QATAR UNIVERSITY

Graduate Studies

College of Arts and Sciences

Northeastern Qatari coast hydrodynamic modeling for assessment of sensitive ecosystems under anthropogenic and natural stressors

A Thesis in

Environmental Sciences

By

Submitted in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science

May 2015

The thesis of **Ruqaiya Ammar Yousuf** was reviewed and approved by the following:

We, the committee members listed below accept and approve the Technical report of the student named above. To the best of this committee's knowledge, the technical report confirms the requirements of Qatar University, and we endorse this Technical report for examination.

Name Dr. Radhouan Ben Hamadou

Signature ____ Date__________

Name Dr. Sumith Pathirana

Signature ____ Date__________

Name Dr. Jennifer Dupont

Signature ____ Date__________

Abstract

The Northeastern Qatari coast, comprising diverse and sensitive flora and fauna communities (e.g. coral reefs and patches, seagrass meadows and turtles) is expected to undergo changes imposed by anthropogenic stressors (coastal development projects) in the near future. Therefore, the need to study the impacts of such scenarios on the existing ecosystems is pressing. Ecohydrological models are theoretical, mathematical representations of a natural system, made to understand the functionalities of the real ecological system under physical forcing. Using gathered data from sites, ecological associations are inferred and then combined to build a functional ecosystem model that mimics the real environment. These model systems are then used in order to assist the impact assessment of future scenarios on real systems.

The aim of this study was to create hydrodynamic simulation along with a sediment transport model for a stretch of coastline off of Jabal Fuwairat. This aim was achieved using GEMSS modeler software, which requires the following data for a proper model (1) spatial data (that is included as shape files imported from ArcGIS), primarily the water body shoreline and bathymetry, additionally the locations, altitudes, and formations of man-made structures; (2) time-based data, that are varying in time (i.e. tidal changes, influx rate and temperature and meteorological data) and (3) Sediment composition. These data were collected and gathered into time varying data files that are loaded into a control file. A hydrodynamic model (HDM) simulating the spatial dynamics of the water was developed, calibrated and validated using field data. Additionally, a sediment transport model (STM) identifying, under present or simulated scenarios, the fate of the suspended sediment in the region and identifying potentially erosion and sedimentation area in the studied coastal zone is proposed. This STM assimilates data about sediment typologies, suspended particulate matter and currents near the seafloor (shear stress). Results from both HDM and STM models demonstrated that the study area is highly dynamic, being mainly controlled by tides and with relatively high shear stress (potential for erosion) in the northern and east-western boundaries.

Considering these factors, the present research work intends to understand through a modeling approach the ecohydrological features of this area with special emphasis on the sediment dynamics and potential risks facing the sensitive coral reefs located in the area. This work provides three scenarios of future development that might take place in the area and shows the alteration of the dynamics of water and sediments accordingly. These simulations help the development of recommendations to decision makers for a better management of the considered coastal zone. It also provides a tool that can be replicated in future hydrodynamic studies along the Qatari coastal zone.

Keywords: Hydrodynamic Model, Sediment Transport Model, Anthropogenic stressors, coastal dynamics, GEMSS

ملخص البحث

من المتوقع أن يخضع الساحل الشمالي الشرقي القطري في المستقبل القريب لتغييرات التي تفرضها الضغوطات البشرية (مشاريع التنمية الساحلية). يتألف هذا الساحل من النباتات المتنوعة والحيوانات حساسة (مثل الشعاب المرجانية ، ومروج الأعشاب البحرية والسلاحف) لذلك هناك حاجة ملحة إلى دراسة الآثار المترتبة على مثل هذه الثغيرات على النظم الإيكولوجية.

النماذج الإيكولوجية ، هي عبارة عن تمثيلات رياضية و نظرية للنظام الطبيعي، التي أدخلت على فهم الخصائص الوظيفية للنظام البيئي الحقيقي تحت تاثيرات فيزيائية معروفة تمثل النظام المدروس. باستخدام البيانات التي تم جمعها من حقول او من الجمعيات البيئية لبناء نموذج النظام البيئي الوظيفي الذي يحاكي البيئة الحقيقية .ثم يتم استخدام هذه النظم كنموذج من أجل مساعدة تقييم تأثير السيناريوهات المستقبلية على الأنظمة الحقيقية.

الهدف من هذه الدراسة هو خلق المحاكاة الهيدروديناميكية جنبا إلى جنب مع نموذج نقل الرواسب لتمتد من الساحل قبالة جبل فويرط .وقد تحقق هذا الهدف باستخدام برنامج **GEMSS** لصناعة النماذج، و الذي يتطلب البيانات التالية للحصول على نموذج السليم

(1) البيانات الفضائيه (كملفات من نظام **ArcGIS**)، الذي يتضمن الخط الساحلي للمنطقة وقياس الأعماق، بالإضافة إلى المواقع، الارتفاعات، و تشكيلات الهياكل التي من صنع الإنسان .

(2) .البيانات التي تستند على الوقت، والتي هي متفاوتة في الوقت المناسب (أي تغيرات المد والجزر، ومعدل التدفق ودرجة الحرارة وبيانات الأرصاد الجوية) .

(3)تكوين الرواسب.

تم صنع النموذج الهيدروديناميكي لمحاكاة ميكانيكيات المياة والتحقق من صحة البيانات بمقارنتها مع بيانات حقليه .بالإضافة إلى ذلك, تم صنع نموذج نقل الرواسب الذي يحدد مصير الرواسب العالقة في المنطقة وتحديد أحتمل حدوث التعرية اوالترسيب في اي منطقة اخرى .

أظهرت النتائج لكل من النموذج الهيدروديناميكي والنموذج نقل الرواسب أن منطقة الدراسة هي منطقة ديناميكية للغاية، يتم التحكم بها بشكل رئيسي من قبل المد والجزر وأن احتمال التعريه للرواسب تتزايد في الحدود الشمالية والشرق والغرب.

يوفر هذا العمل ثلاثة سيناريوهات للتنميه المستقبلية التي قد تحدث في هذه المنطقة، ويظهر تغيير ديناميكيات المياه والرواسب وفقا لذلك .وفقا لذلك خرجنا بمجموعة من التوصيات لصناع القرار لتحسين إدارة المنطقة الساحلية .كما أنه يوفر الأدوات التي يمكن تكرارها في الدراسات الهيدروديناميكية في المستقبل على طول المنطقة الساحلية القطرية.

List of abbreviations

1D: One dimension

2D: Two dimensions

3D: Three dimensions

CSA: Continental Shelf Associates

EEZ: Exclusive Economic Zone

EMRQ: ExxonMobil Research Qatar

ERM: Ecological Responses Model

ESC: Environmental Studies Center

GEMSS: Generalized Environmental Modeling System for Surface waters

GIS: Geographic Information System

GUI: Graphical user interface.

HDM: Hydrodynamic model

NSE: Navier Stokes Equations

QMZ: Qatar Marine Zone

SPH: Smoothed Particles Hydrodynamics

STM: Sediment Transport Model

SWAN: Simulating Wave Near Shore

UCC: UrbanCo Constructions

Table of Contents

List of Figures

List of tables

Acknowledgment

First of all I'm thankful to the department of Environmental Sciences in Qatar University for the grate knowledge and for providing necessary guidance.

I genuinely thank my supervisor Dr. Radhouan Bin Hamadou for his great support, advice and for assistance in every step of this work. Without his superior knowledge and experience, this thesis would lack in quality of outcomes, and therefore his support has been essential.

I'm also grateful to the advisory of committee Dr. Sumith Pathirana and Dr. Jennifer Dupont for provision of expertise, and technical support in the implementation.

I also thankfully acknowledge Dr. Christopher Warren for supervising me at ExxonMobil, and for giving me beneficial and extremely intelligent advices and important thoughts.

I would like to thank Dr. Venkat S. Kolluru and Dr. Shwet Prakash from ERM group for hosting me in there office in Pennsylvania, USA, and for helping me learning about GEMSS model.

I 'm very appreciative to the ESC in particular Dr.Sinan and Dr. Ismail for sharing me there knowledge.

I 'm very thankful to the department of meteorology for providing me with the needed data.

Finally I'm very grateful to my colleges Noora Al-Shamari, Rabhab and Mohammed for their support and motivation.

Dedication

This Thesis is dedicated to my parents, husband, and my daughter (Wassan).

Chapter 1

INTRODUCTION

1.1 Problem definition

The environmental science program at Qatar University considers studying global and local environmental issues and concerns. One of the diverse coastal areas in Qatar is Fuwairet, which is located in the Northeastern coasts of Qatar (Arabian Gulf)Due to the main environmental, meteorological and oceanographic conditions, the coastal marine area of Fuwairat is regarded as a special marine environment, comprising diverse and sensitive flora and fauna communities (e.g. coral reefs and patches, seagrass meadows, and turtles) (figure 1).

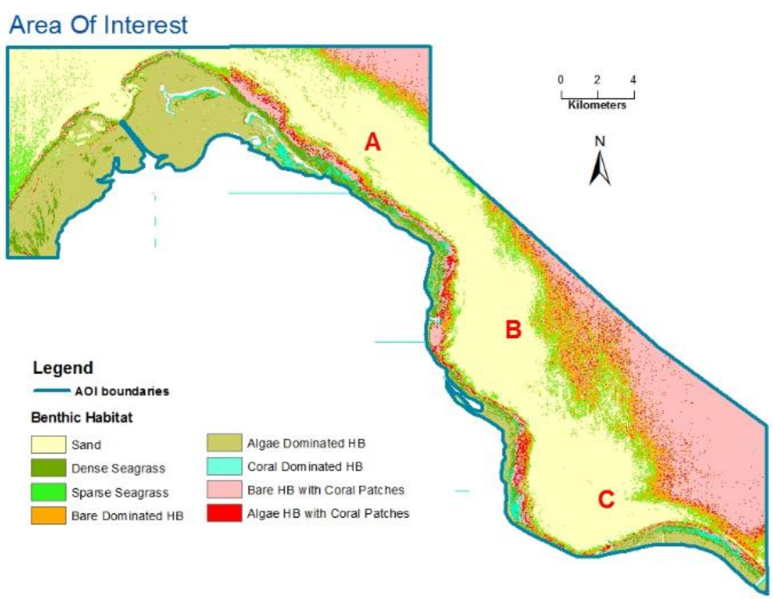


Figure 1: *Base line survey conducted by ExxonMobil Research Qatar for benthic identification in the study area*

This shallow area is also characterized by highly hydrodynamic conditions under the influence of the northern currents, high salinity and temperature along with oceanographic structures like eddies forcing the marine life. Considering these factors, the present research thesis intend to understand through a modeling approach the ecohydrological features of this area with special emphasis on the sediment dynamics, and potential risks facing the sensitive coral reefs located in the area. This work will help the development of recommendations to decision makers for a better management of the considered coastal zone.

Three hyptotical scenarios for future fishery harbour to be constructed in the study area were developed in order to suggest the closest scenario to real life simulation coparing surface elevation, average velocity, and shear stress which force the sediment erosions. The scenarios take into consideration the current Al-wakrah jetty design and dimensions.

1.2 Aims and Objectives

The aim of this project is to develop a hydrodynamic and sediment transport model in the North- Eastern part of Qatar marine zone (QMZ), by combining field data and GEMSS modeling program to simulate response of the system to potential dredging activities or the increase of sediment load in the considered area.

In order to achieve this aim, the following specific objectives were considered:

1. Simulate the 3-D hydrodynamic and sediment transport model.
2. Risk assessment of coastal marine habitats under anthropogenic/natural pressures
3. Provide recommendations for decision/policy makers for the protection of the coastal environment located in Northern Qatar.

Chapter 2

BACKGROUND AND LITERATURE REVIEW

The Arabian Gulf is a shallow semi- enclosed marginal subtropical sea. The dynamics of water masses inside the Gulf is complex and mostly connected to the tide. Beside tide, winds and differential water density affect the water movement in the Gulf. The average monthly water temperature varies between 19^{o} C to 35^{o} C (figure 2) [1]:

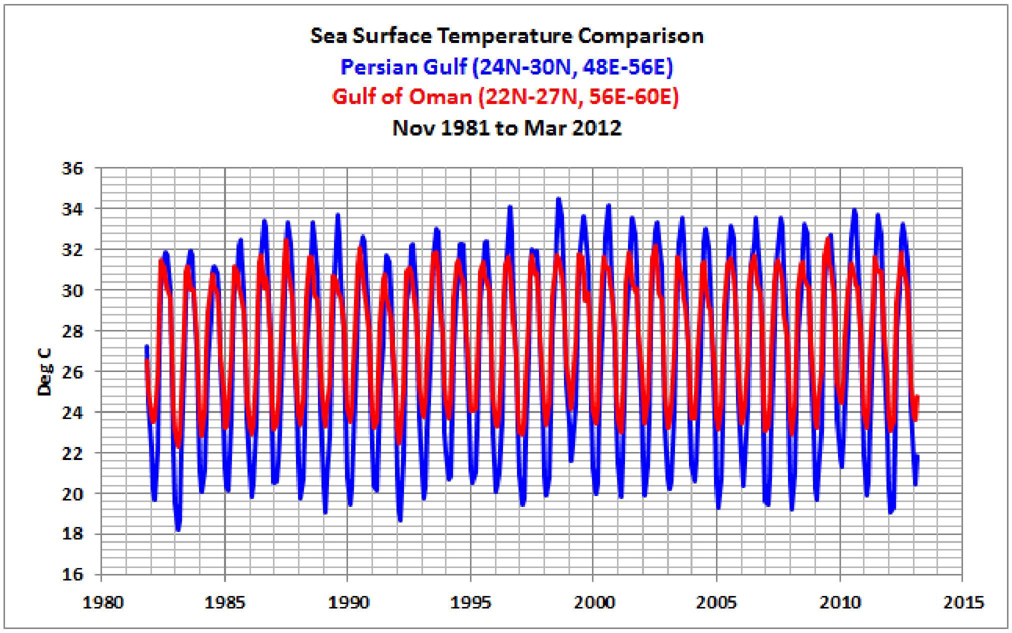


Figure 2 *The monthly surface temperatures of Arabian Gulf Vs Gulf of Oman [2].*

The Qatar peninsula is surrounded by the Arabian Gulf in its northern, eastern and western coasts, where the average sea surface temperature varies between 14^{0}C in winter to 42^{0}C in summer (Figure 3)[2].

The high temperature records coupled to its reduced depths and limited freshwater inputs from land and precipitation explain the high salinity recorded in coastal waters of Qatar.

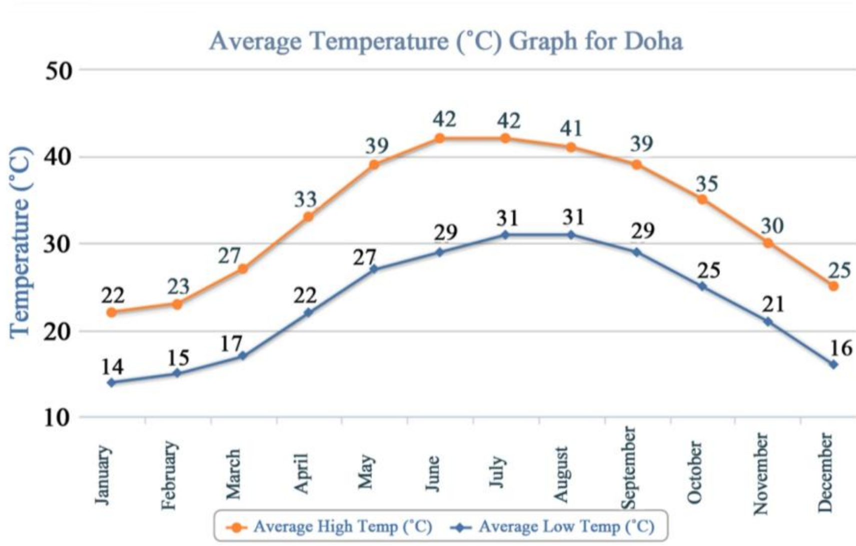


Figure 3: *Average High (red line) / low (blue line) sea surface temperature in Doha, Qatar [2].*

The natural stresses that the Qatari marine environment faces include high temperature, high salinity and low rate of precipitation, which all affect the metabolic rates of aquatic organisms. The primary producers are especially affected by such conditions since light and temperature positively influence the primary productivity up to a maximum growth rate; beyond these optimum conditions the rise of temperature (and light) will inhibit the growth and productivity of photosynthetic organisms [3]. These extremes conditions found in the Qatar coastal waters boost extremophile organisms adapted to thrive in such conditions, especially able to tolerate high temperature and salinity. Beside natural stressors, Qatari marine life undergoes anthropogenic stresses. Qatar is a fast growing country boosted by a booming oil and gas industry and leading to a sustained coastal development (coastal and offshore constructions), with several dredging works affecting sediment dynamics in the coastal areas. Anomalous coastal erosion and accretion processes are then intensified along the coasts of Qatar, impacting the shore and shelf dynamics and associated biota (e.g. penetration of light and reduction of photosynthetic processes of primary producers)[4].

One of the most important primary producers impacted by the above stressors are symbiotic algae, or zooxanthellae, living in corals. These microorganisms provide corals with organic matter and oxygen and contribute to the water clearance. In return the algae uptakes carbon dioxide and other nutrients from the coral polyps. This symbiotic relation is generally found in shallow waters with little amounts of suspended material. Corals reefs provide habitat for other marine biota and are considered key habitats located offshore and along the coastal area of Qatar (Figure 4) [5].

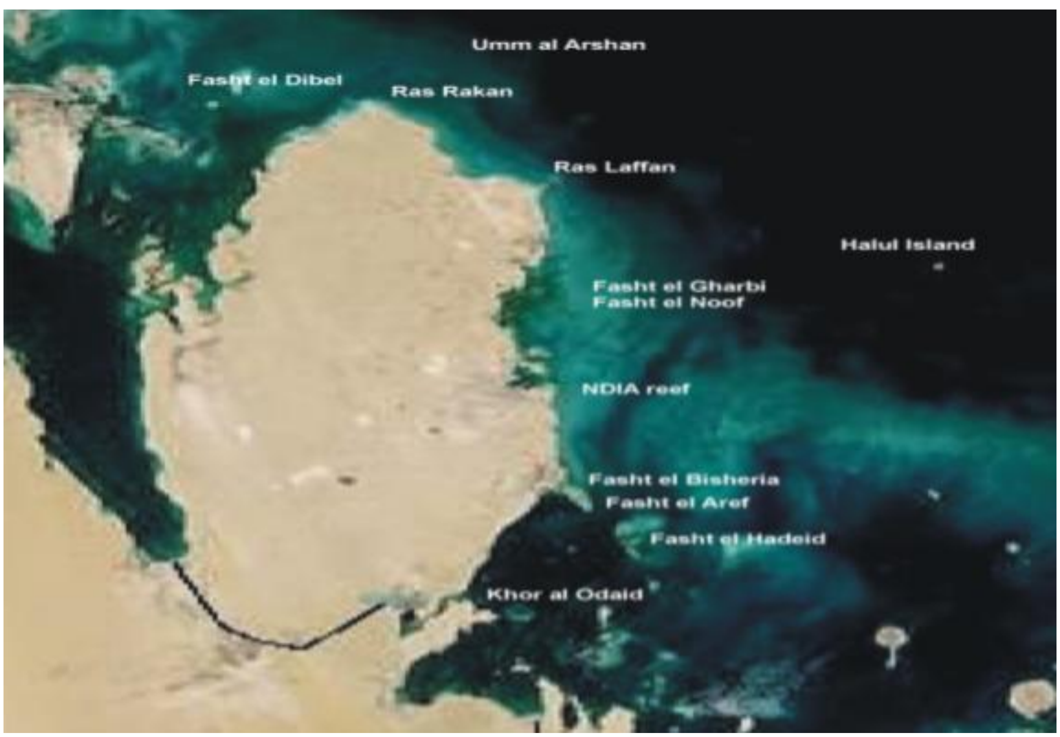


Figure 4: *Location of corals in Qatar (2004) [5].*

Surveys conducted in 2004 showed that main corals located in the Exclusive Economic Zone (EEZ) of Qatar belongs to the genus *Cyphastrea*, *Favia*, *Acropora*, *Platygyra*, *Pavona*, *Psammocora*, *Plesiastrea*, *Leptastrea*, and *Porites*. This survey depicted the increase of bleached corals and the decrease of coral cover in areas closer to the coast (Table 1) [5][6].

Table 1 : *Survey assessment of healthy coral species located in Qatar coastal and offshore waters[5][6]*

Site name	Number of f live species
NDIA and RAF reef	None
Khor Al Odaid	8
Halul Island	16
Umm Al Arshan	14
Ras Laffan	None
Fasht Al-Ghabi	3
Fasht Al-Dibal	3
Fasht Al-Aref	2
Fasht Al-Hedied	1
Fasht Al-Bisheriah	None
Shrura'aw	6

that resulted in many important articles starting with article #14 imposing all the operators in the marine environment to submit an environmental risk management report of any planned project to the Ministry of Environment before obtaining a license for operation. Then article #18 enforces all operators to keep a record of the surrounding ecosystems with mitigation reports comparing the environmental status before and after project implementation [7]. Therefore any coastal project should keep a record and a study of the area surrounding the project for which ecological and hydrodynamic models are key tools to better assess the potential impacts and propose mitigation or adaptation measures.

2.1 Ecological modeling

An Ecological model is a theoretical, mathematical representation of a natural system, made to understand the functionality of the real system [8]. Using gathered data from sites, ecological associations are infered and then combined to build a functional ecosystem models that mimic real environment. These model systems are then used in order to assist the impact assessment of future scenarios in real system.

There are two main types of ecological model, analytic models and, computational models [8]. Analytic models are usually more complex mathematically, they are useful when working with simple or abstract systems that can be described by a set of mathematical equations that have well known behavior and can be solved mathematically. The results of analytic modeling are certain and will always have the same outputs for the same inputs [8].

Alternatively, computational models use numerical techniques to solve problems that cannot be solved by analytic models. They are used more than analytic models because they are in general considered as ecologically sensible and many analytical models cannot be solved mathematically. The results of the computational model can vary between different numerical techniques or modeling software, resulting in uncertainty that should be estimated [9].

2.2 Hydrodynamic modeling or (HDM)

The hydrodynamic system is made of four differential equations in four unknown functions, three components of velocity and one pressure. These functions are space and time variable. Usually the system of equations is nonlinear. Therefore the analytical solutions of the hydrodynamic system are imposable and not yet derived [10]. Consequently, and in order to model any ecological phenomena in the marine life, numerical solutions using modeling softwares are developed to establish an adequate representation, miming real life dynamics. There are three main modeling programs that have been used for the development of Ecological Response Models (ERM) in Qatar (SWAN, GEMSS, and TELEMAC-2D).

2.2.1 SWAN modeler

Simulating Waves Near Shore (or SWAN) is a wave model that is used for obtaining realistic estimations of wave functions modeled for coastal areas, lakes and estuaries. The model is feed with wind and current conditions. Nevertheless, it can be used only for waves generated by wind. The main criteria in SWAN are the grid creation parameters (resolution, direction, etc.). In general, there are two types of grids: structured or unstructured. Structured grids can be rectilinear, uniform, or curvilinear. They consist of quadrilaterals where the numeral of grid cells meeting each other in an interior grid point is 4. In unstructured grids, the internal grid points can be arbitrarily (between 4 and 10) as a result it may contain triangles or a mixture of triangles and quadrilaterals. SWAN can be obtained using 1D and 2D grid or model [11].

2.2.1.1 HDM of Al-Wakrah port using SWAN

This study was submitted by the Private Engineering Office under the supervision of TECHNOTAC in 2012. The study purpose was the development of an appropriate understanding for the coastal process and sediment dynamics in Al-Wakrah port of both anthropogenic and natural induced dynamics. Results were used as a Decision Support System to select the best alternative port location and typology. A large set of analysis was conducted in this study, whereby, all major processes that may cause variation in the surrounding environment were conducted [12].

This study included the evaluation of hydrodynamic, environmental and morphological process for both present situation and for the future construction work of the port. Data was collected and analyzed using specific mathematical models setup in SWAN program. The data sets used in the model were water level, wave conditions, and wind field. Additionally tidal currents and wave height were used to calibrate the model. Figure 5 shows water depth of present situation and all alternative solutions used to create the model mesh or grid.

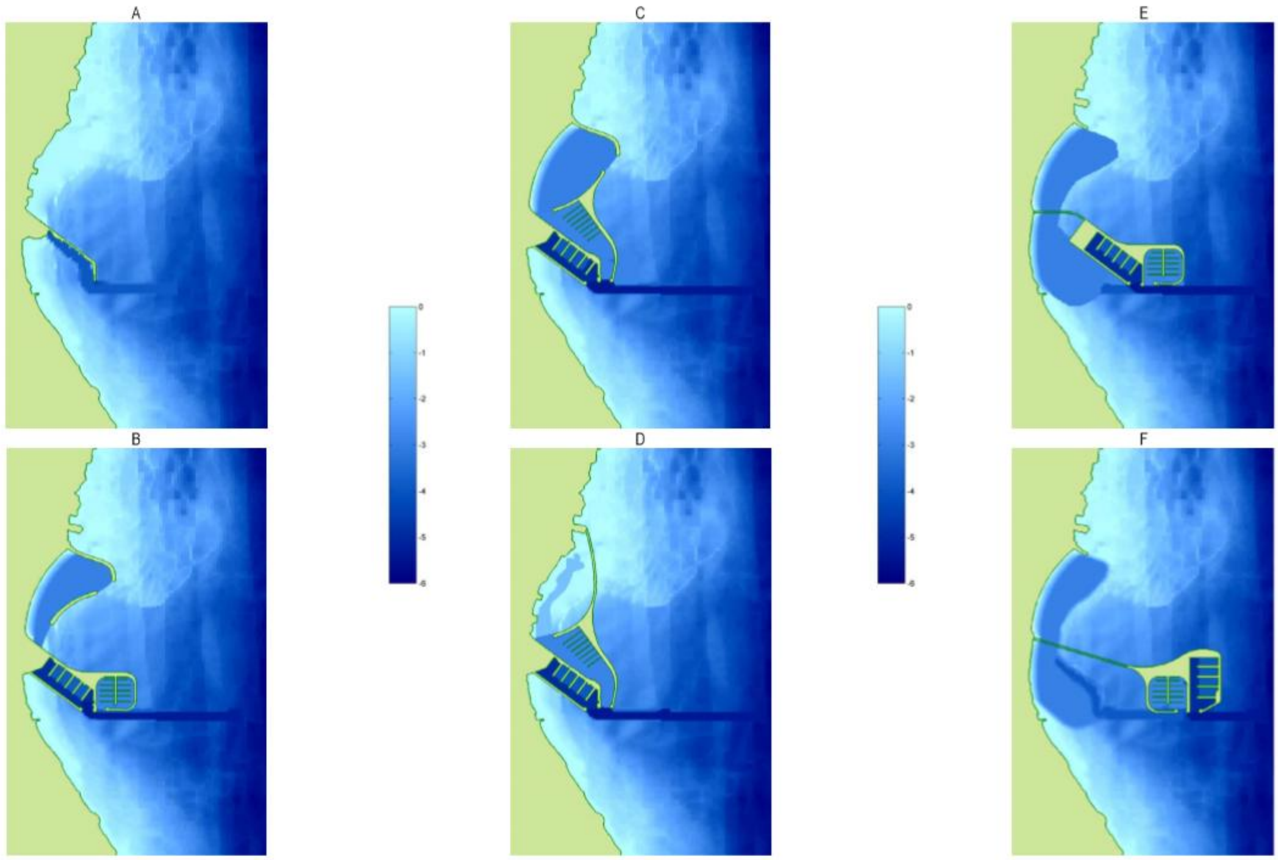


Figure 5: *Depth analyses (in meters) of: A) Present situation , B) Alternative layout 1, C) Alternative layout 1-A, D) Alternative layout 2, E) Alternative layout 3, F) Alternative layout 4 [12].*

A comparative analysis of the simulations produced for all proposed alternatives indicates that the present hydrodynamic conditions shows that the maximum flood and maximum Ebb situations occur during the tidal cycles when tidal levels gradients are at their maximum, therefore, the associated currents are also at their maximum. (Figures 6 and 7) indicates that the area is characterized by shallow waters and that nearby parts of the shoreline will emerge during low tide. by comparing the Present Situation and Alternative layout 1, which shows the velocity distribution during maximum flood and maximum ebb, no modification for the velocity is expected. The only difference is that there is a slight increase in the velocity fields near the inlets of the basin due to the section narrowing. Therefore, it is noticeable that the hydrodynamics are barely modified by the suggested interventions.

Alternative layout 1-A is very similar to the one in the present situation (figures 5 and 6). However, velocity fields decrease in the area in front of the seashore dredged north of the port and in the internal parts, where a small increase occurs in the northern opening of the basin due to the narrow section. As for the offshore velocity, values are the same as those ones simulated for the present situation. By comparing layout 1-A to Present Situation, it can be noticed that the hydrodynamics of the area of interest are moderately modified with the new settings.

Alternative layout 2 shows low velocities in the closed basin, and there is a small increase only near the inlet of the northern part of the port located between the open sea to the lagoon basin, in this area the velocities reaches about 10 cm/s as shown in (Figures 6 and 7). The main distinction is noticed in the southern bay where velocity fields' conditions are changed because of the constructions made along the seashore.

Alternative layout 2 results show connection between the northern and southern basins, with a tendency to increase velocity along the coast, mainly during the ebb phase resulting in an increase of the water exchange (Figures 6 and 7). Fundamentally it can be confirmed that there is a general increase of hydrodynamic conditions towards the coast line that induce higher currents compared to the present situation. finally simulations for alternative layout 3 and 4 show that in the eastern boundary of the new port higher currents are created. Additionally, increased velocity fields are observed offshore (Figures 6 and 7) suggesting higher transport processes in the area [12].

