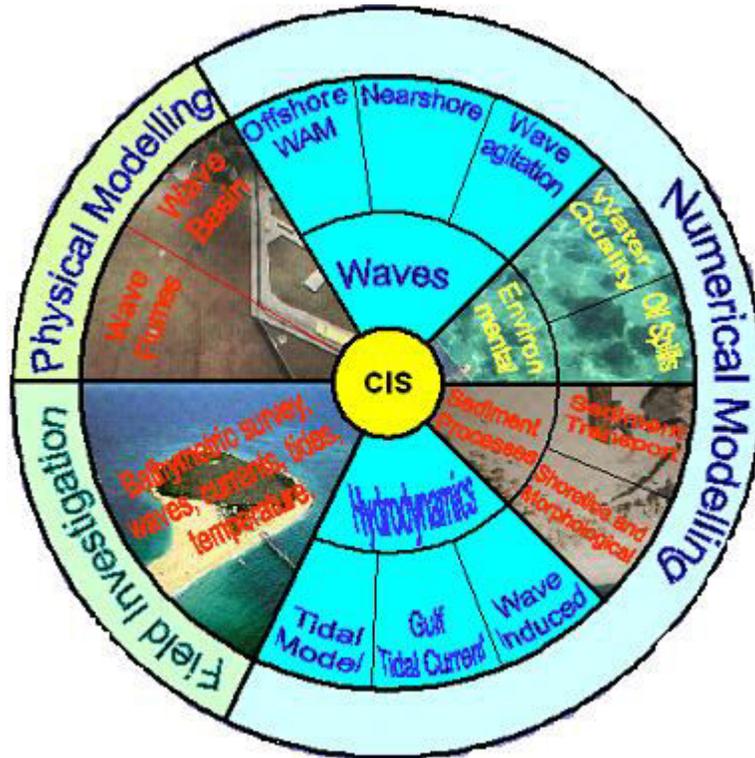# H.C.A

Description Manual For
Hydraulics and Coastal Application Programs

H.C.A.

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COASTAL MANAGEMENT PROGRAM
KUWAIT INSTITUTE FOR SCIENTIFIC RESEARCH

Table

1. Introduction

The shorelines of Kuwait extend over a distance of about 500 km. Marinas, harbours, ports, power plants, and other projects are being constructed or planned in the near shore area. Such projects require data on the extreme wave conditions for the design of the coastal structures. Yearly average wave conditions are also important for the prediction of the wave induced currents. These currents are important for the prediction of the sediment transport rates in the surf zone. The calculation of the littoral drift is essential for the prediction of the shoreline changes due to any proposed structure in the near shore area. This data will be very important for the design of the future extensions of the water front along the shorelines of Kuwait. The tidal currents are also essential in predicting the fate of any oil spill in the marine environment or in predicting the water quality.

Such projects require data on the water levels, the currents, and the extreme wave conditions for the design of the coastal structures. The risk associated with different extreme wave conditions is also essential for the proper design of coastal structures. Thus, it is essential to know the risk of failure for any coastal structures.

No long term wave or current measurements exist for the Kuwaiti territorial waters. The long term wave data available along the shorelines of Kuwait are based on simplistic empirical wave hindcast formulas (KWave model by Al-Salem 2005). These formulas assume a stationary and homogeneous wind speed over the Gulf. Such formulas provide realistic data as will be discussed later.

Finally, all the coastal model were stored in a (Hydraulics and coastal application system HCA by Al-Salem K.) developed in a different of programing codes as:

- Visual Fortran F90
- Visual Basic 6.0
- Script coding For Surfer Utility
- Active server page (ASP) web coding
- Objective C++ for Mobile coding

These models provide for a user friendly tool for solving coastal engineering application.

2. Hydraulics and Costal Hydrodynamic s application
2.1. 1D/2D hydrodynamic model; KGulf model
[Khaled Al-Salem 2009] (Pc Version)

Hydrodynamic models (HD) represent the core of any simulation for flow field, water quality, erosion and siltation, and morphological studies. HD models vary from fully three dimensional (3D) to simpler one dimensional (1D) models. For such models they may differ in the choice of the numerical grid, the discritization method, the time difference scheme, the solution technique, and the treatment of boundary conditions. Finite difference models using Cartesian grids require the application of several nested models in order to model a certain area with a fine grid. Finite element models have the advantage that an unstructured grid can be used thus providing fine grid resolution in the areas of interest only. But the disadvantage with this method is that the computation takes much time for simulation. A new Tidal Current prediction technique is developed for hind-cast, now-cast and forecasting of Tidal current conditions over the Kuwaiti territorial water and the Arabian Gulf. It is an interactive online model. The computer simulation time required for this model technique for Tidal Current history prediction in very little. The

present technique is validated with RMA 10 model and with measured field data. The model is named as KGulf model developed by [Al-Salem 2009]

Model Description
In this study, the KGulf model was developed and set up for the Arabian Gulf and Kuwait territorial waters. The KGulf model is a two dimensional (2D) and is based on the calculated grid constituents values, which is stored and linked as database to the model. The model is capable of simulating 2D tidal current and water level at any selected grid inside the Arabian Gulf waters starting from the year 1970 to 2035 with hourly output results.

Model Setup
Grid was generated covering the Arabian Gulf from the Hormoz inlet till the upper part of the Gulf (Fig. 1). The grid spacing is about 5-8 km in the Arabian Gulf as show in Fig. 1 with a total of 3692 wet grid inside the Gulf. For some local areas in Kuwait the refined grid spacing reached less than 50 m (Fig.1) with total wet refined grid of about 9696 and 7346 grids. For more refine grid inside Kuwaiti territorial water and Arabian Gulf one can refer to Figs. A1, A2 and A2 list at the [Appendix Section 2.1].
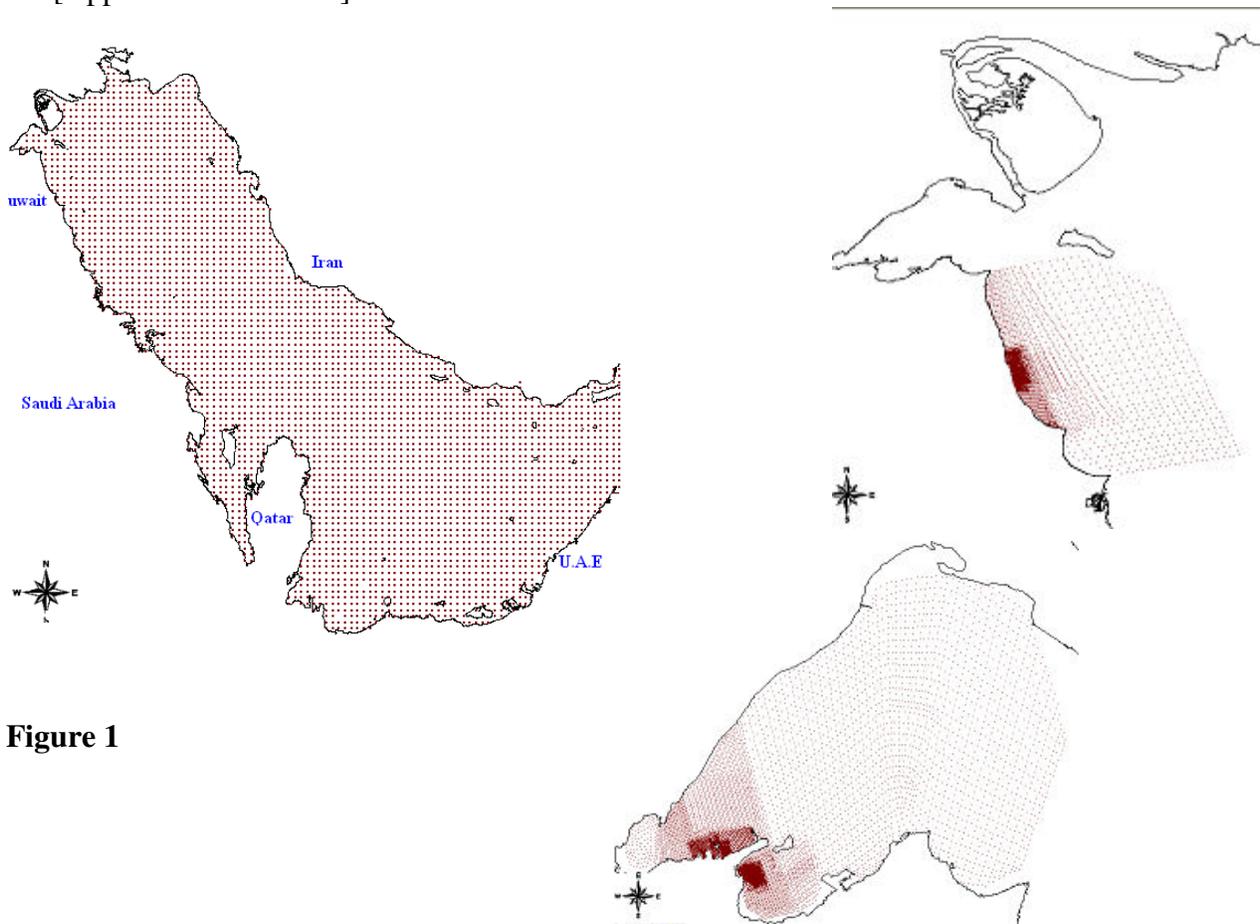
Figure 1

Model simulation options

KGulf model was developed and set up for the Arabian Gulf and Kuwait territorial waters with multi grid system for solving hydraulic engineering application as the following:

- 1D/2D tidal current speed and direction hourly perdition
- 1D/2D tide Level hourly prediction and Water level analysis
- Trajectory Oil spill prediction [see section 3 P50]
- Back Track Oil Spill [see section 3 P59]

To start simulate the KGulf model user must select [🌀] to stat the model Fig 2 will display the following input Option for user to state as follows:

For 1D tidal Current and water level Prediction

I.   Domain Grid Selection; to grid size resolution and Area.

II.   Domain Limit, shows the selected area coordinates in degrees.

III.   For 1D option user must select longitude/Latitude location if two method
      1- Display map option from [MAP] the click on the map to get Location.
      2-Manuly input the Longitude/Latitude then select [**C**]

IV.   User Must Select [*Prediction Type*]. A two option will display as following
      1- 24 hours prediction   as shown in Fig 3
      2- Time Serious prediction as shown in Fig 3
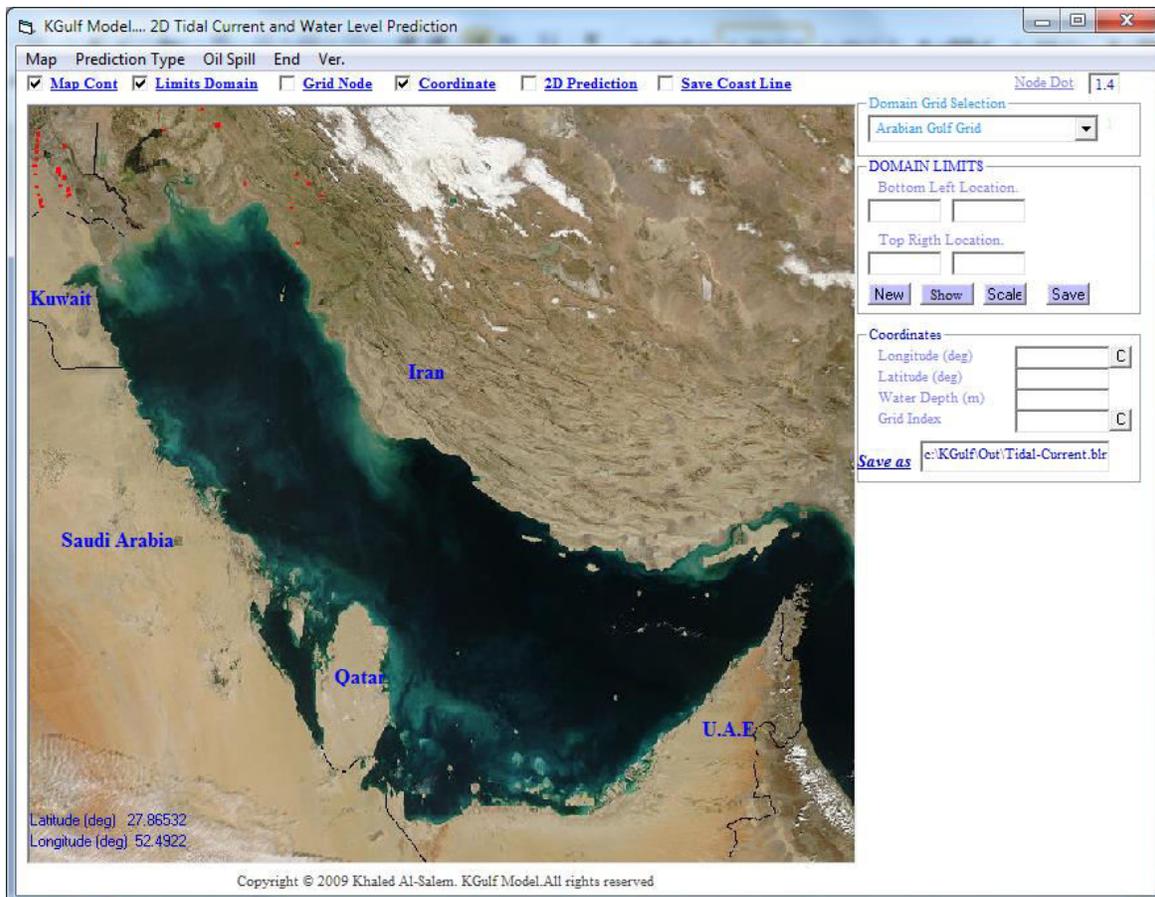
Figure 2

From Fig 3 user must select [2**4 Hours Prediction**] based on Calculated datum.
Start predict 1D hourly tidal Current and Direction and Water Level for the Current day as
display in Figure 4 If user want to change the Date for prediction must Check the [*DATE*] from
Fig 4. A new Frame of Date Select will display to enter data .As Shown in Fig 4.
User can covert Water level Prediction To MEAN SEA LEVEL by check on CheckBox [*WL*].
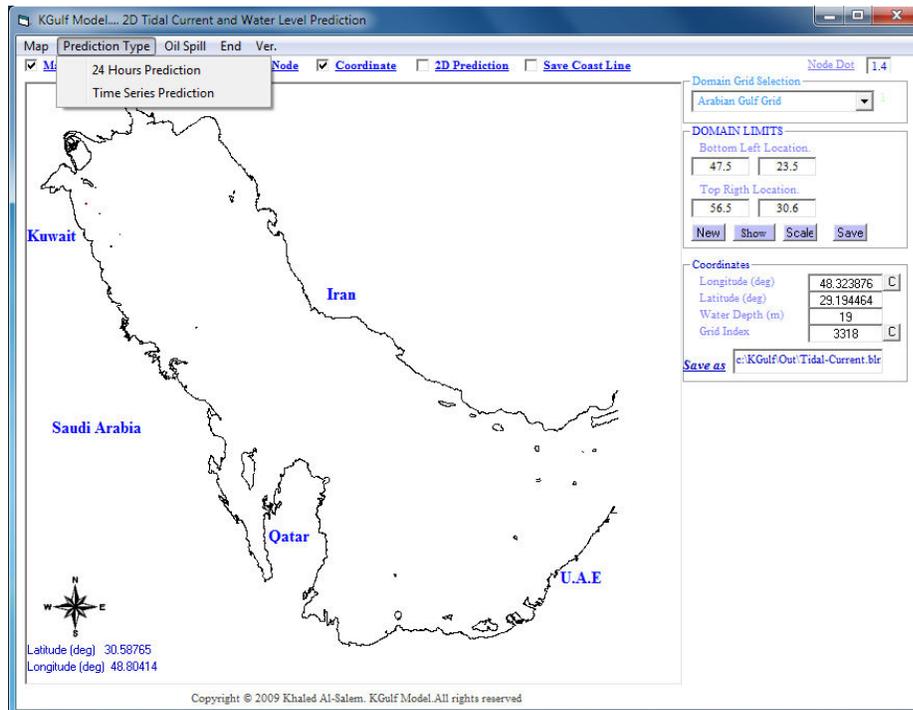
Figure 3
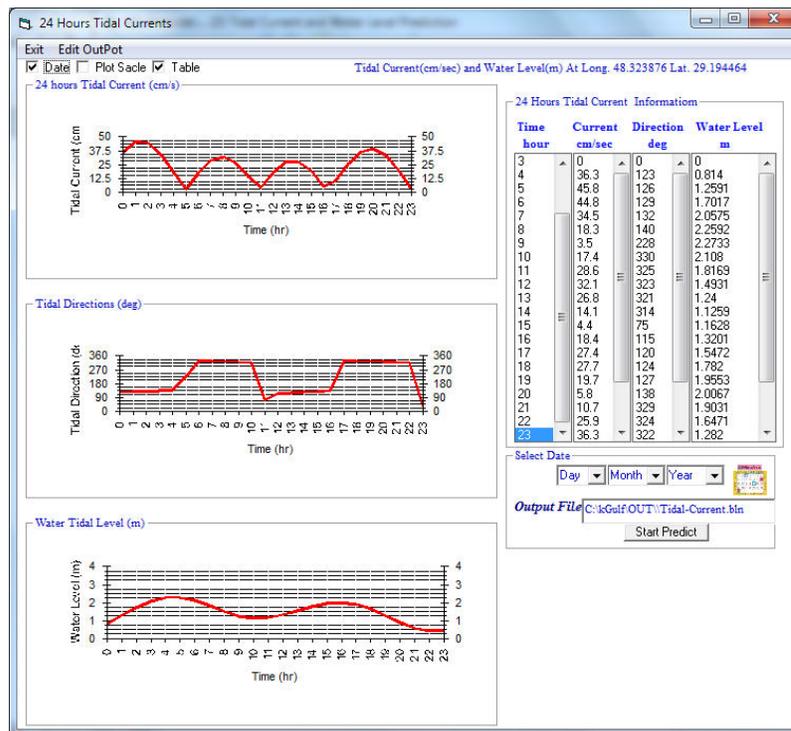
Figure 4

For 1D tidal Current and water level Prediction [Time Serous prediction]

Domain Grid Selection; to grid size resolution and Area.

Domain Limit, shows the selected area coordinates in degrees.

      For 1D option user must select longitude/Latitude location if two method

        1- Display map option from [MAP] the click on the map to get Location.

        2-Manuly input the Longitude/Latitude then select [**C**]

User Must Select [***Prediction Type***] Time Serious prediction as shown in Fig 5 To user to enter the require input as

    1- Start Date

    2- End Date

    3- Water Level base on calculated datum Check box [**WL**] is OFF.

      Water Level based MEAN SEA Level Reference [**WL**] is ON

Then user selct [***Predict***]. A three graphs will display as shown in Fig 5 as follows:

  1- Tidal Current VS Time

  2- Tidal Direction VS Time

  3- Tide Level VS Time
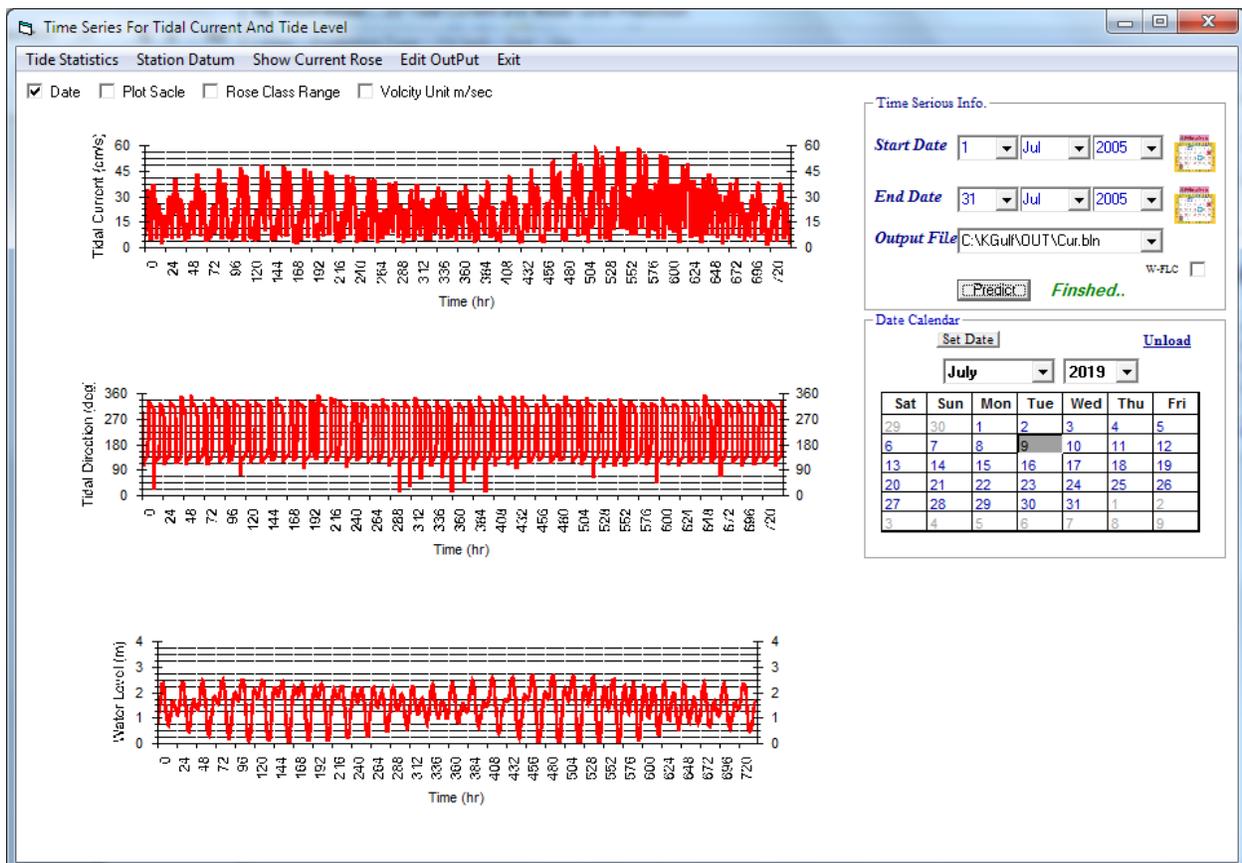
Figure 5

From Fig 5 a two Analysis option as follows:
1- [*Station Datum analysis*]. Figure 6 display the station datum analysis
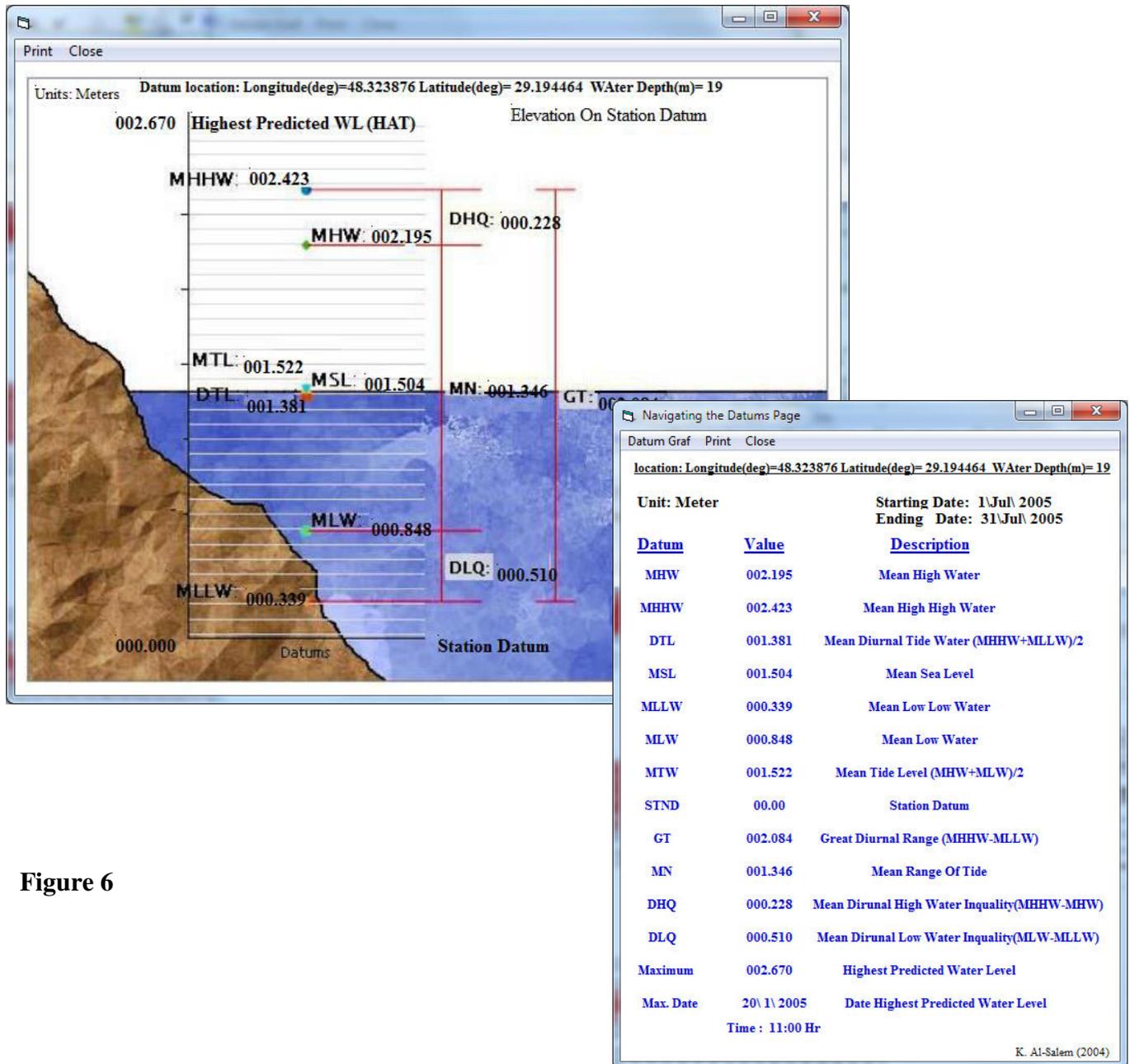
Figure 6

