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 – January to March 2018

Revision 0

August 2018

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Document Code: 0400720_CMP Quarterly Jan – Mar 2018_v0.doc

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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: 6 August 2018 Approved by:  Craig A. Reid *Partner*

Revision	Description	By	Checked	Approved	Date
v0	Quarterly EM&A Report for ESC CMPs and SB CMPs	RC	JT	CAR	6/8/18

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OHSAS 18001:2007
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ISO 9001 : 2008
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CEDD Civil Engineering and Development Department

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Dredging, Management and Capping of Contaminated Sediment Disposal Facility at Sha Chau and to the South of The Brothers

Environmental Certification Sheet
EP-312/2008/A & EP-427/2011/A

Reference Document/Plan

Document/~~Plan~~ to be ~~Certified~~/ Verified:	Quarterly EM&A Report for Contaminated Mud Pits to the East of Sha Chau and the South of The Brothers – January to March 2018
Date of Report:	6 August 2018
Date prepared by ET:	6 August 2018
Date received by IA:	6 August 2018

Reference EP Condition

Environmental Permit Condition:

Condition 3.1 of EP-312/2008/A and Condition 4.1 of EP-427/2011/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.

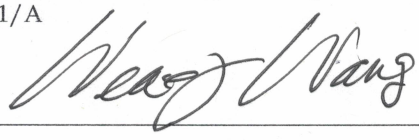
ET Certification

I hereby certify that the above referenced document/~~plan~~ complies with the above referenced condition of EP-312/2008/A and EP-427/2011/A

Craig A. Reid,
Environmental Team Leader:  Date: 6/8/2018

IA Verification

I hereby verify that the above referenced document/~~plan~~ complies with the above referenced condition of EP-312/2008/A and EP-427/2011/A

Dr Wang Wen Xiong,
Independent Auditor:  Date: 6/8/2018

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 January to March 2018

EXECUTIVE SUMMARY

Water Column Profiling, Routine Water Quality Monitoring, Pit Specific Sediment Chemistry, Cumulative Impact Sediment Chemistry, Sediment Toxicity Test and Demersal Trawling were carried out for Contaminated Mud Pits (CMPs) at East of Sha Chau (ESC) during the quarterly period of January to March 2018. 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

Water Column Profiling of ESC CMP Vd – January to March 2018

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) also 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 deterioration in water quality during this quarterly period.

Routine Water Quality Monitoring of ESC CMPs – January and February 2018

Results of Routine Water Quality Monitoring conducted in January and February 2018 showed that levels of DO, Salinity and pH complied with the WQOs at the Impact, Intermediate and Reference 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 deterioration in water quality during the reporting period.

Sediment Quality Monitoring for ESC CMPs

Pit Specific Sediment Chemistry of ESC CMP Vd – January to March 2018

Monitoring results showed that the concentrations of inorganic contaminants were generally below the Lower Chemical Exceedance Levels (LCELs) at all 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 did not cause any unacceptable deterioration in sediment quality of ESC CMP Vd during the reporting period.

Cumulative Impact Sediment Chemistry of ESC CMPs – February 2018

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 deterioration in sediment quality during the reporting period.

Demersal Trawling for ESC CMPs

During the sampling period in January and February 2018, the mean number of faunal species caught at Impact stations was lower than at Reference stations in January and February 2018. Biotic abundance, biomass, Catch per Unit Effort (CPUE) and Yield per Unit Effort (YPUE) were lower at Impact stations ESC-INA and ESC-INB in January and February 2018.

Sediment Toxicity Test of ESC CMPs

Statistical analysis showed that there were no significant differences between Impact and Reference stations in the toxicity tests of all tested marine benthos. Therefore, there did not appear to be any evidence of unacceptable impacts to sediment toxicity due to the mud disposal operations at ESC CMPs.

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（二零一八年一月至三月）

行政摘要

在2018年1月至3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水層質量監察、例行水質監察、指定污泥坑沉積物化學監察、沉積物化學累積性影響監察、沉積物毒性測試及底棲漁業資源監察。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

水層質量監察－2018年1月至3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 － 2018年1月和2月

2018年1月和2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－2018年1月至3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。

沉積物化學累積性影響監察－2018年2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。

沙洲以東污泥坑之底棲漁業資源監察

監察結果顯示，2018年1月和2月的底棲漁業資源在受影響監測站錄得較低的品種數量。而在2018年1月及2月受影響監測站ESC-INA及ESC-INB的生物量、生物重量、單位努力漁獲量及單位努力生產量均錄得較低的數值。

沙洲以東污泥坑之沉積物毒性測試

從統計結果顯示，所有已測試的海洋底棲生物在受影響監測站及參考監測站的沉積物毒性測試沒有明顯分別。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毒性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).

1.2 ACTIVITIES CONDUCTED DURING THE REPORTING PERIOD

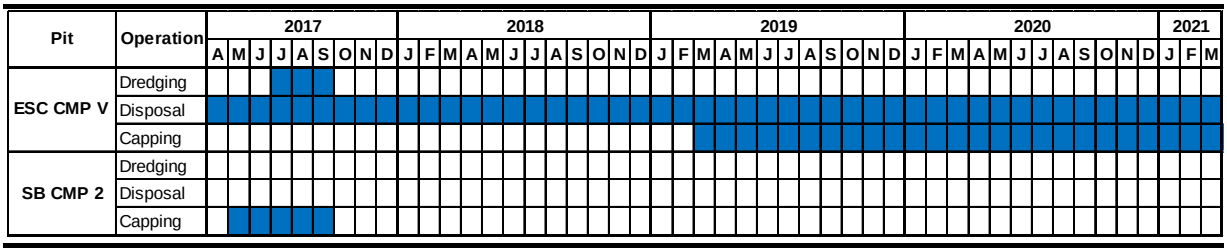
1.2.1 Detailed works schedule for ESC CMP V and SB CMPs is shown in *Figure 1.1*. During the reporting period of January to March 2018, the following works were being undertaken at the CMPs:

- Disposal of contaminated mud at ESC CMP Vd

(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.

Figure 1.1 Works Schedule for ESC CMPs



1.2.2 The records for contaminated mud disposal at ESC CMP Vd during the reporting period are presented in *Annex B* respectively.

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 January to March 2018* is to provide information regarding the findings in the quarterly reporting period of January to March 2018 on the environmental impacts resulting from 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 of ESC and SB. 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) (2) as well as the *Contract No. CV/2013/11 Sediment Disposal Facilities to the South of The Brothers, East of Sha Chau and East of Tung Lung Chau – Sampling* and *Contract No. CV/2013/12 Sediment Disposal Facilities to the South of The Brothers, East of Sha Chau and East of Tung Lung Chau – Testing*. Lam Geotechnics Limited and Wellab Limited were responsible for the sampling under *Contract No. CV/2013/11* and laboratory analyses under *Contract No. CV/2013/12*, 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).

(2) ERM (2015). Final Second Review of the EM&A Manual for SB CMPs. Prepared for CEDD for EM&A for Contaminated Mud Pit to the South of The Brothers and at East Sha Chau (2012-2017) – Investigation. Agreement No. CE 23/2012 (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 January to March 2018

Key Task	Date of Sampling & *in-situ* Measurement	Date of Results Received from the Contractors
ESC CMPs		
Water Column Profiling of ESC CMP Vd	5 January 2018 9 February 2018 6 March 2018	5 February 2018 5 March 2018 11 April 2018
Routine Water Quality Monitoring of ESC CMP V	3 January 2018 8 February 2018	5 February 2018 5 March 2018
Pit Specific Sediment Chemistry of ESC CMP Vd	2 January 2018 5 February 2018 5 March 2018	5 February 2018 5 March 2018 11 April 2018
Cumulative Impact Sediment Chemistry of ESC CMPs	6 and 7 February 2018	11 April 2018
Sediment Toxicity Tests of ESC CMP V	6 and 7 February 2018	3 April 2018
Demersal Trawling of ESC CMP V	10 and 11 January 2018 26 and 27 February 2018	6 February 2018 3 April 2018

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.

3.2 SUMMARY OF MONITORING RESULTS AND STATISTICAL ANALYSES FOR ESC CMPS

3.2.1 Water Column Profiling of ESC CMP Vd

3.2.2 *Water Column Profiling* for ESC CMP Vd was conducted once every month from January to March 2018 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 Dissolved Oxygen (DO) complied with the Water Quality Objectives (WQOs) at both Upstream and Downstream stations. Levels of DO, Turbidity and Suspended Solids (SS) also complied with the Action and Limit Levels at all stations.

