Annex 5A

Water Quality Modelling Methodology Statement

CONTENTS

1 INTRODUCTION 1

1.1 BACKGROUND 1
1.2 PURPOSE OF THE METHOD STATEMENT 3
1.3 INTERPRETATION OF THE REQUIREMENTS: KEY ISSUES AND CONSTRAINTS 3
1.4 MODEL SELECTION 3
1.5 COASTLINE CONFIGURATIONS & BATHYMETRY 7
1.6 BOUNDARY CONDITIONS AND INITIAL CONDITIONS 9
1.7 AMBIENT ENVIRONMENTAL CONDITIONS – BACKGROUND TEMPERATURE, SOLAR RADIATION AND WIND 9
1.8 SIMULATION PERIODS 9
1.9 MODEL VERIFICATION 10
1.10 UNCERTAINTIES IN ASSESSMENT METHODOLOGIES 10

2 WATER SENSITIVE RECEIVERS 13

3 CONSTRUCTION PHASE 15

3.1 ASSESSMENT CRITERIA FOR CONSTRUCTION PHASE 15
3.2 WORKING TIME FOR MARINE DREDGING 18
3.3 OVERVIEW OF DREDGING PLANT - GRAB DREDGERS 19
3.4 CONSTRUCTION SCENARIO – GRAB DREDGING FOR SUBMARINE OUTFALL 22
3.5 SEDIMENT INPUT PARAMETERS 24
3.6 DISSOLVED OXYGEN DEPLETION 24
3.7 NUTRIENTS 25
3.8 HEAVY METALS AND MICRO-ORGANIC POLLUTANTS 26
3.9 EFFLUENT DISCHARGE FROM TEMPORARY SEWAGE TREATMENT PLANT 26

4 OPERATION PHASE 27

4.1 ASSESSMENT CRITERIA FOR OPERATION PHASE 27
4.2 MODELLING SCENARIOS 27
4.3 COMPILATION OF BACKGROUND POLLUTION LOADING 28

5 CUMULATIVE IMPACTS 38

5.1 DC/2012/09 NORTH DISTRICT SEWERAGE, STAGE 2 PART 2A - PAK HOK LAM TRUNK SEWER AND SHA TAU KOK VILLAGE SEWERAGE 38
5.2 SEDIMENT REMOVAL AT SHA TAU KOK FISH CULTURE ZONE, BOAT SHELTER AND APPROACH CHANNEL 39

6 MODEL SCENARIOS 41

Annex A Delft3D FLOW Model Verification

1 *INTRODUCTION*

1.1 *BACKGROUND*

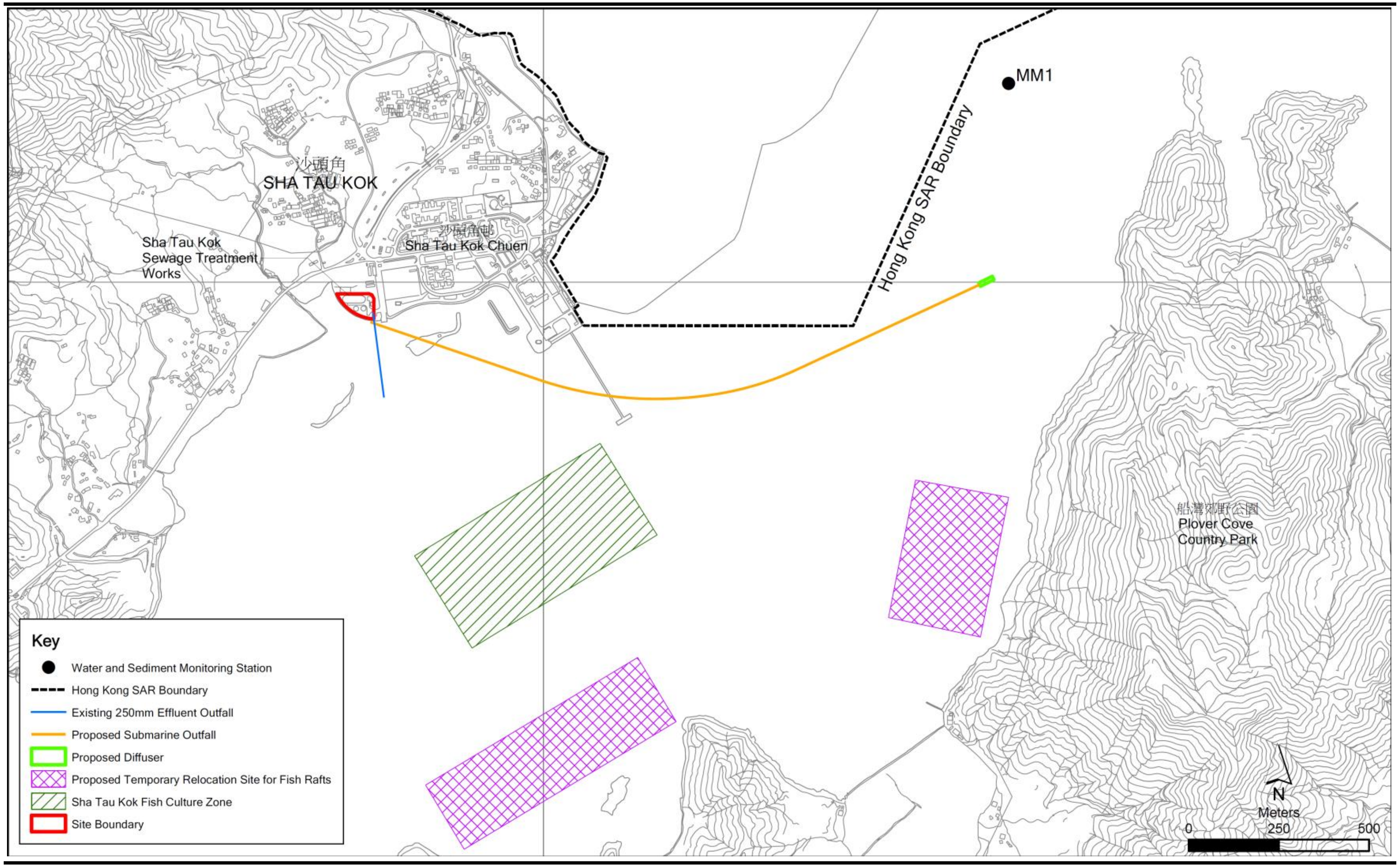
The existing Sha Tau Kok Sewage Treatment Works (STKSTW) provides secondary level treatment to sewage collected from Sha Tau Kok Township (including Yim Liu Ha, Tsoi Yuen Kok and Sha Tau Kok Tsuen). STKSTW was commissioned in 1989 with a design capacity of 1,660 m^3/day at average dry weather flow (ADWF). The STKSTW and its surrounding environment are shown in *Figure 1.1* below.

To cope with the forecast increase in sewage flow upon completion of sewerage under the project "North District sewerage, stage 2 part 2A - Pak Hok Lam trunk sewer and Sha Tau Kok village sewerage" in Sha Tau Kok areas and extension of village sewerage in the areas as planned by Environmental Protection Department (EPD), as well as the proposed housing developments in Sha Tau Kok town, there is an urgent need for the expansion of STKSTW. The existing capacity is expected to be fully committed in early 2019 based on the flow projection derived from the latest planning data and village sewerage programme. The Drainage Services Department (DSD) is undertaking a project named *"Expansion of Sha Tau Kok Sewage Treatment Works, Phase 1"* (hereinafter referred to as the "Project") to develop engineering design and assess the associated environmental impacts from the required expansion.

The Project requires an Environmental Permit from the Hong Kong SAR Government. In relation to this, DSD has prepared a Project Profile for application for an Environmental Impact Assessment (EIA) Study Brief which was submitted to Environmental Protection Department (EPD) on 5 November 2012. The EIA Study Brief (No. ESB-253/2012) was issued by EPD on 17 December 2012.

As part of the EIA, computational hydrodynamic and water quality modelling will be undertaken to quantify and evaluate potential water quality impacts associated with the construction and operation of this Project.

Figure 1.1 Location of the Sha Tau Kok Sewage Treatment Works



1.2 *PURPOSE OF THE METHOD STATEMENT*

This *Method Statement* presents information on the approach for numerical modelling and assessment works for the EIA. It is important to note that at the time of writing this *Method Statement* the detailed engineering information for both construction and operation activities is yet to be confirmed and therefore a general approach as to how the modelling works would be carried out is presented herein, with relevant assumptions provided as appropriate.

The methodology has been based on the following three focus areas, as follows:

- Model Selection;
- Development of Background Pollution Loading; and
- Model Scenarios.

It should be highlighted that this *Method Statement* would only present the modelling assumptions and does not mean to provide any water quality assessment. Detailed assessment of water quality impacts would be provided in the water quality chapter of the EIA.

1.3 *INTERPRETATION OF THE REQUIREMENTS: KEY ISSUES AND CONSTRAINTS*

The objectives of the modelling exercise are to assess:

- Water quality impacts from new submarine discharge outfall construction within the Starling Inlet, which would be assessed using the PART module of the Delft3D suit of model;

- Water quality impacts due to effluent discharge from the expanded new STKSTW during project operation, which would be assessed using the WAQ module of the Delft3D suit of model; and

- Any cumulative impacts due to other projects or activities within the study area.

Other potential water quality impacts from the construction and operation of the Project, such as construction site runoff, would be assessed qualitatively and would not be covered under this *Method Statement*

1.4 *MODEL SELECTION*

The Delft-3D suite of models will be utilized to provide a modelling platform for hydrodynamic and water quality modelling. A 3-dimensional Refined Model using Delft-3D will be built up for this Project to provide a detailed assessment on hydrodynamics and water quality during construction and operation of the Project. The Delft3D Sha Tau Kok Fine Grid Model (STK

Model) is developed based on the Tolo Harbour-Mirs Bay Model (THMB Model) with high level of refinement at the Starling Inlet and the Northern Mirs Bay. The THMB Model was developed by the EPD under *Agreement No. WP01-277* and its derivative model was used in past approved EIA studies[1]. Daily variations of river discharges, solar radiation, water temperature and wind velocity, which are derived from actual forcing from field measurements under *Agreement No. WP01-277*, were incorporated into the models The spatial extent of the STK Model covers the same extend of waters as the THMB model extending over 22 km away from the Project site. Comparisons of the STK Model grid and the THMB Model grid are provided below in *Figure 1.2* and *Figure 1.3*. It should be highlighted that there are some notable alteration of coastline of the existing Yantian Container Terminal when compared with the THMB Model, as shown in *Figure 1.2*. The latest coastal development at the Yantian Container Terminal has been taken into account in the STK Model.

As shown, the grid resolution of the STK Model near the existing STKSTW effluent outfall is about 50 m × 70 m while the grid resolution of near the proposed effluent outfall for the expanded STKSTW is about 60 m × 70 m. The general grid size of the STK Model within the Starling Inlet is below 80 m × 80 m, with some exception for the grid cells next to coastline. For comparison, the resolution of the THMB Model in the Starling Inlet is around 80 m × 220 m. The grid size of the STK Model increases as its distance from the Starling Inlet increase. Beyond the northern Mirs Bay (including the whole Tolo Harbour and Tolo Channel), the STK Model is the same as the original THMB Model.

For the purpose of determining the near field behaviour of the effluent plume from the STKSTW, near field simulation using CORMIX would be conducted. CORMIX is a USEPA-supported mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones resulting from continuous point source discharges. The CORMIX suite of model is widely used in various kinds of near field simulation for river and marine discharge world-wide. In this Study, CORMIX would be used to determine the vertical profile of the effluent plume at the immediate vicinity of the effluent outfall. The predicted vertical profile from the CORMIX would be incorporated in the far field Delft3D Model as stipulated in paragraph 4 of Appendix D-1 of the EIA Study Brief..

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[1] The refined THMB model was used in the approved EIA of Tai Po Sewage Treatment Works – Stage V (AEIAR-081/2004) and direct-to-permit application of Sediment Removal at Yim Tin Tsai, Yim Tin Tsai (East) Fish Culture Zones and Shuen Wan Typhoon Shelter (DIR-191/2009).

Figure 1.2 Overview of the STK Model and THMB Model

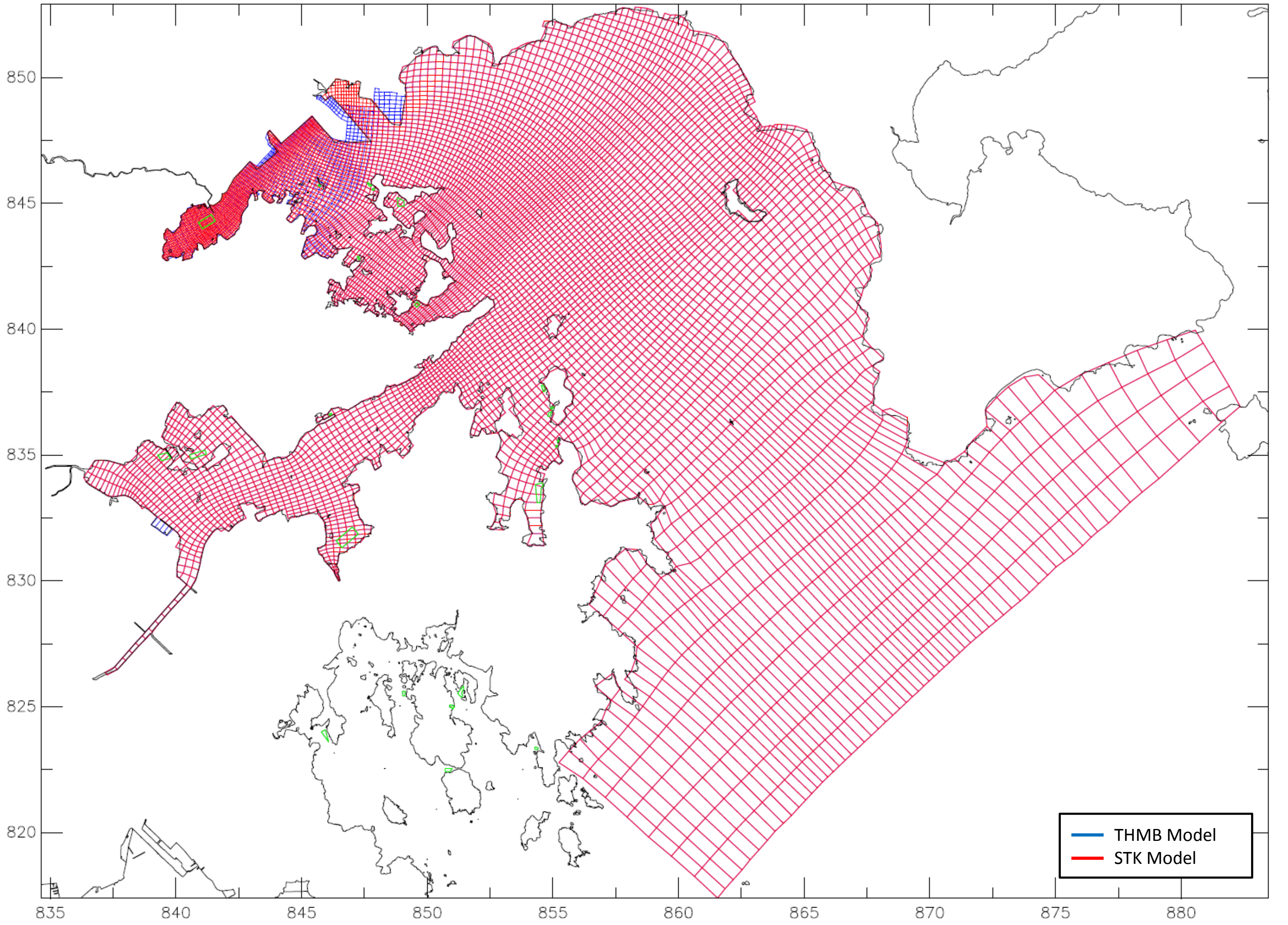
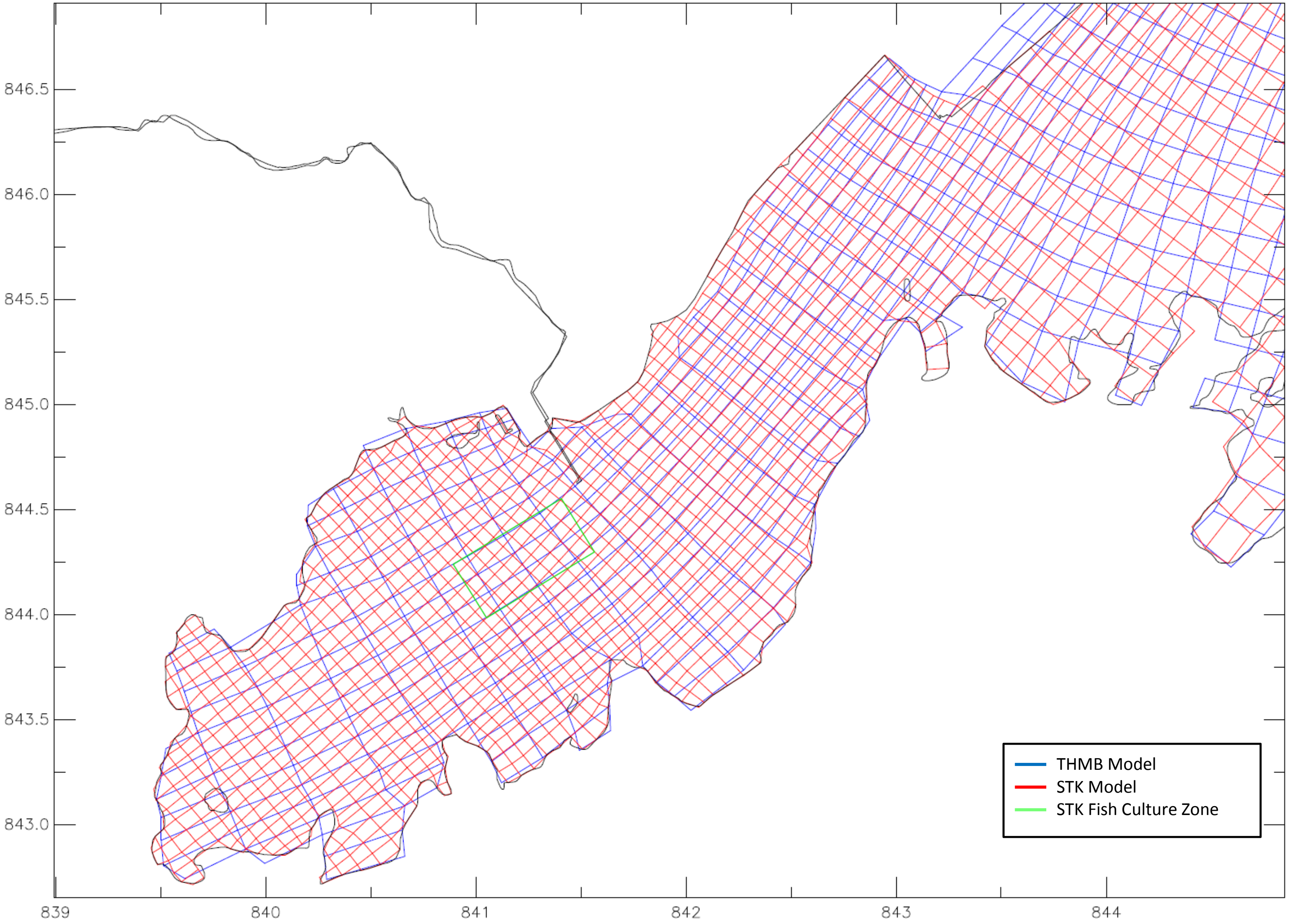


Figure 1.3 *Close up of the STK Model and THMB Model at the Starling Inlet*



Since the STK Model covers the same area and share the same boundary with the calibrated THMB Model, the STK Model will be validated by demonstrating the consistency with the THMB Model for the computed hydrodynamic outputs. This comparison aims to ensure that the introduction of the grid refinement in the vicinity of the Starling Inlet would not alter the established calibration of the Update Model and that the spin-up period is sufficiently long enough to allow the model to reach equilibrium.

Computed water levels, salinity, temperature, current speed and directions will be compared at selected corresponding locations for different water levels in both models. Comparisons will be made between the two models for both wet and dry seasons.