2- *[Show Current Rose*]. Will Display the Tidal Current analysis as follows
- Frequency Of Statistical Current Seep and Direction Tabel as shown in Fig 7
- Tidal Current Rose Plot as shown in Fig 8

Figure 7

K-Rose Statistical Table

Graph   Exit

Frequency of Statistical Current Speed and Direction
DATA SHOWN IN PERCENT OF OCCURRENCES

CURRENT SPEED CLASSES (cm/s)

Direction	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	>-55	
E	000.94	001.88	000.81	000.13	000.00	000.00	000.00	000.00	000.00	000.00	000.00	3.76
NE	001.08	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	1.08
N	000.81	001.75	001.48	000.40	000.00	000.00	000.00	000.00	000.00	000.00	000.00	4.44
NW	000.67	003.23	004.30	006.45	008.33	006.45	004.70	003.76	002.55	001.21	000.81	42.47
W	001.61	001.21	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	2.82
SW	001.34	000.13	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	1.48
S	001.88	001.08	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	2.96
SE	000.94	003.90	006.18	004.84	004.30	004.84	003.63	005.38	002.42	002.69	001.88	40.99

Total (%) =   100.000

KGulfMODEL 2009 K. AL-SALEM

Figure 8

Current Rose

2D Tidal Current and Water Level Prediction
KGulf Model

TIDAL CURRENT (Cm/s)

0- 5   5- 10   10- 15   15- 20   20- 25   25- 30
30- 35   35- 40   40- 45   45- 50   >- 55 Cm/s

(KGulf Model 2009 K. AL-SALEM)

For 2 D tidal Current and water level Prediction

      I.   Domain Grid Selection; to grid size resolution and Area.

     II.   Domain Limit, shows the selected area coordinates in degrees.

    III.   For 2D option user must check on [2D Prediction] in Fig 9. A new Frame Box will display to input the require information as follows

        1- Enter the date for prediction

        2-Enetr the Hour in the Selected Date

Then user must select [***2D Predict***] Button. Figs 10, 11 and 12 will display for user for the following as :

-    Figure 10 for Tidal current at select Date and Hour
-    Figure 11 For Tide level at Select Date and hour
-    Figure 12 for Superimpose tidal current and water level at select date and hour.
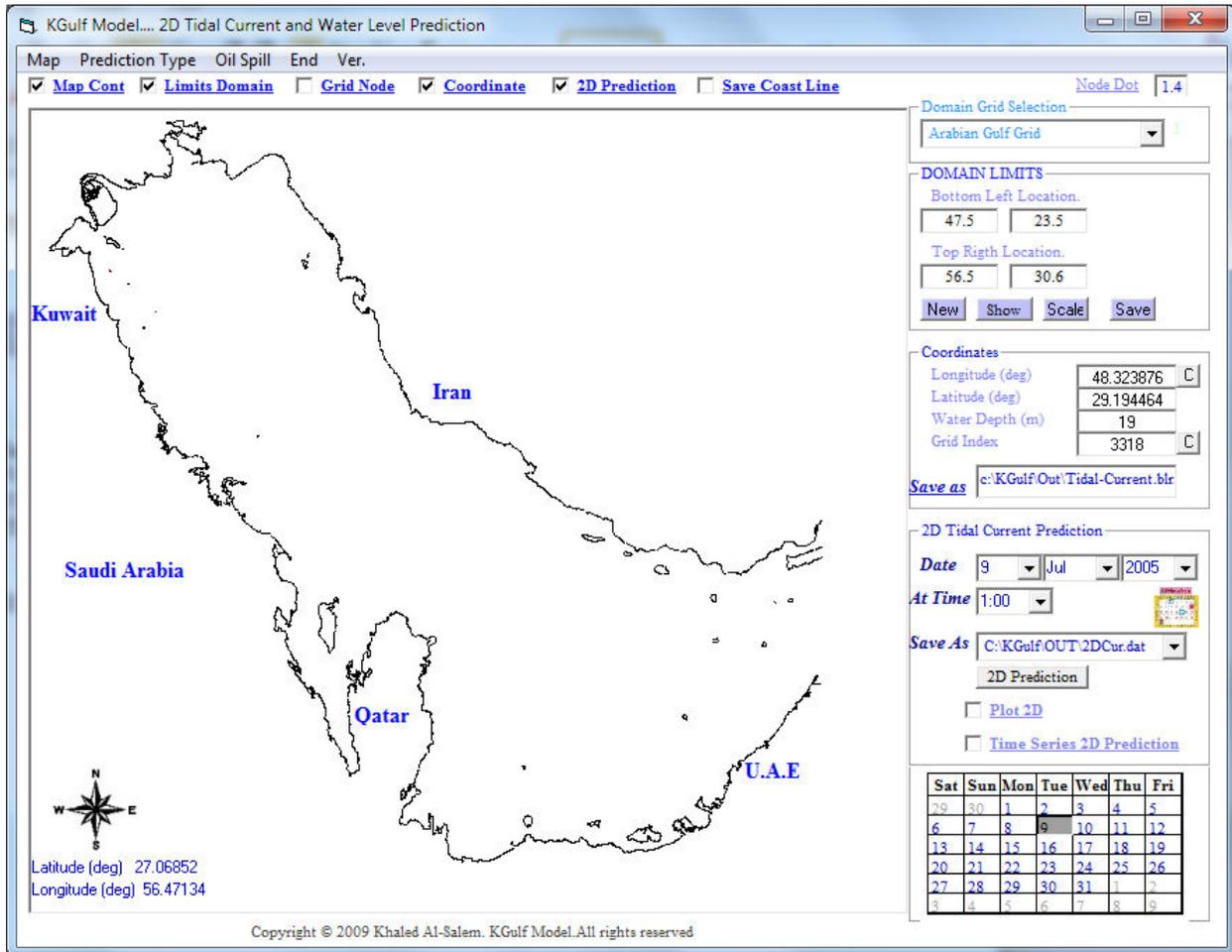
Figure 9
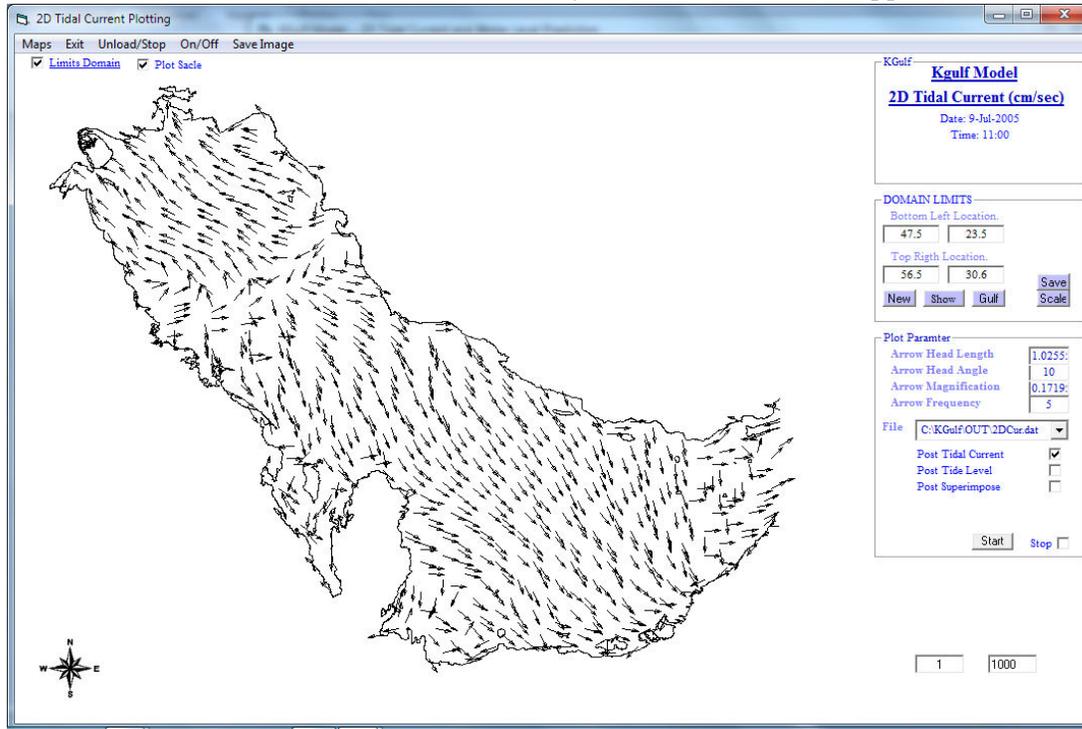
Figure 10
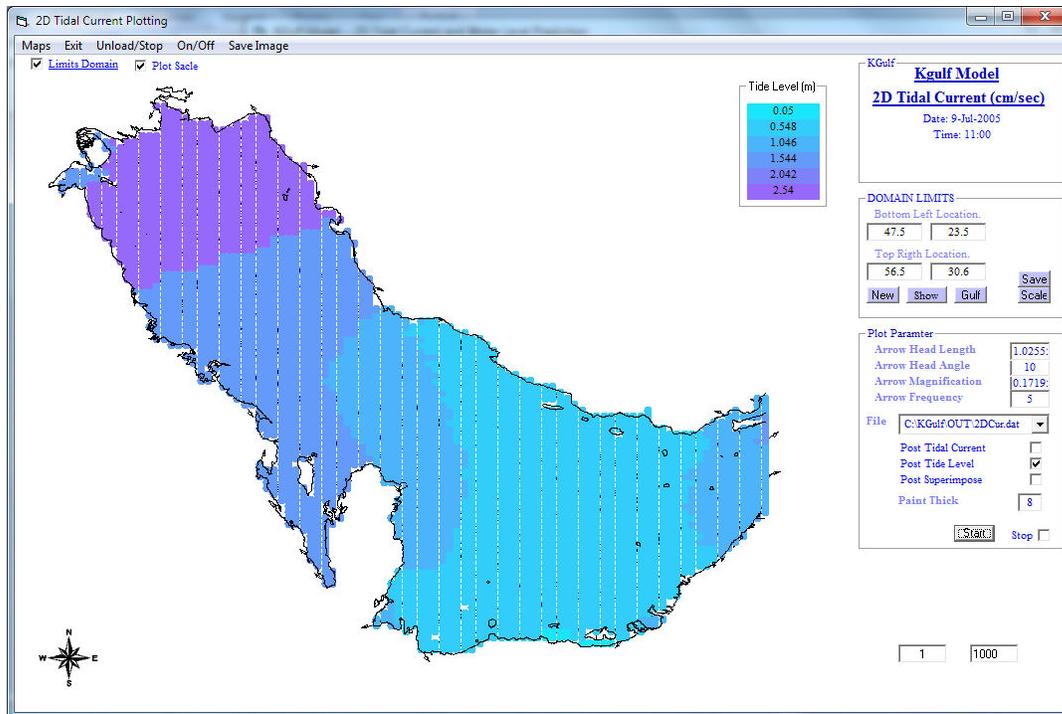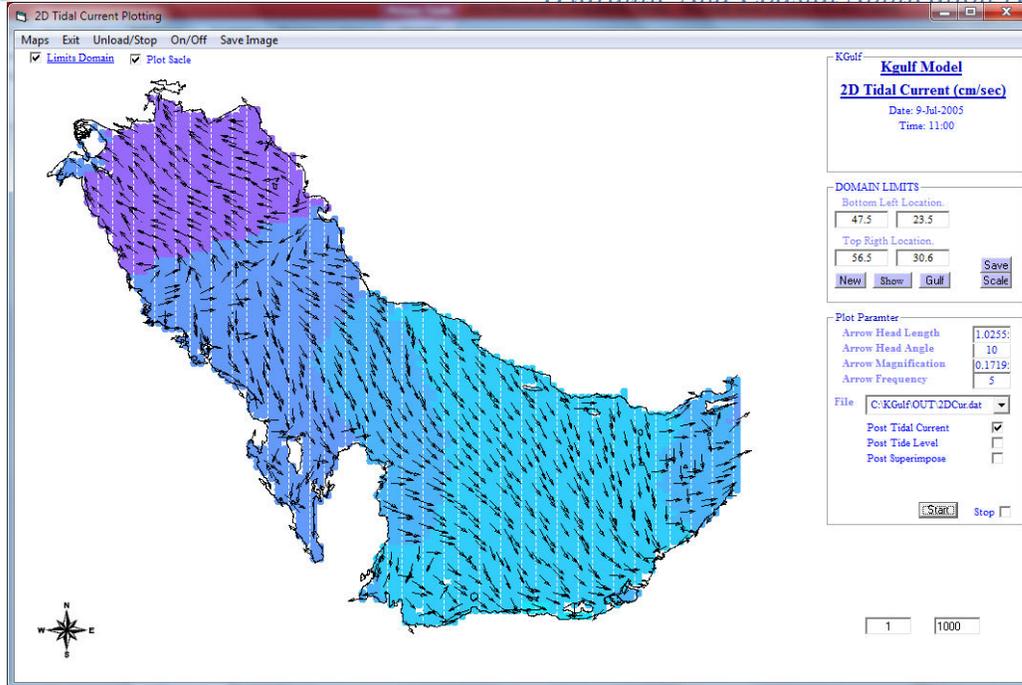
Figure 11

Figure 12

For 2 D tidal Current and water level Prediction [Time Serious prediction option]
  V.   Domain Grid Selection; to grid size resolution and Area.
  VI.   Domain Limit, shows the selected area coordinates in degrees.
  VII. For 2D prediction option user check on [[***2D Prediction***] in Fig 9
VIII.   For 2D time serious option user must check on [***Time Serious 2D Prediction***] in Fig 9.
  IX.   Figure 13 will display to input the require information as follows
          1- Enter the start and end date for prediction
          2-Enetr output file name
Then user must Select [***START***]
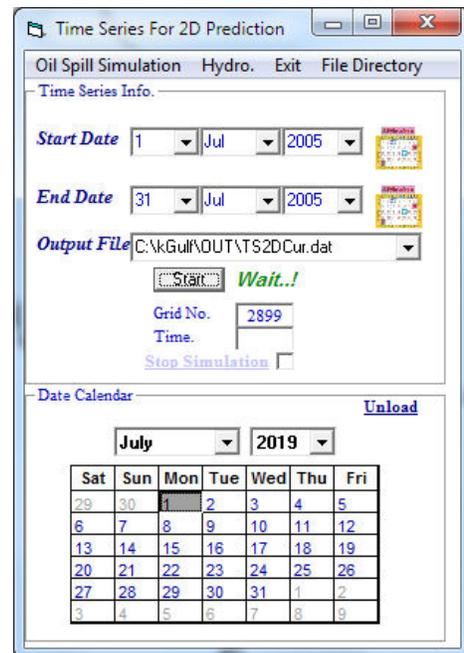
Figure 13

For output analysis; At Figure 13 user has to 2 options to select as follows:

 1- Hydrodynamic output display [**HYDRO**]

 2- Oil Spill Simulation **[Oil Spill Simulation**] *SEE Description in SECTION 3.0 Page 42*

If user select Hydrodynamic output display [**HYDRO**].

Figure 14 will display for user to start display 2D animation option for the results for:

 1- Tidal current Animation

 2- Water level Animation
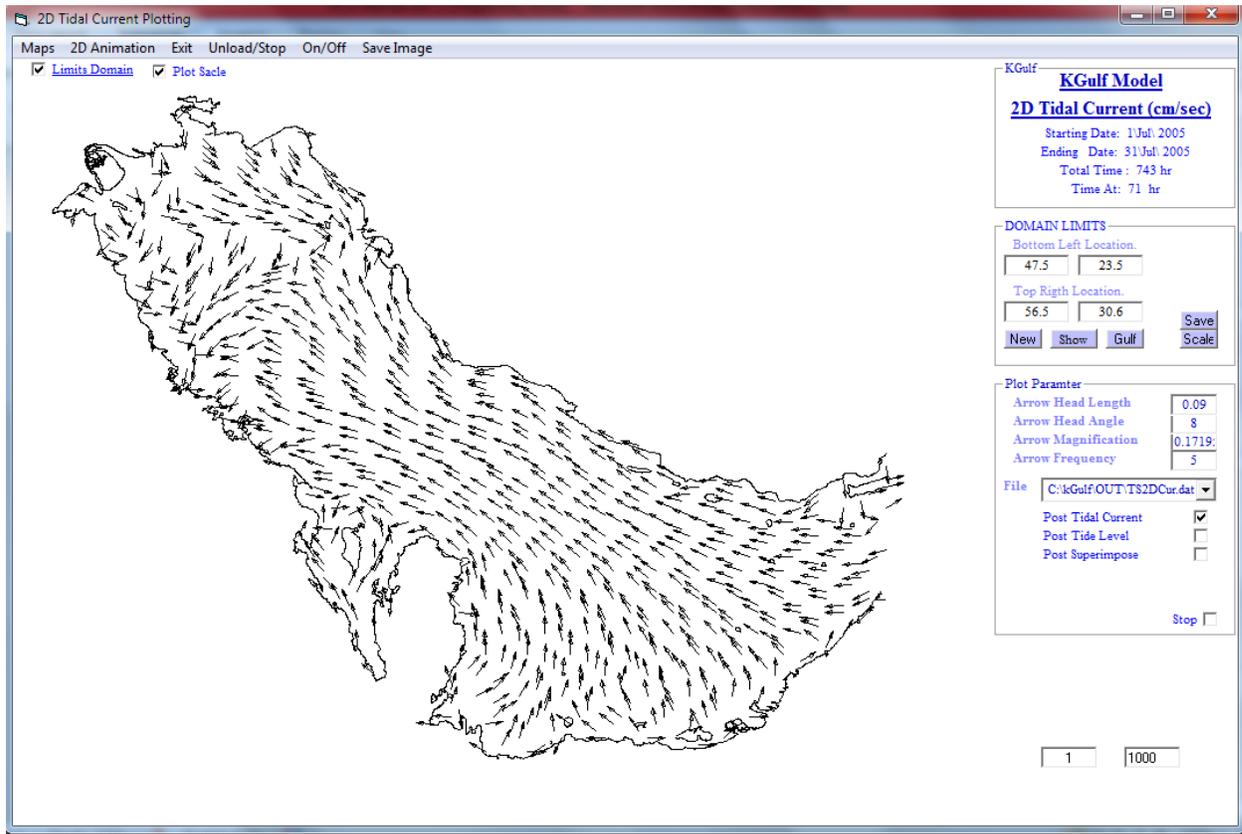
Figure 14

2.2 1D/2D hydrodynamic program (ver. 1) KCurrnt model

[Khaled Al-Salem 2005] (First Version of 2D tidal current program)

Introduction.

    A new Tidal Current prediction technique is developed for hind-cast, now-cast and forecasting of Tidal current conditions over the Kuwaiti territorial water and the Arabian gulf. It is an interactive, online model. The computer simulation time required for this new modeling technique for Tidal Current history prediction in very little. The present technique is validated and named as KCurrent model. The results of this technique are compared with RMA model results and are found to be good.

 The following files contain exetuable and linked data files for the KCurrent model:

    Kcurrent.exe -- VisualeBase source code Interface for tidal Current prediction.
    Cur-ADMequil.   – Fixed input data describing the Kuwait stations.
    Cur-gulf-ADMequil.   – Fixed input data describing the Arabian Gulf stations.

Procedure for Stand-Alone Usage of "KCurrent model"

    Kuwait Tidal Current model is an efficient and interactive model and easy to use for any user with a little experience in a computer usage. Although more advanced features are anticipated to evolve in the future, this version is sufficiently user-friendly and can provide the base information for water circulation for Kuwait Waters. The information provided by this model can be further used to calculate sediment/pollutant transport for Kuwait waters. In this section of the report, step-by-step instructions are given for use of KCurrent model. The procedure outlined here to run the model, click on (KCurrent Tide) icon. Fig.15 will display for user three option to select as:

                Option 1.Kuwait water
                Option 2.Arabian Gulf
                Option 3.Time Series
                Option 4 2D Prediction

    If user select option 1 (Kuwait Waters) as shown in fig 15 before select Kuwait waters user must select the Location from the map shown in fig. 15 by using the mouse. Click on the interest location, fig.16 will display to check the selected location.

Figure 15

Figure 16

Then user should select **Kuwait Waters** to run the tidal current prediction model to forecast the 24 hours for the current date then displayed the 24 hours forecasting table as shown in fig.17.
 Then if user wants to display the 24 hours tidal current forecasting information as in graphically form user should select **Show Graphic form** fig. 18 will display the tidal current plot.

Figure 17

Figure 18

If user want to HindCast , Nowcast , Forecast or change location should select **Predicted Current** as shown in fig. 17. Then fig.19 will display two sub-option as:

        1-Select Date

        2-Select Station (long/lat)

User should select first Sub-option 1 **Select Date** to setup the prediction Date from (1 Jan 1970) until (31 Dec 2037) as shown in fig 20.

Then user should select Sub-option 2 **Select Station** to change a different location for tidal prediction (based on Longitude and Latitude in Degrees) as shown in fig 20.