3.2.3 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.

3.2.4 Routine Water Quality Monitoring of ESC CMP V

Background

3.2.5 *Routine Water Quality Monitoring* for ESC CMPs was conducted in January and February 2018 as presented in *Table 3.1*. A total of sixteen (16) and ten (10) stations were sampled in January and February 2018 respectively, and locations of the monitoring stations are presented in *Figures 3.1* and *3.2*. The disposal volume during the reporting period is detailed in *Annex B*. The monitoring results showed that levels of DO, Salinity and pH complied with the WQOs at the Impact, Intermediate and Reference stations in January and February 2018. Levels of DO, Turbidity and SS complied with the Action and Limit Levels at all stations in January and February 2018.

Summary of Statistical Analyses

3.2.6 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 February 2018 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.

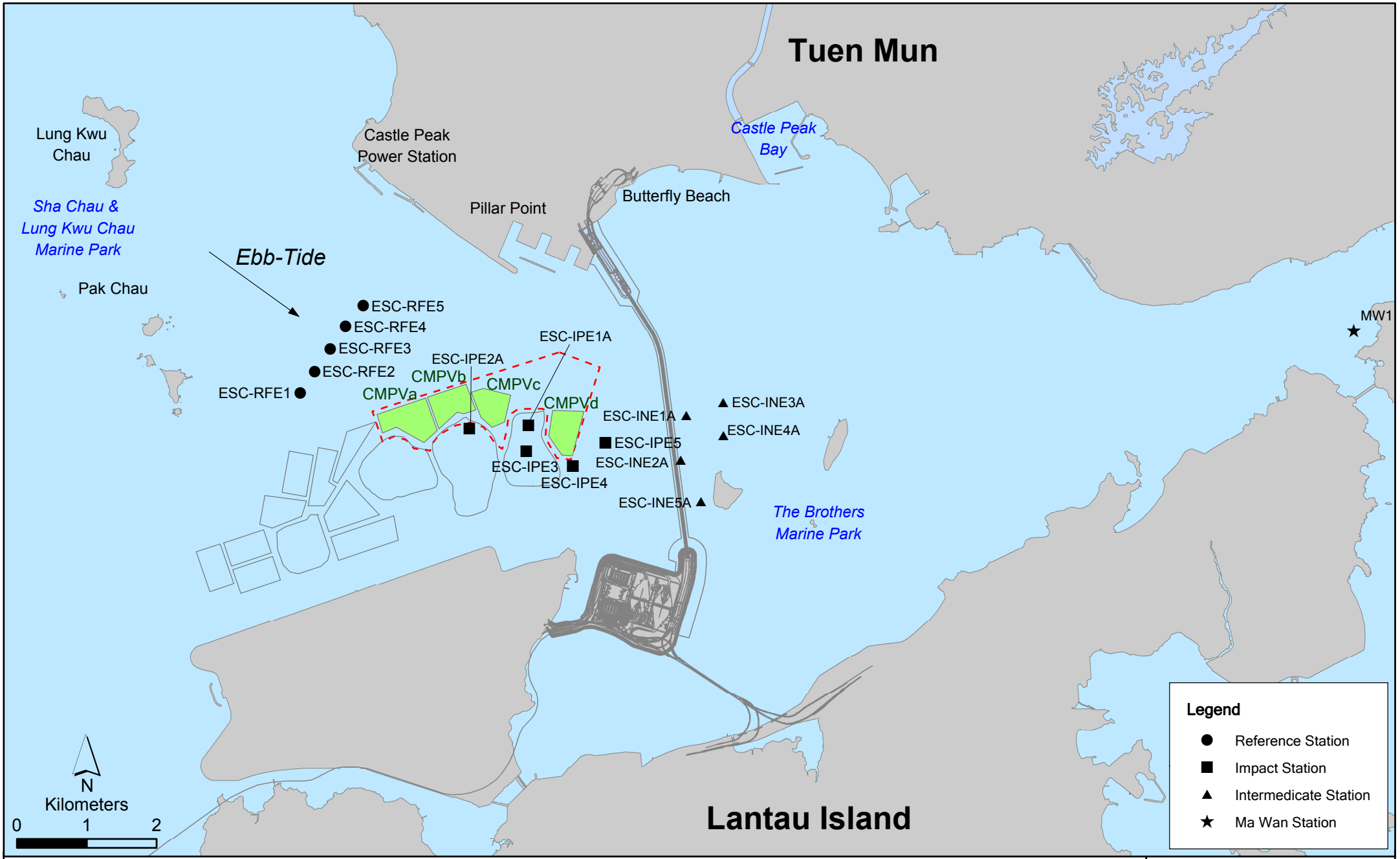


Figure 3.1

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

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Date: 19/4/2017

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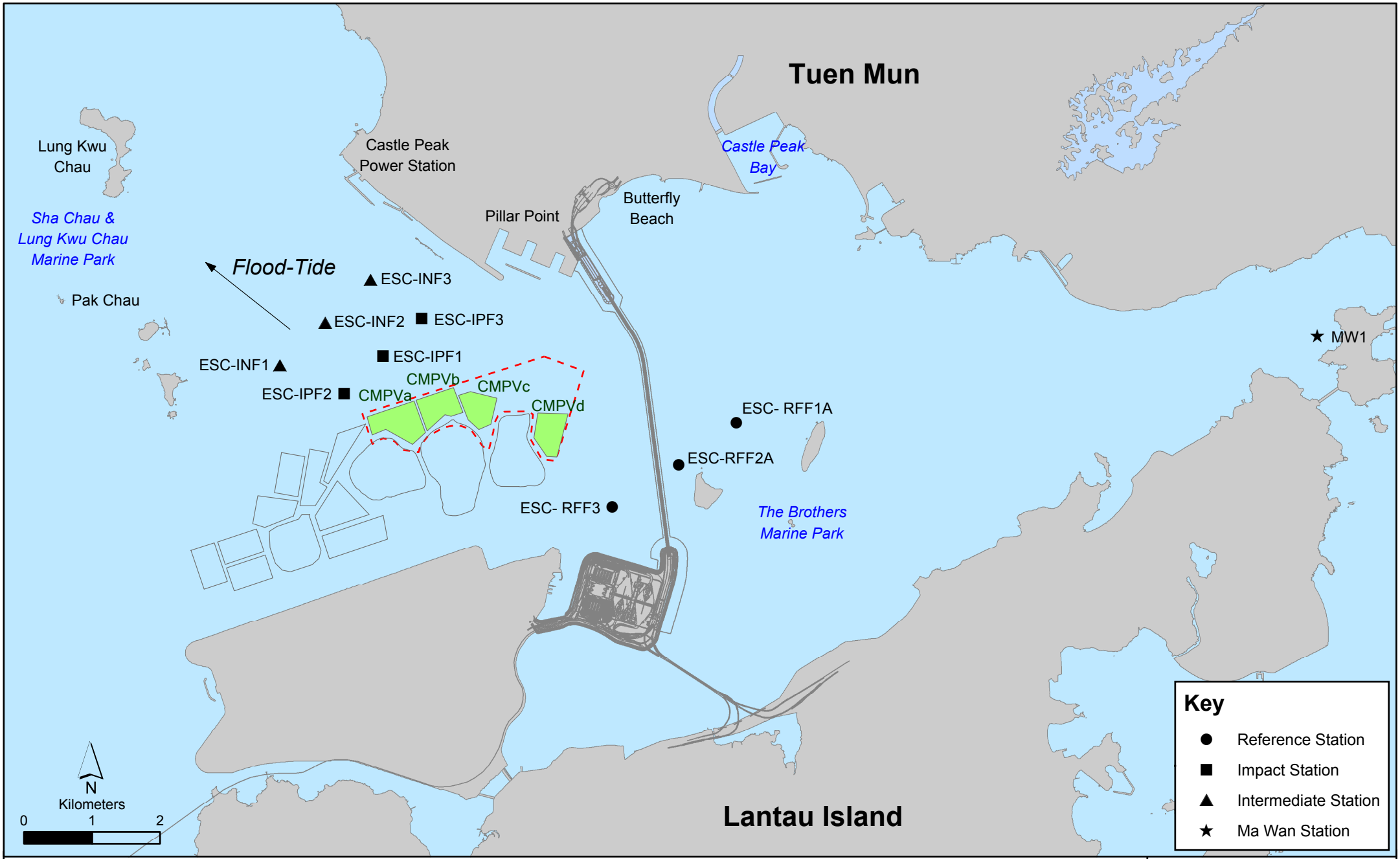

Figure 3.2

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

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Date: 25/4/2017

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3.2.7 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.