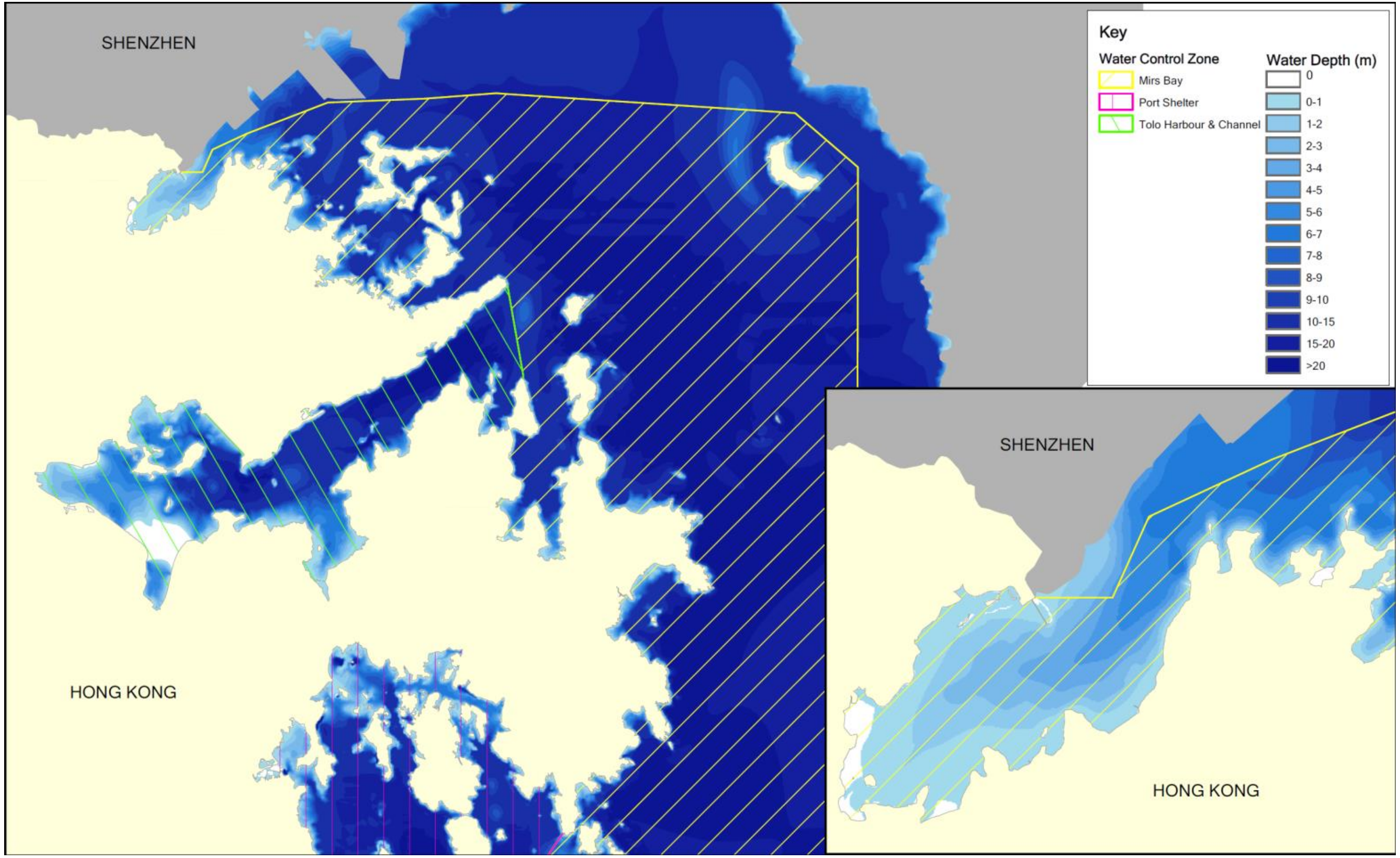
The detailed inputs to the STK Model are present in the following sections.

1.5 COASTLINE CONFIGURATIONS & BATHYMETRY

The existing coastline configuration of Hong Kong will be adopted in model simulations. There is no known future reclamation within the coverage of the STK Model except the proposed Ma Liu Shui Reclamation within the Tolo Harbour. Yet the potential change from the Ma Liu Shui Reclamation is not expected to induce any material change on the hydrodynamic of the Starling Inlet. Therefore the potential change in coastline from the Ma Liu Shui Reclamation is not taken into account in the STK Model.

The coastline configuration and bathymetry to be adopted in the STK Model are shown in *Figure 1.4*. The bathymetry data are obtained from the Hydrographic Office, Hong Kong Electronic Navigational Chart (ENC), 2011. The reference level of the STK Model is Principal Datum Hong Kong and the depth data are relative to this datum.

Figure 1.4 Coastline and Bathymetry to be used in the STK Model



Source: (1) Hydrographic Office, Hong Kong Electronic Navigational Chart (ENC), 2011

1.6 BOUNDARY CONDITIONS AND INITIAL CONDITIONS

There are 3 open boundaries for the STK Model, which are the same as that of the THMB Model. The set of hydrodynamic boundary conditions of the THMB Model were obtained from the actual forcing of wind, rainfall and temperature and are known to be reliable in past approved EIAs and other studies. The same set of hydrodynamic boundary condition is adopted under this Study.

The water quality boundary condition of the STK Model is derived from the water quality monitoring results of the 2 nearest EPD stations MM15 and PM11 (from 1986 to 2013 for MM15 and from 1993 to 2013 for PM11). Monthly averages throughout the whole monitoring period of the EPD water quality monitoring stations were used to produce depth-varying boundary conditions for simulations in both dry and wet seasons. The surface, middle and bottom level results from water quality monitoring results from EPD monitoring were used in the corresponding layers of the water quality model boundary and interpolation was conducted to produce the boundary conditions of the layers in between.

1.7 AMBIENT ENVIRONMENTAL CONDITIONS – BACKGROUND TEMPERATURE, SOLAR RADIATION AND WIND

The ambient environmental conditions are closely linked to the processes of hydrodynamic changes. As discussed under *section 1.3*, field measurements were to derive ambient conditions of solar radiation, water temperature and wind velocity, etc. for the THMB Model *Agreement No. WP01-277*. These ambient conditions are daily varying and are adopted directly in the STK Model.

1.8 SIMULATION PERIODS

The simulation periods covered by the STK Model are presented in *Table 1.1*. Due to the highly landlocked geometry of the Mirs Bay, Tolo Harbour and Starling Inlet waters, a long spin-up period of over one year would be provided before the actual 15-days spring-neap tidal cycle simulations for both seasons to allow complete convergent of the hydrodynamic model. A computational time step of 1 minute was adopted in the model simulation of both the dry and wet seasons.

Table 1.1 Hydrodynamic Model Simulation Periods

Season	Spin Up	Model Start Time	Model End Time
Wet	2 Jan 2019 00:00:00 – 15 Jun 2020 00:00:00	15 Jun 2020 00:00:00	30 Jun 2020 00:00:00
Dry	2 Jan 2019 00:00:00 – 9 Jan 2020 00:00:00	9 Jan 2020 00:00:00	24 Jan 2020 00:00:00

1.9 MODEL VERIFICATION

The key parameters of interest in the verification of hydrodynamic modelling include water level, salinity, temperature, current direction and current magnitude. The results of model verification are provided in *Annex A*. As shown in *Annex A*, the simulated water level, salinity, current magnitude, current direction and water temperature of the STK Model match well with those of the THMB Model. Minor deviations from on current magnitude and direction are observed and are considered the results of a combination of change in grid resolution, bathymetry, control volume and coastline refinement. These minor deviations are considered acceptable. In conclusion, the model performance of the STK Model is consistent with the THMB model and is considered suitable for use under this study. Verification of the water quality model performance of the STK Model would be provided under the water quality section of the EIA assessment.

1.10 UNCERTAINTIES IN ASSESSMENT METHODOLOGIES

1.10.1 Uncertainties in Sediment Transport Assessment

Uncertainties in the assessment of the impacts from suspended sediment plumes will be considered when drawing conclusions from the assessment. In carrying out the assessment, the worst case assumptions have been made in order to provide a conservative assessment of environmental impacts. These assumptions are as follows:

- The calculations of loss rates of sediment to suspension are based on conservative estimates for the methods of working;
- The modelled sediment loss period covers a whole tidal spring-neap cycle (15 days) for dredging at submarine outfall to ensure the worst case tidal condition within a spring-neap cycle could be captured in the modelling exercise; and
- The assessment is based on maximum practical rate for sheetpile installation and removal.

1.10.2 Uncertainties arising from Operations

The uncertainties in operation phase water quality modelling assessment include the followings:

- Potential change in effluent discharge on the Mainland side of the Mirs Bay; and
- Potential change in capacity of mariculture activities in the Starling Inlet and the rest of the Mirs Bay.

It should be highlighted that the pollution loading from the Mainland side of the Mirs Bay was adopted from the approved EIA of Tai Po Sewage Treatment

Works Stage 5 and there could be some changes on the number of pollution sources as well as pollution loading intensity for each sources. Yet most WSRs under this Study are located within the Starling Inlet, where the pollution loadings are captured more accurately with the pollution loading inventory compiled using the latest population data (discussed in details below in *Section 4.3*). Other WSRs beyond the Starling Inlet are all located on or near the shoreline of the Shuen Wan Country Park and is away from the Mainland coastline where pollution sources are located. As such, the limitation on the accuracy of pollution loading from the Mainland side of the Mirs Bay would not significantly affect the reliability of the prediction of the water quality modelling exercise. Water quality model verification run would be conducted based on HK background pollution loading derived from 2011 population data from Planning Department, actual STKSTW flow and effluent water quality data in 2011. The results of water quality verification run would be compared against the EPD routine water quality modelling data to ensure the water quality conditions are appropriately represented in the water quality modelling exercise. The results for water quality model verification would be provided in the water quality section of the EIA in this Project.

The pollution loading of mariculture activities in the Starling Inlet and the rest of the Mirs Bay are adopted from the approved EIA of HATS Stage 2A and the Update Study. In the Update Study, pollution loading of mariculture activities was estimated based on the followings:

- Wastage and leaching of fish feed;
- Excretion and faecal production from fish
- Disposal of dead fish

The scale of mariculture may vary from year to year depending on mariculturists' expectation of market demand and other commercial considerations. However, the AFCD Departmental Annual Reports (http://www.afcd.gov.hk/english/publications/publications_dep/publications_dep.html) indicate there is a trend for decrease in an annual production of mariculture fish through year 2001 to 2013. It is expected that the decrease in production scale would result in less fish feed wasted, less fish excreta and faeces and less dead fish, thus a lower pollution loading. It is therefore consider the pollution loading calculated based on 1997 data in the Update Study a conservative estimation to be used under this Study.

1.10.3 *Limitation in Near Field Models*

CORMIX has two key limitations. It assumes steady-state conditions and unidirectional, uniform flow in the receiving water body. Secondly, CORMIX has simplified geometric capabilities.

It should be highlighted that the tidal current within the Startling Inlet is unidirectional in each of the ebb and flood tide condition. During flood tide, the tidal current near the proposed new submarine outfall flows into the Starling Inlet at around 210° of compass angle. During ebb tide, the tidal flows at around 30° of compass angle. The direction of the tidal current is quite stable throughout the (ebb and flood) tides with exception of a short period when the tide changes its direction. Also, the water depth near the proposed new submarine outfall is quite shallow (around 7.3 m) and the profile of water temperature, salinity and flow velocity is quite homogeneous throughout the water column. Therefore, the actual conditions are not expected to deviate significantly from the assumed steady-state conditions and unidirectional, uniform flow in the receiving water body.

CORMIX also assumes an idealized water body with straight sides and a uniform bottom along the flow direction. To ensure conservative prediction using CORMIX and limits the potential deviation from the actual conditions due to uneven seabed, only the predicted vertical profile of effluent plume from the CORMIX near field simulations would be implemented in the far field Delft3D water quality modelling. Pollutants from outfall discharge are assumed to discharge within the same horizontally grid cell where the outfall diffuser of the proposed submarine outfall will be located, and horizontal spreading due to near field dispersion will not be taken into account.

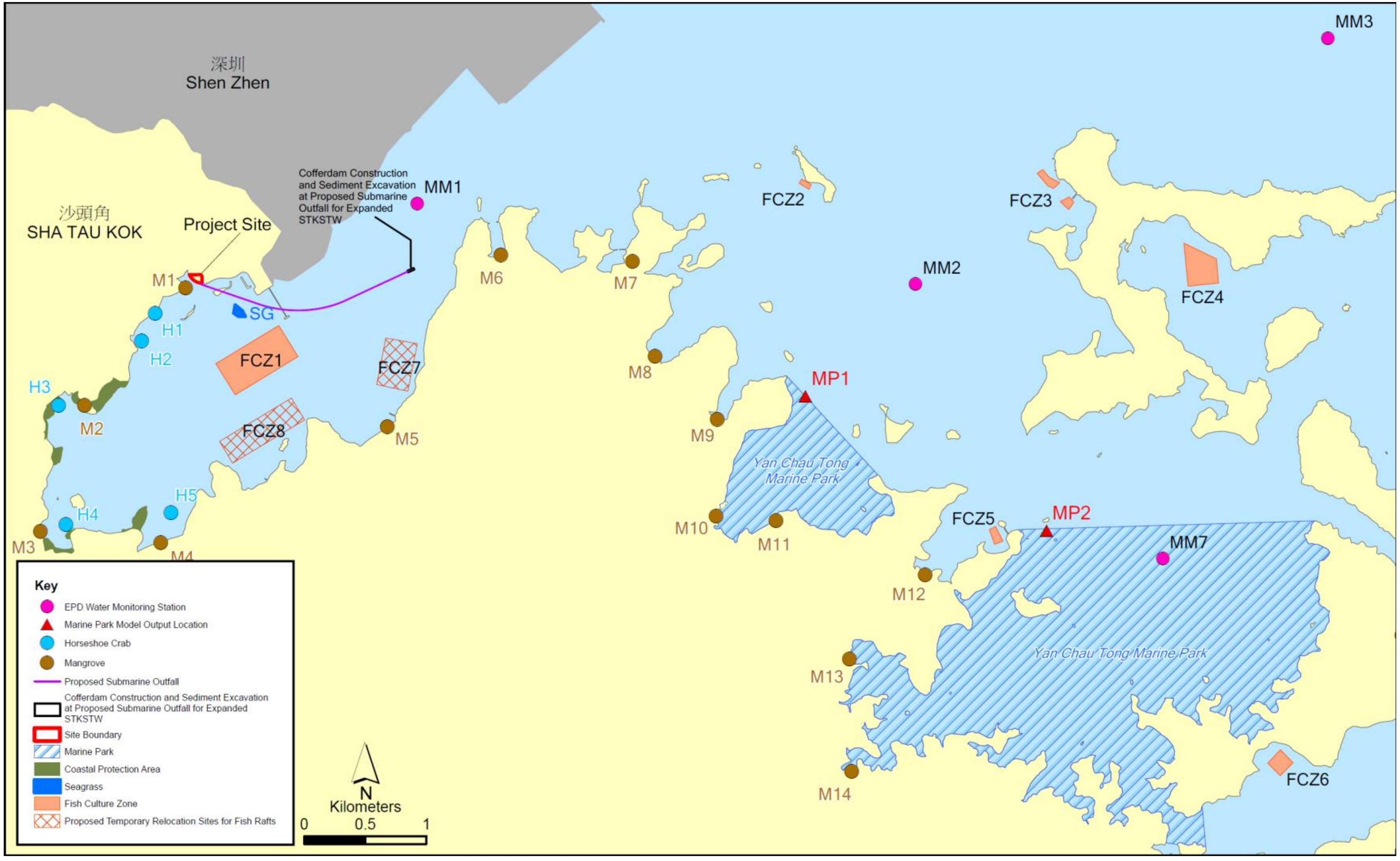
2 WATER SENSITIVE RECEIVERS

The water quality sensitive receivers (WSRs) have been identified in accordance with *Annex 14* of the *Technical Memorandum on EIA Process* (*EIAO, Cap.499, S.16*) and *Environmental Impact Assessment Study Brief for Expansion of Sha Tau Kok Sewage Treatment Works (No. ESB-253/2012)*. These WSRs are illustrated in *Figure 2.1* and listed in *Table 2.1*. The corresponding locations shown in *Figure 2.1* would be selected as modelling output locations to represent the level of impact experienced by the WSRs.

Table 2.1 Water Quality Sensitive Receivers (WSRs) in the Vicinity of the Project Site

Description	Location	Model Output Location
Fisheries Sensitive Receivers		
Fish Culture Zones	Sha Tau Kok	FCZ1
	Ap Chau	FCZ2
	Kat O	FCZ3
	O Pui Tong	FCZ4
	Sai Lau Kong	FCZ5
	Wong Wan	FCZ6
	Temporary Relocation Zones of Fish Raft for the Sha Tau Kok Fish Culture Zone	FCZ7, FCZ8
Ecological Sensitive Receivers		
Seagrass bed	-	SG
Horseshoe crab	Off Muk Min Tau	H1
	Off Pak Hok Lam	H2
	Off Nga Yiu Tau	H3
	A Chau	H4
	Off Luk Keng	H5
Mangrove stand	Off STKSTW	M1
	Off Wu Shek Kok	M2
	Off Tai Wan	M3
	Off Luk Keng	M4
	Off Kuk Po	M5
	Kei Shan Tsui	M6
	Tai Sham Chung	M7
	So Lo Pun	M8
	Pak Kok Wan	M9
	Yan Chau Tong Marine Park	M10, M11, M13, M14
	Ngau Shi Wu Wan	M12
Marine Park	Yan Chau Tong	MP1, MP2
EPD Water Quality Monitoring Station		
Water Quality Monitoring Station	Mirs Bay Water Control Zone (WCZ)	MM1, MM2, MM3, MM7

Figure 2.1 Water Sensitive Receiver near the Project



3 CONSTRUCTION PHASE

For the construction phase the Delft-PART model will be used to directly simulate the following parameters:

- Suspended sediments (SS); and
- Sediment deposition.

It is assumed that the worst-case construction phase impacts will be at the commencement of dredging, when there is no depression formed to trap sediments disturbed during dredging works.

Note that dissolved oxygen (DO) depletion, total inorganic nitrogen (TIN), unionized ammonia (UIA), heavy metals and organic compounds will be calculated using the modeled maximum SS concentrations. This method has been adopted in recently approved EIAs (1) (2).

3.1 ASSESSMENT CRITERIA FOR CONSTRUCTION PHASE

The study area will cover the Mirs Bay Water Control Zones (WCZs) as shown in *Figure 1.3*. Hence, Water Quality Objectives (WQOs) in the Mirs Bay WCZs will be used to assess water quality impacts in SS, DO, TIN, UIA and *E.coli* released in the process of dredging as well as effluent discharge from TSTP (*Table 3.1*).

Table 3.1 ***Summary of Assessment Criteria (WQOs)***

Parameters (1)	**Mirs Bay**
Dissolved Oxygen (Bottom) (mg/L)	Not less than 2 mg/L for 90% of samples
Dissolved Oxygen (Depth-averaged) (mg/L)	Not less than 5 mg/L for 90% of samples for fish culture subzone Not less than 4 mg/L for 90% of samples for other marine waters
Total Inorganic Nitrogen (mg/L)	< 0.3
Unionized Ammonia (mg/L)	< 0.021 mg/L
Suspended Solids (mg/L)	Increase < 30% of ambient for all WCZs
E.coli (cfu/100mL)	610 for fish culture subzone

In accordance with the WQO, the DO criterion for FCZs is set at > 5 mg/L measured as water column average.

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(1) ERM - Hong Kong, Ltd (2006) EIA Study for Liquefied Natural Gas (LNG) Receiving Terminal and Associated Facilities. For CAPCO. Register No.: AEIAR-106/2007, http://www.epd.gov.hk/eia/register/report/eiareport/eia_1252006/html/index.htm

(2) ERM - Hong Kong, Ltd (2010) EIA Study for Black Point Gas Supply Project. For CAPCO. Register No. AEIAR-150/2010, http://www.epd.gov.hk/eia/register/report/eiareport/eia_1782009/index.html

There are no existing regulatory standards or guidelines for dissolved metals and organic contaminants in the marine waters of Hong Kong. It is thus proposed to make reference to relevant international standards and this approach has been adopted in previous approved EIAs, i.e., *EIA for Decommissioning of Cheoy Lee Shipyard at Penny's Bay* (1), *EIA for Disposal of Contaminated Mud in the East Sha Chau Marine Borrow Pit* (2), *EIA for Wanchai Development Phase II* (3), *EIA for Liquefied Natural Gas (LNG) Receiving Terminal and Associated Facilities* (4),*EIA for Hong Kong Offshore Wind Farm in Southeastern Waters* (5) and *EIA for Shatin to Central Link Cross Harbour Section (Phase II - Hung Hom to Admiralty)* (6. *Table 3.2* shows the assessment criteria for dissolved metals and organic pollutants for this Study.

Table 3.2 Summary of Assessment Criteria for Dissolved Metals and Organic Compounds for Construction Phase

Parameter	Unit	Assessment Criteria for this Study
Metals		
Cadmium (Cd)	µg/L	2.5 (a) (b)
Chromium (Cr)	µg/L	15 (a) (b)
Copper (Cu)	µg/L	5 (a) (b)
Nickel (Ni)	µg/L	30 (a) (b)
Lead (Pb)	µg/L	25 (a) (b)
Zinc (Zn)	µg/L	40 (a) (c)
Mercury (Hg)	µg/L	0.3 (b)
Arsenic (As)	µg/L	25 (a) (b)
Silver (Ag)	µg/L	1.9 (d)
Total PAHs	µg/L	3.0 (f)
PCBs		
Total PCBs	µg/L	0.03 (d)
Organotins		
Tributyltin (TBT)	µg/L	0.1 (e) (maximum concentration)

Notes:

(a) UK Environment Agency, Environmental Quality Standards (EQS) for List 1 & 2 dangerous substances, EC Dangerous Substances Directive (76/464/EEC) (http://www.ukmarinesac.org.uk/activities/water-quality/wq4_1.htm).

(b) Annual average dissolved concentration (i.e. usually involving filtration a 0.45-um membrane filter before analysis).

(c) Annual average total concentration (i.e. without filtration).

(d) U.S. Environmental Protection Agency, National Recommended Water Quality Criteria, 2009. (http://www.epa.gov/waterscience/criteria/wqctable). The Criteria Maximum Concentration (CMC) is an estimate of the highest concentration of a material in surface water (i.e. saltwater) to which an aquatic community can be exposed briefly without

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(1) Maunsell (2002). EIA for Decommissioning of Cheoy Lee Shipyard at Penny's Bay. For Civil Engineering Department, Hong Kong SAR Government.

(2) ERM – Hong Kong (1997). EIA for Disposal of Contaminated Mud in the East Sha Chau Marine Borrow Pit. For Civil Engineering Department, Hong Kong SAR Government.

(3) Maunsell (2001). EIA for Wanchai Development Phase II - Comprehensive Feasibility Study. For Territory Development Department, Hong Kong SAR Government.

(4) ERM - Hong Kong, Ltd (2006) Op Cit

(5) BMT Asia Pacific Ltd (2009). EIA for Hong Kong Offshore Wind Farm in Southeastern Waters. For HK Offshore Wind Limited

(6) AECOM (2011). EIA for Shatin to Central Link Cross Harbour Section (Phase II - Hung Hom to Admiralty) for MTR

resulting in an unacceptable effect. CMC is used as the criterion of the respective compounds in this study.

(e) Salazar MH, Salazar SM (1996) Mussels as Bioindicators: Effects of TBT on Survival, Bioaccumulation, and Growth under Natural Conditions. In Organotin, edited by M.A. Champ and P.F. Seligman. Chapman & Hall, London.