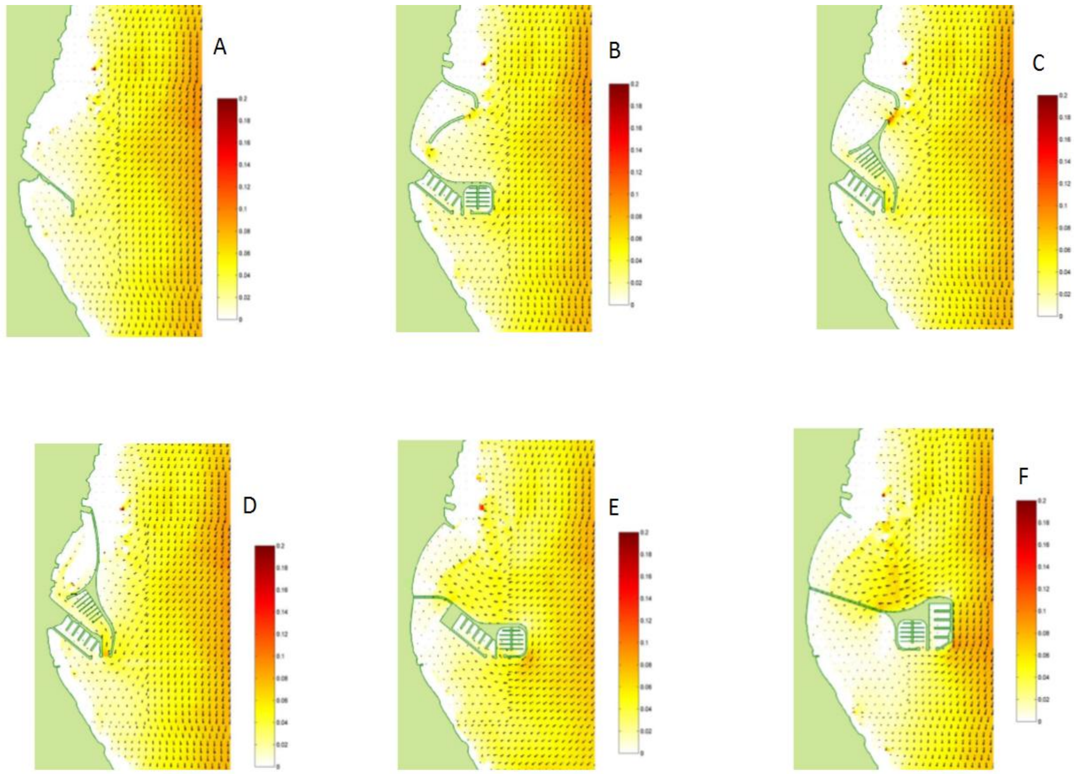


Figure 6: *Velocity Fields during maximum flow (M/S) of: A) Present Situation, B) Alternative Layout 1, C) Alternative Layout 1-A, D) Alternative Layout 2, E) Alternative Layout 3, F) Alternative Layout 4 [12].*

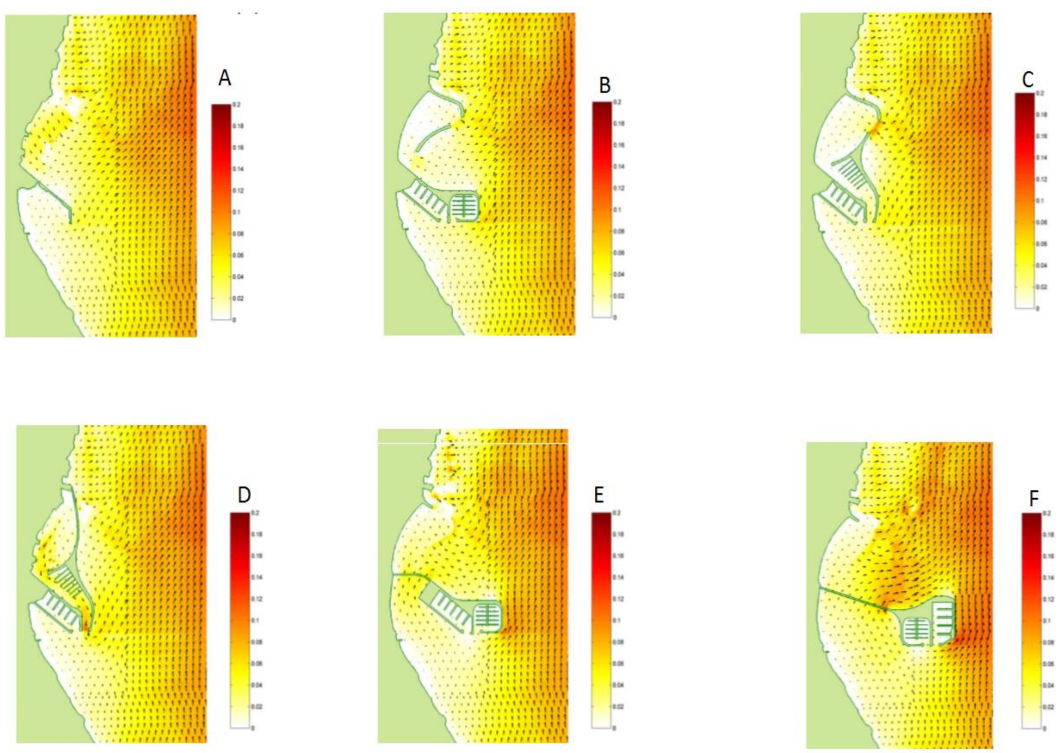


Figure 7: *Velocity Fields during maximum ebb (M/S) of: A) Present Situation, B) Alternative Layout 1, C) Alternative Layout 1-A, D) Alternative Layout 2, E) Alternative Layout 3, F) Alternative Layout 4 [12].*

2.2.1.2 Morphologic simulation of Al-Wakrah port Using SWAN

The morphologic simulation was conducted to identify the areas characterized by a trend for erosion or deposition. The simulation period covered by the simulations was 15 days. In the present situation higher transport rates of sediments are expected to occur in the area north of the jetty, where there is the major mass of available sediment. This transport tends to move sediments from the sea to the coastal zone [12].

The presence and the shape of the jetty protect the coastal area from erosion or deposition especially in the southern area. A small sedimentation is evident along the edge of the dredged channel, while an evident deposition occurs on the south coastal zone (Figure 8), where the areas with different morphological behavior are reported. The yellow to dark red color denote a trend to sedimentation, while colors from light to dark blue denote a trend to erosion.

Alternative layout 1 shows a reduction of the deposition in the area immediately north of the jetty, where a 3m deep basin is predicted. In this area, protected by new breakwaters, the currents are not intense enough to re-suspend and move the seafloor sediments, and a slight redistribution of sediment (sand) along the coastline is expected to occur (Figure 8) [12]. All the Alternative Layouts showed an accumulation of sediments close the protective structures and at the above basin inlet. Comparing this solution with the Present Situation the tendency to erosion or sedimentation conditions are unchanged in the whole considered coastal area. A slight higher sedimentation can be noted along the edges of the dredged main navigational channel, because of the depth increase (Figure 8) [12].

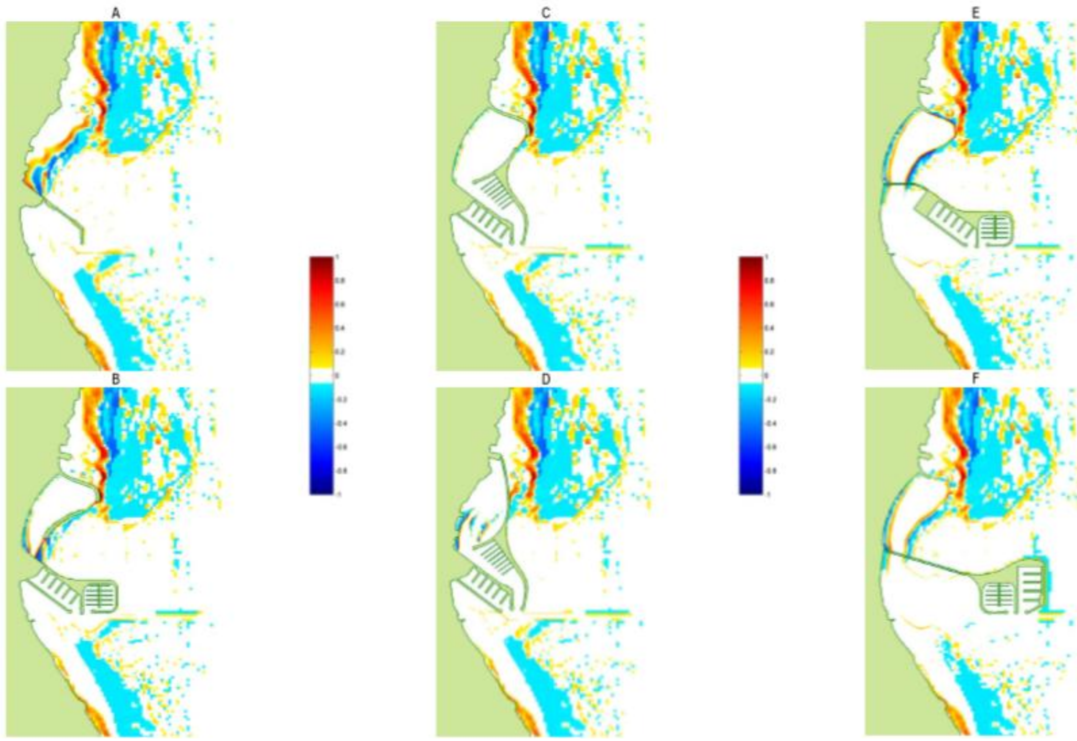


Figure 8: *Morphological trend: A) Present Situation, B) Alternative Layout 1, C) Alternative Layout 1-A, D) Alternative Layout 2, E) Alternative Layout 3, F) Alternative Layout 4 .[12].*

2.2.2 TELEMAC-2D

TELEMAC-2D code solves depth averaged free surface flow. The main results at each node of the grid are the water depth and depth averaged by velocity components. Application of TELEMAC-2D is in free-surface maritime or river hydraulics, it has many fields of application. It includes the following modules [13]:

- Propagation of long waves, taking into account non-linear effects
- Bed friction
- Influence of Coriolis force

- Meteorological factor.
- Turbulence.
- Water body flows.
- Effect of temperature / salinity on density
- Cartesian coordinates for large domains
- Trace model including the source and sink of contaminate.

The grid consists of a polygon starting from triangle until octagon.

2.2.2.1 HDM of Zakhira Marina using TELEMAC-2D

This project was developed by the UCC (UrbanCo Constructions) using TELEMAC-2D using a hydrodynamic model that quantitatively evaluate tidal, currents and flushing for the Zakhira Marina constructions. First a mesh was created (Figure 9).

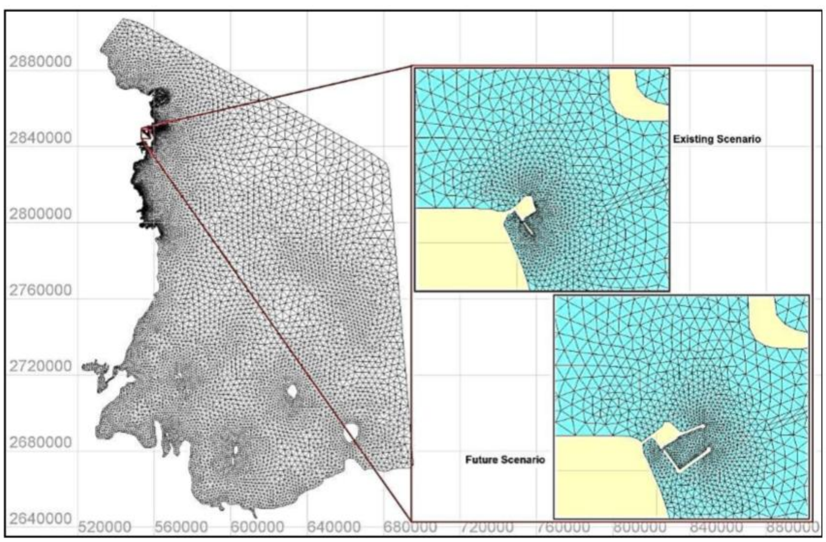


Figure 9: *Creation of Zakhira mesh for both present and future scenarios [14].*

The model was calibrated and validated using field data for currents (measured by Acoustic Doppler Current Profiler - ADCP) and tide data (measured by tide gauge records). The results of the hydrodynamic model suggest that the average tide generated currents will usually not surpass 0.6 m/s and 0.8m/s in the nearby areas of Zakhira Marina development for both pre- and post-development scenario. On the other hand the proposed development results show changes of the flow patterns and directions in the immediacy of the breakwaters (within the marina and near the navigation channel) (Figure 10)[14].

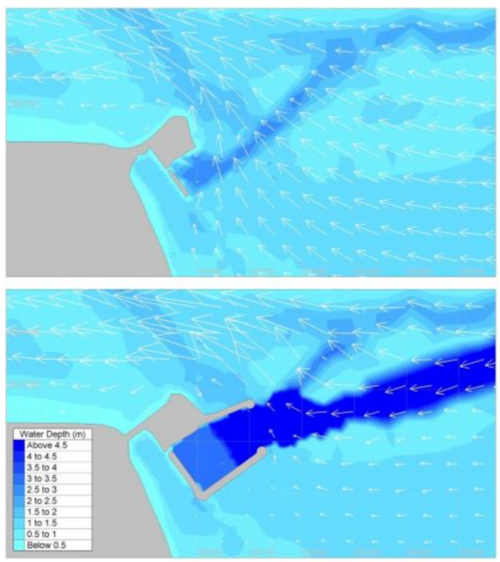


Figure 10: *Hydrodynamic of the present (top) and future (bottom) sceneries in the spring flood [14].*

The HDM results demonstrate that presented tidal and current speeds surrounding the present site are moderate (below 0.5m/s). Whereas tidal and current speeds are reduced in the future site (to the extent of 0.3m/s) in the surrounding area of Zakhira Marina project site because of the increased water depths in the navigation channel. Also, an increase of peak current speeds (up to 0.4m/s) is evident for the future development scenario in the immediacy of the breakwater on the northern side of the marina.

2.2.2.2 HDM of Banana Island Marina using TELEMAC-2D

This project was developed by the UCC (UrbanCo Constructions) using TELEMAC-2D using hydrodynamic model to quantitatively and assesses tidal hydrodynamics and water renewal for the Banana Island construction. The model mesh grid was created (Figure 11) [15].

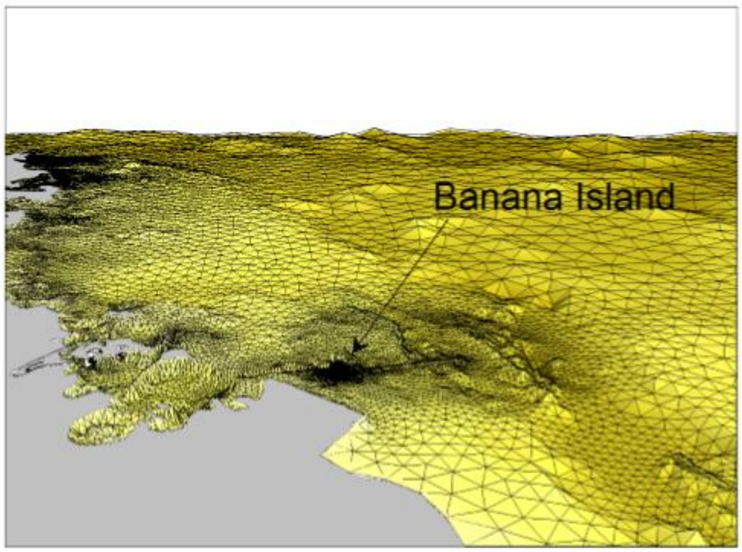


Figure 11: *Modeling mesh of Banana island and surrounding area [15].*

The HDM results shows that the existing tidal current speeds at the present site typically range from lower than 0.2m/s on the inner side of the island up to 0.5m/s on the eastern (outer) side of the island. For the post-development (future) scenario, max out tidal and current speeds are decreased to around of 0.3m/s compared to the pre-development (present) scenario in the nearby areas of the future marina and detached breakwaters because of the sheltering effects. Though, for the majority of the nearby areas to the proposed project, peak tidal current speeds differ by less than 0.1m/s from the pre-development scenario (Figure 12)[15].

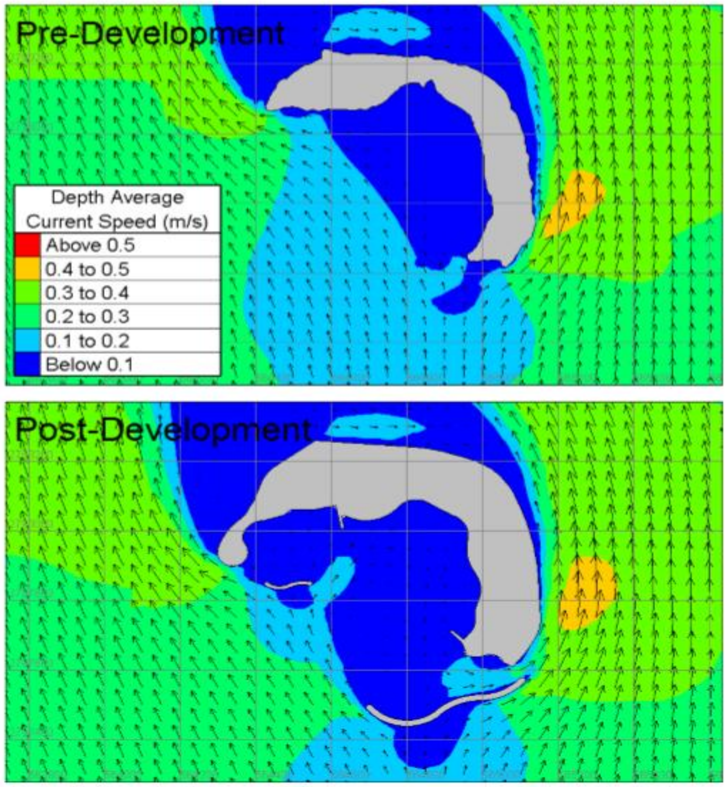


Figure 12: *Hydrodynamic of the present (top) and future (bottom) scenarios in the spring flood [15].*

The suggested impact of the development on local tide potentially stimulates bed shear stresses. Nevertheless, bed shear stresses on the sheltered inner side of the island are typically below the threshold for enlistment of sediment by currents. The beaches and the area between the southern detached breakwater and the island should therefore be monitored to ensure that, deposition of sediment occurs; this should be addressed through appropriate management and maintenance measures.

2.1.3 GEMSS software

GEMSS (Generalized Environmental Modeling System for Surface waters) is an integrated system of 3D hydrodynamic and transport models implanted on environmental information and geographical structured data (GIS) [16]. Grid creator and editor, controller file generator, 2D and 3D features support processing viewers and other tools that contain meteorological information, support the 3D modeling. GEMSS is provided with a set of hydrodynamic, transportation and water quality modules allowing the development of integrated ecohydrological models according to the needs of each modeler application [17].

2.1.3.1 HDM of Ras laffan using GEMSS

This project was developed by ExxonMobil Research Qatar (EMRQ) using GEMSS modeling to create a transport model that study the fate of chlorinate by products in the coastal waters of the industrial city which is located in Ras Laffan in northeastern Qatar. To achieve this goal a numerical three-dimensional hydrodynamic model was developed as a base for the transport model starting with numerical model grid, then collection of data to calibrate and validate the model using instruments deployed to collect hydrodynamics data (Figure13)[18].

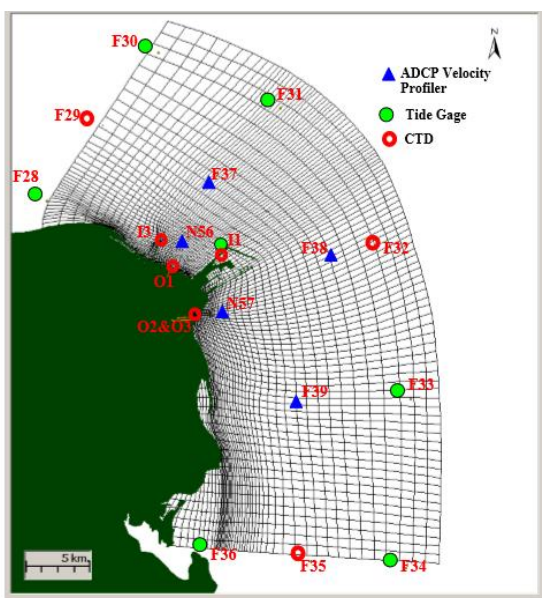


Figure 13:model grid along with location of data collection stations [18]

Good harmony between model results and field data shows that the model is able to simulate the main hydrodynamic features as shown in (Figure 14).

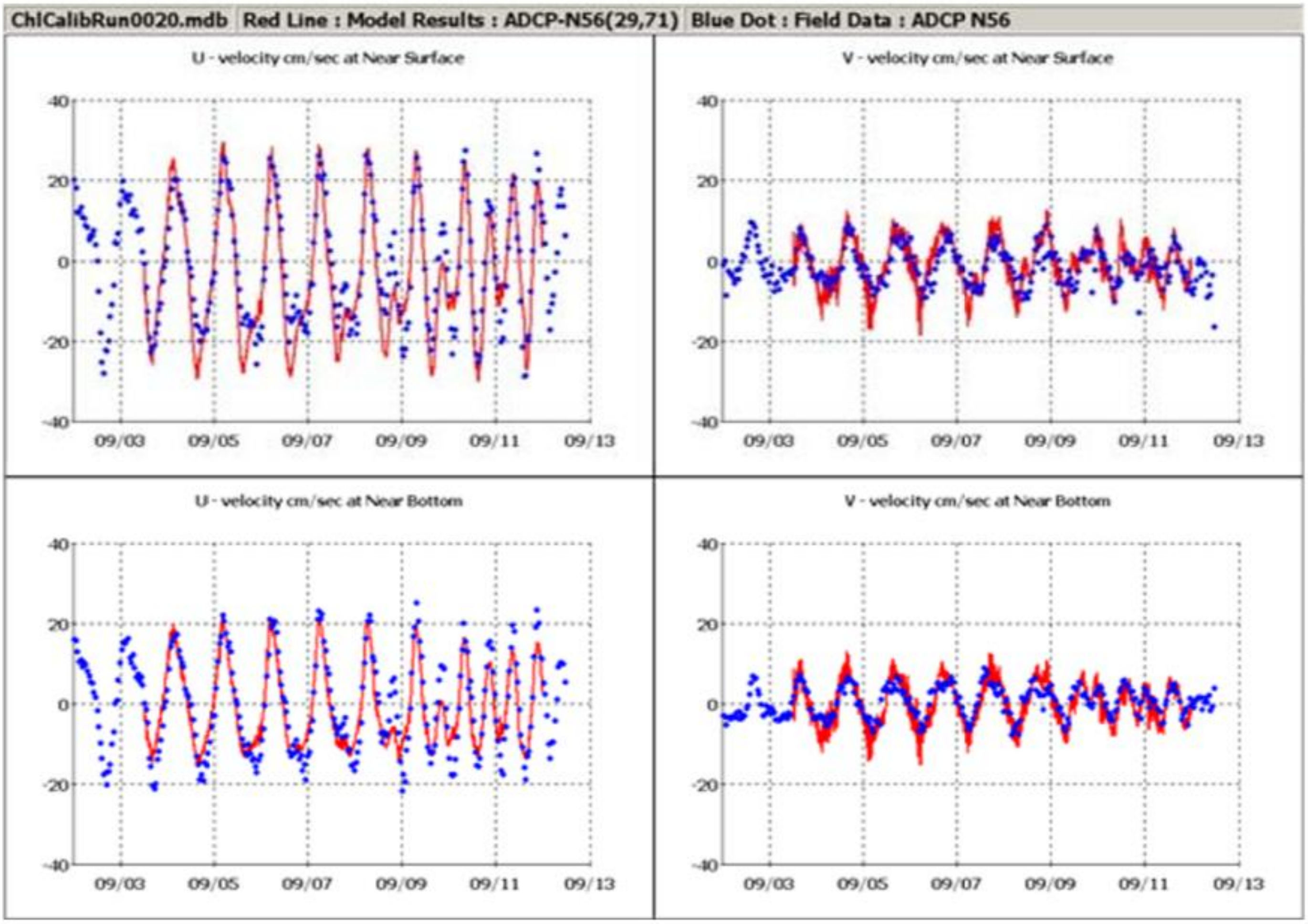


Figure 14: *comparing the simulated model (red line) and field measurement (blue dots) for the hydrodynamic model (water velocity [18].*

Chapter 3

DATA AND METHODOLOGY

3.1 Study Area

The study area is located in the North-Eastern Qatari coastline and included in the Qatar EEZ, starting from Al-Ruwais (26^0 08.7' N, 51^0 12.6' E) to Ras Laffan (25^0 55.4' N, 51^0 35.5' E) as respectively the Northern and Southern boundaries, confined by the coastline in the East and the 11m depth isobath towards the open sea (Figure 15). The area extends for about 35 km along the coastline and the total area covers 235 km^2 [19].

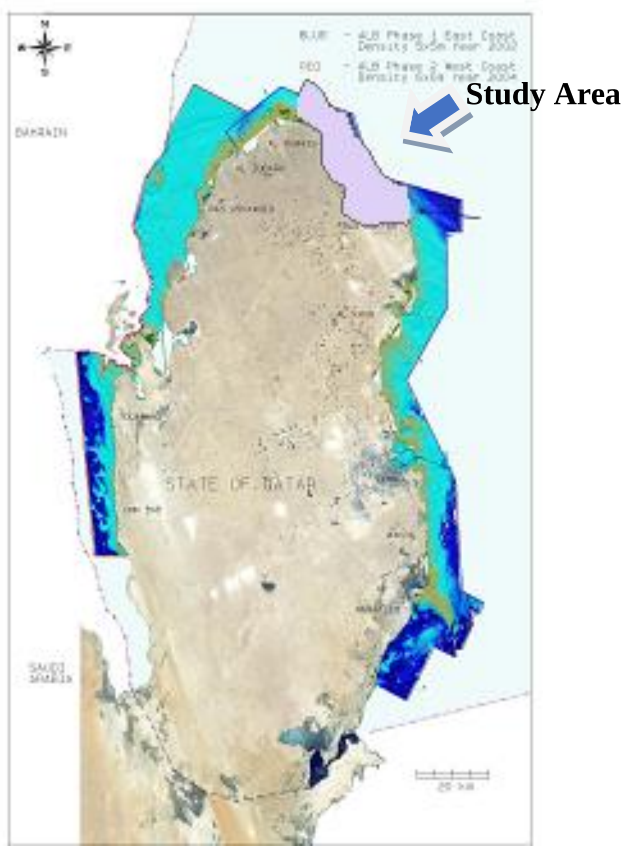


Figure 15: *Map of Qatar [19], showing the marine region included in the current study*

This area represent a very diverse environment, where an estimated 184 Hawksbill turtles nest on the northern coast of Fuwairit and Umm Taes [20]. The seabed includes algal or seagrass beds and coral reefs used by turtles and other sensitive marine populations as habitat. Hawksbill turtles *Eretmochelys imbricata* and juvenile green turtles *Chelonia mydas* nesting areas are located in Fuwairat shores (Figure 16). High diverse populations of fishes and marine mammals are found in these ecosystems associated to invertebrates and algae growing around and at coral reefs [20].

Figure 16:*Map of Fuwairat with key turtles nesting area bordered by dotted line [20]*

3.2 Simulation software (GEMSS)

GEMSS data requirement for a proper model are: (1) spatial data (that is included as shape files imported from ArcGIS), primarily the water body shoreline and bathymetry, additionally the locations, altitudes, and formations of man-made structures and (2) time-based data, that is varying in time (i.e. tidal changes, influx rate and temperature and meteorological data). Moreover the data should be collected accurately and simultaneously as the program requires that all datasets should be synchronous for the proposed simulation period preventing any long time gaps among datasets. The data is subjected to quality assurance procedures by using GEMSS design, afterward visual examination of singular data points, both regular and outliers is conducted. The set of input files and the GEMSS executable program constitute the model application.

The following layout (Figure 17) shows how GEMSS will be used in association with GIS for the spatial data:

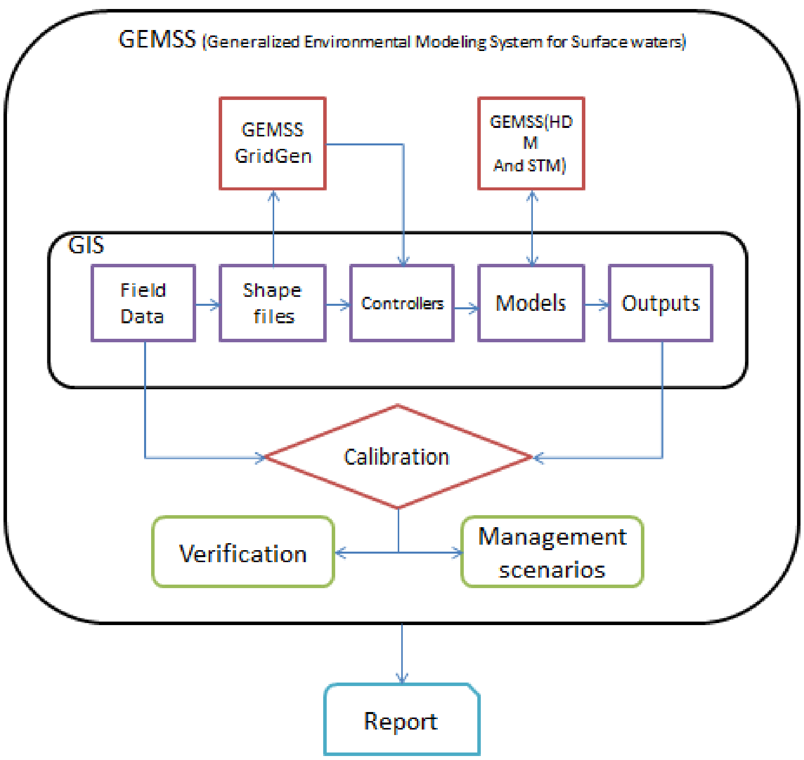


Figure 17: *flow chart of the way GEMSS modeler operate*

3.2.1 GEMSS Grid generator

GEMSS contains a grid creator tool which is under the name *GridGen*, it is used to create 1D, 2D or 3D grid with respectively (x), (x,y) or (x,y,z) dimensions, and comes under the file format of (.g3g). It is considered as the first step taken to create a model, as it is considered to be a base for any spatial distributed model. The grid should contain the area of interest specified by the user as a shape file created by ArcGIS, the shape file may contain bathymetric information. Then the shape file is opened as a new project in GEMSS and divided into small grid area (square-grid model). ThisThis step is needed to model the system numerically in case it was not possible to model it analytically. Higher resolution of the grid will generate higher accurate numerical model, but will imply higher computational time to run the model. A balance between resolution and needed computational time should be found (parsimonious modeling) to generate accurate simulations with lowest time for computation. A recommended approach is to create a grid with higher resolution on the area of interest only forced by lower resolution grid model in the boundaries.

As mentioned above, in order to create a grid, a shape file for the study area that contain bathymetric information is needed where the (x,y) represents the geographic positions and z is the depth value (bathymetry) at each (x,y) location. Once these files are available the shape file is created using two main steps:

1. Defining the horizontal structure of the grid.
2. Defining the vertical structure of the grid.

Following the grid generation the grid should assimilate the bathymetry data using *Scan depth* option and *Bathy wizard* to read from the file the depth in each sampled node and interpolate to the missing bathymetry data at remaining nodes, to create the 3D model (x,y,z).

GridGen can be used to create three types of grids (Figure18) [21]:

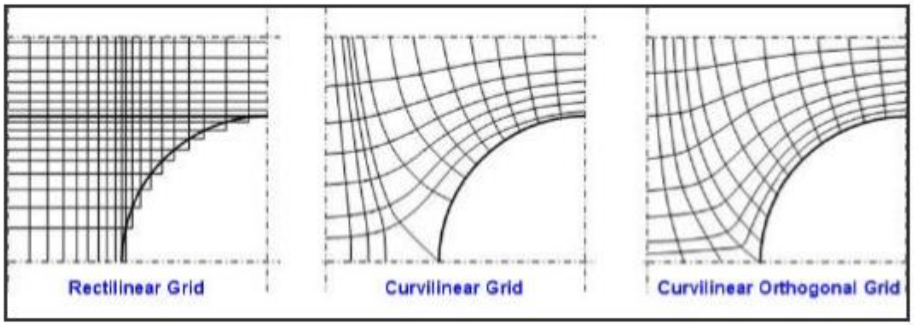


***Figure 18**: types of grids that can be created in GridGen [21].*

Rectilinear grid is a simple method of creating a grid, where it is made out of straight lines across *i* and *j* axes. It might be adequate to set up a rectangular area and then if there is any extra edges or curves the grid will be deactivated using the delete *grid bottom* Function. It might have equal grid spaces (parameters) or not. The higher grid resolution in some selected areas can be used where higher variability of bathymetry is identified.