Then fig. 21 will display the tidal current predicted information.
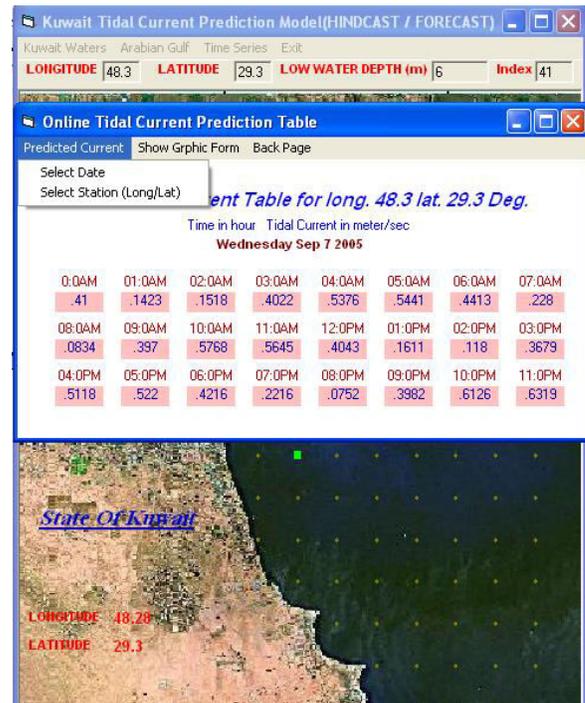
Figure 19
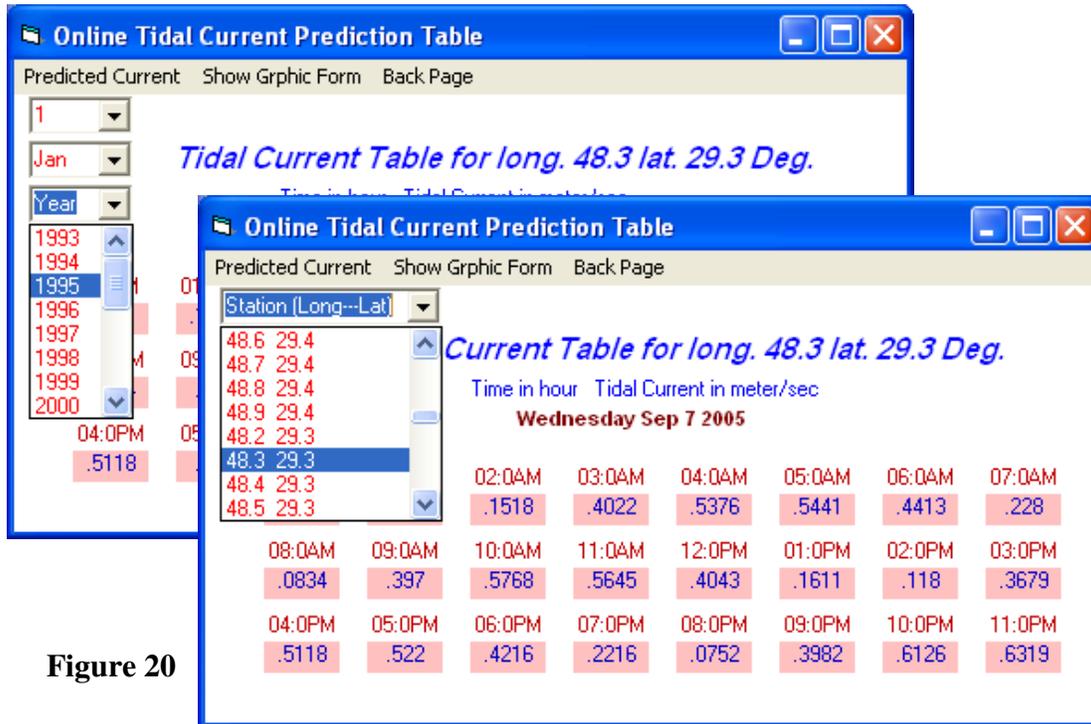
Figure 20
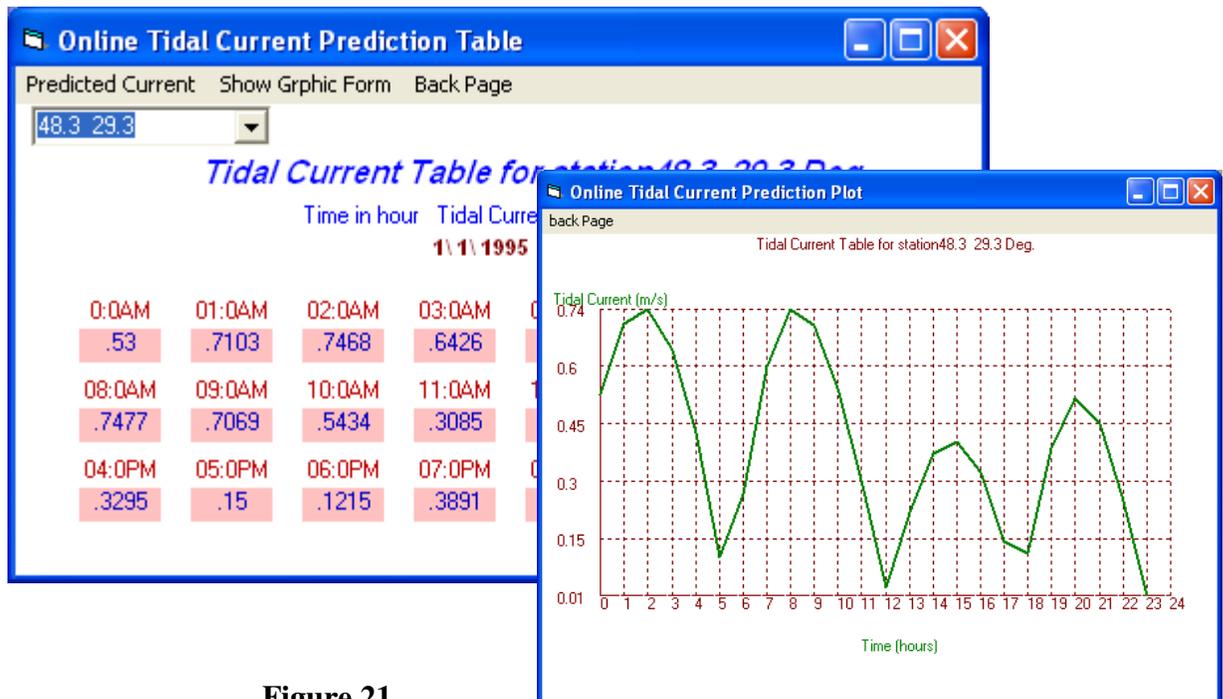
Figure 21

If user selects **option 2 (Arabian Gulf)** as shown in fig 15. Figure 22 will display the Arabian Gulf Map for user to select the interest Location from the map shown in fig.22 by using the mouse. Click on the interest location, fig.23 will display to check the selected location.
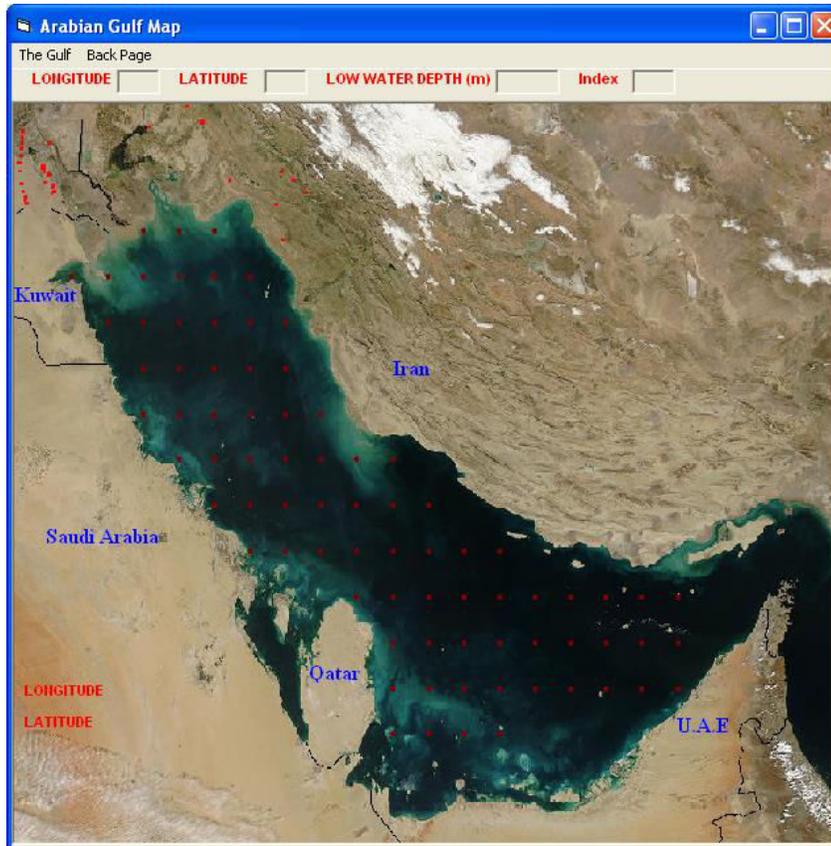
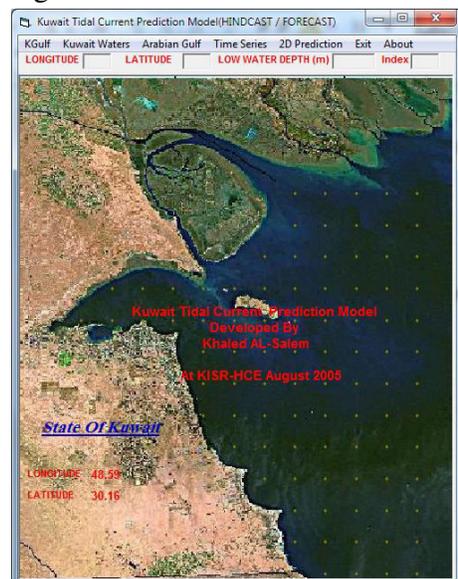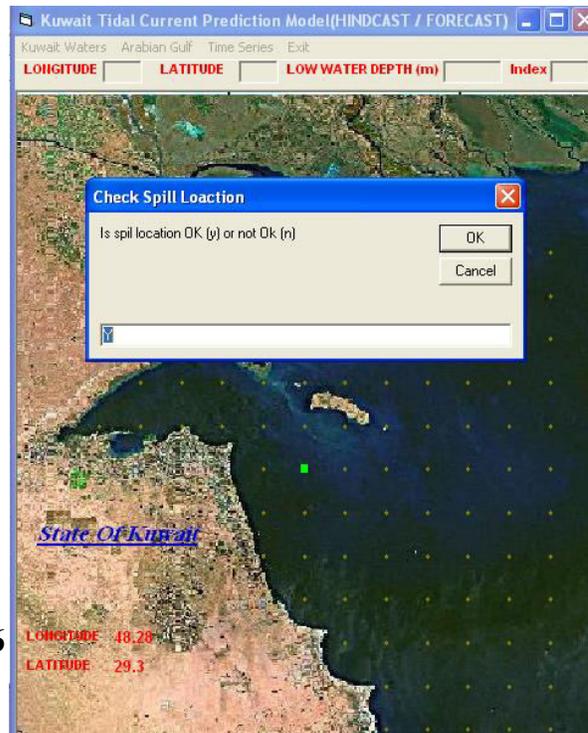**Fig. 22**

Then user should select **The Gulf** to run the tidal current prediction model to forecast the 24 hours for the current date then displayed the 24 hours forecasting table as shown in fig.24.

Then if user wants to display the 24 hours tidal current forecasting information as in graphically form user should select **Show Graphic form** as shown in fig. 24. Fig 25 will display the tidal current plot.
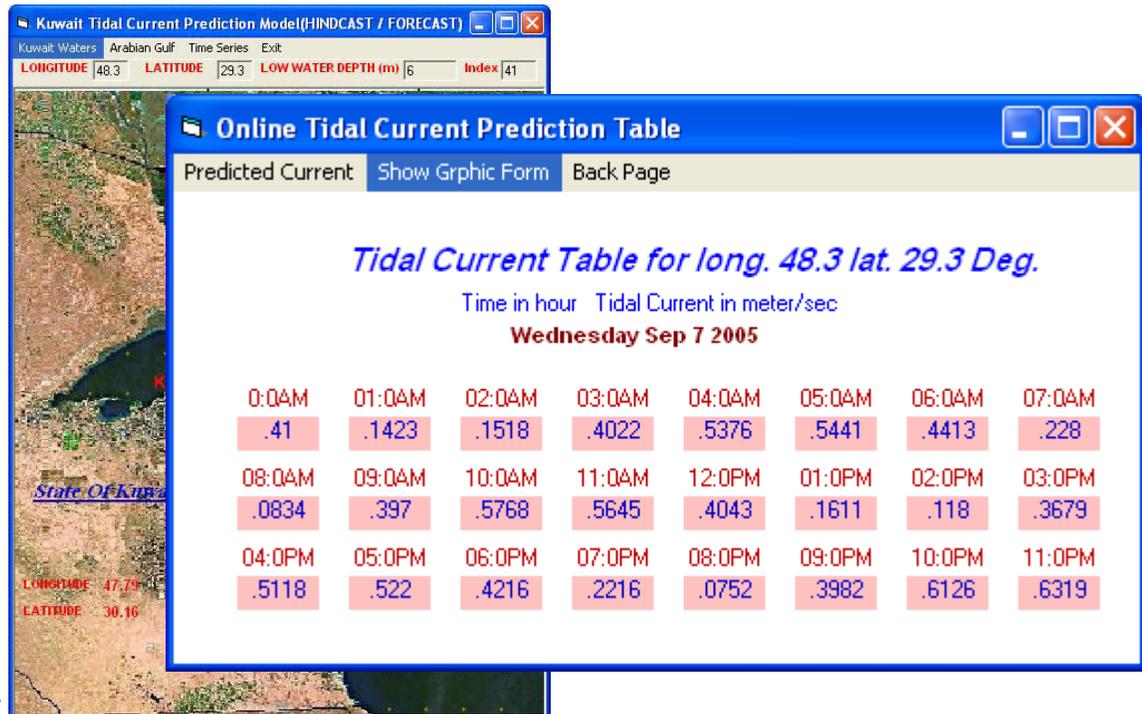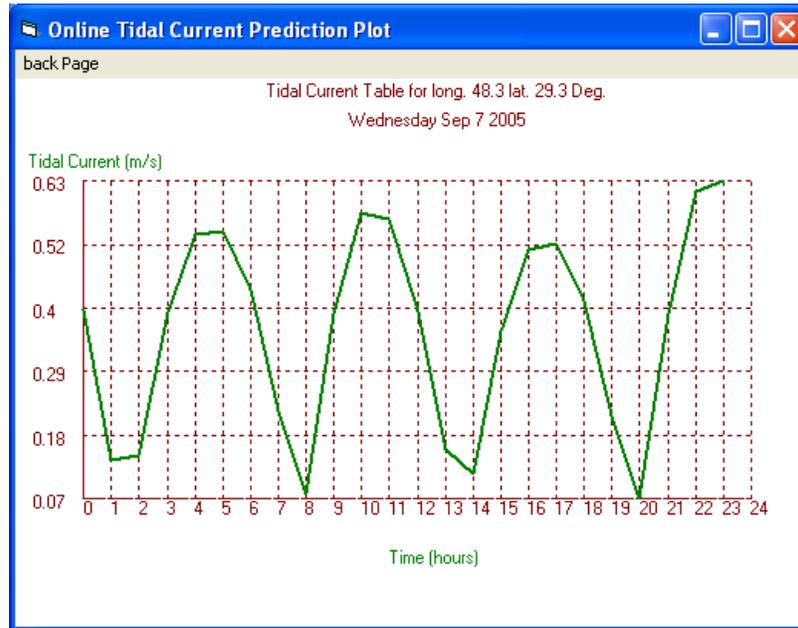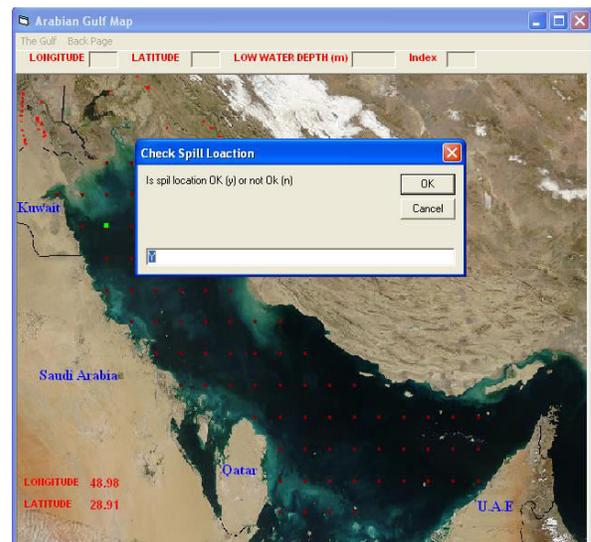

Figure 23
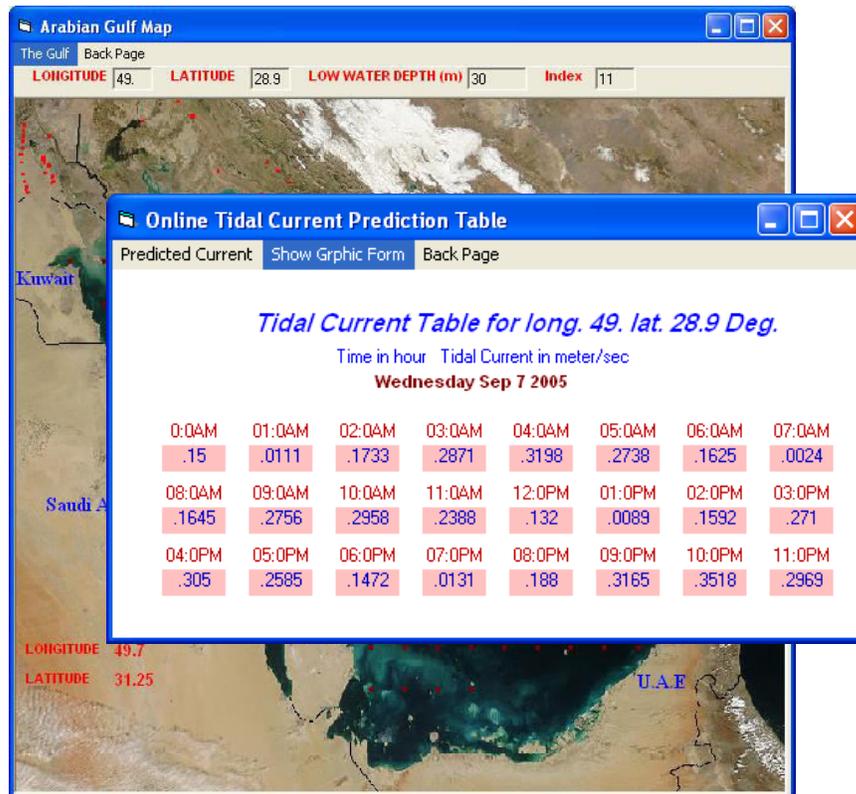
Figure 24
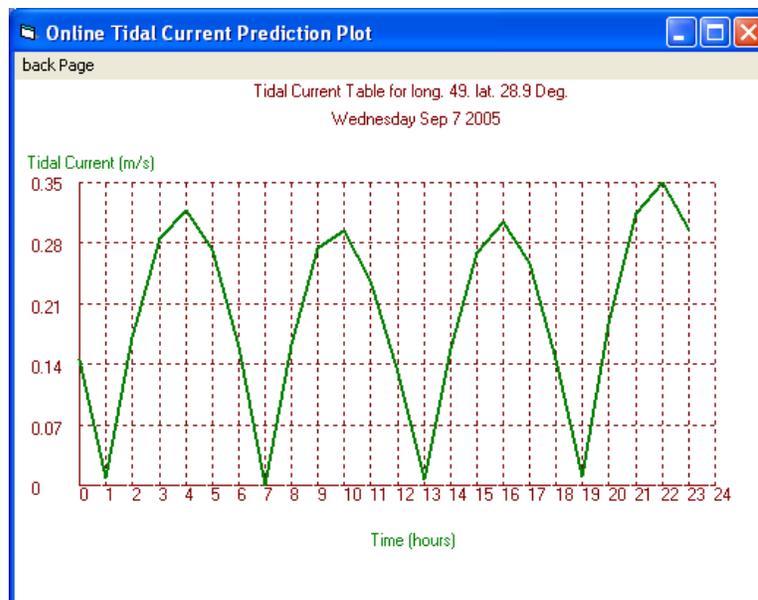
Figure 25

If user want to HindCast , Nowcast , Forecast or change location should select **Predicted Current** as shown in fig.26. Then fig.27 will display two sub-option as:

1-Select Date

2-Select Station (long/lat)

User should select first Sub-option 1 **Select Date** to setup the prediction Date from (1 Jan 1970) until (31 Dec 2037) as shown in fig 27.

Then user should select Sub-option 2 **Select Station** to change a different location for tidal prediction (based on Longitude and Latitude in Degrees) as shown in fig 27.

Then fig. 27 will display the tidal current predicted information.
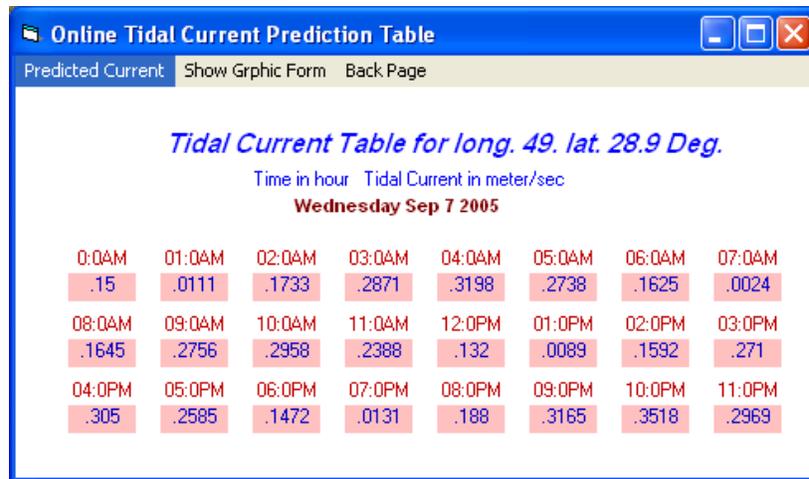
Figure 26
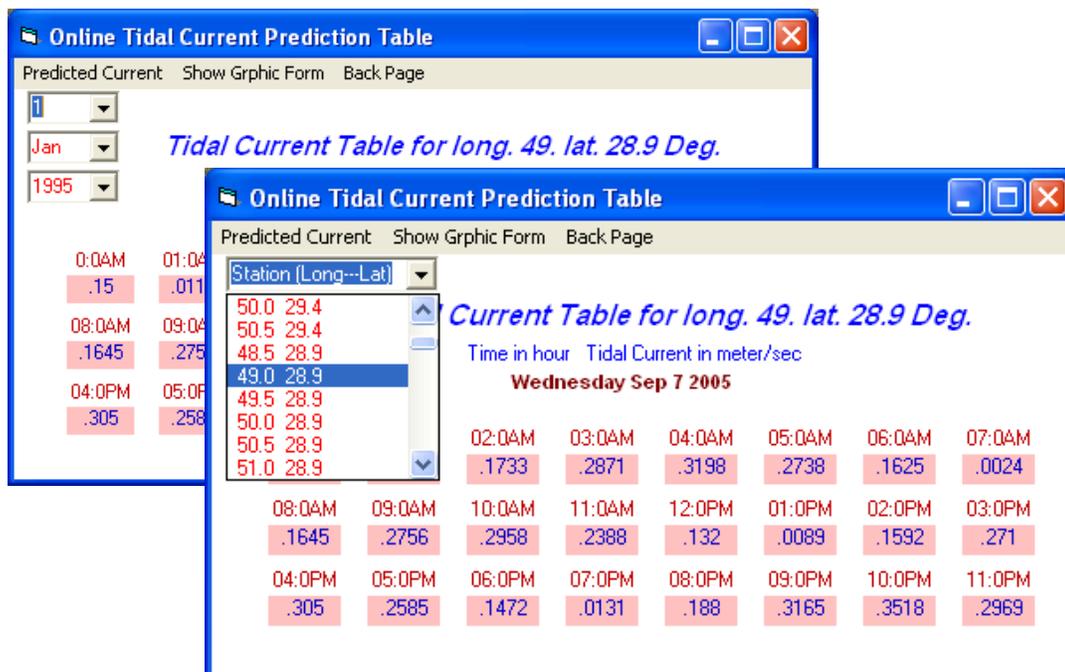
Figure 27

If user select **Option 3.Time Series** as shown in fig 28. Fig 29 will display for user to enter the request input data as:

1. User must select (the area for prediction ether Kuwait waters or Arabian Gulf)
2. Enter the location in (longitude/latitude) in degree.
3. Input Staring Date for prediction as (Day/Month/Year)
4. Input End Date for prediction as (Day/Month/year)
5. Output File Name must be entered.

