)	856866841.628	360	2380185.671	16.741	**
Error	553359953.625	3892	142178.816		
Total	29300780279.000	4448			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Aug 13 > May 18 > Feb 12 > Nov 18 = Jul 18 = Aug 19 ≥ **Nov 19** = Jul 13 ≥ Apr 12 ≥ **Oct 19** > Feb 19 = Oct 18 = Aug 18 = Jan 13 > Jan 19 = Apr 13 = May 16 = May 19 = Apr 18 = Nov 12 > Apr 17 > May 12 > Apr 16 = Oct 12 > Jul 16 = May 13 = Jan 18 ≥ Apr 19 = May 17 ≥ Aug 16 > Aug 12 = Jul 19 = Jul 12 ≥ Nov 17 ≥ Feb 13 ≥ Feb 18 ≥ Aug 17 = Oct 17 > Oct 16 = Jan 17 = Jul 17 ≥ Feb 17 ≥ Nov 16
- Ma Wan Station = Reference > Impact > Intermediate

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	3875153760.078	41	94515945.368	413.964	**
Area	36897299.686	3	12299099.895	53.868	**
Station(Area)	103152711.632	24	4298029.651	18.825	**
Period * Area	716253735.431	120	5968781.129	26.142	**
Period * Station(Area)	537746824.930	360	1493741.180	6.542	**
Error	888162586.371	3890	228319.431		
Total	29197991360.000	4446			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Apr 12 = Aug 13 = May 13 > May 12 ≥ Aug 16 = Apr 13 = Jul 13 ≥ Jan 13 = Oct 12 ≥ Feb 12 = Aug 12 = Nov 12 > Jul 17 = Apr 18 = Jul 12 > Feb 17 = Aug 17 > Apr 17 = Feb 18 = May 18 = Nov 18 = Jul 18 > Jan 18 = Oct 18 = Aug 18 = May 19 = **Oct 19** = Feb 13 ≥ Apr 19 ≥ Oct 17 = Aug 19 > May 17 ≥ Oct 16 = Jul 16 ≥ Nov 17 ≥ **Nov 19** > Jul 19 = Jan 17 > Apr 16 ≥ Jan 19 = Nov 16 = Feb 19 ≥ May 16
- Reference > Impact > Intermediate > Ma Wan Station

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	4499903795.958	41	109753751.121	606.874	**
Area	78304381.911	3	26101460.637	144.326	**
Station(Area)	77929815.305	24	3247075.638	17.954	**
Period * Area	498368130.021	120	4153067.750	22.964	**
Period * Station(Area)	766929129.057	360	2130358.692	11.780	**
Error	703872365.875	3892	180851.070		
Total	29342596819.500	4448			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Nov 17 ≥ Jul 17 ≥ Oct 17 ≥ Feb 17 ≥ Apr 17 = Aug 17 = Feb 18 ≥ Jan 18 ≥ May 17 = Nov 18 = Jul 18 ≥ Apr 18 > Aug 19 > **Nov 19** = May 18 > Apr 12 = Feb 12 = Aug 13 > **Oct 19** = Oct 18 = Aug 18 ≥ Jul 12 ≥ Nov 12 ≥ Apr 19 ≥ Jul 13 ≥ Feb 19 ≥ May 16 = May 12 ≥ Jan 19 > Jan 17 = Jan 13 = Apr 13 = Oct 16 = Apr 16 = May 19 = Oct 12 > Jul 16 = Nov 16 > Jul 19 > May 13 = Aug 12 > Aug 16 = Feb 13
- Ma Wan Station > Reference > Impact > Intermediate