The Curvilinear orthogonal grid is similar to the non-orthogonal grid but it has one more addition of certain lines along areas of interest to be perpendicularly intersecting at grid points, this allows the numerical solution to be more accurate [21].

Where Curvilinear non-orthogonal grid has moderate complexity when creating the grid, it is more common for curved or irregular shapes, or boundary fitted shapes which resemble the study area. It is done by creating control points along the shore lines. This a sensitive task and is time consuming. Each control point consists of (i,j) where the i value should fit the length while the j value should fit width of the grid. For a clearer understanding of how the model was developed in our case a step-by-step procedure using GEMSS is provided below and showing the sequential parameterization outputs. In our case the width of the grid created with 40 control points and 100 in the length generating a 100x40 grid (Figure 19).

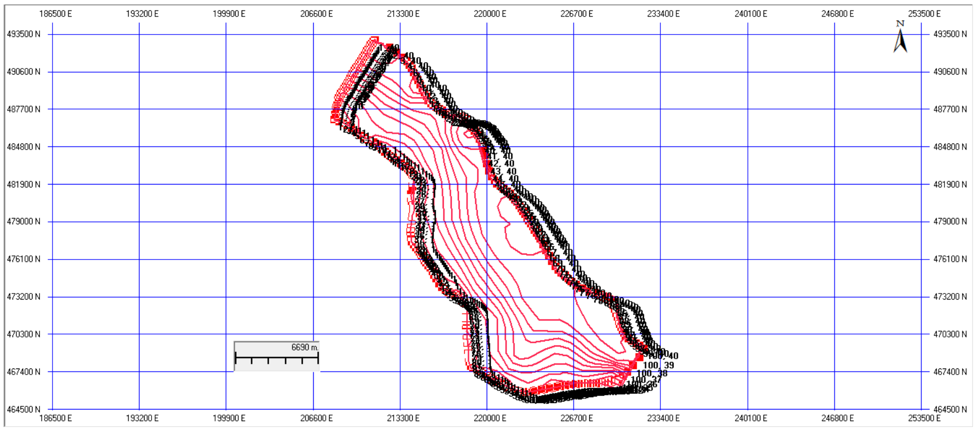


Figure 19: *Boundary fitted control points with varying number of (100,40) cells*

The grid is then created using computational plane to specify the water body (Figure 20), then the grid can be created as a 2D grid (Figure 21).

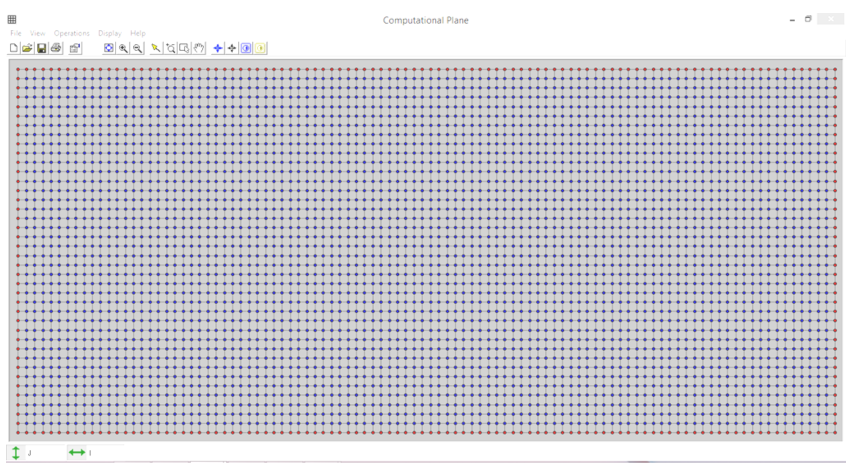


Figure 20: *Computational plane window showing the location of water colored with blue, and control point with red (in the boundary).*

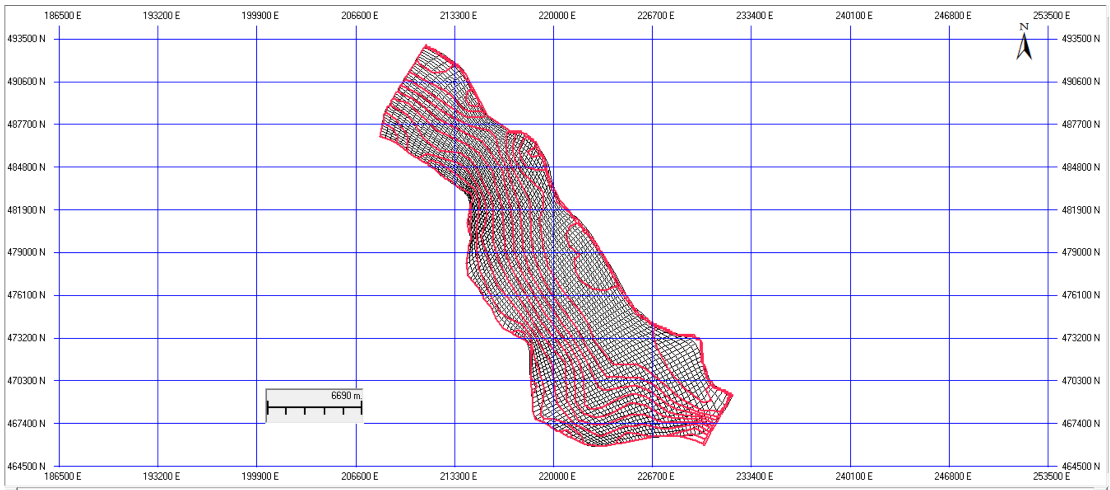


Figure 21: Grid created in the study area using GridGen with no depth information..

To create the 3D grid the depth point source data was used to create a Raster (IDW) file using ArcGIS, then converted to shape file using *Int tool* in 3D analyst tools located in ArcGIS, This shape file was then used in GEMSS GridGen Bathymetry wizard to simulate missing depth data using the 4 neighboring *GridGen* cells. Later the vertical layering was made using 7 layers each layer is 1.92 m thick (figure 22).

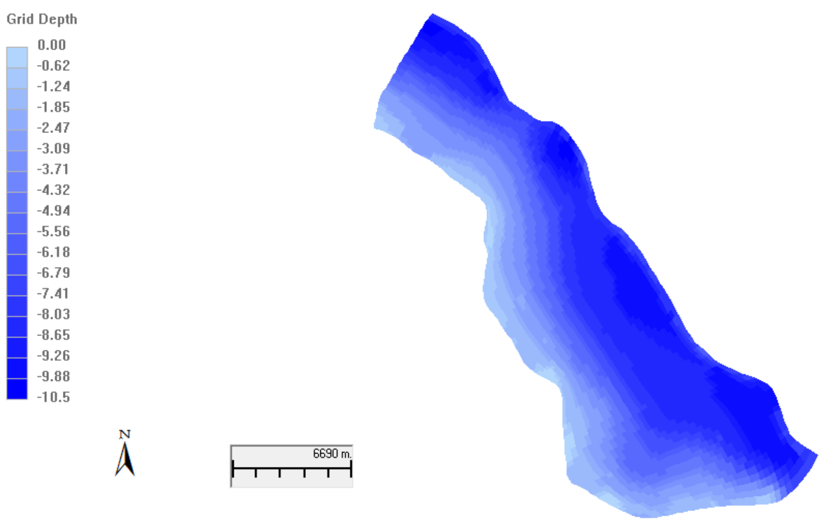


Figure 22: Final 3D Grid created in the study area using GridGen including depth data.

3.2.2 Hydrodynamic model

Hydrodynamic model is considered as a mathematical model that will describe main physical processes which is built to scale. Most of modern hydrodynamic modeling tools are numerical models where the user uses a Graphical User Interface (GUI) to model, calibrate and display the outcomes [22]. Consequently, hydrodynamic models are applied in coastal ocean application and linked to models developed for meteorology and uses the HDM as the base of other models (e.g. transport model).

HDM provides outputs that can have time records of water surface elevation, current velocity and direction, temperature, and salinity. In case of transport modeling, the transport fate of any substance is simulated using hydrodynamic features of the studied area and characteristics of transported elements. HDM outputs simulating hydrodynamic conditions under developed scenarios are useful for many users and decision makers [23].

The fundamentals ways to compute HDMs are used in most of spatial dynamic modeling using a set of equations describing the motion of fluids. For instance Navier-Stokes equations, i.e. equation of motions and continuity, are considered as base equations in most of HDMs and in GEMSS specifically.

3.3.2.1 Navier-Stokes Equations (NSE)

NSE are developed under two different types: compressible and incompressible which present the normal physical phenomena when the volume is filled by a constant mass of gas that may be compressed or expanded (compressible), but in the case of a liquid, the mass density will not change and will remain stable during movement (incompressible). In HDM the incompressible NSE is used (applied to water masses).

3.3.2.1.1 The incompressible NSE

The incompressible NSW is defined as:

$$\rho\left(\frac{dv}{dt} + v \cdot \nabla v\right) = \rho g - \nabla p + M\nabla^2 v \quad (1)$$

$where$:

$$\rho(\nabla v) = 0$$

$$\nabla p = [\frac{dp}{dx}, \frac{dp}{dy}, \frac{dp}{dz}]$$

$$v \cdot \nabla v = [v_x \frac{dv_x}{dx}, v_y \frac{dv_y}{dy}, v_z \frac{dv_z}{dz}]$$

$$\rho = k(\rho - \rho_0)$$

Where the left hand side of the equation represents the equation of motion and the ρg in the right will remain stable during movement. In the first case, where the density is a variable, the used equation is the compressible NSE (it is usually used with gases) whereas in the second case the incompressible NSE is used (it's usually with water) which is the case of the HDM. Hand side represents the gravity effect, ∇p change in pressure or gradient of pressure, $M\nabla^2 v$ is the viscosity, k numerical constant, ρ is the actual density, and ρ_0 is the resting density where the pressure is at equilateral. The condition of $\rho(\nabla v) = 0$ is for mass continuity [24].

The fluid moves from higher pressure to lower pressure (p), and the same for viscosity where high viscosity will move in clusters to lower viscosity areas ($M\nabla^2 v$). In equation (1) $\rho\ and\ p$ represent a scalier variables, where as $g\ and\ v$ represent a vectors variable. The Laplace operator for $\nabla^2 v$ which describes the differential equation of the momentum in a system is:

$$\nabla^2 v = \frac{d^2 v_x}{dx} + \frac{d^2 v_x}{dy} + \frac{d^2 v_x}{dz} \quad (2)$$

Due to the continuity condition for $\rho(\nabla v) = 0$, and changing the derivative into material derivative [23]:

$$\rho \frac{Dv}{Dt} = \rho g - \nabla p + M\nabla^2 v \quad (3)$$

Now considering the equation for each single particle (i) and dividing by ρ_i

$$\frac{dv_i}{dt} = g - \frac{\nabla p}{\rho_i} + \frac{M}{\rho_i}\nabla^2 v \quad (4)$$

Which is a simple equation, but with main drawback that it is numerically sensitive to scale. To solve the NSE the equation should be simulated into small scale, there are many methods to solve it but the best method is to use smoothed particles hydrodynamics (SPH) [23].

$$A_i(r) = \sum_b A(r_b) \times w(r - r_b, h) \quad (5)$$

Where $A_i(r)$ refers to any quantity, $\sum_b A(r_b)$ is the summation of nearby quantities, and $w(r - r_b, h)$ represents the function for smoothing that gives higher influence for nearby points then far ones specified by h which is the radius. Applying SPH to NSE:

$$\rho_i = \sum_j m_j \cdot w(r - r_b, h) \quad (6)$$

$$\frac{\nabla p}{p_i} = \sum_j m_j \cdot \left(\frac{p_i}{{\rho_i}^2} + \frac{p_j}{{\rho_j}^2}\right) \cdot \nabla w(r - r_b, h) \quad (7)$$

$$\frac{M}{\rho_i}\nabla^2 v = \frac{M}{\rho_i}\sum_j m_j \cdot \left(\frac{v_j - v_i}{\rho_i}\right) \cdot \nabla^2 w(r - r_b, h) \quad (8)$$

where:

$$w(r - r_b, h) = \frac{315}{64\pi h^2}(h^2 - \|r - r_j\|^2)^3 \quad (9)$$

$$\nabla w(r - r_b, h) = \frac{-45}{\pi h^6}(h - \|r - r_j\|)^2 \frac{r - r_j}{\|r - r_j\|} \quad (10)$$

$$\nabla^2 w(r - r_b, h) = \frac{45}{\pi h^6}(h - \|r - r_j\|) \quad (11)$$

Adding all the above in equation (4) $\frac{dv_i}{dt} = g - \frac{\nabla p}{\rho_i} + \frac{M}{\rho_i}\nabla^2 v$ where:

$$\rho_i = \sum_j m_j \cdot \frac{315}{64\pi h^2}(h^2 - \|r - r_j\|^2)^3 \quad (12)$$

$$\frac{\nabla p}{p_i} = \sum_j m_j \cdot \left(\frac{p_i}{{\rho_i}^2} + \frac{p_j}{{\rho_j}^2}\right) \cdot \frac{-45}{\pi h^6}(h - \|r - r_j\|)^2 \frac{r - r_j}{\|r - r_j\|} \quad (13)$$

$$\frac{M}{\rho_i}\nabla^2 v = \frac{M}{\rho_i}\sum_j m_j \cdot \left(\frac{v_j - v_i}{\rho_i}\right) \cdot \frac{45}{\pi h^6}(h - \|r - r_j\|) \quad (14)$$

3.3.2.2 Hydrodynamic differential equation of motion

First equation of averaged turbulent motions of the rotating earth which is applied through time and space motion of sea [24]:

$$\frac{du}{dt} + u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz} - fv = -\frac{1}{\rho}\frac{dp}{dx} + k\frac{d^2u}{dz^2} + A\,\Delta u \quad (15)$$

$$\frac{dv}{dt} + u\frac{dv}{dx} + v\frac{dv}{dy} + w\frac{dv}{dz} - fu = -\frac{1}{\rho}\frac{dp}{dy} + k\frac{d^2v}{dz^2} + A\,\Delta v \quad (16)$$

$$\frac{dw}{dt} + u\frac{dw}{dx} + v\frac{dw}{dy} + w\frac{dw}{dz} = -\frac{1}{\rho}\frac{dp}{dz} - g + k\frac{d^2w}{dz^2} + A\,\Delta w \quad (17)$$

The velocity components are u, v, w, and t is the time, f is the Coriolis effect where $f = \omega \sin\varphi$ (ω is the angular velocity = $7.29 \mathrm{x} 10^{-3}$, and φ is the latitude), ρ is the sea water density, g is the gravity acceleration, p is the pressure, k is eddy viscosity coefficient (coefficient of exchanging in momentum in vertical direction), A is eddy viscosity coefficient (coefficient of exchanging in momentum in horizontal direction),

$\Delta = \frac{d^2}{dx^2} + \frac{d^2}{dy^2}$ two dimensional Laplace operation[25] ,and x, y, z represent the system of coordinates seen (Figure23):

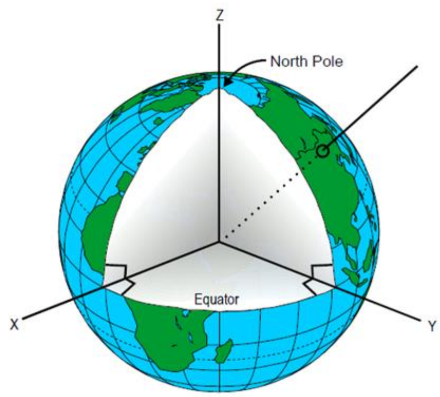


Figure 23: *Earth coordinate axis [24].*

Because sea water can be considered as an incompressible fluid a known continuity equation will be added to the equations of motion:

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0 \quad (18)$$

In order to simplify the equation of motion and continuity, first characteristic of values will state the variables of interest. From equation (18) one can get information and can rewrite it in dimensional form:

$$\frac{u}{L} + \frac{v}{L} + \frac{w}{H} = 0 \text{ considering } u = v = P \quad (19)$$

$\frac{2p}{L} = \frac{-w}{H}$ cross multiply and taking the square root the following equation is obtained:

$$\frac{2H}{L} = \left|\frac{w}{p}\right| = 2 \times 10^{-4} \quad (20)$$

Since w is considered as vertical velocity and it is a small value compared to horizontal velocity it can be ignored, which leads to eliminate the term $\frac{d}{dw}$ from the equations of motion and will be rewritten as [25]:

$$\frac{du}{dt} + u\frac{du}{dx} + v\frac{du}{dy} - fv = -\frac{1}{\rho}\frac{dp}{dx} + k\frac{d^2u}{dz^2} + A\,\Delta u \tag{21}$$

$$\frac{dv}{dt} + u\frac{dv}{dx} + v\frac{dv}{dy} - fu = -\frac{1}{\rho}\frac{dp}{dy} + k\frac{d^2v}{dz^2} + A\,\Delta v \tag{22}$$

$$\frac{dw}{dt} = -\frac{1}{\rho}\frac{dp}{dz} - g \tag{23}$$

To continue the dimensional analysis, the typical horizontal velocity is introduced as $u = v = P$ = 100 cm/sec, eddy viscosity both vertical and horizontal (k = 10^3 cm /sec ,and A = 10^7 cm/sec). Knowing these variables each term can be evaluated individually:

1. Nonlinear terms. It is important to analyze at least one of the nonlinear expressions, because the velocity and the horizontal dimensions are equivalent among the *x* and *y* directions.

$$u\frac{du}{dx} = \frac{p^2}{L} = 10^{-4} \tag{24}$$

It is seen that the non-liner terms are important when the velocity is changing in a short horizontal distance (L).

2. Coriolis term (p=10^{-4} x 10^2 =10^{-2}) (25)
3. Vertical friction term,

$$k\frac{p}{H^2} = 10^7 \times 10^3 \times 10^{-16} = 10^{-6} \tag{26}$$

The friction term will be larger when a thin vertical layer is introduced.

4. Horizontal friction term, $k\frac{p}{L^2} = 10^{-6}$ (27)
5. Vertical acceleration term ($\frac{dw}{dt}$) to get an accurate approximation value the characteristic time should be known of the considered area. This time can

be establish by comparing the horizontal acceleration $\frac{P}{T}$, in the equation of horizontal motion where $T=10^4$. Which leads to $\frac{dw}{dt} \ll$ g, and the vertical acceleration can be ignored. At the end it is of specific interest to conclude the horizontal dimensions of the flow in case the horizontal friction term within the same order as the Coriolis term:

$$A\frac{p}{l^2} = pf \ and \ l = 3.2 \ km \tag{28}$$

which shows that the horizontal friction forces are significant only in the near-shore zone. Dimensional analysis states that in the equations of motion the derivative of the pressure (slope) is balanced by the Coriolis force and the exchange of momentum along the vertical direction. Therefore, the simplified equations of motion in shallow area with high vertical friction are [25]:

$$\frac{du}{dt} - fv = -\frac{1}{\rho}\frac{dp}{dx} + k\frac{d^2u}{dz^2} \tag{29}$$

$$\frac{dv}{dt} - fu = -\frac{1}{\rho}\frac{dp}{dy} + k\frac{d^2v}{dz^2} \tag{30}$$

$$-\frac{1}{\rho}\frac{dp}{dy} - g = 0 \tag{31}$$

3.3.2.2 GEMSS hydrodynamic model

GEMSS uses FORTRAN code to create HDM using control files that contains three main sections (General variables, Model switch variables, and Output files Control variables). General variables consist of specification of the model as transport module and the scenarios settings that have the control file name and the input/output directory, specification of the grid file on which the simulations will be run. Along with the meteorological data (air temperature, wind speed and direction) that uses the TVD (time varying data) for both Al-Ruwais and Al-Khor sites. Finally the initialization of both water temperature and salinity is performed. Water temperature initialization using field data is created using *GEMSSPrepare* that convert excel folders to GEMSS filed data in different locations along the study area. Salinity initialization was set as a constant of 40ppm [1](Figure 24).

Model switch variables, including the modeling scheme used at the preliminarily run was Upwind first order as it is a simple transport scheme of first order with the upstream prejudice used in shallow water. For the final simulation, higher order scheme *such Quickest with ultimate* was used [26]. The *Quickest with ultimate* scheme is expanded to three dimensions and included in GEMSS. Unlike upwind scheme, it is third order accurate and performs well for sharp slopes.

Inside the *model switch section* the boundary conditions section, three boundary conditions were set one of which is open boundary condition which is located in the eastern side, the other two includes two TVD files one for the hydrodynamics input which uses the tidal data in both north (Al-Ruwais) and south (Al-Khor) along with transport and water quality data which uses water temperature as an input.

Finally the output files control variables that specify the output files of the model time varying velocities (*u*, *v* and *w*), water surface elevations, and water temperature in the study area (refer to appendix A for more information). Also the selection of a point to create a time varying output file for calibration which is located in point (42,2) that represents Fuwairat (Figure 24).

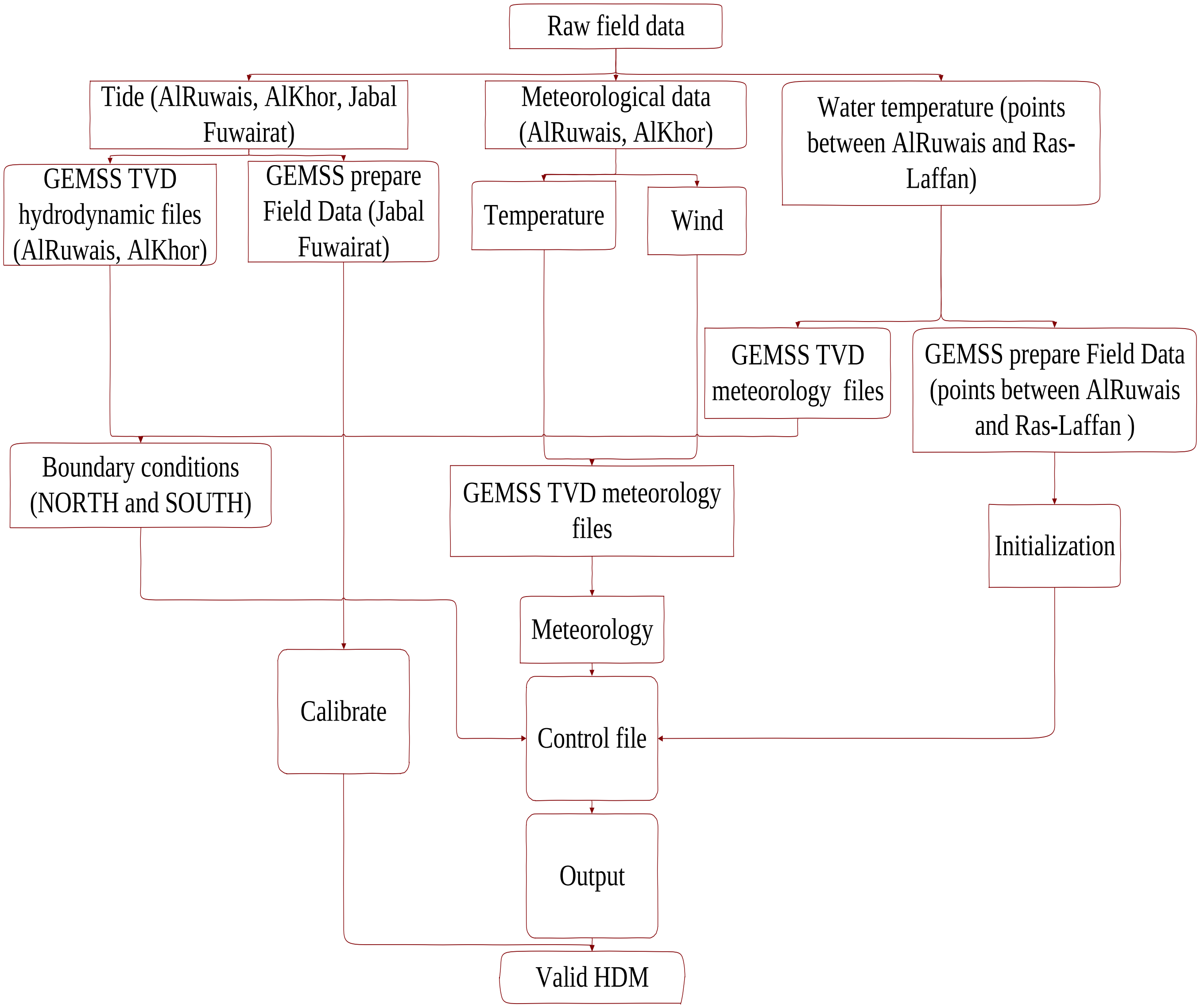


Figure 24: *Flow chart of the designed HDM using GEMSS model*

There will be two methods to calibrate the model first one by using *GEMSS field data converter*, to convert raw field data from excel sheets to (.mdb) files that can be displayed as points in a coordinate and then overlap it with simulation data for the same point over the same period of time [26].

Second method of calibration is using statistical analysis first by regression analysis which is a statistical procedure for estimating the relationship among field data and model results. The model results were converted into excel file using *GEMSS database viewer*.

Next the two data were combined in one excel sheet then subtract the elevation of the field data from the model result to obtain the residuals [27].

Then these points were plotted to use regression analysis to generate a regression equation of best fit. To infer the difference between the two data (observed and simulated) the slope of the line of best fit should be close to zero, meaning that the line in neither decreasing nor increasing [28].

The second method used was by representing actual data (*x*- axis) vs. simulated data (*y*-axis), then to calculate the associated R^2 fine and significancet represented *p*-value, to infer the performance of the model in retrieving observed data [29].

3.3.3 Sediment transport model (STM)

Sediment transport models are used to answer many environmental, geotechnical, and ecological issues related to sediment transport in coastal zone.

In order to model sediment dynamics a quantification of the amount of sediments is needed, this fulfilled using sediment measuring traps that are designed, manufactured and deployed in the studied area. Sedimentation of fine to larger particles is important as it provides habitat for fish and other organisms in water bodies or may affect other habitats (e.g. coral reefs).

Fine sediment transport processes are studied and simulated prior and during project implementation since environmental issues may be generated due to human activities, causing, among others, destruction of a habitat or siltation of a navigation channel.

3.3.3.1 GEMSS sediment transport model (GEMSS-STM)

In order to create an STM model using GEMSS, several input data are required. The percentage of each sediment type (sand, silt and clay) along with initial sedimentation ratefor the study area should be incorporated into GEMSS.

These three sediment fractions are added in the initialization section as GIS raster shape files (.rst) to be added in the HDM control file as initial condition. The model output will provide the contour isoclines of shear stress in the study area which represents the force acting on the sea bed, through gravitational acceleration of 9.8 kg.m/sec^2 , and suspending sedimentation in the water column (Figure 25) [30][31].

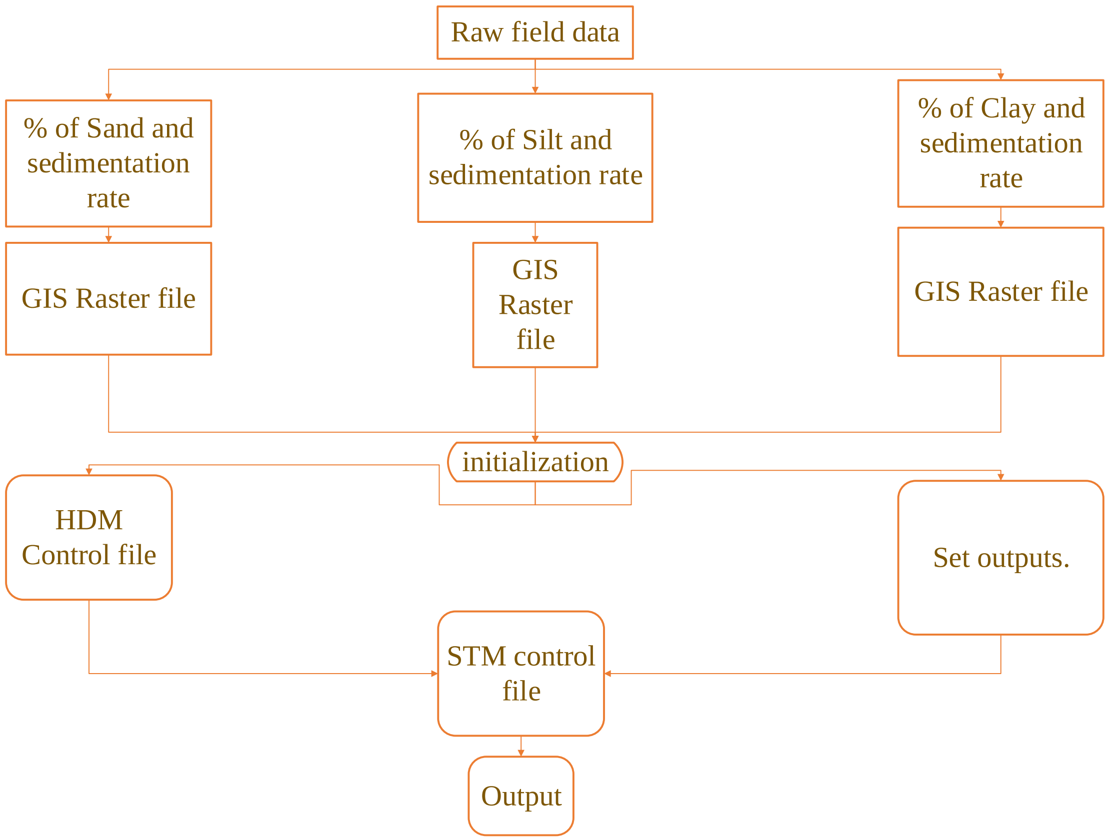


Figure 25: *Flow chart for the STM initialization and simulation using GEMSS model*

3.2 Field Data

This research uses field data from several sources. The data required included water depth, water and air temperatures, tides, wind (direction and speed) and sediment grain composition and size percentages. Depth and water temperatures were collected from Ecological Baseline survey made by the Environmental Studies Center (ESC) of Qatar University associated with ExxonMobil Research Qatar (EMRQ). The study was conducted during two months (Jan - Feb 2010), along 100m transects. It was performed by expert scuba divers with a marine biologist taking measures at each point along the transects. Each point was imported into a unified geographic information system (*GIS ArcMap*) map (Figure 26).

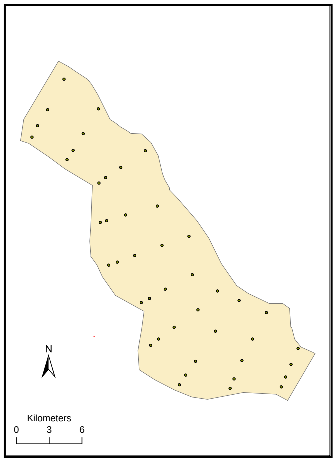


Figure 26: *Distribution of transects in the study area during the Ecological Baseline Survey for collection of depth and water temperature.*

Tides, air temperature, and wind (speed and direction) data were collected from Civil Aviation Authority (Department of Meteorology). These data were collected from stations located at Al-Ruwais, Al-Khor and Jabal Fuwairat for a period of three months (January 1st until March 31st 2014). Measurements were recorded hourly.