Fig . 29 display the input information for prediction; Then User must select **Run** as shown in fig. 29 to start tidal current prediction for the Selected time period.
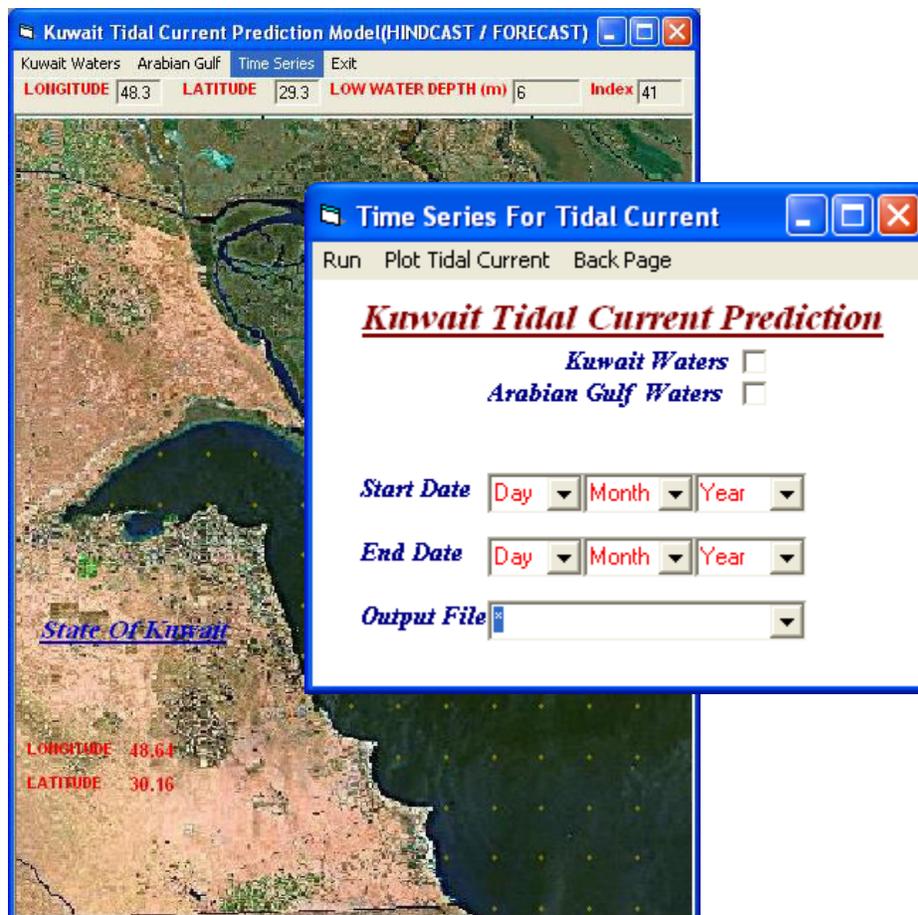
Figure 28

Then if user wants to display the tidal current information as in graphically form user should select **Plot Tidal Current** as shown in fig. 29. Fig 30 will display the tidal current plot.
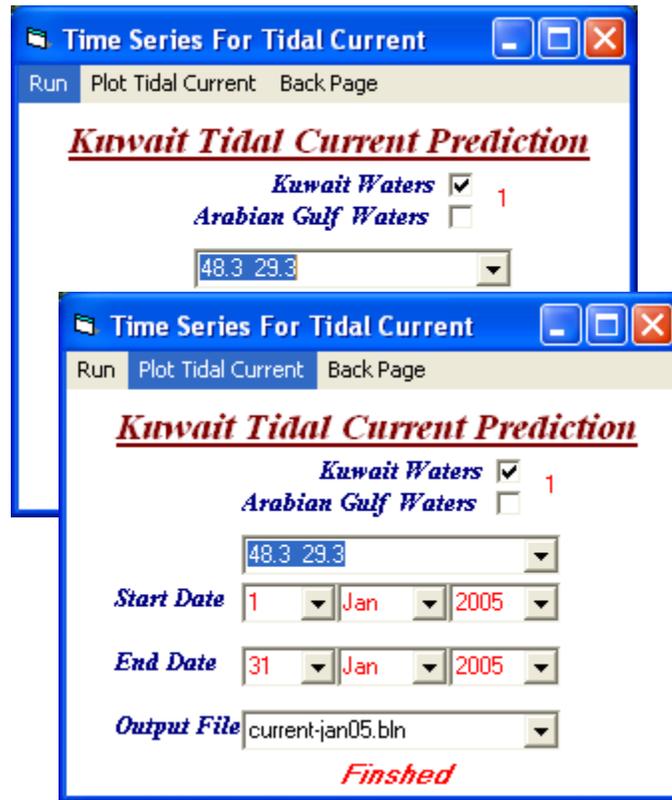
Figure 29
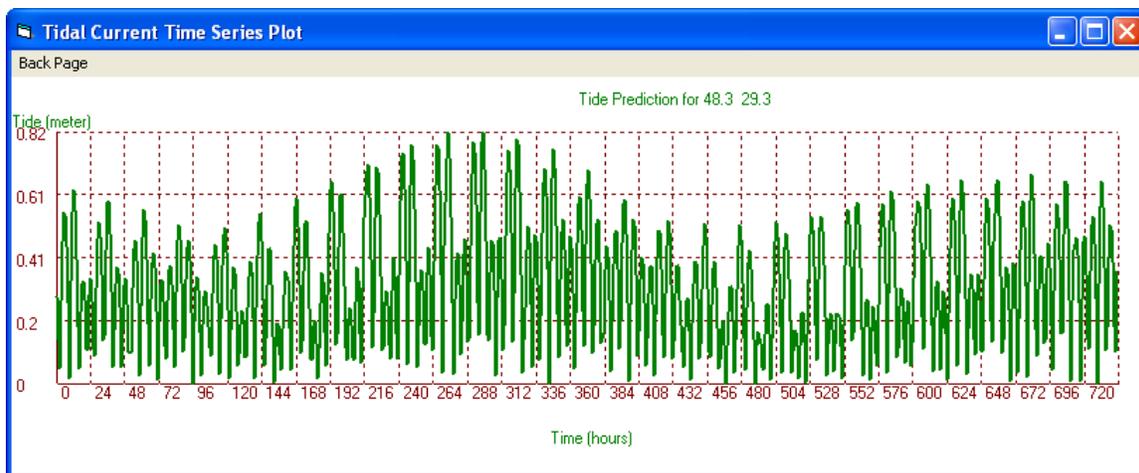
Figure 30

If user select **Option 4.**
[*2D prediction*] as shown in fig 15. Fig 31 will display for user to enter the require input as follows:

    1- Enter The date
    2- Enter The hour in the selected date
    3-Enter Output file name

To display the 2D tidal current by select [*Plot 2D Tidal current into SUFER*] as shown in Fig 32.
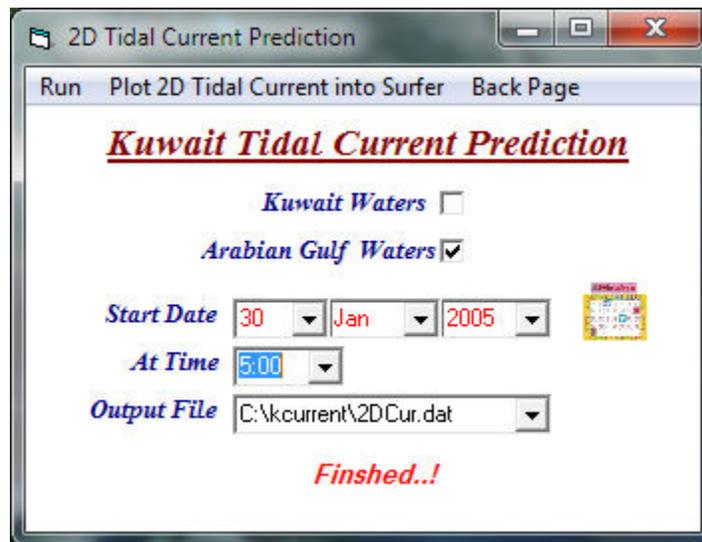
Figure 31
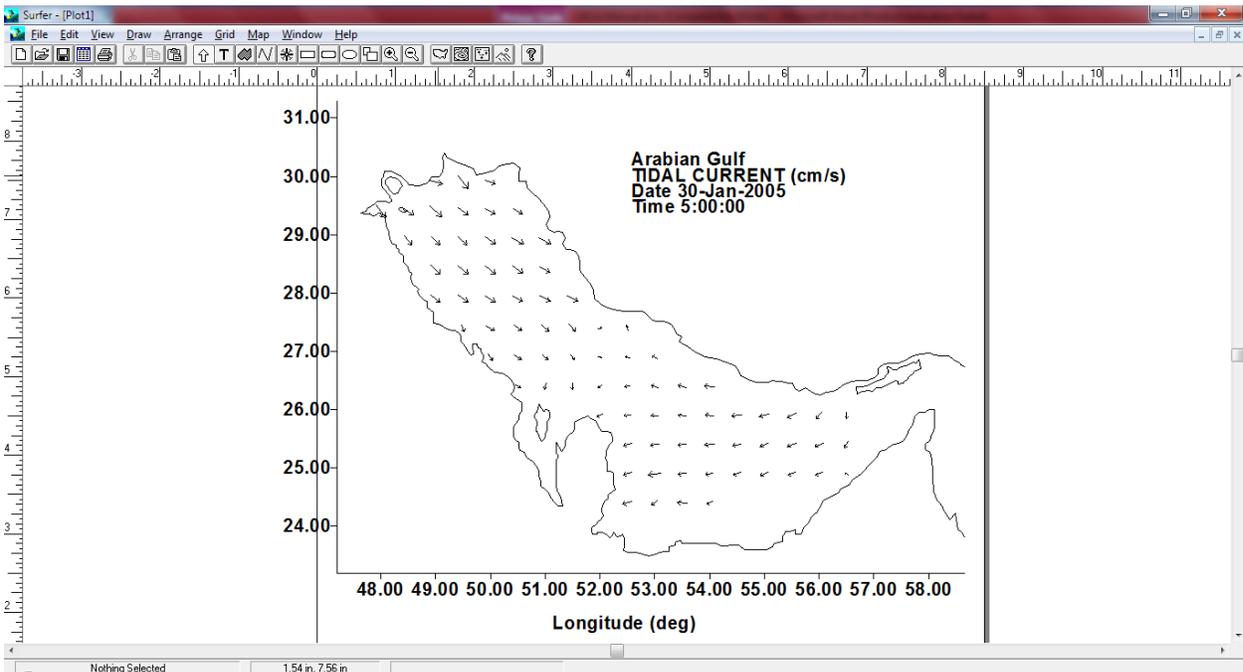
Figure 32

2.3 Water level prediction for Arabian Gulf ,KTide model

[Khaled Al-Salem 2005] (Pc Version)

Model Description

The Tidecalc software, which is a version of the tidal prediction program developed by United Kingdom's Hydrographic Office for publication in the Admiralty Tide Tables, is used at the Coastal and Air pollution Department (CAD) of KISR to predict the water level variations at different locations in Kuwaiti territorial waters. The data set generated using the Tidecalc software covers only a maximum of 3 days. For driving the Tidal Current model, it is essential to have a tool capable of generating tides for longer periods and in a suitable format that can be used directly into other models. For this purpose the KTIDE model was developed by (Al-Salem K., 2004) for Kuwaiti territorial waters and the Arabian Gulf. The KTIDE model predicts the tides from the following equation,

$$H(t) = H_o + \sum f_n H_n \cos\left[a_n t + \left(V_o + u\right)_n - \kappa_n\right] \qquad (5)$$

where

H(t)	=	Water level at time t (t is measured from start of the year)
H_o	=	Mean water level above some defined datum
H_n	=	Mean amplitude of tidal constituent n
f_n	=	Factor for adjusting mean amplitude (for each year)
a_n	=	speed of constituent n (2π / T where T is the tidal period)
$(V_o+u)_n$	=	Equilibrium argument (for each year)
κ_n	=	Phase shift of tidal constituent n

The KTIDE model includes the values of f_n and $(V_o+u)_n$ for the years from 1970 till 2037. A total of 22 constituents were included in the KTIDE model a sample were listed in Table 1.

Procedure for Stand-Alone Usage of Kuwait Tide model [KTide]

Kuwait Tide model is an efficient and easy-to-use tide model. Although more advanced features are anticipated to evolve in the future, this version is sufficiently user-friendly and can provide the base information for water elevation for Kuwait Waters. The information provided by this model can be further used to calculate sediment/pollutant transport and to predict the tidal circulation for Kuwait waters. In this section of the report, step-by-step instructions are given for use of **Kuwait Tide mode**l. The procedure outlined here to run the model, click on (**Kuwait Tide**) icon. Figure 33 display a number of option as follows:

- *Tide Station*
- *Arabian Gulf*
- *Time Serious*
- *Data Export*

Table 1. A Sample of Constituents used in KTIDE model for Station in Kuwait Waters.

Constituent	Tidal Period (hr)	Speed (deg/hr)
M_2	12.421	28.984
S_2	12.000	30.000
K_1	23.935	15.041
O_1	25.819	13.943
Sa	8780.488	0.041
Ssa	4390.244	0.082
Mm	661.765	0.544
Msf	354.680	1.015
Mf	327.869	1.098
S_1	24.000	15.000
Q_1	26.870	13.398
P_1	24.067	14.958
N_2	12.659	28.439
υ_2 (NU$_2$)	12.626	28.512
K_2	11.967	30.082
L_2	12.192	29.528
$(2N)_2$	12.906	27.895
μ_2(MU$_2$)	12.872	27.968
T_2	12.017	29.958
M_4	6.2103	57.968
$(MS)_4$	6.103	58.984
$(2MS)_6$	4.092	87.968

Option 1, if user chooses [Tide Predict].

This option allows the user to select the station name for tide prediction as shown in fig.33 in two ways for Kuwait waters as follows:

       -From Dropdown List as shown in Fig 34

       -By Click on Station Name on Screen as shown in Fig 34

If user select any of the station name of the fig.34 list fig.35 will display showing the 24 hours tide for the current day.

To select different date or Station Name for tide prediction as shown Fig 36 by select *[Tide Predict]*

To Plot the water level user select [*Show Graphic Form*] as shown in Fig 37.
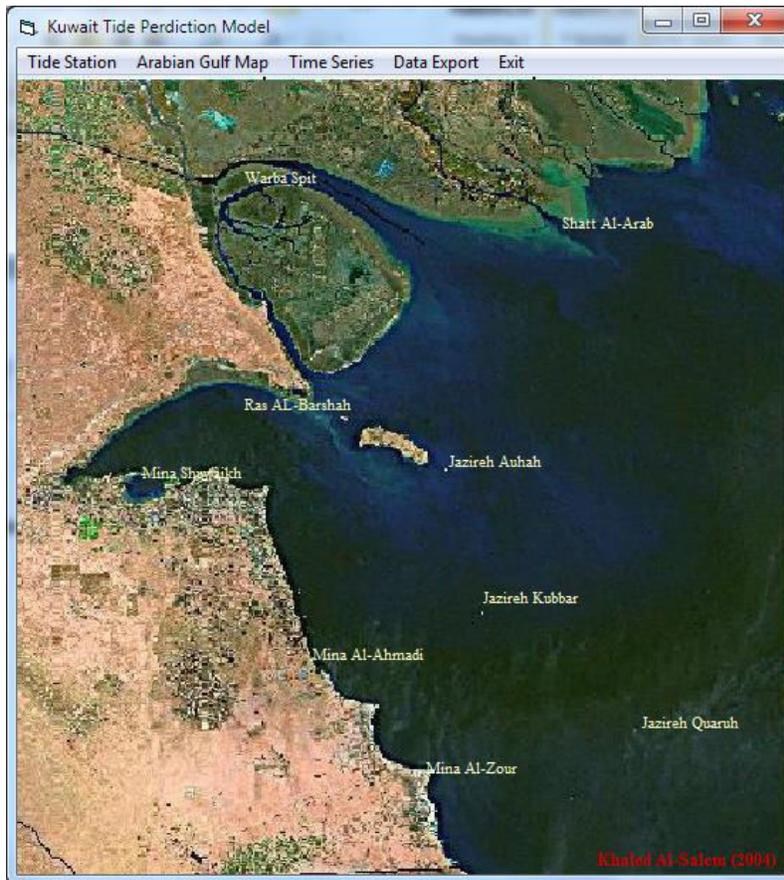
Figure 33
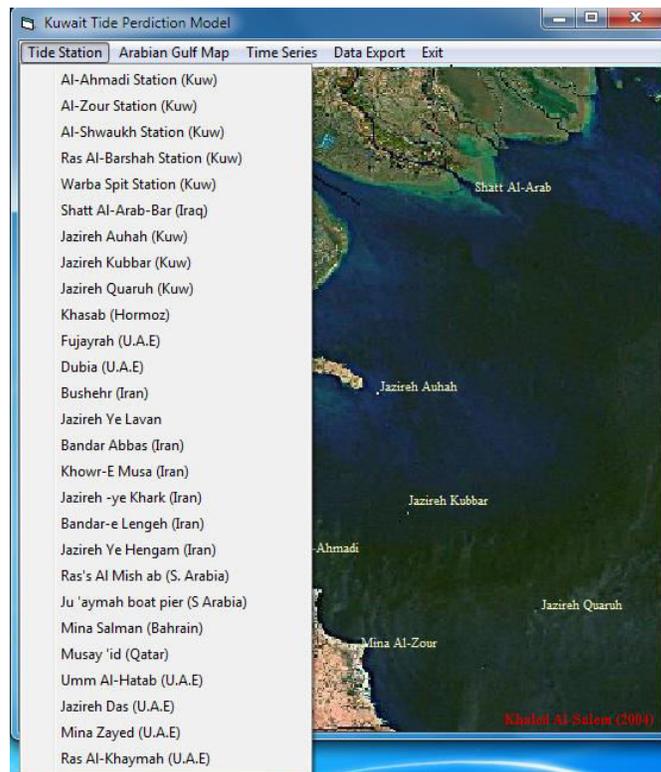
Figure 34
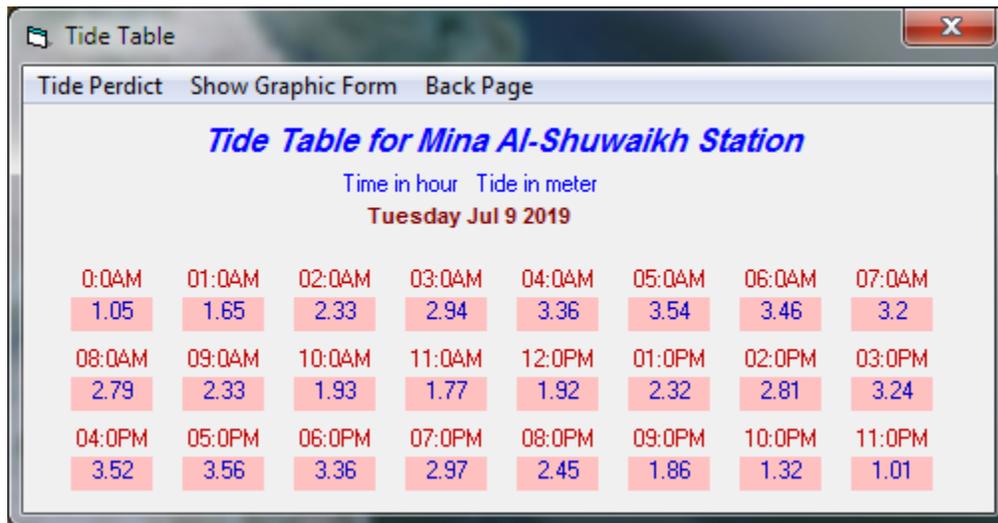
Figure 35
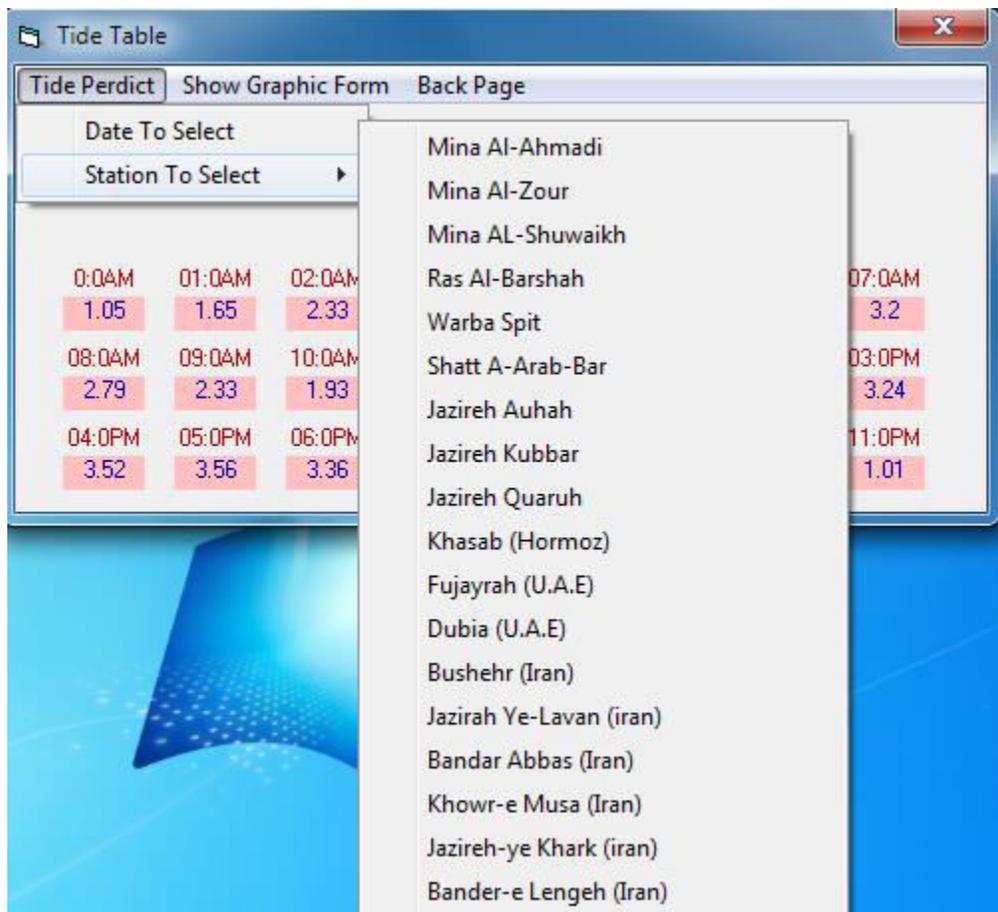
Figure 36
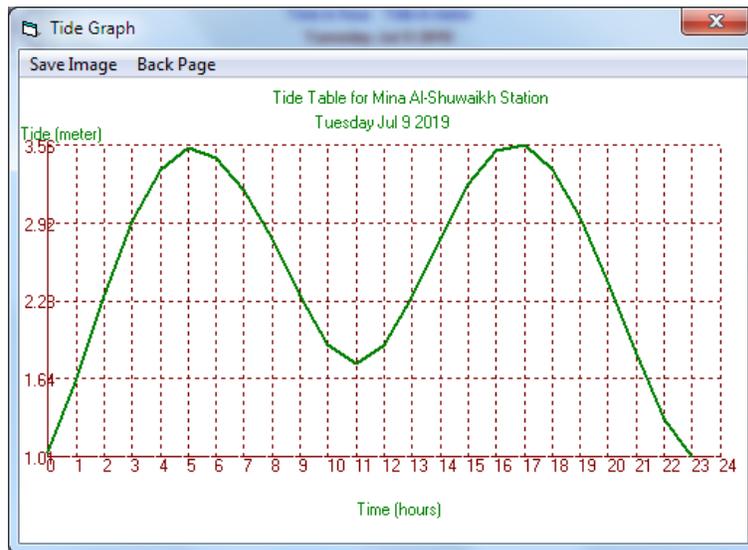
Figure 37

Option 2, if user chooses [Arabian Gulf]

This option allows the user to select Arabian Gulf Station name for tide prediction as shown in fig.38 in two ways for Kuwait waters as follows:

-From Dropdown List as shown in Fig 34

-By Click on Station Name on Screen as shown in Fig 38

If user select any station name from Fig.34 or Fig 38. Fig.35 will display showing the 24 hours tide for the current day.

