APPENDIX 5.2

DETAILS ON HYDRODYNAMIC AND WATER QUALITY MODELLING

Table of Contents

List of Figures

List of Tables

1.1 General Model Description

1.1.1 A computer modelling approach was adopted to assess the potential impact on marine water quality associated with the Project. The Delft3D suite of models, namely Delft3D-FLOW, Delft3D-WAQ and Delft3D-SED, developed by Delft Hydraulics, was used as the platform for hydrodynamic, water quality and sediment plume modelling, respectively. Delft3D is a state-of-the-art computer program that simulates three-dimensional flow and water quality processes and is capable of handling the interactions between different hydrodynamic and water quality processes.

1.1.2 Delft3D-FLOW is a 3-dimensional hydrodynamic simulation module with applications for coastal, river and estuarine areas. The model calculates non-steady flow and transport phenomena that result from tidal and meteorological forcing on a curvilinear, boundary fitted grid. Delft3D-WAQ is a water quality module for numerical simulation of various physical, biological and chemical processes in three dimensions. It solves the advection diffusion-reaction equation for a predefined computational grid and for a wide range of model substances.

1.1.3 A **Local Fine Grid Model**, which covers the local areas of the proposed project was set up using the Delft3D suite of models for hydrodynamic and water quality simulations. The grid sizes of the Local Fine Grid Model were around 30m near the proposed Tai O STW, which is less than 75m to meet the modelling requirements specified in the study brief.

1.1.4 The effects on the hydrodynamic regime were determined by examining the changes in speeds and directions of flow currents, and water levels at selected monitoring points and cross-sections. Predicted water quality results were compared with existing regional **Update Model** for a number of parameters including salinity, biochemical oxygen demand, ammonia nitrogen, nitrate, dissolved oxygen and chlorophyll-a, etc.

1.2 Model Selection and Setup

1.2.1 The existing regional model **Update Model**, which is a fully calibrated and verified model developed under "*Update on Cumulative Water Quality and Hydrological Effect of Coastal Developments and Upgrading of Assessment Tool Study (1998)"* by EPD based on the Delft3D suite of models, was used to simulate effects on hydrodynamics and water quality. The existing grid of the Update Model in the vicinity of the Tai O STW is shown in **Figure 5A-1**. The grid size of the existing Update Model near the project site is in the order of about 300 m. It is, therefore, necessary to refine the model mesh to provide improved resolution (less than 75m) in key areas of interest. A proposed Local Fine Grid Model was used for this EIA for the vicinity of project area is shown in **Figure 5A-2** and **Figure 5A-3**.

1.2.2 The Local Fine Grid Model was linked to the regional Update Model, which is shown in **Figure 5A-4**. Open boundary conditions of the Local Fine Grid Model were transferred from the Update Model. That is, modelling was first carried out using the regional Update Model, and the output from the Update Model at the interface with the Local Fine Grid Model were used as the boundary conditions for input to the Local Fine Grid Model for both hydrodynamic and water quality simulations. The cumulative effects from the Pearl River estuaries and pollution loadings were accounted for in the Update Model, which covers the whole of the Hong Kong waters and the Pearl River estuaries.

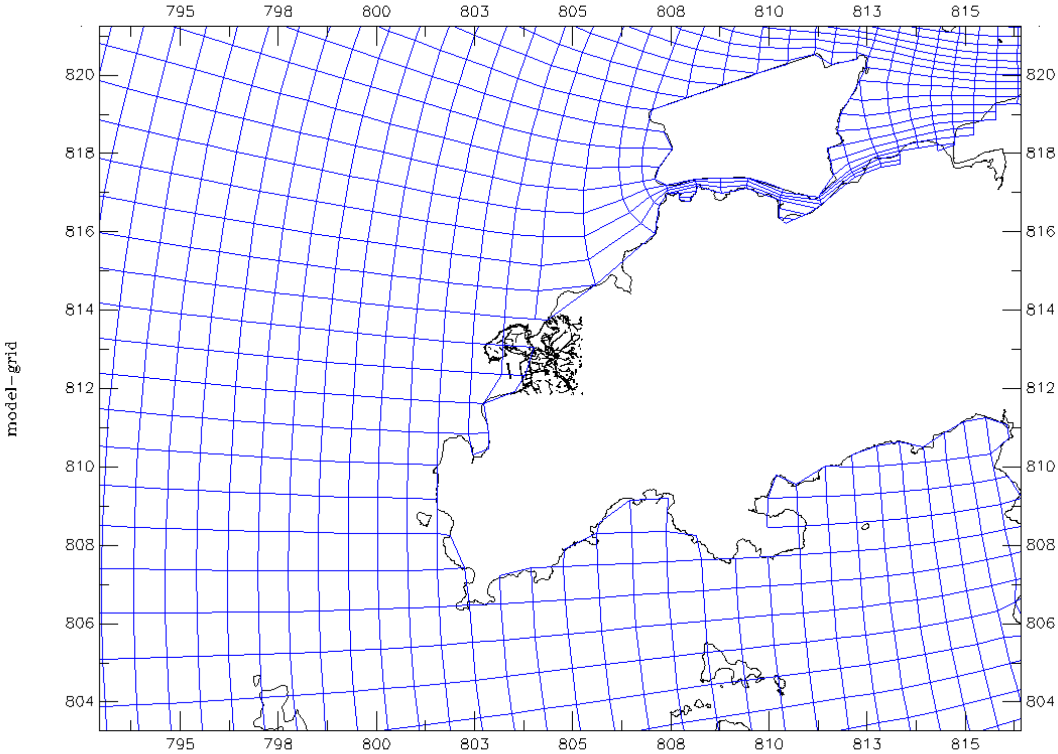


Figure 5A- 1 Existing grid of the Update Model in the vicinity of Tai O STW

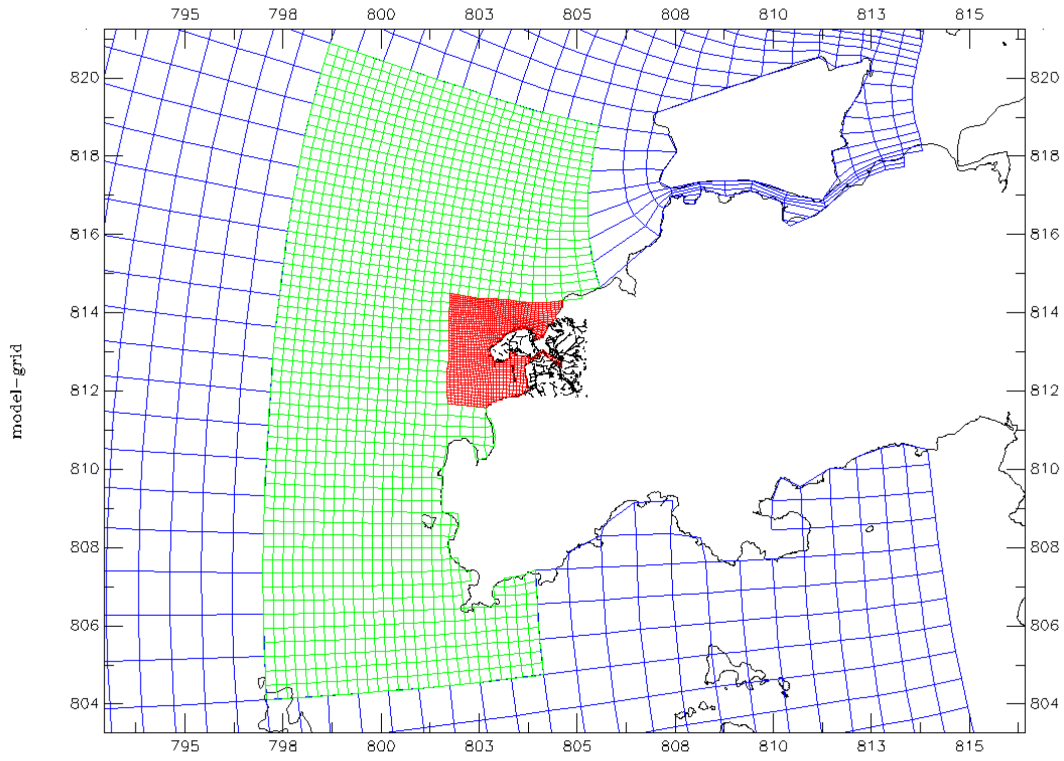


Figure 5A- 2 Local Fine Grid Model in the vicinity of Tai O STW

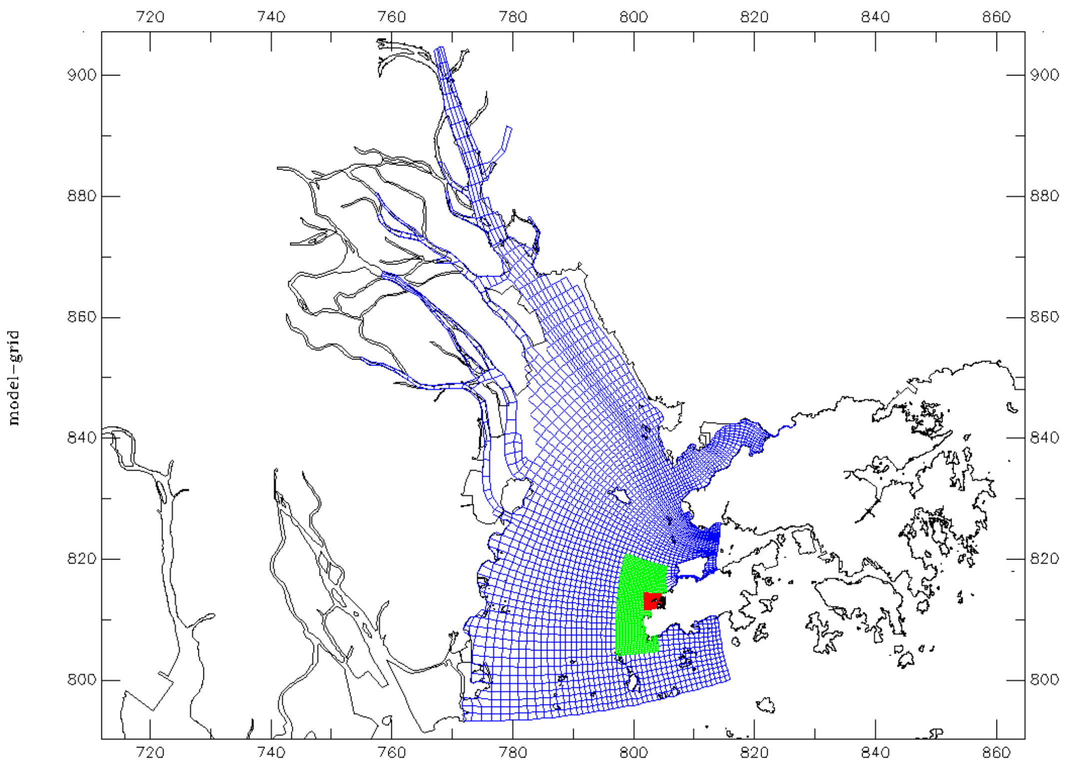


Figure 5A- 3 Local Fine Grid Model of Tai O STW

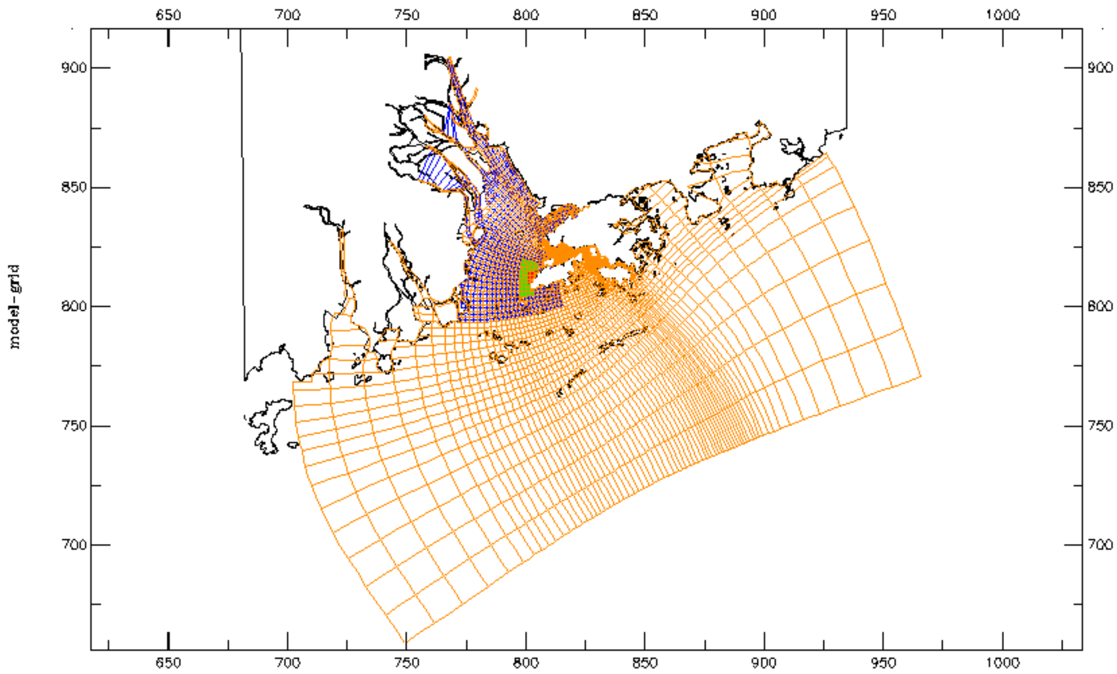


Figure 5A- 4 Linkage of the Update Model and Local Fine Grid Model

Domain Decomposition

1.2.3 The grid refinement of the Update Model was to set up the Local Fine Grid Model was realised by means of a domain decomposition technique.

1.2.4 Domain decomposition is a technique to subdivide a model domain into several smaller model domains, which are called sub-domains. Domain decomposition allows for local grid refinement, both in horizontal direction and in vertical direction. Grid refinement in the horizontal direction means that mesh sizes (fine grid) in one sub-domain are smaller than those in other subdomains (coarse grid).

1.2.5 Model computations are carried out separately on the sub-domains. The communication between the sub-domains takes place along internal open boundaries, or so-called dd-boundaries. The resulting equations are solved simultaneously for all boundaries.

1.2.6 For this Tai O STW EIA study, three different horizontally refined sub-domains were used. The division among the sub-domains was based on the requirements for horizontal model resolution to represent the coastline and bathymetry near the project site and to adequately simulate physical processes.

Meteorological forcing

1.2.7 Meteorological forcing including solar radiation and water temperature recorded at King's Part station by the Hong Kong Observatory was defined in the water quality model.

Vertical Layers of Hydrodynamic Model

1.2.8 The vertical water column was divided into ten layers for hydrodynamic simulation. The thickness of each water layer in the vertical direction was 10% of the total water depth from surface to bottom.

Boundary and Initial Conditions

1.2.9 The Local Fine Grid Model was linked to the Regional Model "Update Model", which is a fully calibrated and verified model developed under "*Update on Cumulative Water Quality and Hydrological Effect of Coastal Developments and Upgrading of Assessment Tool Study (1998)"* by EPD.

1.2.10 Open boundary conditions of the Local Fine Grid Model were defined by the Update model. That is, modelling was first carried out using the Update Model, and the output from the regional Update Model at the interface with the Local Fine Grid Model were used as the boundary condition for input to the Local Fine Grid Model for hydrodynamic and water quality simulation. The cumulative effects from the Pearl River estuaries are accounted for in the Update Model, which covers the entire Hong Kong waters and the Pearl River estuaries.

Initial and Boundary Conditions

1.2.11 The Local Fine Grid Model was linked to the Update Model. Hydrodynamic computations were first carried out using the Update Model. The Update Model provides open boundary conditions to the Local Fine Grid Model through the nesting process.

1.2.12 The initial conditions for the Local Fine Grid Model were selected to be the same as those of the Update Model. This was done by using a utility program to map the information contained in the restart file of the Update Model to the restart file of the Local Fine Grid Model.

Flow Aggregation for Water Quality Modeling

1.2.13 The grid for water quality simulation was based on the hydrodynamic grid model. To reduce computation time and computer storage, flow aggregation in the vertical direction of the grid were performed to reduce the total number of computation cells for water quality simulation. The thickness distribution of the layers was 10%, 20%, 20%, 30% and 20% of the total water depth from surface to bottom to optimise the computational time and data storage.

1.2.14 In the horizontal directions, no flow aggregation was planned to be performed to provide sufficient resolution of modelled results for assessment of impact to Water Sensitive Receivers in the local areas of the Project.

Simulation Periods and Time Step

1.2.15 For each assessment scenario, the simulation period of the hydrodynamic model covered two 15-day full spring-neap cycles (excluding the spin-up period) for dry and wet seasons, respectively.

1.2.16 Water quality simulation also covered two 15-day full spring-neap cycles (excluding the spin-up period) for dry and wet seasons respectively. A sufficient spin-up period was provided to ensure that initial condition effects can be neglected.

1.2.17 The time steps in the hydrodynamic and water quality model were tentatively set equal to 0.5 minute and 0.5 hour, respectively.

Wind

1.2.18 To be identical to the Update Model, a north-eastern wind with a belonging wind speed of 5 m/s was used for the dry season computations. The wet season computations applied a south western wind of 5 m/s.