(f) Australian and New Zealand Environment and Conservation Council (ANZECC), Australian and New Zealand Guidelines for Fresh and Marine Water Quality (1992)

There are no existing regulatory standards or guidelines for total PCBs, total PAHs and TBT in water and hence reference has been made to the USEPA water quality criteria, Australian water quality guidelines, and international literature, respectively. The assessment criteria for total PCBs, total PAHs and TBT are 0.03 µg/L, 3.0 µg/L and 0.1 µg/L respectively. The same assessment criteria for these 3 chemicals are adopted in past approved EIA such as the approved EIA of Shatin to Central Link.

Reference would also be made to *People's Republic of China Sea Water Quality Standard (GB 3097-1997)* in view of the relatively short distance from the HK-Mainland marine border. It should be highlighted that the coastal development on the Mainland side of the 7 km Study Area includes only residential and commercial (near the Shataujiao Town) as well as port works (the Yantian Port). Therefore, the waters within the Study Area is considered either category 3 or 4 stipulated under the *GB 3097-1997.* Assessment criteria for category 3 waters are adopted for conservative assessment.

Table 3.3 People's Republic of China Sea Water Quality Standard (GB 3097-1997)

Unit: mg/L	**Category 1: Fisheries, Marine Reserve and Conservation Area of rare or Endangered Species**	**Category 2: Mariculture, Bathing Beach, Secondary Contact Recreation, Industrial Use related to Direct Human Consumption**	**Category 3: General Industrial Use and General Aesthetic**	**Category 4: Harbour Area and Marine Development Area**
Floating Object	No oil film, floating foam and other debris on water surface	No oil film, floating foam and other debris on water surface	No oil film, floating foam and other debris on water surface	No observable oil film, floating foam and other debris on water surface
Colour / Odour / Taste	No abnormal colour, odour or taste should be presented in sea water	No abnormal colour, odour or taste should be presented in sea water	No abnormal colour, odour or taste should be presented in sea water	No objectionable or unpleasant colour, odour or taste should be presented in sea water
Suspended Solid	Increase from human activities should be less than 10	Increase from human activities should be less than 10	Increase from human activities should be less than 100	Increase from human activities should be less than 150
Coliform (count/L)	10000 700 for mariculture of shellfish for direct human consumption	10000 700 for mariculture of shellfish for direct human consumption	-	-
E.coli (count/L)	2000 140 for mariculture of shellfish for direct human consumption	2000 140 for mariculture of shellfish for direct human consumption	-	-
Pathogen	Not to present for mariculture of shellfish for direct human consumption	Not to present for mariculture of shellfish for direct human consumption	Not to present for mariculture of shellfish for direct human consumption	Not to present for mariculture of shellfish for direct human consumption

Unit: mg/L	**Category 1: Fisheries, Marine Reserve and Conservation Area of rare or Endangered Species**	**Category 2: Mariculture, Bathing Beach, Secondary Contact Recreation, Industrial Use related to Direct Human Consumption**	**Category 3: General Industrial Use and General Aesthetic**	**Category 4: Harbour Area and Marine Development Area**
Water Temperature (°C)	Change due to human activities should not cause increase for 1°C in summer, 2°C in other seasons	Change due to human activities should not cause increase for 4°C	Change due to human activities should not cause increase for 4°C	Change due to human activities should not cause increase for 4°C
pH	7.8-8.5 Change should not exceed normal range by 0.2 pH unit	6.8-8.8 Change should not exceed normal range by 0.5pH unit	6.8-8.8 Change should not exceed normal range by 0.5pH unit	6.8-8.8 Change should not exceed normal range by 0.5pH unit
Dissolved Oxygen	6	5	4	3
Chemical Oxygen Demand	2	3	4	5
5-day Biochemical Oxygen Demand	1	3	4	5
Inorganic Nitrogen (as N)	0.2	0.3	0.4	0.5
Unionized Ammonia (as N)	0.020	0.020	0.020	0.020
Reactive Phosphate (as P)	0.015	0.030	0.030	0.045
Mercury	0.00005	0.0002	0.0002	0.0005
Cadmium	0.001	0.005	0.010	0.010
Lead	0.001	0.005	0.010	0.050
Hexavalent Chromium	0.005	0.010	0.020	0.050
Total Chromium	0.05	0.10	0.20	0.50
Arsenic	0.020	0.030	0.050	0.050
Copper	0.005	0.010	0.050	0.050
Zinc	0.020	0.050	0.10	0.50
Selenium	0.010	0.020	0.020	0.050
Nickel	0.005	0.010	0.020	0.050
Cyanide	0.005	0.005	0.10	0.20
Sulphide (as S)	0.02	0.05	0.10	0.20
Volatile Phenol	0.005	0.005	0.010	0.050
Petroleum Hydrocarbon	0.05	0.05	0.30	0.50
Hexachlorocyclohexane	0.001	0.002	0.003	0.005
Dichlorodiphenyltrichloroethane	0.00005	0.0001	0.0001	0.0001
Malathion	0.0005	0.001	0.001	0.001
Parathion	0.0005	0.001	0.001	0.001

3.2 CONSTRUCTION PROGRAMME AND WORKING TIME FOR MARINE CONSTRUCTION

At this stage it is understood that the outfall diffusers of the proposed STKSTW will be installed by trenchless method (i.e. horizontal directional drilling, HDD). HDD would proceed from the landside of the Project side and approach to the diffuser site. After the commencement of HDD, cofferdam would be installed at the diffuser site. The cofferdam would be constructed using interlocking sheetpiles, which would be completely watertight. Seawater would be drained from the cofferdam before further construction. When the HDD reach the diffuser site, excavation (i.e. in dry condition) of marine sediment within the cofferdam would proceed and installation of precast outfall structure would then follow. As such excavation is limited to an area of the seabed for the installation of the above-seabed portion of the outfalls structures. Based on the latest information, marine sheetpiling for cofferdam construction would tentatively be conducted from Sep 2017 to Nov 2017 while marine sediment excavation and installation of submarine outfall diffuser would tentatively be conducted from July 2019 to Nov 2019.

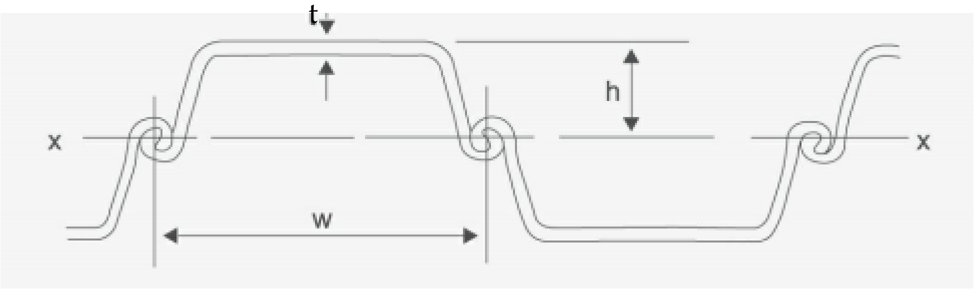
The works programme for construction activities for the submarine facilities is based on the assumption of a 12 working hour day with 7 working days per week.

3.3 *OVERVIEW OF MARINE CONSTRUCTION*

Since marine sediment at submarine outfall would be excavated within the fully-drained watertight cofferdam, release of sediment to the water column (from ordinary marine dredging) is not anticipated. Instead, the potential for sediment release from installation of sheetpiles (and removal after the completion) for cofferdam installation, which is the only marine construction process that may disturb bottom sediment and result in resuspension, would be assessed.

Sheetpiles that are used for cofferdam construction come with varies dimension. A schematic drawing showing the typical cross-section of sheetpile is shown below in *Figure 3.1*. Based on the preliminary design information, the length (measured in the horizontal direction, *w* in *Figure 3.1*) would be about 300 – 500 mm and the breadth (measured in the horizontal direction, *h* in *Figure 3.1*) would be about 100 – 150 mm. The longitudinal length (which goes vertically down into the sediment when installed) varies and the sheetpiles are generally cut at appropriate length according to installation depth.

Figure 3.1 Typical Cross-section for Cofferdam Sheetpiles



During installation of cofferdam, sheetpiles are driven down into the sediment by vibration. Vibratory installation of sheetpiles for marine works are being adopted in major marine construction projects including HKBCF and TM-

CLKL and is known to have limited impact on bottom sediment (1) (2) (3). During installation, a vibratory hammer would be used to press sheetpiles downward. Vibration transmitted from the vibration hammer would reduce friction experienced by the sheetpiles and allow the sheetpiles to go down more easily. Limited level localized resuspension of bottom sediment could be resulted from the vertical vibrational motion from the sheetpile.

Similarly, the sheetpiles would be pulled out from the sediment using vibratory hammer. Since the removal of sheetpiles involves more significant upward motion, the sediment release due to removal of sheetpiles would be modelled for worst case assessment.

In the transport of excavated materials, sediment may be lost through leakage from barges. However, dumping permits in Hong Kong include requirements that barges used for the transport of dredging materials have bottom-doors that are properly maintained and have tight-fitting seals in order to prevent leakage. Given this requirement, sediment release during transport is not proposed for modelling and its impact on water quality will not be addressed under this Study.

Sediment is also lost to the water column when discharging material at disposal sites. It is considered that potential water quality issues associated with disposal at the intended government disposal site(s) have already been assessed by Civil Engineering and Development Department (CEDD) and permitted by EPD, hence and the environmental acceptability of such disposal operations is demonstrated. Therefore modelling of impacts at disposal sites does not need to be addressed and reference to relevant studies will be provided in the EIA for this Project where appropriate.

Review of sediment density has been conducted based on previously accepted EIAs and DIR in Hong Kong which includes the followings:

- *Shatin to Central Link - Hung Hom to Admiralty Section* (AEIAR-166/2012). EP granted in Feb 2012 (EP-064/2000).
- *ShaTin to Central Link Protection Works at Causeway Bay Typhoon Shelter* (AEIAR-159/2011). EP granted in Feb 2011 (EP-416/2011).
- *Wan Chai Development Phase II and Central-Wan Chai Bypass* (AEIAR-125/2008). EP granted in Dec 2008 (EP-356/2009).
- *Liquefied Natural Gas (LNG) Receiving Terminal and Associated Facilities* (AEIAR-106/2007). EP granted on 3 April 2007 (EP-257/2007).

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(1) AECOM (2011) *Development of the Integrated Waste Management Facilities Phase 1*, for EPD. Register No.: AEIAR-163/2012, http://www.epd.gov.hk/eia/register/report/eiareport/eia_2012011/index.htm

(2) Mott MacDonald (2010) *South Island Line (East) Environmental Impact Assessment*, for MTR. Register No.: AEIAR-155/2010 http://www.epd.gov.hk/eia/register/report/eiareport/eia_1852010/Index.html

(3) AECOM (2009) *Tuen Mun – Chek Lap Kok Link*, for HyD. Register No.: AEIAR-146/2009 http://www.epd.gov.hk/eia/register/report/eiareport/eia_1742009/index.html

- *The Proposed Submarine Gas Pipelines from Cheng Tou Jiao Liquefied Natural Gas Receiving Terminal, Shenzhen to Tai Po Gas Production Plant, Hong Kong* – EIA Study (AEIAR-071/2003). EP granted on 23 April 2003 (EP-167/2003).

- *132kV Submarine Cable Installation for Wong Chuk Hang - Chung Hom Kok 132kV Circuits* (AEP-126/2002). EP granted on 2 April 2002 (EP-126/2002).

- *FLAG North Asian Loop* (AEP-099/2001). EP granted on 18 June 2001 (EP-099/2001).

- *East Asian Crossing (EAC) Cable System (TKO), Asia Global Crossing* (AEP-081/2000). EP granted on 4 October 2000 (EP-081/2000).

- *East Asian Crossing (EAC) Cable System, Asia Global Crossing*(AEP-079/2000). EP granted on 6 September 2000 (EP-079/2000).

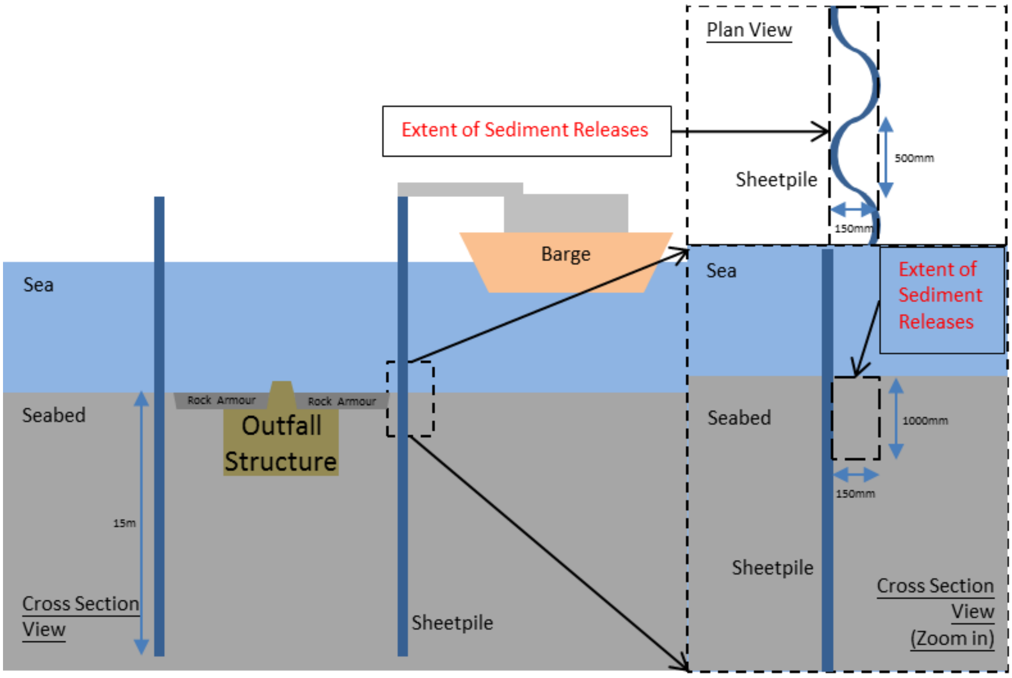
- *Submarine Cable Landing Installation in Tong Fuk Lantau for Asia Pacific Cable Network 2 (APCN 2) Fibre Optic Submarine Cable System, EGS*. EP granted on 26 July 2000 (EP-069/2000).

- *Telecommunication Installation at Lot 591SA in DD 328, Tong Fuk, South Lantau Coast and the Associated Cable Landing Work in Tong Fuk, South Lantau for the North Asia Cable (NAC) Fibre Optic Submarine Cable System* (AEP-064/2000). EP granted in June 2000 (EP-064/2000).

Dry density of marine sediment varies from 600 kg/m^3 to 1600 kg/m^3 based on the above EIAs. The upper limit of 1600 kg/m^3 would be taken for assessment in this Study. It is conservatively assumed that the first 1 meter of sediment at the surface of the seabed that is enclosed in three sides (i.e. $w \times h$ in *Figure 3.1*) would be disturbed by the removal of the sheetpiles and be release to the water column continuously throughout the process. Sediment below 1 m of the existing seabed level is expected to be suppressed by the weight of sediment above and would unlikely be brought up to the surface by the action of sheetpiles. Typically, it takes around 3 hours for a piece of sheetpile to pass through 5 – 10 m of sediment by vibratory hammer. In this modelling exercise, it is assumed that the 500 mm (length) × 150 mm (breadth) sheetpile would be used and installed / removed at a rate of 3 hours per piece to maximize the potential sediment loss rate. The location and extent of the sediment that is considered above is illustrated in *Figure 3.2* below. It is expected that only part of the disturbed sediment would be entrained during the installation / removal of sheetpiles. An entrainment percentage of 20% is taken from jetting EIAs / DIR projects reviewed above. It is considered conservative since the disturbance of marine sediment by installation / removal sheetpiles is expected to be far less significant than the jetting process assessed in the relevant EIAs / DIR projects above. It is also assumed that sheetpiles would be installed / removed at both end of the cofferdam simultaneously (so the modelled rate of sediment release would be doubled).

Based on the above assumptions, the volume of sediment that would be disturbed = (60 + 60 + 30 + 30) m (perimeter of excavation area) × 0.15 m (width) × 1 m (depth) = 27 m^3 (*in-situ* volume). Based on the above assumptions, the maximum (horizontal) length of sheetpiles installed / removed per day would be 500 mm (horizontal length per piece of sheetpile) ÷ 3 hr (time required per piece) × 12 hr (working hours per day) × 2 (installation at both ends of cofferdam) = 4 m.

Figure 3.2 Location and Extent of Sediment Released by the Movement of Sheetpiles



Note: The above schematic is prepared to illustrate the location and extent of sediment that is expected to be disturbed by the movement of sheetpiles. It is not prepared in scale and certain engineering details may not be presented.

3.4 *CONSTRUCTION SCENARIO – MARINE INSTALLATION/REMOVAL OF SHEETPILES*

The estimated volume and mass of disturbed sediment is 27 m^3 and 43,200 kg respectively. Working hours are assumed to be 12 hours per day with a maximum rate of sheetpile installation / removal of 4 m^3/day (0.333 m/hr), giving a rate of release (in kg/s) of sediment as follows:

Loss Rate (kg/s)

= *Total mass of Sediment Disturbed (kg)* ÷ *Total Time Required (s)* × *Entrainment Percentage*

= *43200 kg* ÷ *(180 m* ÷ *0.333 m/hr)* × *20%*

= *43200 kg* ÷ *540hr* × *20%*

= *16 kg/hr*

= 0.0044 kg/s

In view of the very small sediment loss rate, it is assumed no silt curtain would be installed to contain the sediment loss from the installation and removal of sheetpiles under unmitigated scenario. Given the small extent of marine construction works area, one stationary source at the outfall discharge point is assumed in the model to represent the installation / removal of sheetpiles at both ends. *Table 3.3* summarises the inputs defined in the sediment dispersion simulation for construction phase modelling scenario.

Table 3.4 *Summary of Model Inputs for Construction Phase Modelling*

Emission Point		Removal of Sheetpiles from Cofferdam
No. of Working Plant		2 Vibratory Hammers
Length of Sheetpiles Removed	**m/day**	4
Operation Duration	**hours**	12
Loss Type		Continuous
Loss Rate	**kg s^{-1}**	0.0044 (without silt curtain)
Input Layer		Whole Column

Based on the latest information provided by CEDD, there would be a number of marine dredging works under *Sediment Removal at Sha Tau Kok Fish Culture Zone, Boat Shelter and Approach Channel*, which is located close to the marine dredging under this Project. Further background on this sediment removal project is provided under *Section 5.2* below. There are three dredging area under this sediment removal project and the corresponding dredging rate would be 2600 (for STKFCZ), 800 (for boat shelter and approach channel) and 300 (for dredging area between the shore and the island) m^3/day respectively. These sediment sources are modelled under this Study as concurrent project for assessment of cumulative water quality impact of marine construction.

Table 3.5 *Summary of Model Inputs for Concurrent Marine Construction*

Emission Point		Sediment Removal at STKFCZ	Sediment Removal at boat shelter and approach channel	Sediment Removal at dredging area between the shore and the island
No. of Working Plant		1 Grab Dredger with a grab size of 8 m^3	1 Grab Dredger with a grab size of 8 m^3	1 Grab Dredger with a grab size of 8 m^3
Dredging Rate	**m^3/day/plant**	2,600	800	300
Operation Duration	**hours**	12	12	12
Loss Type		Continuous	Continuous	Continuous
Loss Rate	**kg m^{-3}**	5 (with silt curtain)	5 (with silt curtain)	5 (with silt curtain)
Loss Rate	**kg s^{-1}**	0.3006 (with silt curtain)	0.0926 (with silt curtain)	0.0347 (with silt curtain)
Input Layer		Whole Column	Whole Column	Whole Column

3.5 *SEDIMENT INPUT PARAMETERS*

For simulating sediment impacts the following general parameters will be assumed:

- Settling velocity – 0.1 mm/s
- Critical shear stress for deposition – 0.2 N/m^2
- Critical shear stress for erosion – 0.3 N/m^2
- Resuspension rate – 30 $g/m^2/d$
- Number of Particles used for each sediment source – 4,000,000 (× 4 sources = 16,000,000)

The above parameters have been used to simulate the impacts from sediment plumes in Hong Kong associated with uncontaminated mud disposal into the Brothers MBA (1) and dredging for the Permanent Aviation Fuel Facility at Sha Chau (2). The critical shear stress values for erosion and deposition were determined by laboratory testing of a large sample of marine mud from Hong Kong as part of the original Water Quality and Hydraulic Mathematical Model (WAHMO) studies associated with the new airport at Chek Lap Kok.

3.6 *DISSOLVED OXYGEN DEPLETION*

The degree of DO depletion exerted by a sediment plume is a function of the sediment oxygen demand of the sediment, its concentration in the water column and the rate of oxygen replenishment. The impact of the sediment oxygen demand on DO concentrations has been calculated based on the following equation (3):

$$\text{DO (mg } O_2/L) = \text{DO (g } O_2/m^3) = \text{SS (g DW}/m^3) \times \text{fraction of organic matter in sediment (g C/g DW)} \times 2.67 \text{ (g } O_2/gC)$$

The assumption behind this equation is that all the released organic matter is eventually re-mineralized within the water column. This leads to an estimated depletion with respect to the background DO concentrations. This DO depletion depends on the quality of the released sediments, i.e. on the percentage of organic matter in the sediment. The fraction of organic matter in sediment (Chemical oxygen demand) from the nearby EPD sediment quality monitoring station MS1 from 2009-2013 would be used for calculation.

This is a conservative prediction of DO depletion since oxygen depletion is not instantaneous and will depend on tidally averaged suspended sediment

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(1) Mouchel (2002a). *Environmental Assessment Study for Backfilling of Marine Borrow Pits at North of the Brothers. Environmental Assessment Report*.