3.2.8 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)

3.2.9 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 significantly higher in February 2017 and were the lowest in July 2013, August 2016 and July 2017. DO levels were significantly higher at Intermediate stations than at other stations.

Turbidity

3.2.10 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 significantly higher in November 2017 than in other sampling periods. Ma Wan station had the significantly lowest Turbidity than at other stations.

Metals and Metalloid

3.2.11 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 February 2018). 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. The concentration of Copper was significantly higher in August 2013 when compared to all other sampling periods. The concentration of Nickel was significantly higher in April 2012 and August 2013. The concentration of Zinc was significantly higher in November 2017 when compared to all other sampling periods. Concentrations of Copper and Zinc were significantly lower at Intermediate stations than at other stations while concentrations of Nickel were significantly higher at Reference stations than other stations.

Inorganic Contaminants

Ammonia Nitrogen (NH_3-N)

3.2.12 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. Concentrations of NH_3-N were significantly higher in April 2012. Concentrations of NH_3-N were significantly lower at Intermediate stations than at other stations.

Total Inorganic Nitrogen (TIN)

3.2.13 TIN concentrations varied significantly with sampling periods and stations. 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. Concentrations of TIN were significantly higher in April 2012. Concentrations of TIN were significantly lower at Ma Wan station than at other stations.

5-Day Biochemical Oxygen Demand (BOD_5)

3.2.14 Levels of BOD_5 varied significantly with sampling area and periods. 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. Levels of BOD_5 were significantly higher in August 2016. Levels of BOD_5 were significantly lower at the Intermediate stations and Impact stations than at other stations.

Suspended Solids (SS)

3.2.15 SS levels varied significantly with sampling areas and periods. There was no consistent temporal trend of increasing concentrations of SS over time. SS levels were significantly higher in November 2017. SS levels were significantly higher at Impact stations, then at Intermediate stations and in turn higher than at Reference stations. 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 ($r^2 < 0.60$).

3.2.16 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.

3.2.17 ***Pit Specific Sediment Chemistry of ESC CMP Vd***

Background

3.2.18 *Pit Specific Sediment Chemistry of ESC CMP Vd* was conducted once every month from January to March 2018 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 most inorganic contaminants were below the Lower Chemical Exceedance Levels (LCELs) at all monitoring stations from January to March 2018, except for Arsenic at Active Pit station ESC-NPAB in March 2018.

Summary of Statistical Analyses

3.2.19 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.

3.2.20 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 3.2.7* and *3.2.8*. Detailed results of statistical analyses are presented in *Annex C*.

Metals and Metalloids

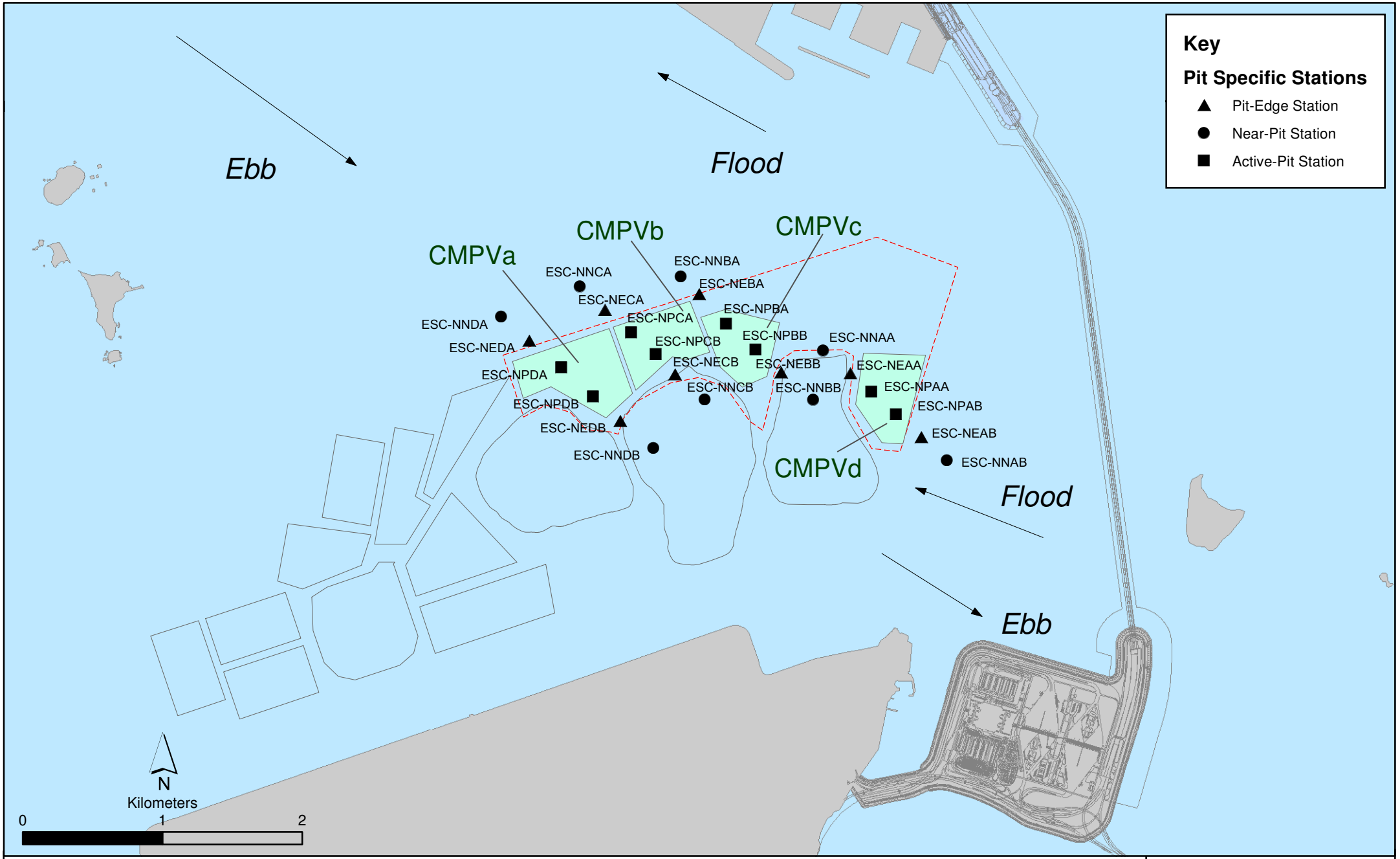

Figure 3.3

Pit Specific Sediment Quality Monitoring Stations for CMPV

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

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3.2.21 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, Copper, Lead, Mercury 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, Copper, Lead, Mercury 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, Copper, Lead, Mercury and Zinc levels and proximity to the pit ($r^2 < 0.60$).

Organic Contaminants

3.2.22 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.

3.2.23 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 Pit-Edge stations than at other stations. There was no consistent spatial trend of increasing concentrations of TOC with proximity to the pit or consistent temporal trend of increasing concentrations of TOC over time.

3.2.24 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.

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

Background

3.2.26 *Cumulative Impact Sediment Chemistry of ESC CMPs* was conducted in February 2018 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 below the LCELs at all monitoring stations in February 2018, except for Arsenic at Far-Field stations ESC-RFA and ESC-RFB, and Mid-Field stations ESC-RMA and ESC-RMB.