Ammonia Nitrogen

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	4942049676.923	41	120537796.998	620.447	**
Area	4240686.713	3	1413562.238	7.276	**
Station(Area)	25072780.655	24	1044699.194	5.377	**
Period * Area	320987589.308	120	2674896.578	13.769	**
Period * Station(Area)	264509591.815	360	734748.866	3.782	**
Error	756121118.125	3892	194275.724		
Total	29328367403.000	4448			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Apr 12 > Apr 13 = Apr 16 > May 13 = Feb 19 = Jan 18 = Apr 17 > May 19 ≥ Feb 17 = May 17 ≥ Feb 12 = Apr 19 ≥ Apr 18 > Feb 18 = May 16 ≥ Jan 13 ≥ Jan 17 ≥ Nov 17 = Jul 16 > Jul 18 = May 18 > Oct 17 = Jan 19 > **Oct 19** ≥ Jul 13 ≥ Nov 16 ≥ Aug 19 ≥ Aug 16 = **Nov 19** = Jul 19 ≥ Aug 12 ≥ Aug 17 ≥ May 12 > Jul 17 = Oct 16 = Aug 18 > Oct 12 = Oct 18 = Aug 13 > Nov 12 > Jul 12 = Feb 13 > Nov 18
- Reference = Ma Wan Station > Impact > Intermediate

Total Inorganic Nitrogen

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	4860628227.457	41	118551907.987	1175.295	**
Area	90375526.194	3	30125175.398	298.654	**
Station(Area)	117530493.336	24	4897103.889	48.549	**
Period * Area	397035456.936	120	3308628.808	32.801	**
Period * Station(Area)	387667097.273	360	1076853.048	10.676	**
Error	392585808.125	3892	100869.940		
Total	29342425985.500	4448			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Apr 12 = May 18 > Aug 13 > Apr 17 > Aug 19 = Jul 16 = May 13 > Jul 12 > Nov 18 = Aug 17 > Jul 17 > May 12 = Aug 16 > Jul 19 = May 17 = Aug 12 = Apr 18 = Jul 18 > Jul 13 = May 16 > May 19 > Aug 18 = Oct 17 > Apr 13 > Feb 17 = Apr 16 = Jan 18 > Oct 12 = Apr 19 ≥ Feb 19 ≥ Feb 12 > Nov 16 > Jan 17 = Oct 18 = Oct 16 = **Oct 19** > Nov 12 > Feb 18 > Jan 19 = **Nov 19** > Nov 17 = Jan 13 > Feb 13
- Reference = Impact > Intermediate > Ma Wan Station

BOD_5

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	2665825692.338	41	65020138.838	192.047	**
Area	96748907.327	3	32249635.776	95.254	**
Station(Area)	58390316.942	24	2432929.873	7.186	**
Period * Area	1222006928.825	120	10183391.074	30.078	**
Period * Station(Area)	1011397148.829	360	2809436.525	8.298	**
Error	1317687128.063	3892	338562.983		
Total	29321385499.500	4447			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Aug 16 > Aug 19 = Nov 16 = Apr 16 > Jan 17 = Apr 19 = May 12 ≥ **Oct 19** > Aug 18 = Jan 13 ≥ May 18 = Jul 17 = Nov 17 = May 17 ≥ May 16 ≥ Oct 18 = Jul 19 = Apr 18 = Feb 12 = Nov 18 = Jul 18 = May 19 = Feb 18 = Apr 17 = Oct 16 > **Nov 19** ≥ Feb 19 = Oct 17 ≥ Apr 13 ≥ Nov 12 ≥ Jan 19 = Apr 12 = Jul 12 ≥ Feb 13 = Oct 12 > Feb 17 > May 13 = Aug 17 = Jul 16 > Aug 12 = Jan 18 > Aug 13 > Jul 13
- Ma Wan Station = Reference > Impact = Intermediate