Hydrodynamic Forcing

1.2.19 Hydrodynamic simulations were carried out with the Local Fine Grid Model for a spring neap cycle for both the wet season and the dry season. The results were written to a so-called "communication file" in the Delft3D model with a time interval of 1 hour, that is, the hydrodynamic modelling results were saved to a result file every one hour. Given that the time step for model simulation was tentatively 0.5 minute, this means that hydrodynamic modelling results were saved to a result file for later use for water quality simulation once every 120 steps of model simulation. The intermediate results during the spin-up period of the hydrodynamic model were omitted in this process, creating the simulating results for two spring-neap tidal cycles for dry and wet seasons, respectively.

1.2.20 From the communication file, the hydrodynamic forcing data for the water quality model were derived, by using the coupling module of Delft3D.

Meteorological Forcing

1.2.21 Meteorological forcing was defined in the water quality model. Seasonal variations in Pearl River discharges, solar radiation and wind velocity were incorporated into the water quality simulation.

Key Modeling Parameters

1.2.22 The key water quality parameters to be included in water quality impact assessment are shown in **Table 5A- 1**.

Table 5A- 1 Key Modeling Parameters

Parameter	Description
Salinity	Salinity
ModTemp	Water Temperature
E Coli	E. coli Bacteria
Oxy	Dissolved Oxygen
BOD_5	5-day Biochemical Oxygen Demand
SS	Suspended Solids
TotN	Total Nitrogen
TotP	Total Phosphorus
TIN	Total Inorganic Nitrogen
NH_3	Unionised Ammonia

Pollution Loading

1.2.23 The pollution loading inventory for the assessment scenarios were compiled using the latest planning data for domestic, commercial and industrial activities. The inventory incorporated all possible pollution sources including those from landfill sites, non-point source surface run-off and sewage from cross connections.

1.2.24 The inventory also covered all storm and sewage outfalls within the modelling areas for cumulative assessment for 2019.

Coastline Configurations & Bathymetry

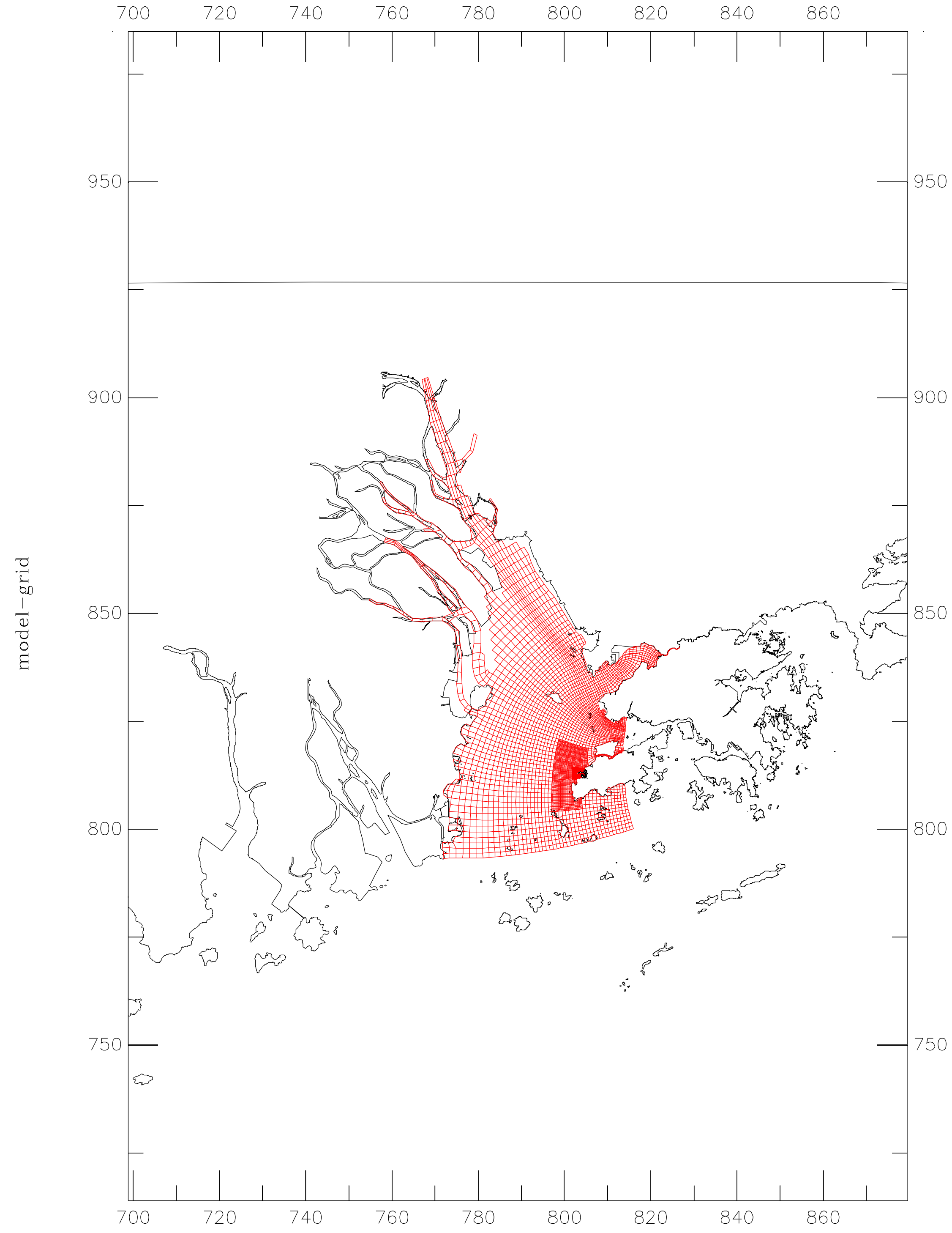
1.2.25 The latest coastline configuration for the assessment year of 2019 was adopted in model simulations of the potential impact from the Project in this EIA study. Changes in coastline configuration due to reclamation and other development activities were reflected in the model setup. The changes in coastline configuration bathymetry condition included the effects by the following development projects:

- Sunny Bay Reclamation;
- Further Development of Tseung Kwan O;
- Lung Kwu Tan Pipeline EIA study;
- Tuen Mun – Chek Lap Kok Link (TMCLKL);
- Hong Kong – Zhuhai – Macao Bridge Hong Kong Boundary Crossing Facilities
- (HKZMB - HKBCF);
- Wanchai Reclamation Phase II;
- Kwai Tsing Container Terminal Basin dredging;
- Cruise Terminal at Kai Tak;
- Hong Kong Link Road;
- Lantau Logistic Park; and
- Shatin-to-Central Link.

1.3 Model Verification and Validation

1.3.1 Hydrodynamic and water quality results predicted with the Local Fine Grid Model for the Tai O STW were compared to those obtained from the Update Model to validate and calibrate the Local Fine Grid Model. The calibration figures are shown in **Figure 5A-5** to **Figure 5A-22**. The calibration shows that the results from the Local Fine Grid Model and the Update Model matched well, which indicate that the accuracy of Local Fine Grid Model can be guaranteed.

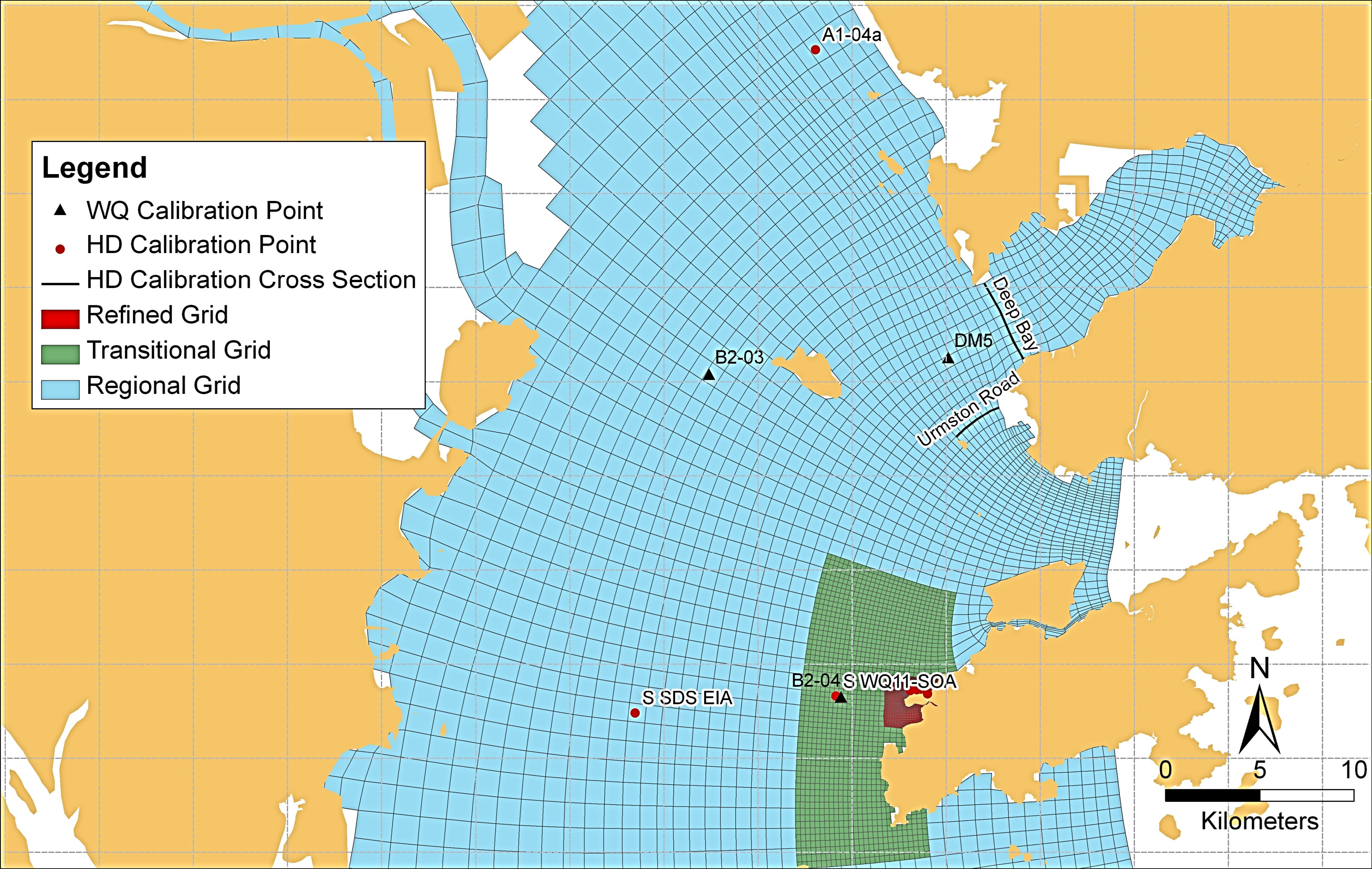
1.3.2 Having been calibrated, the Local Fine Grid Model was then used to simulate and predict the impact on receiving marine waters and water sensitive receivers under different assessment scenarios.



Tai O Sewage Treatment Works
Hydrodynamic and Water Quality
Local Refine Grid Model

Figure 5A-5

DSD & ATKINS



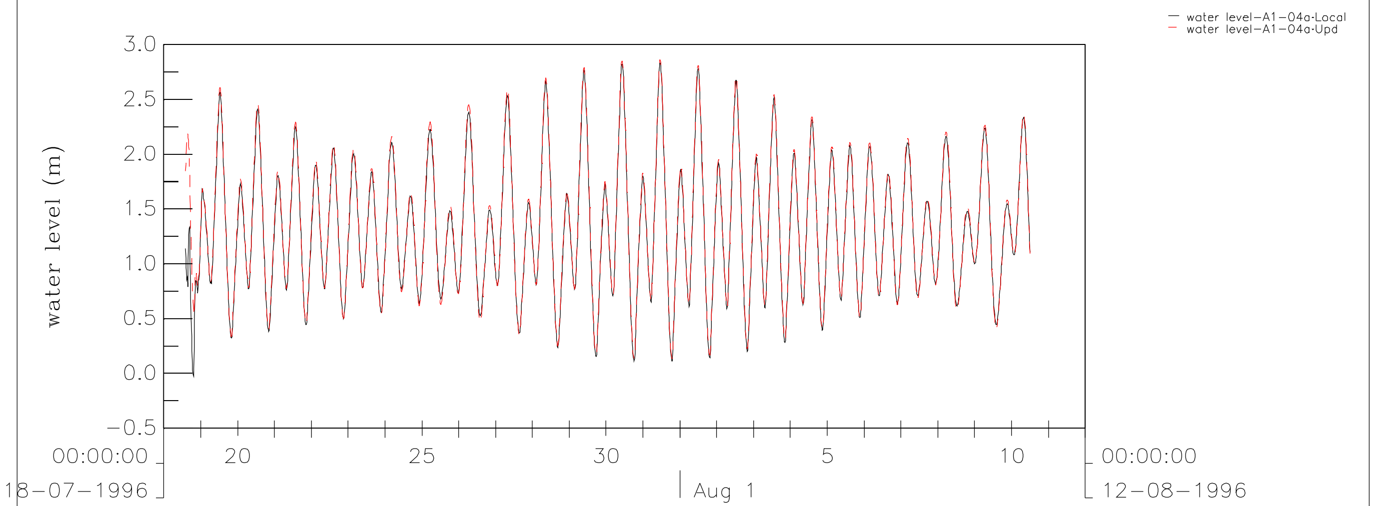
渠務署
DRAINAGE SERVICES DEPARTMENT

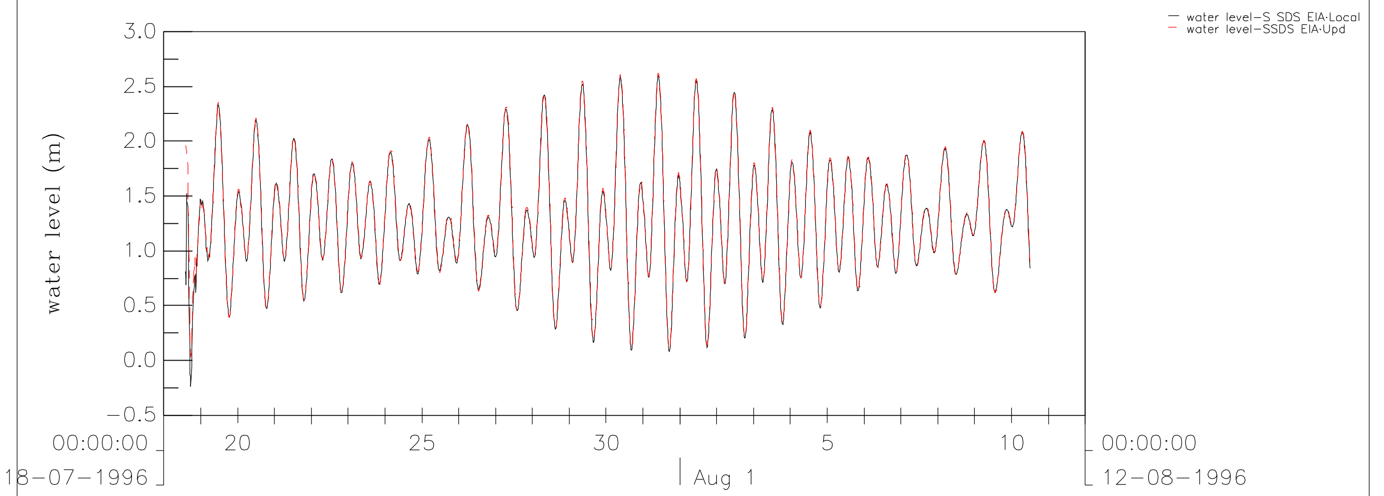
ATKINS

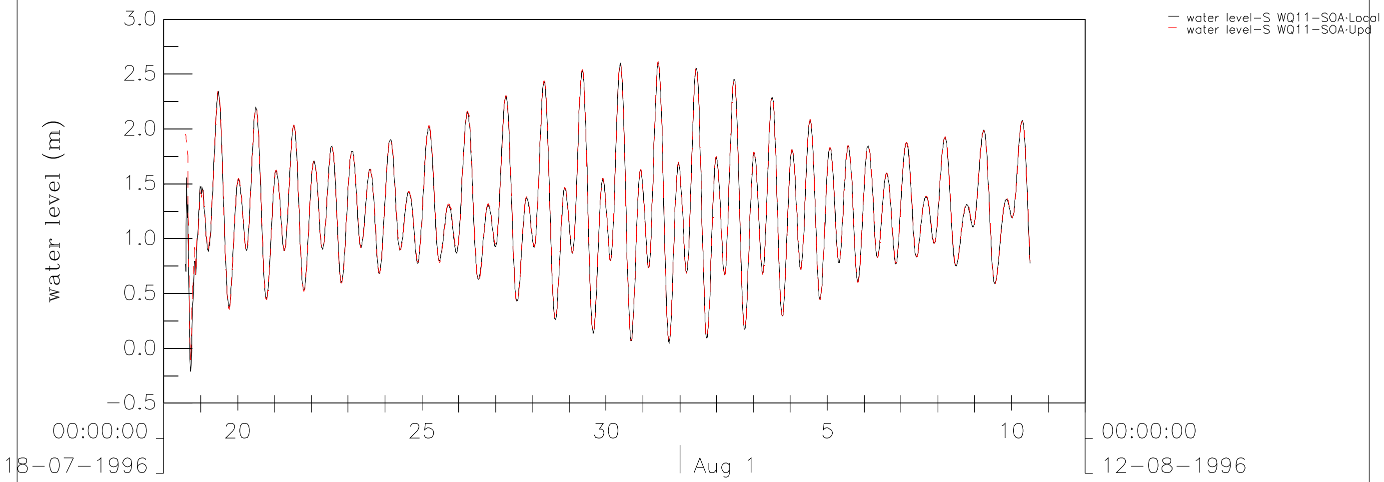
Agreemeng No. CE 15/2010 (DS)
Upgrading of Cheung Chau and Tai O Sewage Collection, Treatment and Disposal Facilities - Design and Construction