To select different date or Station Name for tide prediction as shown Fig 36 by select *[Tide Predict*]

To Plot the water level user select [*Show Graphic Form*] as shown in Fig 37.
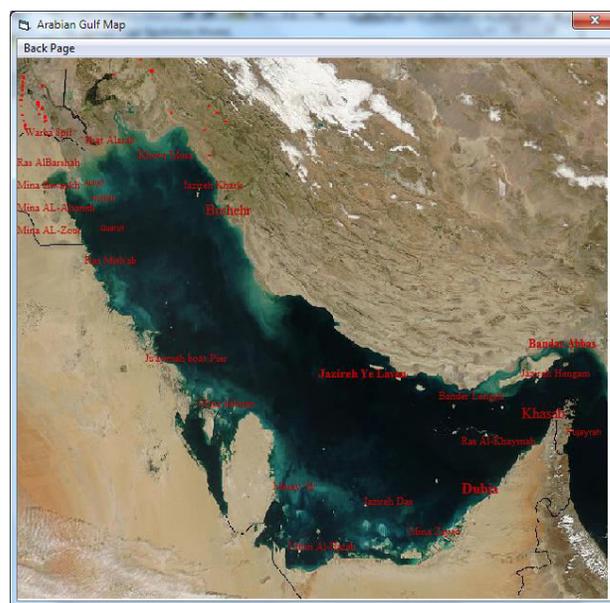
Figure 38

Option 3, if user chooses [Time Serious]

This option allows the user to select Kuwait Waters or Arabian Gulf Station name for tide prediction as shown in Fig.33 for Time serious. Figure 39 will display for user to input requires infromation as follow:

- Input station Name
- Input Stat and End Date
- Input Output file name

To start Simulation user must select [*RUN*].

In Figure 39 shows a number of output analysis as follows:

- [**Plot Tide Predicted**] . Plot line for Data predicted as (WL Vs T) as shown in Fig 40
- [**Interpolation**]. To Interpolate the predicted data
- [***Datum's***] . To Display Tide Level Datum's as shown in Fig 42

Water Level Prediction By Default the datum based on Admiralty Chart datum.

If water level based on MEAN SEA WATER LEVEL [MSL] user must Check [**W-FLC**]
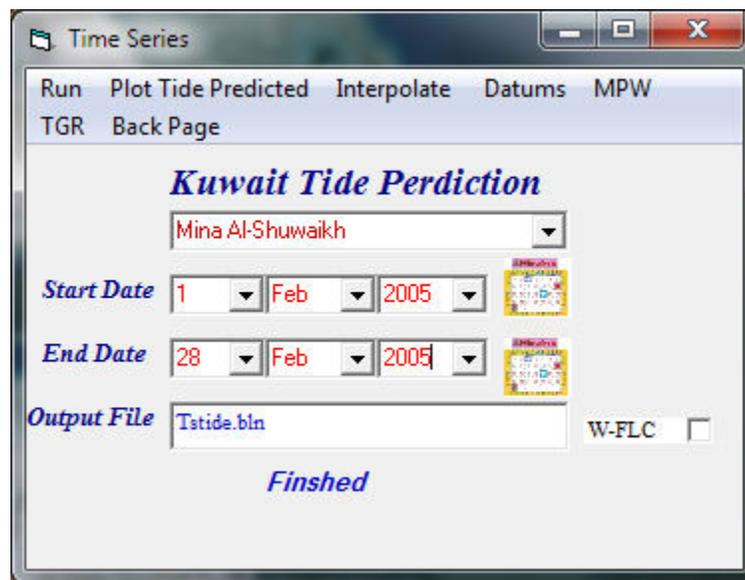
Figure 39
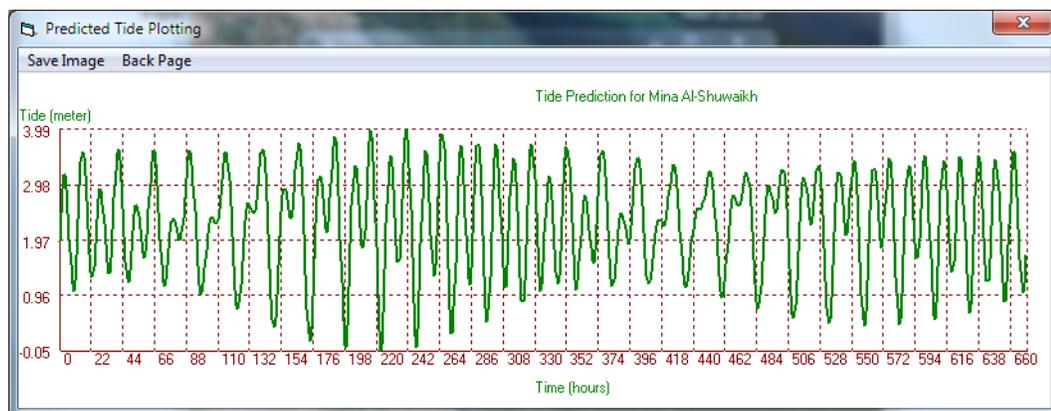
Figure 40

To Interpolate the predicted data user select [***Interpolation***] Fig 41 will display for user to enter a require information as follows:
- Enter [Time Increment (SEC)
- Enter output file name to store the interpolated data

Select [***Start***] To start the interpolation process.

Select plot the interpolated data by [***PLOT***] as shown in 41
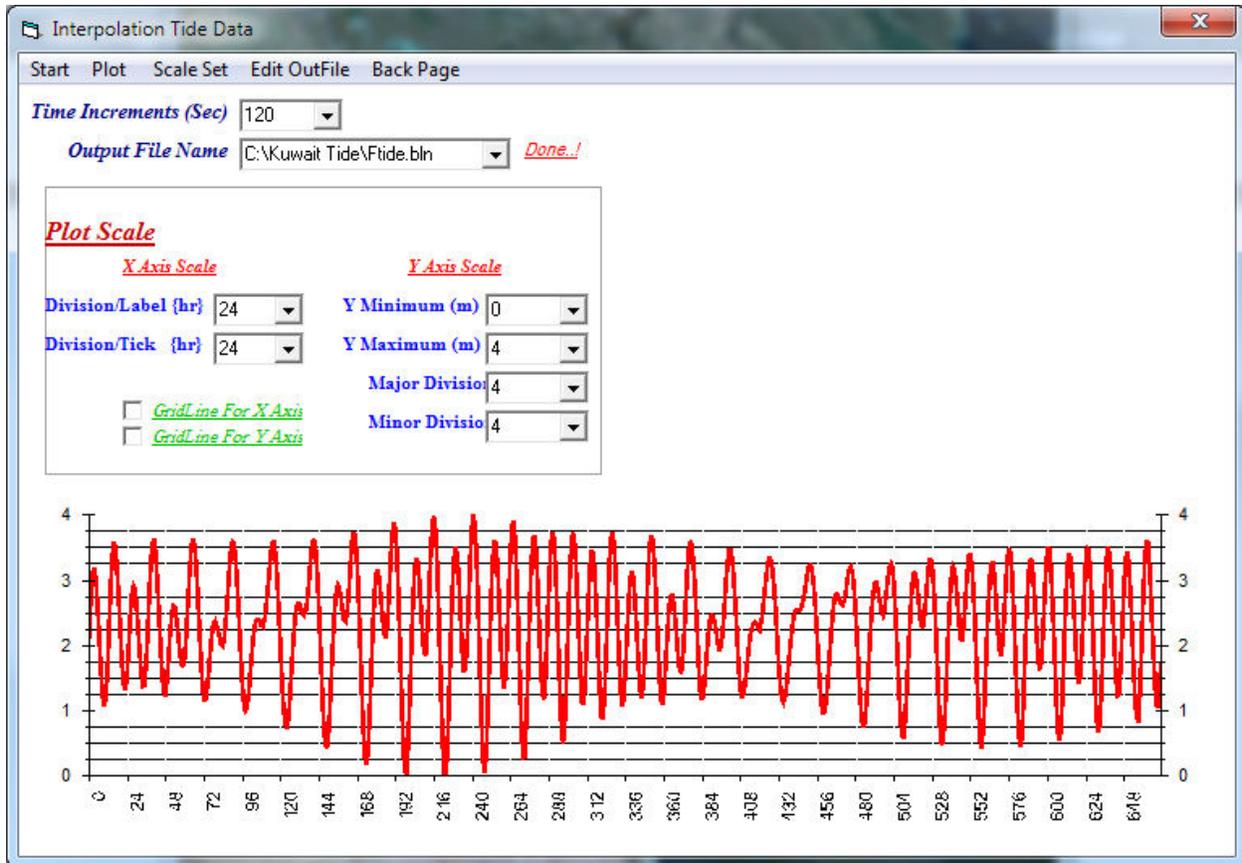
Figure 41

Option 4, if user chooses [Data Export]

This option allows the user to setup an export formatted output file by select [***Data Export***] in Fig 33. Figure 43 will display for user to input requires information as follow:

      - Input station Name

      - Input Stat and End Date

      - Input Output file name

To start Simulation user must select [***Export***] as shown in Fig 43.

To Display the export file by select [***Edit File***] as shown in Fig 43.

Note: by default water level based on admiralty Chart datum

     For water level based on MEAN SEA LEVEL {MSL} by click on [***W-FLC***]
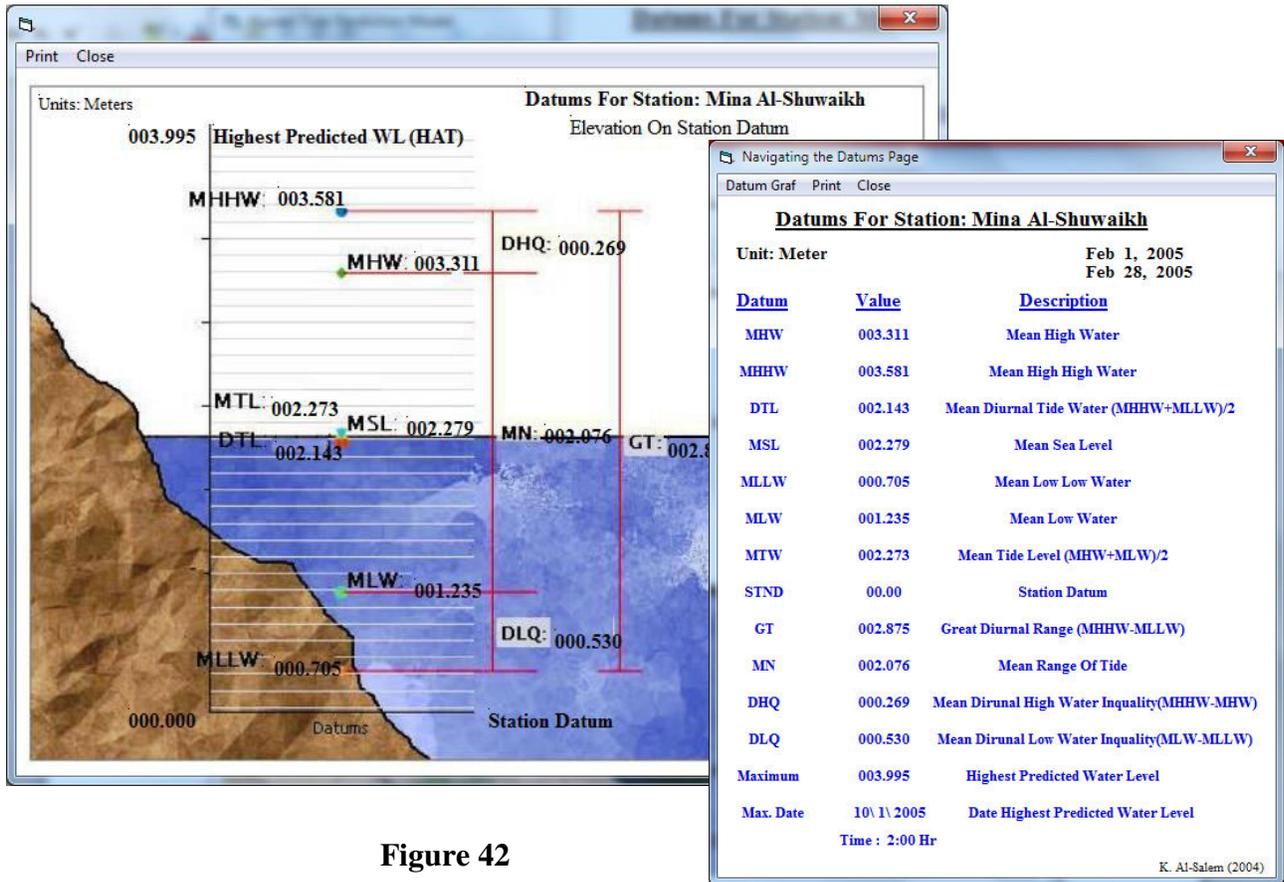
Figure 42
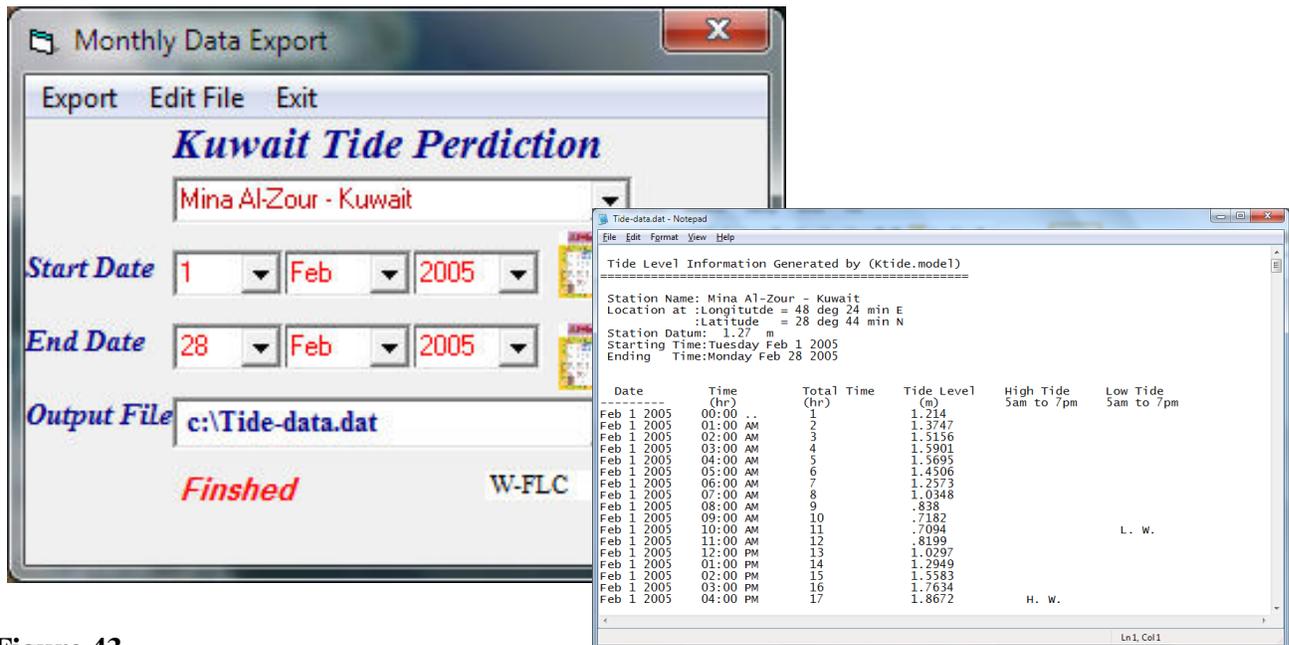
Figure 43

2.4 2D water level prediction for Arabian Gulf and Gulf of Oman [KTide-Tunami-N2KISR, *[Khaled Al-Salem 2016]*

2D Tidal level prediction was developed and coupled inside the tsunami model [TUNAMI-N2KISR model interface] for Tsunami wave Prediction with the effect of water level. The model has been tested with the newly available DEM successfully for tsunami wave prediction with and without the effect tidal level.

Coupled 2D Water Level Prediction model with TUnami-N2KISR model

2D tidal model can predict tide level at any time covering the whole Arabian Gulf and Gulf of Oman region based on KTide model [AL-Salem 2005]. The tide water level distribution at an hour interval is shown in Fig 47. These results suggested that there are several rapid changes of the water level at different locations (especially at the head of the Arabian Gulf) which should have some significant effect to tsunami wave propagation.

Model Concept description

KTide-Tunami-N2KISR model version was developed based on Multi grid system.
The model mean domain was list as follow

    i. Arabian Gulf and Gulf Of Oman for grid Size 1215m
    ii. Arabian Gulf grid size 405m
    iii. Sub area of Arabian Gulf for Grid size 135m
    iv. Sub area of Kuwait water grid size 45
    v. Sub area of Kuwait for grid size 15m
    vi. Sub area of Kuwait for grid size 5m

Then user must create System Connection From TUnami-N2KISR Model. A Sample of system Connection will display at Fig 44.

Then to start the model user must create system connect by
1- Tunami-N2KISR model
2- From Figure 46 user can Switch On/OFF The Require Connected system file
2- Manually setup the connection system file as Fig 47
Figure 45 will display when model start.
User must select [**START**] on Figure 46. To start simulate and predict 2D water level based on mean sea water level (MSL).

Fig 48 shown 2D water levels predicted over Arabian Gulf water for different hour by GMT plot Code.
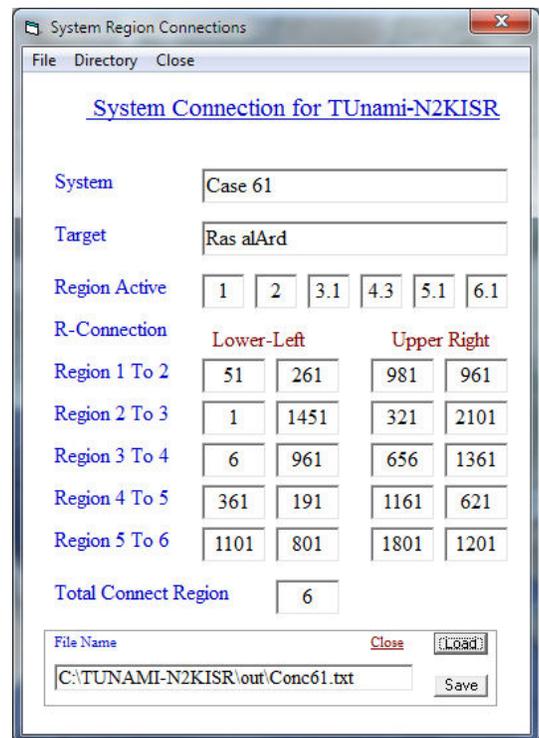
Figure 44
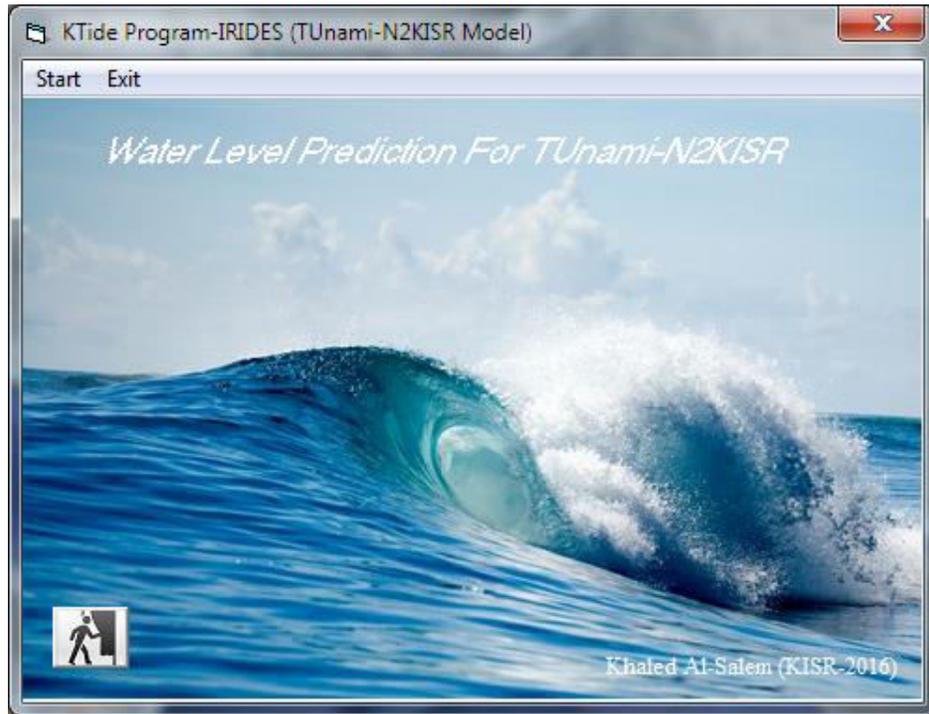
Figure 45
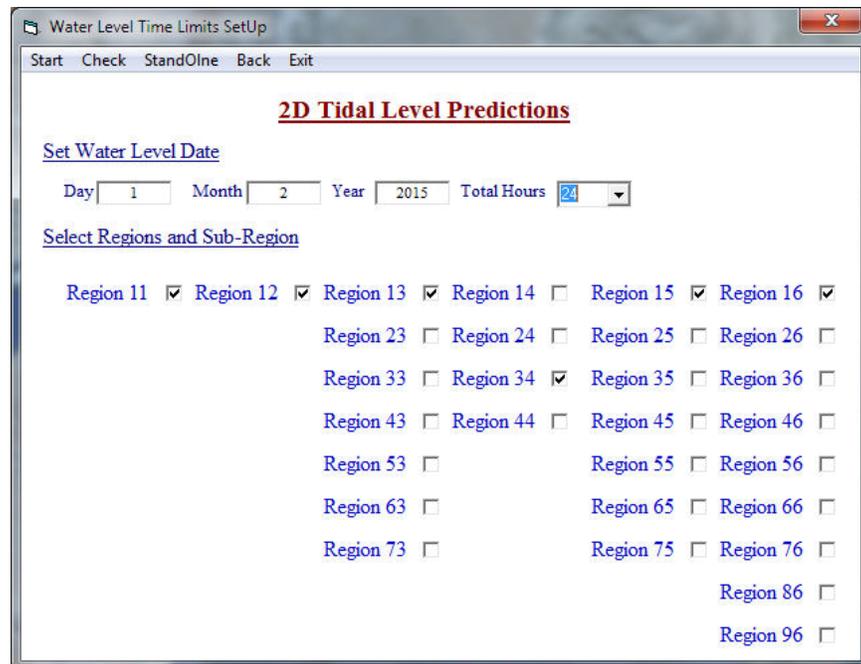
Figure 46

System Connection System File Format

System Connection No.   System Connection index each Region [lower/left] and [Upper/right]

Proj. No   Proj. Name
Case 61,   Ras al Ard,   1,2,3.1,4.3,5.1,6.1,   51,261,1,1451,6,961,361,191,1101,801,981,961,321,2101,656,1361,1161,621,1801,1201
6
Total Active Region