Suspended Solids

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	3876533975.437	41	94549609.157	1298.681	**
Area	32275065.372	3	10758355.124	147.771	**
Station(Area)	219354241.472	24	9139760.061	125.539	**
Period * Area	767830564.876	120	6398588.041	87.887	**
Period * Station(Area)	1457226461.199	360	4047851.281	55.599	**
Error	283354454.438	3892	72804.331		
Total	29341828793.500	4448			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Nov 17 > Jul 12 > Nov 12 = Jan 19 > Nov 16 = Jul 16 = Oct 16 = Aug 12 > Apr 12 = Apr 17 = Oct 17 ≥ May 16 ≥ May 19 = Oct 12 > Aug 13 > Jan 17 = Nov 18 = Jul 18 ≥ Aug 18 = Apr 16 = Jul 17 = Oct 18 ≥ Apr 13 > Aug 19 = Feb 12 > Jan 18 > **Oct 19** = Aug 16 > May 18 = Feb 13 > Apr 19 = Feb 18 = Apr 18 = Jan 13 > Aug 17 > Feb 19 = **Nov 19** = May 13 = Jul 19 ≥ Jul 13 ≥ May 12 > May 17 > Feb 17
- Impact > Intermediate > Reference > Ma Wan Station

Linear Regression Analysis

Source	df	Slope	r	r^2	P
Area	1	-0.761	0.121	0.015	**

Note: Linear regression analysis on spatial changes of contaminant concentrations.

Pit Specific Sediment Chemistry for ESC CMP Vd – Analysis of Variance (up to December 2019)

Arsenic

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	1701206321.164	45	37804584.915	317.382	**
Area	37624766.195	2	18812383.097	157.936	**
Station(Area)	248557434.255	3	82852478.085	695.575	**
Period * Area	348806661.863	90	3875629.576	32.537	**
Period * Station(Area)	286834338.052	134	2140554.762	17.971	**
Error	359842412.990	3021	119113.675		
Total	11940722456.500	3296			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Sep 19 ≥ Jun 19 = Aug 19 ≥ Jul 19 = Oct 17 ≥ Jul 18 ≥ Jun 18 = Nov 18 = Oct 18 ≥ Feb 19 ≥ **Oct 19** = Jan 19 ≥ Apr 19 = Mar 19 ≥ May 19 = Jul 17 = May 18 = Mar 18 = **Nov 19** = **Dec 19** ≥ Nov 17 > Aug 18 = Sep 18 ≥ Sep 17 = Aug 17 = Aug 16 = Dec 18 ≥ Apr 18 ≥ Dec 17 = Feb 18 = Jan 18 = Mar 16 > May 17 ≥ Jun 17 = Jul 16 ≥ Apr 16 ≥ Feb 17 = Apr 17 > Oct 16 = May 16 = Nov 16 > Mar 17 = Jun 16 = Jan 17 = Sep 16 > Dec 16
- Active Pit > Pit Edge = Near Pit

Cadmium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	791031312.777	45	17578473.617	87.197	**
Area	785803955.625	2	392901977.813	1948.963	**
Station(Area)	39217802.658	3	13072600.886	64.846	**
Period * Area	322680154.069	90	3585335.045	17.785	**
Period * Station(Area)	397386476.939	134	2965570.723	14.711	**
Error	608415041.946	3018	201595.441		
Total	11888930444.000	3293			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Oct 18 = Jun 18 > **Oct 19** ≥ Jun 16 = May 17 ≥ Dec 17 = Aug 19 = Mar 18 = Jul 17 ≥ May 18 ≥ Sep 19 ≥ Nov 17 = **Nov 19** ≥ Oct 17 ≥ Sep 17 = Aug 17 = Apr 16 ≥ Apr 18 ≥ Apr 19 ≥ May 16 = May 19 ≥ Sep 16 = Nov 18 = **Dec 19** = Aug 16 ≥ Feb 17 ≥ Jun 17 ≥ Feb 18 = Jan 18 ≥ Dec 16 ≥ Sep 18 ≥ Jun 19 = Aug 18 ≥ Mar 17 ≥ Mar 16 = Nov 16 ≥ Apr 17 ≥ Jul 19 ≥ Jan 17 = Jul 16 ≥ Jan 19 = Feb 19 ≥ Dec 18 = Mar 19 ≥ Jul 18 > Oct 16
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-0.053	0.326	0.107	**
Note: Linear regression analysis on spatial changes of contaminant concentrations.					