(2) Mouchel (2002b). *Permanent Aviation Fuel Facility. EIA Report.* Environmental Permit EP-139/20

(3) ERM - HK Ltd (2010). Development of an Offshore Wind Farm in Hong Kong. Final Environmental Impact Assessment. For the Hong Kong Electric Company

concentrations. It is worth noting that the above equation does not account for re-aeration which would tend to reduce impacts of the SS on DO concentrations in the water column. The proposed analysis, which is on the conservative side, will not, therefore, underestimate the DO depletion. Further, it should be noted that, for sediment in suspension to exert any oxygen demand in the water column will take time and, in the meantime, the sediment will be transported and mixed or dispersed with oxygenated water. As a result, the oxygen demand and the impact on DO concentrations will diminish as the suspended sediment concentrations decrease.

3.7 *NUTRIENTS*

An assessment of nutrient release during marine dredging for submarine outfall has been carried out based on the predicted SS elevation and the testing results of EPD sediment monitoring station. In the calculation it is assumed that all total kjeldahl nitrogen (TKN) concentrations in the sediments are released to the water. This is a highly conservative assumption and will result in the overestimation of the potential impacts.

The maximum predicted SS concentration at each WSR is multiplied by the maximum concentration of TKN in sediment (mg/kg) at the EPD sediment quality monitoring station MS1 from 2009-2013 to give the maximum elevation in TIN (mg/L). While nitrate and nitrite may also be constituent of TIN in marine water, they are generally in negligible concentration in view of low electrochemical potential of marine sediment. The calculations of maximum elevation in TIN (from TKN) at WSRs are shown below:

$$\text{Max TIN (mg/L)} = \text{Max SS (mg DW/L)} \times \text{Max TKN (mg N/ kg DW)} \times 10^{-6}$$

Ammonia nitrogen is the sum of ionized ammonia and unionized ammonia (UIA). Under normal conditions of Hong Kong waters, more than 90% of the ammonia nitrogen would be in the ionized form. EPD marine water quality monitoring data at MM1 from 1986 to 2013 indicated that on average 7.8% of ammonia nitrogen exists as UIA. For the purpose of assessment, this average value would be adopted for estimation of UIA from disturbance of marine sediment due to marine construction. In view that the mineralization of the organic nitrogen will also contribute to ammonia, the calculations of NH_3-N are based on maximum total TKN concentrations from the nearby EPD sediment quality monitoring station MS1 from 2009-2013. TKN is the total of ammonia nitrogen and organic nitrogen. Note that it is a highly conservative approach since it is assumed that 100% of organic nitrogen will be mineralized to ammonia but this is unlikely to occur in reality.

The maximum SS concentration at each WSR is multiplied by the following factors to predict the maximum UIA elevations:

$$\text{Max UIA (mg/L)} = \text{Max SS (mg DW/L)} \times \text{Max TKN (mg N/ kg DW)} \times 10^{-6} \times 7.8\%$$

3.8 HEAVY METALS AND MICRO-ORGANIC POLLUTANTS

Contaminant levels in sediment as well as the tendency for dissolution of contaminants from disturbed sediment are determined by means of sediment testing and sediment elutriated testing respectively under this Project. First the results of sediment elutriate test would be compared against the water quality assessment criteria stipulated under *Table 3.2*. In case the level pollutants presence in the elutriate exceedance the proposed water quality assessment criteria, the dispersion of pollutants would be modelled using Delft3D WAQ (inert, non-settling tracer) based on the maximum level of pollutants identified in the geophysical survey conducted under this Study, assuming 100% release of sediment-bounded pollutants. For instance, the rate of contaminants release (as tracer in model) would be 0.0044 kg/s (sediment loss rate from *section 0*) multiplied by the corresponding maximum contaminant level(s) from sediment sample. The corresponding level of contaminants at receivers will be determined from the tracer model results from Delft3D WAQ.

4 OPERATION PHASE

4.1 ASSESSMENT CRITERIA FOR OPERATION PHASE

The same set of assessment criteria stipulated under *Section 3.1*, including DO, SS, TIN, UIA, *E.coli* would be adopted for the operation phase water quality modelling.

4.2 MODELLING SCENARIOS

Upon the completion of the proposed expansion of the STKSTW, the final treatment capacity of the STKSTW would be increased from 1,660 m^3/day to 10,000 m^3/day (average dry weather flow, ADWF). There would also be a change in the outfall location as well as effluent quality. The potential change in water quality within the Starling Inlet and the nearby northern Mirs Bay would be studied using the Delft3D WAQ module. Based on the latest design information, a number of design features would be included to avoid any risk of emergency bypass. These measures include:

- Provision of dual electricity supply;
- Provision of stand-by equipment for all treatment units; and
- Provision of onsite storage of raw sewage up to 6 hours in case all the above fail

It is expected that the provision of dual power supply, stand-by treatment equipment would provide sufficient protection against the risk of any power outage or plan breakdown. Therefore, the risk of emergency discharge from the expanded STKSTW would be minimal. Further detailed qualitative assessment would be provided in the WQ section of the EIA.

4.2.1 *Selection of Modelling Years*

Based on the EIA Project Profile of this Project, the tentative year of commissioning of the Phase 2 of this Project (i.e. treatment capacity increase to 10,000 m^3/day ADWF) is 2030. Therefore, the modelling year for the baseline and operation phase scenarios of Delft3d Modelling would be conducted for 2030.

Table 4.1 Modelling Years for Delft3d Water Quality Modelling Scenarios

Scenarios	**Simulation Year**	**Simulated Flow (m^3/day)**	**Description**
Far field water quality - baseline	2011	Actual daily flow rate of 2011	Baseline scenario of 2011 at actual flow rate and actual effluent concentration of the existing STKSTW for model verification

Scenarios	**Simulation Year**	**Simulated Flow (m^3/day)**	**Description**
Far field water quality - baseline	2030	1,660	Baseline scenario of 2030 at maximum ADWF of the existing STKSTW for project operation
Far field water quality - operation	2030	10,000	Operation scenario of 2030 at maximum ADWF of the expanded STKSTW

4.3 *COMPILATION OF BACKGROUND POLLUTION LOADING*

The pollution loading for compiled for the storm and sewage outfalls within the STK Model grid coverage for input into the water quality model year 2011 and 2030 for cumulative impact assessment. The methodologies for compiling the pollution loading are presented in the following sections.

4.3.1 *Sources of Population Data*

The projected population data of 2031 are provided by the Planning Department. The Territorial Population and Employment Data Matrices (TPEDM) of 2011, 2016, 2021, 2026 and 2031 are used for compiling storm runoff in the modelled area. Linear interpolation between 2026-based and 2031-based TPEDM is conducted to generate the population data of 2030. The latest forecast data give projected population breakdown by Planning Vision and Strategy (PVS) zones. To facilitate the estimation of pollution loading from the population data, the population and employment data are required to be divided at the level of catchment areas shown in *Figure 4.1*.

Data Manipulation

The latest planning data provide the number of usual residents, mobile residents and school places within the territory at PVS zones. Employment population is divided by 19 job types as listed below:

- S1 Agriculture, forestry and fishing, mining and quarrying
- S2 Manufacturing
- S3 Electricity and gas supply, water supply, sewerage and waste management
- S4 Construction
- S5 Import and export trade
- S6 Wholesale
- S7 Retail trade
- S8 Transportation, storage, postal and courier services

- S9 Short term accommodation activities
- S10 Food and beverage service activities
- S11 Information and communications
- S12 Financial and insurance activities
- S13 Real estate activities
- S14 Professional, scientific/ technical, administrative and support service activities
- S15 Public administration
- S16 Education
- S17 Human health activities
- S18 Other social and personal services
- S19 Work activities within domestic households

The population data were manipulated and presented at the following categories:

- Residential population (by usual residents and mobile residents)
- Transient Population (by total employment number and total school places), where total employment = S1+S2+S3+S4+S5+…+S18+S19
- Number of employees in commercial sector (by S3, S4, S6-S10, S16-S19)
- Number of employees in manufacturing sector (=S2) by 6 sub-categories, namely food, textiles, leather, paper, manufacturing and machinery respectively.

The domestic pollution load to be generated from a catchment would be affected by the number of resident population and transient population within the catchment. The total employee number comprises 19 job types listed above. It is considered that commercial effluents are contributed from job S3, S4, S6 to S10 and S16 to S19. Industrial effluents are contributed from job type S2. The population employed under each of the 6 sub-categories under manufacturing section is not provided in the TPEDM. The relative contribution in population employed under these 6 sub-categories estimated for 2012 Scenario II in the Update Study is followed in this Study.

Unit Flow and Load Factors

Relevant per head flow and load were assigned to residential, transient, commercial and industrial population to obtain the quantity and quality of total untreated wastewater by individual catchment areas. *Table 4.2* and *Table 4.3* shows the flow and load factors. Load factors for industrial activities are provided in *Table 4.4*.

Table 4.2 *Unit Flow Factors for Domestic Flows*

Description	Flow [1] m^3/d/head	SS [2] g/d/head	BOD$_5$ [2] g/d/head	TKN [2] g/d/head	NH$_3$-N [2] g/d/head	TP [3] g/d/head	Cu [3] g/d/head	*E. coli* [2] no./d/head
Usual residents								
Sai Kung	0.26	40	42	8.5	5.0	1.33	0.0065	4.3×10^{10}
Sha Tin, Tai Po	0.21	40	42	8.5	5.0	1.33	0.0065	4.3×10^{10}
Shek Wu Hui	0.20	40	42	8.5	5.0	1.33	0.0065	4.3×10^{10}
Mobile residents	0.19	40	42	8.5	5.0	1.33	0.0065	4.3×10^{10}
Employed population	0.08	34	34	6.7	4	1.06	0.0052	3.5×10^{10}
Students	0.04	34	34	6.7	4	1.06	0.0052	3.5×10^{10}

Note:

1. Guidelines for Estimating Sewage Flows for Sewage Infrastructure Planning (Version 1.0), EPD, March 2005
2. Table 4 of DSD Sewerage Manual
3. EPD Update Study

Table 4.3 *Flow and Load Factors for Employees in Commercial Activities*

Description	SS [1] g/d/head	BOD$_5$ [1] g/d/head	TKN [1] g/d/head	NH$_3$-N [1] g/d/head	TP [2] g/d/head	*E. coli* [1] no./d/head
Commercial Activities	25	53	2.5	0.8	0.53	0

Note:

1. Table 4 of DSD Sewerage Manual
2. EPD Update Study

Table 4.4 *Load Factors for Industrial Activities*

Description	SS [1] g/d/head	BOD$_5$ [1] g/d/head	TKN [1] g/d/head	NH$_3$-N [1] g/d/head	Cu [1] g/d/head	*E. coli* [1] no./d/head
S2 Manufacturing						
Food	502	713	39	0	0	0
Textiles	2095	3680	67	0	4.4	0
Leather	115	115	29	7	0.1	0
Paper	2228	2150	33	0	0	0
Manufacturing	355	931	0	0	2.4	0
Machinery	40	90	29	22	0.9	0

Note:

1. EPD Update Study

4.3.2 *Storm Outfalls*

The major sources of water pollution in storm outfalls which are considered in this modelling exercise include:

- Sewage loading from unsewered developments (dry weather load)
- Pollution due to expedient connections from trade and residential premises, and integrity problems of aged drainage and sewerage systems (dry weather load)

- Rainfall related load.

Livestock waste is also known to be a source of water pollution in Hong Kong. Yet the majority of livestock farming is conducted in the western / northwestern New Territories and the practice is not widely and extensively conducted in the Mirs Bay and Tolo Harbour area. Therefore, the discharge of livestock waste is not further considered in this Study.

Dry Weather Load

Domestic, commercial and industrial activities are expected to be the major contributors of dry weather load in storm drains. Total pollution loads generated from these activities were compiled by catchment areas as shown in *Figure 4.1* below with reference to the projected population and employment data provided by the Planning Department. Details of these planning data and the methodology for calculating the pollution loads from domestic commercial and industrial activities are given in *Section 4.3.1* above.

It was assumed that a portion of total pollution load generated within a catchment would be lost to the storm system whilst the rest of the flow would be diverted to the sewerage system. The assumed percentages of pollution load discharged into the storm system for different catchments are presented in *Table 4.5*.

Table 4.5 Assumed % of Pollution Load in the Storm System

Catchment	**Catchment ID**	**Assumed % of Load in the Storm System**	**Foul interception to:**
Sai Kung Country Park [1]	1A	50%	Sai Kung Sewage Treatment Works
Tolo Harbour	37	10%	Tolo Harbour Effluent Export Scheme
Sha Tau Kok	40	10%	STKSTW

Note:

1. While the Sai Kung Country Park catchment is adjacent to the marine waters covered under the model domain of the STK model, there is no major storm outfall in the catchment.

Figure 4.1 Sewage Catchment Boundaries under this Study

The percentage interceptions assumed in *Table 4.5* were adopted from the approved EIA of HATS Stage 2A. It should be highlighted that the percentage interceptions within the Sha Tau Kok sewage catchment is assumed to be the same before and after expansion of the STKSTW for conservative assessment. The pollution loading compiled for each catchment was distributed to appropriate discharge points (i.e. storm culverts / outfalls, rivers and nullahs).

Rainfall Related Loading

Following the approach adopted under the approved EIA of HATS Stage 2A (and other relevant previous studies), it was assumed that runoff arise when rainfall is greater than 10mm per day and greater than 2mm per hour. The same set of average rainfall data between 1981 and 2010 from the Hong Kong Observatory adopted under approved EIA of *Expansion of Hong Kong International Airport into a Three-Runway System* is adopted under this Study for the calculation of runoff percentage according to the following:

Runoff percentage = (Sum of the rainfall volume for the days with rainfall volume > 10mm and intensity > 2mm/hr within the season) ÷ Total rainfall volume for the season x 100%

The runoff percentage for wet season is calculated based on data from May to September, and runoff percentage for dry season is calculated from those from November to March. Accordingly, the runoff percentage was calculated as 93% and 70% for wet and dry seasons respectively. The daily runoff value is calculated for each season from the runoff percentage and the 30-year long term average rainfall data.

Daily runoff value = runoff percentage × 30-year long term average daily rainfall data

The runoff value was calculated as 0.01150 m/day for wet season and 0.00105 m/day for dry seasons. The amount of rainfall related load that would enter the sea depends on the amount of impermeable area within each catchment. All urbanized/developed areas within the catchment are assumed to be impermeable. The daily volume of runoff generated within each catchment was estimated according to the following:

Daily volume of runoff in each catchment (m^3/day) = daily runoff value (m/day) × impermeable area within each catchment (m^2)

The rainfall related loading is calculated from the daily volume of runoff estimated for each catchment and the mean event concentration of each pollutant for stormwater runoff from the EPD *Pilot Study of Stormwater Pollution*. The assumed runoff concentrations are shown below in *Table 4.6*.

Table 4.6 Event Mean Concentrations for Stormwater Runoff

TSS	**BOD5**	**NH_3-N**	**Cu**	**TP**	**Ortho-P**	**Silicate**	**TON**	**TKN**
(g/m^3)	(g/m^3)	(g/m^3)	(g/m^3)	(g/m^3)	(g/m^3)	(g/m^3)	(g/m^3)	(g/m^3)
43.25	22.48	0.20	0.01	0.20	0.04	3.28	0.40	1.40

The rainfall related loading was compiled to the catchment levels shown in *Figure 4.1*. Similar to the dry weather load discussed in the previous section, the pollution loading compiled for each catchment was distributed to appropriate discharge points. Reference is made to the approved EIA of the Tai Po Sewage Treatment Works Stage V on the relative proportion flow and load among major storm water outfall to ensure consistent results.

4.3.3 *Sewage Outfalls*

There are three major sewage treatment works within the sewerage catchments of the Tolo Harbour and Mirs Bay waters. They include the Sha Tin Sewage Treatment Works, the Tai Po Sewage Treatment Works as well as the STKSTW (which is the Project itself).

Currently the effluents from the Sha Tin Sewage Treatment Works and the Tai Po Sewage Treatment Works are exported to the Kai Tak area of the Victoria Harbour under the Tolo Harbour Effluent Export Scheme (THEES) under normal operation. While emergency bypass into the Tolo Harbour may occur in case of plant failure, power failure and regular maintenance of the THEES effluent tunnel, any change of operation of the Sha Tin Sewage Treatment Works and the Tai Po Sewage Treatment Works is unlikely to exert notable change to the water quality near the Starling Inlet in view of the vast distance and landlocked geometry (geodesic distance is about 11 km and the shortest distance by sea is about 31 km). It is therefore considered appropriate to assume the Sha Tin Sewage Treatment Works, the Tai Po Sewage Treatment Works as well as the THEES are all under normal operation under this Study.

Based on the latest design information, the effluent flow and load of the STKSTW under the baseline and operation phase scenarios are provided below in *Table 4.7*. The maximum allowed concentration would be adopted for simulation for all scenarios (except 2011 scenario for calibration) under this Study.

Table 4.7 Flow and Load of Effluent Discharged from the STKSTW in Modelled Scenarios

Parameters	**Unit**	**Baseline**	**Operation**
Flow	m^3/s	0.0192	0.1157
BOD5	mg/L	10/20/40	10/20/40
SS	mg/L	15/30/60	15/30/60
TN	mg/L	22/43/86	6/12/24
TIN	mg/L	9.43/18.19/36.38*	4/8/16
NH_3-N	mg/L	3.14/6.62/13.23*	1/2/4
Organic Nitrogen	mg/L	3.14/6.62/13.23*	2/4/8

Parameters	Unit	Baseline	Operation
NO_3 and NO_2	mg/L	6.29/11.58/23.15*	3/6/12
Ortho-phosphate Phosphorus	mg/L	3.7/4.5/9	2/3/5
Total Phosphorus	mg/L	4/5/10	3/4/8
E. Coli	count/100mL	100/1500	100/1500

Note: For all parameters except *E.coli*, the first, second and third numbers indicate the mean, 95th percentile and maximum concentration respectively. For *E.coli*, the first number indicates the monthly geometric mean value while the second number indicates the maximum concentration.

* The effluent quality data for baseline (i.e. from the existing STKSTW) is extracted from effluent quality monitoring records required under the existing WPCO discharge permit for the existing STKSTW. As total nitrogen (TN) is the only criteria for nitrogenous species stipulated in the existing WPCO discharge permit, effluent quality of other nitrogenous species are estimated based on the weighting of nitrogenous species in the expanded STKSTW.

As shown in *Table 4.7*, the loading assumed (maximum allowed concentration), is 2.5 (ortho-phosphate) to 15 (*E.coli*) times of the mean effluent concentration. For comparison, the peaking factor of the expanded STKSTW is expected to be 3 and the peak wet weather flow (PWWF) would be 30,000 m^3/day. This means the modelled scenarios ADWF with maximum effluent concentration would give rise to pollution load greater than the PWWF with mean effluent concentration for most of the pollutant parameters. It is therefore considered the adoption of maximum concentration would be sufficiently conservative and modelling of PWWF discharge (which would only last for very short period of time) is not necessary. For the 2011 modelling scenario for model verification, the actual daily flow rate and actual effluent concentration are adopted in the model.

4.3.4 *Pollution Loading from Remote / Rural / Countryside Area of Hong Kong*

The compilation of pollution loading stipulated in the *Section 4.3.1* and *4.3.2* above followed the assumed locations of discharge of pollution loading based on the methodology adopted by the 1998 EPD's *Update Study*, which was a high level regional study and the pollution loadings contributed from the remote and rural area are generally bundled with other major pollution sources. This means for this Study, the pollution loading from population living in the remote area of Study Area (such as the Plover Cover Country Park, Crooked Island), would already been taken into account in the pollution loading within the Starling Inlet because these areas share the same Planning Data Zone and Sewage Catchment Area with the population around the Starling Inlet. As a result, the pollution loading from these remote areas is shifted to Starling Inlet, resulting in underestimation of pollution loading at these remote areas.

To ensure reasonably conservative assessment for water quality modelling exercise, additional pollution loadings at these remote areas are compiled separately. Six settlements within 1 km from the nearest WSRs identified under this Study were identified within the Study Area. They include:

- Yung Shue Au

- So Lo Pun
- Lai Chi Wo
- Sam A Tsuen
- Crooked Island (Kat O)
- Wong Wan

Since the population in these remote areas shared the same Planning Data Zone, it is not possible to make use of population data in the TPEDM for compilation of pollution loading. Instead, the number of houses within these six identified settlements was counted using digital maps from the Town Planning Board Outline Zoning Plan, based on the following criteria:

- For settlement with postal address (Lai Chi Wo and Crooked Island), all houses with a postal address number and complete wall confinement are counted as one household (i.e. houses with damaged wall or without postal address number do not count).
- For settlement without postal address (Yung Shue Au, So Lo Pun and Sam A Tsuen), all houses within the corresponding village development area (shown in OZP) with complete wall confinement are counted as one household (i.e. houses with damaged wall or outside village development area do not count).

Population at these five settlements are calculated by assuming an average household population of 2.9 (based on average household size from the 2011 Census). The pollution loading to storm system are then compiled following the same loading intensity stipulated in *Section 4.3.2* above.

There is no known permanent settlement on Wong Wan. There is a camp site operated by the HK Outward Bound at Wong Wan and the camp site is routinely occupied by campers and training staff. Population on camp site is around 60 when fully occupied. The pollution loading to storm system are compiled following the same loading intensity stipulated in *Section 4.3.2* above. A summary of assumed population in the 6 identified settlements are provided in *Table 4.8* below.

Table 4.8 Assumed Number of Active Household and Population at the Six Identified Remote Settlements in the Study Area

Settlements	**Number of Active Households**	**Population**
Yung Shue Au	24	69.6
So Lo Pun	4	11.6
Lai Chi Wo	124	359.6
Sam A Tsuen	19	55.1
Crooked Island (Kat O)	218	632.2
Wong Wan	-	60

The pollution loadings compiled for these six settlements are assumed to be discharged at the nearest coastline in the WQ model as a single source, except for the settlement on the Crooked Island. For the settlement on the Crooked Island, the area occupied by the settlement is relatively large. The pollution loading from the settlement is therefore distributed into 3 equal sources and discharge to O Pui Tong in the east, Chung Kan O in the west and Tung O Wan in the north respectively.