Grain size of sea water suspended sediment and sediment deposition rate were measured using seven sediment traps cleaned and washed then sealed to avoid contamination before deployment (Figure 27). The sediment traps were deployed for two weeks (April 8th - April 22nd 2015) at seven locations (Figure28) by Continental Shelf Associates (CSA) as part of an ecological survey commissioned by ExxonMobil Research Qatar (EMRQ).

Figure 27: *Sediment traps attached to concrete base to guarantee a vertical position when deployed on site*

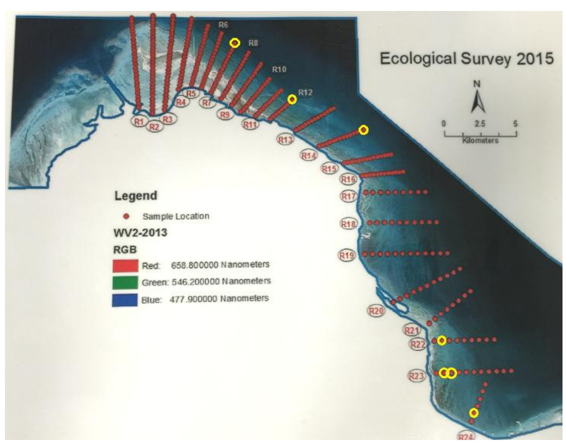


Figure 28: *Distribution of the sediment traps along the study area.*

While retrieving the samples three of the seven traps were mishandled and eliminating from our analysis The remaining four traps (R23-2, R23-4, R24, and R7-

10) were found in a good shape sealed onsite by the divers and subsequently analyzed (Refer to Appendix B.1 for more figures).

These traps were then analyzed in the ESC for grain size and sedimentation rate. The remaining sea water into the traps was disposed using small pumps and the sediment sample was placed in a beaker (Figure 29) (Refer to appendix B.2 for more figures).

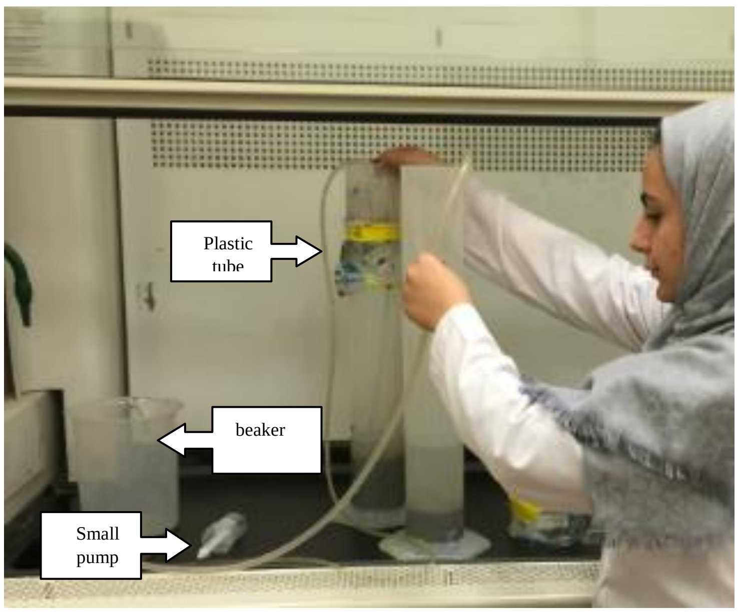


Figure 29: *Water disposal before the analysis of the sediment*

The grain size was analyzed using *Mastersizer 2000* which uses lazier to analyze the percentage of each sediment type the result is shown in (Table 2) (for more details refer to appendix B.3).

Table 2: Grain size and sediment type and persentage in each sample.

Sample No.	Grain size			Sediment type
	Sand	Silt	Clay	
R23-2	52.67	43.44	3.89	Silty sand
R23-3	60.21	36.91	2.88	Silty sand
R24	39.36	56.78	3.86	Sandy silt
R7-10	81.98	17.18	0.84	Silty sand

In order to calculate the sediment deposition rate the sample was dried in an oven under 60°C for 1day then left to cool in a desiccator, to prevent the sediment form absorbing moisture. After cooling, the weight of the sample is determined (Refer to appendix B.3 for more information). The sedimentation rate is then calculated considering the 14 days of deployment and the sediment trap section (0.16 x π)[32].

3.3 Scenarios for anthropogenic pressures

Three anthropogenic scenarios were developed in order to simulate changes in surface elevation, average velocity, and shear stress which force the sediment erosions [33]. The scenarios were developed considering the potential development of construction works of fishing harbor into the studied area. This harbor is meant to substitute the one located in Al-wakrah (south of Doha).

The scenarios take into consideration the current Al-wakrah jetty design and dimensions (c.f literature review). Where scenario (1) wave break is 2.3 km; scenario (2) wave break is 2.3 km; Scenario (3) wave break is 2.4 km. In order to create these scenarios under GEMSS, the control file for the HDM and STM was modified to add wall boundaries in three different control files, one for the northern coast near Al-

Ruwais (scenario 1), one for the middle coast near Fuwarit (scenario 2), and final scenario (3) in the eastern coast near Ras-Laffan (Figure 30).

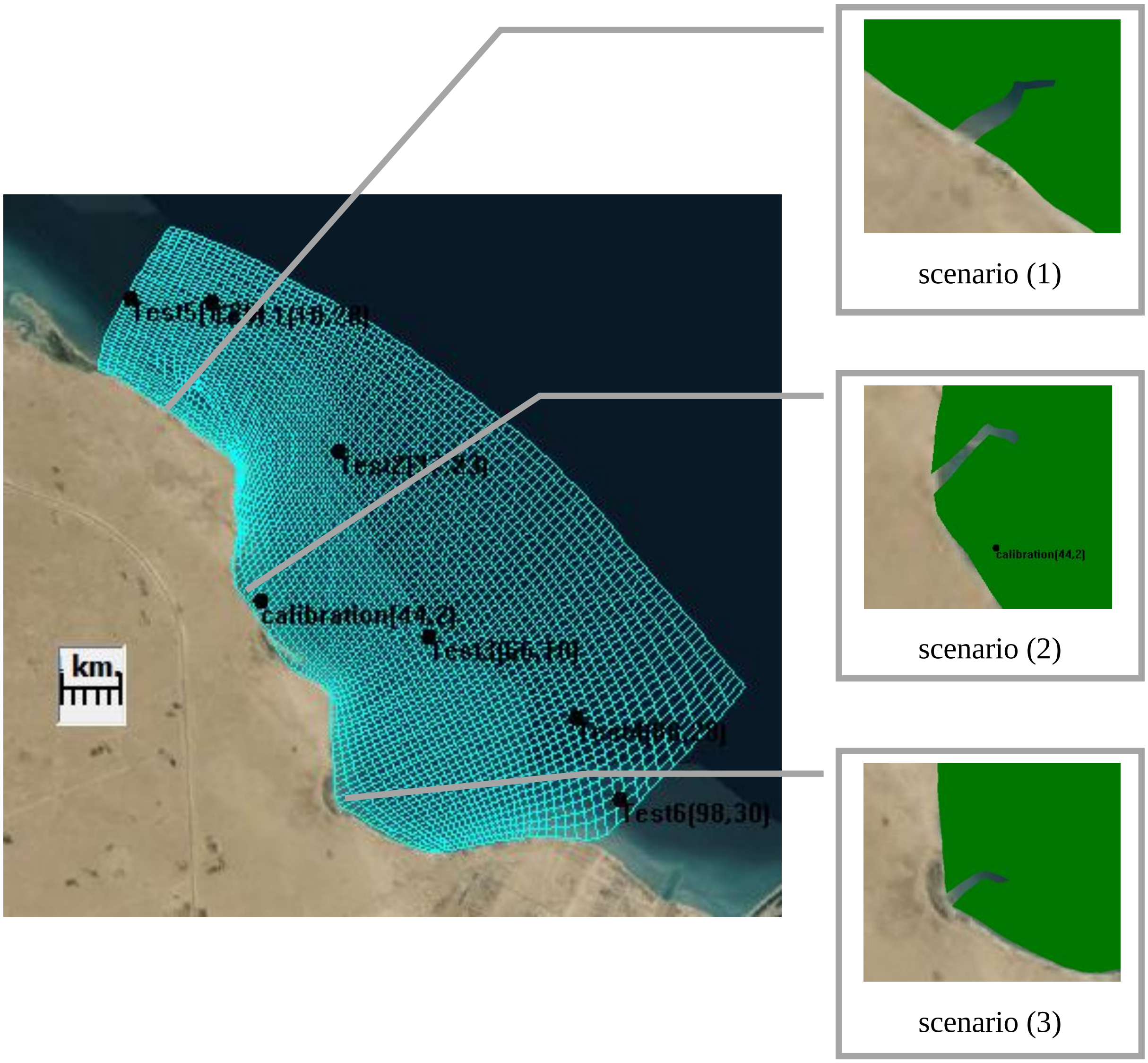


Figure 30:*Distribution of anthropogenic scenarios along the grid in the study area.*

Chapter 4

IMPLEMENTATION AND RESULTS

The model Grid with bathymetry information was overlaid with the satellite image from Google-Earth® and projected on QND coordinate using *ArcMap* **(**Figure 31)

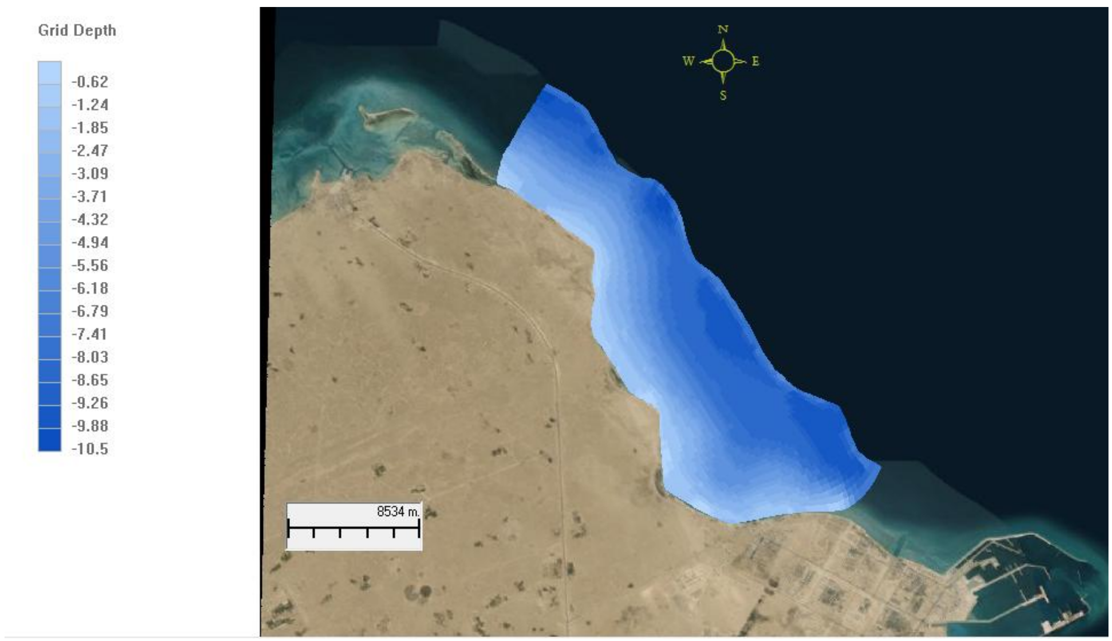


Figure 31: *GEMSS 3-D grid overlaid with Google satellite.*

4.1 GEMSS hydrodynamic model

The real current simulation output was set to display velocities (*u*, *v*, *w* and average velocity), water surface elevations, and water temperature along the study area, under velocity), water surface elevations, and water temperature along the study area, under normal conditions without considering any anthropogenic stressors.

4.1.1 Present simulation

Starting with present situation the temperature variation shows that warm water is located in the western side of the coast (most coastal) while the cold water is situated in the northern coast. The coastal waters in the middle (offshore of Jabal Fuwairat) maintain a mixture of intermediate temperature varying from 20°C until 31°C (Figure 32) for more output refer to (appendix C.1).

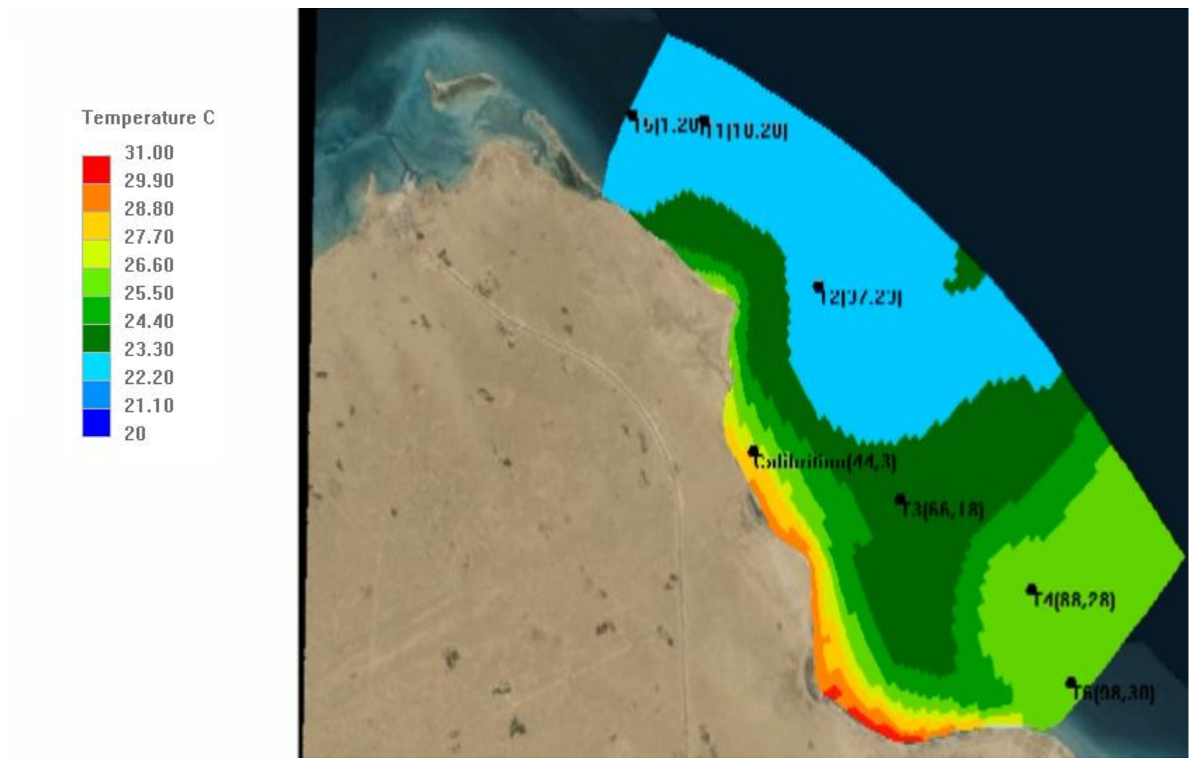


Figure 32: *Present simulation of water temperature in 22/1/2014 at 8:00 a.m.*

The Average velocity and the surface elevation both showed that the water moves from northern side to the western side, the surface elevation fluctuates between 0-2.2 m (Figure 33) for more output captures refer to (appendix C.2).

Figure 33: *Present conditions simulation for surface elevation in mete (m) and average velocity (cm/sec) vector in 08/1/2014 at 11:00 a.m.*

The *u*- velocity also indicate that water net movement is from the northern sector to the western coastal waters, but also in some part of the day it showed that water may moves from/ to the coast. It varies from -250 cm/sec to 200 cm/sec (Figure 34).

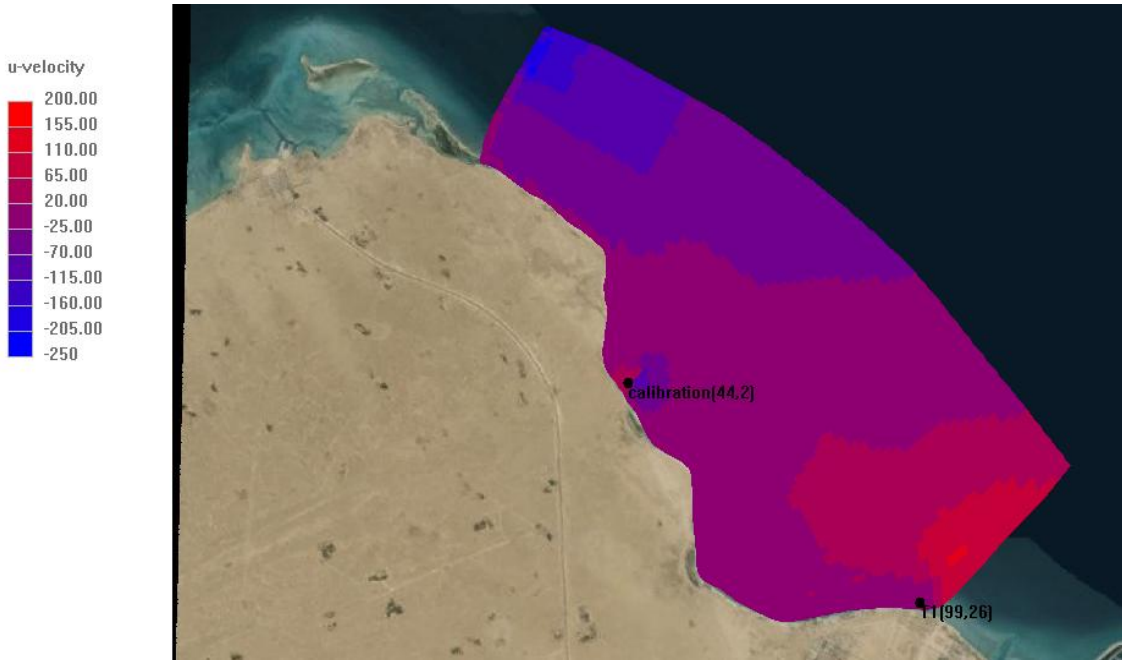


Figure 34: Present conditions simulation for u- velocity(cm/sec) in 08/1/2014 at 11:00 a.m.

The *v*- velocity shows that water moves from the boundaries to the eastern side (to offshore) or vise versa from open water to the coast, it fluctuate between -165 cm/sec up to 141 cm/sec (Figure 35).

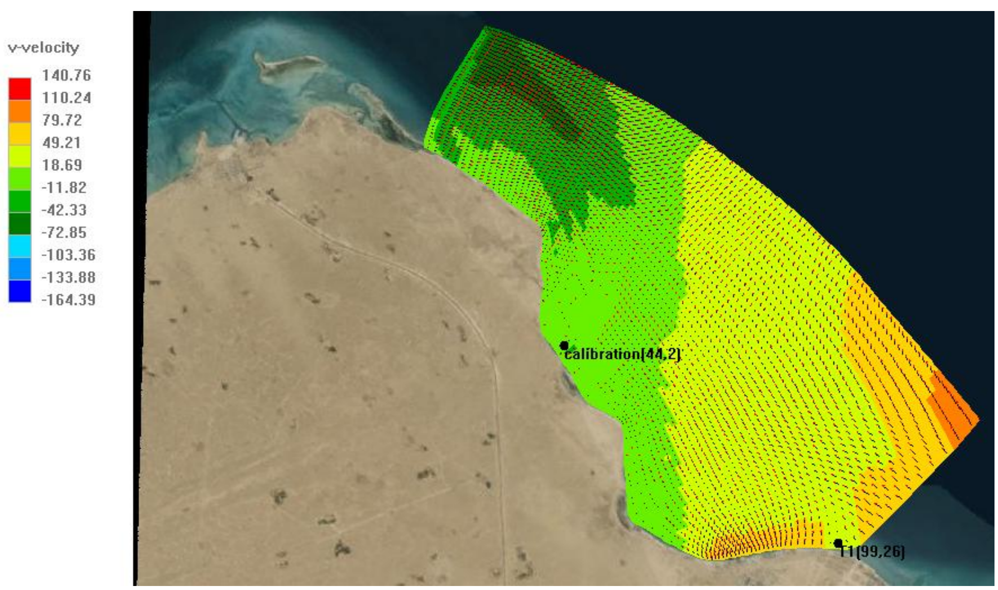


Figure 35: Present conditions simulation for v-velocity (cm/sec) vector in 08/1/2014 at 11:00 a.m.

Finally the *w*-velocity have a smaller value according to *u* and *v* velocities (in the surface of the sea) where it is between -1 cm/sec until 1 cm/sec and the water moves from the surface to deep water (Figure 36).

Figure 36: *Present conditions simulation for w-velocity w- velocity (cm/sec) vector in 08/1/2014 at 11:00 a.m.*

4.1.1.1 Calibration and validation

The calibration of the model was set using data from point (44,2) from the grid for which velocity data is available. The calibration using GEMSS software is conducted overlapping both the time series of surface elevation field data and model outputs and showed a good match between both observed and simulated data (Figure 37) where slight differences using surface elevation data are observed (simulated values are overestimated by 0.1 to 0.2 m). Differences in sea surface elevations and velocities at the boundaries edges are considered an artifact of the model and then discarded.

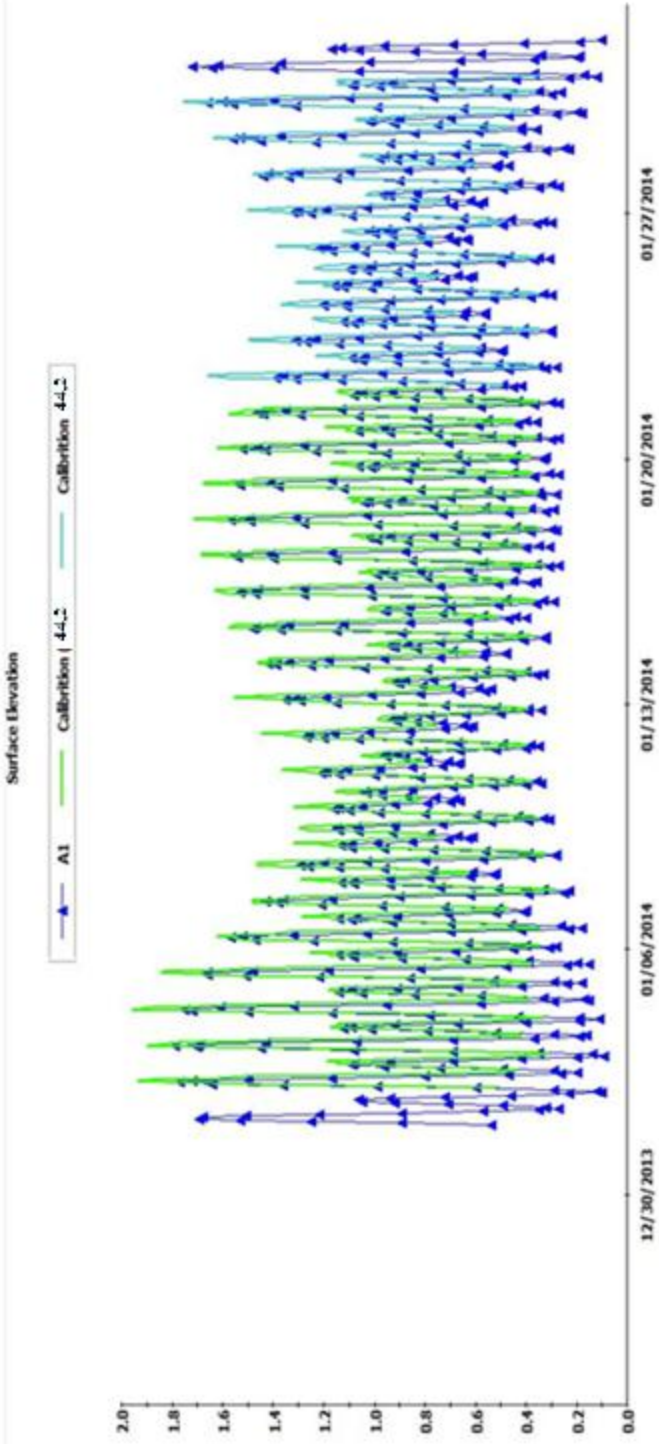


Figure 37: *Calibration for surface elevation (in meters) for field data represented in A1 and model data represented at Calibration site (44,2)*

Regression analysis method shows that the maximum difference is 0.15 m, and the equation of the line of best fit is:

$$y = 0.0004x - 0.0157$$

where the slope (m) is equal to 0.0004 which is close to zero therefore the variation is not significant which indicates a good performance of the model (Figure 38) it can be shown also that during neap tides the variance between the actual data and field data will increase, but during spring tides there will be less variance.

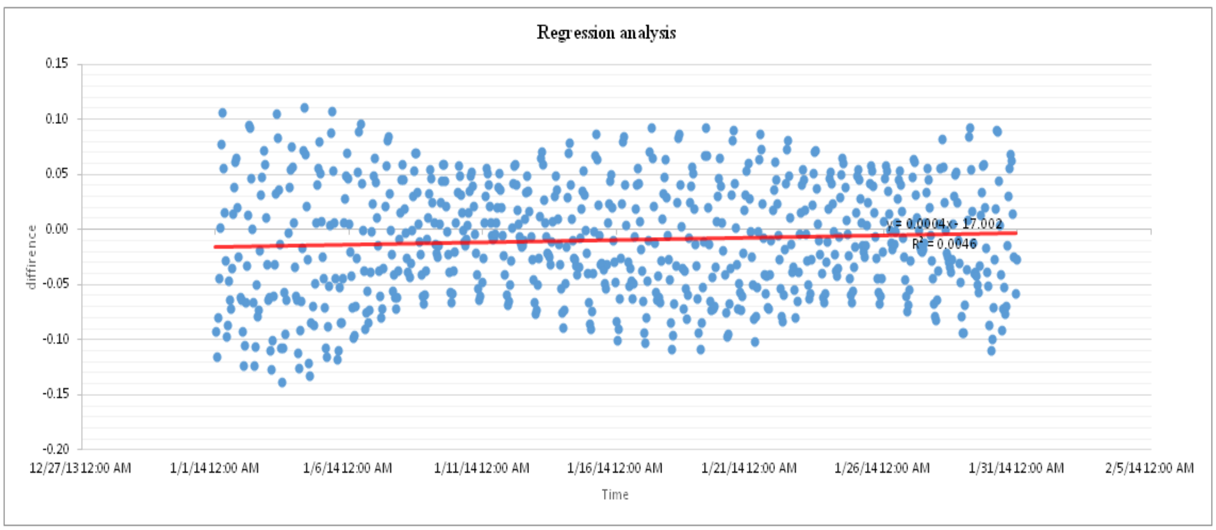


Figure 38: *Calibration for surface elevation for field data represented using regression analysis.*

Finally it can be seen from (Figure 39) that the R^2 value is equal to 0.9833 which means that there is 98.33% correlation ($p<0.0001$) suggesting no statistical differences between simulated and observed data.

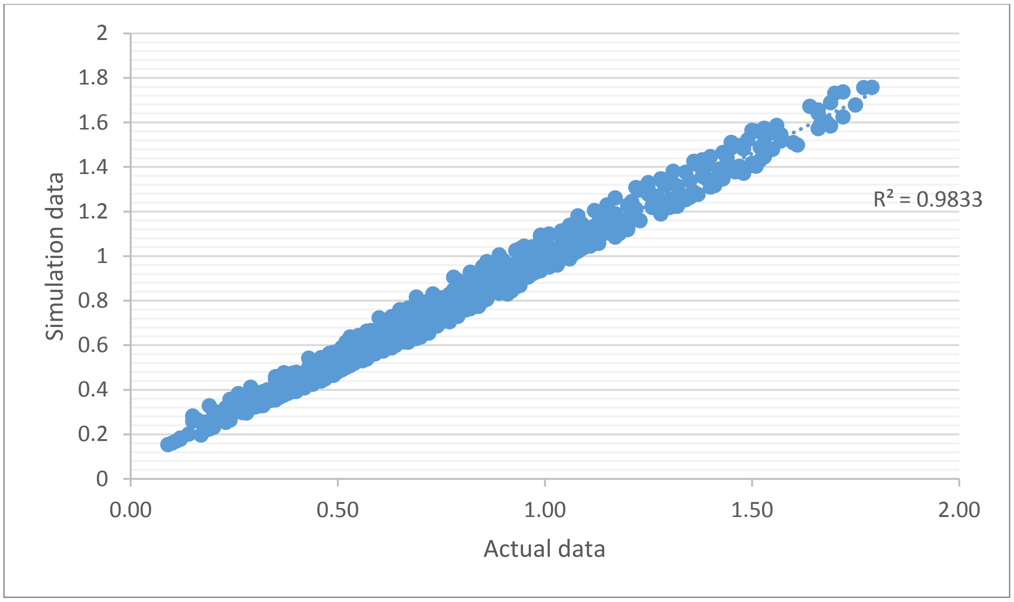


Figure 39: *Correlation between simulated and observed Surface Elevation data.*

The three considered scenarios generated an increase of the surface elevation a change of the stratification of water columns is also observed. Indeed current situation generated six layers while all the scenarios decreased this number to three. Scenario (1) increases the average velocity in the western area and decrease it on the eastern side of the study area (Figure 40). An increase of the average velocity on Fuwairat beach point (44,2) is also observed for this scenario.

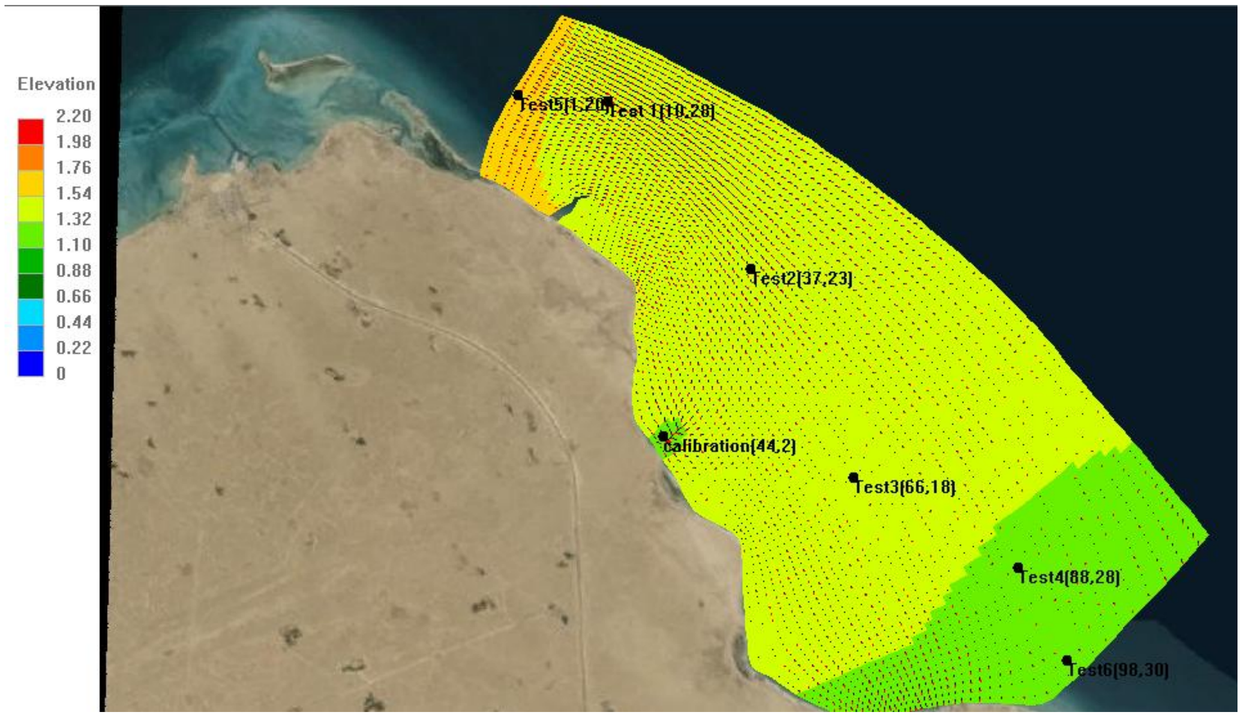


Figure 40: *Scenarios (1) conditions simulation for surface elevation (m) and average velocity(cm/m) vector in 08/1/2014 at 11:00 a.m.*

Scenario (2) affects the average velocity by decreasing it around the boundaries (Figure 41). This variation increased the velocity on Fuwairat beach point (44,2) where it creates some kind of a low energy zone for water circulation.