Summary of statistical analysis

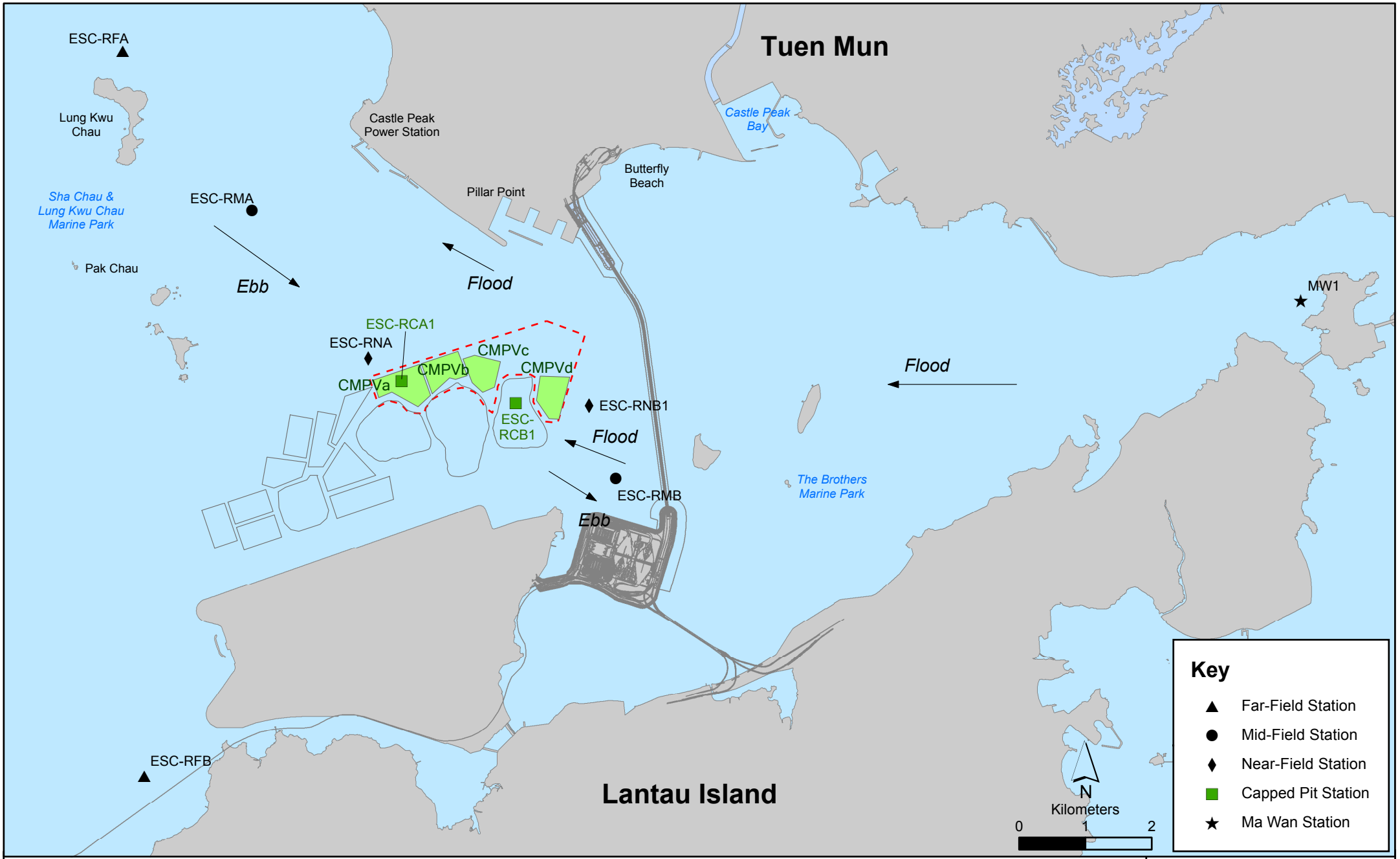

Figure 3.4

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

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3.2.27 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.

3.2.28 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 3.2.7* and *3.2.8*. Detailed results of statistical analyses are presented in *Annex C*.

Metals and Metalloid

3.2.29 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. In most cases, metal concentrations were significantly higher at Mid-Field or Ma Wan stations. The concentrations of all measured metals and metalloids did not appear to increase over time.

Organic Contaminants

3.2.30 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.

3.2.31 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. They were significantly higher at Ma Wan station than at other stations. 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.

3.2.32 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.

3.2.33 ***Sediment Toxicity Test of ESC CMP V***

3.2.34 Sediment Toxicity Tests were undertaken for sediments collected from the Impact (Near Pit), Reference and Ma Wan stations (see *Figure 3.5* for the sampling locations) in February 2018 using three international species (burrowing amphipod *Leptocheirus plumulosus*, marine benthic polychaete *Neanthes arenaceodentata* and marine bivalve *Crassostrea gigas*) and two local species (barnacles *Balanus amphitrite* and shrimp *Penaeus vannamei*).

3.2.35 Appropriate statistical test, i.e. ANOVA, was applied for comparing and determining the level of significance in the results in February 2018. For all of the ANOVA techniques, initial analyses were performed to ensure that the data are independent of each other, normally distributed and homogeneous. Should the data not comply with these assumptions then the appropriate transformation would be applied to the data. Data transformation (e.g. natural logarithm of chemical concentrations, square-root of a count and arcsine square-root of a proportion or percentage) would be used to reduce the within class heterogeneity of variance. If, after transformation, the data are still non-compliant (i.e. the residual errors are not normally distributed or variances are still heterogeneous) then rank transformed data would be applied to parametric or non-parametric equivalents to ANOVA such as Kruskal-Wallis tests. When significant difference are detected then multiple comparison procedures would be used (e.g. Student Newman Keuls Test or Turkey's HSD or Dunn's Test) to isolate where the differences is occurring.

3.2.36 Results of the Sediment Toxicity Tests in February 2018 showed that there were no significant differences between Impact and Reference stations in the toxicity tests of all tested marine benthos. Therefore, there did not appear to be any evidence of unacceptable impacts to sediment toxicity due to the mud disposal operations at ESC CMPs.

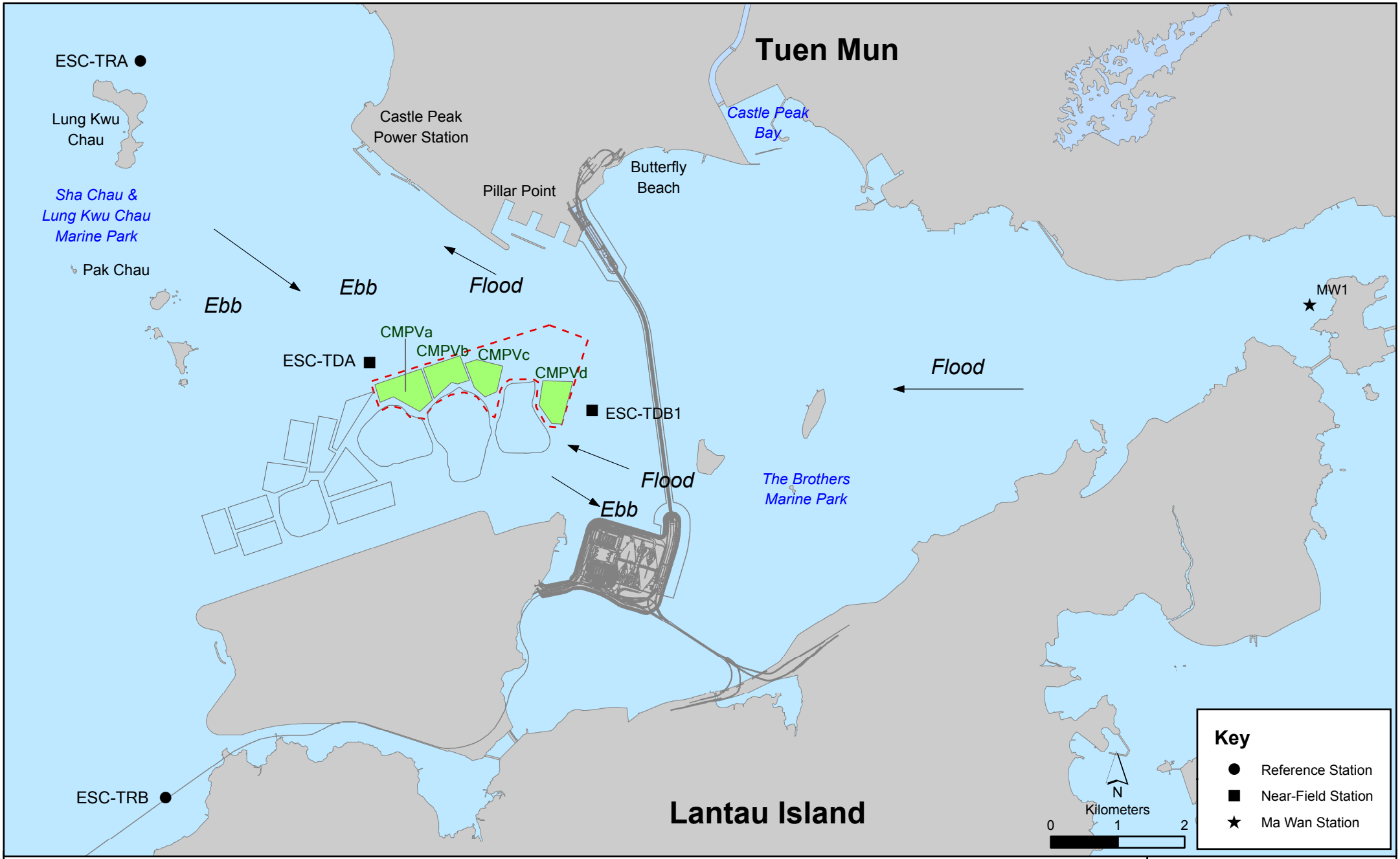

Figure 3.5

Sediment Toxicity Monitoring Stations for ESC CMPs

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

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3.2.37 ***Demersal Trawling – January and February 2018***

3.2.38 Fishery resources monitoring by demersal trawling was carried out at two (2) impact and four (4) reference stations (see *Figure 3.6* for locations) in January and February 2018. Monitoring results are presented in the following sections.