4.3.5 Other Point Source Pollution Loading

The pollution loading from marine culture zones within the model domain are adopted from the *Update Study* and summarized below in *Table 4.9*. It should be highlighted some of these marine culture zones are also considered as WSRs under these Study. The corresponding WSR IDs are shown below in *Table 4.9* as well and their locations are shown in *Figure 2.1*. Other marine culture zones are far from the existing and proposed outfall of the STKSTW. They are not expected to be affected by the Project and are therefore not considered as WSRs.

Table 4.9 ***Pollution Loading from Marine Culture Zone within Study Area***

Marine Culture Zone	WSR ID	BOD (g/d)	SS (g/d)	Org-N (g/d)	NH3-N (g/d)	TP (g/d)	OrthoP (g/d)
Sha Tau Kok	FCZ1	42806	124916	10569	38075	2038	1595
Ap Chau	FCZ2	999	2915	247	888	48	37
Kat O	FCZ3	7705	22485	1902	6854	367	287
O Pui Tong	FCZ4	25113	73284	6200	22338	1196	936
Sai Lau Kong	FCZ5	1712	4997	423	1523	82	64
Wong Wan	FCZ6	5351	15615	1321	4759	255	199
Tap Mun	-	17217	50244	4251	15315	820	642
Kau Lau Wan	-	2663	7773	658	2369	127	99
Sham Wan	-	42948	125333	10604	38202	2045	1600
Lo Fu Wat	-	1284	3747	317	1142	61	48
Yung Shue Au	-	81330	237341	20081	72343	3872	3031
Yim Tin Tsai	-	35552	103750	8778	31624	1693	1325
Yim Tin Tsai (East)	-	35499	103750	4406	31754	1197	1051

4.3.6 Background Pollution Loading from Mainland

An elaborate set of background pollution loading data in the Mirs Bay is available in the approved EIA of the Tai Po Sewage Treatment Works Stage V. The same set of background pollution loading would be adopted.

5 CUMULATIVE IMPACTS

As discussed in *Section 1.5* above, the proposed Ma Liu Shui Reclamation within the Tolo Harbour is the only known potential future reclamation within the coverage of the STK Model. The Ma Liu Shui Reclamation is deemed too far away to exert any effect on the flow regime and water quality of the Starling Inlet. Other future projects in the Tolo Harbour, such as the proposed Sha Tin Cavern Sewage Treatment Works, are also considered too far to exert any notable effect on water quality at Starling Inlet and are therefore not considered. A list of identified project at the vicinity (i.e. geodesic distance < 7 km) of the Starling Inlet is summarized below in *Table 5.1* based publicly available sources.

Table 5.1 Nearby Projects Identified

Project	**Duration**	**Location**	**Major Marine Activity / Sewage Discharge**
North District sewerage, stage 2 part 2A - Pak Hok Lam trunk sewer and Sha Tau Kok village sewerage	2012 - 2017	Pak Hok Lam and Sha Tau Kok Village	Increase sewage flow to STKSTW
Sediment Removal at Sha Tau Kok Fish Culture Zone, Boat Shelter and Approach Channel	2017-2018	Sha Tau Kok Fish Culture Zone, Boat Shelter and Approach Channel	(1) Sediment dredging (2) Temporary relocation of fish rafts (3) Change in seabed level
Drainage Improvement Works at North District, including various drainage improvement measures in Sha Tau Kok.	2016 – 2020	Sha Tau Kok Town area	Drainage improvement works in Sha Tau Kok Town area

5.1 *DC/2012/09 NORTH DISTRICT SEWERAGE, STAGE 2 PART 2A - PAK HOK LAM TRUNK SEWER AND SHA TAU KOK VILLAGE SEWERAGE*

The scope of the North District Sewerage Stage 2 Part 2A project comprises the construction of about 2 km of trunk sewers along Sha Tau Kok Road; about 7.5 km of sewers for the nine unsewered areas; and one sewage pumping station at Wu Shek Kok with associated twin rising mains. This project would significantly increase the amount of sewage collected in the STKSTW catchment and is the main drive for the expansion of the STKSTW. The increased sewage flow to the STKSTW from 1,660 m^3/day ADWF to 10,000 m^3/day ADWF would be taken into account in this Study and be modelled as the project scenario.

5.2 *SEDIMENT REMOVAL AT SHA TAU KOK FISH CULTURE ZONE, BOAT SHELTER AND APPROACH CHANNEL*

An EIA project profile (PP-350/2008) of the captioned project is submitted to EPD on 2008 and an EIA study brief (ESB-186/2008) was issued. No approved EIA is available at the time of preparation of this methodology. Based on the latest information provided by CEDD, the construction works for are scheduled to commence in the 1st half of 2017 for completion in the 1st half of 2018 tentatively, which will overlap with the marine construction of cofferdam under this Project. As such, the sediment removal project will be assessed as a concurrent project under this Study.

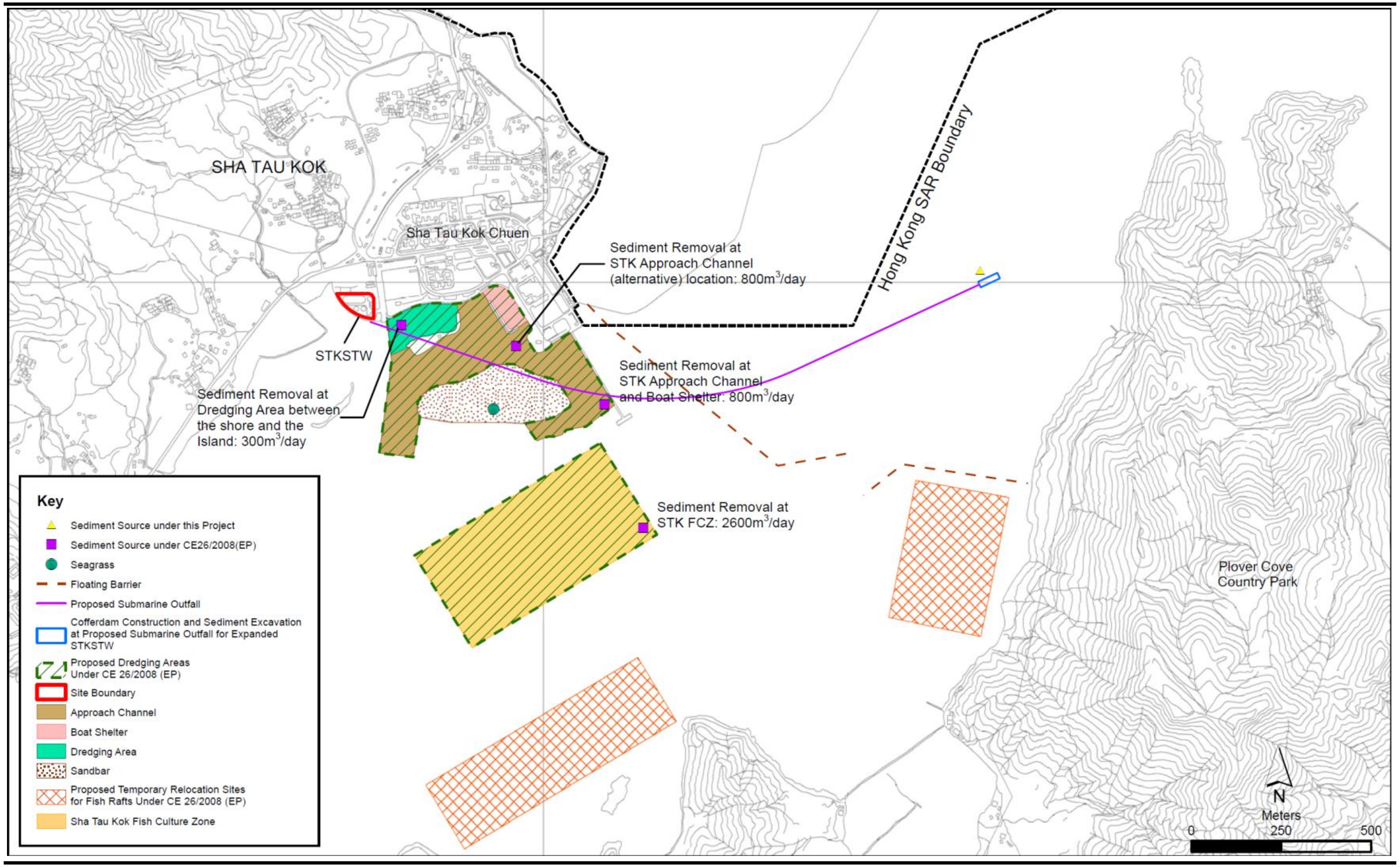
Under the sediment removal project, dredging operation would be conducted at the Sha Tau Kok fish culture zone (STKFCZ), Sha Tau Kok boat shelter, approach channel and dredging area between the shore and the island. Tentative dredging rate would be 2600 (for STKFCZ), 800 (for boat shelter and approach channel) and 300 (for dredging area between the shore and the island) m^3/day respectively. During the dredging operation, the fish rafts of the STKFCZ would be relocated to two proposed temporary relocation zones. One of the relocation zones is about 800 m east to the existing STKFCZ (FCZ7 shown in *Figure 2.1*) and the other would be about 250 m south to the existing STKFCZ (FCZ8 shown in *Figure 2.1*). In view of this, the sediment contribution from the sediment removal works would be considered in the construction phase sediment dispersion modelling under this Project. The temporary relocation sites for fish rafts of the STKFCZ would also be considered as WSR in the construction phase sediment dispersion modelling. The dredging areas and relocation zone under the sediment removal project in relation with the marine dredging area under this Project are shown in *Figure 5.1* below.

Since the marine construction and plant operation under this Project would be carried out after the after the sediment removal project, the seabed level at the dredging areas covered under sediment removal project is assumed to be the same as the proposed dredging level under that project for construction phase and operation phase scenarios, with the exception of operation phase scenario for model calibration.

5.3 *DRAINAGE IMPROVEMENT WORKS AT NORTH DISTRICT, INCLUDING VARIOUS DRAINAGE IMPROVEMENT MEASURES IN SHA TAU KOK.*

This drainage improvement project is tentatively scheduled from 2016 to 2020. Under this drainage improvement project, a 600 mm diameter covered U-channel is proposed to be constructed along the access road to STKSTW and a pair of 1350 mm diameter drainage pipes are proposed to be constructed along Sha Tau Kok Road – Shek Chung Au. There will be minor interface between the drainage pipes by Drainage Projects Division and the proposed gravity sewer. No marine construction is required and no additional pollution loading from this Project is expected. Therefore no cumulative water quality impact from this drainage improvement project is expected.

Figure 5.1 Consideration of Concurrent Project



6 MODEL SCENARIOS

The water quality modelling exercise will commence with the set-up of hydrodynamic baseline models (covering a complete spring/neap cycle for both the dry and wet seasons). It will be conducted with regard to two main components, construction phase and operation phase as detailed below.

- **Construction Phase**: the assessment will examine potential water quality impacts arising from dredging for the installation of the proposed submarine outfall, with the extent of seabed dredging of about 18,000 m^3;
- **Operation Phase**: the assessment will examine potential water quality impacts arising primarily from the effluent discharge from the interim operation and expanded operation via the proposed outfall.

Table 6.1 summarizes the proposed near-field and far-field modelling scenarios below:

Table 6.1 Proposed Far-field and Near-field Model Scenarios

Scenario ID	Modelling Scenario	Project Phase	Model Year	Seasons
Far-field Delft3D Model				
F01W	FLOW model for baseline	Baseline	-	Wet Season
F01D	FLOW model for baseline	Baseline	-	Dry Season
F03W	FLOW model for project operation	Project operation	-	Wet Season
F03D	FLOW model for project operation	Project operation	-	Dry Season
C01W	Sediment Plume Model (Delft-PART)	Outfall construction	2017	Wet Season
C01W	Sediment Plume Model (Delft-PART)	Outfall construction	2017	Dry Season
O01W	WAQ model for baseline	Normal Operation	2020	Wet Season
O01D	WAQ model for baseline	Normal Operation	2020	Dry Season
O03W	WAQ model for baseline	Normal Operation	2030	Wet Season
O03D	WAQ model for baseline	Normal Operation	2030	Dry Season
O04W	WAQ model for project operation	Normal Operation	2030	Wet Season
O04D	WAQ model for project operation	Normal Operation	2030	Dry Season
Near-field CORMIX Model				
ND-A10	CORMIX for existing	Existing Operation	2016	Dry Season
ND-A50	CORMIX for existing	Existing Operation	2016	Dry Season
ND-A90	CORMIX for existing	Existing Operation	2016	Dry Season
NW-A10	CORMIX for existing	Existing Operation	2016	Wet Season
NW-A50	CORMIX for existing	Existing Operation	2016	Wet Season
NW-A90	CORMIX for existing	Existing Operation	2016	Wet Season
ND-B10	CORMIX for operation	Normal Operation	2030	Dry Season
ND-B50	CORMIX for operation	Normal Operation	2030	Dry Season
ND-B90	CORMIX for operation	Normal Operation	2030	Dry Season
NW-B10	CORMIX for operation	Normal Operation	2030	Wet Season
NW-B50	CORMIX for operation	Normal Operation	2030	Wet Season

Scenario ID	Modelling Scenario	Project Phase	Model Year	Seasons
NW-B90	CORMIX for operation	Normal Operation	2030	Wet Season

Annex A

Delft3D FLOW Verification Plots

Location of Verification Points

ERM

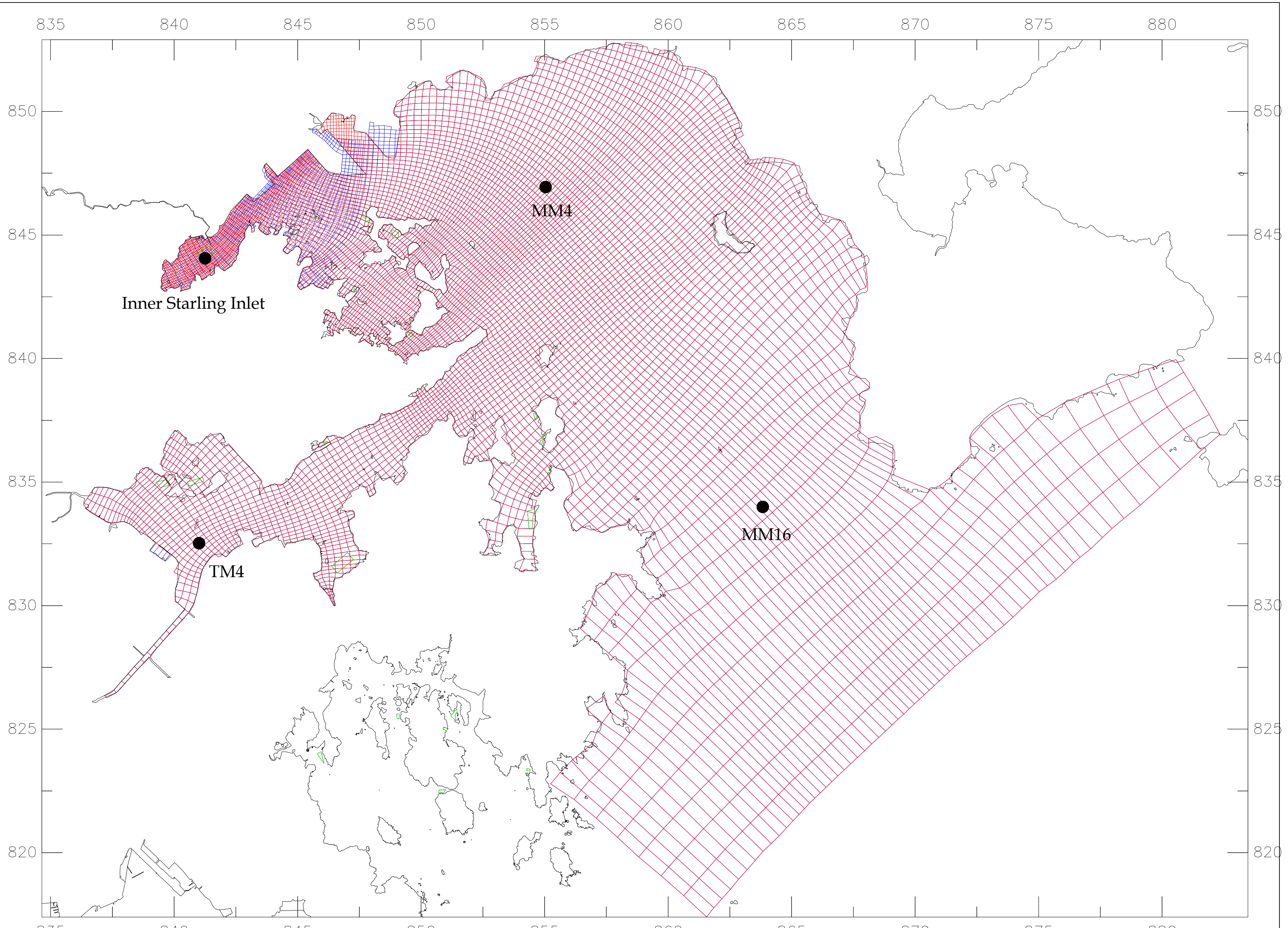
GPP/

Grid.ssn

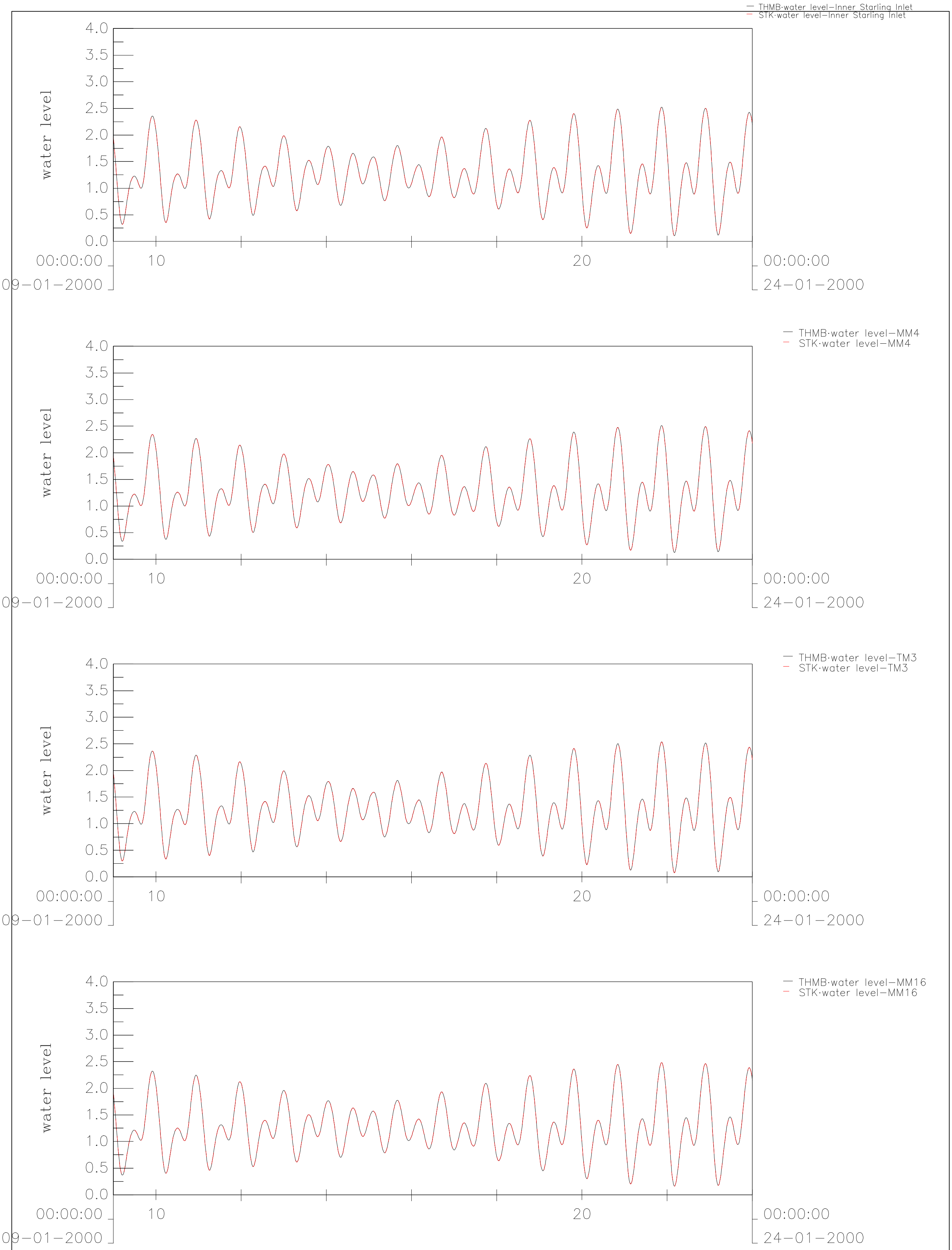
Expansion of Sha Tau Kok Sewage Treatment Works, Phase 1