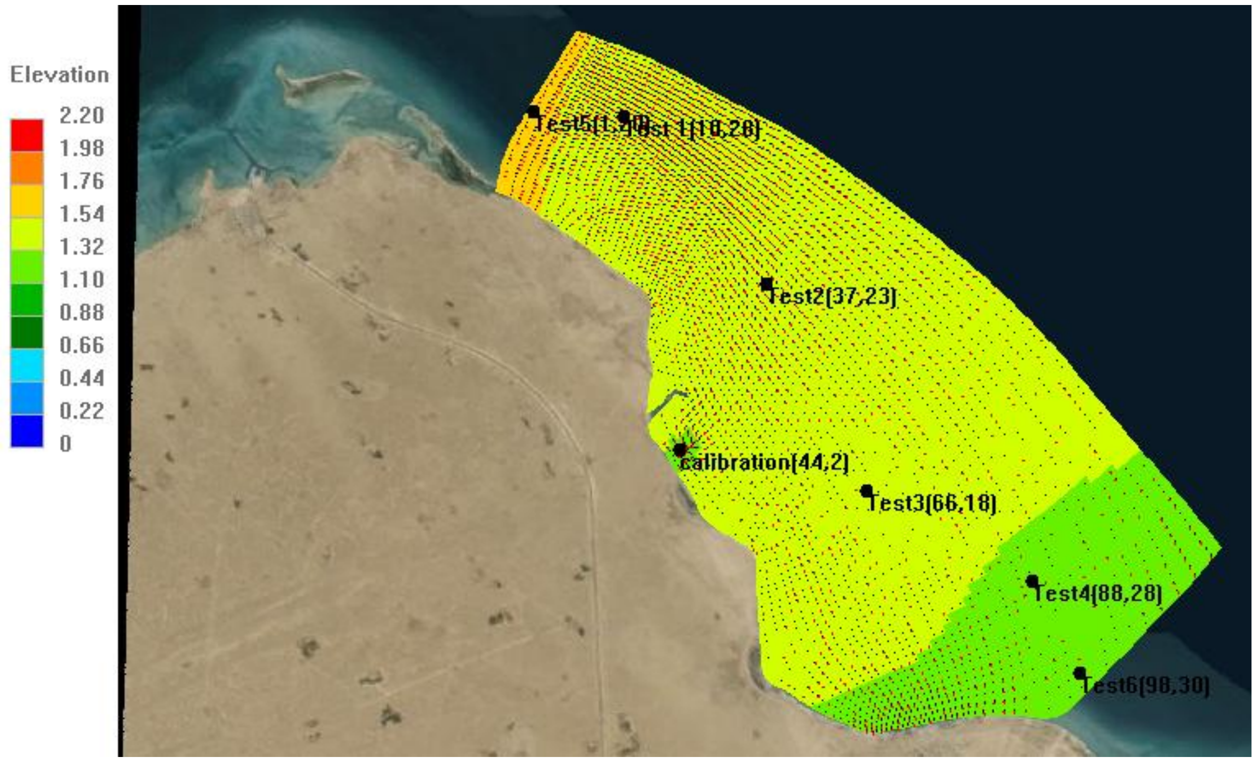


Figure 41: *Scenarios (2) conditions simulation for surface elevation (m) and average velocity(cm/sec) vector in 08/1/2014 at 11:00 a.m.*

Finally scenario (3) mainly decreaces the average velocity in the northern side of the study area, which will decrease the circulation of the water in this coast (Figure 42). These variation do not alter the average velocity at Fuwairat beach point (44,3).

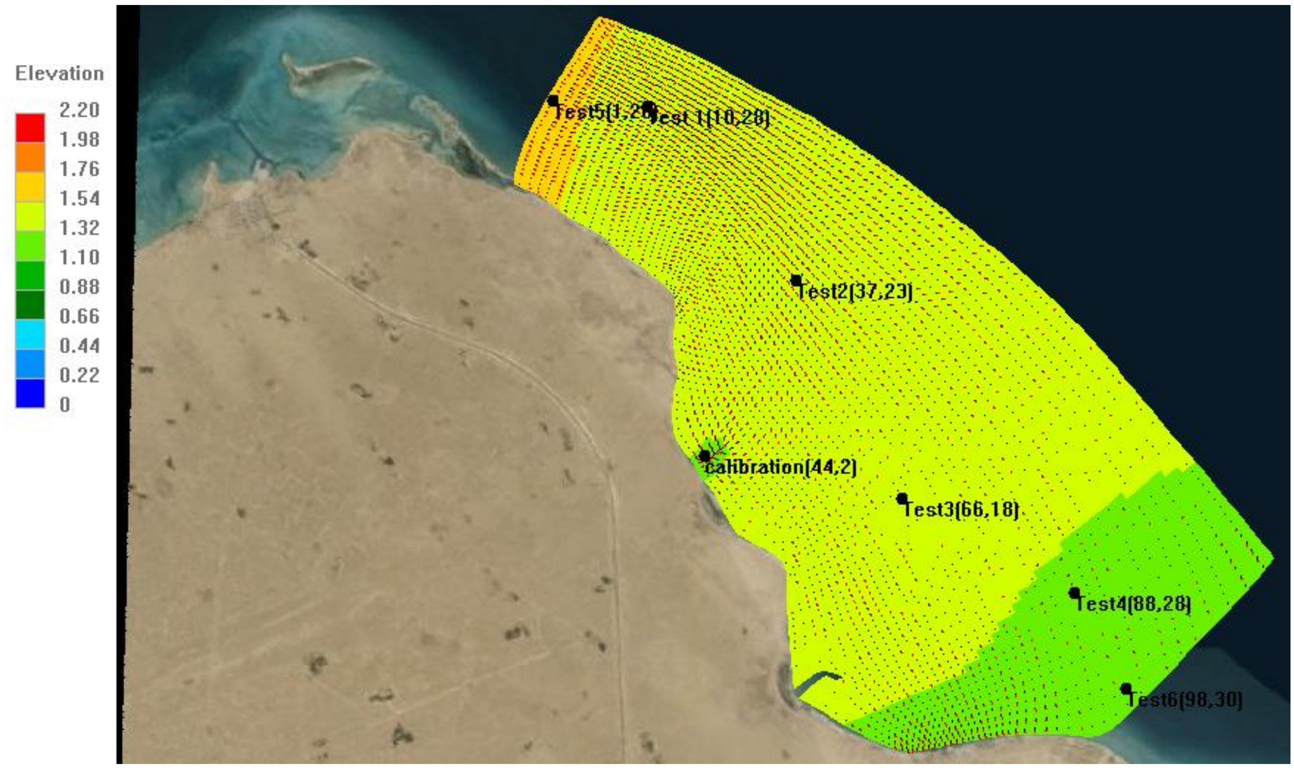


__Figure 42:__ Scenarios (3) conditions simulation for surface elevation (m) and average velocity(cm/sec) vector in 08/1/2014 at 11:00 a.m.

4.2 Sediment transport model

The result of the sedimentation rate is shown in (Table 3):

__Table 3:__ Calculations of the sedimentation rate for each sample.

	Weight (mg)			**Sedimentation rate**
Sample No.	Beaker	Sample	Sediment	mg/day/m2
R23-2	27.3	34.5	7.2	1.02313892
R23-3	33.4	44.5	11.1	1.577339168
R24	32.3	52.8	20.5	2.913103869
R7-10	33	39.2	6.2	0.881036292

The STM output shows a shear stress fluctuating between 0- 21.29 $\frac{kg.m}{sec^2}$ (Figure 43). There is a negative proportional relation between sedimentation and shear stress. For instance, for high shear stress there will be higher erosion of sediment. As seen from the methodology that the bottom sediment is mostly characterised by sandy silt or silty sand, therefore the resuspension of these particle is most likely to happen. It can be observed from Figure 43 (the unfilled cells represents zero shear stress) that the northern and eastern boundaries have the highest shear stress and it is decreasing toward the open water. Which can indicate that the sediment will move in the same direction. It can be seen also that the shear stress is equal or close to zero in Jabal Fuwairet area, which indicates that there isn't much erosion or resuspension of sediments in this area.

Figure 43: *Present conditions simulation for Shear stress (kg.m/sec^2) in 08/1/2014 at 11:00 a.m.*

The model simulations denote the movement of suspended sediments (Sand, Silt, and Clay). Suspended sand in low content in the water column as it varies between 0-400 $\frac{mg}{L}$ showing higher concentration in the eastern part of coast and it moves from the coast before Fuwairet coming to Fuwairet but flushed out quickly to the northern coast (Figure 44). Suspended silt and clay move similarly as sand but differ in concentration in the water column: 0-1000 $\frac{mg}{L}$ (Figures 45 and 46).

Figure 44: *Present conditions simulation for concentration of sand (mg/l) 08/1/2014 at 11:00 a.m.*

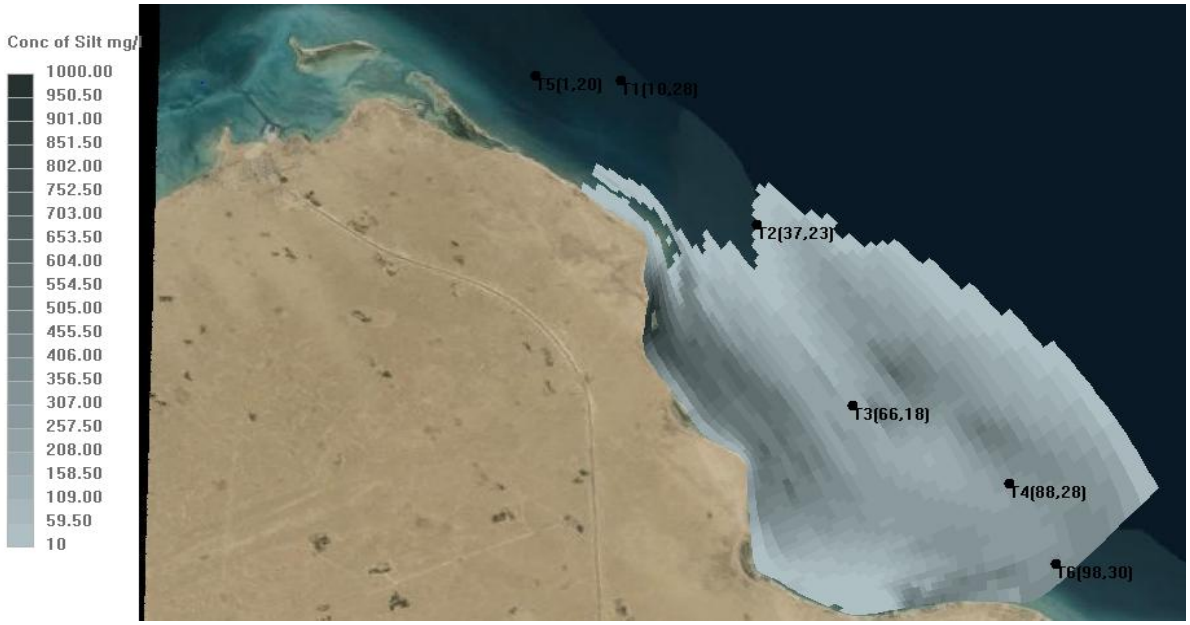


Figure 45:*Present conditions simulation for concentration of silt 08/1/2014 at 11:00 a.m.*

Figure 46:*Present conditions simulation for concentration of Clay 08/1/2014 at 11:00 a.m.*

4.2.1 Simulation scenarios for STM

The three scenarios will increase the shear stress in the northern boundary and all the coastal areas however decrease it in the eastern boundary. But these changes significantly vary in each scenario. Where scenario (3) (Figure 44) decreases the shear stress more in the eastern boundary then scenario (1) (Figure 45) and (2) (Figure 46). On the other hand the shear stress slightly increases in the western areas in scenario (1) compared to other scenarios.

Figure 47: *Scenario (1) conditions simulation for Shear stress (kg.m/sec^2) in 08/1/2014 at 11:00 a.m.*

Figure 48: *Scenario (2) conditions simulation for Shear stress (kg.m/sec^2) in 08/1/2014 at 11:00 a.m.*

Figure 49: *Scenario (3) conditions simulation for Shear stress(kg.m/sec^2) in 08/1/2014 at 11:00 a.m.*

Chapter 5

DISCUSSION

The present scenario simulations shows that the main driving force for water movement are tides. the sea surface elevation varies between 0-2.2 m. Due to the geographical features of Qatar, the northern part of the study area (Al-Ruwais) shows high water dynamics, average velocity and shear stress but low water temperature since warmer water comes from the eastern coast where the area (a semi enclosed sea within the Arabian Gulf) Due to the geographical features of Qatar, the northern part of the study area (Al-Ruwais) shows high water dynamics, average velocity and shear stress but low water temperature since warmer water comes from the eastern coast of the area. All of these features increase the water recirculation and increase the resuspension of the seabed sediment (especially fine sediments) and to accumulate in the middle coastal area (low energy zone). The range of suspended sediment load was within the same range in other studies done on Al-Zakhira [33]. All of these hydrodynamic characteristics may explain the proliferation of seagrass in this area (as highlighted in the introduction). However the trapping ability of the seagrass is in reality resulting from equilibrium between deposition (or sedimentation) and erosion (or resuspension) [34]. This sedimentation process may nevertheless cause negative impacts on seagrass meadows if sediment load in the water column exceeds tolerable levels for seagrasses [35] [36]. These detrimental impacts may be even more important for coral reefs were sedimentation potentially causes lower light penetration and therefore a lower photosynthetic performance by zooxanthellae [37]. Least light necessities for corals range from <1% to as much as 60% of surface irradiance. Some individual coral species can tolerate contiunes exposure (days) to suspended sediment concentration as high as 1000 *mg/L* while others show mortality after exposure for weeks to concentrations as low as 30 *mg/L*. All in all the duration that corals can survive continues high turbidities ranges from several days (sensitive corals) to as a minimum of 5–6 weeks (tolerant corals) [38]. Fine sediments shows greater effects on corals than coarse sediments [39]. The fine (silt and clay) sedimentation rate in Fuwairat where coral batches is located (as highlighted in the introduction) varies between 1- 700 *mg/L* which can be considered as tolerant corals and may reach mortality incase of having other stressors.

Fuwairat coastal water has low average velocity but the surface elevation is changing more frequently than other locations forcing the water to circulate and the light to penetrate at different wave lengths. It also have very low shear stress which means that there isn't much erosion of coarse particle, and small silt and clay particles are always suspended in water and circulating to the eastern coast. These features may explain the benthic habitats distribution in the considered area (unpublished data, EMRQ). Indeed the seagrass meadows and coral patches and reefs are unevenly distributed with higher covers in the zones identified as high energy zones from our model outputs. Additionally the water temperature in this area is relatively warm and doesn't change much through considered time and space. All of these physical characteristics may explain higher biological diversity in Fuwairat coastal waters as shown in the introduction.

Finally the water in eastern boundary just before Ras-Laffan, have high average velocity and dynamics, also it have relatively high shear stress, and the temperature in this area reaches very high levels. This area is under high anthropogenic pressures (being close to Ras-Laffan) coupled to the natural stress of high temperature and high shear stress may explain lower biodiversity records compared to other regions along the coast

All the presented scenarios alter the water column stratification and elevation, average velocity, and the shear stress around the boundaries. Scenario (2) and (3) have the highest effect on the average velocity but Scenario (2) decrease rapidly the average velocity while slightly increases the shear stress in Fuwairat coast and reduce water circulation altering sediment dynamics and potentially impacting local benthic habitats. Therefore scenario (2) is foreseen to impact the surrounding habitats and should be avoided in any future development.

On the other hand scenario (1) is the closest to present scenario increasing the average velocity in Fuwairat coast allowing more water to circulate, consequently it might be considered as a better option for future development that may enhance the physical characteristic in surrounding areas.

Chapter 6

CONCLUSION

This study is the first study that provides ecohydrological model for the Northeastern Qatari coast; it provides a tool for decision makers to characterize the current hydrodynamic condition and identify most vulnerable regions. From different meteorological and hydrodynamic field data, HDM was created and calibrated using GEMSS model.

Four sediment traps were placed and retrieved in the eastern and northern boundaries to examine the physical characteristic of the sediment which were used to create STM under GEMSS model. Both HDM and STM models showed that the northern and the eastern coasts have strong water movement and high shear stress which results in resuspension of the sediments which moves to the coasts forced by the water currents, however they were different in the temperature, as the temperature travel from cold water in the northern coast to the warm water in the eastern coast. While the middle coast (Jabal Al-Fuwairet) has lower water dynamics, velocity, and sediment transport but fluctuating temperature.

These models were used to simulate water and sediment dynamics under three foreseen scenarios (harbor development in the northern coast, middle coast, and eastern coast respectively). Each of the scenarios was compared to the present scenario. Scenario (1) which was located in the northern coast showed similar results to the actual model while scenarios 2 and 3 aletered the physical dynamics of the studies area. Scenario (2) simulating the creation of wave breakers in the central area showed greater differences with the creation of low enery zones and shold therefore be avoided in future developments.

Chapter 7

RECOMMENDATION

As a result of our present investigation, the use of ecohydrological models is recommended to understand the dynamics of water and sediment in the region. Hydrodynamic and sediment transport models should be developed and adequately calibrated through the acquisition of complementary data. The obtained model outputs are of outmost importance to understand the habitat distribution and potential impacts of future anthropogenic developments.

The biological diversity located in the area contrasts with other Qatari coastal areas and its sensitivity to anthropogenic pressures (coupled to natural extreme condition) justifies the creation of protected area. Indeed changes or alteration of the water and sediment dynamics may heavily impact the already sensitive habitats (seagrass meadows and coral reefs) located in this area.

Further investigation should be developed to understand the vulnerability of such habitats in this and other coastal areas and understand through a holistic approach (experimental and modeling) the potential changes that may occur under anthropogenic and natural pressures.

Finally, and considering the scarcity of data acquired in this region, the creation of a public repository of acquired data through governmental or private studies would enhance the development of science based management of the coastal zone.

LIST OF REFERENCES

1] V.ChandyJOHN, 2013. Seasonal cycles of temperature, salinity and water massesof the Arabian Gulf. Oceanologica Acta. Vol (13). 273-281 pp.

[2] M.A.AL-ANSI, 2002. Causes of fish mortality along the Qatari waters (Arabian Gulf). Intern. J. Environ. Studies. Vol (59). 59-71 pp.

[3] Falkowski, P. G. and J.A. Raven,1997. Aquatic Photosynthesis. Blackwell, Oxford, UK . ISBN 0-86542-387-3. 375 pp.

[4] Reyes-Prieto A, Weber AP, Bhattacharya D , 2007. The origin and establishment of the plastid in algae and plants. Annu. Rev. Genet. Vol (41) 147–68 pp.

[5] Muhammad Alaa Abdel -Moati, 2004. Coral Reef Conservation in Qatar. SCENR SCENR-State of Qatar.

[6] Muhammad R. Tayab, 2001. Distribution of Coral Reefs Around the Coastal Areas of Ras Laffan Industrial City, Qatar (Arabian Gulf). Qatar Petroleum.

[7] Annexes of the Executive By-Law for The Environment Protection Law, Issued vide the Decree Law No. 30 for the Year 2002.

[8] Gimblett, H. Randal, 2002. Integrating geographic information systems and agent-based modeling techniques for simulating social and ecological processes. Oxford University Press.

[9] Hall, Charles A.S. & Day, John W, 1990. Ecosystem Modeling in Theory and Practice: An Introduction with Case Histories. University Press of Colorado. ISBN 0-87081-216-5. Chapter 1 pp 9-20.

[10] HA NS-G ERHA RD RAMMING , ZYGMUNT KOWALIK, 1980. Numerical Modelling of Marine Hydrodynamics Applications to Dynamic Physical Processes. Elsevier. Amsterdam. Oxford - New York.

[11] The SWAN Team, cited 2009: User Manual SWAN Cycle III Version 40.72ABCDE.

[12] TECHNITAL, 2012. Pre-contract consultancy and general supervision services for development of Al-Wakrah jetty, Private Engineering Office.

[13] Galland, J.C.; Goutal, N.; Hervouet, J.M, 1991. TELEMAC: A New Numerical Model for Solving Shallow Water Equations. Advances in Water Resources. Vol 14 (3). 138–14 pp.

[14]Sogreah Groupe Artelia, March 2012. Zakhira Marina Hydrodynamic Modelling and Flushing Report. UrbaCon Co.

[15] Sogreah Groupe Artelia, June 2012. Banana Island Marina Hydrodynamic Modelling and Flushing Report. Al Khayyat Contracting & Trading.

[16] GEMSS Development Team Surfacewater Modeling Group (SMG) ERM Inc, August 2006. User Guide – GEMSS-*GridGen*. Exton, Pennsylvania.

[17] GEMSS Development Team Surfacewater Modeling Group (SMG) ERM Inc, August 2006. A User Guide to Customize GEMSS Computations. Exton, Pennsylvania.

[18] Adeyinka E. Adenekan, Venkat S. Kolluru, 2009. Transport and Fate of Chlorinated By-Products Associated with Cooling Water Discharges. Elsevier.

[19] Bathymetric Data Coverage for the State of Qatar, Ministry of Municipality & Urban Planning.

[20] Meshin Al-Ansi, Jassim Al-Khayat, 2008.Marine Turtles in the State of Qatar, National Council for Culture Arts and Heritage. QATAR NATIONAL PRINTING PRESS.

[21] Venkat S. Kolluru, April 2003. Hydrodynamic Modeling of Coastal LNG Cooling Water Discharge. Energy Eng. Vol (129). 16-31 pp.

[22] J.P. Bondorf, April 1977. A simple analytic hydrodynamic model for expanding fireballs. ELSEVIER. Vol (296). 320-332 pp.

[23] David P. Hamilton, Nov 1995. Prediction of water quality in lakes and reservoirs. ELSEVIER. Vol (96). 91-110 pp.

[24] Acheson D, 1990. Elementary Fluid Dynamics, Oxford Applied Mathematics and Computing Science Series. Oxford University Press, ISBN 19-859679, 21-45 PP.

[25] HA NS-G ERHA RD RAMMING, 1980. Numerical Modelling of Marine Hydrodynamics Applications to Dynamic Physical Processes. ELSEVIE. ISBN 0444-41849-0. Vol (26). 4-178 pp.

[26] GEMSS Development Team Surface water Modeling Group (SMG) ERM Inc, April 2006. Hydrodynamic and Transport Module Technical Documentation. A User Guide to Customize GEMSS Computations. Exton, Pennsylvania.

[27] Upton, G, Cook, 2006. Oxford Dictionary of Statistics. Oxford University Press. ISBN 978-0-19-954145. 12-30 pp.

[28] K. H., Pooi, 2008. Calibration Intervals in Linear Regression Models, Communications in Statistics . Vol (37).1688–1696 pp.

[29] Nuzzo, R., 2014. Scientific method: Statistical errors. Nature. Vol (506). 15-28 pp.

[30] GEMSS Development Team Surface water Modeling Group (SMG) ERM Inc, April 2006. Sediment Module Technical Documentation. A User Guide to Customize GEMSS Computations. Exton, Pennsylvania.

[31] GEMSS Development Team Surface water Modeling Group (SMG) ERM Inc, April 2006. Sediment Contamination Modeling. A User Guide to Customize GEMSS Computations. Exton, Pennsylvania.

[32] Gillum RF., 1993. A racial difference in erythrocyte sedimentation. Journal of the National Medical Association. Vol (85) Issue (1). 47–50 pp.

[33] Sogreah Groupe Artelia, Nov 2012. Zakhira Marina Sediment Plume Modelling Report. UrbaCon Co.

[34] Koch E.W. 1999. Sediment resuspension in a shallow Thallasia testudinum banks ex Konig bed. Aquatic Botany. Vol (65). 269-280 pp.

[35] Marba N. 2009. Losses of Seagrass meadows from Spanish coast: results of the Praderas project. In Duarte C. (Eds) .Global loss of coastal habitats. Rates causes and Consequences. Fundacion BBVA. 49-90 pp.

[36] Duarte C., Marba N. and Santos R. 2004. What may cause loss of seagrasses? in J. Borum, C. M. Duarte, D. Krause-Jensen, & T. M. Greeve (Eds.), European

seagrasses: An introduction to monitoring and management. Monitoring and Managing of European Seagrasses Project (M&MS): [s.l.]. ISBN 87-89143-21-3.

[37] Rogers C. S. 1990. Responses of coral reefs and reef organisms to sedimentation. Marine Ecology Progress Series. Vol (62). 185-202 pp.

[38] Paul L.A. Erftemeijer, September 2012. Environmental impacts of dredging and other sediment disturbances on corals: A review. Marine Pollution Bulletin. Marine Pollution Bulletin. Vol (64). 1737–1765 pp.

[39] Michael J. Risk, Evan Edinger, 2011. Impacts of Sediment on Coral Reefs. Encyclopedia of Earth Sciences Series. 575-586 pp.

APPENDIX

Appendix A: HDM Control file

$GEMSSModelResults,19

$GEMSS-SHWETControlFile,5.01

$Creation Date: 04/08/2015

$Waterbody Name: alriways 1

$Modeler Name: Ra-Sk

##

1: Scenario variables,

##

"IntGDS,","Option to use GEMSS data structure,", 1

"Scenario,","Scenario file path and name; Project file path,","C:\GEMSS\Apps\alriways 1\Output\Run008b,","C:\GEMSS\Apps\alriways 1\,"

"DoText2MDBConversion,","Use Scenario Output Direct Database conversion,",1,1

"GenerateMultipleOutputDatabases,","Generate multiple databases,", 1

"ZipOutputFile,","Zip text output files after creating the database,",0,0

"DoCompUsingGEMSSOutput,","Existing GEMSS Output Files Type; Rerun Model or Get New Output;Use Maximum Time Step for Rerun Model,",0,0,0

"GEMSSHDMInputFile,","Existing GEMSS Contour Output Header Text Files,",","

"CurrentDBType,","Currents Database Type,", 0

##

2: Grid variables,

##

"igrid,","Switch to read grid data from a file,",1,1

"GridFile,","Grid file name,","C:\GEMSS\Apps\alriways 1\Grid\new 100 by 40 best_2.g3g,","04/15/2015 07:28:36,","04/19/2015 16:02:32,"

"InputHDatumUnit,","Input grid data is in geographic coordinate system switch,",2

"UseLinearConversionIn,","Use linear conversion for input grid data,",1

"cstypeIn,","Input coordinate conversion mode,",0

"cscodeIn,","Input coordinate conversion zone number,",0,None

"csdatumIn,","Input UTM datum,",0

"InputVDatumUnit,","Input grid data is in geographic coordinate system switch,",2

"OutputHDatumUnit,","Output grid data is in geographic coordinate system switch,",2

"UseLinearConversionOut,","Use linear conversion for output grid data,",1 "cstypeOut,","Output coordinate conversion mode,",0

"cscodeOut,","Output coordinate conversion zone number,",0,None

"csdatumOut,","Output UTM datum,",0

"OutputVDatumUnit,","Output grid data is in geographic coordinate system switch,",2

"elioption,","switch to Use TVD From Boundary Condition File or Initial elevation,", 1

"eli,","Initial elevation,",1

"iwbs,","Waterbody switches,", 1

"eldatum,","Reference elevation of 3rd layer in meters,",0

"UseSigmaStretching,","Switch to Use Sigma stretching,",0

"NSLevel,","Number of Sigma Layers,",1

"SigDistType,","Sigma Layer Distribution type,",0

"Slevel,","User Defined Sigma Distribution,",0.0,-1

"ZtoSigmaBCDepthTransform,","Use BC Depth Transformation from Vertical to Sigma Level,",0

"SmoothBathy,","Switch to Perform Bathymetry Smoothening,",0

"SlpMax,","Maximum Allowable Slope for bathymetry smoothening,",0

"NSmoothCycle,","Number of Smoothening Cycles,",0

****

* Volume-Elevation Regions,

****

"VERegionStatus,","Switch to adjust grid regions for VE calibration,",0

"NumGridVERegions;NumVariables,","Number of grid regions to be adjusted for Volume-Elevation calibration,",0,17

##

#3:	Meteorological variables,

##

"MetDataType,","Switch to use Meteorological time varying data; VB Use verion; Number of Meteorology variables,",1,2.2,14

"metss,","Use Meteorological data in current simulation status,",1

"Metfile1,","Meteorological time varying data input file name,","C:\GEMSS\Apps\alriways 1\Meteorology\NCDC Doha Airport jan 2014Calculate SR Method 1_v1.met,",1,1,0,0,0,1,1,1,1,0,0,1,0,0

"xyMet1,","xy-coordinate of Meterological station,",0,0,0,0,0

"metinterp,","Switch to perform interpolation on met data,",3

"ievap;EvapScaleFactor,","Switch for evaporation;Evaporation scale facotr,",0,1

"iwndhyd,","Use wind in hydrodynamics computations,",1

"UseLimitWindSpeed,","Limit the maximum wind speed in all the met files,",0

"LimitWindSpeed,","Limiting maximum wind speed in all the met files,",-99

"ta,","temperature of air C,",-99,0

"td,","Dew point temperature C,",-99,0

"twb,","Wet bulb temperature C,",-99,0

"rt,","response temperature C,",-99,0

"phi,","Wind direction degrees,",-99

"wad,","Wind speed m/sec,",-99, 0

"cc,","Cloud coverage Octal,",-99

"solrad,","Solar radiation W/m^2,",-99,0

"ps,","Atmoshpheric pressure mm of Hg,",-99

"ishe,","Surace heat exchange method,",0

"KEMethod,","Method to Compute K and E,",0

"cshe,","Coefficient of surface heat exchange w/m2/C,",-99

"te,","Equlibrium temperature C,",-99,0

"secchi,","Secchi depth; light transmission depth m,",-99

"rsts,","Vegetative and Topographic Shading Factor; 0 to 1.0,",-99

"wscoef,","Wind sheltering coefficient; 0 to 1.0,",-99

"iwsf,","Wind speed function,",1

"MetInterpolationMethod,","Met Interpolation Method,",0

"IDWPOW,","Exponent value for inverse weighting scheme,",0

"PAR,","Fraction of solar radiation in the range of 400 to 700 nm,",-99

"Albedo,","Fraction of solar radiation reflected from the water surface,",-99

"BetaMethod,","Method to compute fraction of solar energy absorbed at the surface,",0