Abundance and Biomass

3.2.39 The average number of species collected in the period of January and February 2018 is presented in *Table 3.2*. Mean number of faunal species caught at Impact stations was lower than at Reference stations in January and February 2018.

3.2.40 Biotic abundance, Biomass, Catch per Unit Effort (CPUE) and Yield per Unit Effort (YPUE) were lower at Impact stations ESC-INA and ESC-INB in January and February 2018 (*Table 3.3*). Annual trend and statistical analyses will be conducted in the Annual EM&A Review Report to determine whether there is any evidence of unacceptable impact to fishery resources caused by the mud disposal operations at ESC CMP Vd.

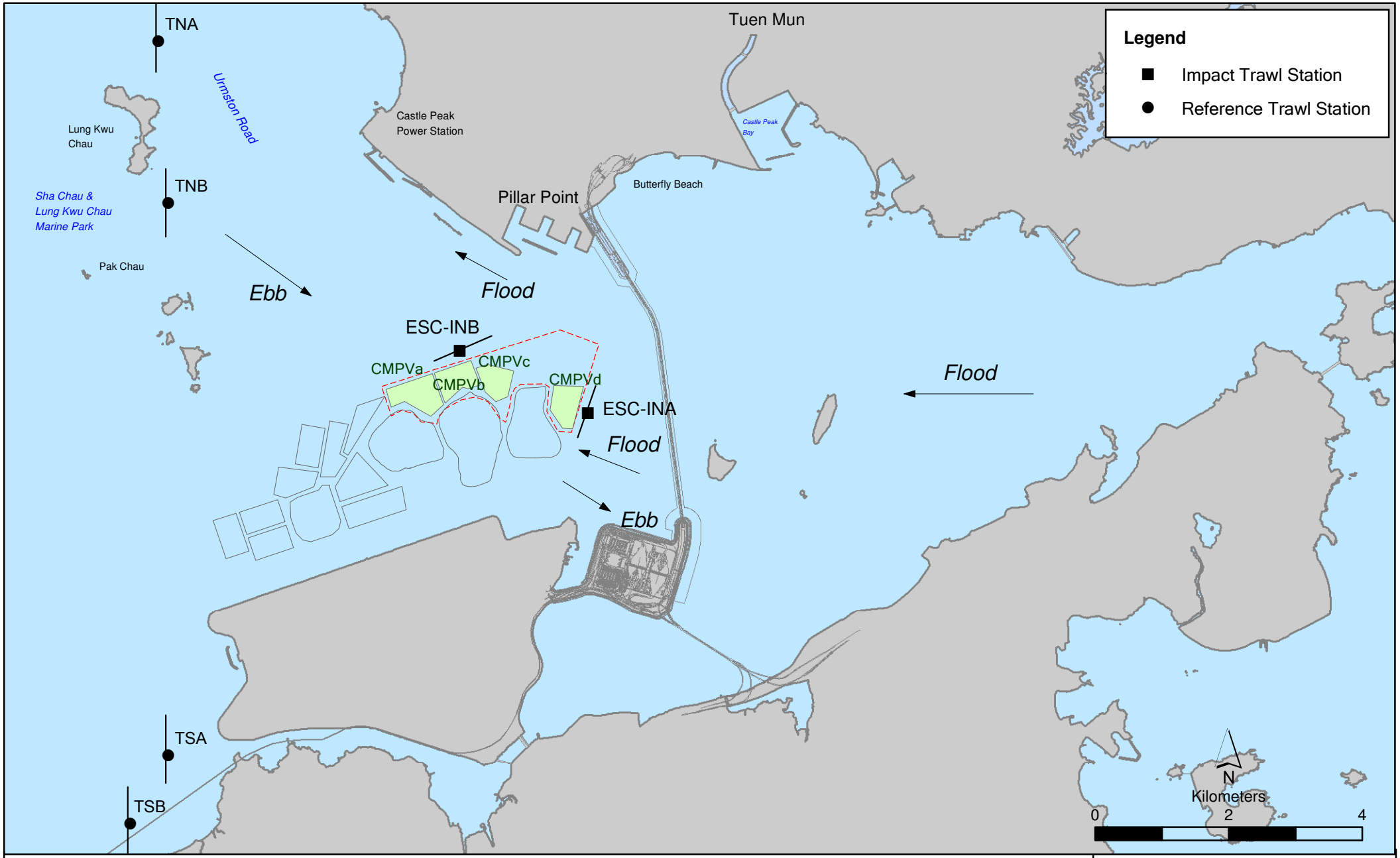

Figure 3.6

Marine Biota Monitoring Stations for CMPV

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Date: 2/6/2017

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Table 3.2 Summary of the Mean Number of Faunal Species Caught during January and February 2018 Monitoring

Mean Number of Faunal Species	Impact Stations		Reference Stations			
	ESC-INA	ESC-INB	TNA	TNB	TSA	TSB
January 2018	26.6	19.2	28.6	31.0	34.2	29.2
February 2018	31.4	32.0	33.6	41.2	43.2	35.2

Table 3.3 Summary of CPUE and YPUE during January and February 2018 Monitoring

Date	Stations	Stations	No. of Individuals per Station	Total Biomass per Station (g)	Mean CPUE#1 per Tow (No. / hr / net)	Mean YPUE#2 per Tow (g / hr / net)
Jan 2018	ESC-INA	Impact	761	16,608	152	3,322
Jan 2018	ESC-INB	Impact	658	8,925	132	1,785
Jan 2018	TNA	Reference	2,052	20,617	410	4,123
Jan 2018	TNB	Reference	1,385	24,074	277	4,815
Jan 2018	TSA	Reference	3,540	61,014	708	12,203
Jan 2018	TSB	Reference	1,031	31,158	206	6,232
Feb 2018	ESC-INA	Impact	2,399	17,510	480	3,502
Feb 2018	ESC-INB	Impact	2,349	16,684	470	3,337
Feb 2018	TNA	Reference	4,955	50,285	991	10,057
Feb 2018	TNB	Reference	4,785	47,186	957	9,437
Feb 2018	TSA	Reference	5,000	54,182	1,000	10,836
Feb 2018	TSB	Reference	4,234	47,776	847	9,555

Notes:

#1 CPUE is calculated by dividing the number of individuals with the trawling time and number of nets (in hour and number of nets)

#2 YPUE is calculated by dividing the weight (g) of fish with trawling effort (in hour and number of nets)

4 ACTIVITIES SCHEDULED FOR THE NEXT REPORTING PERIOD

4.1.1 The monitoring activities to be conducted in the next quarterly period of April to June 2018 for ESC CMPs include:

- *Water Column Profiling of ESC CMP Vd* in April, May and June 2018;
- *Routine Water Quality Monitoring of ESC CMPs* in April and May 2018;
- *Pit Specific Sediment Chemistry of ESC CMP Vd* in April, May and June 2018; and
- *Cumulative Impact Sediment Chemistry of ESC CMPs* in June 2018.