Figure 47
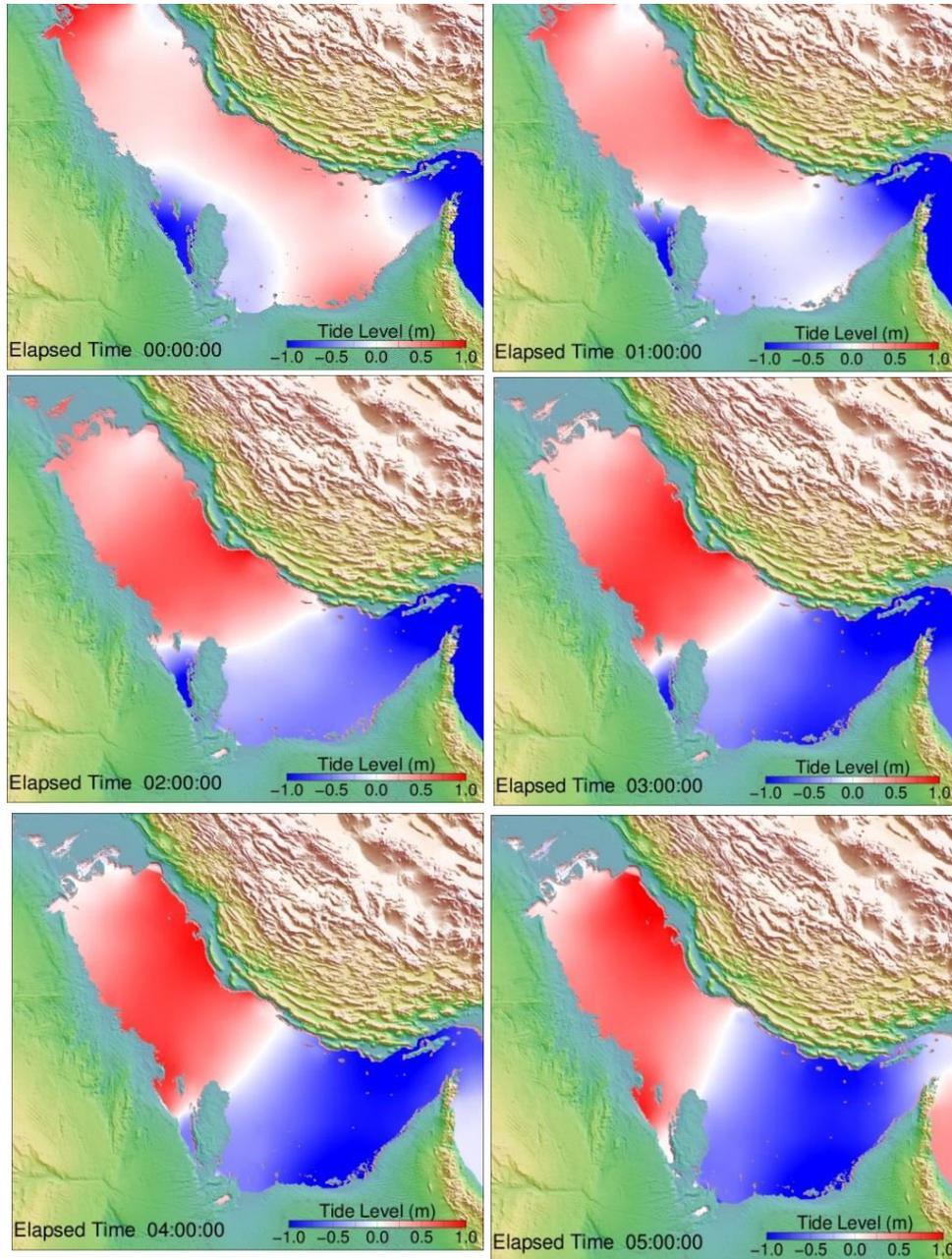
Figure 48. Results of new developed tide model showing distribution of water level in the Arabian Gulf from tide at hourly interval

2.5. Global Water Level Prediction. MTide model
[Khaled Al-Salem 2016] (Pc Version)

Global Tide model was developed by (Al-Salem K., 2006) for Global Water Level Prediction as shown in Fig 49; This version is sufficiently user-friendly and can provide the base information for water tide elevation for Global Regions (Asia, Africa, Europe, North America and South America) based on Station Longitude/Latitude with water level reference MEAN SEA LEVEL (MSL). The information provided by this model can be further used to calculate sediment/pollutant transport and used as input for tidal circulation models.
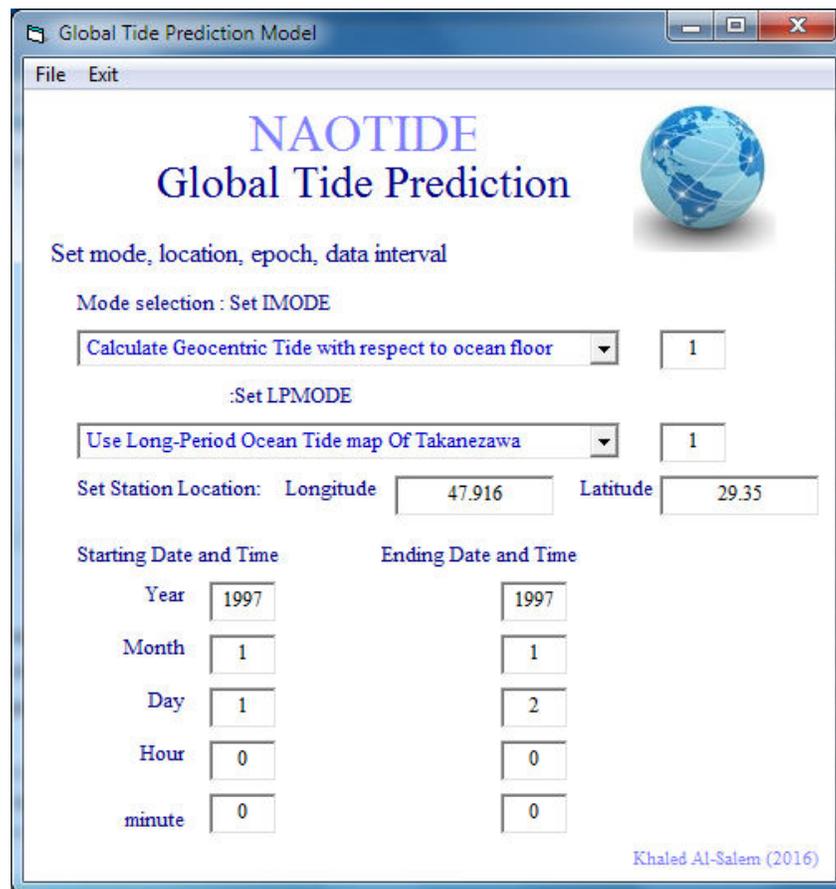
Figure 49

Model simulation Description

User must select [MTIDE] to start the model as shown in Fig 49.
User must select the reqire input as
  Set [IMODE]
   Set [LPMODE]
  Set Station Location [Longitude and Latitude] in Degrees
  Set Start Date and End date
Then user must select [***FILE***].

A New Window will display for user to inform data saved and new Button Will Appear for user to select to start simulation [**START**] as shown in Fig 50.

Figure 51 will display for user show the simulation Process.

From Fig 50 can select [Edit Output] to display the output file as shown in Fig 52.

Figure 53 display water level plot line compared to KTIDE model.

Figure 50

Figure 51

Figure 52

Figure 53

2.6. Virtual Real-Time Hydrodynamic monitoring Khydro
[Khaled Al-Salem 2011] (PC Version 2.0)

Kuwait Real-time Hydrodynamic Virtual Monitoring System (Khydro System as shown in Fig 54). Khydro system was developed by (Al-Salem K., 2005 as ver. 1.0) for hydrodynamics virtual monitoring in real-time for Kuwaiti territorial waters, it is an efficient and easy-to-use system. Although more advanced features are anticipated to evolve in the future, this version is sufficiently user-friendly and can provide and displays highly detailed output of hydrodynamics virtual monitoring information in real-time for Kuwait Water's.

Model simulation Description

Kydro program are based on
   -Tidal prediction [KTIDE mode] see in section 2 p24
   -Tidal Current Prediction [KGULF model] see section 2 p3
   -Significant wave height, direction and period prediction [KWAVE model] see section 4 p88
   -Wind Data used for prediction Wave height will updated every 6 days. And operator will
     download wind data online from Website address

[http://www.hceatkuwait.net/web_pas/main.aspx]

To start KHydro program user must select [　　　] . Figure 54 will display doe user.
User must select [***START***] for run the hydrodynamic monitoring system program as shown in Fig. 54. Figure 55 will display automatic startup of monitoring for Current Date/Time.
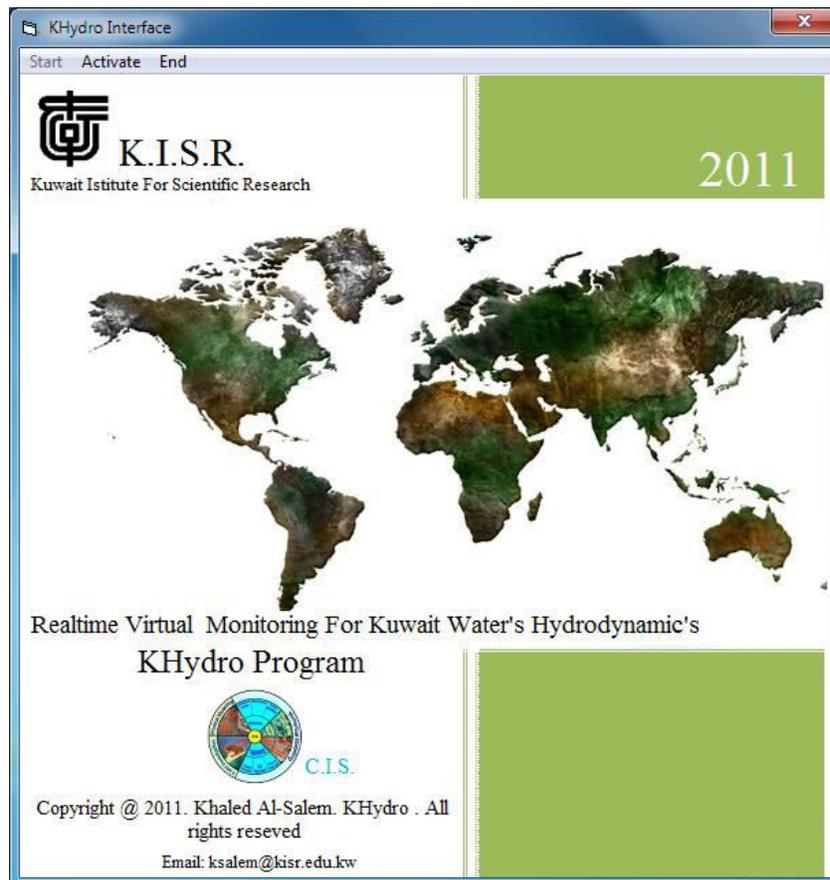
Figure 54
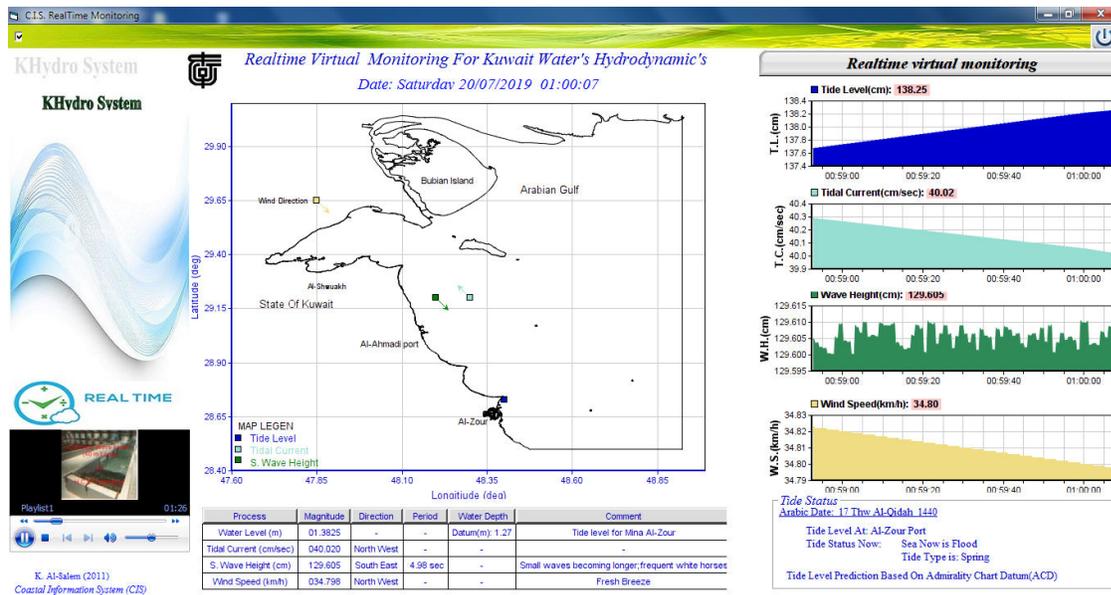
Figure 55

To Change the monitoring Location In Kuwait water user must Uncheck on Checkbox Located on the top-Left Figure 55. Then Figure 56 will display to change object location.
By Default water level reference is Admirality Chart Daum to Get to MEAN SEA LEVEL (MSL) datum user must check [*MEAN SEA LEVEL*] checkbox as shown Fig 56.
To Update Wind Data user must download wind data then Click [*Update*].
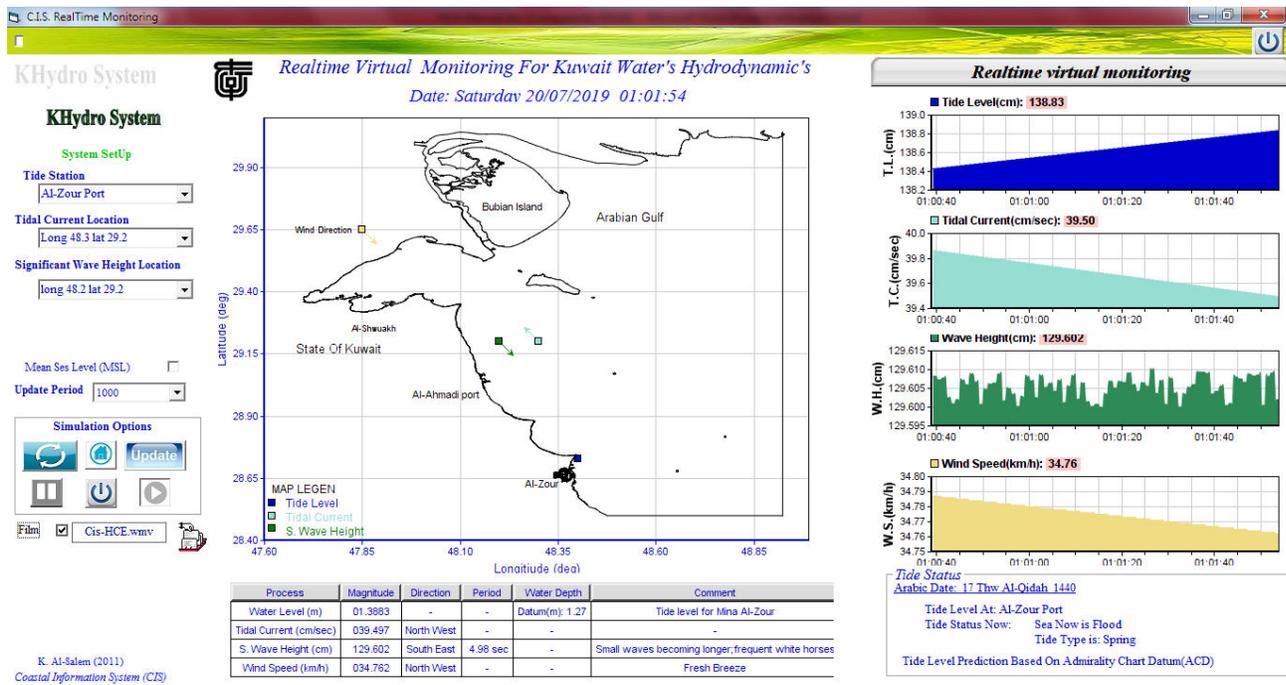
Figure 56

2.7. Kuwait Hydrodynamic monitoring Baywatch

[Al-Salem 2005] (PC Version 1.0)

Kuwait Hydrodynamic Monitoring System (BayWatch System as shown in Fig 57). BayWatch system was developed by (Al-Salem K., 2005 as ver. 1.0) for hydrodynamics monitoring in real-time for Kuwaiti territorial waters, it is an efficient and easy-to-use system. Although more advanced features are anticipated to evolve in the future, this version is sufficiently user-friendly and can provide and displays highly detailed output of hydrodynamics monitoring information in for Kuwait Water's.

Model simulation Description

To start the program user must select [***BayWach***]

Figure 57 will display for user to start by Enter system Password [bay1]. Then Fig 57 will also display a number of option:

- o [***Time Interval Forecast Table Update***]
  To display the hydrodynamic monitoring as shown in Fig 58
- o [***Film***] To display HCE groups capabilities movie as shown in Fig 58

In Figure 59 display for user two table for 24hr of water level of Tidal Current shown hourly for selected a station from Dropdown List.

To Show the HCE groups capabilities movie in Full Screen mode just double click on Movie screen
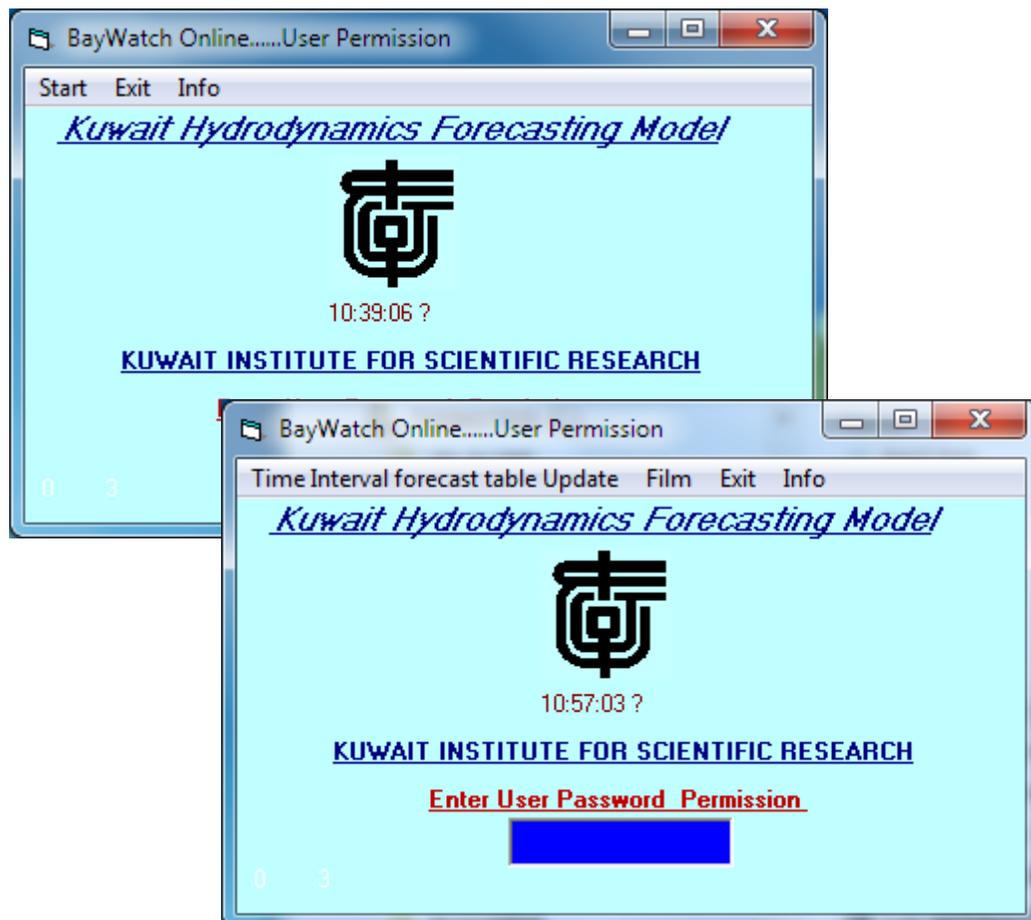
Figure 57
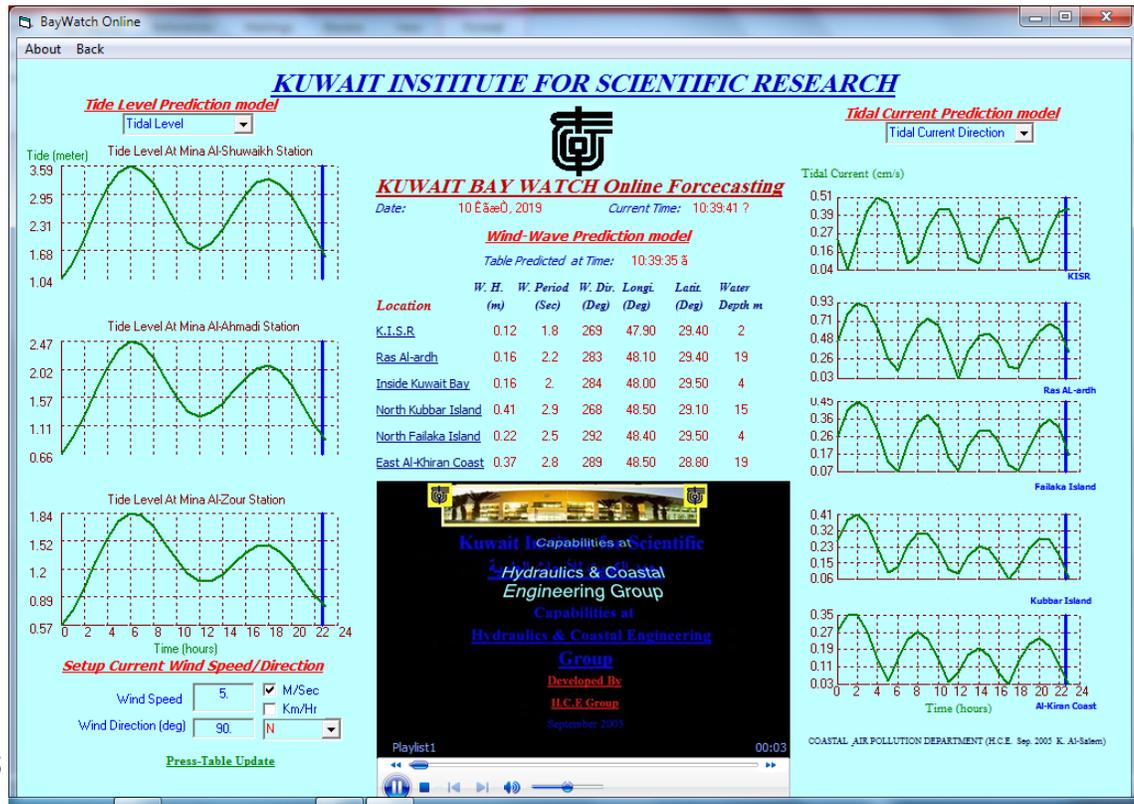
Figure 58
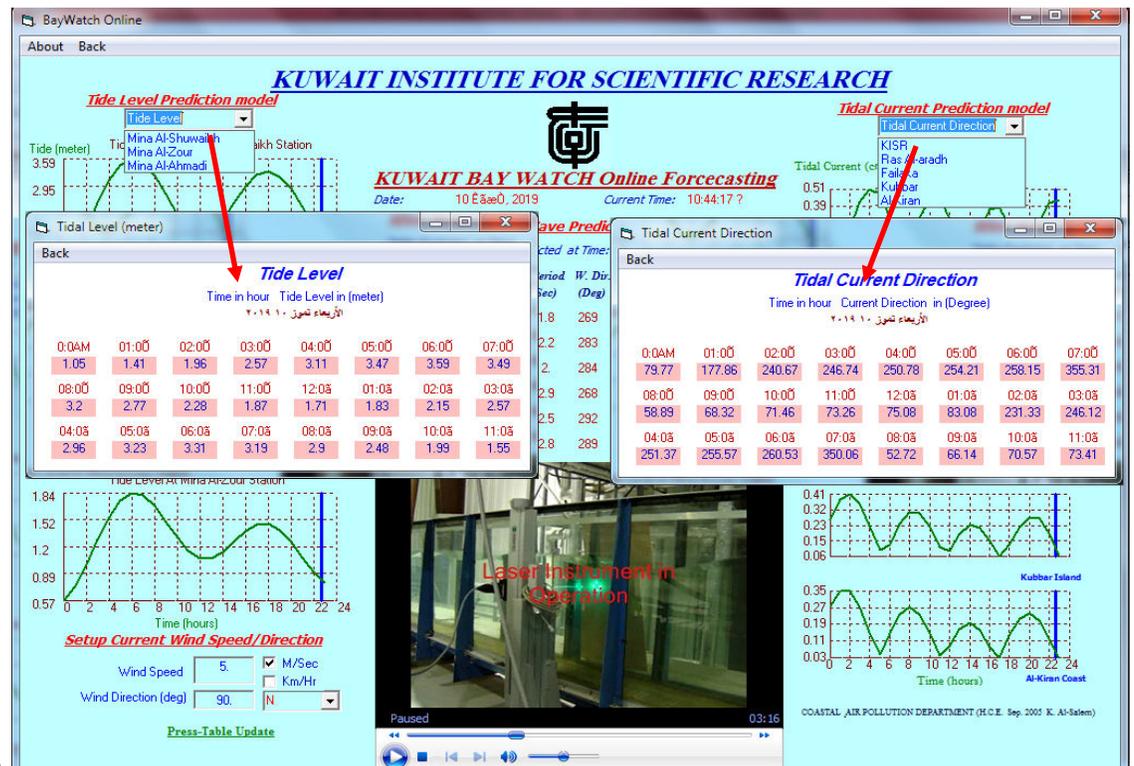
Figure 59

3. Hydraulics Costal Oil Spill application

3.1. Oil Spill trajectory for Arabian Gulf [KOil model]
[Al-Salem 2009] (Pc Version)

Models to predict the behavior of the oil spill include the calculation of the spreading, the displacement and the mass/volume balance over the different compartments (air, water surface, water column and bottom) of a released substance. The phenomenon of spreading results from a dynamic equilibrium between the forces of gravity, inertia, friction, viscosity, and surface tension. The variables that mainly influence the dispersion and evaporation are the wind speed, marine currents, time, density of the oil and the amount of the oil released. Many oil spill models are commercially available and can be setup for the Arabian Gulf and the Kuwaiti territorial waters. Such models however, require accurate data on the marine currents which are usually provided from a separate hydrodynamic model HD (Lo and Al-Salem. 1999) and (K. Al-Salem ,2008) that it takes very long computer time for simulation of the marine current condition.