"Beta,","Fraction of Solar energy absorbed at the surface,",0.9

"Gamma_A,","Light attenuation parameter a,",1.1

"Gamma_B,","Light attenuation parameter b,",0.73

"MetVarInterpSwitch;MetVarInterp,","Met Individuall interpolatey switch and interpolation methods,",0

****

* Meteorological Scale Factor Variables,

****

"UseMetRegionSF;MetRegionSFSS,","Met factor switch,",0,0

****

* Meteorological Dynamic Shading Variables,

****

"UseDSHDRegionSF;DSHDRegionSFSS,","Met dynamic shading switch,",0,0

****

* Icel Growth Model Variables,

****

"UseIGModel;UseIGModelStatus,","Switch to control the use of ice growth model and status,",0,0

****

* Wave Model Variables,

****

"iwvc;iwvcss,","Wave model activation switch and status,",0,0

****

* Atmospheric Model Variables,

****

"UseAtmModelData;UseAtmModelDataStatus,","Use global or regional atmospheric model switch and status,",0,0

##

4: Constituents,

##

"iCWMc;iCWMcss,","Predefined module type,",0,0

"itrc,","Transport switch; computation status; number of variables,",1,1,5

"iwqc,","Water quality model type; computation status; number of variables,",0,0,0

"iwqaddc,","Water quality ADD model switch; computations status; number of variables,",0,0,0

"iGTMc,","Gas Transfer model computations; status; number of variables,",0,0,0

"iGAMc,","Algae model computations; status,",0,0

"nGAMs,","Number of algae,",0,1

"UseGAMInsideWQM,","Use Generalized Algae Model inside Water Quality Model,",0

"isnec,","Sediment nutrient exchange computations,",0,0

"iPTM,","Particle transport model computations,",0,0

"istc,","Sediment transport model computations,",0,0

"nstcs,","Number of sediment transport type,",0,1

"ientc,","Entrainment computations,",0,0

"nezones,","Number of entrainment zones,",0,1

"iatc,","Optional to add more constituents,",0,0

"natc,","Number of additional constituents,",0,1 "icfmc,","Coliform Bacteria Model computations and status,",0,0

"ncfmcs,","Number of coliform bacteria type,",0

"iCKMc;iCKMcss,","Chlorine kinetics Model computations and status,",0,0

"nCKMc,","Number of chlorine kinetics type,",0

"iMGM;iMGMss,","Macrophyte grouth model computations and status,",0,0

"nMGMs,","Number of macrophyte type,",0,1

"UseMGMInsideWQM,","Use Macrophyte Grouth Model inside Water Quality Model,",0

"PhytoDandEinWQADD,","Apply Phyto Death and Excretion to WQADD constituents,",0

"iGEM;iGEMss,","Epiphyte grouth model computations and status,",0,0

"nGEMs,","Number of Epiphyte type,",0,1

"iWQMTLc;iWQMTLcss;nWQMTLs,","Metal model computations; status; number of variables,",0,0,0

"WriteTransportOutput,","Write TRM model internal variables to GEMSS output output,",0

"WriteWQMOutput,","Write WQM model internal variables to GEMSS output output,",0

"WriteSFMOutput,","Write SFM model internal variables to GEMSS output output,",0

"WriteWQADDOutput,","Write WQADD model internal variables to GEMSS output output,",0

"WriteGTMOutput,","Write GTM model internal variables to GEMSS output output,",0

"WriteGAMOutput,","Write GAM model internal variables to GEMSS output output,",0

"WriteENMOutput,","Write ENM model internal variables to GEMSS output output,",0

"WriteUDCOutput,","Write UDM model internal variables to GEMSS output output,",0

"WriteCFMOutput,","Write CFM model internal variables to GEMSS output output,",0

"WriteSTMOutput,","Write STM model internal variables to GEMSS output output,",0

"WriteMGMOutput,","Write MGM model internal variables to GEMSS output output,",0

"WriteCKMOutput,","Write CKM model internal variables to GEMSS output output,",0

"WritePTMOutput,","Write PTM model internal variables to GEMSS output output,",0

"WriteGEMOutput,","Write Epiphytes model internal variables to GEMSS output output,",0

"WriteWQMTL3DOutput,","Write Metals model internal variables to GEMSS output output,",0

"WriteCWMOutputOutput,","Write CWM model internal variables to GEMSS output output,",0

"cnum,","Number of Constituents,",5

"Index,","Model Name,","Identifier; Cannot be Modified,","User Given Name,","Activity of Constituent,","Output Time,","Units,","Transport Switch,"

"C0,","Transport,",I_Temp,"I_Temp,",1,1,0,1

"C1,","Transport,",I_Saln,"I_Saln,",1,1,0,1

"C2,","Transport,",I_lDye,"I_lDye,",0,1,0,1

"C3,","Transport,",I_CDye,"I_CDye,",0,1,0,1

```
"C4,","Transport,",I_Exst,"I_Exst,",0,1,0,1
######################################################################
# 5:     Model switches,
######################################################################
"Use3DModel,","Switch to control 3D model simulations,",1,3.7
"issflw,","switch on/off ssflow input data that is available in the sscontrol.csv,",1
"itrcs,","transport computation algorithm switch,",1
"udwtf,","advection theta in z-direction,",0
"vdwft,","diffusion theta in z-direction,",0
"HOTSIniTime,","HOTS initization time period,",-99
"SetNegVe2Zero,","Set negative concentration to zero,",1
"itrbs,","Turbulence scheme,",1
"itrbsm,","Turbulence sub model,",1
"itrbparam,","Turbulence parameters,",0,1,1,2.44,2.44,0.9,0.5,1,2.53
"imxls,","Mixing length scheme,",1
"ihmdcx,","momentum diffusion coefficient scheme selector in x-direction,",2
"ihmdcy,","momentum diffusion coefficient scheme selector in y-direction,",2
"hmdcx,","momentum diffusion coefficient in x-direction m2/sec,",0.00584,1.1
"hmdcy,","momentum diffusion coefficient in y-direction m2/sec,",0.00584,1.1
"prnm,","Prandtl number,",10
"ihtdcx,","transport diffusion coefficient scheme in x-direction,",3
"ihtdcy,","transport diffusion coefficient scheme in y-direction,",3
"htdcx,","transport diffusion coefficient in x-direction m2/sec,",,
"htdcy,","transport diffusion coefficient in y-direction m2/sec,",,
"idnf,","Density function selector,",-99
"ideep,","Compressibility usage,",-99
"iBottomMethod,","Bottom Method,",0
"ManningsFactor,","Mannings Factor,",
"ichezy,","Chezy coefficient selector,",0
"ilchezy,","Limiting Chezy selector,",0
"chezy,","Chezy coefficient; Czo;do;n,",20,,
"WSCoeffType,","Wind stress coefficient type,",0
"WSConstA,","Wind stress constant A,",0.8
```

"WSConstB,","Wind stress constant B,",0.065

"WSUseVDWindShear,","Use vertical distribution of wind shear,",0

"WSWindSpeedThreshold,","Wind speed threshold,",10

"WSNumLayers,","Number of vertical layers,",0

"icors,","Coriolis force selector,",1

"RefLatOption;RefLat,","Referene Latitude Option; Reference Latitude Value,",1,40

"ivaterms,","Vertical acceleration terms,",1

"idbg,","Debug switch,",0

"tvdscheck,","time varying data consistency check,",0

"iWDLayers,","Use wetting and drying of layers,",0

"lraddthk,","Layer addition thickness m,",0

"lrsubthk,","Layer subtraction thickness m,",0

"StabilizeInversionFlag,","StabilizeInversionFlag,",0

"InvCoeff,","InvCoeff,",-99

"iUsed1DModel,","Switch to use 1D model; Switch grid has 1D model,",0,0,1

"ComputeStat,","Statisdtical method to output variables,",0

"StatMin,","Statisdtical output minimun data,",0

"StatMax,","Statisdtical output maximun data,",0

"StatAVG,","Statisdtical output average data,",0

"StatFreq;StatUnit,","Statisdtical frequency and unit to write output variables,",0,0

"StatStartTime,","Start time for statistical computations,",41640

"StatEndTime,","End time for statistical computations,",41667.9895833333

"ReturnTime1DDn,","Return time,",0

"UseZCheck,","Control z calculations,",0

"ZStabilityFactor,","Stability factor for z,",0

"CheckTimeStepUsingNewValues,","Redo computations using new time step values,",0

"LoopModelSimTime,","Do multi-year simulation useing short time period inputs,",0

"LoopSimTime,","Date to rerun simulation,","01/28/2014 23:45"

"UseWindRamp,","Use time ramp function for larger wind speeds,",0

"NumWindRampLevels,","Number of time step intervale for the wind ramp function,",1

"RampLimitWindSpeed,","Limiting wind speed for the usege of time ramp function,",0

"WriteBCTVD,","Write boundary condition time varying data files in time Series output files,",0

"WriteBCLoads,","Write boundary condition data as loads in time series output files,",0

"WriteSDTVD,","Write sediment data time varying data files in time series outoput files,",0

"SSDataType,","Source and sinks data type for use in boundary conditon data writing procedure,",1

"iDo1DHDM,","Do 1D hydrodynamics,",0

"iSetdt1DAsdt,","Set 1D model time step same as 3D model,",0

"ZAmplificationFactor,","Z amplification factor for stability checks,",4

"CGCLimit1,","Conjugate Gradient Computation Error Limit 1,",1,-7

"CGCLimit2,","Conjugate Gradient Computation Error Limit 2,",1,-9

"ConvLimitMethod,","Complete CGC iterations,",1

"UseRampFlowFunction,","Use ramp flow function to stabilize the model simulation,",0

"NumRampFlowBCs,","Number of ramp flow boundary conditions,",0,

"SaveCSDataInArray,","Convert cross-section data to depth vs width array,",0

"DelHforCS,","Depth interval for depth vs width array computations,",0.1

"HDMVersionNumber,","Use far-field/near-field modeling approach,",0

"CapitolLakeVarsSwi,","Switch for Capitol lake variables,",0,0

"UseLOTTMethod,","Use LOTT Method for WQCBM Algorithms,",0

##

# 6:	Simulation time variables,

##

"stryear,","Model start time year,",2014

"strmonth,","Model srart time month,",1

"strday,","Model start time day,",1

"strhour,","Model start hour,",0

"strmin,","Model start minutes,",0

"endyear,","Model end time year,",2014

"endmonth,","Model end month year,",1

"endday,","Model end day,",31

"endhour,","Model end hour,",0

"endmin,","Model end minutes,",0

"MaxTimeSlots,","Maximun number of output time slots used in outputs,",2

"idltt,","Time step control switch,",0,1

"dltminm,","Minimum time step,",60

"dltlimit,","Start Up time step,",120

"omega,","Time step under relaxation factor,",0.75

```
######################################################################
# 7:	Derived variables,
######################################################################
"idv,","Option to use derived variables computations,",0
######################################################################
# 8:	Probability Plume variables,
######################################################################
"ComputeProPlume,","Computation of Probability Plume,",0
######################################################################
# 9:	Snapshot output variables,
######################################################################
"isnp,","Snapshot output selector,",1,2.2,20
"isnpss,","Ouput status,",1
"snpfile,","Snapshot output file path and name,","C:\GEMSS\Apps\alriways 1\Output\Run008b\Run008b.snp,"
"iMetInfo,","Switch to write meteorology to snapshot output,",1
"iVolumeBalance,","Volume Balance switch,",1
"iMassBalance,","Mass Balance switch,",1
"nsnp,","Number of snapshot output times,",2
"snpyear,","Snapshot output year,",2014,2014
"snpmonth,","Snapshot output month,",1,1
"snpday,","Snapshot output day,",1,31
"snphour,","Snapshot output hour,",0,0
"snpmin,","Snapshot output minutes,",0,0
"snpfrequ,","Snapshot output frequency unit,",1,1
"snpfreq,","Snapshot output frequency value,",1,999
"nsnpkpk;kpk,","Number of snapshot output K planes; output K plane values,",1,5
"nsnpkpkv;kpv,","Number of snapshot output variables for selected K planes; output variable ID values,",1,1
"nsnpjpj;jpj,","Number of snapshot output J planes; output J plane values,",6,1,2,3,4,5,6
"nsnpjpjv;jpv,","Number of snapshot outputvariables for selected J planes; output variable ID values,",3,1,31,32
"nsnpipi;ipi,","Number of snapshot output I planes; output I plane values,",7,1,2,3,4,5,6,94
"nsnpipiv;ipv,","Number of snapshot output variables for selected I planes; output variable ID values,",4,1,2,3,4
"nsnpijpij,","Number of snapshot output I J points,",0
"snpijpi;snpijpj;snpijpnm,","Snapshot output information,",ICell,JCell,Location names
```

"nsnpijpv;ijpv,","Snapshot output number of output variables for all selected IJ cells; output variable IDs for all selected IJ cells,",0

"HydVar,","Hydrodynamic constituent name,",Surface Elevation,U-Velocity,V-Velocity,W-Velocity,Density,Z Momentum Diffusivity,Chezy,Flow Rate,Buoyancy Frequency,Z Avg U Velocity,Z Avg V Velocity,Z Total Velocity,Shear Stress,Internal Radius of Deformation,Halocline Depth,Circulation Strength in x-direction,Circulation Strength in y-direction,Circulation Strength in z-direction,Current Persistency %,Richardson Number

"hdunits,","Constituent unit type,",0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

"hdamp,","Scaling factor,",100,1,1,1,1,10000,1,1,1,1,1,1,1,1,1,1,1,1,1,1

"hddigits,","Number of digits to print in the snapshot,",2,2,2,2,2,2,2,2,3,2,2,2,2,2,2,2,2,2,2,2

Scaling factor, No. of digits, ConstituentID, Constituent name, Output Type, Units

1,2,I_Temp,I_Temp,1 : Concentration,0 : C

1,2,I_Saln,I_Saln,1 : Concentration,0 : ppt

1,2,I_lDye,I_lDye,1 : Concentration,0 : mg/l

1,2,I_CDye,I_CDye,1 : Concentration,0 : mg/l

1,2,I_Exst,I_Exst,1 : Concentration,0 : deg C

"Stat3DSnapShot,","Do stat analysis for 3D SnapShot,",0

"DV3DSnapShot,","Derived Variables for 3D ShapShot,",0

"ProbPlumeSnapshotStatus,","Status to write probability plume data to the snapshot output,",0

"WriteMetSnapshot,","Switch to write meteorology variable output to snapshot,",0

"SnpOutputMetVars,","Numberof meteorology variables;Output meteorology variable ID to snapshot,",0

"WriteICESnapshot,","Write ice growth model output Variables,",0

"WriteWaveSnapshot,","Write wave model output Variables,",0

"WriteTBTSnapshot,","Write term by term output Variables,",0

"WriteTransportSnapshot,","Write TRM model internal variables to snapshot output,",0

"WriteWQMSnapshot,","Write WQM model internal variables to snapshot output,",0

"WriteSFMSnapshot,","Write SFM model internal variables to snapshot output,",0

"WriteWQADDSnapshot,","Write WQADD model internal variables to snapshot output,",0

"WriteGTMSnapshot,","Write GTM model internal variables to snapshot output,",0

"WriteGAMSnapshot,","Write GAM model internal variables to snapshot output,",0

"WriteENMSnapshot,","Write ENM model internal variables to snapshot output,",0

"WriteUDCSnapshot,","Write UDM model internal variables to snapshot output,",0

"WriteCFMSnapshot,","Write CFM model internal variables to snapshot output,",0

"WriteSTMSnapshot,","Write STM model internal variables to snapshot output,",0

"WriteMGMSnapshot,","Write MGM model internal variables to snapshot output,",0

"WriteCKMSnapshot,","Write CKM model internal variables to snapshot output,",0

"WritePTMSnapshot,","Write PTM model internal variables to snapshot output,",0

"WriteGEMSnapshot,","Write Epiphytes model internal variables to snapshot output,",0

"WriteWQMTL3DSnapshot,","Write Metals model internal variables to snapshot output,",0

"WriteCWMOutputSnapshot,","Write CWM model internal variables to snapshot output,",0

##

10:   Console output variables,

##

"icle,","Console output selector,",1,1.1

"icless,","Ouput status,",1

"ncle,","Number of console ouput times,",2

"cleyear,","Console output year,",2014,2014

"clemonth,","Console output month,",1,1

"cleday,","Console output day,",1,31

"clehour,","Console output hour,",0,0

"clemin,","Console output minutes,",0,0

"clefrequ,","Console output frequency unit,",1,1

"clefreq,","Console output frequency value,",1,999

"nclep,","Number of Console output I J points,",4

"clei;clej;clenm;clenijpk;clenijpv,","Console output information,",ICell,JCell,Location names,Number of K, Number of Variables

"cleP1,","Point 1,",7,28,"C2,",1,1

"cleP2,","Point 2,",31,26,"C3,",1,1

"cleP3,","Point 3,",61,22,"C4,",1,1

"cleP4,","Point 4,",87,28,"C1,",1,1

"clek1,","Console output number of K values and K layer values for point 1,",1,4

"clek2,","Console output number of K values and K layer values for point 2,",1,5

"clek3,","Console output number of K values and K layer values for point 3,",1,5

"clek4,","Console output number of K values and K layer values for point 4,",1,5

"clev1,","Console output number of output variables and variable IDs for point 1,",1,1

"clev2,","Console output number of output variables and variable IDs for point 2,",1,1

"clev3,","Console output number of output variables and variable IDs for point 3,",1,1

"clev4,","Console output number of output variables and variable IDs for point 4,",1,1

"Stat3DConsole,","Do stat analysis for 3D Console,",0

"DV3DConsole,","Derived Variables for 3D Console,",0

"WriteICEConsole,","Write ice growth model output Variables,",0

"WriteWaveConsole,","Write wave model output Variables,",0

"WriteTBTConsole,","Write term by term output Variables,",0

"WriteTransportConsole,","Write TRM model internal variables to console output,",0

"WriteWQMConsole,","Write WQM model internal variables to console output,",0

"WriteSFMConsole,","Write SFM model internal variables to console output,",0

"WriteWQADDConsole,","Write WQADD model internal variables to console output,",0

"WriteGTMConsole,","Write GTM model internal variables to console output,",0

"WriteGAMConsole,","Write GAM model internal variables to console output,",0

"WriteENMConsole,","Write ENM model internal variables to console output,",0

"WriteUDCConsole,","Write UDM model internal variables to console output,",0

"WriteCFMConsole,","Write CFM model internal variables to console output,",0

"WriteSTMConsole,","Write STM model internal variables to console output,",0

"WriteMGMConsole,","Write MGM model internal variables to console output,",0

"WriteCKMConsole,","Write CKM model internal variables to console output,",0

"WritePTMConsole,","Write PTM model internal variables to console output,",0

"WriteGEMConsole,","Write Epiphytes model internal variables to console output,",0

"WriteWQMTL3DConsole,","Write Metals model internal variables to console output,",0

"WriteCWMOutputConsole,","Write CWM model internal variables to console output,",0

##

11: Diagnostic output variables,

##

"idgn,","Diagnostic output selector,",0

##

12: Restart output variables,

##

"irst,","Restart output selector,",0

##

13: Time series output variables,

##

"itsr,","Time series output selector,",1,4.2

"itsrss,","Ouput status,",1

"tsrfile,","Time series output file path and name,","C:\GEMSS\Apps\alriways 1\Output\Run008b\Run008b_TSM.txt,"

"itsrVolumeBalance,","Volume Balance switch,",0

"itsrMassBalance,","Mass Balance switch,",0

"ntsr,","Number of time steries output times,",2

"tsryear,","Time series output year,",2014,2014

"tsrmonth,","Time series output month,",1,1

"tsrday,","Time series output day,",1,31

"tsrhour,","Time series output hour,",0,0

"tsrmin,","Time series output minutes,",0,0

"tsrfrequ,","Time series output frequency unit,",1,1

"tsrfreq,","Time series output frequency value,",1,999

"ntsrp,","Number of time series output points,",1

"tsri;tsrj;tsrnm;tsrnijpk;tsrnijpv,","Time series output information,",ICell,JCell,Location names,Number of K, Number of Variables

"tsP1,","Point 1,",44,3,"T1,",1,3

"tsrk1,","Time series output number of K values and K layer values for point 1,",1,4

"tsrv1,","Time series output number of output variables and variable IDs for point 1,",3,1,2,3

"Stat3DTimeSeries,","Do stat analysis for 3D time series,",0

"DV3DTimeSeries,","Derived Variables for 3D time series,",0

"ProbPlumeTimeSeriesStatus,","Status to write probability plume data to the time series output,",0

"WriteMetTimeSeries,","Switch to write meteorology variable output to time series,",0

"TSOutputMetVars,","Numberof meteorology variables;Output meteorology variable ID to time series,",0

"WriteICETimeSeries,","Write ice growth model output Variables,",0

"WriteWaveTimeSeries,","Write wave model output Variables,",0

"WriteTBTTimeSeries,","Write term by term output Variables,",0

"WriteTransportTimeSeries,","Write TRM model internal variables to time series output,",0

"WriteWQMTimeSeries,","Write WQM model internal variables to time series output,",0

"WriteSFMTimeSeries,","Write SFM model internal variables to time series output,",0

"WriteWQADDTimeSeries,","Write WQADD model internal variables to time series output,",0

"WriteGTMTimeSeries,","Write GTM model internal variables to time series output,",0

"WriteGAMTimeSeries,","Write GAM model internal variables to time series output,",0

"WriteENMTimeSeries,","Write ENM model internal variables to time series output,",0

"WriteUDCTimeSeries,","Write UDM model internal variables to time series output,",0

"WriteCFMTimeSeries,","Write CFM model internal variables to time series output,",0

"WriteSTMTimeSeries,","Write STM model internal variables to time series output,",0

"WriteMGMTimeSeries,","Write MGM model internal variables to time series output,",0

"WriteCKMTimeSeries,","Write CKM model internal variables to time series output,",0

"WritePTMTimeSeries,","Write PTM model internal variables to time series output,",0

"WriteGEMTimeSeries,","Write Epiphytes model internal variables to time series output,",0

"WriteWQMTL3DTimeSeries,","Write Metals model internal variables to time series output,",0

"WriteCWMOutputTimeSeries,","Write CWM model internal variables to time series output,",0

"itrn,","Time series transport output selector,",0

##

14: Vertical profile output variables,

##

"ivpf,","Vertical profile output selector,",1,4

"ivpfss,","Ouput status,",0

"vpffile,","Vertical profile output file path and name,","C:\GEMSS\Apps\alriways 1\Output\Run008b\Run008b_VPM.txt,"

"nvpft,","Number of vertical profile output times,",2

"vpfyear,","Vertical profile output year,",2014,2014

"vpfmonth,","Vertical profile output month,",1,1

"vpfday,","Vertical profile output day,",1,31

"vpfhour,","Vertical profile output hour,",0,0

"vpfmin,","Vertical profile output minutes,",0,0

"vpffrequ,","Vertical profile output frequency units,",1,1

"vpffreq,","Vertical profile output frequency value,",1,999

"nvpfp,","Number of vertical profile output points,",2

"vpfi;vpfj;vpfn,","Vertical profile output information,",ICell,JCell,Location names

"vpfP1,","Point 1,",99,26,"P1,"

"vpfP2,","Point 2,",44,2,"P2,"

"nvpfv; vpfv,","Vertical profile output number of output variabels for all selected IJ cells; output variable IDs for all selected IJ cells,",1,1

"Stat3DVProfile,","Do stat analysis for 3D vertical profile,",0

"DV3DVprofile,","Derived Variables for 3D vertical profile,",0

"ProbPlumeProfileStatus,","Status to write probability plume data to the profile output,",0

"WriteWaveProfile,","Switch to write wave model output to profile,",0

"WriteTBTProfile,","Write term by term output Variables,",0

"WriteTransportProfile,","Write TRM model internal variables to profile output,",0

"WriteWQMProfile,","Write WQM model internal variables to profile output,",0

"WriteSFMProfile,","Write SFM model internal variables to profile output,",0

"WriteWQADDProfile,","Write WQADD model internal variables to profile output,",0

"WriteGTMProfile,","Write GTM model internal variables to profile output,",0

"WriteGAMProfile,","Write GAM model internal variables to profile output,",0

"WriteENMProfile,","Write ENM model internal variables to profile output,",0

"WriteUDCProfile,","Write UDM model internal variables to profile output,",0

"WriteCFMProfile,","Write CFM model internal variables to profile output,",0

"WriteSTMProfile,","Write STM model internal variables to profile output,",0

"WriteMGMProfile,","Write MGM model internal variables to profile output,",0

"WriteCKMProfile,","Write CKM model internal variables to profile output,",0

"WritePTMProfile,","Write PTM model internal variables to profile output,",0

"WriteGEMProfile,","Write Epiphytes model internal variables to profile output,",0

"WriteWQMTL3DProfile,","Write Metals model internal variables to profile output,",0

"WriteCWMOutputProfile,","Write CWM model internal variables to profile output,",0

"itrnvp,","Profile transport output selector,",0

##

15: GPP contour output variables,

##

"igpp,","GPP output selector,",1,2.2

"igppss,","Ouput status,",1

"iSADAss,","SADA Ouput status,",0

"iVisitss,","Vist Ouput status,",0

"iEVS_PROss,","EVS-PRO Ouput status,",0

"gppctmfile,","Contour output contour file path and name,","C:\GEMSS\Apps\alriways 1\Output\Run008b\Run008b_CTM.txt,"

"gpphdmfile,","Contour output header file path and name,","C:\GEMSS\Apps\alriways 1\Output\Run008b\Run008b_HDM.txt,"

"gppgrdfile,","Contour output element file path and name,","C:\GEMSS\Apps\alriways 1\Output\Run008b\Run008b_GRD.txt,"

"WritegppAtAllSurfaces,","Option to write output at all surface and cells,", 1

"ngppkpk;gppkpk,","Number of GPP contour output K planes; output K plane values,",0

"ngppjpj;gppjpj,","Number of GPP contour output J planes; output J plane values,",0 "ngppipi;gppipi,","Number of GPP contour output I planes; output I plane values,",0

"ngpp,","Number of GPP contour output times,",2

"gppyear,","GPP contour output year,",2014,2014

"gppmonth,","GPP contour output month,",1,1

"gppday,","GPP contour output day,",1,31

"gpphour,","GPP contour output hour,",0,0

"gppmin,","GPP contour output minutes,",0,0

"gppfrequ,","GPP contour output frequency unit,",1,1

"gppfreq,","GPP contour output frequency value,",1,999

"ngppv; gppv,","GPP contour output number of output variables for all selected IJ cells; GPP contour output variable IDs for selected location,",6,1,2,3,4,31,32

"Stat3DContour,","Do stat analysis for 3D contour,",0

"DV3DContour,","Derived Variables for 3D contour,",0

"ProbPlumeContourStatus,","Status to write probability plume data to the contour output,",0

"WriteMetContour,","Switch to write meteorology variable output to GPP contour,",0

"gppOutputMetVars,","Numberof meteorology variables;Output meteorology variable ID to GPP contour,",0

"WriteICEContour,","Write ice growth model output Variables,",0

"WriteWaveContour,","Write wave model output Variables,",0

"WriteTBTContour,","Write term by term output Variables,",0

"WriteTransportContour,","Write TRM model internal variables to contour output,",0

"WriteWQMContour,","Write WQM model internal variables to contour output,",0

"WriteSFMContour,","Write SFM model internal variables to contour output,",0

"WriteWQADDContour,","Write WQADD model internal variables to contour output,",0

"WriteGTMContour,","Write GTM model internal variables to contour output,",0

"WriteGAMContour,","Write GAM model internal variables to contour output,",0

"WriteENMContour,","Write ENM model internal variables to contour output,",0

"WriteUDCContour,","Write UDM model internal variables to contour output,",0

"WriteCFMContour,","Write CFM model internal variables to contour output,",0

"WriteSTMContour,","Write STM model internal variables to contour output,",0

"WriteMGMContour,","Write MGM model internal variables to contour output,",0

"WriteCKMContour,","Write CKM model internal variables to contour output,",0

"WritePTMContour,","Write PTM model internal variables to contour output,",0

"WriteGEMContour,","Write Epiphytes model internal variables to contour output,",0

"WriteWQMTL3DContour,","Write Metals model internal variables to contour output,",0

"WriteCWMOutputContour,","Write CWM model internal variables to contour output,",0

##

16: QualView vertical field output variables,

##

"icvf,","Vertical field output for Qual View selector,",0

##

17: QualView contour output variables,

##

"icnt,","Qual View contour output selector,",0

##

18: Current meter type output variables,

##

"idcm,","Current meter type output selector,",0

##

19: TMDL Output Variables,

##

"iTML,","TML output selector,",0,1.1

##

20: Oil Spil output variables,

##

"iSVF,","Oil Spill output selector,",0

##

#21: User defined output variables 1,

##

"iudo1,","User defined variable output selector1,",0

##

#22: User defined output variables 2,

##

"iudo2,","User defined variable output selector2,",0

##

#23: User defined output variables 3,

##

"iudo3,","User defined variable output selector3,",0

##

#24: User defined output variables 4,

##

"iudo4,","User defined variable output selector4,",0

##

#25: User defined output variables 5,

##

"iudo5,","User defined variable output selector5,",0

##

26: NCF NETCDF output variables,

##

"iNCF,","NETCDF output selector,",0

##

27: CFD output variables,

##

"WriteCFDOutput;WriteCFDOutputS,","Switch to Turn on CFD output; Ouput status,",0,0

##

28: Particle transport output variables,

##

"iPTM,","Particle transport output selector,",0

##

29: Initial conditions; constant and spatial data,

##

"iicff,","Initial condition far field file use,",1,2.5,27

"icffile,","Initial condition far field file,","C:\GEMSS\Apps\alriways 1\IC\IC Temperature.icn,"

"icDoSTInterpolate,","Do Spatial and Temporal Interpolation,",0

"RestartToleranceTime,","Time toloerance for using restart file,",0

"AdjustICData,","Adjust initial conditoin data using data before the model simulation time,",1

"NumInterpSerarchCycles,","Number of smoothening cycles,",1

"DoFourByFourSearch,","Switch to activate 4 nearby cells approach,",1

"DoEightByEightSearch,","Switch to activate 8 nearby cells approach,",1

"SmoothCoefficient,","Factor to control parent cell dependency,",0

"IPIStart,","Interpolation starting I cell index,",1

"IPIEnd,","Interpolation ending I cell index,",98

"IPJStart,","Interpolation starting J cell index,",1

"IPJEnd,","Interpolation ending J cell index,",32

"DoRecursiveSmoothening,","Do recursive smoothening on all cells,",0

"ICInterpolationScheme,","Initial condition interpolation scheme,",0

"IDWPOW,","Power for interpolation,",2

"ICGeoFileStatus,","Initial Condition Geo File Status,",0

"ICGeoFileName,","Initial Condition Geo File Name,","No_Data_File,"

"WFNorth,","Weighting factor in the north direction ,",1

"WFSouh,","Weighting factor in the south direction ,",1

"WFWest,","Weighting factor in the west direction ,",1

"WFEast,","Weighting factor in the east direction ,",1

"WFNorthWest,","Weighting factor in the north west direction ,",1

"WFNorthEast,","Weighting factor in the north east direction ,",1

"WFSouthWest,","Weighting factor in the sout westh direction ,",1

"WFSouthEast,","Weighting factor in the south east direction ,",1

"ICGeoStnFileStatus,","Use field data stations look up file,",0

"ICGeoStnFileName,","Field data station look up file name,","No_Data_File,"