Outlying Islands Sewage Stage 2 -
Upgrading of Tai O Sewage Collection, Treatment and Disposal Facilities

Title:	**Calibration Point and Cross-Section**
Date:	**February 2012**
Figure:	5A-6





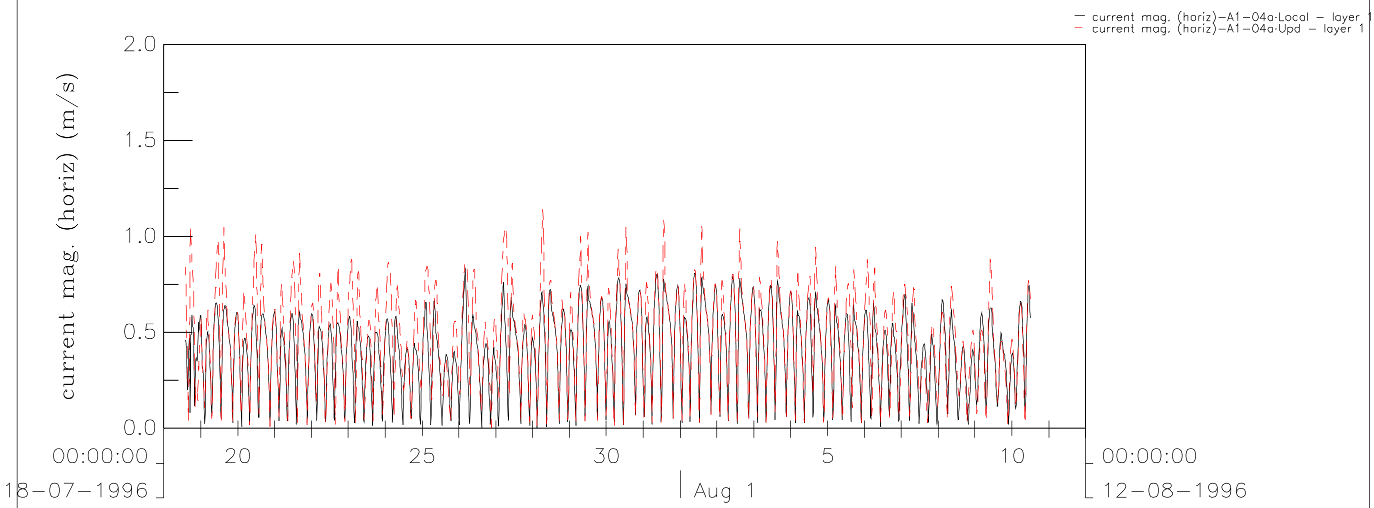


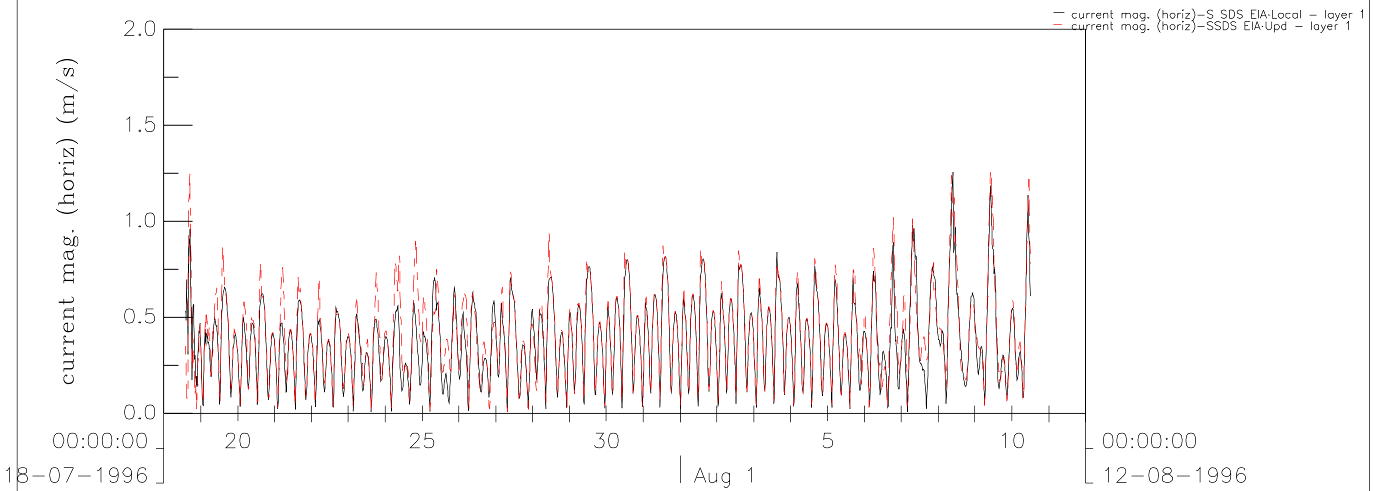
Water Level Comparison between Update Model and Local Fine Grid Model at A1-04a (Upper), S SDS EIA (Middle) and S WQ11-SOA (Lower).

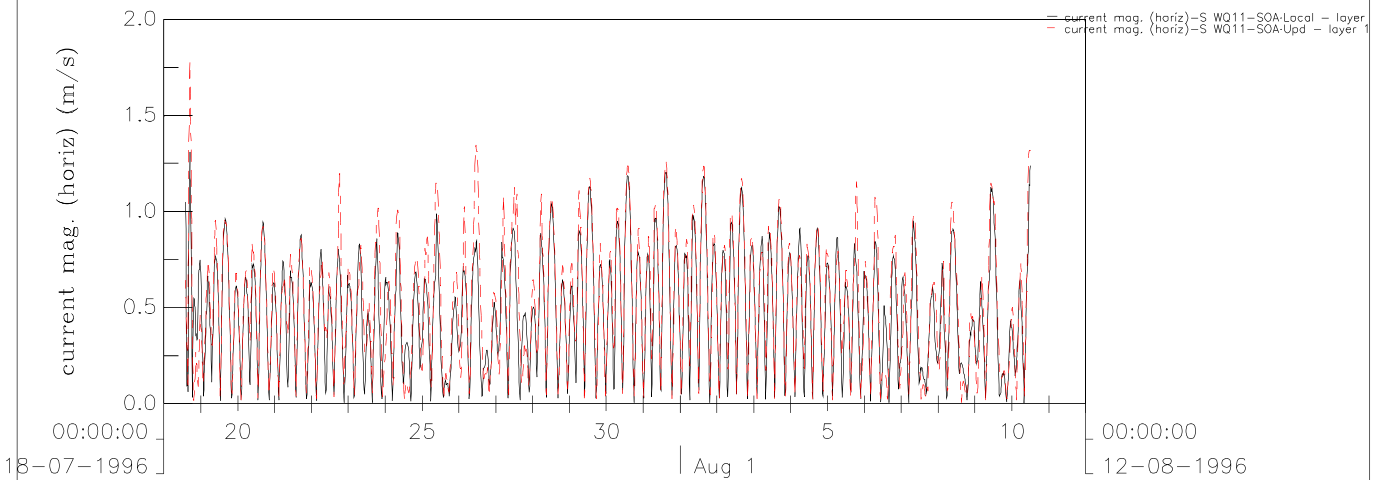
Dry Season

Figure 5A-7

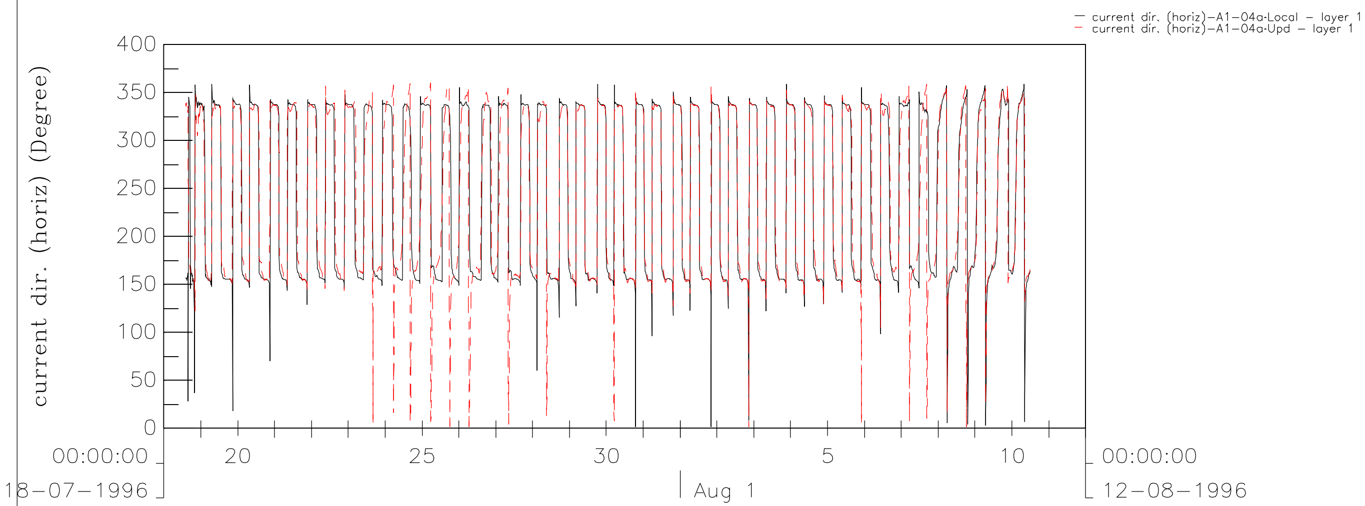
DSD & ATKINS

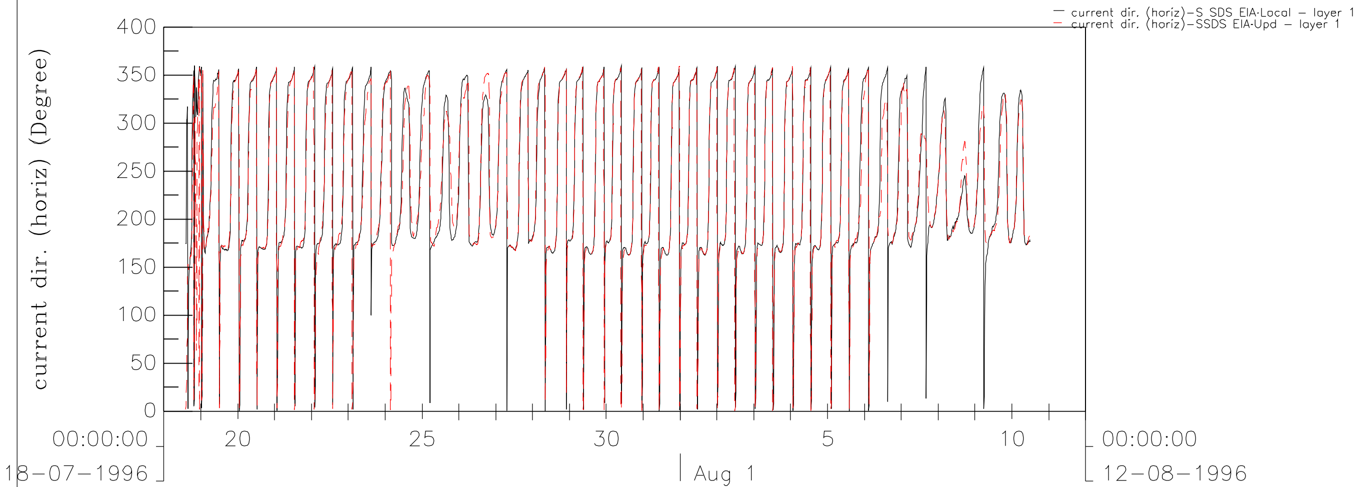


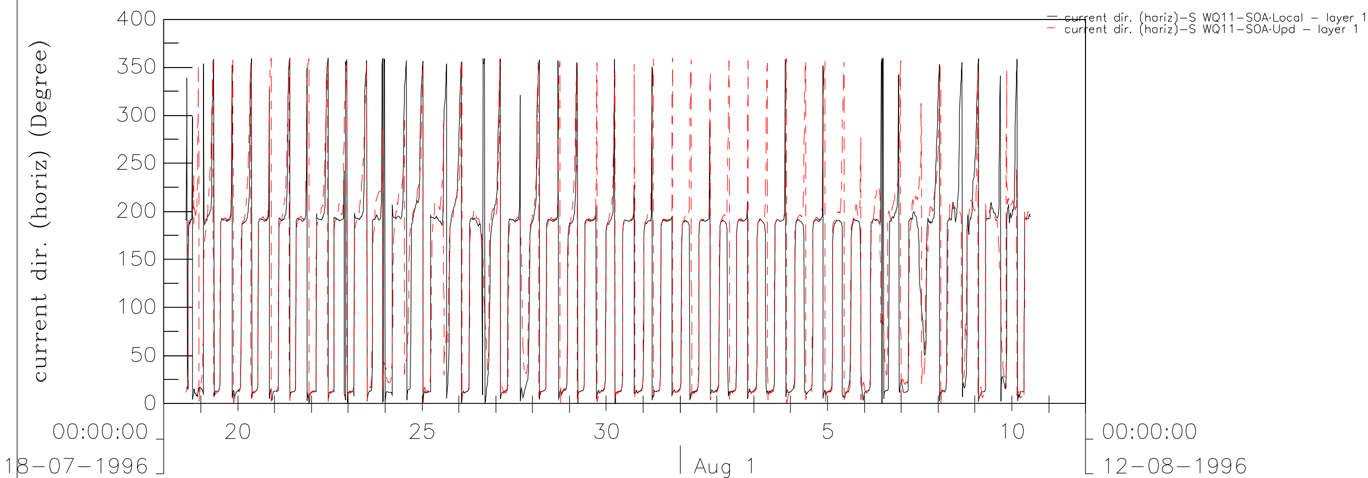




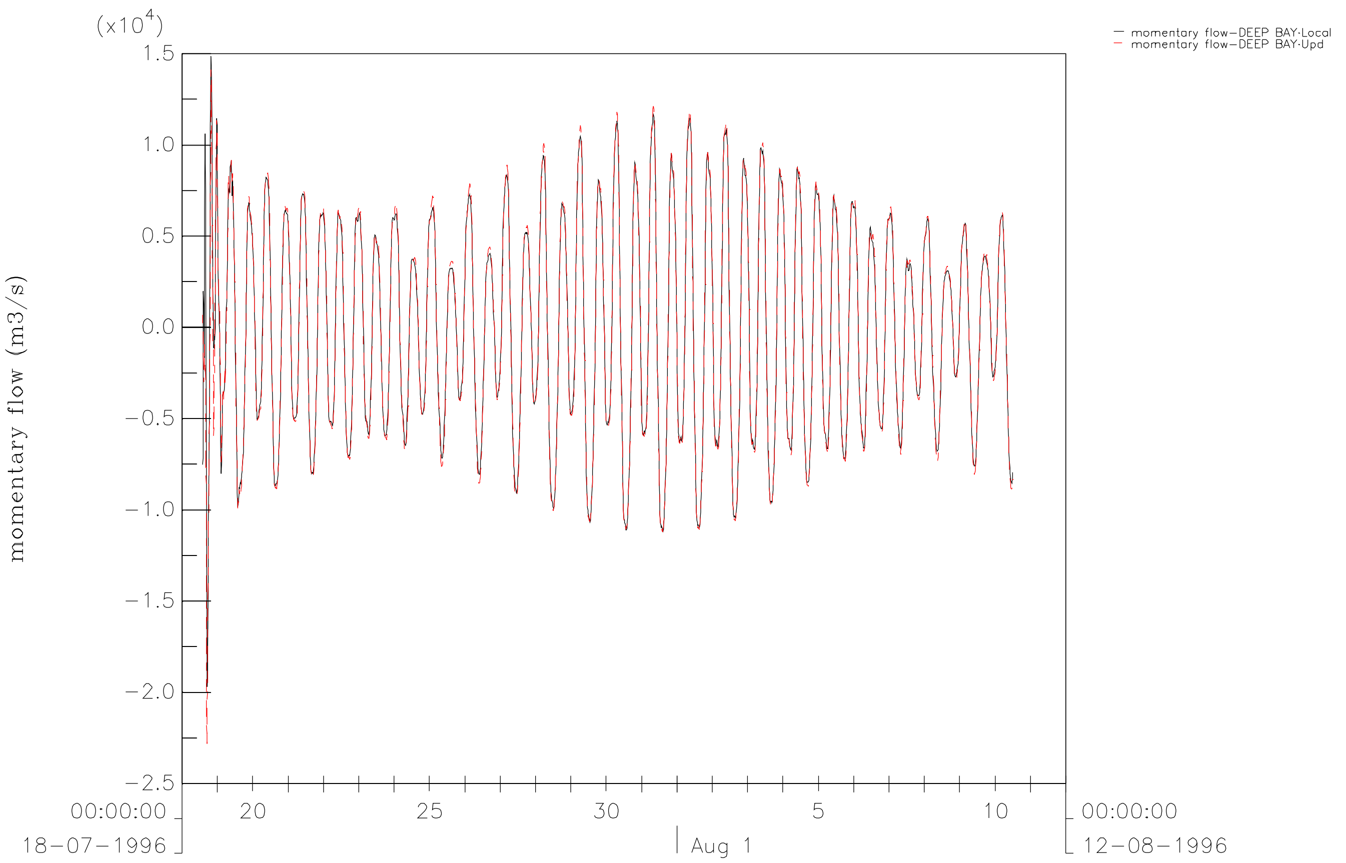
Current Velocity Comparison between Update Model and Local Fine Grid Model at A1-04a (Upper), S SDS EIA (Middle) and S WQ11-SOA (Lower).	Dry Season
	Figure 5A-8
DSD & ATKINS	