Chromium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	951359707.559	45	21141326.835	99.649	**
Area	258057766.145	2	129028883.073	608.172	**
Station(Area)	97730645.193	3	32576881.731	153.550	**
Period * Area	547100002.429	90	6078888.916	28.653	**
Period * Station(Area)	487441134.046	134	3637620.403	17.146	**
Error	640930610.941	3021	212158.428		
Total	11940923382.000	3296			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jul 17 > Oct 17 ≥ **Dec 19** = Sep 19 = Mar 16 ≥ **Oct 19** ≥ Oct 18 ≥ Jun 18 ≥ Aug 19 ≥ Nov 17 ≥ Mar 19 ≥ Jan 19 = Feb 19 = Jul 19 = Jul 18 ≥ Nov 18 ≥ Apr 19 = Jun 19 ≥ Sep 17 = Aug 17 ≥ Jun 16 ≥ Mar 18 = Apr 16 ≥ May 18 ≥ **Nov 19** ≥ Aug 16 ≥ Feb 18 ≥ Jan 18 ≥ Jul 16 ≥ Aug 18 ≥ Sep 18 ≥ Dec 18 = Sep 16 = Apr 18 = May 16 ≥ Nov 16 ≥ Dec 16 ≥ Feb 17 = Oct 16 ≥ May 19 ≥ May 17 = Dec 17 = Jan 17 > Mar 17 = Jun 17 > Apr 17
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-3.666	0.231	0.053	**

Note: Linear regression analysis on spatial changes of contaminant concentrations.

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	951359707.559	45	21141326.835	99.649	**
Area	258057766.145	2	129028883.073	608.172	**
Station(Area)	97730645.193	3	32576881.731	153.550	**
Period * Area	547100002.429	90	6078888.916	28.653	**
Period * Station(Area)	487441134.046	134	3637620.403	17.146	**
Error	640930610.941	3021	212158.428		
Total	11940923382.000	3296			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Nov 18 ≥ **Dec 19** ≥ **Nov 19** = Aug 19 > Sep 19 = Mar 19 ≥ Oct 17 ≥ Nov 17 = Mar 18 = Apr 19 = Oct 18 = Jun 18 ≥ **Oct 19** ≥ May 18 ≥ Dec 17 ≥ Jan 19 = Aug 16 = Feb 19 ≥ Feb 18 ≥ Apr 18 = Sep 18 = Sep 17 = Aug 17 = Dec 18 ≥ Aug 18 ≥ Jul 18 = Sep 16 = Feb 17 ≥ Jun 16 ≥ Jan 18 ≥ Jul 19 ≥ Jun 19 ≥ Apr 16 ≥ Jun 17 ≥ Mar 16 = Dec 16 ≥ May 16 ≥ May 19 ≥ May 17 = Mar 17 ≥ Oct 16 ≥ Jan 17 = Jul 17 ≥ Nov 16 ≥ Jul 16 > Apr 17
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-32.144	0.197	0.039	**

Note: Linear regression analysis on spatial changes of contaminant concentrations.

Lead

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	767718791.727	45	17060417.594	77.635	**
Area	396153923.784	2	198076961.892	901.366	**
Station(Area)	293659195.982	3	97886398.661	445.440	**
Period * Area	398194457.089	90	4424382.857	20.134	**
Period * Station(Area)	465240114.568	134	3471941.153	15.799	**
Error	663870622.042	3021	219751.944		
Total	11940923727.000	3296			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Mar 17 = May 19 ≥ **Dec 19** ≥ Nov 18 ≥ Mar 19 = Sep 19 ≥ Oct 18 = Jul 17 ≥ Jun 18 = Oct 17 ≥ **Nov 19** ≥ May 17 = Aug 19 = Apr 19 ≥ Jul 18 ≥ Jul 19 = **Oct 19** = Jan 19 = Feb 19 = Jun 19 ≥ Jun 17 = Sep 17 = Aug 17 = Mar 18 ≥ May 18 ≥ Nov 17 ≥ Apr 16 ≥ Mar 16 = Dec 18 = Jan 18 ≥ Jul 16 = Jun 16 ≥ Aug 16 ≥ Nov 16 ≥ Apr 17 = Aug 18 ≥ Feb 18 = Sep 18 = May 16 ≥ Dec 17 = Oct 16 = Apr 18 ≥ Feb 17 > Dec 16 > Sep 16 = Jan 17
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-5.057	0.227	0.051	**

Note: Linear regression analysis on spatial changes of contaminant concentrations.