"UseRT,","Use response temperature for background temperature,",1

"UseStnBGTemp,","Use field data station for setting up background temperature,",0

"QuadInterpolationType,","Interpolation method for quadrilateral shape,",1

"DoPointInterpolation,","Use field station location for point interpolation method,",1

"UseConstituentData,","Use constituent data only from restart file,",0

"UseOnlyVelocities,","Use only velocities and elevation,",0

"ConstituentStartTime,","Constituent start time from restart file,",42102

"FielDataDepthType,","Field data depth measurement type,",1

"VBUseNumConstituents,","Number of constituents,",0

"UseTVICData,","Use time varying initial condition data,",0

"TVICHoldupTime,","TVIC holdup time,",1

"nicp,","Number of initial conditon points,", 1

"icpnm,","Constituent name; User does not change the name or the order,",I_Temp

"icpid,","Initial condition id,",1

"ict,","Initial condition data type,", 3 "icdsg,","SSFlow station number to be used for the specific constituent,",-99

"icifn,","File name for using it when ict value is set to 2,",

"icifn_1,","File name for using it for initial condition 1,","C:\GEMSS\Apps\alriways 1\IC\IC Temperature.icn,"

"icv,","Initial condition constituent value,",-99

"icu,","Initial condition constituent unit when ict is set to 1,",0

"icstd,","Initial condition start date,","01/01/2014,"

"icstt,","Initial condition start time,","00:00,"

"icxst,","Initial condition x starting location specified as I index,",1

"icxend,","Initial condition x ending location specified as I index,",98

"icjst,","Initial condition y starting location specified as j index,",1

"icjend,","Initial condition y ending location specified as j index,",32

"ickst,","Initial condition z starting location specified as k index,",999

"ickend,","Initial condition z ending location specified as k index,",-999

"icswtype,","Initial condition type,",0

"ictvtype,","Initial condition time varying type,",0

##

28:   Initial conditions, Profile data,

##

"kmax,","number of k layers,", 8

"3,","Profile value at k = 1,",-99

"1.29,","Profile value at k = 2,",-99

"-0.42,","Profile value at k = 3,",-99

"-2.13,","Profile value at k = 4,",-99

"-3.84,","Profile value at k = 5,",-99

"-5.55,","Profile value at k = 6,",-99

"-7.26,","Profile value at k = 7,",-99

"-8.97,","Profile value at k = 8,",-99

$$

$ Boundary conditions,

$$

"ndsg,","Number of ssflows,",16

"ndsgdtr,","Number of Distributed Networks,",0

"ndsgTHR,","Number of Tree Harvest Networks,",0 "vbuse1,","Number of Boundary Conditions; Number of Fixed Variables and Total Number of Variables,",16,52,67,1.9,0

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 1

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","West,",West

"dsgdt(1),","Input Data Type for Hydrodynamics,",2,2 : Time Varying Data

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","C:\GEMSS\Apps\alriways 1\BC\JabalFuwarit_Tides_each_hour.hdg,",C:\GEMSS\Apps\alriways 1\BC\JabalFuwarit_Tides_each_hour.hdg

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\A6-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\A6-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",0,0 : No Interpolation

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",0,0 : No Interpolation

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",45,45

"idsgend,","Ending Grid Cell Index in x-Direction,",45,45

"jdsgst,","Starting Grid Cell Index in y-Direction,",2,2

"jdsgend,","Ending Grid Cell Index in y-Direction,",4,4

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",7124611,7124611

"dsgrangess,","Selected Region Display Status,",0,0

"dsgdr,","Open Boundary Dependency Direction,",4,4 : South

"dsgvf,","Open Boundary Velocity Coefficient,",0.9,0.9

"hdsgm,","Head Boundary Input Mode,",0,0 : Dirichlet; z=z(t)

"fdsgd,","Outgoing Constituent Boundary Input Mode,",0,0 : Dirichlet; c=c(t) "fdsgm,","Hydrodynamic Mode,",1,1 : Surface Elevation

"fdsgu,","Hydrodynamic Mode Unit,",0,0 : m

"fdsgv,","Hydrodynamic Mode Value,",0,0 : From TVD File

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",0,0

"pdsg,","Open Boundary Elevation Amplitude Factor,",1,1

"tdsg,","Open Boundary Elevation Distribution Mode,",0,0 : Constant

"ldsg,","Mean Elevation,",0,0

"wdsg,","Open Boundary Neighboring Boundary Number,",0,0 : Not Used

"dsgnp,","Use Relaxing Method at the Open Boundary,",0,0

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0,0

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0,0

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",0,0

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",0,0

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",0,0 : mg/l

"dsgv(I_IDye),","Instantaneous Dye Concentration,",0,0 "dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",0,0

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",0,0 : mg/l

"dsgv(I_CDye),","Continuous Dye Concentration,",0,0

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",0,0

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",0,0 : deg C

"dsgv(I_Exst),","Excess Temperature Concentration,",0,0

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 2

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","SOUTH,",SOUTH

"dsgdt(1),","Input Data Type for Hydrodynamics,",2,2 : Time Varying Data

"dsgdt(2),","Input Data Type for Transport and Water Quality,",0,0 : Not Used

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","C:\GEMSS\Apps\alriways 1\BC\Al-Khoure_Tides_each_hour.hdg,",C:\GEMSS\Apps\alriways 1\BC\Al-Khoure_Tides_each_hour.hdg

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",-99,Not Applicable

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",99,99

"idsgend,","Ending Grid Cell Index in x-Direction,",99,99

"jdsgst,","Starting Grid Cell Index in y-Direction,",1,1

"jdsgend,","Ending Grid Cell Index in y-Direction,",39,39

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",11387778,11387778 "dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",1,1 : East

"dsgvf,","Open Boundary Velocity Coefficient,",0.9,0.9

"hdsgm,","Head Boundary Input Mode,",0,0 : Dirichlet; z=z(t)

"fdsgd,","Outgoing Constituent Boundary Input Mode,",-99,Not Applicable

"fdsgm,","Hydrodynamic Mode,",1,1 : Surface Elevation

"fdsgu,","Hydrodynamic Mode Unit,",0,0 : m

"fdsgv,","Hydrodynamic Mode Value,",0,0 : From TVD File

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",2,2

"pdsg,","Open Boundary Elevation Amplitude Factor,",1,1

"tdsg,","Open Boundary Elevation Distribution Mode,",0,0 : Constant

"ldsg,","Mean Elevation,",0,0

"wdsg,","Open Boundary Neighboring Boundary Number,",0,0 : Not Used

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",1,1

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",-99,Not Applicable

"dsgvu(I_Temp),","Temperature Unit / Status,",-99,Not Applicable

"dsgv(I_Temp),","Temperature Concentration,",-99,Not Applicable

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",-99,Not Applicable "dsgvu(I_Saln),","Salinity Concentration Unit / Status,",-99,Not Applicable

"dsgv(I_Saln),","Salinity Concentration,",-99,Not Applicable

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 3

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","EAST,",EAST

"dsgdt(1),","Input Data Type for Hydrodynamics,",1,1 : Constant

"dsgdt(2),","Input Data Type for Transport and Water Quality,",0,0 : Not Used

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",0,0 : No Interpolation

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",-99,Not Applicable

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",1,1

"idsgend,","Ending Grid Cell Index in x-Direction,",99,99

"jdsgst,","Starting Grid Cell Index in y-Direction,",39,39 "jdsgend,","Ending Grid Cell Index in y-Direction,",39,39

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",2926983,2926983

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",3,3 : North

"dsgvf,","Open Boundary Velocity Coefficient,",0.999,0.999

"hdsgm,","Head Boundary Input Mode,",3,3 : Full Wave Boundary

"fdsgd,","Outgoing Constituent Boundary Input Mode,",-99,Not Applicable

"fdsgm,","Hydrodynamic Mode,",1,1 : Surface Elevation

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",1,1

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0 "dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",-99,Not Applicable

"dsgvu(I_Temp),","Temperature Unit / Status,",-99,Not Applicable

"dsgv(I_Temp),","Temperature Concentration,",-99,Not Applicable

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",-99,Not Applicable

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",-99,Not Applicable

"dsgv(I_Saln),","Salinity Concentration,",-99,Not Applicable

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 4

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","North-1,",North-1

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\A10-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\A10-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",1,1

"idsgend,","Ending Grid Cell Index in x-Direction,",1,1

"jdsgst,","Starting Grid Cell Index in y-Direction,",1,1

"jdsgend,","Ending Grid Cell Index in y-Direction,",3,3

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",4679439,4679439

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",2,2 : West

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",0,0 : Dirichlet; c=c(t)

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable "dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 5

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","North-2,",North-2

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\B10-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\B10-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable "dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",1,1

"idsgend,","Ending Grid Cell Index in x-Direction,",1,1

"jdsgst,","Starting Grid Cell Index in y-Direction,",4,4

"jdsgend,","Ending Grid Cell Index in y-Direction,",17,17

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",7904411,7904411

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",2,2 : West

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",0,0 : Dirichlet; c=c(t)

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable "dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 6

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","North-3,",North-3

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File "dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\B10-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\B10-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",1,1

"idsgend,","Ending Grid Cell Index in x-Direction,",2,2

"jdsgst,","Starting Grid Cell Index in y-Direction,",18,18

"jdsgend,","Ending Grid Cell Index in y-Direction,",33,33

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",16317206,16317206

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",2,2 : West

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",0,0 : Dirichlet; c=c(t)

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1 "qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 7

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary "dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","North-4,",North-4

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\B10-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\B10-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",2,2

"idsgend,","Ending Grid Cell Index in x-Direction,",2,2

"jdsgst,","Starting Grid Cell Index in y-Direction,",34,34

"jdsgend,","Ending Grid Cell Index in y-Direction,",38,38

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",14791534,14791534

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",2,2 : West

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",0,0 : Dirichlet; c=c(t)

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable "pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable "dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 8

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","East-1,",East-1

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\D9-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\D9-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",2,2

"idsgend,","Ending Grid Cell Index in x-Direction,",11,11

"jdsgst,","Starting Grid Cell Index in y-Direction,",39,39

"jdsgend,","Ending Grid Cell Index in y-Direction,",39,39

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",3401497,3401497

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",3,3 : North

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable "fdsgd,","Outgoing Constituent Boundary Input Mode,",2,2 : Second Order Derivative; d^2c/dn^2=0.0

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable "dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 9

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","East-2,",East-2

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\D8-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\D8-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",16,16

"idsgend,","Ending Grid Cell Index in x-Direction,",31,31

"jdsgst,","Starting Grid Cell Index in y-Direction,",30,30

"jdsgend,","Ending Grid Cell Index in y-Direction,",30,30

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB "dsgcolor,","Selected Region Color,",9616195,9616195

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",3,3 : North

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",2,2 : Second Order Derivative; d^2c/dn^2=0.0

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File "dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 10

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","East-3,",East-3

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\D7-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\D7-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",34,34 "idsgend,","Ending Grid Cell Index in x-Direction,",45,45

"jdsgst,","Starting Grid Cell Index in y-Direction,",39,39

"jdsgend,","Ending Grid Cell Index in y-Direction,",39,39

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",3946010,3946010

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",3,3 : North

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",2,2 : Second Order Derivative; d^2c/dn^2=0.0

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable "dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 11

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","East-4,",East-4

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\E6-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\E6-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0 "dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",45,45

"idsgend,","Ending Grid Cell Index in x-Direction,",56,56

"jdsgst,","Starting Grid Cell Index in y-Direction,",25,25

"jdsgend,","Ending Grid Cell Index in y-Direction,",25,25

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",11728050,11728050

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",3,3 : North

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",2,2 : Second Order Derivative; d^2c/dn^2=0.0

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable "dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 12

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","East-5,",East-5

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\E4-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\E4-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File "dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",58,58

"idsgend,","Ending Grid Cell Index in x-Direction,",72,72

"jdsgst,","Starting Grid Cell Index in y-Direction,",39,39

"jdsgend,","Ending Grid Cell Index in y-Direction,",39,39

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",9639571,9639571

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",3,3 : North

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",2,2 : Second Order Derivative; d^2c/dn^2=0.0

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable "dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 13

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","East-6,",East-6

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data "dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\E2-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\E2-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",73,73

"idsgend,","Ending Grid Cell Index in x-Direction,",85,85

"jdsgst,","Starting Grid Cell Index in y-Direction,",25,25

"jdsgend,","Ending Grid Cell Index in y-Direction,",29,29

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",13965616,13965616

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",3,3 : North

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",2,2 : Second Order Derivative; d^2c/dn^2=0.0

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable "dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 14

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary "dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","East-7,",East-7

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\D1-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\D1-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",86,86

"idsgend,","Ending Grid Cell Index in x-Direction,",98,98

"jdsgst,","Starting Grid Cell Index in y-Direction,",30,30

"jdsgend,","Ending Grid Cell Index in y-Direction,",32,32

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",3833712,3833712

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",3,3 : North

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",2,2 : Second Order Derivative; d^2c/dn^2=0.0

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable "sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable "dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 15

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","South-1,",South-1

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\A1-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\A1-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",99,99

"idsgend,","Ending Grid Cell Index in x-Direction,",99,99

"jdsgst,","Starting Grid Cell Index in y-Direction,",1,1

"jdsgend,","Ending Grid Cell Index in y-Direction,",14,14

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT

"kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",11387778,11387778

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",1,1 : East

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable "hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",2,2 : Second Order Derivative; d^2c/dn^2=0.0

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C

"dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable "dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

"vbuse2,","Number of ssFlows for Current Boundary; BC Index,",1, 16

"vbuse3,","boundary condition mode,","Head Boundary,",Head Boundary

"dsgm,","Boundary Condition Mode,",6,6 : Head Boundary

"dsgss,","Boundary Condition Status,",1,1

"dsgnm,","Boundary Condition Name,","South-2,",South-2

"dsgdt(1),","Input Data Type for Hydrodynamics,",0,0 : Not Used

"dsgdt(2),","Input Data Type for Transport and Water Quality,",2,2 : Time Varying Data

"dsgifn(1),","TVD Input File Name for Hydrodynamics,","No_Data_File,",No_Data_File

"dsgifn(2),","TVD Input File Name for Transport and Water Quality,","C:\GEMSS\Apps\alriways 1\BC\A1-tide.wdg,",C:\GEMSS\Apps\alriways 1\BC\A1-tide.wdg

"dsgqfnst,","Use Qualifier File for Transport and Water Quality,",0,0

"dsgqfn,","Qualifier File Name for Transport and Water Quality,","No_Data_File,",No_Data_File

"dsgip(1),","Time Varying Input Data Interpolation Scheme for Hydrodynamics,",-99,Not Applicable

"dsgip(2),","Time Varying Input Data Interpolation Scheme for Water Quality,",1,1 : Linear Interpolation Between Time t1 and t2

"dsgdc,","Grid Domain Type,",3,3 : 3D Model

"dsgwd,","Write Boundary Condition Data to Snapshot Output File,",0,0

"dsgstd,","Boundary Condition Start Date,","01/01/2014,",01/01/2014

"dsgstt,","Boundary Condition Start Time,","00:00,",00:00

"dsgendd,","Boundary Condition End Date,","01/31/2014,",01/31/2014

"dsgendt,","Boundary Condition End Time,","00:00,",00:00

"idsgst,","Starting Grid Cell Index in x-Direction,",99,99

"idsgend,","Ending Grid Cell Index in x-Direction,",99,99

"jdsgst,","Starting Grid Cell Index in y-Direction,",15,15

"jdsgend,","Ending Grid Cell Index in y-Direction,",39,39

"kdsgst,","Starting Vertical Layer Number in z-Direction,",999,999 : KT "kdsgend,","Ending Vertical Layer Number in z-Direction,",-999,-999 : KB

"dsgcolor,","Selected Region Color,",4018447,4018447

"dsgrangess,","Selected Region Display Status,",1,1

"dsgdr,","Open Boundary Dependency Direction,",1,1 : East

"dsgvf,","Open Boundary Velocity Coefficient,",-99,Not Applicable

"hdsgm,","Head Boundary Input Mode,",-99,Not Applicable

"fdsgd,","Outgoing Constituent Boundary Input Mode,",2,2 : Second Order Derivative; d^2c/dn^2=0.0

"fdsgm,","Hydrodynamic Mode,",-99,Not Applicable

"fdsgu,","Hydrodynamic Mode Unit,",-99,Not Applicable

"fdsgv,","Hydrodynamic Mode Value,",-99,Not Applicable

"sdsg,","Open Boundary Time Shift (phase) in Minutes,",-99,Not Applicable

"pdsg,","Open Boundary Elevation Amplitude Factor,",-99,Not Applicable

"tdsg,","Open Boundary Elevation Distribution Mode,",-99,Not Applicable

"ldsg,","Mean Elevation,",-99,Not Applicable

"wdsg,","Open Boundary Neighboring Boundary Number,",-99,Not Applicable

"dsgnp,","Use Relaxing Method at the Open Boundary,",1,1

"qdsg,","Relax Head Boundary Cells Variables,",0,0

"dsgstructurew,","Maximum Allowable Hydrodynamic Model Value Unit,",-99,Not Applicable

"dsgstructureu,","Maximum Allowable Hydrodynamic Model Value,",-99,Not Applicable

"dsgFlowExp,","Flow Exponent,",-99,Not Applicable

"dsgFlowCoeff,","Flow Coefficient,",-99,Not Applicable

"dsgFlowDir,","Hydrodynamic Flow Direction,",-99,Not Applicable

"dsgFlowMode,","Hydrodynamic Mode,",-99,Not Applicable

"dsgFlowUnit,","Hydrodynamic Mode Unit,",-99,Not Applicable

"dsgFlowValue,","Hydrodynamic Mode Value,",-99,Not Applicable

"dsgFlowHeadDiffFW,","Head Difference for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFWUnits,","Heade Difference Units for Flow Withdrawal Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFD,","Head Difference for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgFlowHeadDiffFDUnits,","Head Difference Units for Flow Discharge Using the Structure,",-99,Not Applicable

"dsgrt,","Use Response Temperature,",0,0

"dsgrc(I_Temp),","Boundary Return Coefficient for Temperature,",0.9,0.9

"dsgvu(I_Temp),","Temperature Unit / Status,",0,0 : C "dsgv(I_Temp),","Temperature Concentration,",0,0 : From TVD File

"dsgrc(I_Saln),","Boundary Return Coefficient for Salinity,",0.9,0.9

"dsgvu(I_Saln),","Salinity Concentration Unit / Status,",0,0 : ppt

"dsgv(I_Saln),","Salinity Concentration,",40,40

"dsgrc(I_IDye),","Boundary Return Coefficient for Instantaneous Dye,",-99,Not Applicable

"dsgvu(I_IDye),","Instantaneous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_IDye),","Instantaneous Dye Concentration,",-99,Not Applicable

"dsgrc(I_CDye),","Boundary Return Coefficient for Continuous Dye,",-99,Not Applicable

"dsgvu(I_CDye),","Continuous Dye Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_CDye),","Continuous Dye Concentration,",-99,Not Applicable

"dsgrc(I_Exst),","Boundary Return Coefficient for Excess Temperature,",-99,Not Applicable

"dsgvu(I_Exst),","Excess Temperature Concentration Unit / Status,",-99,-99 : Not Applicable

"dsgv(I_Exst),","Excess Temperature Concentration,",-99,Not Applicable

$$

$ Rates and Constants for GEMSS-WQM,

$$

"iwqc,","Water Quality Model Type ID; Name; Number of parameters; number of regions; number of variables,",0,"Not Used",0,0,0

$$

$ Rates and Constants for GEMSS-SFM,

$$

"isnec,","Sediment Model Type ID; Name; Number of parameters; Number of regions; number of variables,",0,"Not Used",0,0,0

$$

$ Rates and Constants for GEMSS-WQADD

$$

"iwqaddc,","Water Quality ADD switch; number of variables; Number of parameters; Number of regions,",0,0,0,0

$$

$ Rates and Constants for GEMSS-GTM

$$

"iGTMc,","Gas Transfer switch; number of variables; Number of parameters; Number of regions,",0,0,0,0

$$

$ Rates and Constants for GEMSS-GAM

$$

"iGAM,","Algae Model: Switch; Number of Algae; Number of Variables for Each Algae; number of regions,",0,0,0,0

$$

$ Rates and Constants for GEMSS-CFM

$$

"iCFM,","Bacteria Model: Switch; Number of Bacterias; Number of parameters for Each Bacteria; Number of regions,",0,0,0,0

$$

$ Rates and Constants for GEMSS-UDF

$$

"iUDC,","User Defined Model: Switch; Number of variables; Number of parameters for Each Coliform; Number of regions,",0,0,0,0

$$

$ Rates and Constants for GEMSS-ENT

$$

"iENT,","Entrainment Model: Switch; Number of Entrainments; Number of Paraments for Each Variables; Number of regions,",0,0,0,0

$$

$ Rates and Constants for GEMSS-STM

$$

"istc,","Sediment Transport Model Computations: Switch; Number of Sediment Constituents; Number of Paraments for Each Variables; Number of regions,",0,0,0,0

$$

$ Rates and Constants for GEMSS-MGM

$$

"iMGM,","Macrophytes Model: Switch; Number of Macrophytes; Number of Variables for Each Macrophytes; number of regions,",0,0,0,0

$$

$ Rates and Constants for Chlorine Kinetics module-CKM

$$

"iCKM,","Chlorine Kinetics Module: Module tpe; Number of variables; Number of parameters for each variable; Number of regions,",0,0,0,0

$$

$ Particle Transport Variables for GEMSS-PTM,

$$

"iPTM,","particle transport model computations,",0,0

$$

$ Rates and Constants for GEMSS-GEM

$$

"iGEM,","Epiphytes Model: Switch; Number of epiphytes; Number of Variables for Each Epiphytes; number of regions,",0,0,0,0

$$

$ Rates and Constants for GEMSS-WQMTL3D

$$

"iWQMTL,","Water Quality Metal switch; number of variables; Number of parameters; Number of regions,",0,0,0,0

$$

$ Miscellaneous data,

$$

"vbuse1,","Number of columns and rows,",4,0

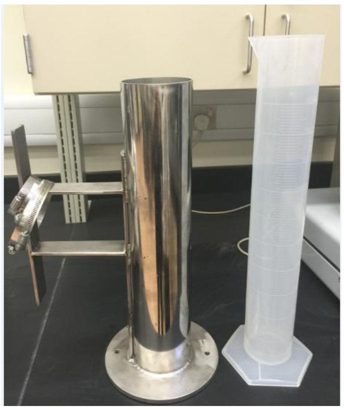
****

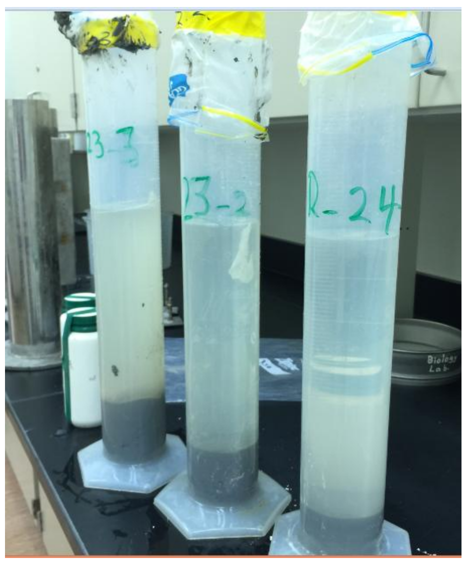
* SECOM Variables,

****

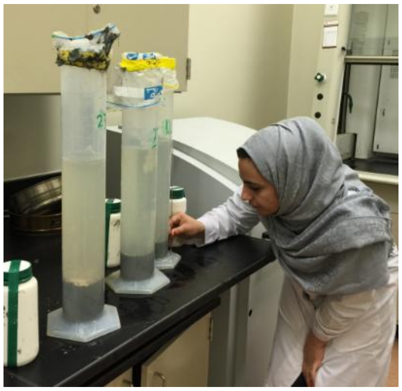
"UsesECOMModel;sECOMStatus,","sECOM model switch; sECOM model status,",0,0

Appendix B: Sediment traps field data





B.1 Placement and retrieving of sediment traps



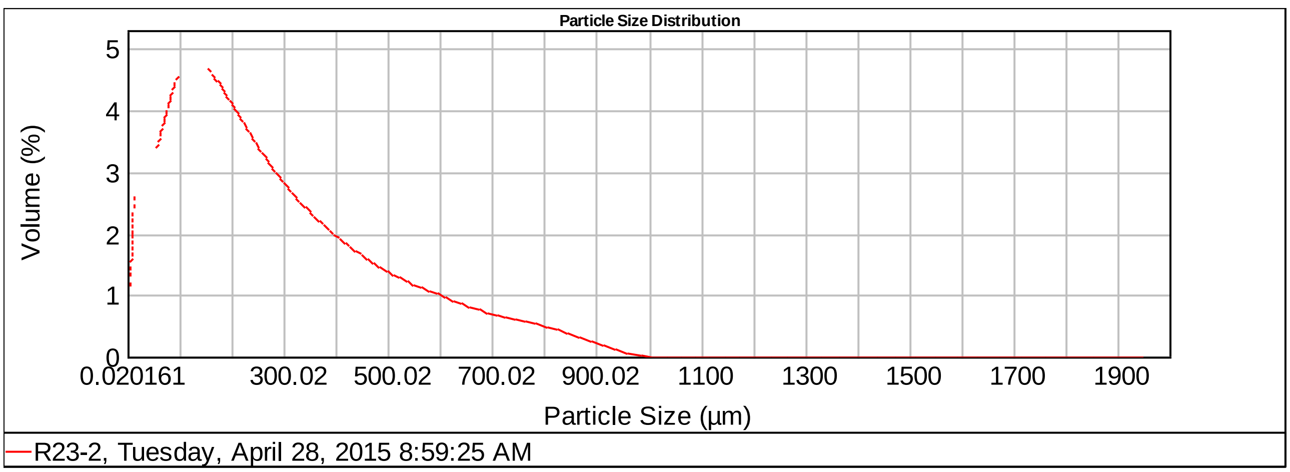
B.2 Sediment analysis

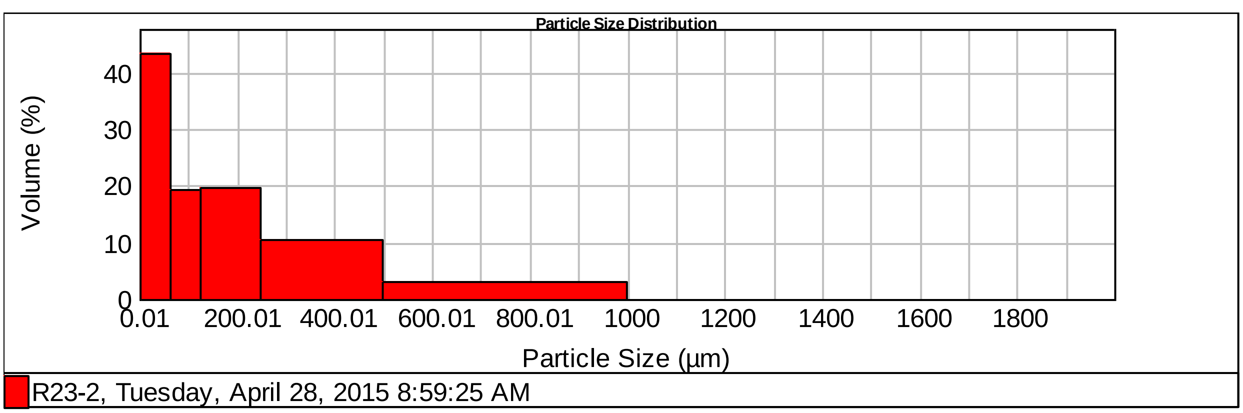
B.3 Grain size distribution of sediment samples

Particle size range and sediment type:

Particle Size Range (µm)	Sediment Type
0.02 – 4.0	Clay
4.0 – 63.0	Silt
63.0 – 125.0	Very fine sand
125.0 – 250.0	Fine sand
250.0 – 500.0	Medium sand
500.0 – 1000.0	Coarse sand
1000.0 – 2000.0	Very coarse sand

R23-2





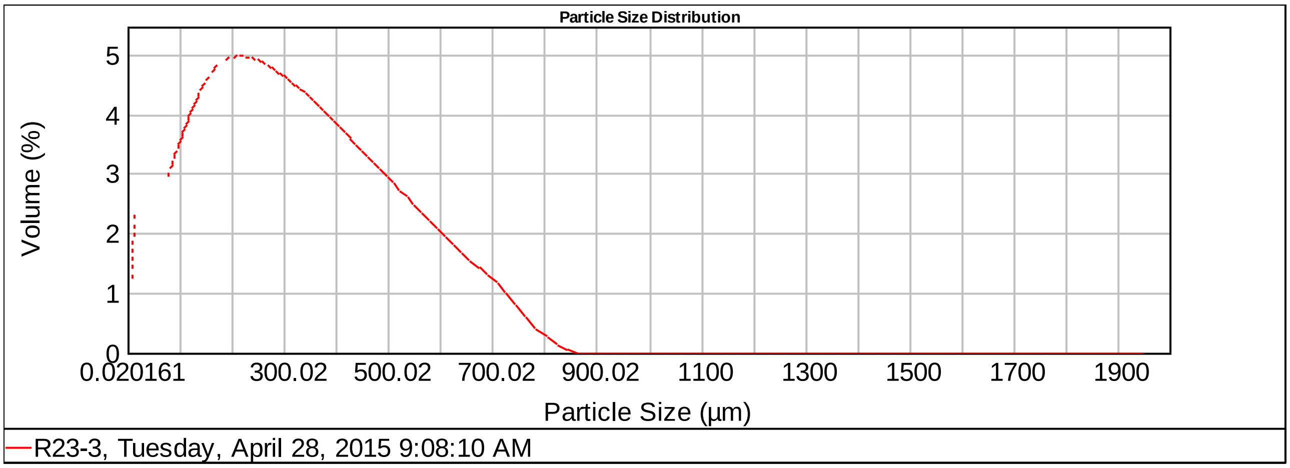
Size (µm)	Volume In %
0.010	
	3.89
4.000	
	43.44
63.000	

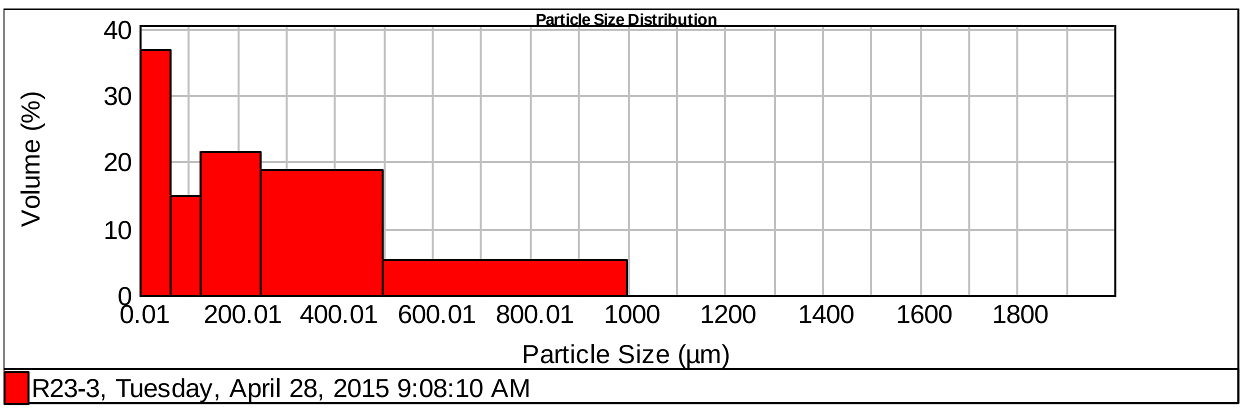
Size (µm)	Volume In %
63.000	
	19.38
125.000	
	19.57
250.000	