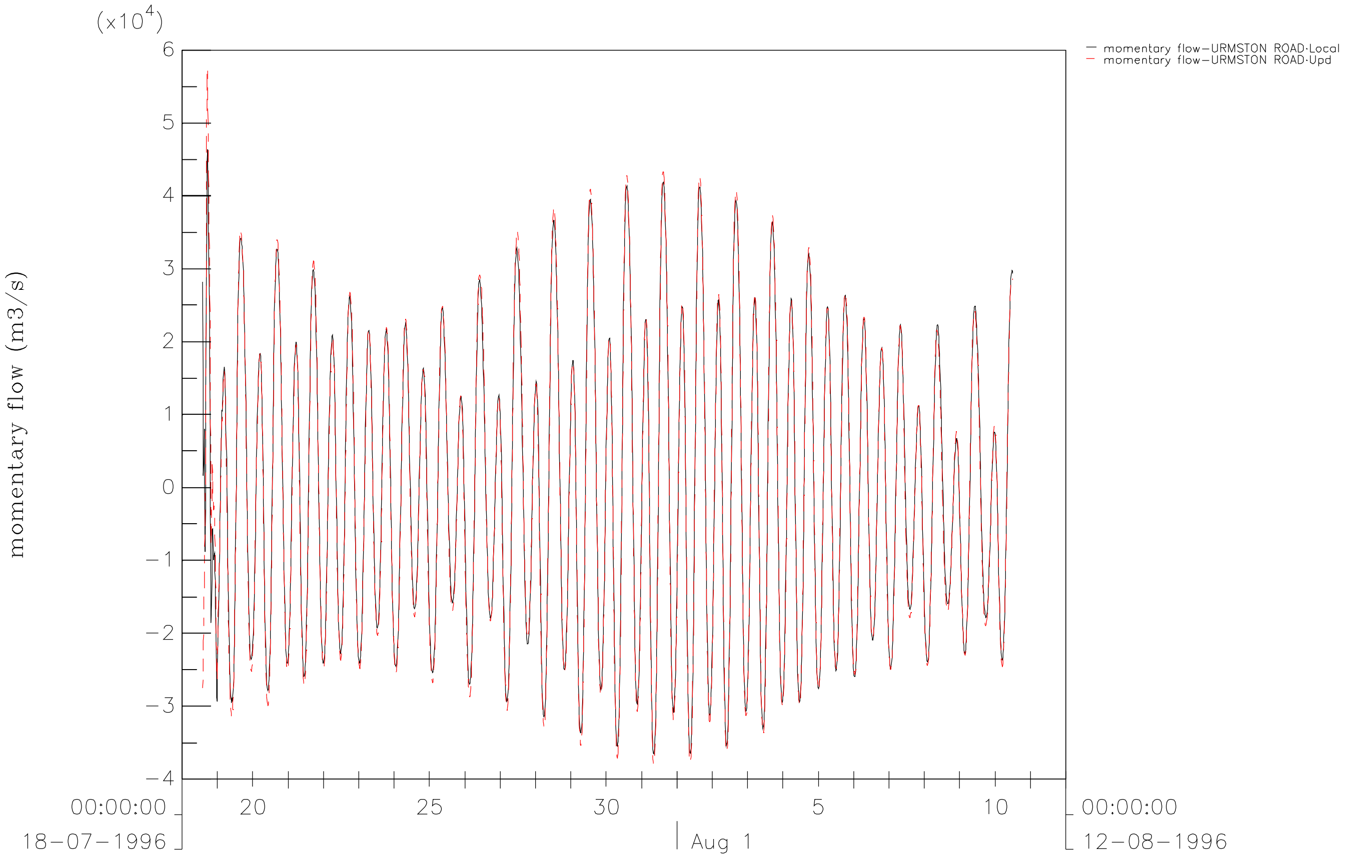




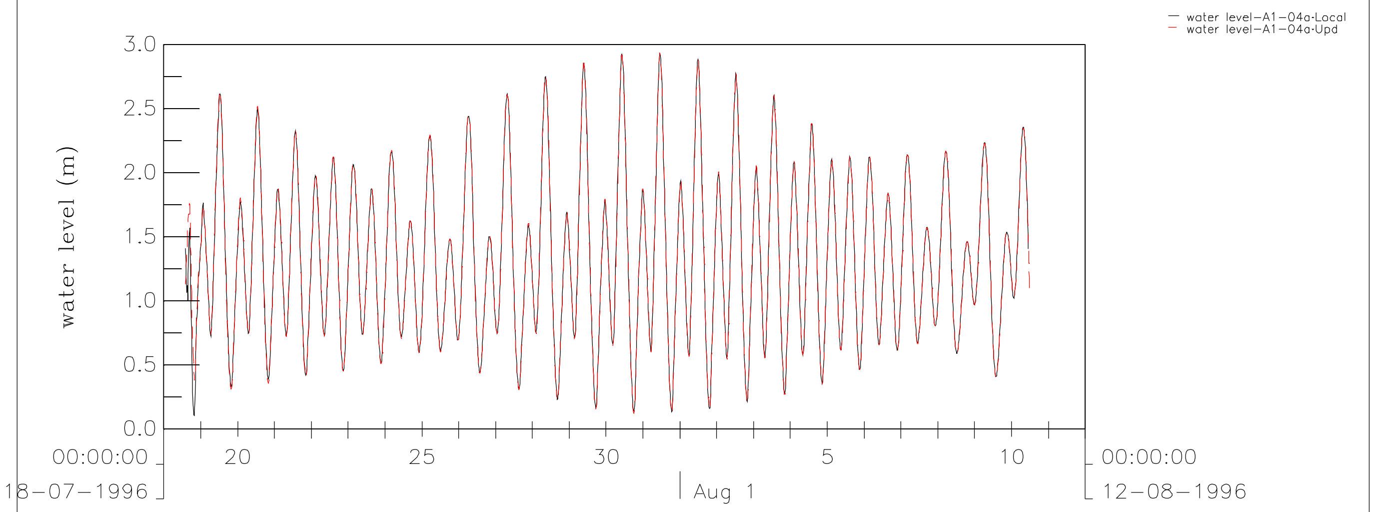


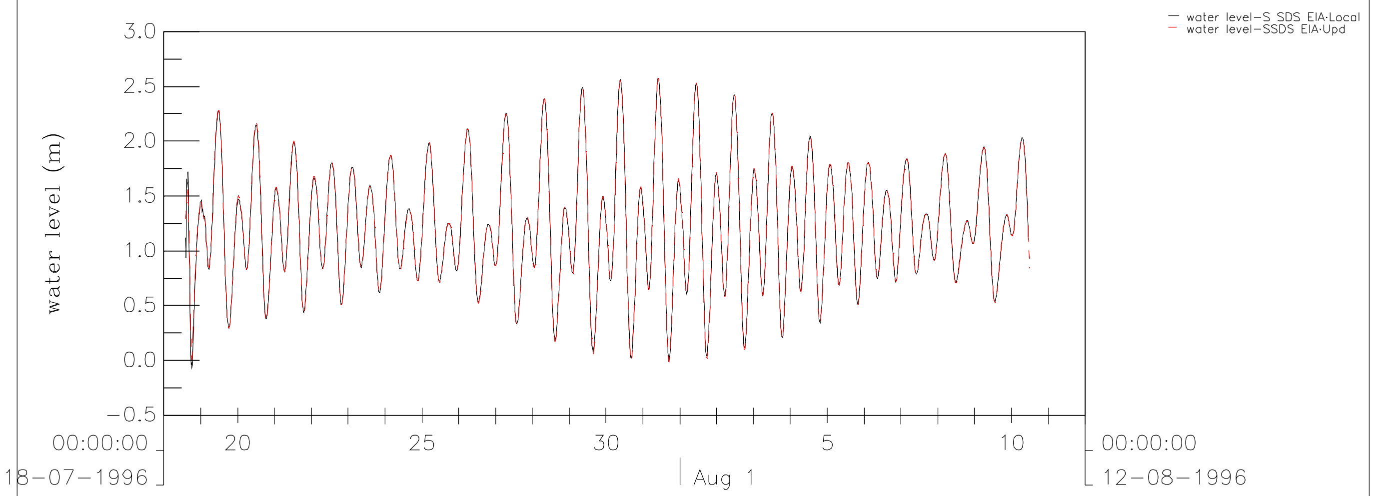
Current Direction Comparison between Update Model and Local Fine Grid Model at A1–04a (Upper), S SDS EIA (Middle) and S WQ11–SOA (Lower).	Dry Season
	Figure 5A-9
DSD & ATKINS	

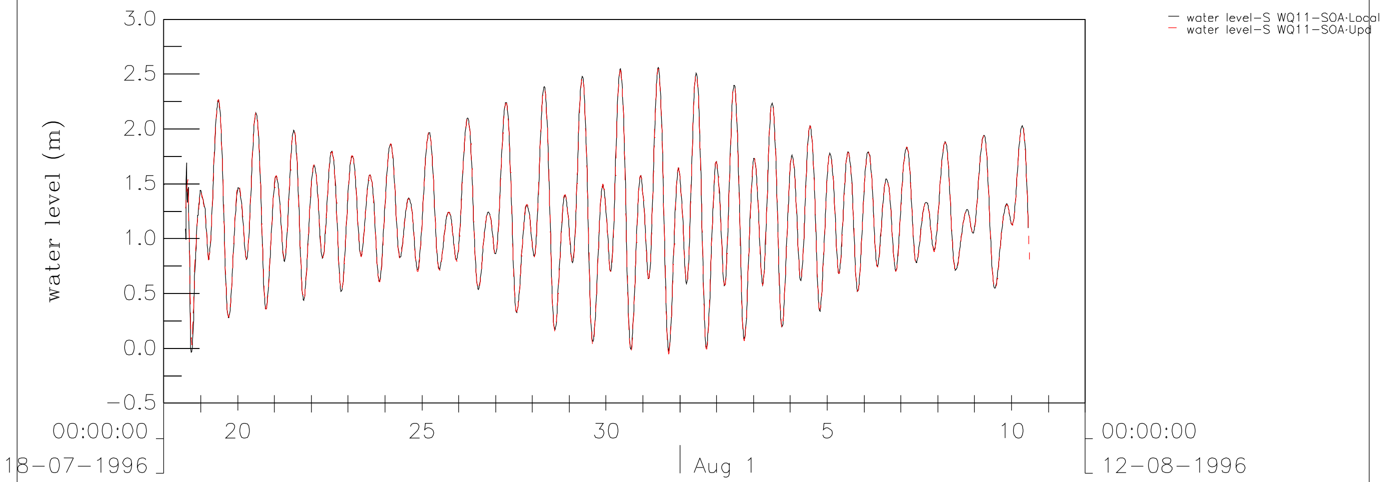




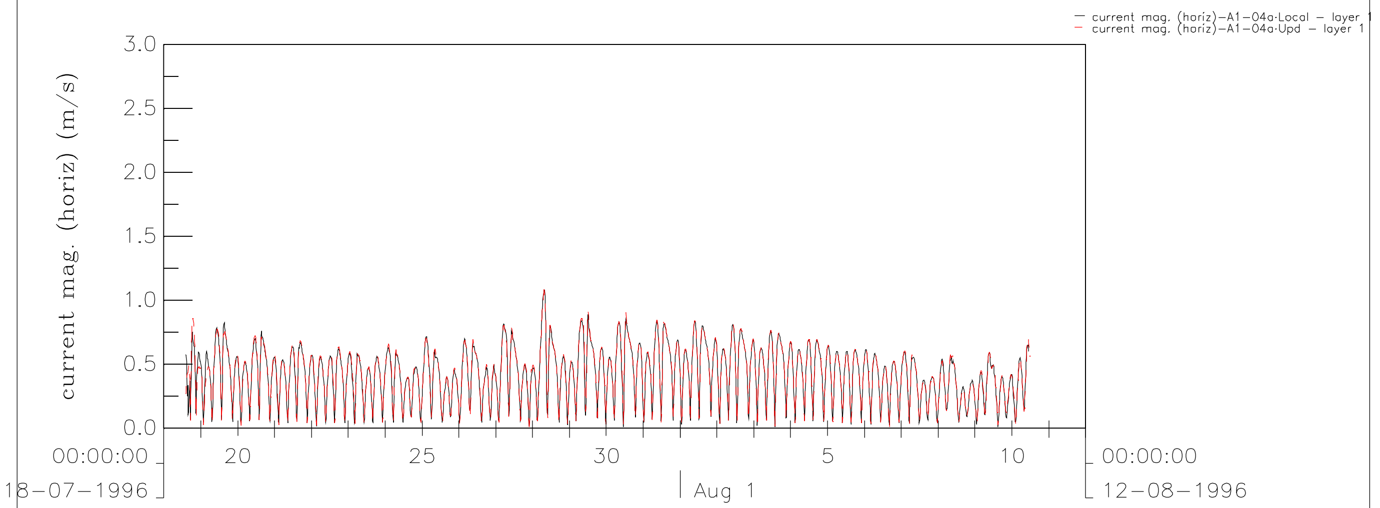
Flow Comparison between Update Model and Local Fine Grid Model at Deep–Bay (Upper) and Urmston Road (Lower).	Dry Season	
	Figure 5A-10	
DSD & ATKINS		