Grid Overview

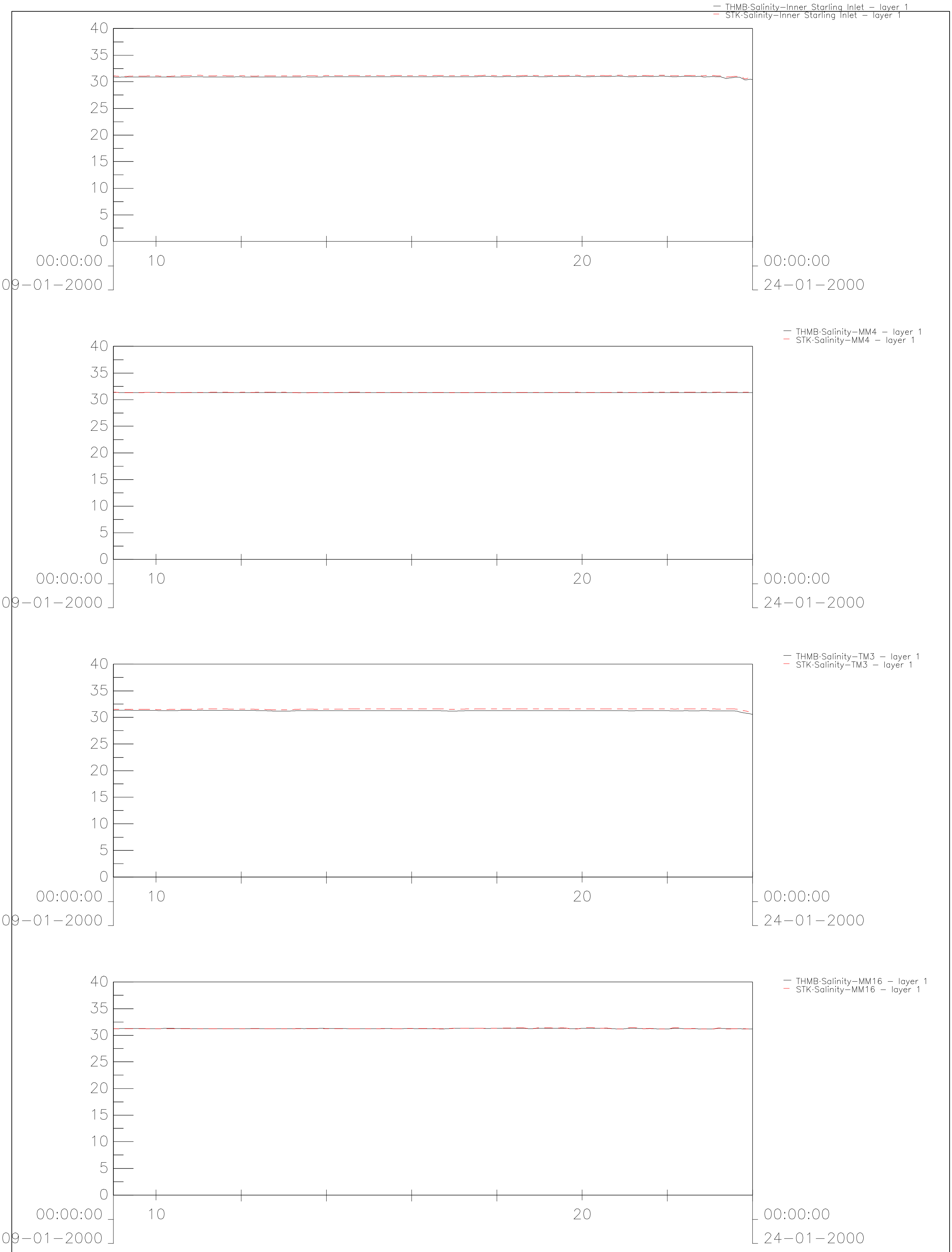
THMB Model: Blue; STK Model: Red



Timeseries Plots at Verification Points



Expansion of Sha Tau Kok Sewage Treatment Works Water Level (Black: THMB Model; Dashed Red: STK Model) From top to bottom: Verification point 1 to 4	Year 2020	Dry
	Annex A	
ERM HK Limited	GPP/Verification	Cal.ssn



Expansion of Sha Tau Kok Sewage Treatment Works

Surface Salinity (Black: THMB Model; Dashed Red: STK Model)

From top to bottom: Verification point 1 to 4

Year 2020

Dry

Annex A

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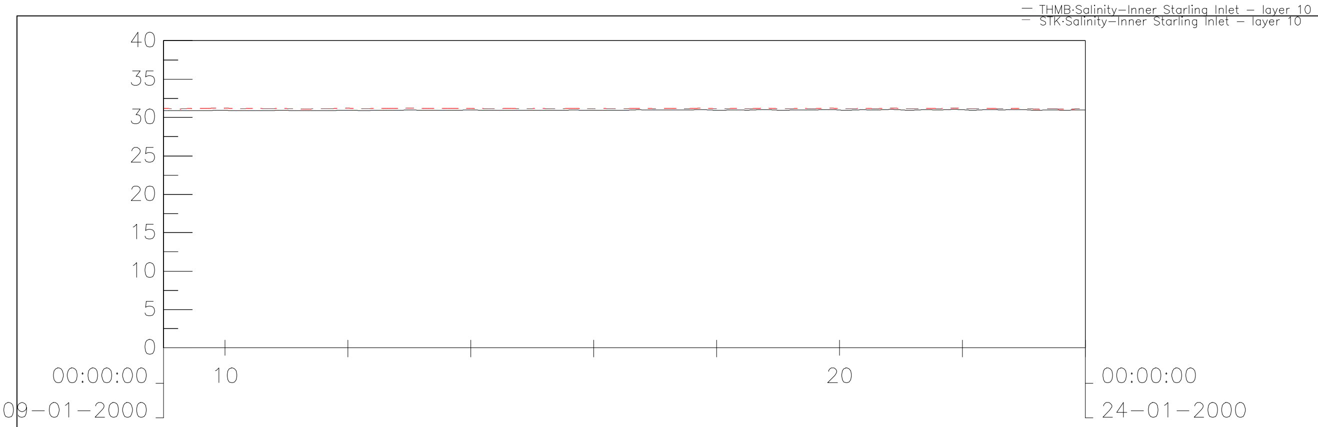
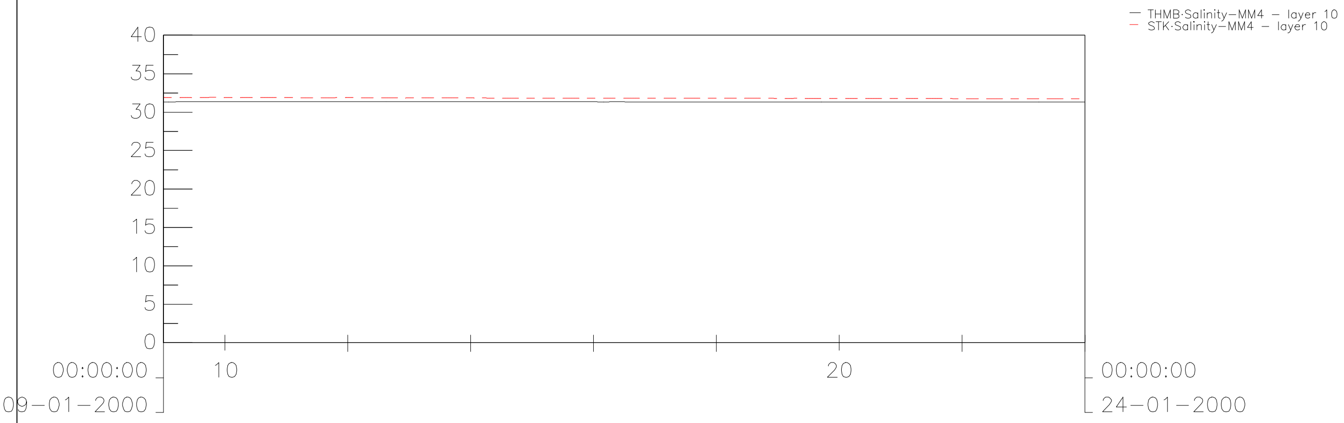
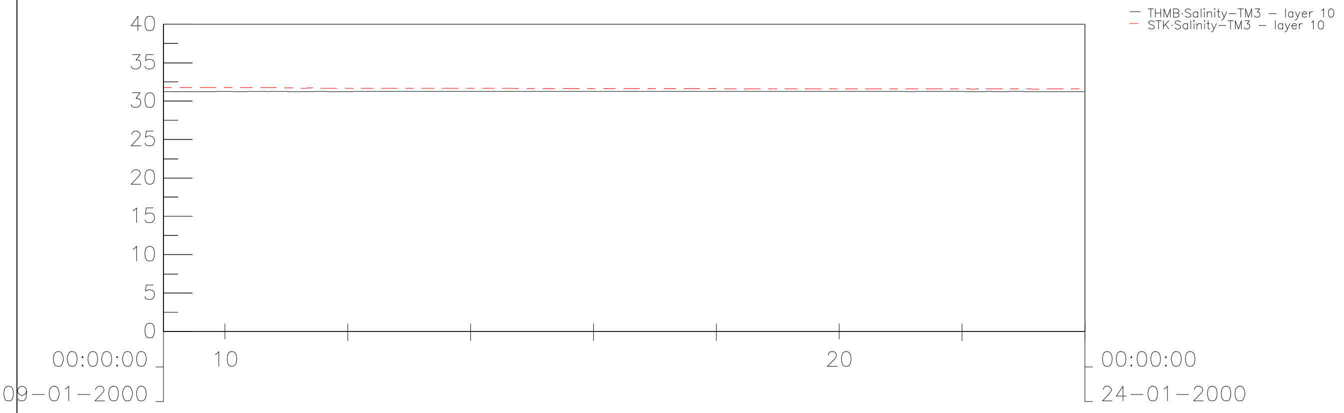
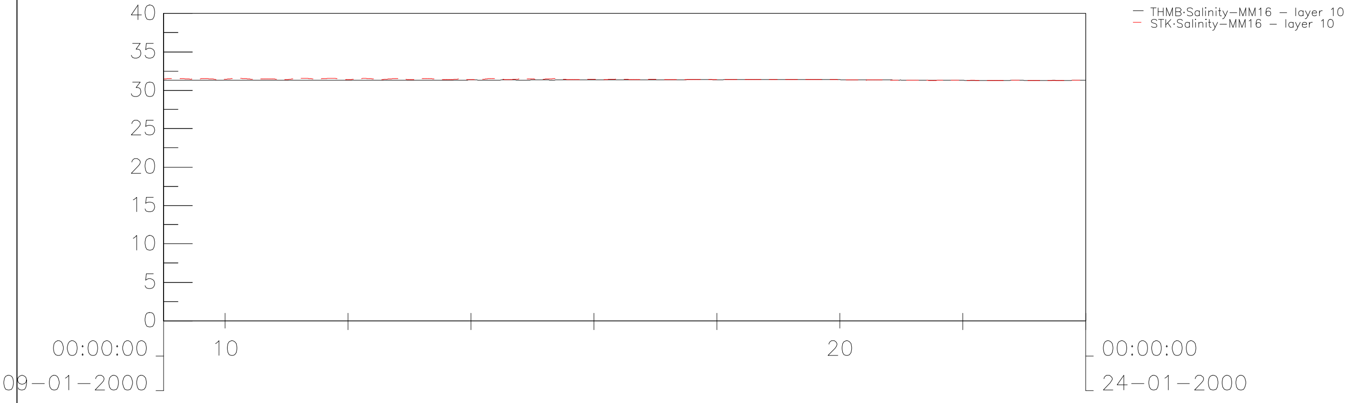
GPP/Verification

Verification.ssn









Expansion of Sha Tau Kok Sewage Treatment Works

Bottom Salinity (Black: THMB Model; Dashed Red: STK Model)

From top to bottom: Verification point 1 to 4

Year 2020

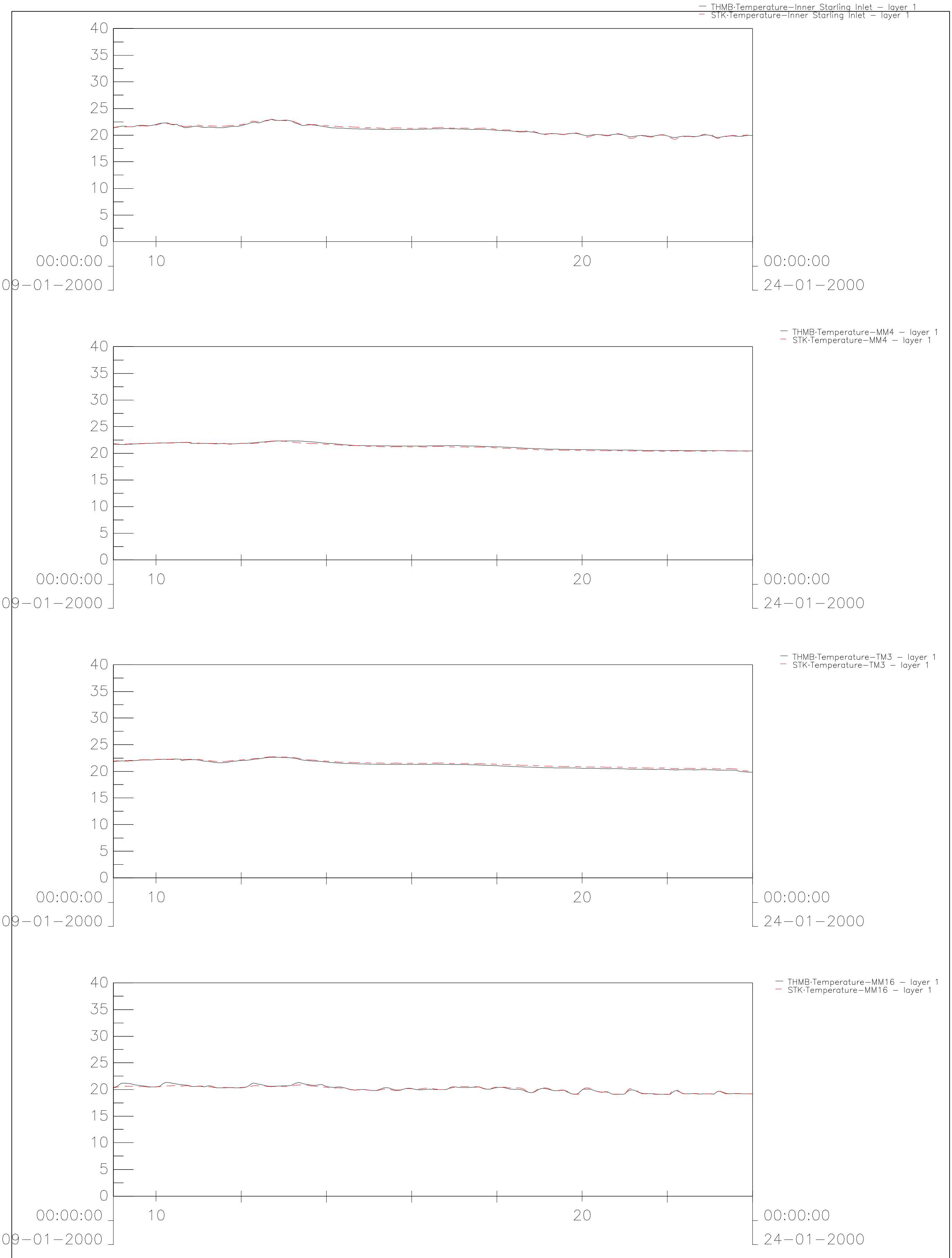
Dry

Annex A

ERM HK Limited

GPP/Verification

Verification.ssn



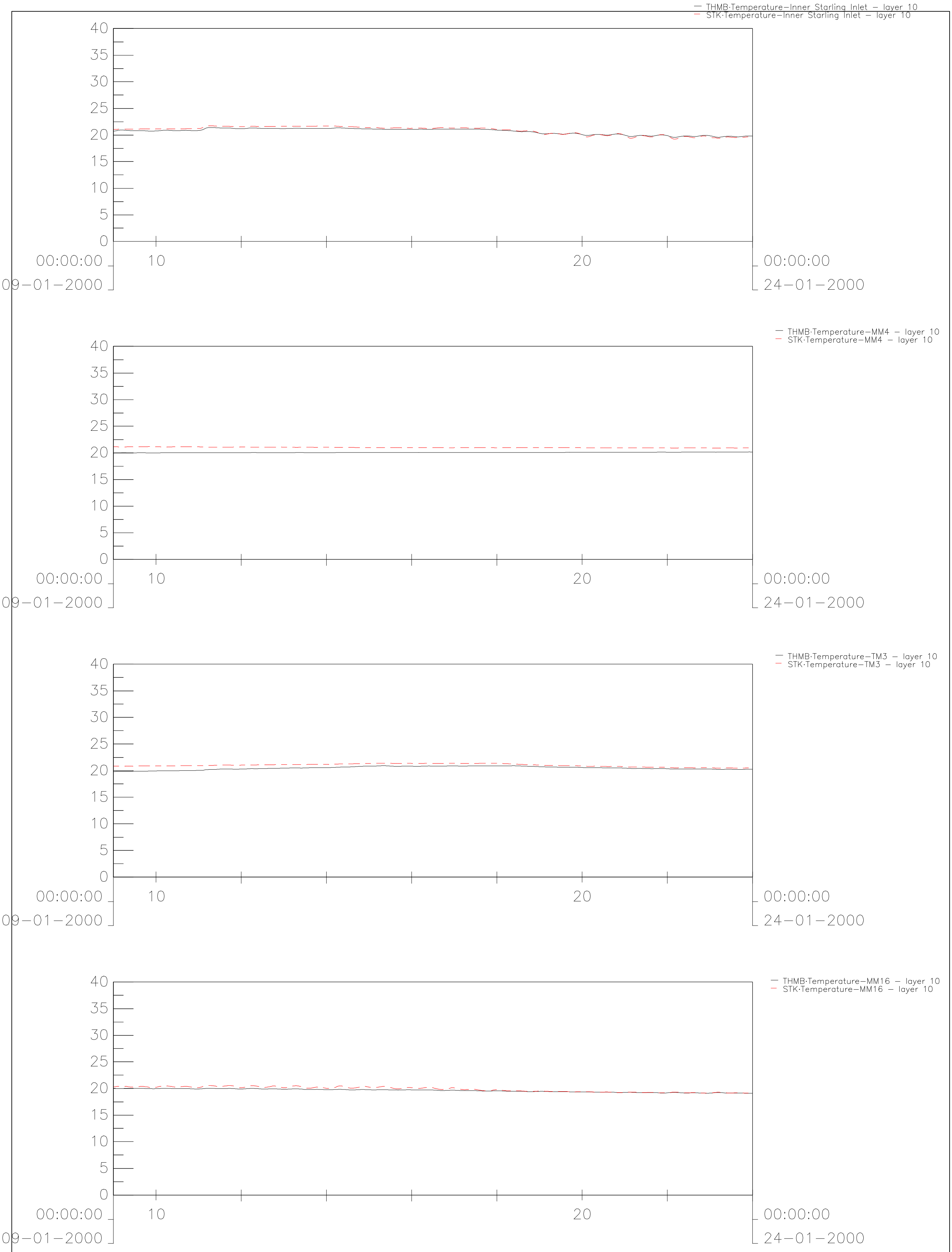
Expansion of Sha Tau Kok Sewage Treatment Works

Surface Temperature (Black: THMB Model; Dashed Red: STK Model)

From top to bottom: Verification point 1 to 4

Year 2020	Dry
Annex A	
GPP/Verification	Verification.ssn

ERM HK Limited



Expansion of Sha Tau Kok Sewage Treatment Works

Bottom Temperature (Black: THMB Model; Dashed Red: STK Model)

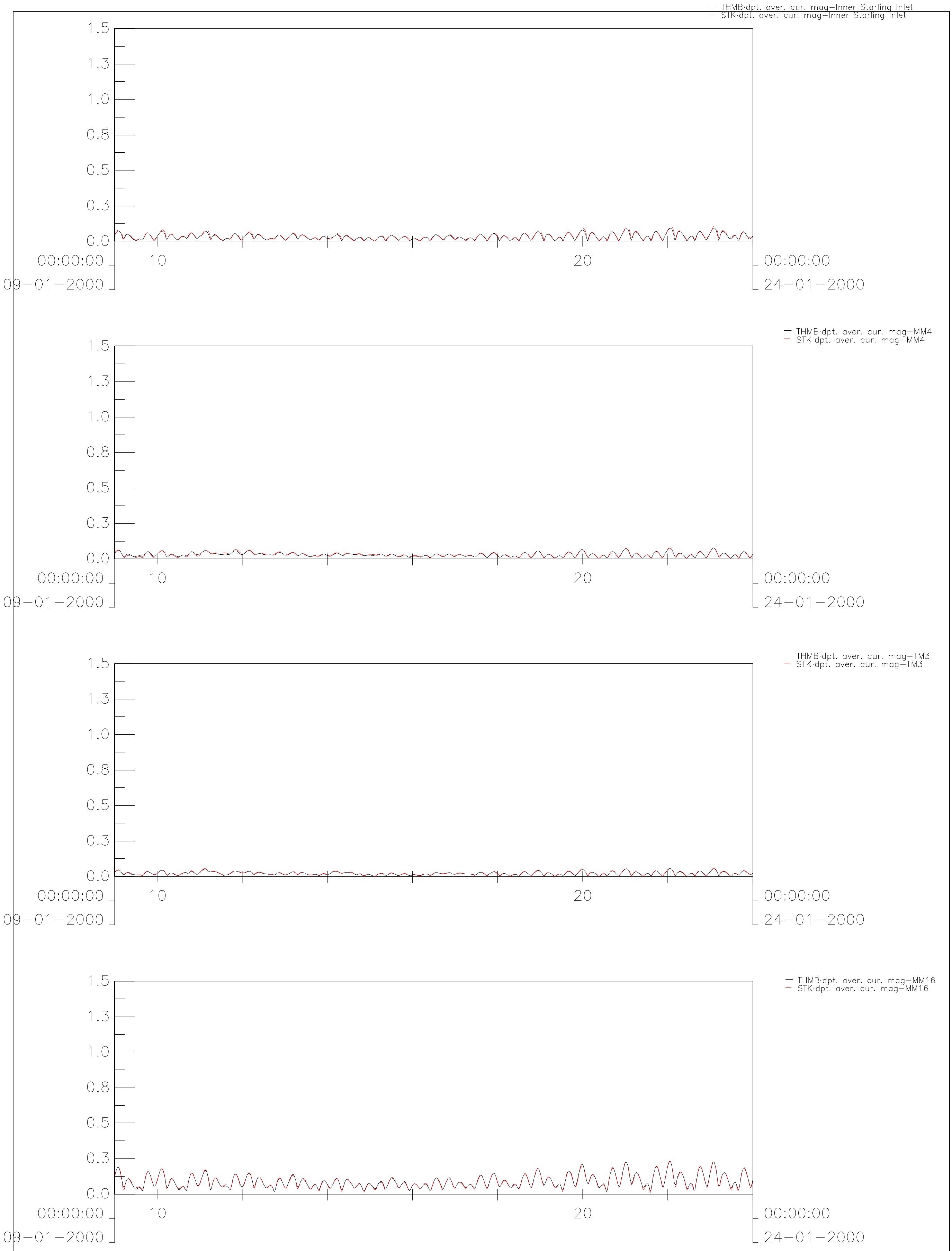
From top to bottom: Verification point 1 to 4