4.1.2 The sampling schedules for ESC CMPs are 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				3		3				3		3	
	ESC-IPE2A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-IPE3	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-IPE4	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-IPE5	4 times per year																							3				3		3				3		3				3		3				3		3	
Intermediate Station Downcurrent																																																			
	ESC-INE1A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INE2A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INE3A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INE4A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INE5A	4 times per year																							3				3		3				3		3				3		3				3		3	
Reference Station Upcurrent																																																			
	ESC-RFE1	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFE2	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFE3	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFE4	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFE5	4 times per year																							3				3		3				3		3				3		3				3		3	
Ma Wan Station																																																			
	MW1	4 times per year																							3				3		3				3		3				3		3				3		3	
Flood Tide																																																			
Impact Station Downcurrent																																																			
	ESC-IPF1	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-IPF2	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-IPF3	4 times per year																							3				3		3				3		3				3		3				3		3	
Intermediate Station Downcurrent																																																			
	ESC-INF1	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INF2	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INF3	4 times per year																							3				3		3				3		3				3		3				3		3	
Reference Station Upcurrent																																																			
	ESC-RFF1A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFF2A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFF3	4 times per year																							3				3		3				3		3				3		3				3		3	
Ma Wan Station																																																			
	MW1	4 times per year																							3				3		3				3		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																																										
	US2	3 times per week				2	2	2																																										
Downstream Stations																																																			
	DS1	3 times per week				2	2	2																																										
	DS2	3 times per week				2	2	2																																										
	DS3	3 times per week				2	2	2																																										
	DS4	3 times per week				2	2	2																																										
	DS5	3 times per week				2	2	2																																										
Ma Wan Station																																																			
	MW1	3 times per week				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 A2 - Environmental Monitoring and Audit Sampling Schedule for South of The Brothers (April 2017 - December 2018)

			2017									2018												
Capping Water Quality Monitoring			**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Ebb Tide																								
Impact Stations Downcurrent																								
	SB-IPE1	4 times per year		3	3		3	3																
	SB-IPE2	4 times per year		3	3		3	3																
	SB-IPE3	4 times per year		3	3		3	3																
	SB-IPE4	4 times per year		3	3		3	3																
	SB-IPE5	4 times per year		3	3		3	3																
Intermediate Stations Downcurrent																								
	SB-INE1	4 times per year		3	3		3	3																
	SB-INE2	4 times per year		3	3		3	3																
	SB-INE3	4 times per year		3	3		3	3																
	SB-INE4	4 times per year		3	3		3	3																
	SB-INE5	4 times per year		3	3		3	3																
Reference Stations Upcurrent																								
	SB-RFE1	4 times per year		3	3		3	3																
	SB-RFE2	4 times per year		3	3		3	3																
	SB-RFE3	4 times per year		3	3		3	3																
	SB-RFE4	4 times per year		3	3		3	3																
	SB-RFE5	4 times per year		3	3		3	3																
Sensitive Receiver Stations																								
	MW1	4 times per year		3	3		3	3																
	THB1	4 times per year		3	3		3	3																
	THB2	4 times per year		3	3		3	3																
	WSR45C	4 times per year		3	3		3	3																
	WSR46	4 times per year		3	3		3	3																
Flood Tide																								
Impact Stations Downcurrent																								
	SB-IPF1	4 times per year		3	3		3	3																
	SB-IPF2	4 times per year		3	3		3	3																
	SB-IPF3	4 times per year		3	3		3	3																
Intermediate Stations Downcurrent																								
	SB-INF1	4 times per year		3	3		3	3																
	SB-INF2	4 times per year		3	3		3	3																
	SB-INF3	4 times per year		3	3		3	3																
Reference Stations Upcurrent																								
	SB-RFF1	4 times per year		3	3		3	3																
	SB-RFF2	4 times per year		3	3		3	3																
	SB-RFF3	4 times per year		3	3		3	3																
Sensitive Receiver Stations																								
	MW1	4 times per year		3	3		3	3																
	THB1	4 times per year		3	3		3	3																
	THB2	4 times per year		3	3		3	3																
	WSR45C	4 times per year		3	3		3	3																
	WSR46	4 times per year		3	3		3	3																

Benthic Recolonisation Studies			**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Capped Contaminated Mud Pits																							
	SB-CPA	2 times per year					12				12								12				12
	SB-CPB	2 times per year					12				12								12				12
Reference Stations																							
	RBA	2 times per year					12				12								12				12
	RBB	2 times per year					12				12								12				12
	RBC	2 times per year					12				12								12				12

Notes:
The number shown in each cell represents the numbers of replicates per monitoring station
Capping works are planned to be conducted between May and December 2017.

Annex B

Disposal Records

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
1-Jan-2018	3148	923,722
2-Jan-2018	1211	924,933
3-Jan-2018	1063	925,996
4-Jan-2018	4305	930,301
5-Jan-2018	4286	934,587
6-Jan-2018	3483	938,070
7-Jan-2018	1840	939,910
8-Jan-2018	1368	941,278
9-Jan-2018	3300	944,578
10-Jan-2018	3400	947,978
11-Jan-2018	3800	951,778
12-Jan-2018	2220	953,998
13-Jan-2018	2000	955,998
14-Jan-2018	3300	959,298
15-Jan-2018	2000	961,298
16-Jan-2018	400	961,698
17-Jan-2018	706	962,404
18-Jan-2018	0	962,404
19-Jan-2018	2004	964,408
20-Jan-2018	2021	966,429
21-Jan-2018	0	966,429
22-Jan-2018	617	967,046
23-Jan-2018	650	967,696
24-Jan-2018	1132	968,828
25-Jan-2018	500	969,328
26-Jan-2018	638	969,966
27-Jan-2018	500	970,466
28-Jan-2018	1201	971,667
29-Jan-2018	1491	973,158
30-Jan-2018	0	973,158
31-Jan-2018	0	973,158
1-Feb-2018	0	973,158
2-Feb-2018	0	973,158
3-Feb-2018	0	973,158
4-Feb-2018	0	973,158
5-Feb-2018	1000	974,158
6-Feb-2018	0	974,158
7-Feb-2018	0	974,158
8-Feb-2018	585	974,743
9-Feb-2018	573	975,316
10-Feb-2018	6399	981,715
11-Feb-2018	5976	987,691
12-Feb-2018	4871	992,562
13-Feb-2018	614	993,176
14-Feb-2018	1263	994,439
15-Feb-2018	0	994,439
16-Feb-2018	0	994,439
17-Feb-2018	0	994,439
18-Feb-2018	0	994,439
19-Feb-2018	0	994,439
20-Feb-2018	1370	995,809
21-Feb-2018	2879	998,688
22-Feb-2018	2626	1,001,314
23-Feb-2018	1437	1,002,751
24-Feb-2018	2758	1,005,509
25-Feb-2018	1600	1,007,109
26-Feb-2018	2629	1,009,738

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
27-Feb-2018	5811	1,015,549
28-Feb-2018	4536	1,020,085
1-Mar-2018	4268	1,024,353
2-Mar-2018	2842	1,027,195
3-Mar-2018	0	1,027,195
4-Mar-2018	0	1,027,195
5-Mar-2018	0	1,027,195
6-Mar-2018	0	1,027,195
7-Mar-2018	0	1,027,195
8-Mar-2018	0	1,027,195
9-Mar-2018	0	1,027,195
10-Mar-2018	600	1,027,795
11-Mar-2018	716	1,028,511
12-Mar-2018	673	1,029,184
13-Mar-2018	514	1,029,698
14-Mar-2018	666	1,030,364
15-Mar-2018	0	1,030,364
16-Mar-2018	1113	1,031,477
17-Mar-2018	0	1,031,477
18-Mar-2018	636	1,032,113
19-Mar-2018	126	1,032,239
20-Mar-2018	737	1,032,976
21-Mar-2018	0	1,032,976
22-Mar-2018	572	1,033,548
23-Mar-2018	1101	1,034,649
24-Mar-2018	1028	1,035,677
25-Mar-2018	0	1,035,677
26-Mar-2018	1113	1,036,790
27-Mar-2018	0	1,036,790
28-Mar-2018	1236	1,038,026
29-Mar-2018	61	1,038,087
30-Mar-2018	1200	1,039,287
31-Mar-2018	1005	1,040,292

Annex C

Statistical Analysis

Routine Water Quality Monitoring for ESC CMPs – Analysis of Variance and Linear Regression Analysis up to February 2018

Dissolved Oxygen

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	463763.967	3	154587.989	9.385	**
Period	416497726.521	28	14874918.804	903.048	**
Area * Period	25422110.652	84	302644.174	18.373	**
Error	30802457.312	1870	16471.902		
Total	2613022497.500	1986			