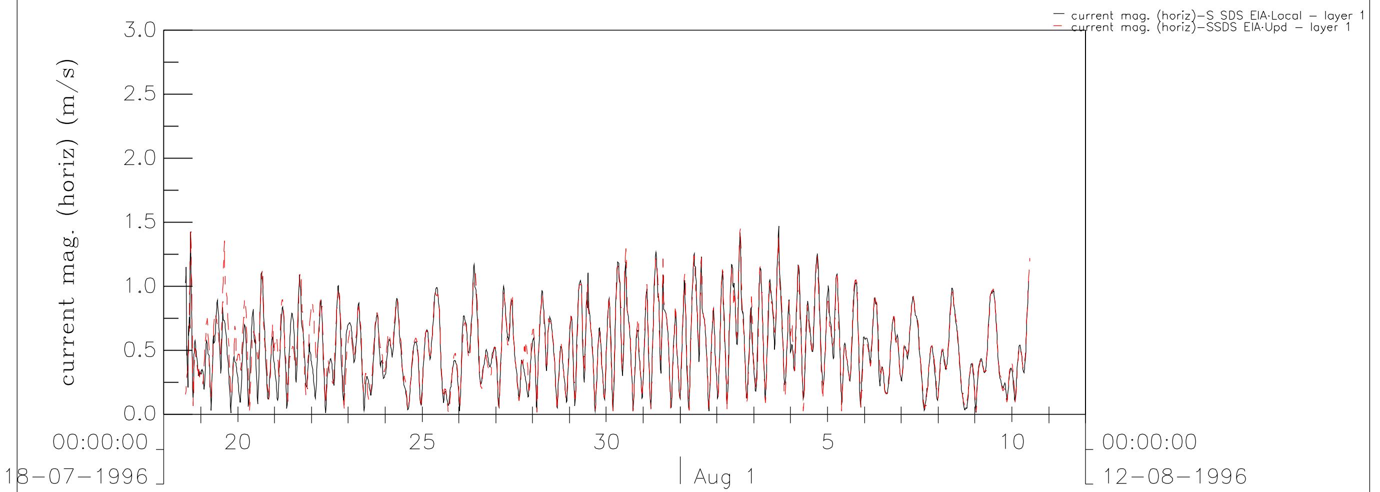


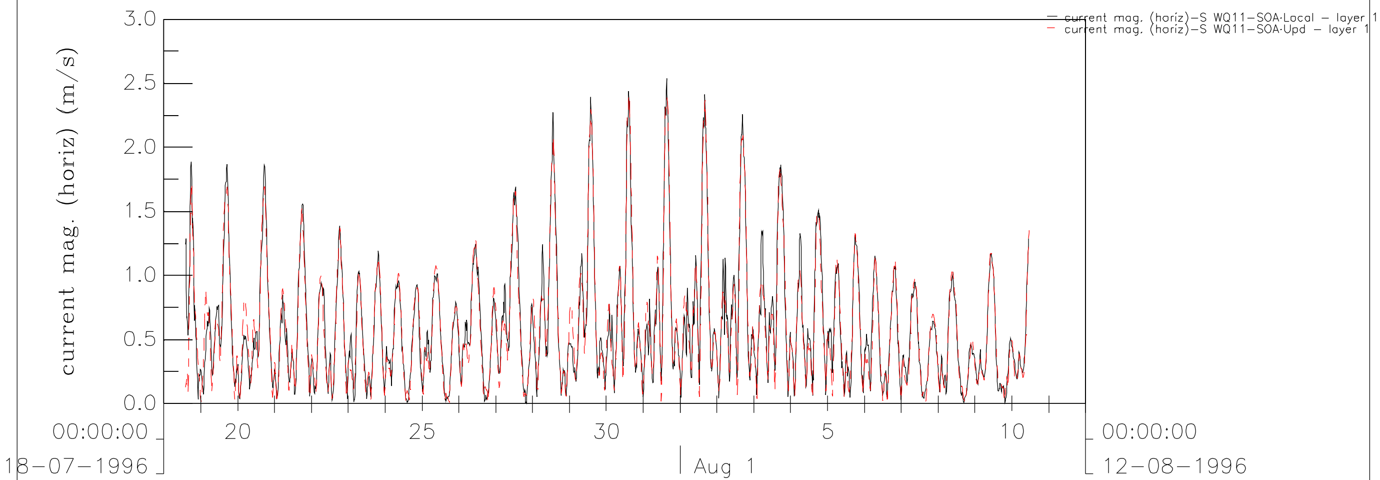




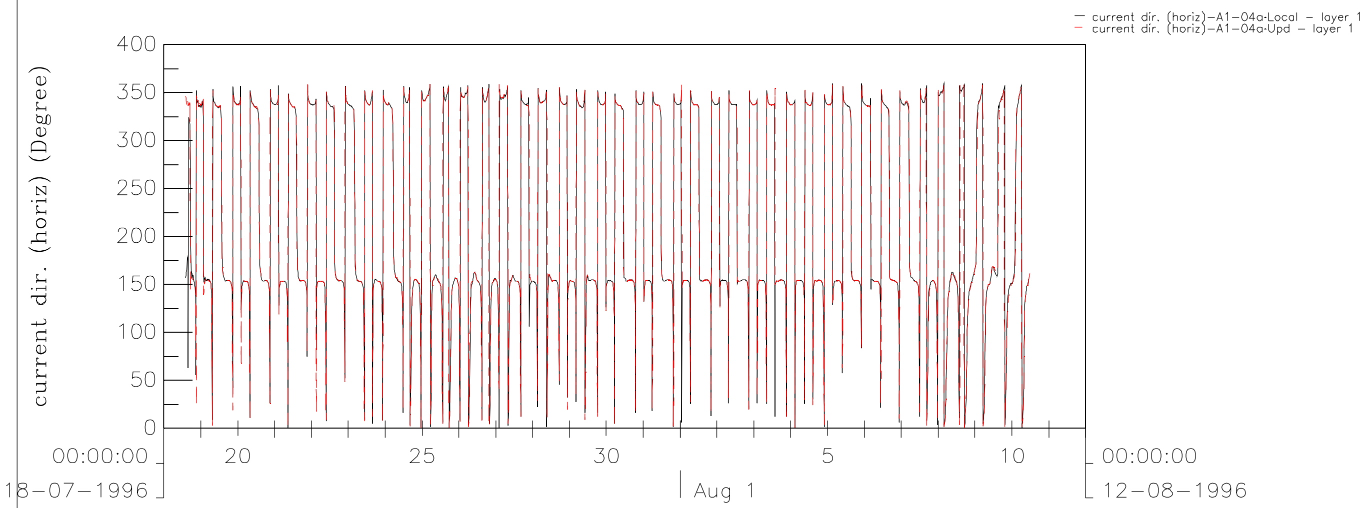
Water Level Comparison between Update Model and Local Fine Grid Model at A1–04a (Upper), S SDS EIA (Middle) and S WQ11–SOA (Lower).	Wet Season
	Figure 5A-11
DSD & ATKINS	

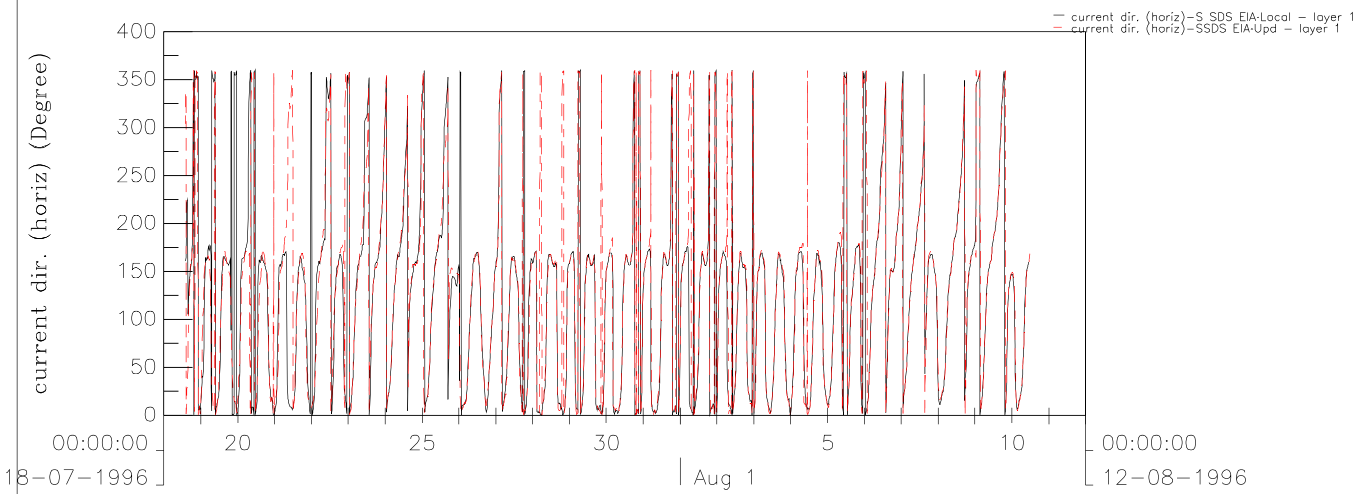


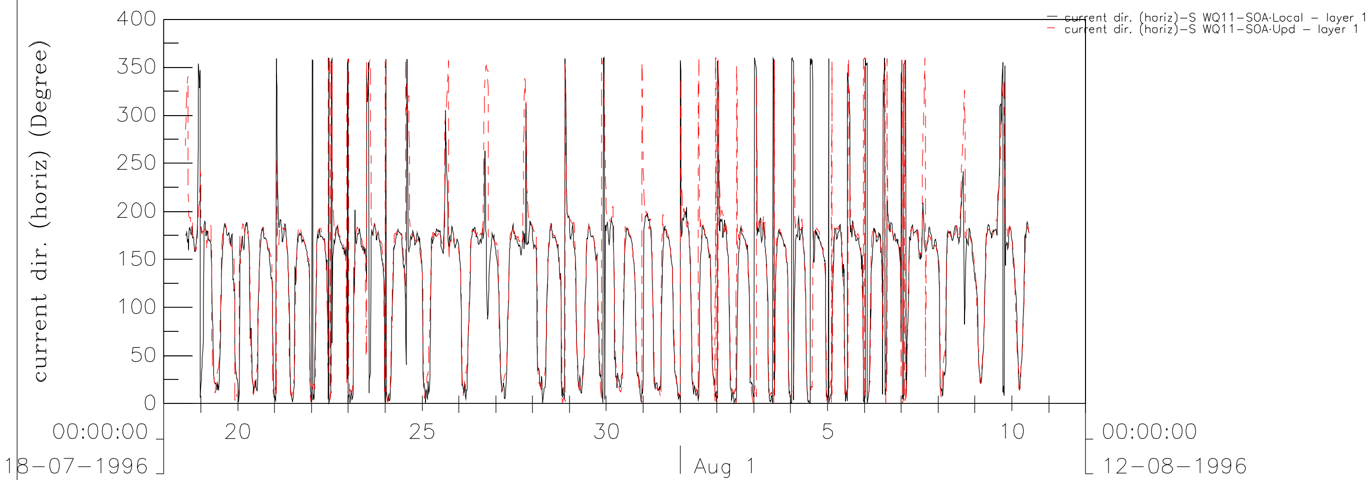




Current Velocity Comparison between Update Model and Local Fine Grid Model at A1–04a (Upper), S SDS EIA (Middle) and S WQ11–SOA (Lower).	Wet Season
	Figure 5A-12
DSD & ATKINS	





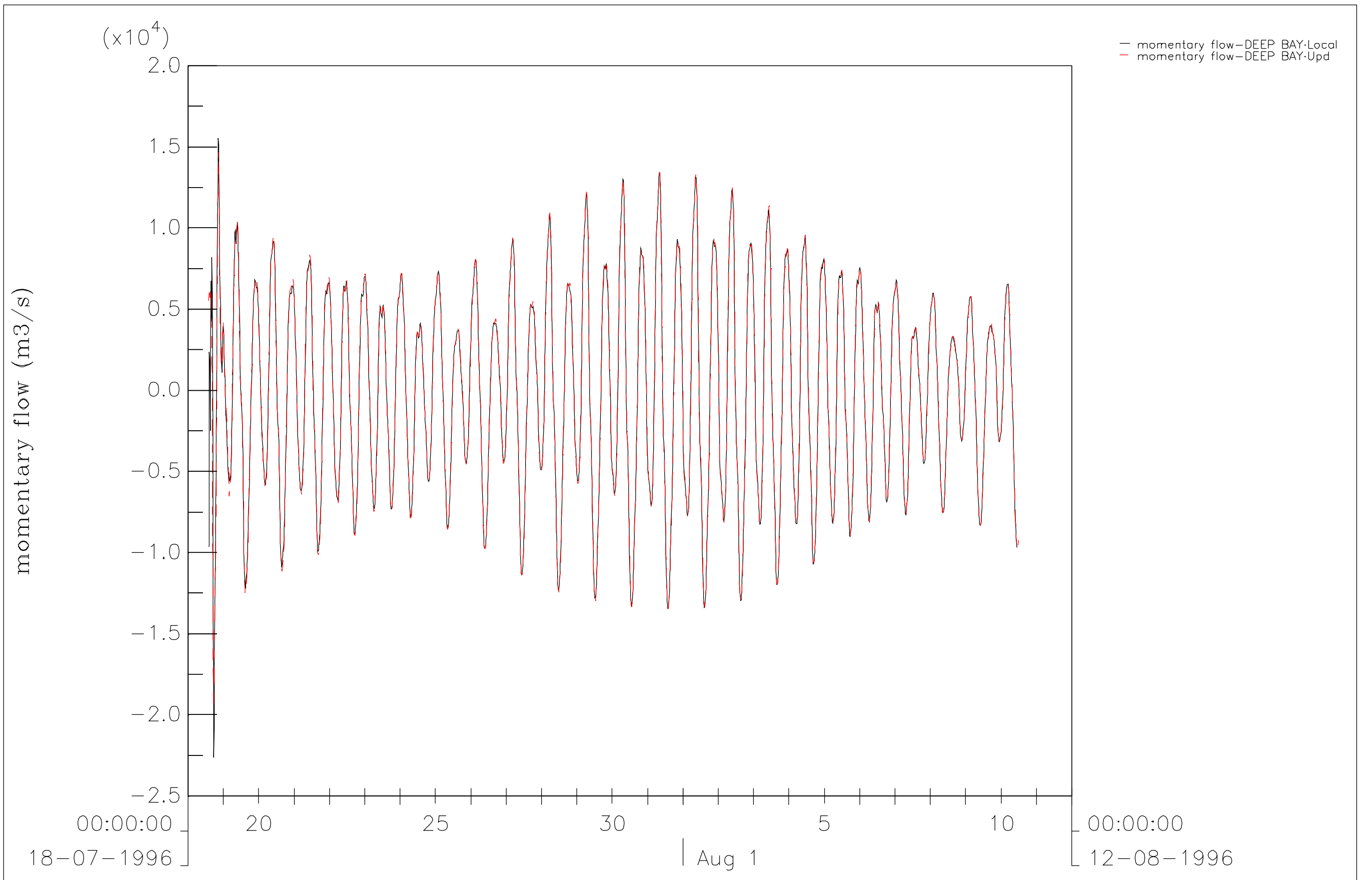


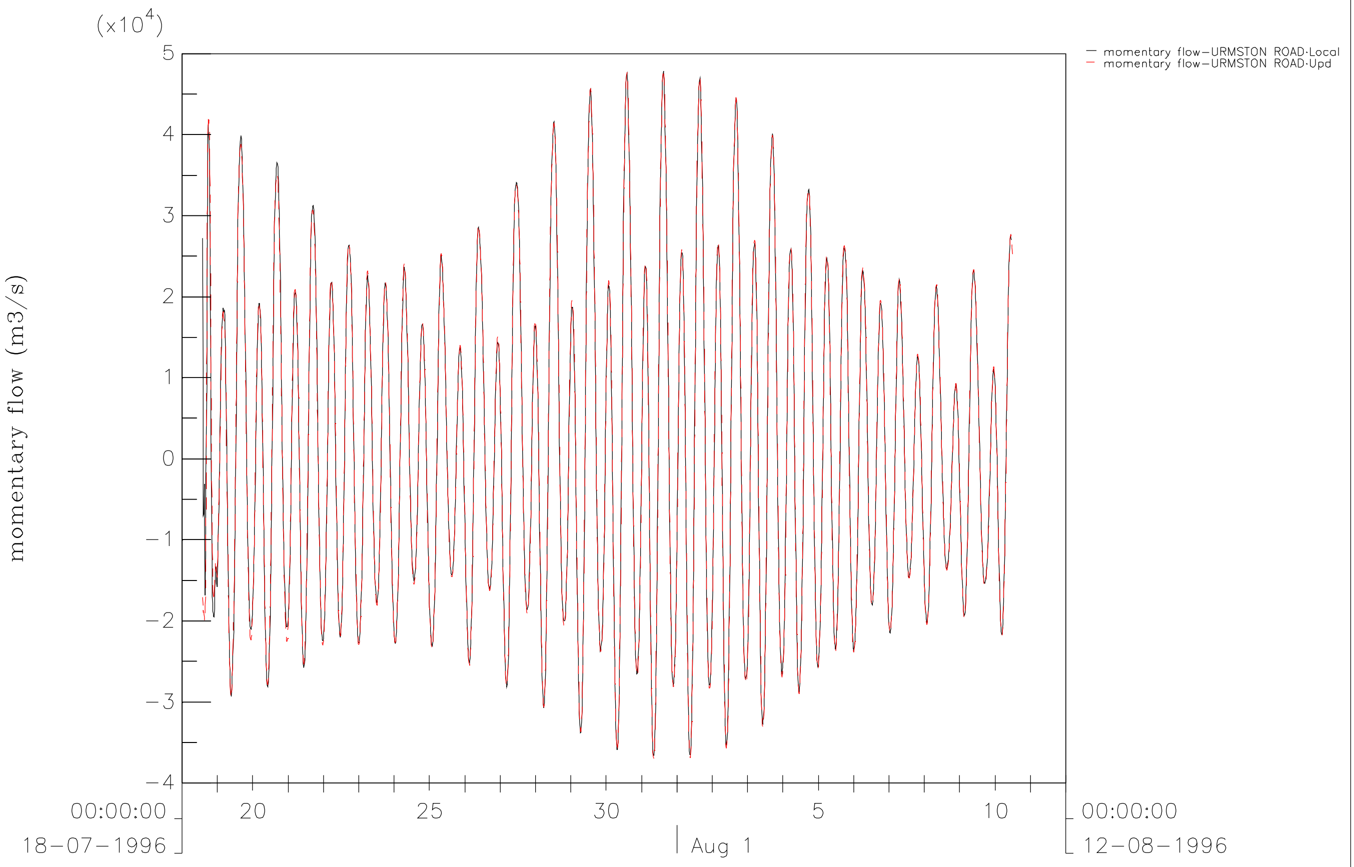
Current Direction Comparison between Update Model and Local Fine Grid Model at A1–04a (Upper), S SDS EIA (Middle) and S WQ11–SOA (Lower).