Mercury

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	1627329907.250	45	36162886.828	198.914	**
Area	133918428.624	2	66959214.312	368.309	**
Station(Area)	16659274.846	3	5553091.615	30.545	**
Period * Area	294404104.469	90	3271156.716	17.993	**
Period * Station(Area)	216094654.754	134	1612646.677	8.870	**
Error	545768127.017	3002	181801.508		
Total	11666139106.500	3277			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Apr 16 = Mar 16 > May 16 = Jun 16 > Sep 16 = Jul 16 = **Oct 19** ≥ Aug 16 ≥ Oct 16 = Sep 19 ≥ Jun 17 ≥ Nov 16 > Dec 16 = May 17 = May 18 = Oct 18 = Aug 19 ≥ Nov 17 ≥ Jan 17 ≥ Jun 19 = **Nov 19** ≥ Jun 18 = Mar 17 ≥ Apr 17 = Sep 18 = Feb 17 = Jul 17 = **Dec 19** = Oct 17 = Jul 18 = Apr 19 ≥ May 19 ≥ Aug 18 ≥ Dec 17 = Jan 19 = Feb 19 = Sep 17 = Aug 17 = Mar 19 ≥ Nov 18 > Dec 18 > Mar 18 = Jul 19 = Jan 18 = Feb 18 = Apr 18
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-0.044	0.147	0.022	**

Note: Linear regression analysis on spatial changes of contaminant concentrations.

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	769884975.664	45	17108555.015	133.025	**
Area	394693720.449	2	197346860.224	1534.445	**
Station(Area)	328982484.927	3	852.654	852.654	**
Period * Area	572536962.114	90	6361521.801	49.463	**
Period * Station(Area)	527899796.473	134	3939550.720	30.631	**
Error	388534541.157	3021	128611.235		
Total	11940922476.500	3296			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jul 17 ≥ Oct 17 = **Dec 19** ≥ Sep 19 > Jun 18 = Oct 18 = Mar 16 = May 17 = Jun 17 = **Oct 19** ≥ Nov 18 ≥ Aug 19 = Jul 19 ≥ Nov 17 ≥ Mar 19 ≥ Sep 17 = Aug 17 ≥ Apr 19 = Jun 19 ≥ Jan 19 = Feb 19 ≥ Apr 16 ≥ Jul 16 = Jul 18 ≥ Jun 16 ≥ **Nov 19** ≥ May 19 ≥ Dec 18 = May 18 = Mar 18 = Jan 18 ≥ Nov 16 = Aug 18 = Sep 18 ≥ Feb 18 ≥ May 16 ≥ Aug 16 ≥ Sep 16 ≥ Apr 18 = Dec 17 = Dec 16= Feb 17 = Jan 17 = Apr 17 > Mar 17 > Oct 16
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-2.409	0.278	0.078	**

Note: Linear regression analysis on spatial changes of contaminant concentrations.

Silver

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	412510358.179	45	9166896.848	59.910	**
Area	1076685115.399	2	538342557.700	3518.319	**
Station(Area)	25632240.420	3	8544080.140	55.840	**
Period * Area	525738283.064	90	5841536.478	38.177	**
Period * Station(Area)	469510579.900	134	3503810.298	22.899	**
Error	462094102.899	3020	153011.292		
Total	11926619321.000	3295			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- May 19 > Jul 19 ≥ Dec 17 ≥ Nov 17 ≥ May 17 ≥ Mar 19 = Apr 17 ≥ May 18 = Aug 16 = Jun 16 ≥ Jun 18 = Oct 18 ≥ Mar 18 = Aug 19 ≥ Jun 17 = **Oct 19** ≥ Mar 17 = Feb 17 = Jul 17 ≥ Sep 16 ≥ Sep 19 = Oct 17 ≥ Apr 19 ≥ Apr 18 ≥ **Nov 19** ≥ Feb 19 = Nov 18 =Feb 18 = Sep 17 = Aug 17 = Jan 18 = Mar 16 = Apr 16 ≥ Sep 18 = May 16 = Aug 18 = **Dec 19** ≥ Jan 19 ≥ Dec 16 ≥ Jul 16 ≥ Nov 16 = Dec 18 ≥ Jan 17 ≥ Jul 18 ≥ Jun 19 > Oct 16
- Active Pit > Near Pit > Pit Edge