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

Turbidity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	15477095.909	3	5159031.970	57.260	**
Period	268755327.721	28	9598404.561	106.532	**
Area * Period	71742104.270	84	854072.670	9.479	**
Error	168484968.554	1870	90098.914		
Total	2612991603.500	1986			

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

SNK Results:

- Nov 17 > Oct 17 = Aug 13 > Apr 17 = Apr 12 = Aug 12 ≥ Nov 16 = Oct 16 ≥ Nov 12 = Jul 16 ≥ Jul 17 = May 16 ≥> Apr 13 = Feb 12 ≥ Apr 16 ≥ Jan 17 ≥ Oct 12 = Jul 12 ≥ **Jan 18** = Aug 17 ≥ Aug 16 = Feb 13 = **Feb 18** = May 12 ≥ Jan 13 ≥ Jul 13 = 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	1060447602.981	27	39275837.147	656.097	**
Area	21800363.138	3	7266787.713	121.391	**
Station(Area)	15357891.197	24	639912.133	10.690	**
Period * Area	208204063.877	78	2669282.870	44.590	**
Period * Station(Area)	179802476.178	228	788607.352	13.174	**
Error	154206806.813	2576	59862.891		
Total	8472657646.500	2944			

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

SNK Results:

- Aug 13 > Feb 12 > Jul 13 = Apr 12 > Jan 13 = May 16 = Apr 13 > Nov 12 > Apr 17 > May 12 > Apr 16 = Oct 12 > Jul 16 ≥ May 13 ≥ **Jan 18** = Aug 16 > May 17 > Aug 12 = Jul 12 > Nov 17 = Feb 13 > **Feb 18** ≥ Aug 17 = Oct 17 > Jan 17 = Oct 16 = 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	1137278866.723	27	42121439.508	425.724	**
Area	23981999.110	3	7993999.703	80.796	**
Station(Area)	33972214.135	24	1415508.922	14.307	**
Period * Area	168161452.873	78	2155916.062	21.790	**
Period * Station(Area)	129231218.349	228	566803.589	5.729	**
Error	254871037.063	2576	98940.620		
Total	8468875329.500	2944			

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

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	1389861942.173	27	51476368.229	802.323	**
Area	25305100.571	3	8435033.524	131.471	**
Station(Area)	31013073.736	24	1292211.406	20.141	**
Period * Area	155840997.506	78	1997961.506	31.141	**
Period * Station(Area)	185877039.685	228	815250.174	12.707	**
Error	165273922.563	2576	64159.131		
Total	8508466155.500	2944			

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 > Apr 12 = Feb 12 = Aug 13 > Jul 12 ≥ Nov 12 = Jul 13 > May 16 ≥ May 12 ≥ Jan 17 ≥ Jan 13 = Apr 13 = Oct 16 = Oct 12 = Apr 16 > Nov 16 = Jul 16 > 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	1489009343.880	27	55148494.218	1061.961	**
Area	4257761.442	3	1419253.814	27.330	**
Station(Area)	12033014.499	24	501375.604	9.655	**
Period * Area	82791937.250	78	1061435.093	20.439	**
Period * Station(Area)	71931693.626	228	315489.884	6.075	**
Error	133773755.125	2576	51930.806		
Total	8504995921.000	2944			

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

SNK Results:

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

Total Inorganic Nitrogen

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	1305698157.327	27	48359191.012	1426.393	**
Area	32193575.141	3	10731191.714	316.525	**
Station(Area)	39414625.295	24	1642276.054	48.440	**
Period * Area	99211402.909	78	1271941.063	37.517	**
Period * Station(Area)	103374779.359	228	453398.155	13.373	**
Error	87334475.375	2576	33903.135		
Total	8509321706.500	2944			

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

SNK Results:
- Apr 12 > Aug 13 > Apr 17 > May 13 = Jul 16 > Jul 12 > Aug 17 > Jul 17 > May 12 = Aug 16 > May 17 = Aug 12 > Jul 13 = May 16 > Oct 17 > Apr 13 > Feb 17 = Apr 16 > **Jan 18** > Oct 12 > Feb 12 > Nov 16 > Jan 17 = Oct 16 > Nov 12 > **Feb 18** > 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	837774727.509	27	31028693.611	209.727	**
Area	13541728.409	3	4513909.470	30.510	**
Station(Area)	12490286.561	24	520428.607	3.518	**
Period * Area	277833744.889	78	3561971.088	24.076	**
Period * Station(Area)	269440827.514	228	1181758.015	7.988	**
Error	381113487.625	2576	147947.782		
Total	8502889831.000	2944			

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

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

Suspended Solids

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	991748682.097	27	36731432.670	1473.240	**
Area	7731375.460	3	2577125.153	103.364	**
Station(Area)	123056341.476	24	5127347.562	205.650	**
Period * Area	248109245.784	78	3180887.766	127.580	**
Period * Station(Area)	424024198.732	228	1859755.258	74.592	**
Error	64225923.000	2576	24932.424		
Total	8508554464.500	2944			

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

SNK Results:

- Nov 17 > Jul 12 > Nov 12 > Nov 16 = Jul 16 = Oct 16 = Aug 12 > Apr 12 ≥ Apr 17 = Oct 17 ≥ May 16 = Oct 12 > Aug 13 > Jan 17 = Apr 16 = Jul 17 > Apr 13 > Feb 12 > **Jan 18** = Aug 16 > Feb 13 > **Feb 18** = Jan 13 > Aug 17 > May 13 > 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	-0.106	0.106	0.011	**

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

Pit Specific Sediment Chemistry for ESC CMP Vd – Analysis of Variance (up to March 2018)

Arsenic

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	272154177.453	24	11339757.394	325.229	**
Area	5923368.522	2	2961684.261	84.942	**
Station(Area)	49952093.050	3	16650697.683	477.549	**
Period * Area	35037918.123	48	729956.628	20.935	**
Period * Station(Area)	52159553.061	71	734641.592	21.070	**
Error	57042452.755	1636	34867.025		
Total	1897346239.000	1785			

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

SNK Results:

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

Cadmium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	99203694.253	24	4133487.261	60.845	**
Area	119363947.954	2	59681973.977	878.520	**
Station(Area)	11744112.636	3	3914704.212	57.625	**
Period * Area	57299562.255	48	1193740.880	17.572	**
Period * Station(Area)	65899293.763	71	928159.067	13.663	**
Error	111073217.629	1635	67934.690		
Total	1890145721.000	1784			

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

SNK Results:

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

Linear Regression Analysis

Source	df	Slope	r	r^2	P
Area	1	-0.502	0.502	0.252	**

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

Chromium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	177277331.647	24	7386555.485	122.694	**
Area	14072497.719	2	7036248.859	116.875	**
Station(Area)	33938187.478	3	11312729.159	187.909	**
Period * Area	67425198.703	48	1404691.640	23.333	**
Period * Station(Area)	81622063.513	71	1149606.528	19.095	**
Error	98492319.739	1636	60203.129		
Total	1897396807.500	1785			

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

SNK Results:

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

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	70899978.926	24	2954165.789	67.153	**
Area	132385926.180	2	66192963.090	1504.667	**
Station(Area)	32606779.534	3	10868926.511	247.067	**
Period * Area	82711240.872	48	1723150.851	39.170	**
Period * Station(Area)	83516022.133	71	1176282.002	26.739	**
Error	71970543.745	1636	43991.775		
Total	1897397000.500	1785			

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

SNK Results:

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

Linear Regression Analysis

Source	df	Slope	r	r^2	P
Area	1	-0.467	0.467	0.218	**

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

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	152070302.469	24	6336262.603	162.038	**
Area	32066207.014	2	16033103.507	410.017	**
Station(Area)	65741531.086	3	21913843.695	560.405	**
Period * Area	65517232.599	48	1364942.346	34.906	**
Period * Station(Area)	93814570.690	71	1321331.982	33.791	**
Error	63973407.906	1636	39103.550		
Total	1897396519.500	1785			

Note:

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

SNK Results:

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

Lead

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	120571072.197	24	5023794.675	65.838	**
Area	23456155.235	2	11728077.617	153.700	**
Station(Area)	60130980.189	3	20043660.063	262.678	**
Period * Area	53478011.379	48	1114125.237	14.601	**
Period * Station(Area)	90902937.267	71	1280323.060	16.779	**
Error	124835201.954	1636	76305.136		
Total	1897396869.000	1785			

Note:

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

SNK Results:

- Mar 17 > Jul 17 ≥ Oct 17 = May 17 > Jun 17 ≥ Sep 17 = Aug 17 = **Mar 18** = Nov 17 ≥ Apr 16 ≥ Mar 16 = **Jan 18** = Jun 16 = Jul 16 = Aug 16 ≥ Nov 16 = Apr 17 ≥ **Feb 18** = May 16 = Dec 17 = Oct 16 = 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	-0.219	0.219	0.048	**
Note: Linear regression analysis on spatial changes of contaminant concentrations.					