Wet Season

Figure 5A-13

DSD & ATKINS



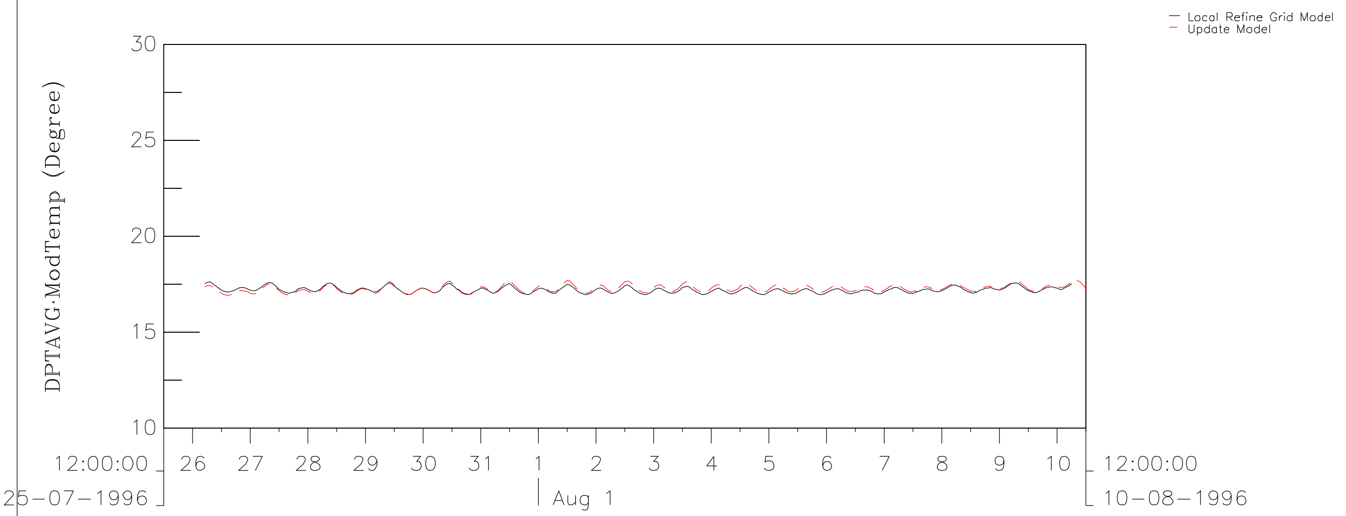


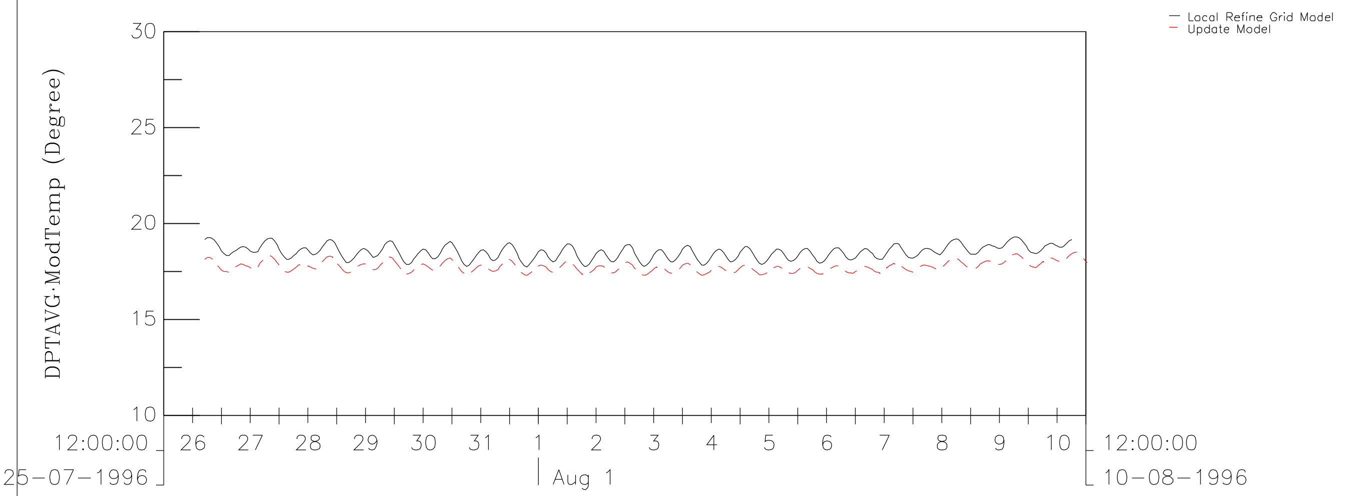
Flow Comparison between Update Model and Local Fine Grid Model at Deep–Bay (Upper) and Urmston Road (Lower).

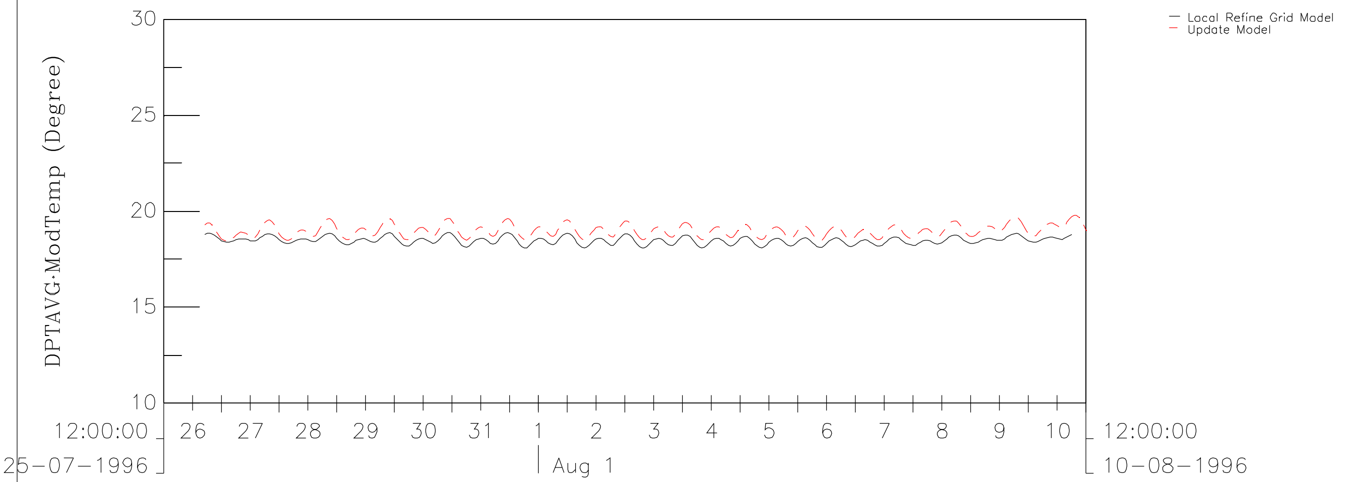
Wet Season

Figure 5A-14

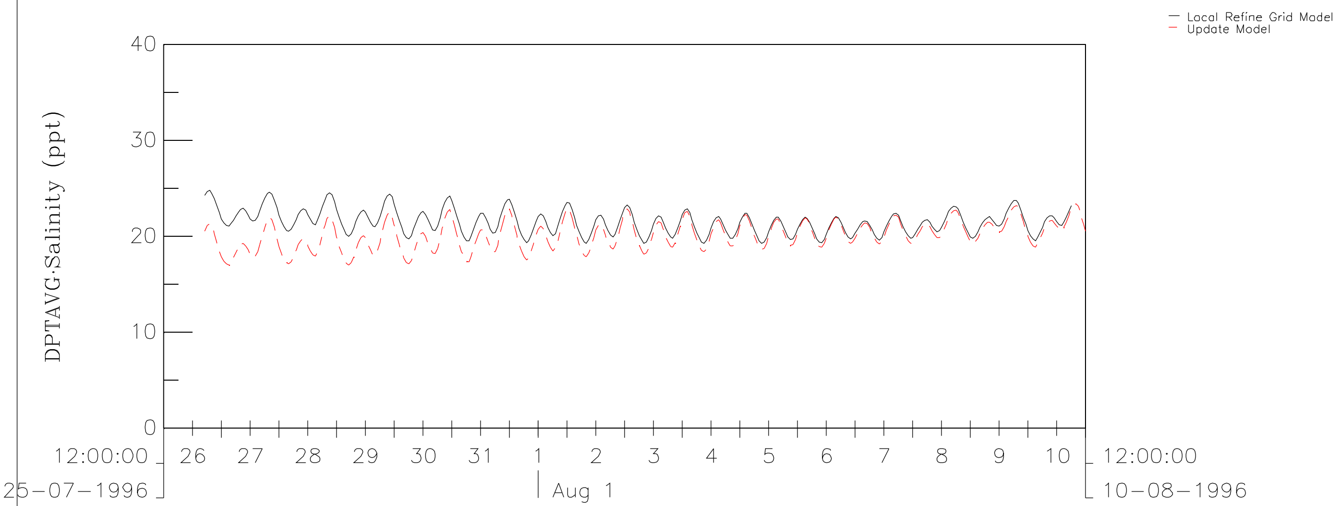
DSD & ATKINS

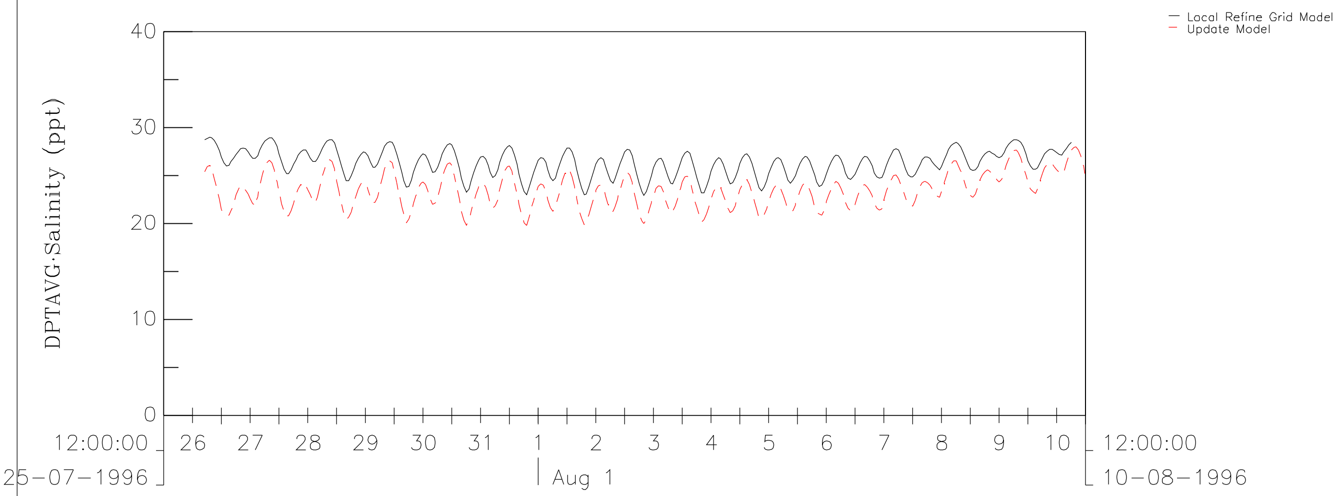


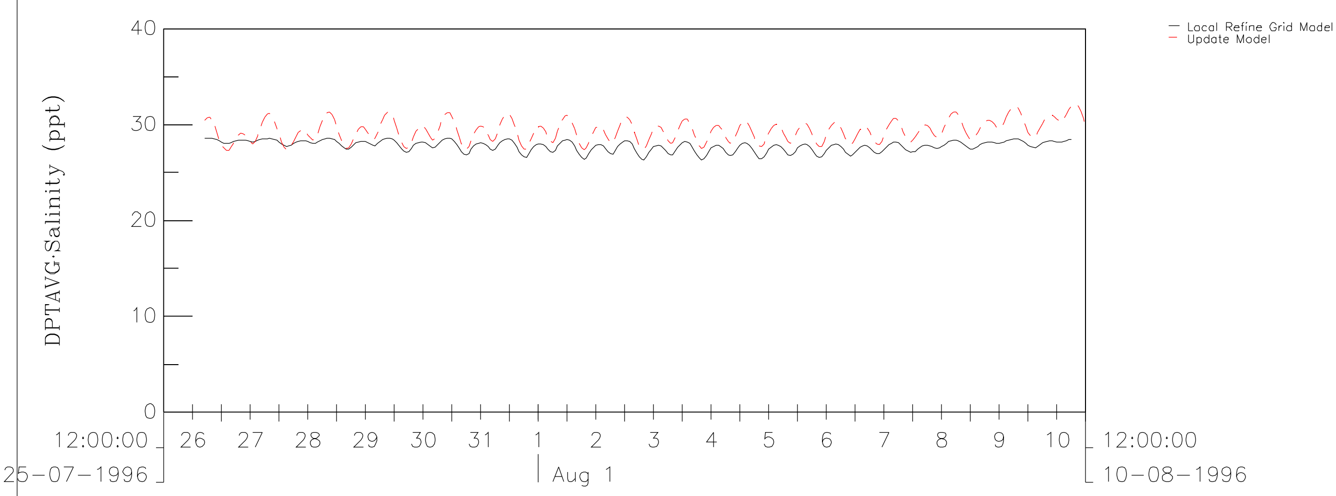




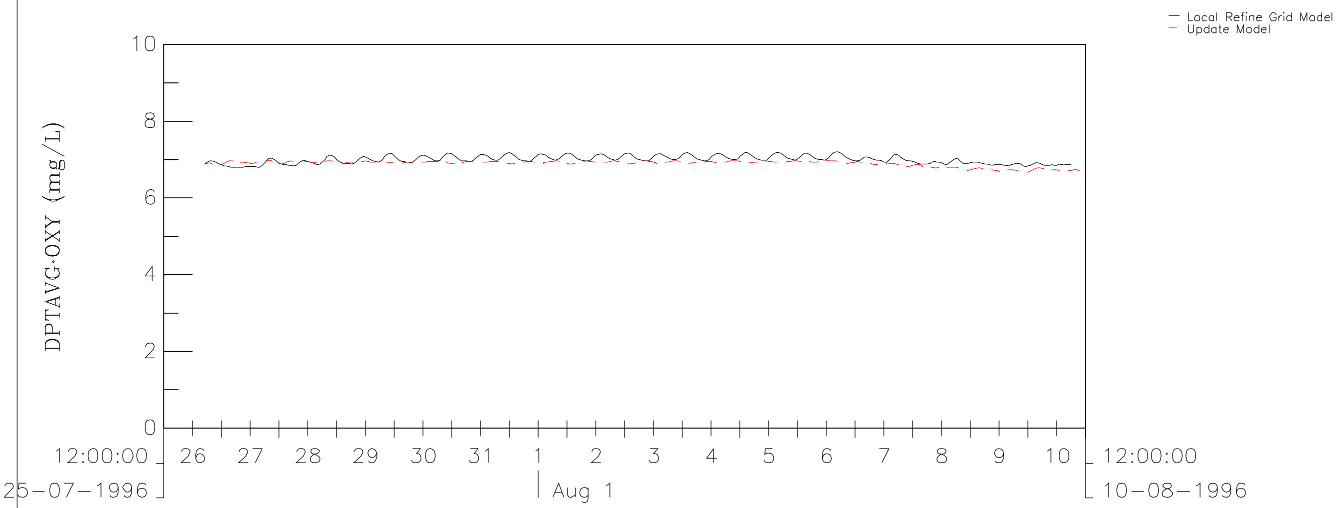
Water Temperature Comparison between Update Model and Local Fine Grid Model at B2-03 (Upper), DM5 (Middle) and B2-04 (Lower).	Dry Season
	Figure 5A-15
DSD & ATKINS	