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	1107784120.926	45	24617424.909	215.871	**
Area	441374747.020	2	220687373.510	1935.216	**
Station(Area)	244020311.875	3	81340103.958	713.274	**
Period * Area	459196089.123	90	5102178.768	44.741	**
Period * Station(Area)	386698101.772	134	2885806.730	25.306	**
Error	344507613.336	3021	114037.608		
Total	11940918101.500	3296			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Sep 19 > Nov 18 ≥ Aug 19 ≥ **Dec 19** ≥ Jul 17 = Oct 17 ≥ Jun 18 = Oct 18 = Mar 19 ≥ **Nov 19** ≥ **Oct 19** ≥ Nov 17 ≥ May 18 = Mar 18 ≥ Feb 19 ≥ Jul 19 ≥ Jul 18 = Apr 18 = Apr 19 = Mar 16 = Feb 18 ≥ Jan 19 ≥ Jun 19 = Sep 17 = Aug 17 ≥ Apr 16 = Jan 18 = Aug 16 ≥ Dec 17 ≥ Jun 16 = Sep 18 = Aug 18 ≥ Dec 18 = Jul 16 > Nov 16 = May 16 = Oct 16 = May 17 > Feb 17 = Dec 16 > Mar 17 = Jan 17 > Jun 17 = Sep 16 = Apr 17 > May 19
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-19.655	0.294	0.086	**

Note: Linear regression analysis on spatial changes of contaminant concentrations.

Total Organic Carbon

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	854751999.264	45	18994488.873	137.573	**
Area	288422932.900	2	144211466.450	1044.492	**
Station(Area)	108562907.528	3	36187635.843	262.099	**
Period * Area	663492179.474	90	7372135.327	53.395	**
Period * Station(Area)	652403059.225	134	4868679.546	35.263	**
Error	417104954.658	3021	138068.505		
Total	11940158969.000	3296			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Oct 17 = Feb 18 ≥ Jun 18 ≥ Aug 19 ≥ Dec 18 ≥ Apr 16 ≥ Aug 18 ≥ Nov 18 ≥ Jul 17 = May 18 = Mar 16 = Dec 17 = Mar 18 = Jul 18 = Apr 19 ≥ Feb 19 ≥ Jun 16 ≥ Aug 16 = Jul 16 = Jan 19 = Jun 19 = Nov 17 = Mar 19 = Nov 16 ≥ Sep 19 = Jan 17 > May 17 ≥ Sep 16 = Oct 16 = Dec 16 = May 16 = Apr 18 = Sep 18 ≥ Sep 17 = Aug 17= Jul 19 = Oct 18 ≥ Jun 17 ≥ May 19 > Jan 18 > Mar 17 = Apr 17 = Feb 17
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-1100.956	0.289	0.084	**

Note: Linear regression analysis on spatial changes of contaminant concentrations.