Methodology
The model currently uses data from the KGulf 2D hydrodynamic HD model for the Arabian Gulf (K. Al-Salem; web address:
[http://www.hceatkuwait.net/web_pas/web-KGulf/KGulfmain.aspx].
KGulf is 2D hydrodynamics Prediction model set up for the Arabian Gulf and Kuwait waters (K. Al-Salem ,2008). The model is capable of simulating 2D tidal current and water level at any selected grid inside Arabian Gulf waters with hourly output results. Also a refine grid was generated for Kuwaiti territorial water. A grid was generated covering the Arabian Gulf from the Hormoz inlet till the upper part of Arabian Gulf . The grid spacing is about 5-8 km in the Arabian Gulf with a total of 3692 grid inside the Gulf. For some local areas in Kuwait waters the refined grid spacing reached about less than 50 m Figs. 1. KGulf model was validated using a tide prediction TIDCALC model (UK's Hydrographic Office), RMA-10 HD model (King, I.P. 1988) and using some field measurements. Result showed that the model is capable of predicting the 2D tidal currents and water level variations well with very short simulation time. Four finer grids have recently been setup for the Kuwaiti territorial waters and include all the power plants in Kuwait. These grids provide detailed tidal currents near the sensitive locations in Kuwait as shown in Figs 1 and Fig A1-A3. Fig 1 shows samples of grid system in Kuwait waters. The Oil transport model is coupled with 2D hydrodynamic model for Kuwait Waters (KGulf model). The velocity distribution is calculated at each time step and is taken as an input for the oil transport simulation model (KOil model) (K. AlSalem ,1993).

Lagrangian description of turbulent diffusion
A Lagrangian discrete-parcel algorithm is used. In this algorithm, the oil slick is viewed as a large ensemble of small parcels. It looks at the subsequent coordinates (trajectories) of a number of individual fluid or fluid property particles that are advected (transported) by currents. When

the current field is known then we may add turbulent diffusion as random walks that have in general Gaussian distribution with dispersion that corresponds to turbulent activity.

For a particle numbered i we get

$$dx_i = u(x_i, y_i, z_i, t)dt + Rnd_x(i)$$
$$dy_i = v(x_i, y_i, z_i, t)dt + Rnd_y(i)$$
$$dz_i = w(x_i, y_i, z_i, t)dt + Rnd_z(i)$$

Model Simulation Description

KGulf model was developed and set up for the Arabian Gulf and Kuwait territorial waters with multi grid system for solving hydraulic engineering application. To start simulate the KGulf model user must select [🌊] to start the model Fig 60 will display the following input Option for user to state as follows:

•   1D/2D tidal current speed and direction hourly perdition
•   1D/2D tide Level hourly prediction and Water level analysis
•   Trajectory Oil spill prediction [KOil 2009]
•   Oil Spill
            KOil model 2012   [See Section 3 p50]
            Back Track Oil Spill [see section 3 p59]

To Simulation Oil Spill Project KGulf model have two Models for user to select from Fig 60 as follow:

  1- [**KOil model 2009**] User must Check [***2D Prediction***]. A new frame will display at Fig 60. User must select again [***Time Serious 2D Prediction***].
  2- [**KOil model 2012**] User must select [***Oil Spill***] from Fig 60. These model will describe on next Section

*For Simulation [**KOil model 2009**]*

User after selected [***Time Serious 2D Prediction***] in Fig 60.

Figure 61 will display for user to generate 2D hydrodynamic Data.

User must enter the following information as:
  -    Start Date and End Date
  -    Output hydrodynamic data file name.
 Then user must select [***Oil Spill Simulation***] as shown in fig 61.

Fig 62 will display for user to setup simulation input:

-Load Select domain map [***MAP***]   -Select [***UV Interpolate***]

-Setup Wind speed [Constant wind or variable wind speed data file]. Then select [***Wind Interpolation***].

-Setup Oil Spell Source [Check on ***Source Info***]. Input Longitude/Latitude Location

Then To Start oil spill simulation by Select [***Start***] from Fig 62.

User can load Satellite image as background by select [***Image Selection***] as in Fig 63

To display 2D tidal current at simulation process Check [Plot Parameter] then [Plot Tidal Current] as shown in Fig 64. Display Evaporation table analysis[***Edit Output***] as shown Fig 65

Display Animation Result [***Result Animation***] as shown in Fig 66.

Display Oil Spill Result On Google as shown in Fig 67. Fig 68 shows oil spill on Google Map.

Fig 68 shown The Part of Html file created to display oil spill location Data on Google Map.
Fig 69 shown result for Continuous Oil Spill Option from Fig 61

Figure 60
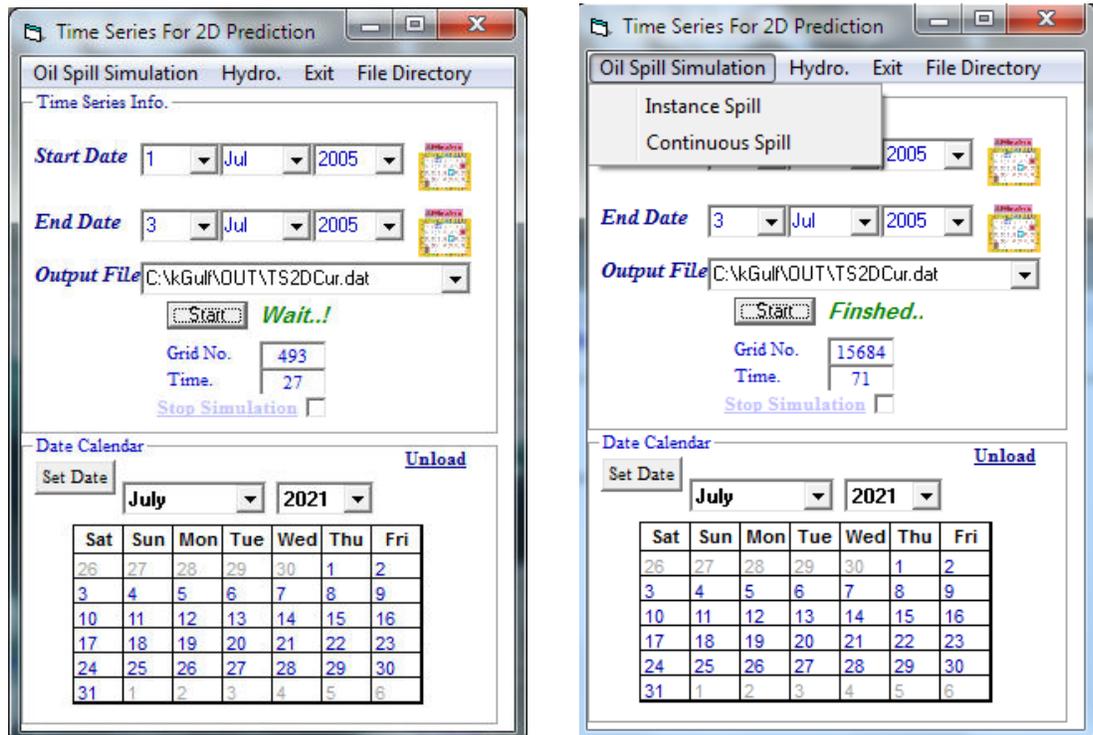
Figure 61
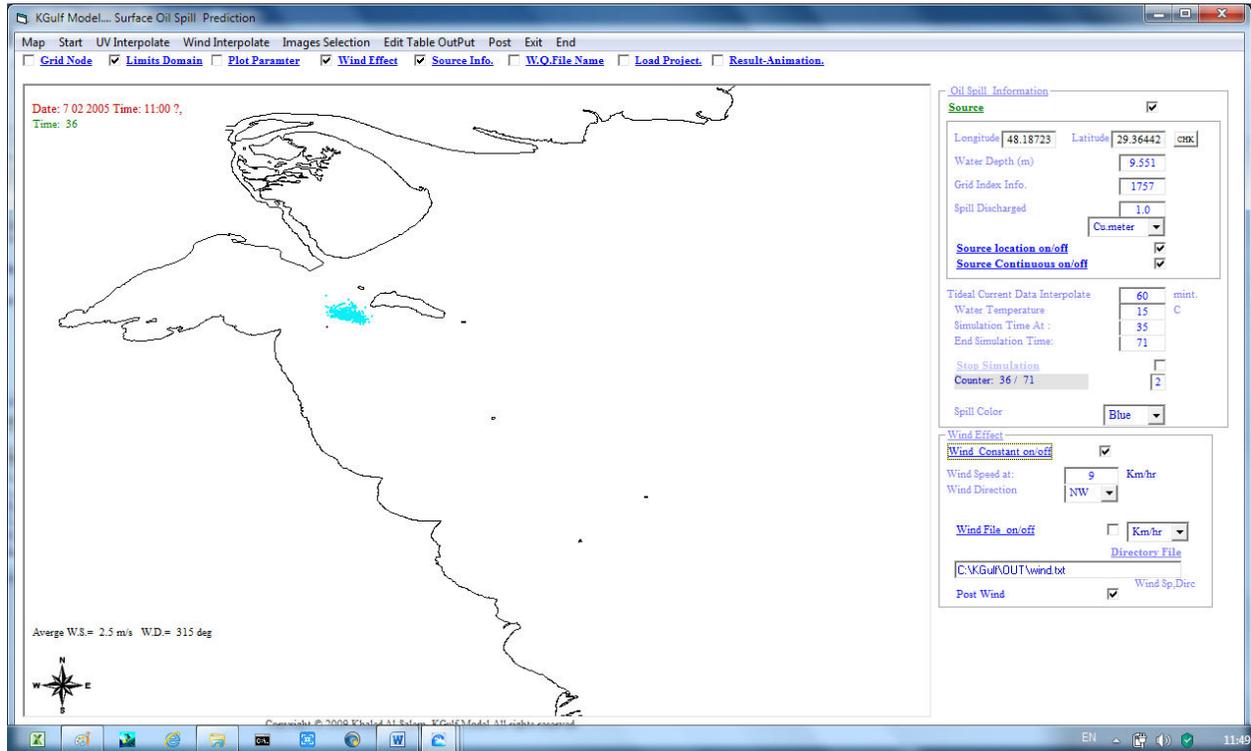
Figure 62
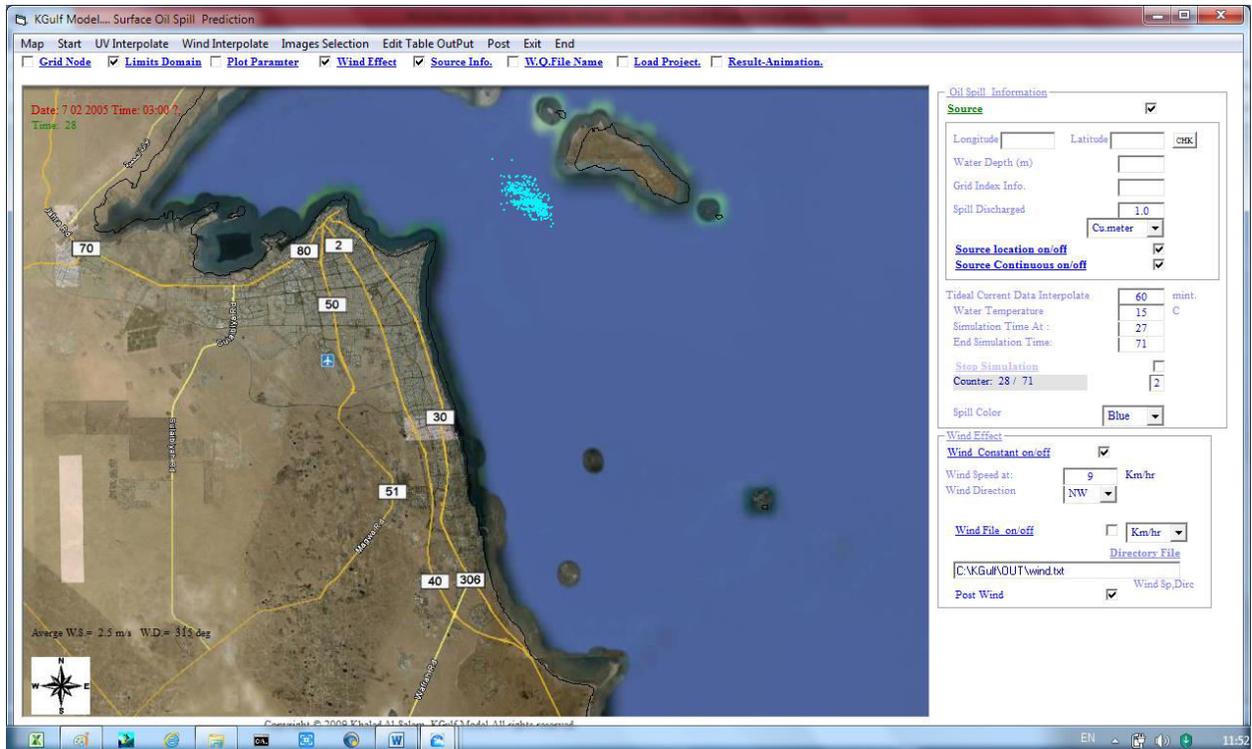
Figure 63
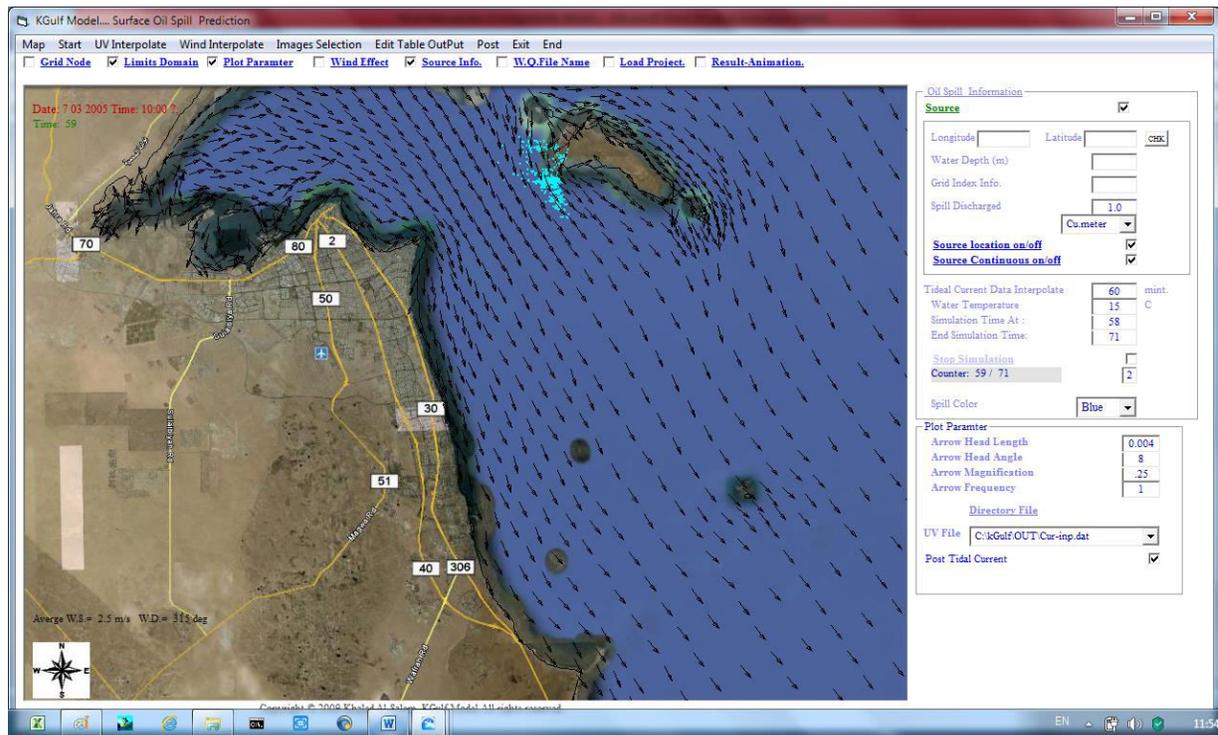
Figure 64


```
     KGulf Model
   Oil  Spill  Prediction
Developed By: K. Al-salem (2009)
   www.hceatkuwait.net
------------------------------
Map Limit
47.609    48.69
28.85     29.514
Grid Index, Discharge Source location, Water Depth
  1757    48.18723   29.36442   9.551
Oil Spill Date.
  1      7       2005
Oil Volume =1.0Cu.meter
Wind Speed Unit,        Km/hr.
Total Time (hr) time Increment (sec)
  71     3600
```

Date	Time	Dispersion Area (sq(m))	Spill Volume %	Evap.Compo.1 %	Evap.Compo.2 %	Evap.Compo.3 %	Evap.Compo.4 %	Evap.Compo.5 %	Evap.Compo.6 %	Evap.Compo.7	Evap.Compo.8	Wind Speed	Wind Direction
...	...	0.000	1.0000	10.000	8.0000	15.0000	20.000	5.0000	2.0000	15.000	25.0000	0.0000	0.0000
7 01 2005	00:00 ..,	0.532	0.8192	4.108	7.9998	7.3993	20.000	0.4221	1.9996	14.995	25.0000	9.0000	315.0000
7 01 2005	01:00 2.	3.641	0.7972	3.296	7.9997	6.1411	20.000	0.2924	1.9994	14.994	25.0000	9.0000	315.0000
7 01 2005	02:00 2.	5.036	0.7773	2.568	7.9996	4.9752	19.999	0.1921	1.9993	14.992	25.0000	9.0000	315.0000
7 01 2005	03:00 2.	6.056	0.7596	1.934	7.9995	3.9179	19.999	0.1183	1.9991	14.990	25.0000	9.0000	315.0000
7 01 2005	04:00 2.	6.881	0.7446	1.407	7.9994	2.9994	19.999	0.0682	1.9989	14.988	25.0000	9.0000	315.0000
7 01 2005	05:00 2.	7.589	0.7324	0.989	7.9993	2.2339	19.999	0.0368	1.9987	14.986	25.0000	9.0000	315.0000
7 01 2005	06:00 2.	8.220	0.7229	0.673	7.9991	1.6197	19.999	0.0185	1.9985	14.983	25.0000	9.0000	315.0000
7 01 2005	07:00 2.	8.800	0.7157	0.443	7.9990	1.1437	19.999	0.0087	1.9982	14.981	25.0000	9.0000	315.0000
7 01 2005	08:00 2.	9.344	0.7105	0.282	7.9989	0.7870	19.999	0.0038	1.9979	14.978	25.0000	9.0000	315.0000
7 01 2005	09:00 2.	9.861	0.7067	0.174	7.9987	0.5278	19.998	0.0015	1.9977	14.975	25.0000	9.0000	315.0000
7 01 2005	10:00 2.	10.357	0.7042	0.104	7.9985	0.3450	19.998	0.0006	1.9974	14.972	25.0000	9.0000	315.0000
7 01 2005	11:00 2.	10.835	0.7024	0.060	7.9984	0.2200	19.998	0.0002	1.9971	14.969	25.0000	9.0000	315.0000
7 01 2005	12:00 2.	11.297	0.7013	0.034	7.9982	0.1367	19.998	0.0001	1.9968	14.965	25.0000	9.0000	315.0000
7 01 2005	01:00 2.	11.745	0.7005	0.018	7.9980	0.0829	19.997	0.0000	1.9964	14.962	25.0000	9.0000	315.0000
7 01 2005	02:00 2.	12.180	0.7001	0.010	7.9978	0.0490	19.997	0.0000	1.9961	14.958	25.0000	9.0000	315.0000
7 01 2005	03:00 2.	12.601	0.6998	0.005	7.9976	0.0283	19.997	0.0000	1.9957	14.954	25.0000	9.0000	315.0000