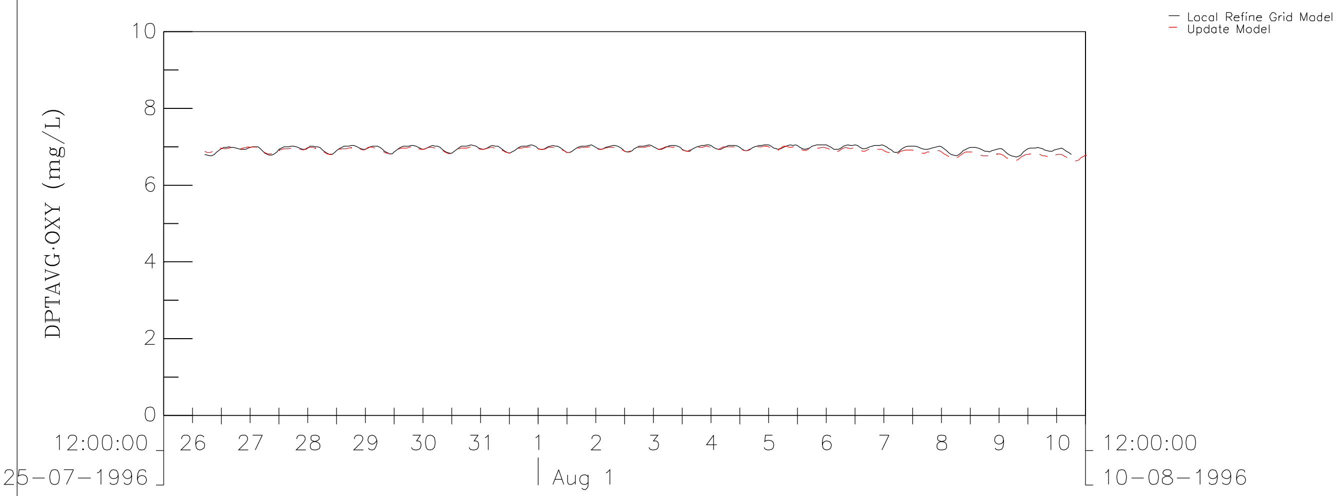


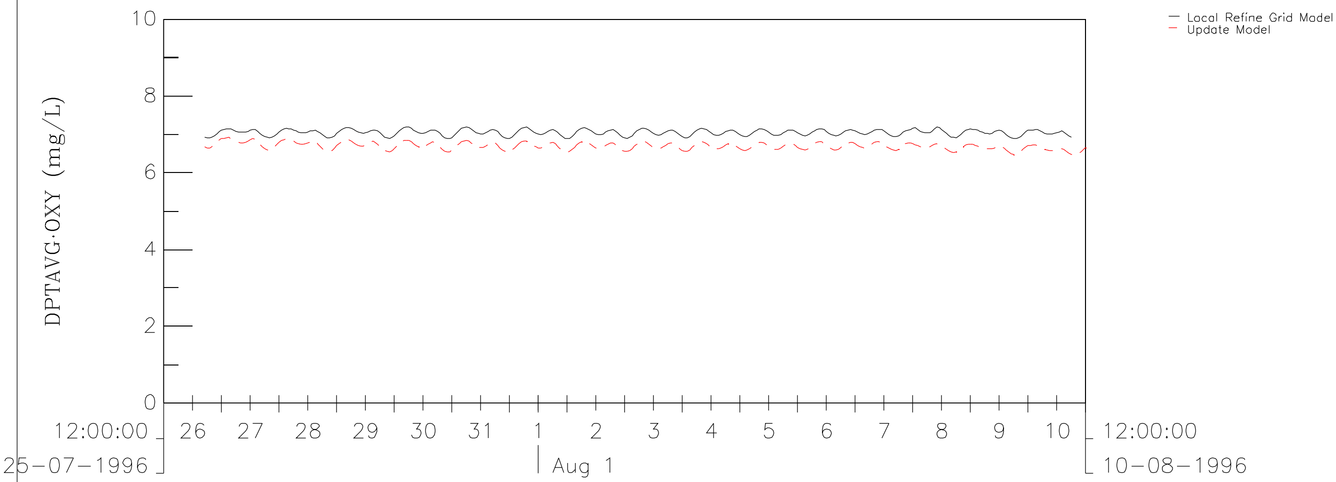




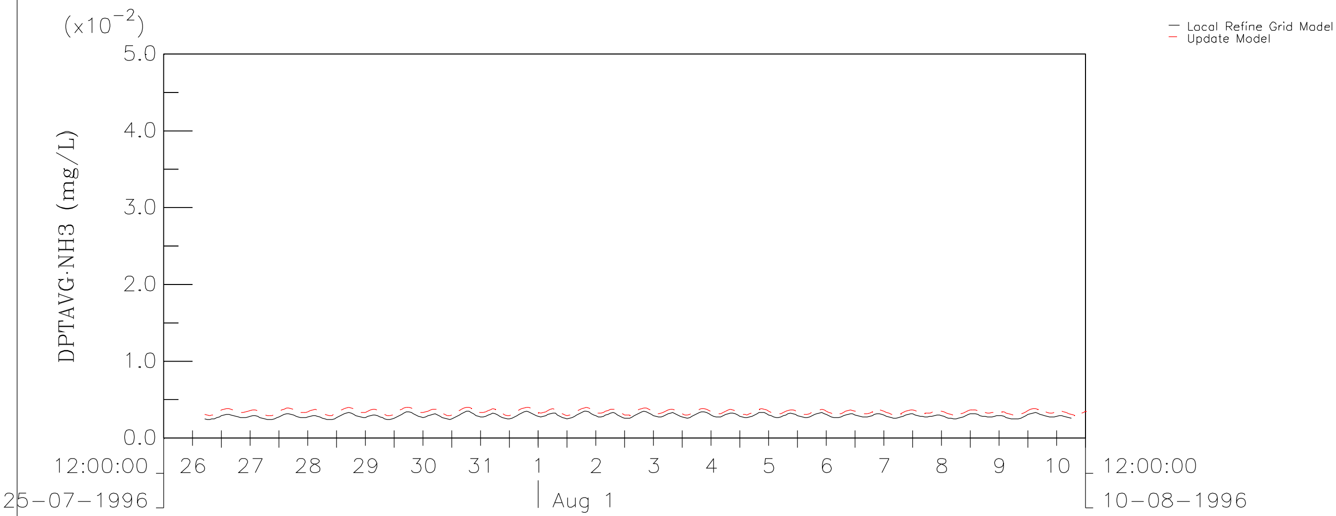
Salinity Comparison between Update Model and Local Fine Grid Model at B2-03 (Upper), DM5 (Middle) and B2-04 (Lower).	Dry Season
	Figure 5A-16
DSD & ATKINS	

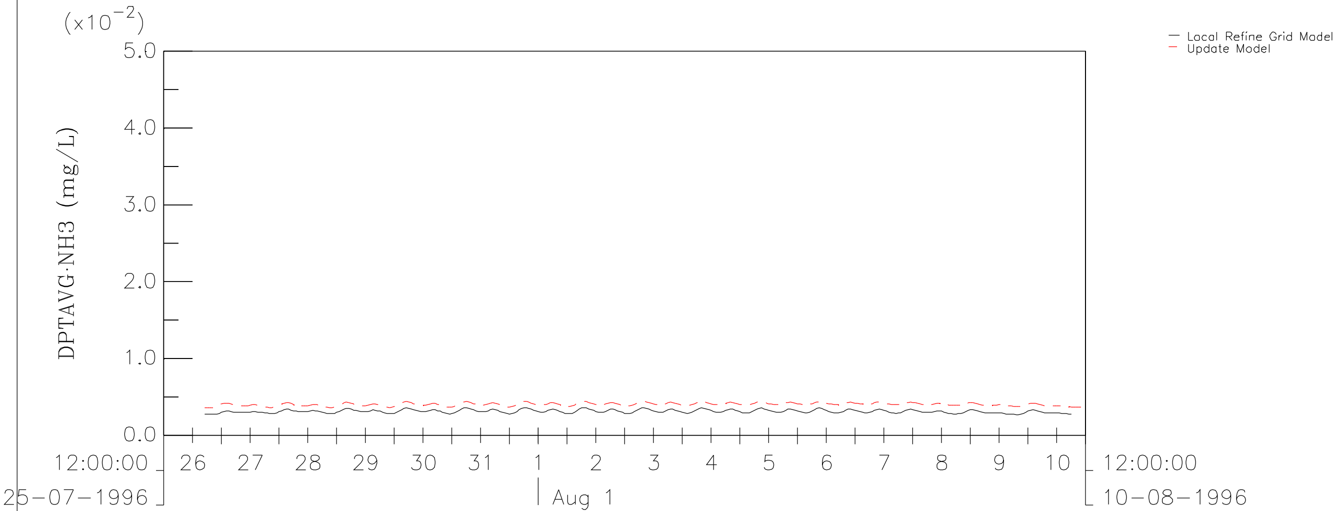


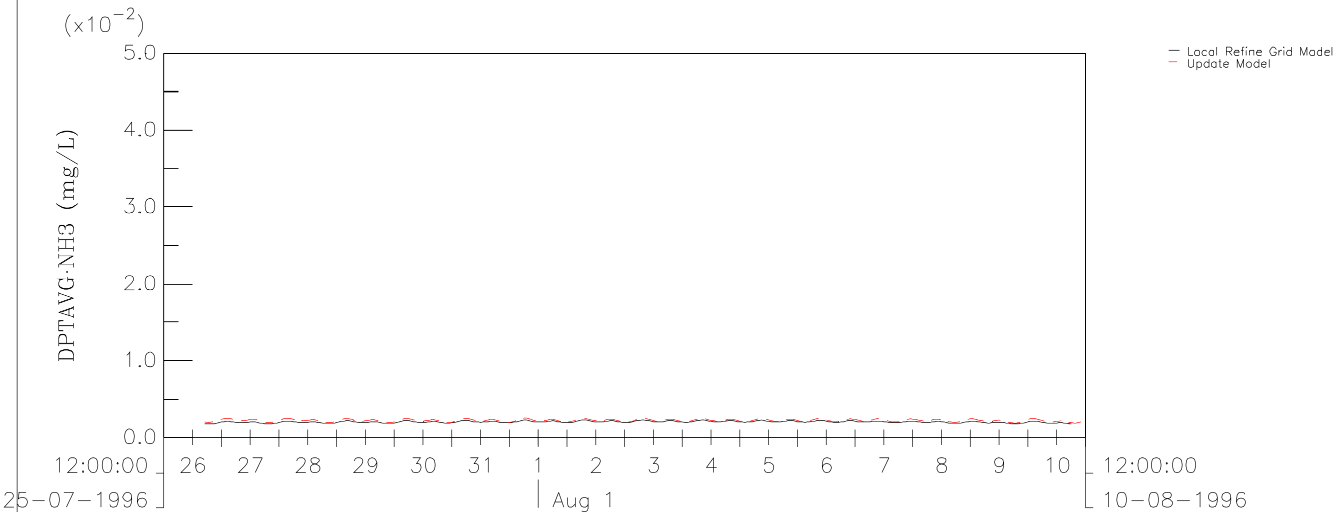




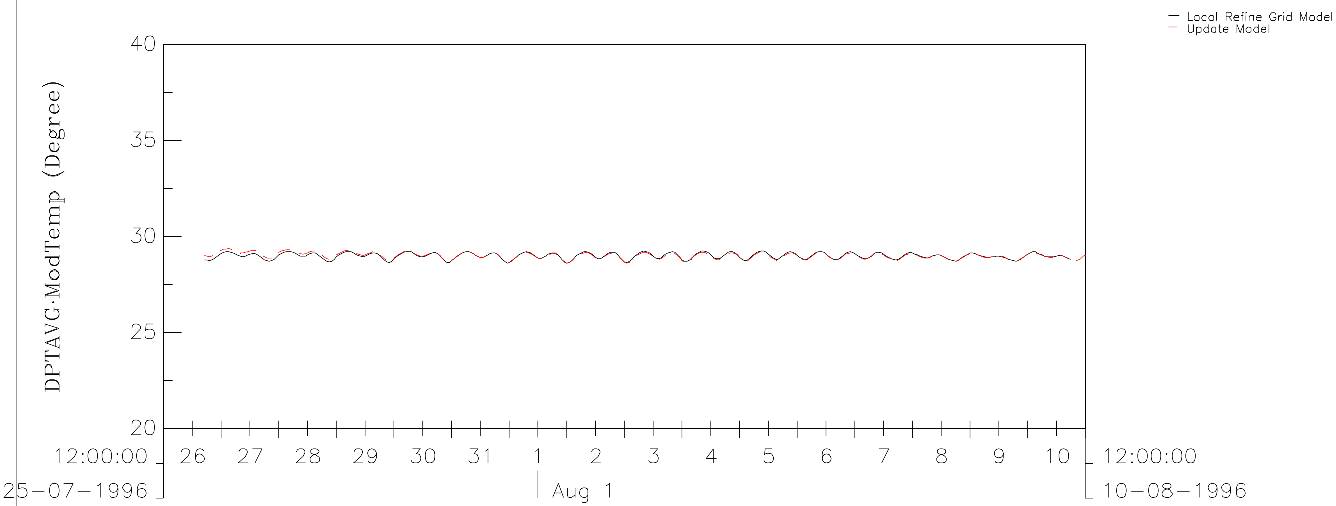
Dissolved Oxygen Comparison between Update Model and Local Fine Grid Model at B2-03 (Upper), DM5 (Middle) and B2-04 (Lower).	Dry Season
	Figure 5A-17
DSD & ATKINS	

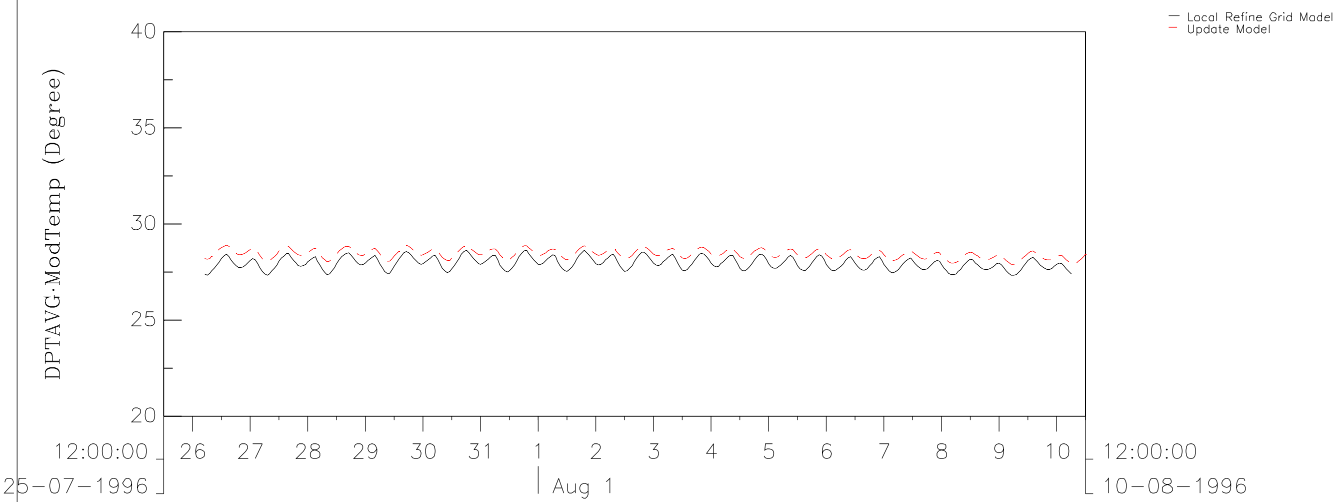


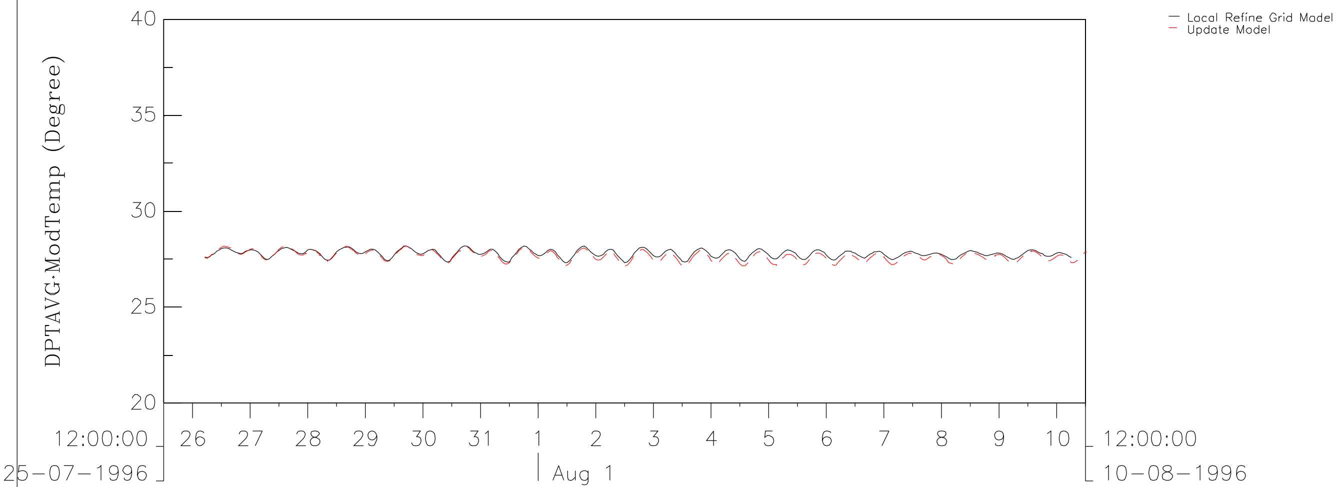




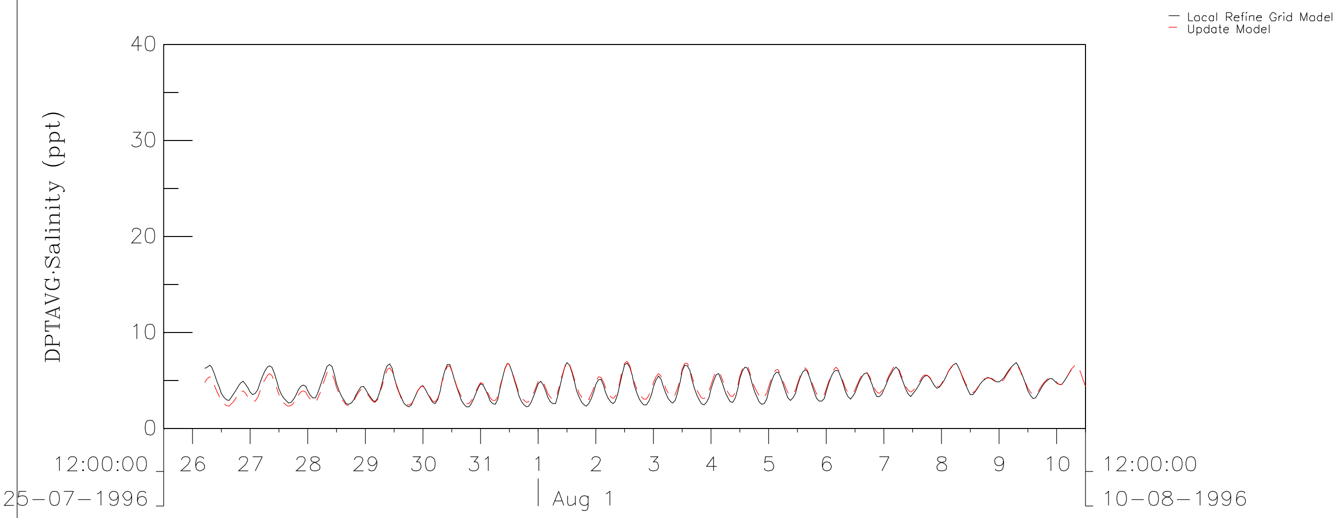
NH3 Comparison between Update Model and Local Fine Grid Model at B2-03 (Upper), DM5 (Middle) and B2-04 (Lower).	Dry Season
	Figure 5A-18
DSD & ATKINS	