Cumulative Impact Sediment Chemistry for ESC CMPs – Analysis of Variance (up to December 2019)

Arsenic

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	98769392.808	14	7054956.629	540.299	**
Area	67820196.182	4	16955049.046	1298.490	**
Area * Station	3762212.881	4	940553.220	72.032	**
Period * Area	147525422.298	55	2682280.405	205.420	**
Period * Area * Station	11652290.400	56	208076.614	15.935	**
Error	19390407.792	1485			
Total	1418460733.500	1620			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- **Dec 19** = Jun 19 = Aug 19 > Jun 18 > Dec 18 = Feb 19 = Dec 17 = Feb 18 > Aug 18 = Jun 17 > Jun 16 = Aug 17 > Dec 16 > Feb 17 = Aug 16
- Mid-Field > Ma Wan = Far-Field > Near-Field > Capped-Pit

Cadmium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	42256077.284	14	3018291.235	44.245	**
Area	27404574.626	4	6851143.656	100.432	**
Area * Station	63062459.031	4	15765614.758	231.110	**
Period * Area	77518962.266	55	1409435.678	20.661	**
Period * Area * Station	37618436.972	56	671757.803	9.847	**
Error	101097600.146	1482	68217.004		
Total	1407349475.500	1617			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jun 16 = Aug 16 ≥ Aug 19 = Aug 17 = Jun 18 = Feb 18 ≥ Dec 17 = **Dec 19** = Dec 18 > Jun 17 = Aug 18 = Feb 19 > Feb 17 = Jun 19 > Dec 16
- Mid-Field > Ma Wan > Far-Field > Capped-Pit = Near-Field

Chromium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	17904086.962	14	1278863.354	64.713	**
Area	142474933.961	4	35618733.490	1802.379	**
Area * Station	24528427.507	4	6132106.877	310.297	**
Period * Area	93579711.359	55	1701449.297	86.097	**
Period * Area * Station	32358544.243	56	577831.147	29.239	**
Error	29346663.125	1485	19762.063		
Total	1418488193.000	1620			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jun 16 > Aug 16 > **Dec 19** ≥ Aug 19 = Aug 17 ≥ Dec 17 ≥ Jun 18 ≥ Jun 17 ≥ Jun 19 = Feb 19 = Feb 18 ≥ Dec 16 > Dec 18 = Feb 17 > Aug 18
- Ma Wan > Mid-Field > Far-Field > Near-Field > Capped-Pit

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	13399711.169	14	957122.226	49.319	**
Area	111577256.664	4	27894314.166	1437.337	**
Area * Station	95125815.067	4	23781453.767	1225.409	**
Period * Area	73814794.380	55	1342087.171	69.155	**
Period * Area * Station	17066679.172	56	304762.128	15.704	**
Error	28819317.042	1485	19406.948		
Total	1418488259.000	1620			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Dec 17 > **Dec 19** > Aug 17 = Jun 16 = Jun 18 = Feb 19 = Jun 19 = Aug 16 = Aug 19 = Jun 17 > Dec 18 > Aug 18 = Dec 16 = Feb 18 = Feb 17
- Ma Wan > Mid-Field > Far-Field = Near-Field > Capped-Pit

Lead

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	90092963.104	14	6435211.650	292.869	**
Area	99816947.741	4	24954236.935	1135.678	**
Area * Station	16084326.189	4	4021081.547	183.001	**
Period * Area	88992454.612	55	1618044.629	73.638	**
Period * Area * Station	21690683.978	56	387333.642	17.628	**
Error	32629894.375	1485	21972.993		
Total	1418488209.500	1620			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Aug 18 > Dec 18 > Aug 16 > Aug 19 = **Dec 19** = Feb 19 = Aug 17 = Jun 18 > Jun 19 = Jun 16 > Feb 18 = Dec 17 > Dec 16 > Jun 17 > Feb 17
- Ma Wan > Mid-Field > Far-Field > Near-Field > Capped-Pit

Mercury

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	141356277.312	14	10096876.951	159.642	**
Area	18826067.210	4	4706516.802	74.415	**
Area * Station	11932499.207	4	2983124.802	47.166	**
Period * Area	53450465.445	55	971826.644	15.366	**
Period * Area * Station	19026104.370	56	339751.864	5.372	**
Error	93858251.386	1484			
Total	1410770749.500	1619			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jun 16 > Aug 16 > Dec 18 = Aug 18 = **Dec 19** = Dec 16 > Feb 19 ≥ Feb 17 ≥ Aug 17 = Jun 19 = Jun 17 ≥ Dec 17 > Jun 18 = Aug 19 > Feb 18
- Ma Wan > Far-Field = Capped-Pit ≥ Mid-Field ≥ Near-Field