Mercury

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	330528376.270	24	13772015.678	301.944	**
Area	4807981.632	2	2403990.816	52.706	**
Station(Area)	566110.816	3	188703.605	4.137	**
Period * Area	30525425.481	48	635946.364	13.943	**
Period * Station(Area)	15171829.244	71	213687.736	4.685	**
Error	74619785.833	1636	45611.116		
Total	1882307760.500	1785			

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

Linear Regression Analysis					
Source	df	Slope	r	r^2	P
Area	1	-0.108	0.108	0.012	**
Note: Linear regression analysis on spatial changes of contaminant concentrations.					

Silver

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	62036261.393	24	2584844.225	52.711	**
Area	146248377.684	2	73124188.842	1491.162	**
Station(Area)	11275475.350	3	3758491.783	76.644	**
Period * Area	95843488.219	48	1996739.338	40.718	**
Period * Station(Area)	74675906.777	71	1051773.335	21.448	**
Error	80177782.519	1635	49038.399		
Total	1893629989.000	1784			

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

SNK Results:

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

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	167485744.840	24	6978572.702	165.494	**
Area	22147869.302	2	11073934.651	262.614	**
Station(Area)	59879550.258	3	19959850.086	473.340	**
Period * Area	81651417.537	48	1701071.199	40.340	**
Period * Station(Area)	72080915.487	71	1015224.162	24.076	**
Error	68987008.359	1636	42168.098		
Total	1897395149.000	1785			

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

SNK Results:

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

Linear Regression Analysis

Source	df	Slope	r	r^2	P
Area	1	-0.215	0.215	0.046	**

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	179011112.156	24	7458796.340	188.140	**
Area	17501061.589	2	8750530.794	220.722	**
Station(Area)	26691021.846	3	8897007.282	224.417	**
Period * Area	80249987.925	48	1671874.748	42.171	**
Period * Station(Area)	105264640.328	71	1482600.568	37.397	**
Error	64859208.092	1636	39644.993		
Total	1897257369.500	1785			

Note:
1. Data are rank-transformed;

2. NS: No significant difference;
3. **: Significant difference

SNK Results:

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

Cumulative Impact Sediment Chemistry for ESC CMPs – Analysis of Variance (up to February 2018)

Arsenic

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	14294311.880	7	2042044.554	402.699	**
Area	3351877.524	4	837969.381	165.251	**
Area * Station	775875.089	4	193968.772	38.251	**
Period * Area	28410363.643	27	1052235.690	207.505	**
Period * Area * Station	2350357.224	28	83941.329	16.554	**
Error	4016146.250	792	5070.892		
Total	215357241.000	864			

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

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

Cadmium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	10399664.782	7	1485666.397	85.690	**
Area	5708456.831	4	1427114.208	82.313	**
Area * Station	9397598.327	4	2349399.582	135.508	**
Period * Area	10771280.756	27	398936.324	23.010	**
Period * Area * Station	2942595.163	28	105092.684	6.062	**
Error	13731470.167	792	17337.715		
Total	214790417.500	864			

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

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

Chromium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	2636500.858	7	376642.980	57.484	**
Area	16230533.672	4	4057633.418	619.285	**
Area * Station	6332480.331	4	1583120.083	241.619	**
Period * Area	14134398.367	27	523496.236	79.897	**
Period * Area * Station	5751437.565	28	205408.484	31.350	**
Error	5189286.125	792	6552.129		
Total	215364157.500	864			

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

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

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	2751315.364	7	393045.052	54.644	**
Area	13208695.681	4	3302173.920	459.095	**
Area * Station	16349420.793	4	4087355.198	568.257	**
Period * Area	9016222.514	27	333934.167	46.426	**
Period * Area * Station	3304034.280	28	118001.224	16.405	**
Error	5696691.000	792	7192.792		
Total	215364181.000	864			

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

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

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	4855919.823	7	693702.832	128.087	**
Area	9459932.253	4	2364983.063	436.677	**
Area * Station	7938584.818	4	1984646.204	366.451	**
Period * Area	17777616.924	27	658430.256	121.574	**
Period * Area * Station	6852164.432	28	244720.158	45.186	**
Error	4289362.208	792	5415.861		
Total	215364106.000	864			

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

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

Lead

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	17195372.886	7	2456481.841	465.102	**
Area	9253508.744	4	2313377.186	438.007	**
Area * Station	3826714.465	4	956678.616	181.134	**
Period * Area	14440547.572	27	534835.095	101.264	**
Period * Area * Station	3553165.691	28	126898.775	24.027	**
Error	4183026.792	792	5281.599		
Total	215364162.500	864			

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

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

Mercury

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	28241346.322	7	4034478.046	225.691	**
Area	729400.046	4	182350.012	10.201	**
Area * Station	688567.846	4	172141.962	9.630	**
Period * Area	4488259.288	27	166231.825	9.299	**
Period * Area * Station	1456023.924	28	52000.854	2.909	**
Error	14157857.375	792	17876.083		
Total	212986948.500	864			

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

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

Silver

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	4277017.002	7	611002.429	66.676	**
Area	15542447.633	4	3885611.908	424.022	**
Area * Station	19561487.297	4	4890371.824	533.668	**
Period * Area	2657833.219	27	98438.267	10.742	**
Period * Area * Station	3531879.495	28	126138.553	13.765	**
Error	7257651.292	792	9163.701		
Total	215294546.500	864			

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

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

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	916069.482	7	130867.069	31.307	**
Area	12454847.187	4	3113711.797	744.884	**
Area * Station	13250235.686	4	3312558.922	792.454	**
Period * Area	16057130.344	27	594708.531	142.270	**
Period * Area * Station	3875417.303	28	138407.761	33.111	**
Error	3310661.333	792	4180.128		
Total	215363833.000	864			

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

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

TOC

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	8823786.804	7	1260540.972	156.444	**
Area	10100715.276	4	2525178.819	313.397	**
Area * Station	3443800.507	4	860950.127	106.851	**
Period * Area	14421834.122	27	534142.005	66.292	**
Period * Area * Station	6672447.108	28	238301.682	29.575	**
Error	6381504.875	792	8057.456		
Total	215345616.000	864			

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

SNK Results:

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

TBT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	11115195.092	7	1587885.013	97.528	**
Area	12614960.231	4	3153740.058	193.702	**
Area * Station	3281611.255	4	820402.814	50.389	**
Period * Area	3392909.509	27	125663.315	7.718	**
Period * Area * Station	3485086.599	28	124467.379	7.645	**
Error	12894869.583	792	16281.401		
Total	211372731.000	864			

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

SNK Results:

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

Sediment Toxicity for ESC CMP Vd – February and March 2018

Survival rate for burrowing amphipod Leptochirus plumulosus

Source	Survival
Chi-Sqaure	0.236
Df	2
Asymp. Sig.	NS

Note:
1. NS: No significant difference;
2. **: Significant difference

Growth rate for benthic polychaete Neanthes arenaceodentata

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2293.160	4	573.290	0.429	NS
Within Groups	160446.340	120	1337.053		
Total	162739.500	124			

Note:
1. NS: No significant difference;
2. **: Significant difference

Survival rate for marine bivalve Crassostrea gigas

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16505.540	4	4126.385	3.390	**
Within Groups	146048.960	120	1217.075		
Total	162554.500	122			

Note:
1. NS: No significant difference;
2. **: Significant difference

SNK Results: MW1 ≥ ESC-TRB = ESC-TRA = ESC-TDB = ESC-TDA

Mortality rate for barnacles Balanus Amphitrite

Source	Mortaility
Chi-Sqaure	2.631
Df	2
Asymp. Sig.	NS

Note:
1. NS: No significant difference;
2. **: Significant difference

Mortality rate for shrimp Penaeus vannaamei

Source	Mortality
Chi-Sqaure	5.277
df	2
Asymp. Sig.	NS

Note:
1. NS: No significant difference;
2. **: Significant difference