Year 2020	Dry
Annex A	

ERM HK Limited

GPP/Verification

Verification.ssn



Expansion of Sha Tau Kok Sewage Treatment Works

Depth—averaged Current Magnitude (Black: THMB Model; Dashed Red: STK Model)

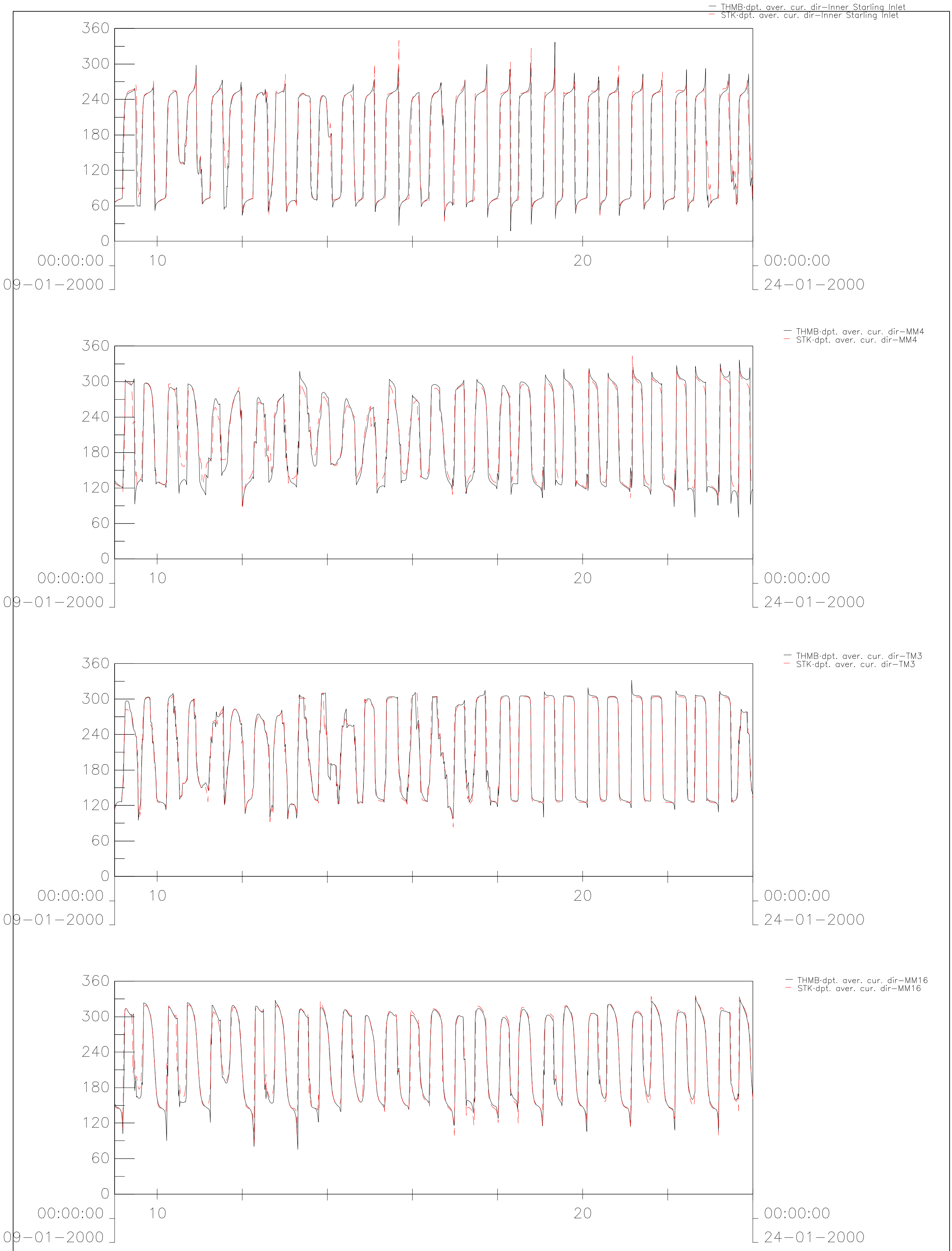
From top to bottom: Verification point 1 to 4

Year 2020 | Dry

Annex A

ERM HK Limited

GPP/Verification | Cal.ssn



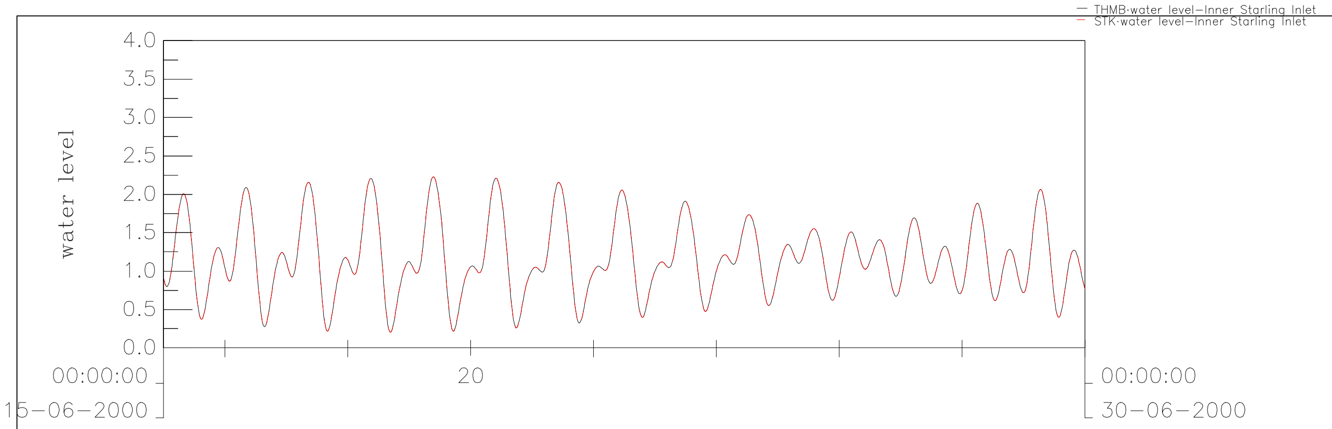
Expansion of Sha Tau Kok Sewage Treatment Works

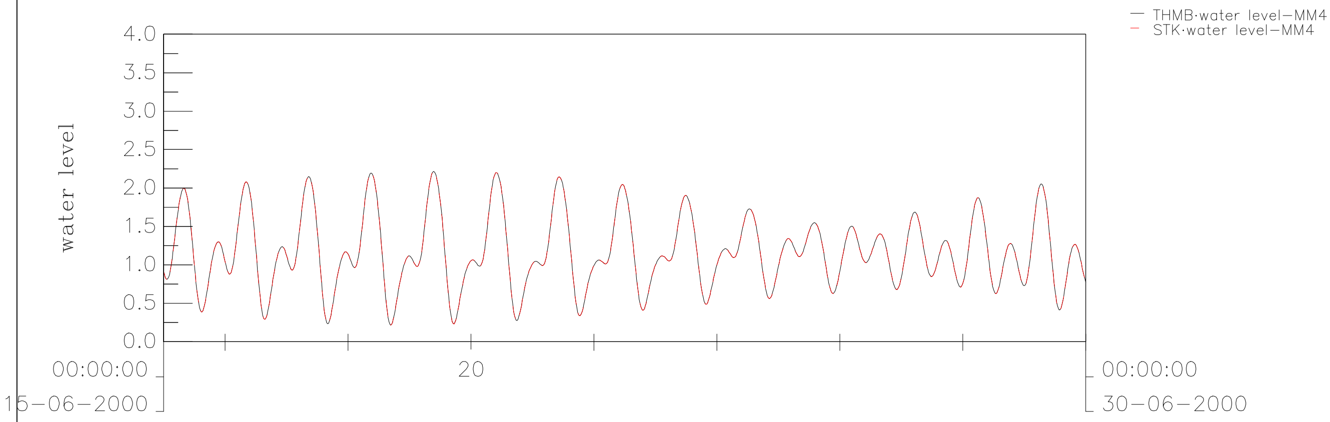
Depth–averaged Current Direction (Black: THMB Model; Dashed Red: STK Model)

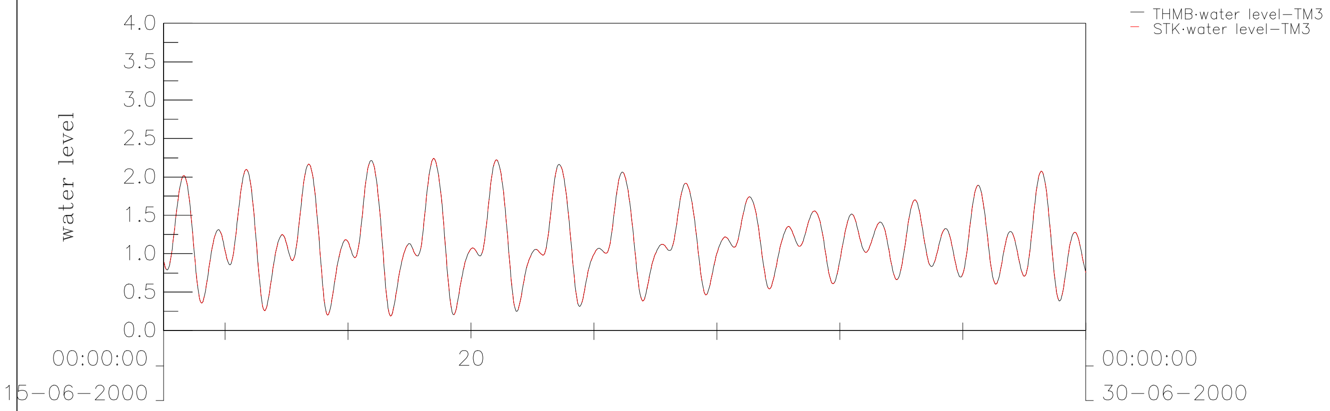
From top to bottom: Verification point 1 to 4

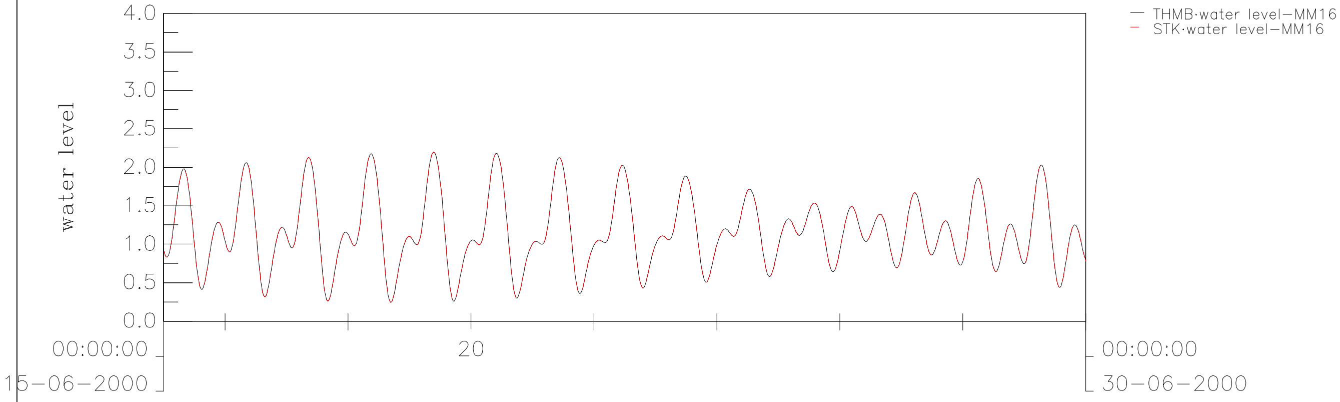
Year 2020	Dry
Annex A	
GPP/Verification	Cal.ssn

ERM HK Limited









Expansion of Sha Tau Kok Sewage Treatment Works

Water Level (Black: THMB Model; Dashed Red: STK Model)

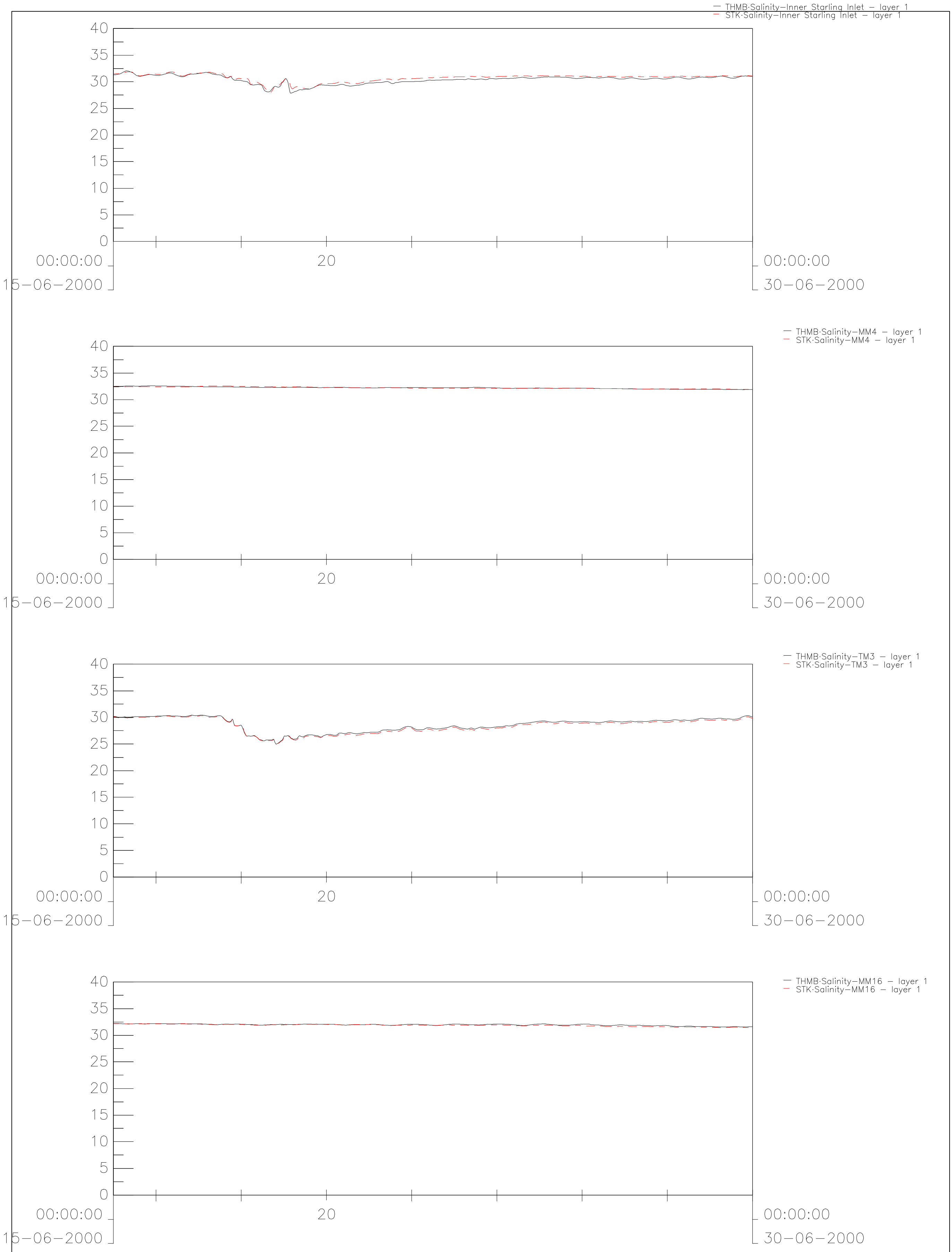
From top to bottom: Verification point 1 to 4

Year 2020 | Wet

Annex A

ERM HK Limited

GPP/Verification | Cal.ssn



Expansion of Sha Tau Kok Sewage Treatment Works

Surface Salinity (Black: THMB Model; Dashed Red: STK Model)

From top to bottom: Verification point 1 to 4

Year 2020

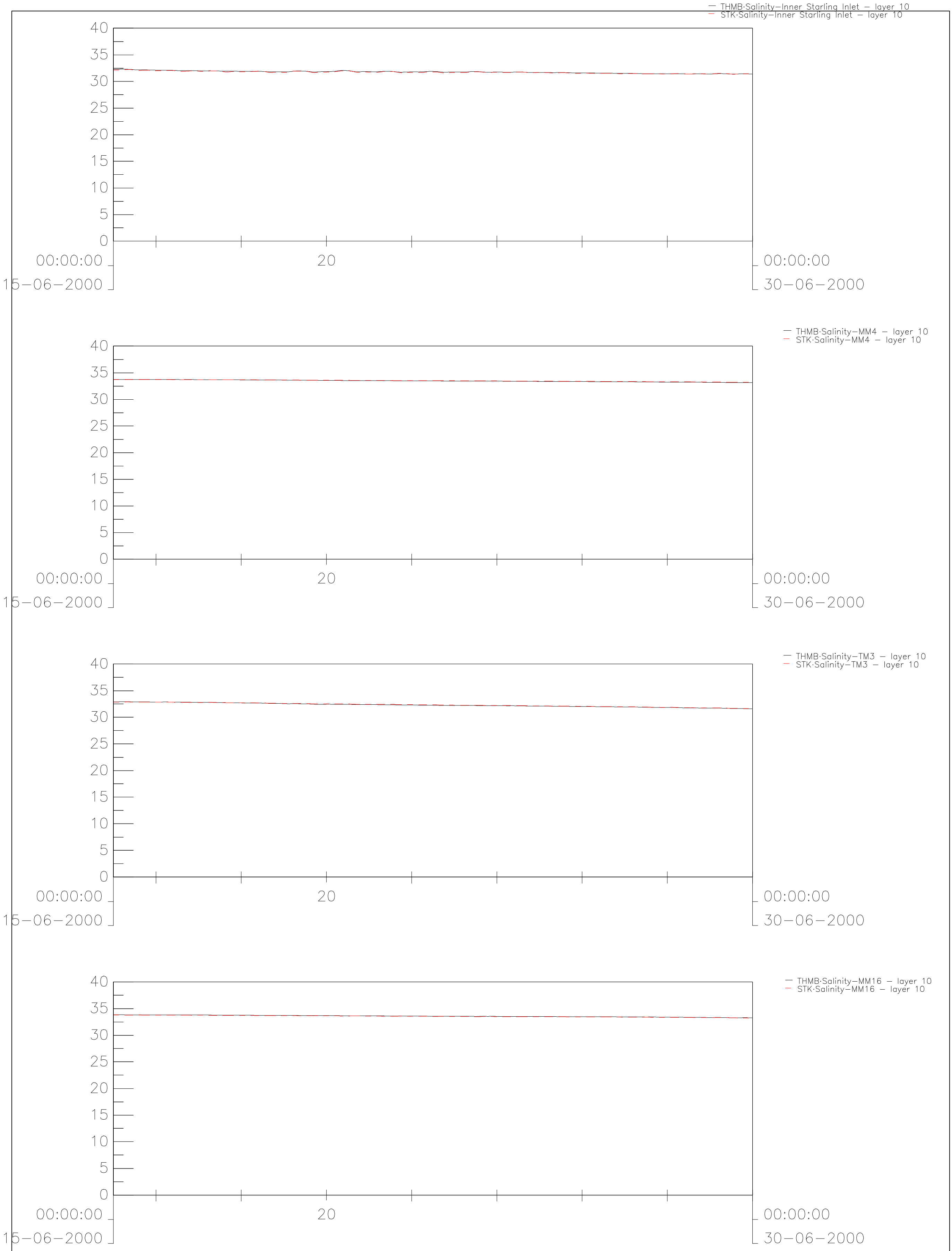
Wet

Annex A

ERM HK Limited

GPP/Verification

Verification.ssn



Expansion of Sha Tau Kok Sewage Treatment Works

Bottom Salinity (Black: THMB Model; Dashed Red: STK Model)