Size (µm)	Volume In %
250.000	
	10.60
500.000	
	3.12
1000.000	

Size (µm)	Volume In %
1000.000	
	0.00
2000.000	

R23-3





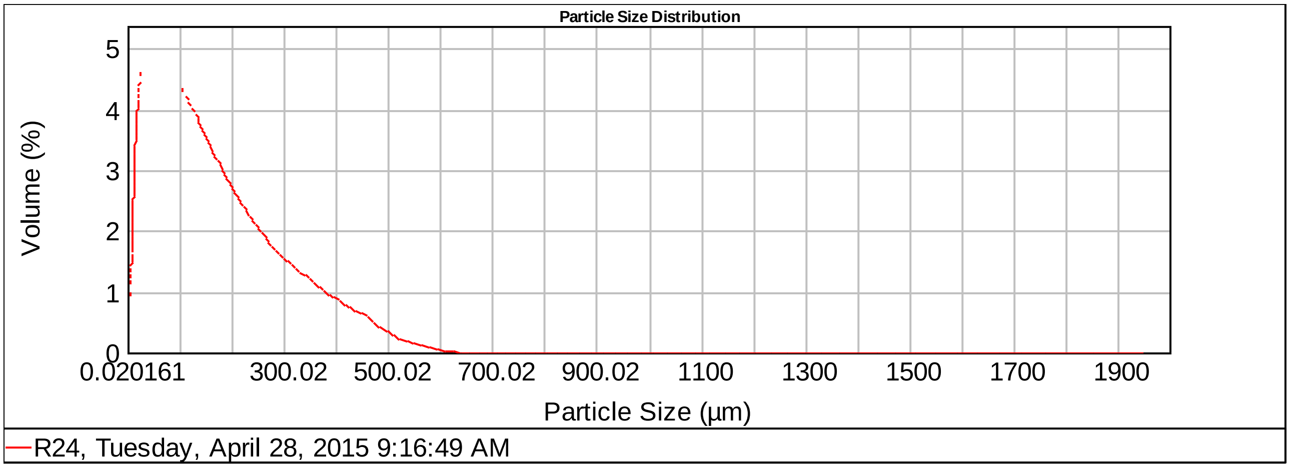
Size (µm)	Volume In %
0.010	
	2.88
4.000	
	36.91
63.000	

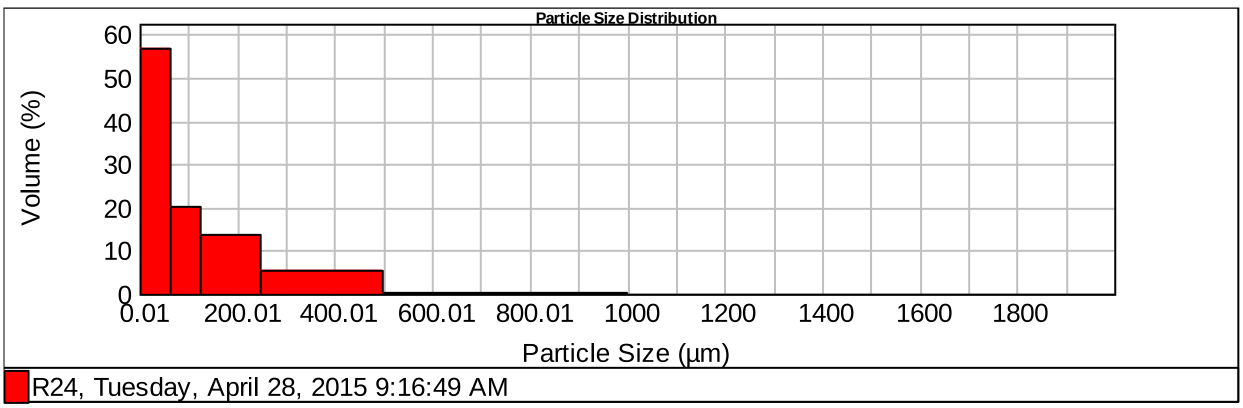
Size (µm)	Volume In %
63.000	
	14.80
125.000	
	21.38
250.000	

Size (µm)	Volume In %
250.000	
	18.72
500.000	
	5.30
1000.000	

Size (µm)	Volume In %
1000.000	
	0.00
2000.000	

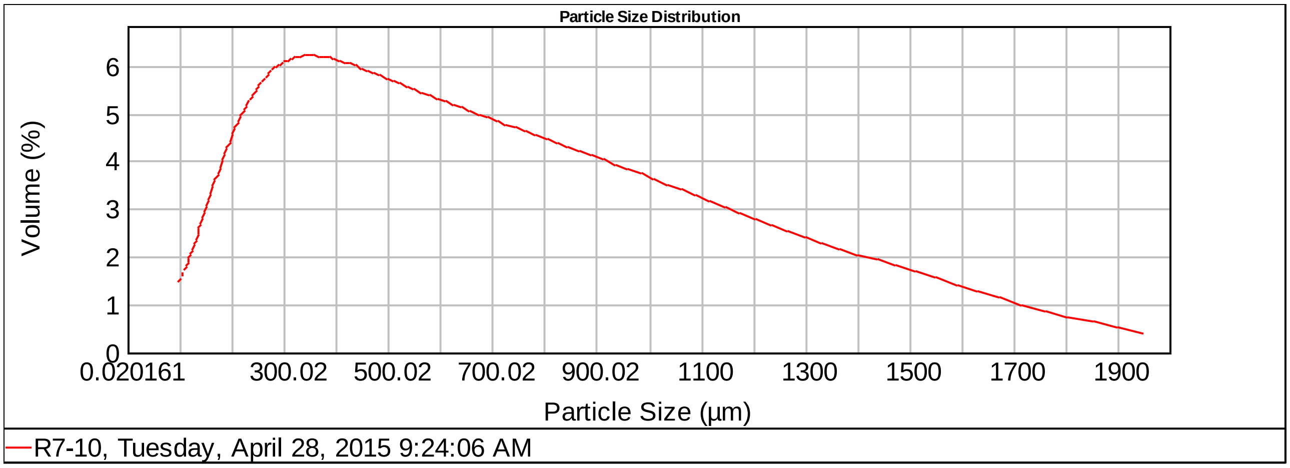
R24

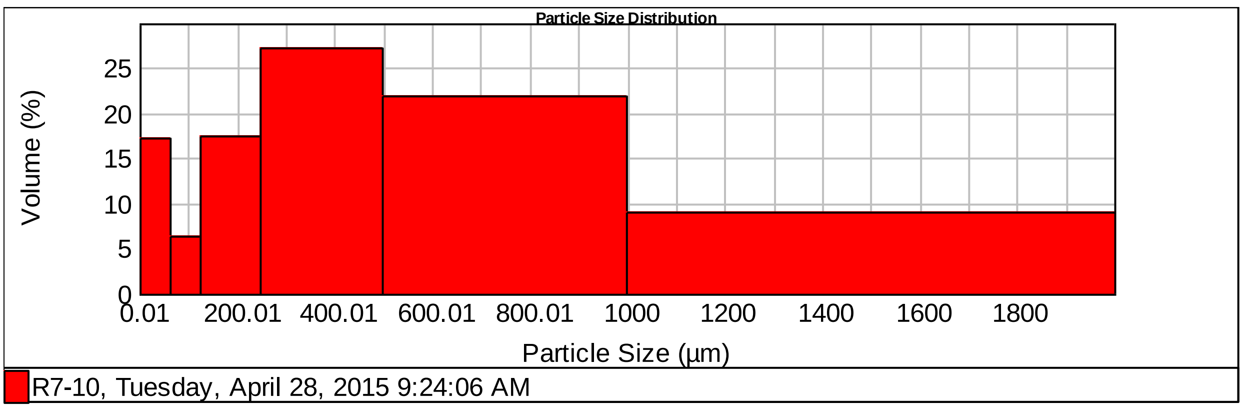




Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010		63.000		250.000		1000.000	
	3.86		19.98		5.36		0.00
4.000		125.000		500.000		2000.000	
	56.78		13.84		0.18		
63.000		250.000		1000.000			

R7-10





Size (µm)	Volume In %
0.010	
	0.84
4.000	
	17.18
63.000	

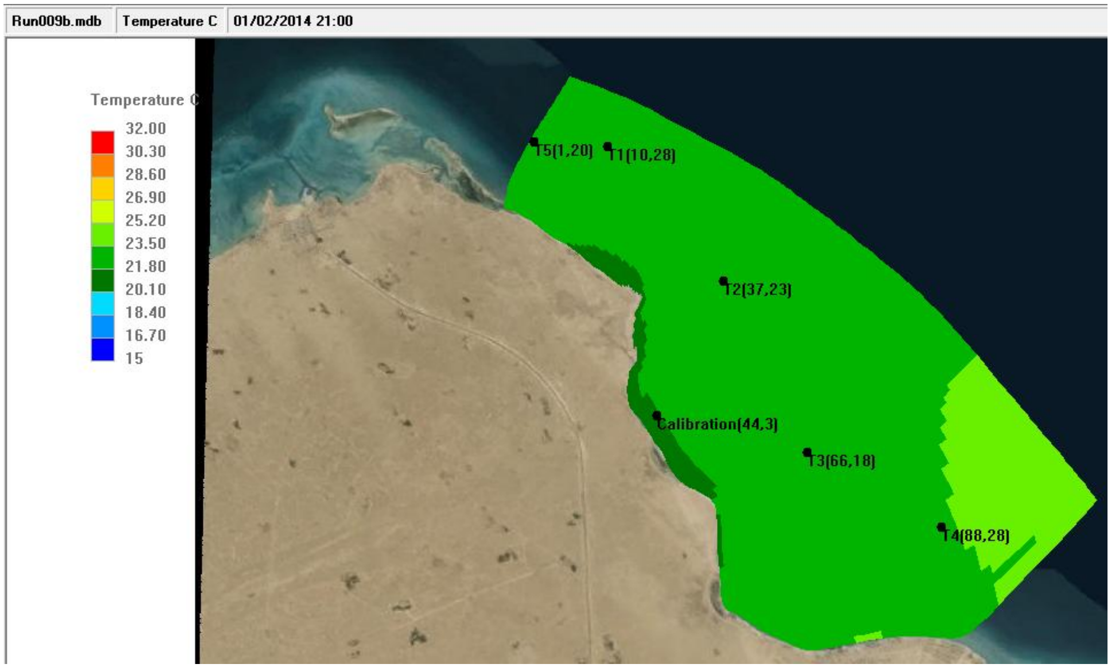
Size (µm)	Volume In %
63.000	
	6.38
125.000	
	17.52
250.000	

Size (µm)	Volume In %
250.000	
	27.24
500.000	
	21.75
1000.000	

Size (µm)	Volume In %
1000.000	
	9.09
2000.000	

Appendix C: HDM outputs

simulation for 1st of January 2014

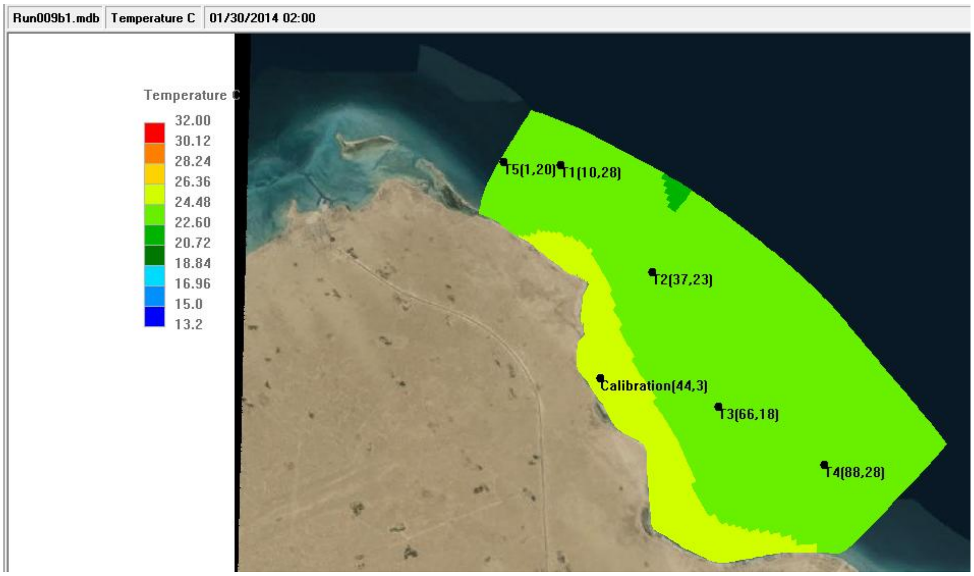


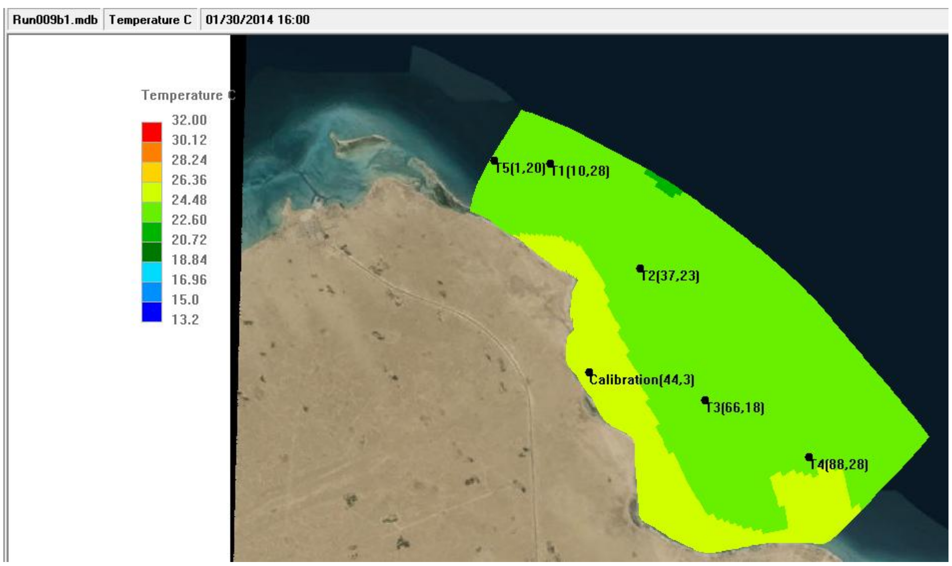
simulation for 15th of January 2014


Run009b.mdb
Temperature C
01/15/2014 12:00
Temperature C
32.00
30.30
28.60
26.90
25.20
23.50
21.80
20.10
18.40
16.70
15
T5(1,20)
T1(10,28)
T2(37,23)
Calibration(44,3)
T3(66,18)
T4(88,28)


Run009b.mdb
Temperature C
01/15/2014 21:00
Temperature C
32.00
30.30
28.60
26.90
25.20
23.50
21.80
20.10
18.40
16.70
15
T5(1,20)
T1(10,28)
T2(37,23)
Calibration(44,3)
T3(66,18)
T4(88,28)

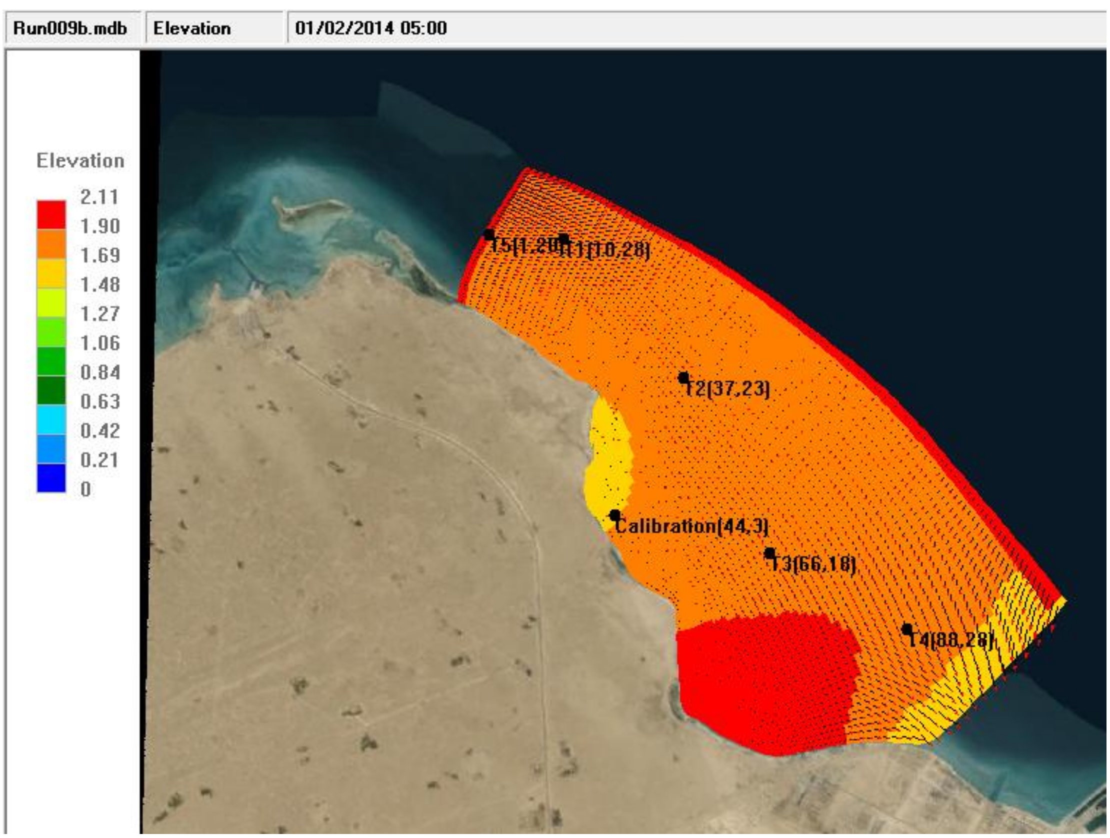
simulation for 30th of January 2014

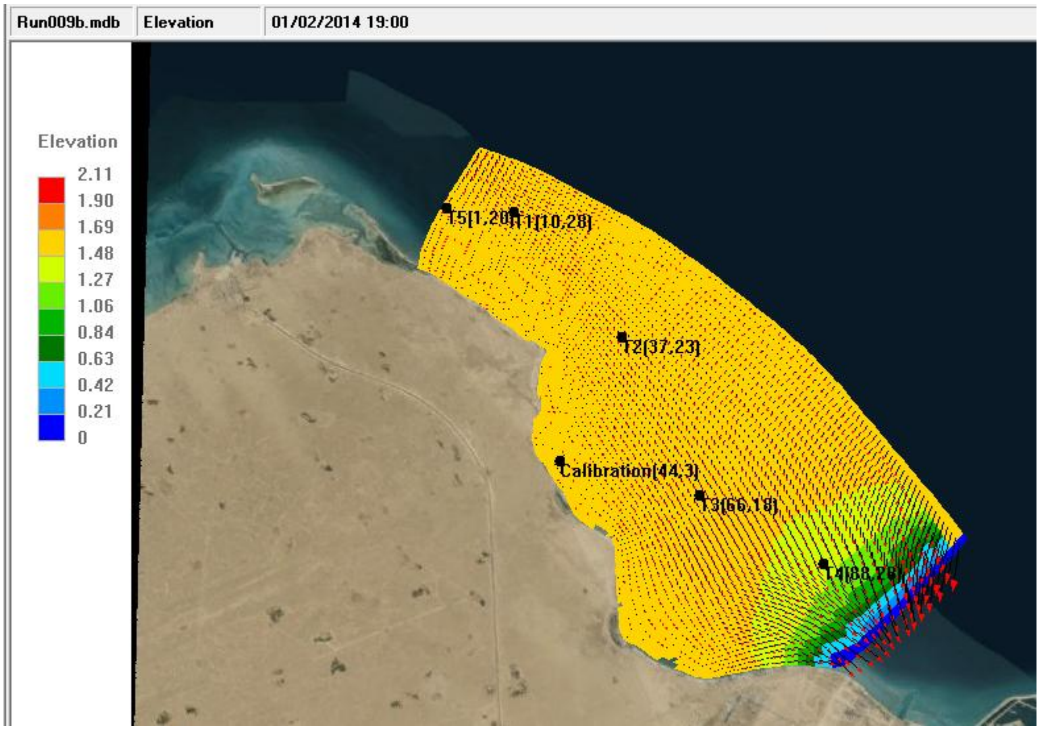




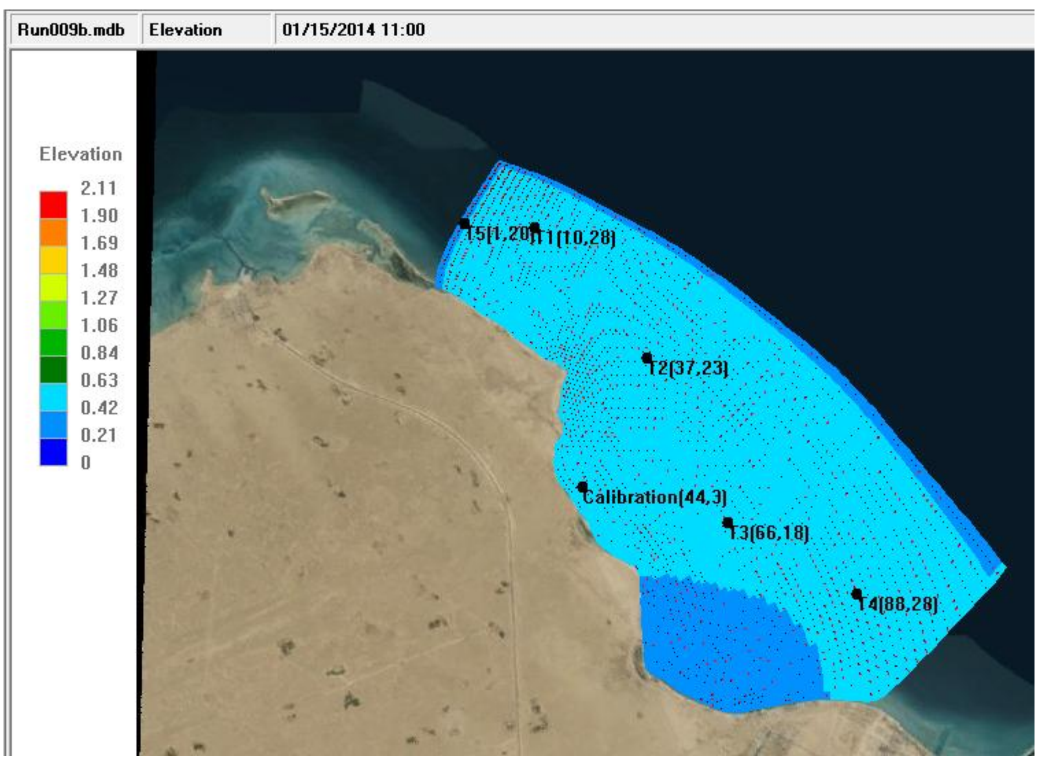
Appendix C.1: Temperature simulation outputs

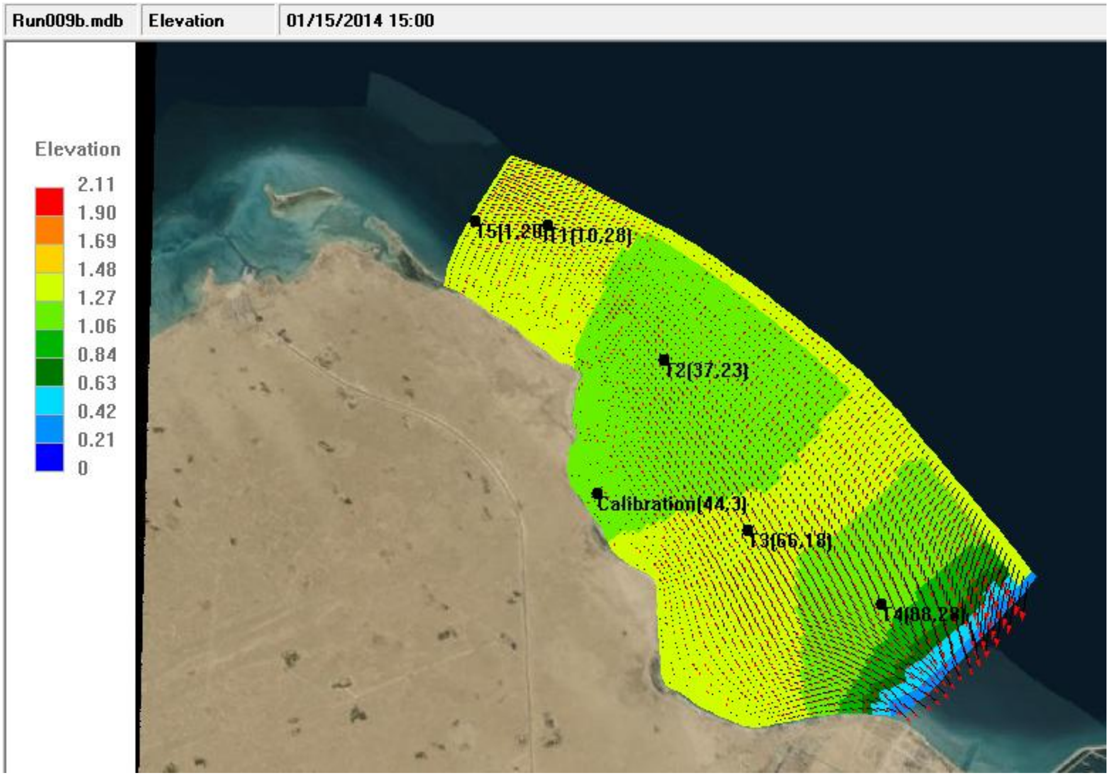
simulation for 2nd of January 2014



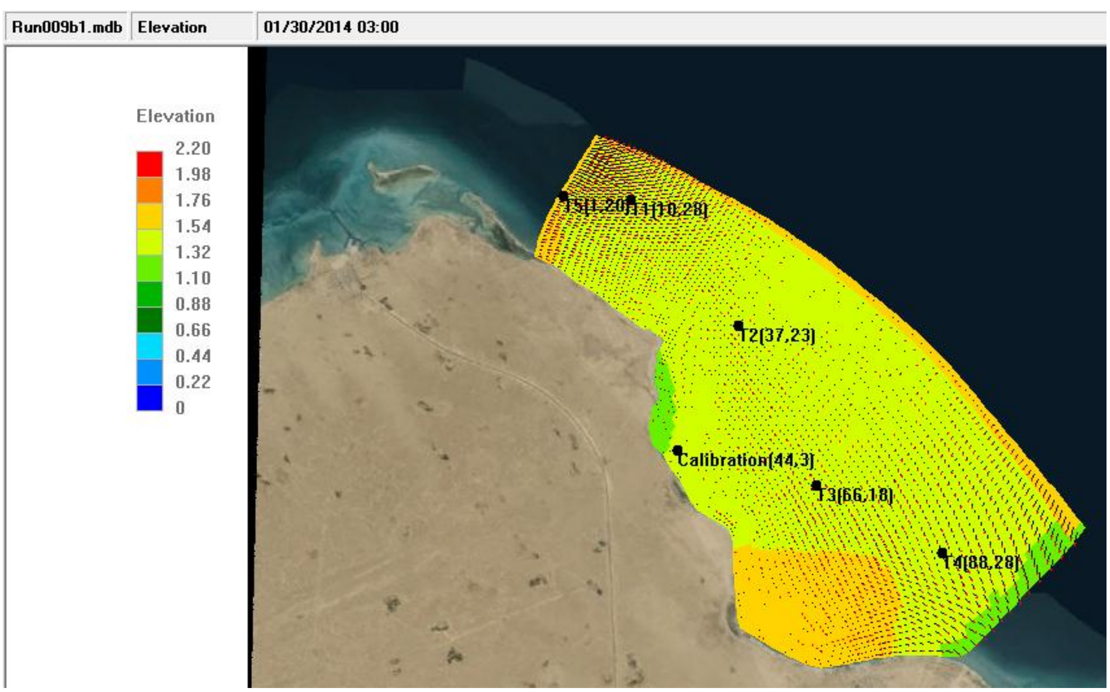


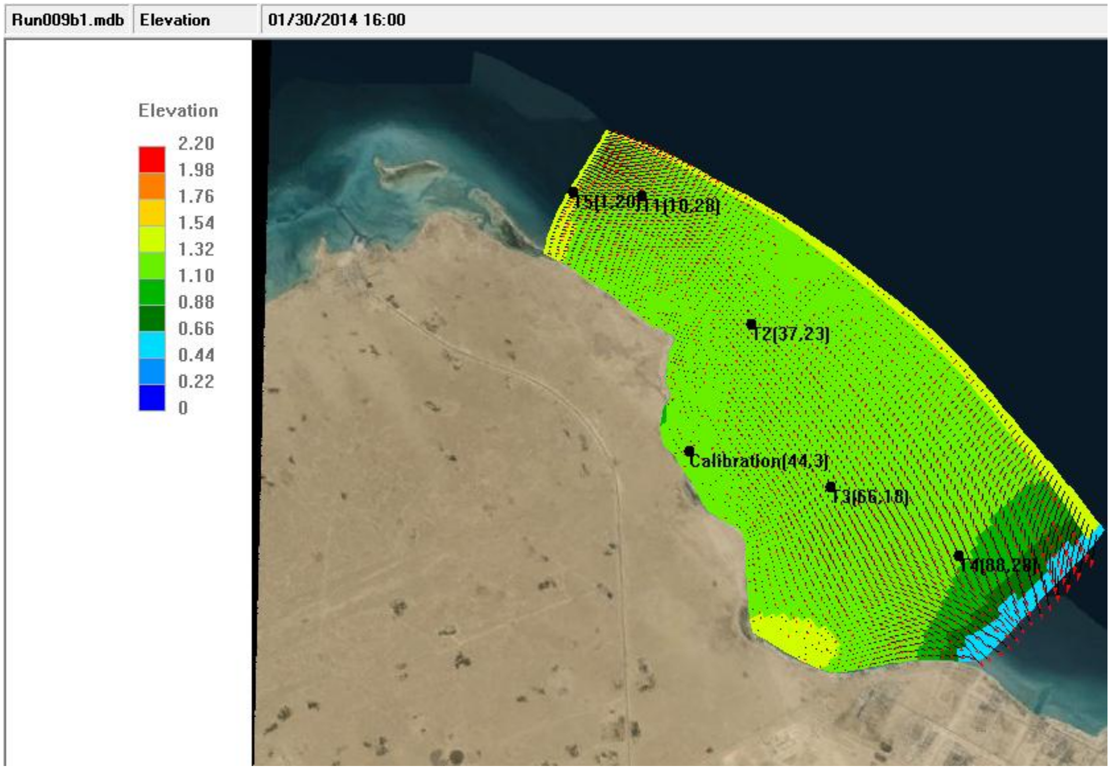
simulation for 15th of January 2014





simulation for 30th of January 2014





Appendix C.2: Surface elevation and average velocity simulation outputs