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	17869215.883	14	1276372.563	67.368	**
Area	123752743.791	4	30938185.948	1632.940	**
Area * Station	30394715.278	4	7598678.820	401.064	**
Period * Area	108106277.350	55	1965568.679	103.744	**
Period * Area * Station	36789968.315	56	656963.720	34.675	**
Error	28135268.333	1485	18946.309		
Total	1418487972.500	1620			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jun 16 > Aug 18 > Dec 18 ≥ **Dec 19** = Aug 17 = Dec 17 ≥ Aug 19 = Dec 16 ≥ Jun 18 ≥ Jun 19 ≥ Jun 17 = Feb 18 = Feb 19 > Aug 16 > Feb 17
- Ma Wan > Mid-Field > Far-Field > Near-Field > Capped-Pit

Silver

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	48112099.026	14	3436578.502	115.485	**
Area	109653092.438	4	27413273.109	921.216	**
Area * Station	86902549.910	4	21725637.478	730.084	**
Period * Area	26596360.669	55	483570.194	16.250	**
Period * Area * Station	29431552.204	56	525563.432	17.661	**
Error	44190207.625	1485	29757.716		
Total	1418103757.500	1620			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Aug 18 > Dec 18 > Dec 17 = Feb 18 = Aug 16 = Aug 17 > Feb 19 = Feb 17 = Aug 19 = **Dec 19** = Jun 17 = Dec 16 > Jun 19 > Jun 16 > Jun 18
- Ma Wan > Mid-Field > Near-Field > Far-Field > Capped-Pit

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	21003286.906	14	1500234.779	92.128	**
Area	105982098.576	4	26495524.644	1627.059	**
Area * Station	63249558.246	4	15812389.561	971.020	**
Period * Area	101828766.134	55	1851432.112	113.694	**
Period * Area * Station	20204111.942	56	360787.713	22.156	**
Error	24182187.875	1485	16284.302		
Total	1418486787.000	1620			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- **Dec 19** > Aug 16 > Aug 19 ≥ Jun 19 = Jun 18 ≥ Jun 16 ≥ Aug 17 ≥ Dec 17 ≥ Jun 17 = Feb 19 ≥ Feb 18 = Dec 16 > Feb 17 > Dec 18 > Aug 18
- Ma Wan > Mid-Field > Near-Field > Far-Field > Capped-Pit

TOC

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	45260459.112	14	3232889.937	107.639	**
Area	78876325.124	4	19719081.281	656.546	**
Area * Station	13514521.251	4	3378630.313	112.491	**
Period * Area	107692874.519	55	1958052.264	65.193	**
Period * Area * Station	51704379.332	56	923292.488	30.741	**
Error	44601329.625	1485	30034.565		
Total	1418368854.000	1620			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jun 16 > **Dec 19** > Dec 16 = Aug 19 = Aug 16 > Dec 17 ≥ Feb 19 ≥ Jun 17 = Jun 18 = Jun 19 ≥ Dec 18 = Feb 18 > Aug 17 ≥ Aug 18 > Feb 17
- Ma Wan > Mid-Field > Far-Field > Capped-Pit > Near-Field

TBT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	74475614.276	14	5319686.734	76.903	**
Area	68350887.025	4	17087721.756	247.025	**
Area * Station	6206151.719	4	1551537.930	22.429	**
Period * Area	31224784.099	55	567723.347	8.207	**
Period * Area * Station	22482379.313	56	401471.059	5.804	**
Error	102723596.917	1485	69174.139		
Total	1384645886.500	1620			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Feb 17 = Dec 16 = Aug 17 = Jun 17 = Aug 18 > Jun 16 ≥ Feb 18 = Dec 18 ≥ Feb 19 = Aug 16 = **Dec 19** ≥ Dec 17 = Aug 19 = Jun 19 > Jun 18
- Ma Wan > Capped-Pit > Near-Field = Far-Field > Mid Field