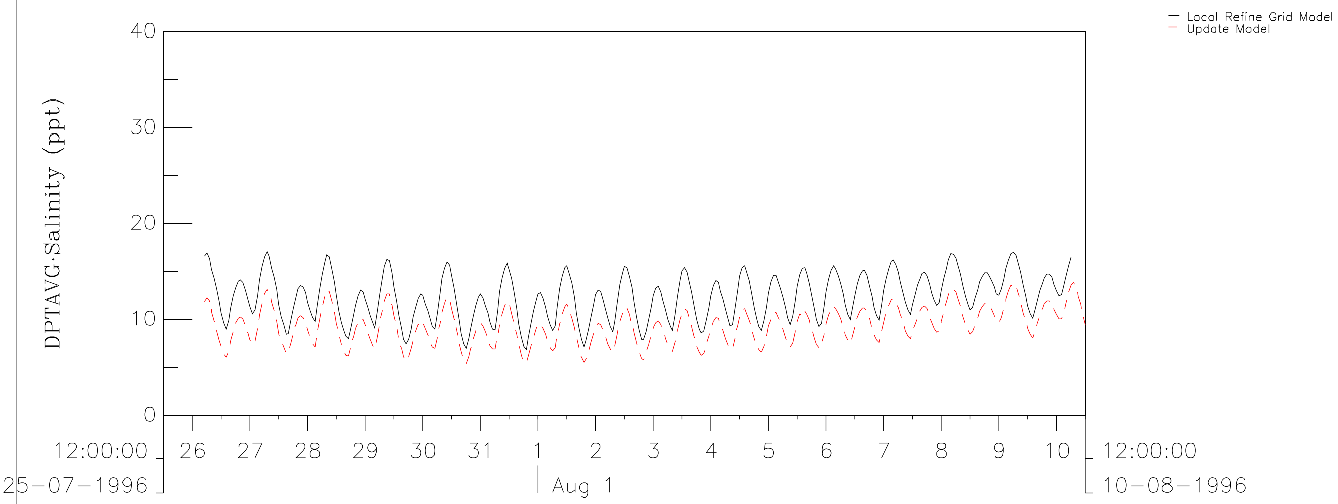


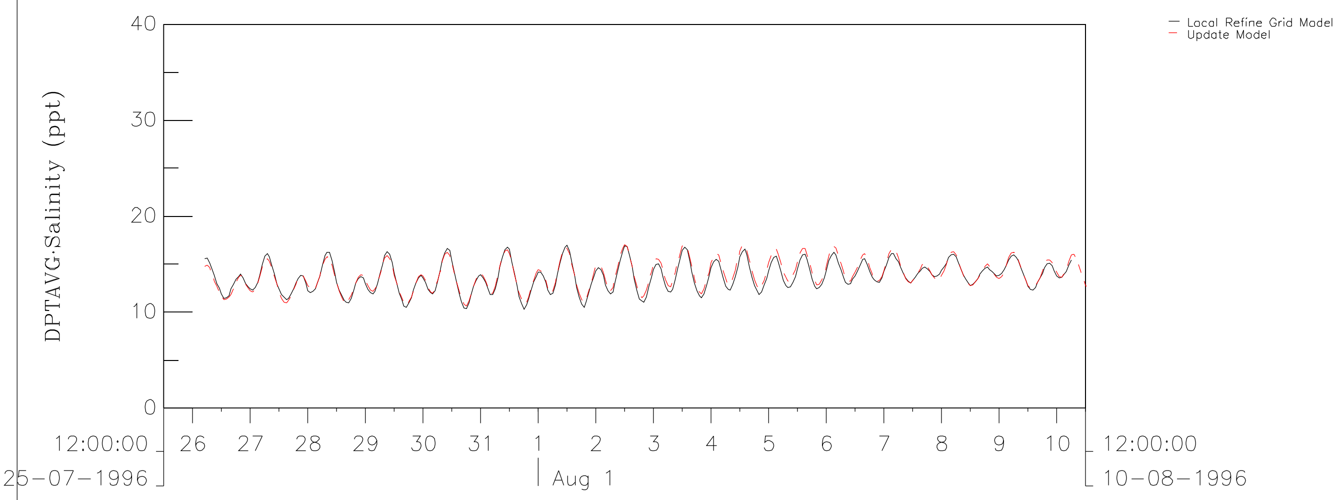




Water Temperature Comparison between Update Model and Local Fine Grid Model at B2-03 (Upper), DM5 (Middle) and B2-04 (Lower).	Wet Season
	Figure 5A-19
DSD & ATKINS	





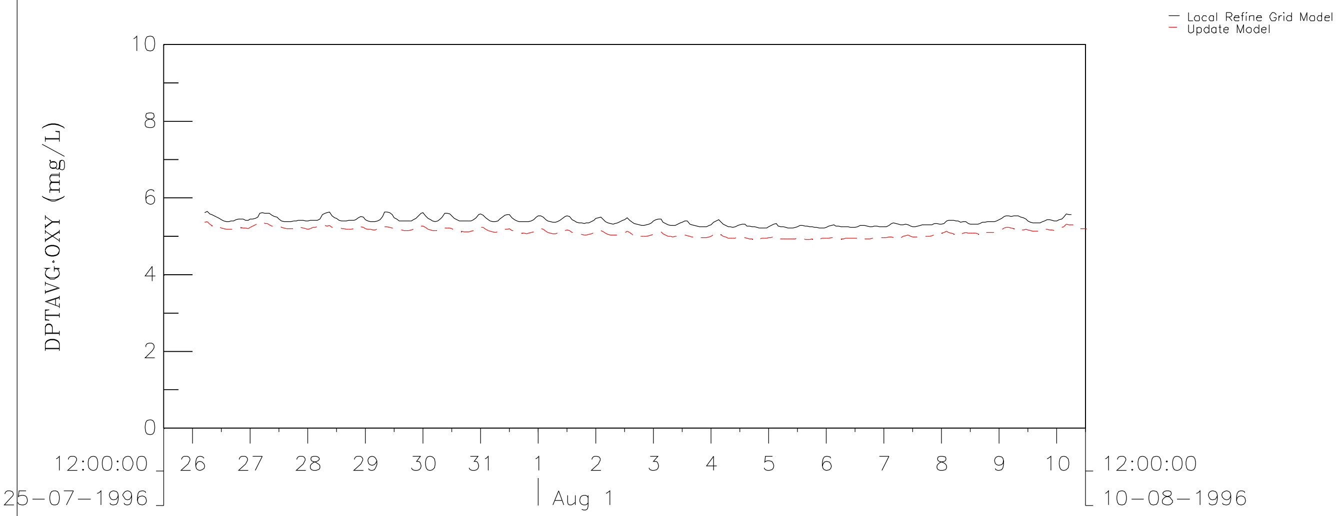


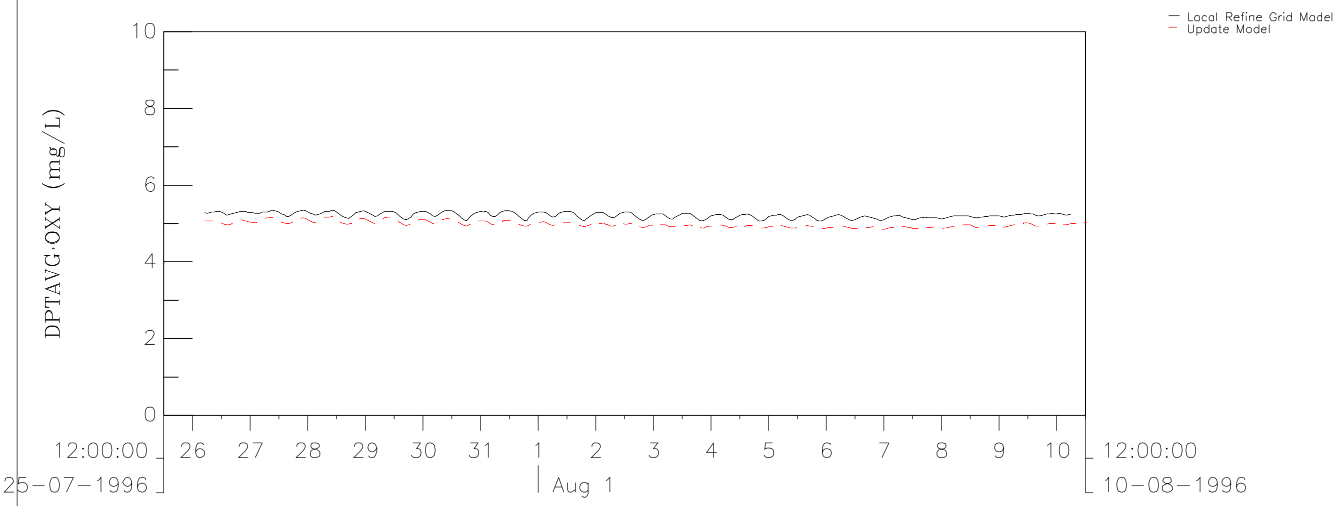
Salinity Comparison between Update Model and
Local Fine Grid Model at B2-03 (Upper), DM5 (Middle)
and B2-04 (Lower).

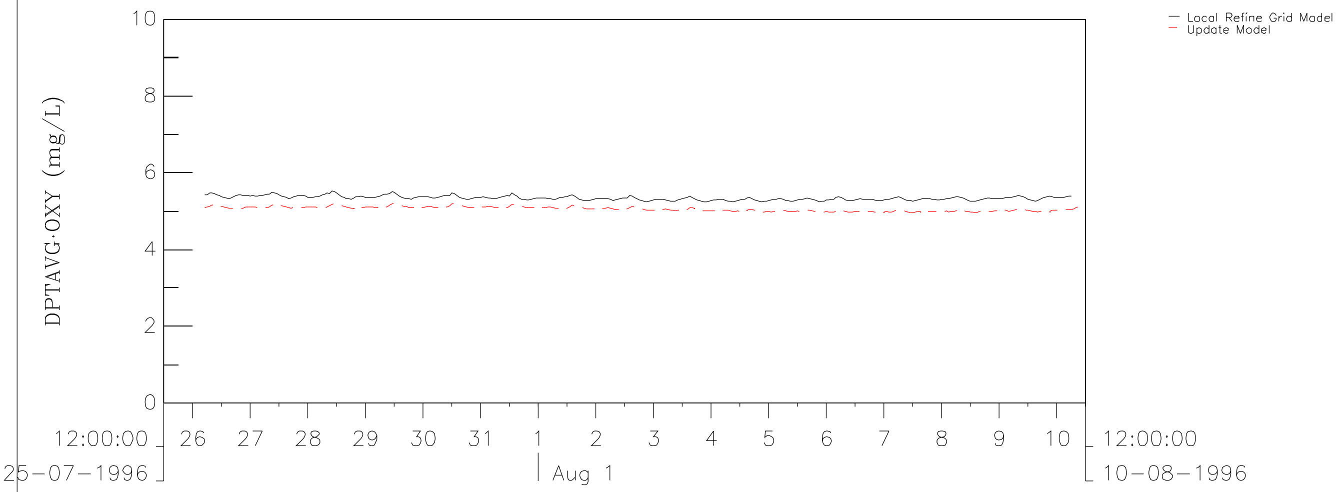
Wet Season

Figure 5A-20

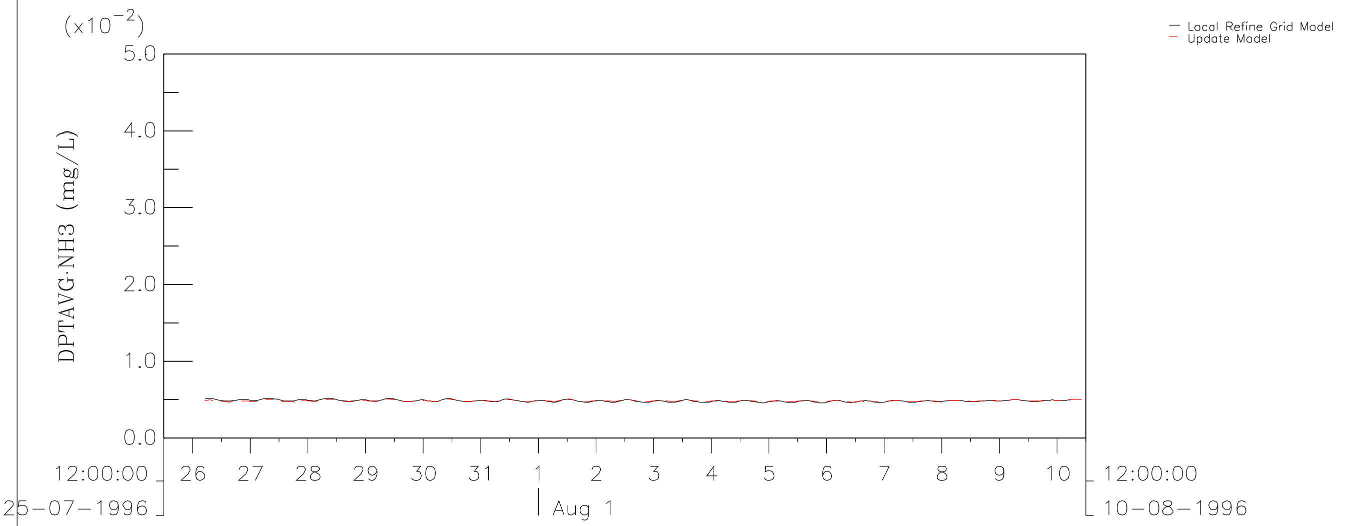
DSD & ATKINS

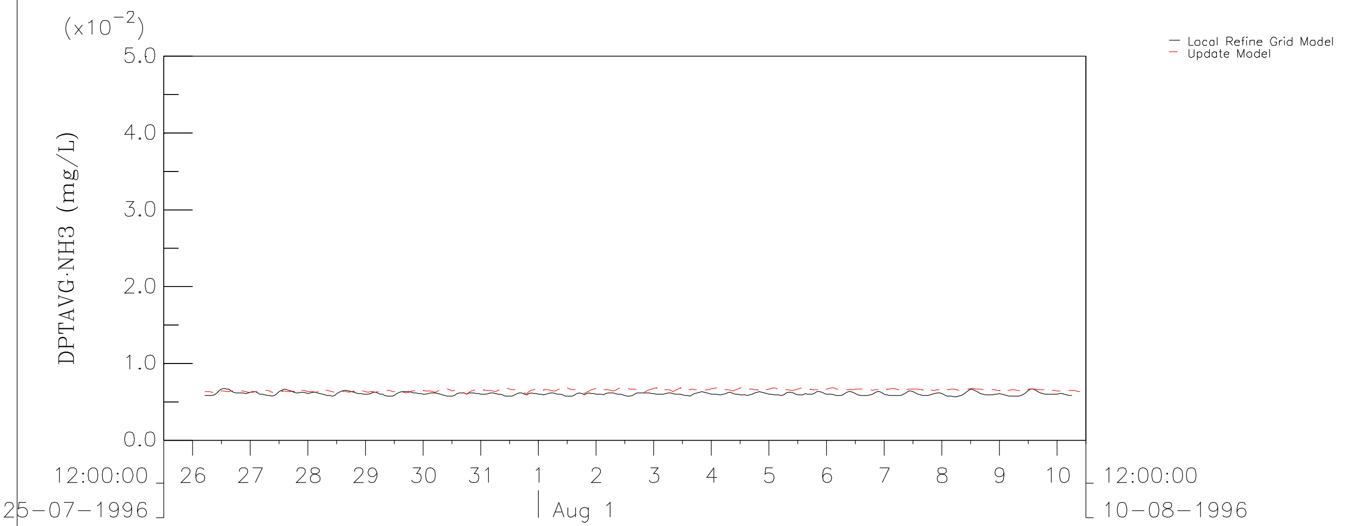


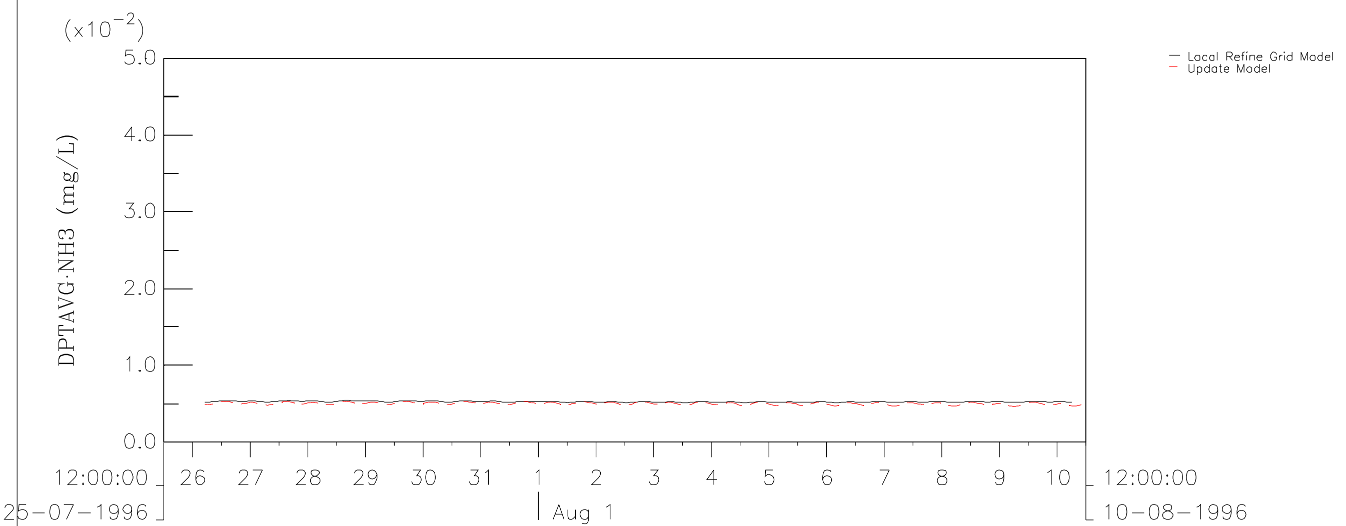




Dissolved Oxygen Comparison between Update Model and Local Fine Grid Model at B2-03 (Upper), DM5 (Middle) and B2-04 (Lower).	Wet Season
	Figure 5A-21
DSD & ATKINS	







NH3 Comparison between Update Model and Local Fine Grid Model at B2-03 (Upper), DM5 (Middle) and B2-04 (Lower).	Wet Season
	Figure 5A-22
DSD & ATKINS	