From top to bottom: Verification point 1 to 4

Year 2020

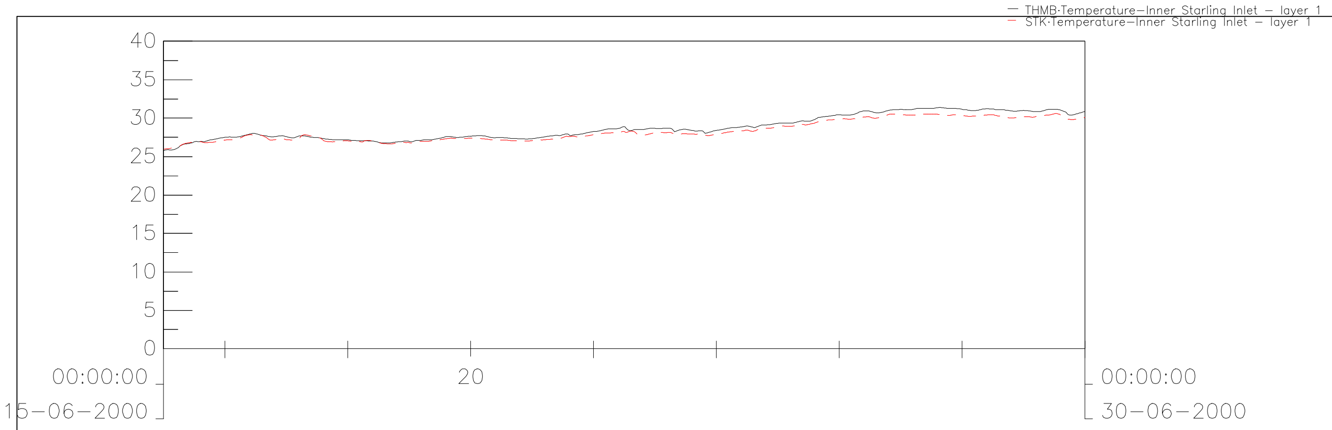
Wet

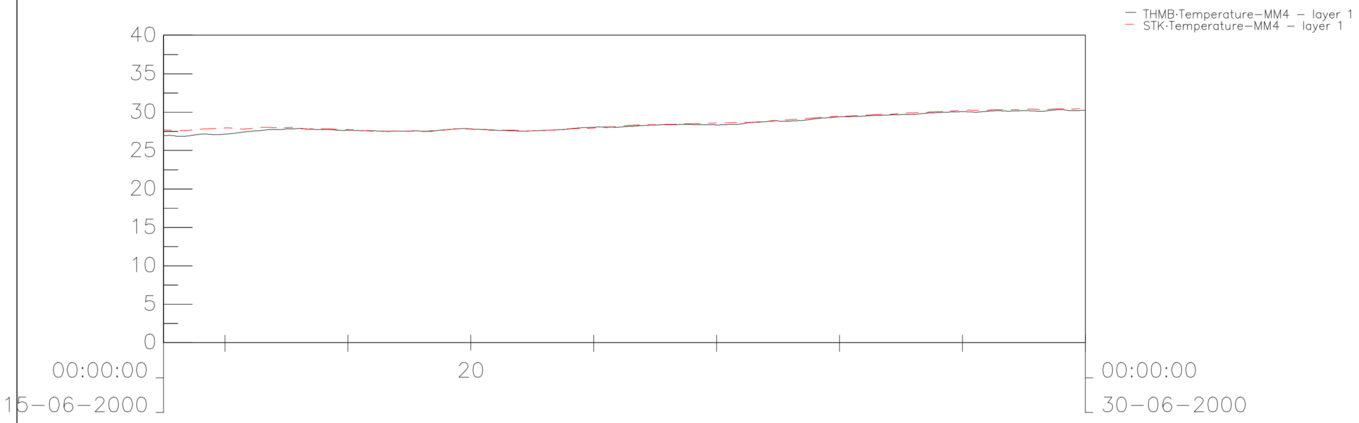
Annex A

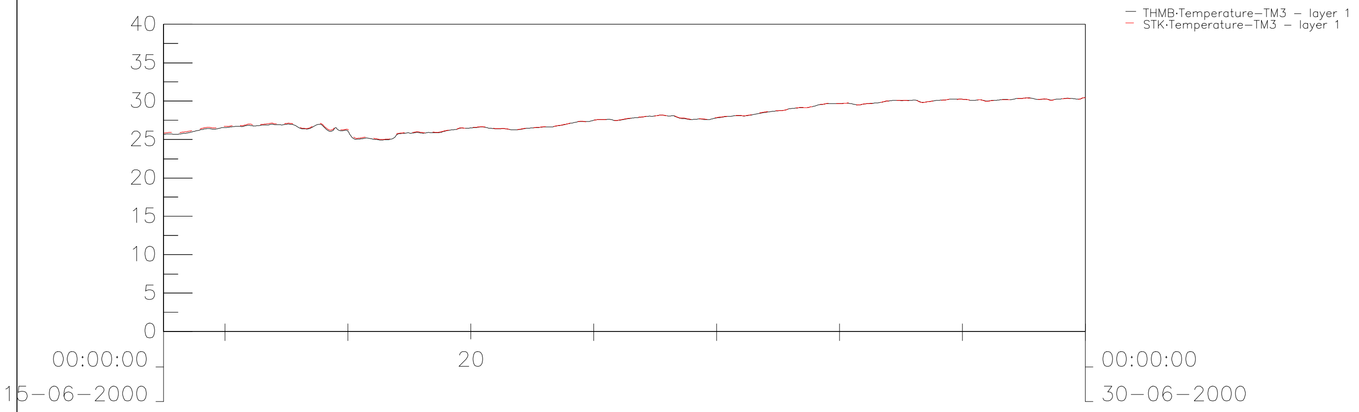
ERM HK Limited

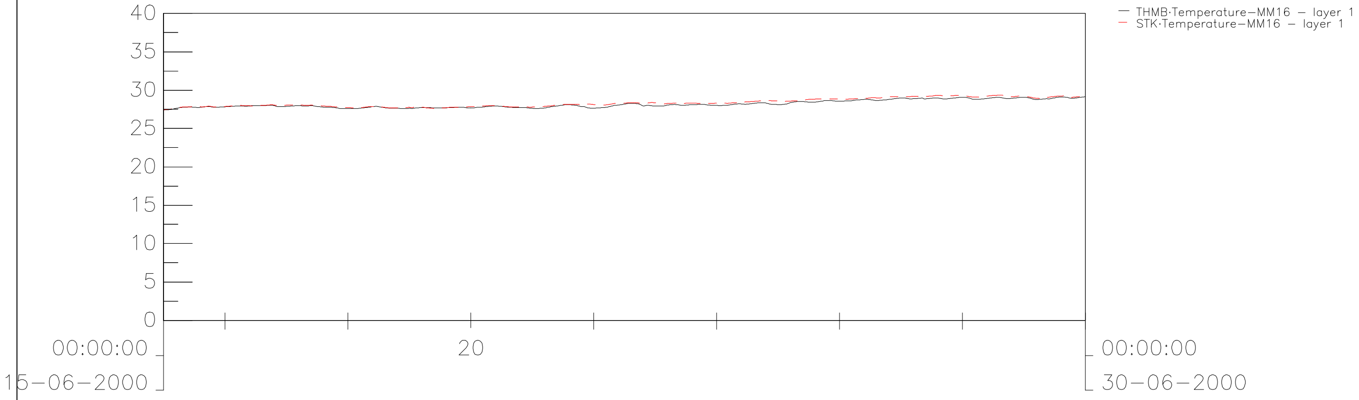
GPP/Verification

Verification.ssn







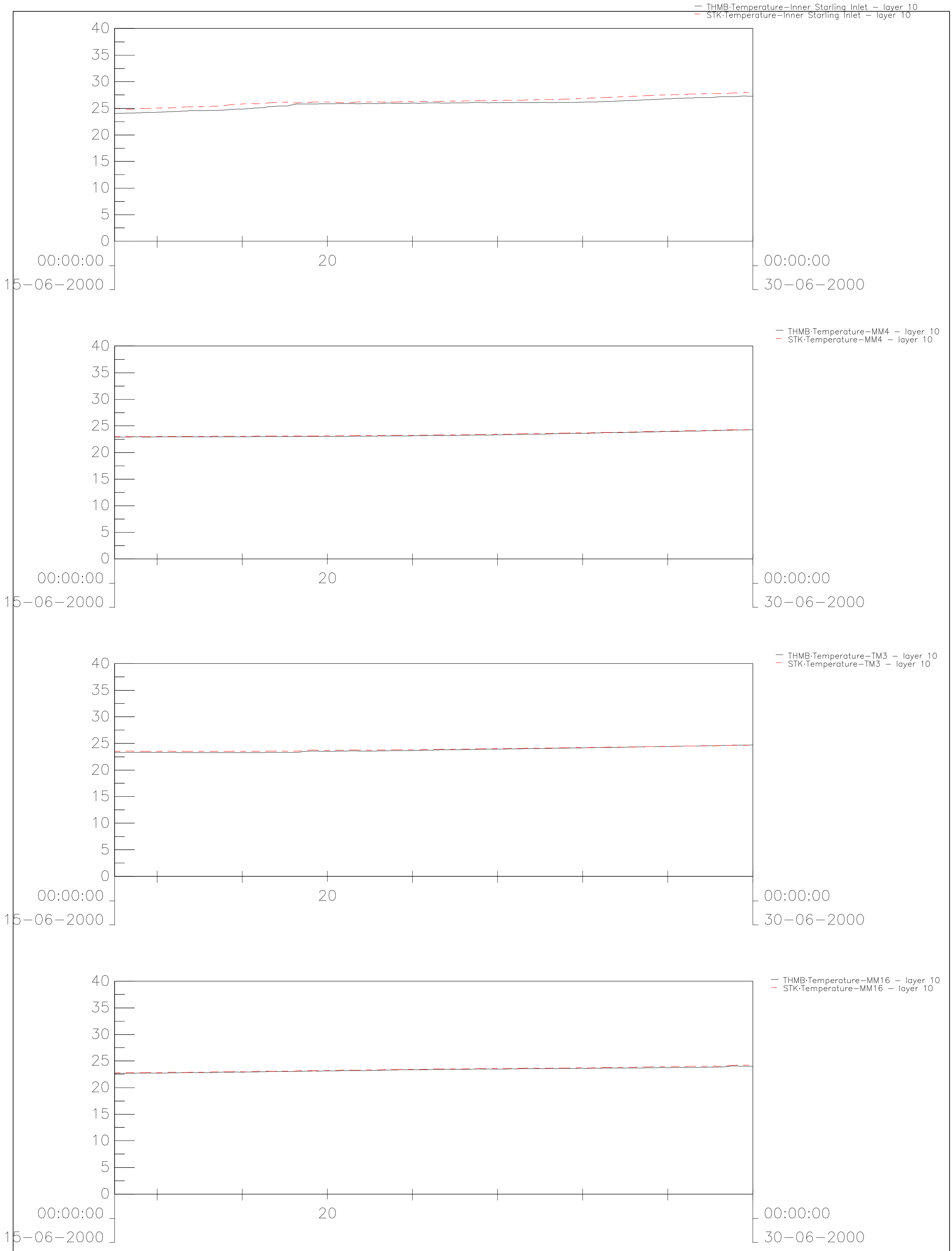


Expansion of Sha Tau Kok Sewage Treatment Works
Surface Temperature (Black: THMB Model; Dashed Red: STK Model)
From top to bottom: Verification point 1 to 4

Year 2020
Wet
Annex A

ERM HK Limited

GPP/Verification
Verification.ssn



Expansion of Sha Tau Kok Sewage Treatment Works

Bottom Temperature (Black: THMB Model; Dashed Red: STK Model)

From top to bottom: Verification point 1 to 4

Year 2020

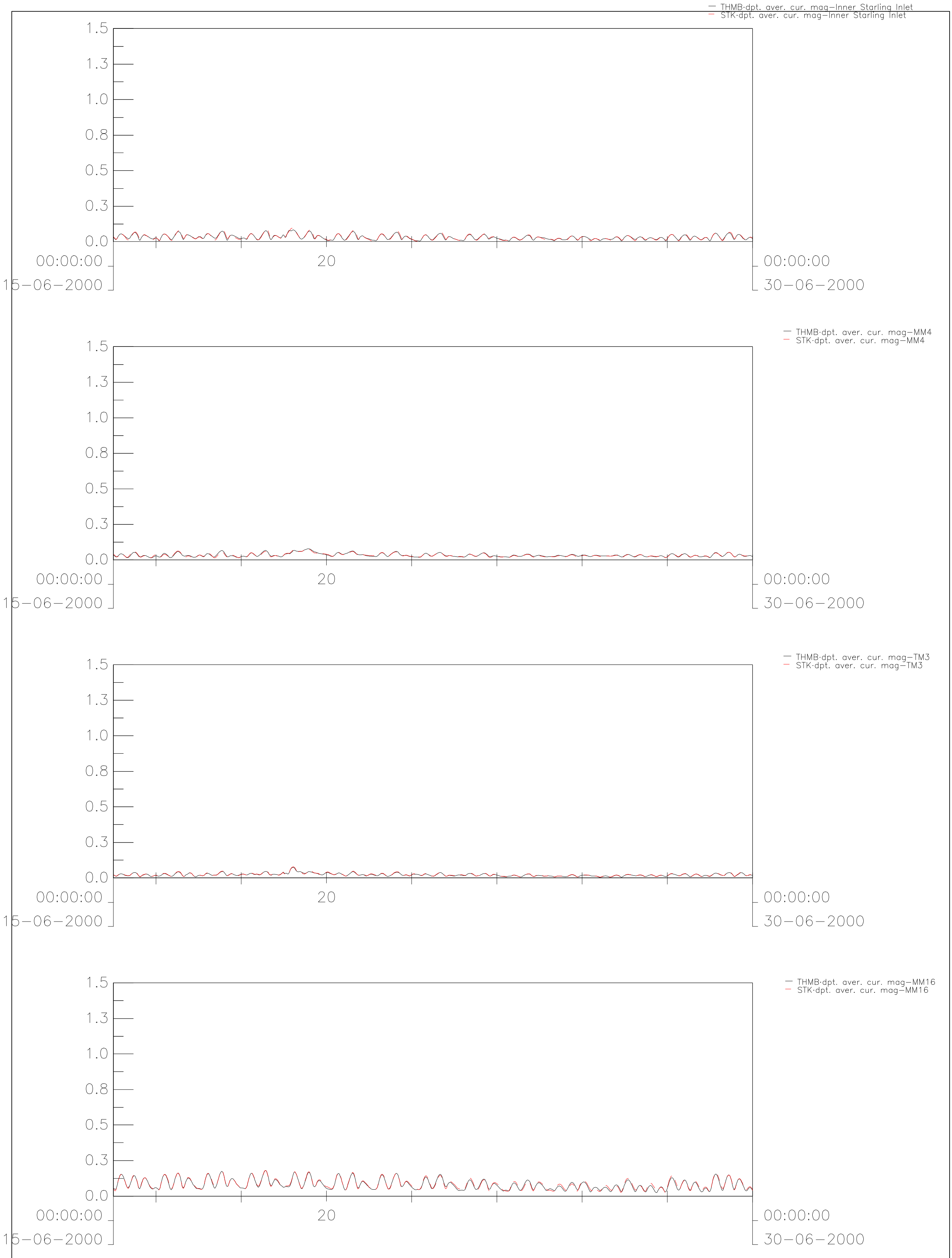
Wet

Annex A

ERM HK Limited

GPP/Verification

Verification.ssn



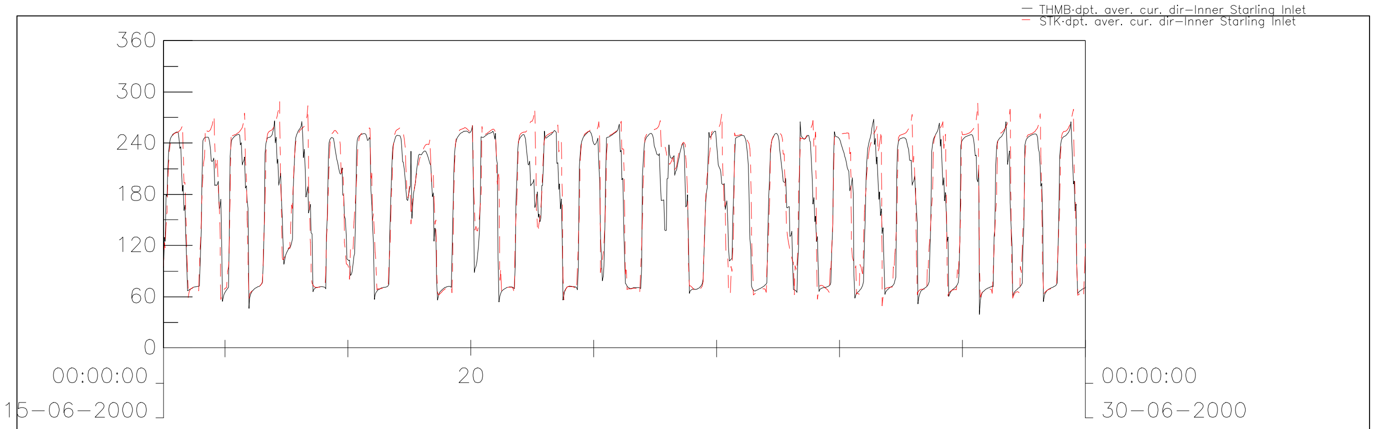
Expansion of Sha Tau Kok Sewage Treatment Works

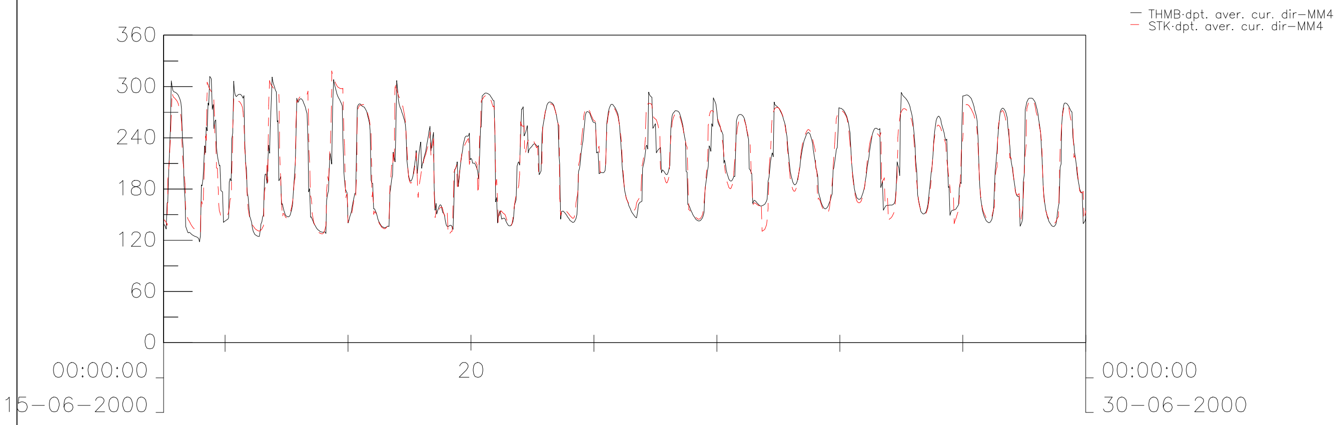
Depth–averaged Current Magnitude (Black: THMB Model; Dashed Red: STK Model)

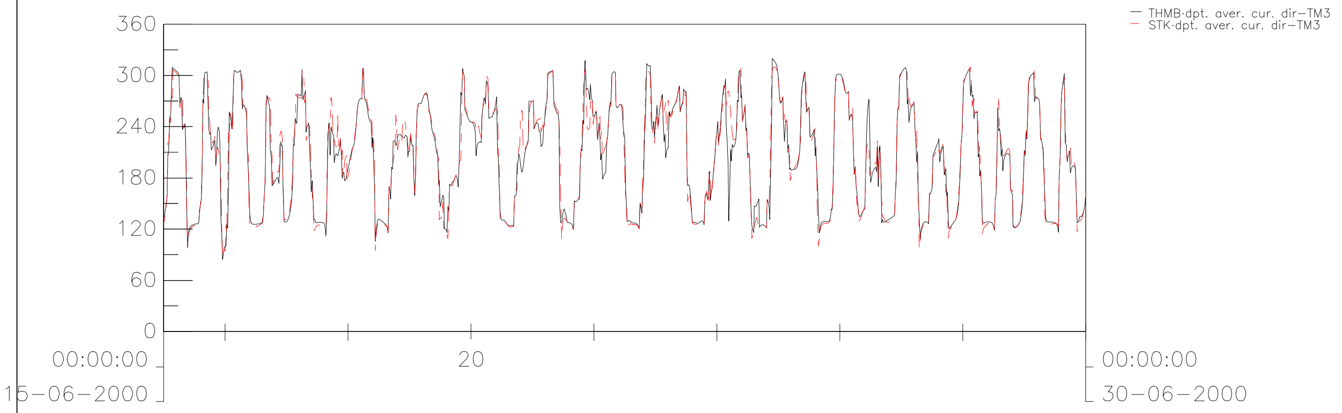
From top to bottom: Verification point 1 to 4

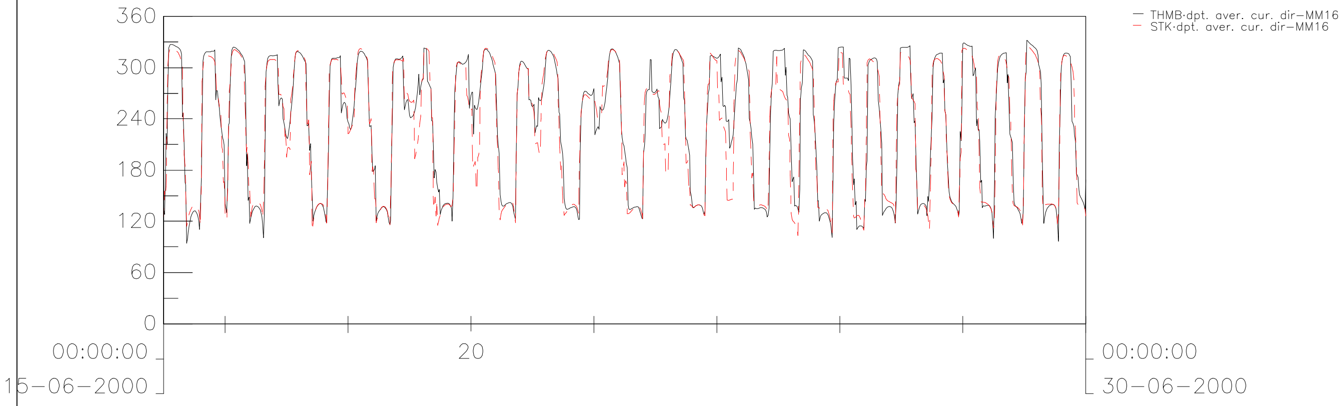
Year 2020	Wet
Annex A	
GPP/Verification	Cal.ssn

ERM HK Limited









Expansion of Sha Tau Kok Sewage Treatment Works

Depth–averaged Current Direction (Black: THMB Model; Dashed Red: STK Model)

From top to bottom: Verification point 1 to 4

Year 2020 | Wet

Annex A

ERM HK Limited

GPP/Verification | Cal.ssn