Figure 65

Figure 66

Figure 67

Copyright @ K. Al-Salem - Oil Spill Location on Google Map (KOil 2012)
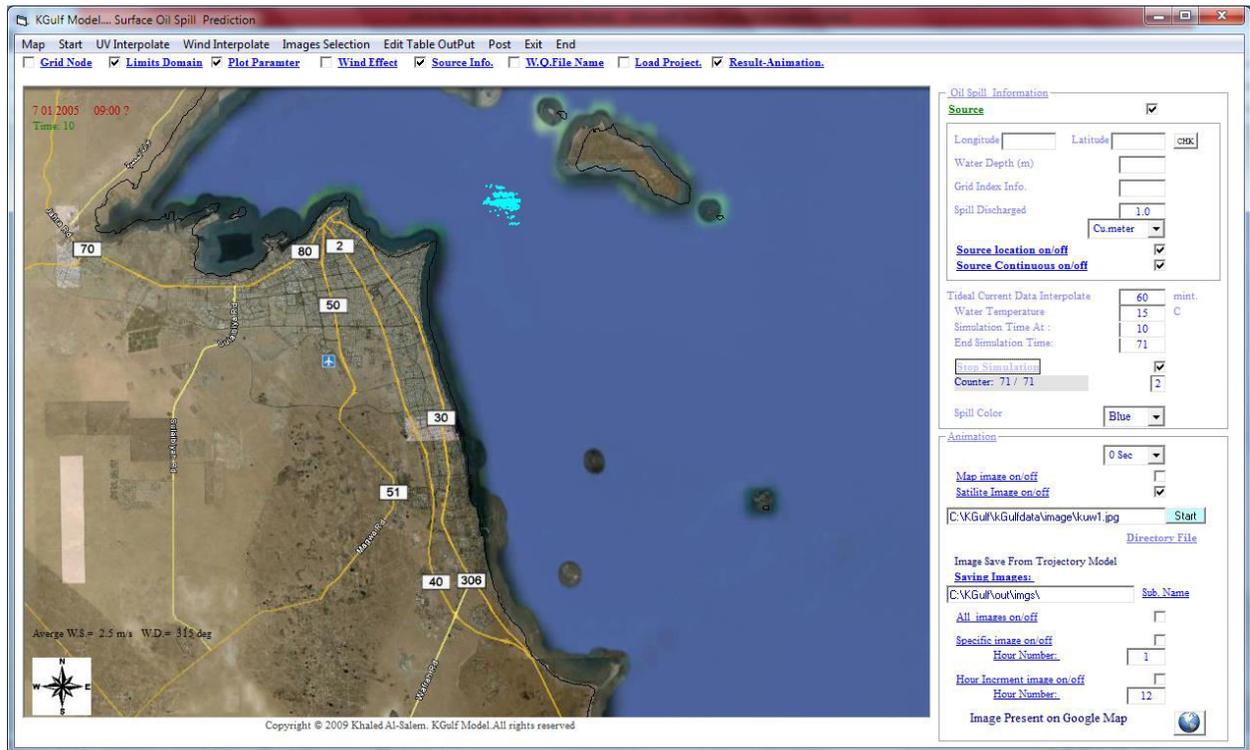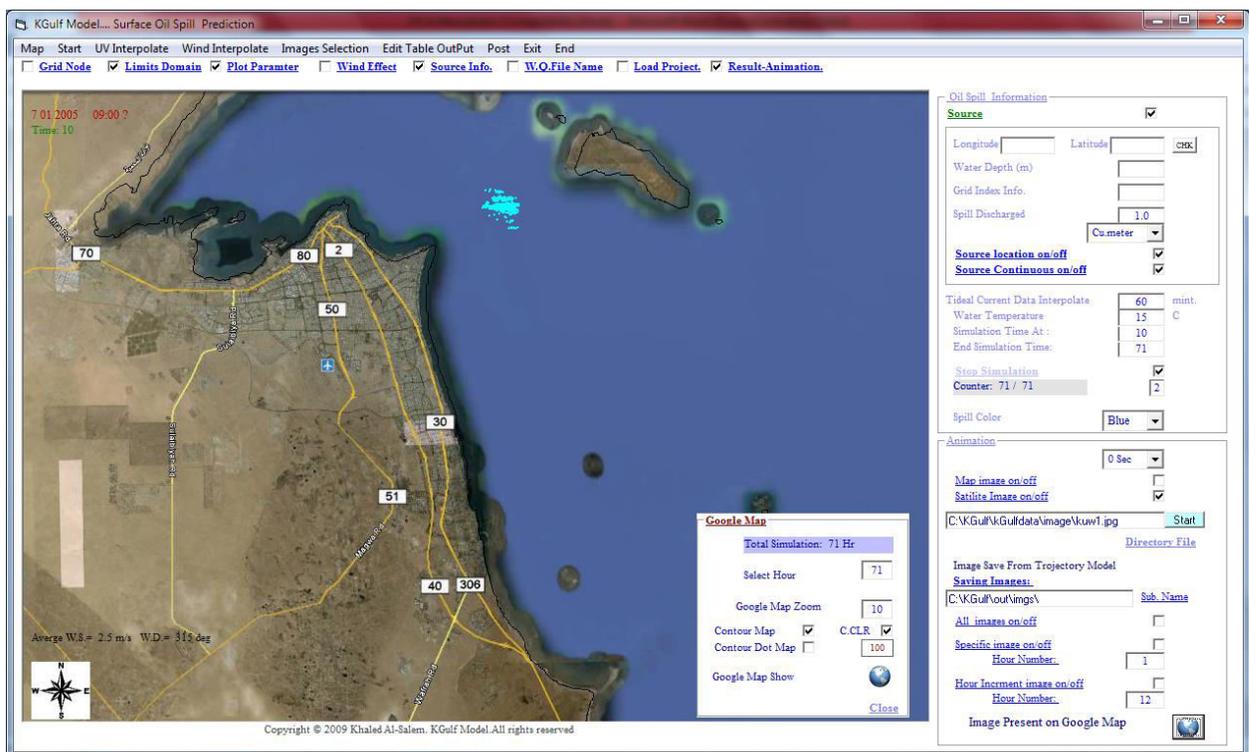
```
<!DOCTYPE html>
<html>
  <head>
  <meta http-equiv='content-type' content='text/html;charset=utf-8'/>
  <meta http-equiv='X-UA-Compatible' content='IE=edge'>

    <title>KOil Model(2012)</title>
    <style>
      #map {
        height: 100%;
      }
      html, body {
        height: 100%;
        margin: 0;
        padding: 0;
      }
      #floating-pane {
        position: absolute;
        top: 10px;
        left: 25%;
        z-index: 5;
        background-color: #fff;
        padding: 5px;
        border: 1px solid #999;
        text-align: center;
        font-family: 'Roboto','sans-serif';
        line-height: 30px;
        padding-left: 10px;
      }
      #floating-panel {
        background-color: #ffff;
        border: 1px solid #999;
        left: 1%;
        padding: 5px;
        position: absolute;
        top:100px;
        z-index: 5;
      }
      #floating-pane2 {
        background-color: #fff;
        border: 1px solid #999;
        left: 1%;
        padding: 5px;
        position: absolute;
        top:80px;
        z-index: 5;
      }
    </style>
  </head>
  <body>
    <div id='floating-panel'>
      <button onclick='changeOpacity()'>Intensity</button>
    </div>
    <div id='floating-pane2'>
    <textbox id='tv4' >Date: 7\ 2\ 2005 02:00 ?</textbox>
    </div>
    <div id='map'></div>
    <script>
      var map, heatmap;
      var gradient1 = ['rgba(0, 0, 0, 0)','rgba(0, 0, 0, 1)'];
      var gradient2 = ['rgba(255, 0, 0, 0)','rgba(255, 0, 0, 1)'];
```

Figure 68
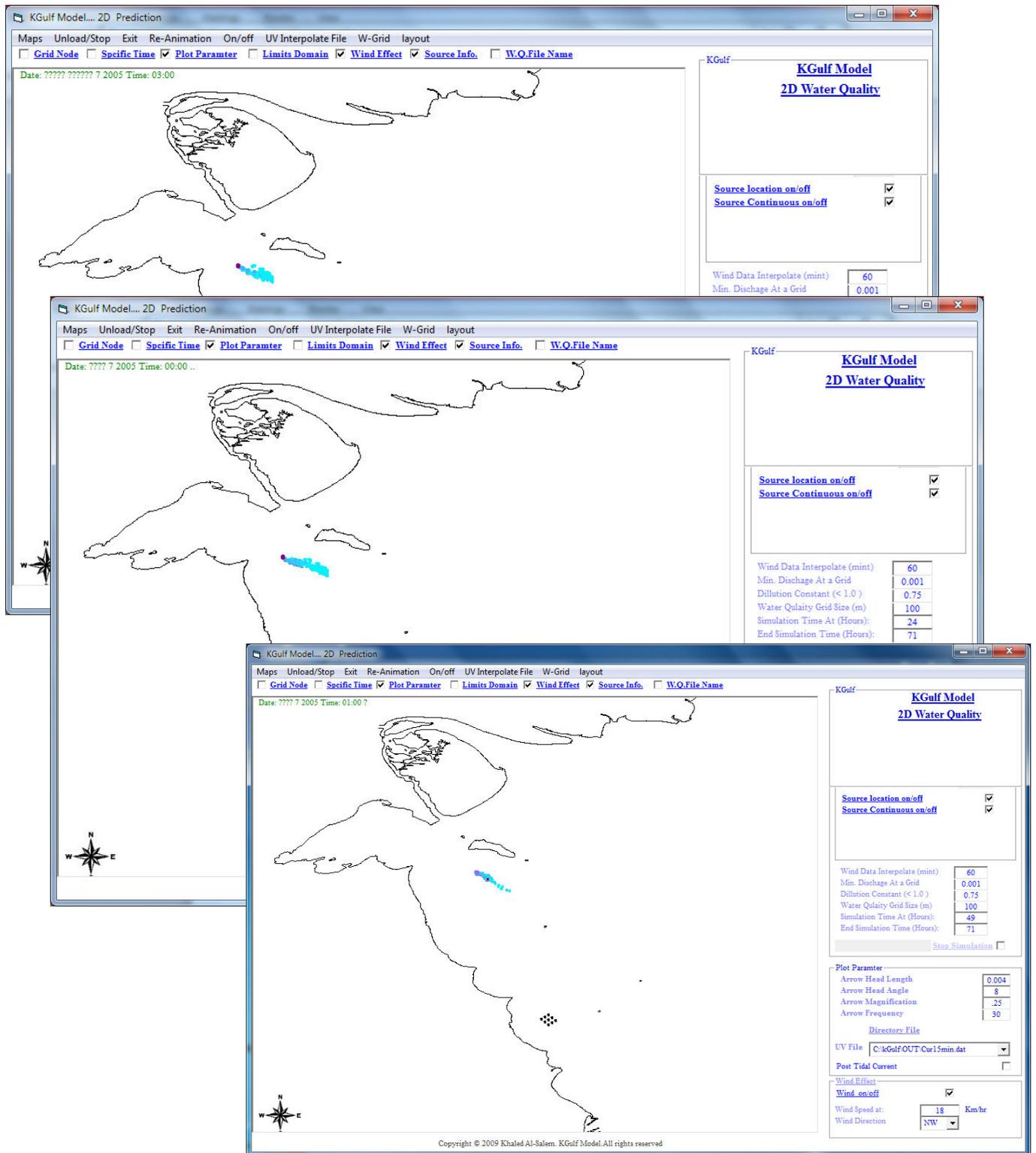
Figure 69

3.2 Oil Spill trajectory for Arabian Gulf [KOil model]

[Al-Salem 2012] (Pc Version)

Models to predict the behavior of the oil spill include the calculation of the spreading, the displacement and the mass/volume balance over the different compartments (air, water surface, water column and bottom) of a released substance. The phenomenon of spreading results from a dynamic equilibrium between the forces of gravity, inertia, friction, viscosity, and surface tension. The variables that mainly influence the dispersion and evaporation are the wind speed, marine currents, time, density of the oil and the amount of the oil released. Many oil spill models are commercially available and can be setup for the Arabian Gulf and the Kuwaiti territorial waters. Such models however, require accurate data on the marine currents which are usually provided from a separate hydrodynamic model HD (Lo and Al-Salem. 1999) and (K. Al-Salem ,2008) that it takes very long computer time for simulation of the marine current condition.

Methodology

The model currently uses data from the KGulf 2D hydrodynamic HD model for the Arabian Gulf (K. Al-Salem; web address:

[http://www.hceatkuwait.net/web_pas/web-KGulf/KGulfmain.aspx].

KGulf is 2D hydrodynamics Prediction model set up for the Arabian Gulf and Kuwait waters (K. Al-Salem ,2008). The model is capable of simulating 2D tidal current and water level at any selected grid inside Arabian Gulf waters with hourly output results. Also a refine grid was generated for Kuwaiti territorial water. A grid was generated covering the Arabian Gulf from the Hormoz inlet till the upper part of Arabian Gulf . The grid spacing is about 5-8 km in the Arabian Gulf with a total of 3692 grid inside the Gulf. For some local areas in Kuwait waters the refined grid spacing reached about less than 50 m Figs. 1. KGulf model was validated using a tide prediction TIDCALC model (UK's Hydrographic Office), RMA-10 HD model (King, I.P. 1988) and using some field measurements. Result showed that the model is capable of predicting the 2D tidal currents and water level variations well with very short simulation time. Four finer grids have recently been setup for the Kuwaiti territorial waters and include all the power plants in Kuwait. These grids provide detailed tidal currents near the sensitive locations in Kuwait as shown in Figs 1 and Fig A1-A3. Fig 1 shows samples of grid system in Kuwait waters. The Oil transport model is coupled with 2D hydrodynamic model for Kuwait Waters (KGulf model). The velocity distribution is calculated at each time step and is taken as an input for the oil transport simulation model (KOil model) (K. AlSalem ,1993).

Lagrangian description of turbulent diffusion

A Lagrangian discrete-parcel algorithm is used. In this algorithm, the oil slick is viewed as a large ensemble of small parcels. It looks at the subsequent coordinates (trajectories) of a number of individual fluid or fluid property particles that are advected (transported) by currents. When the current field is known then we may add turbulent diffusion as random walks   that have in general Gaussian distribution with dispersion that corresponds to turbulent activity.

For a particle numbered i we get

$$dx_i = u(x_i, y_i, z_i, t)dt + Rnd_x(i)$$
$$dy_i = v(x_i, y_i, z_i, t)dt + Rnd_y(i)$$
$$dz_i = w(x_i, y_i, z_i, t)dt + Rnd_z(i)$$

Model Simulation Description

KGulf model was developed and set up for the Arabian Gulf and Kuwait territorial waters with multi grid system for solving hydraulic engineering application. To start simulate the KGulf model user must select [🌀] to start the model Fig 60 will display the following input Option for user to state as follows:

• 1D/2D tidal current speed and direction hourly perdition
• 1D/2D tide Level hourly prediction and Water level analysis
• Trajectory Oil spill prediction [KOil 2009]
• Oil Spill

      KOil model 2012   [See Section 3 p50]

      Back Track Oil Spill [see section 3 p59]

To Simulation Oil Spill Project KGulf model have two Models for user to select from Fig 60 as follow:

  1- [KOil model 2009] User must Check [2D Prediction]. A new frame will display at Fig 60. User must select again [Time Serious 2D Prediction].

  2- [KOil model 2012] User must select [Oil Spill] from Fig 60. These model will describe on next Section

*For Simulation [**KOil model 2012**]*

User after selected [***OIL SPILL***] in Fig 60.

Figure 70 will display for user two models as:

        o Oil Spill Trajectory
        o Back Track Oil Spill.

User must select [***Oil Spill Trajectory***] Fig 71 will display to select the following

        ▪ Grid Domain
        ▪ Domain map

User must Check [***2D hydrodynamics' Setu***p] Fig 72 will display for user to input the hydrodynamic require information as:

        ▪ Start Date
        ▪ End Date

User must check [***Wind Data Setup***] Fig 73 will display for user to input Type of wind data entry as follows:

• Constant Wind Speed data [***Constant Wind speed***].
• Variable wind Speed Data [***Load Wind Speed***]. From Data file [Wind speed, Direction]

User must Check [***Start Simulation***] Fig 74 will display to enter the following

• Time of oil spill in hour of first day.
• Oil Spill Location(Longitude/Latitude) in Degree
• Oil spill Volume

User must press on [***Save spill Location***].

To check location press [***Show***]. Spill location Will display on Map as DOT.

To start oil spill simulation in Fig 74 two option display as follows:

• Point Source Simulation
    User can setup Number of Particle as represent the oil spill volume
    Then must select **[RUN]**
    A Snapshot of oil spill simulation shown in Fig 75

- Continuous Spill Simulation

User can set [*Spill Time in Hour*] as follows

- [0] : mean the oil spill continuous spill until the end on simulation
- [A number on Hour] : Mean; that the total of oil spill hours. Then after that oil spill will stop until end of simulation.

User can setup *Number of Particle* as represent the oil spill volume

Then must select **[RUN]**

A Snapshot of Continuous oil spill simulation option shown in Fig 76

User can run the oil spill result Animation by check [*Simulation Output*] from Fig 76.
Figure 77 will display snapshot of the result animation of oil spill particle for every time step

Display Oil Spill Result On Google user must check [*Google map On/Off*] as shown in Fig 78.
A new frame will display information for selecting the Google map option as in Fig 78
Then user must select [*Google Map Show*] in fig 78
Fig 79 shows oil spill on Google Map.
Fig 79 shown The Part of Html file created to display oil spill location Data on Google Map.

Figure 70
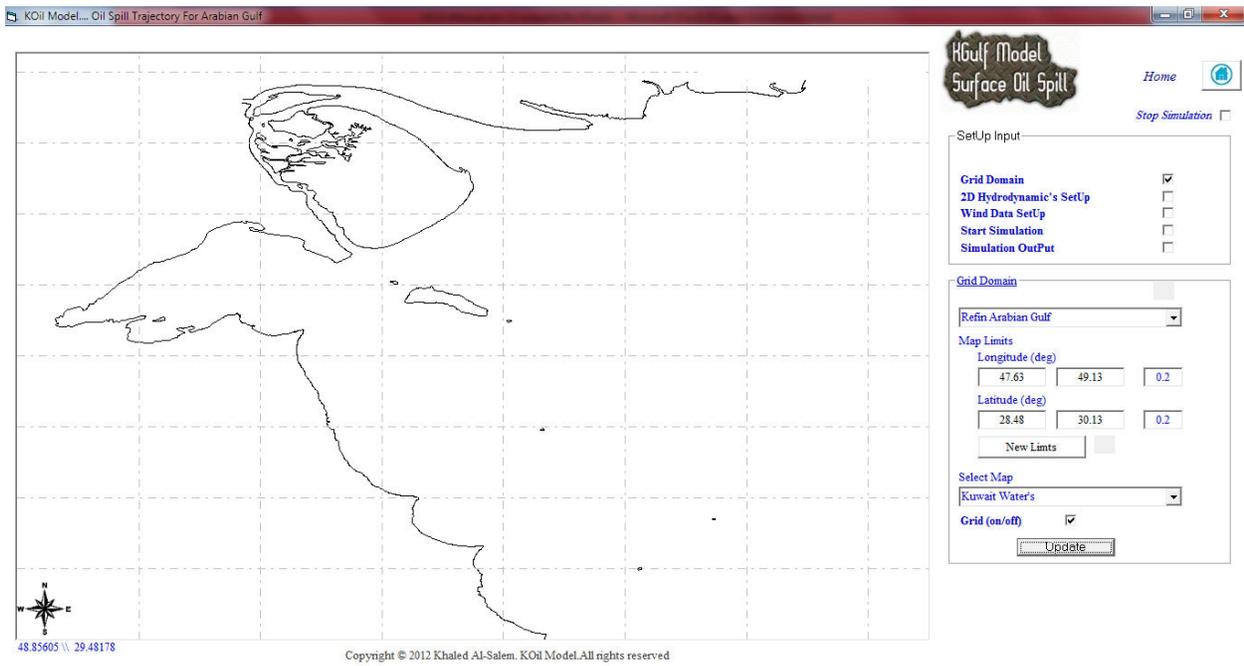
Figure 71
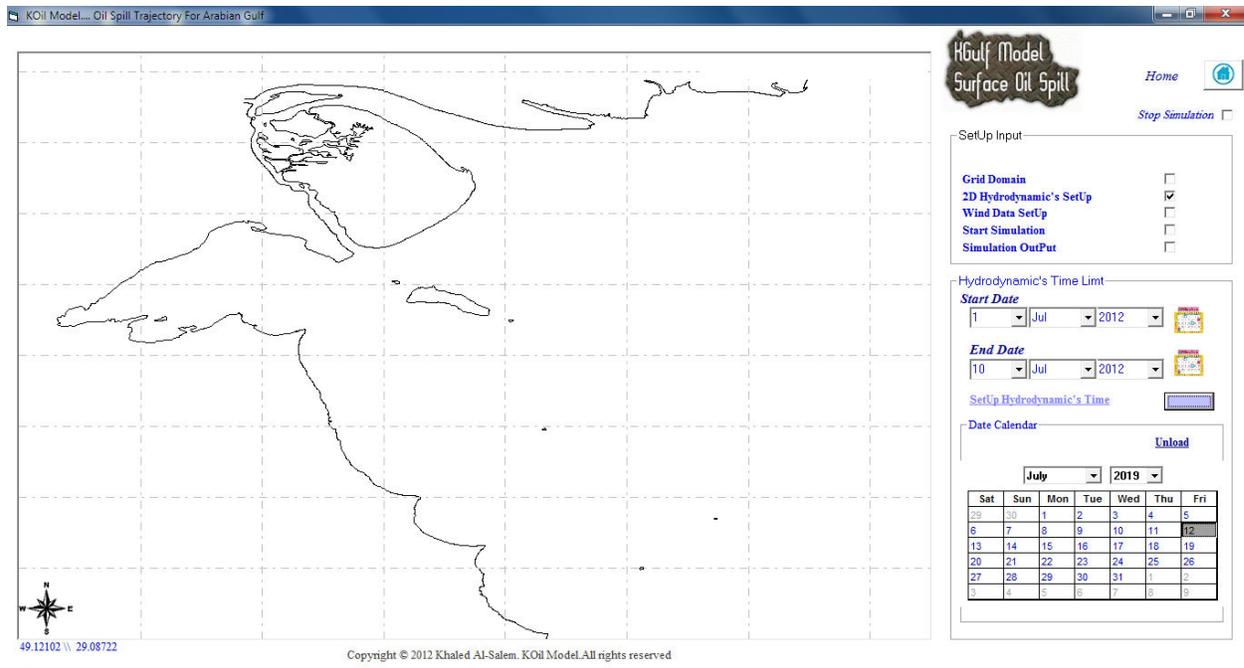
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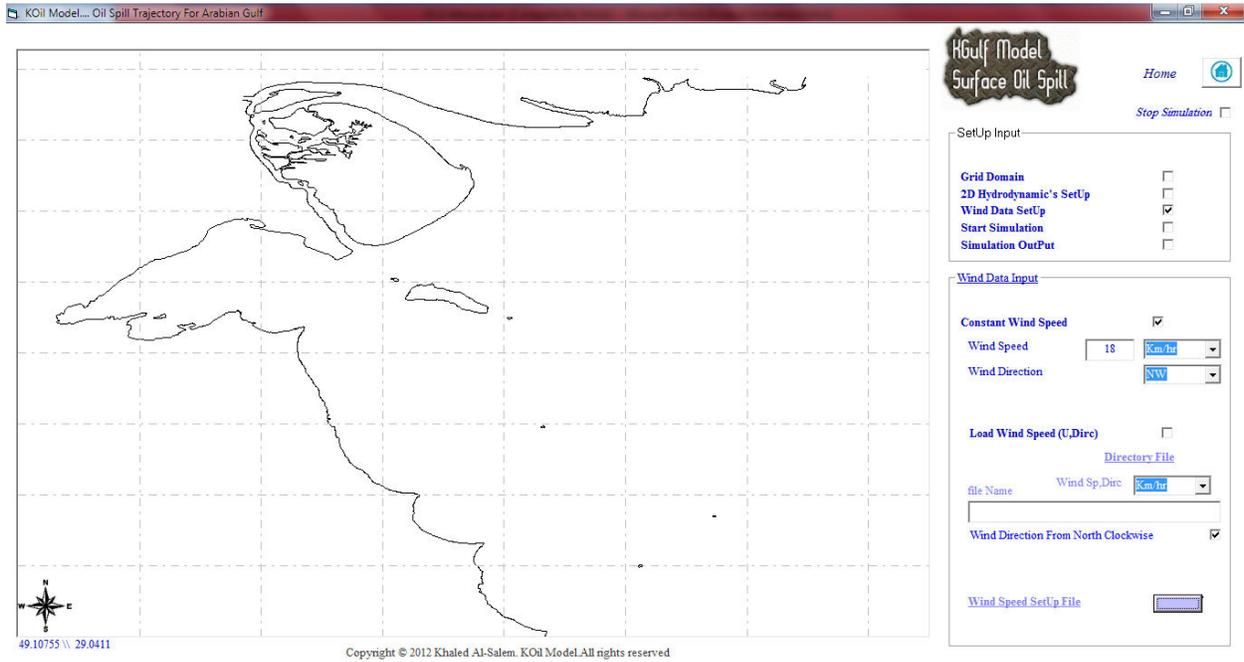
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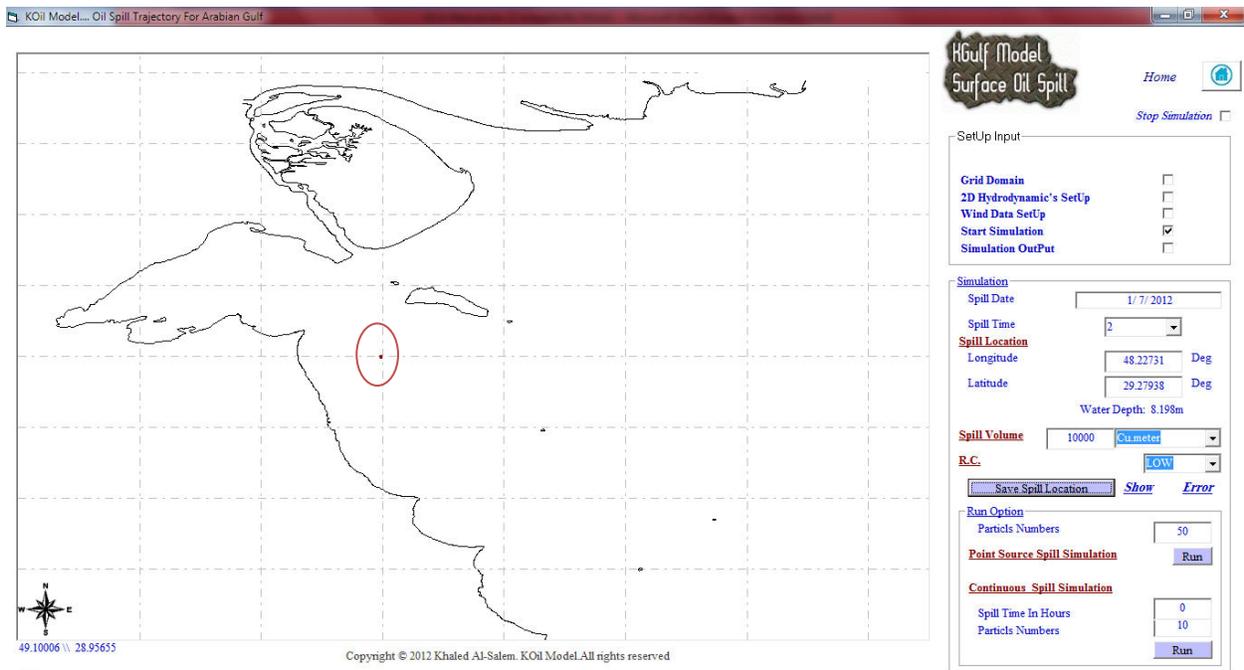
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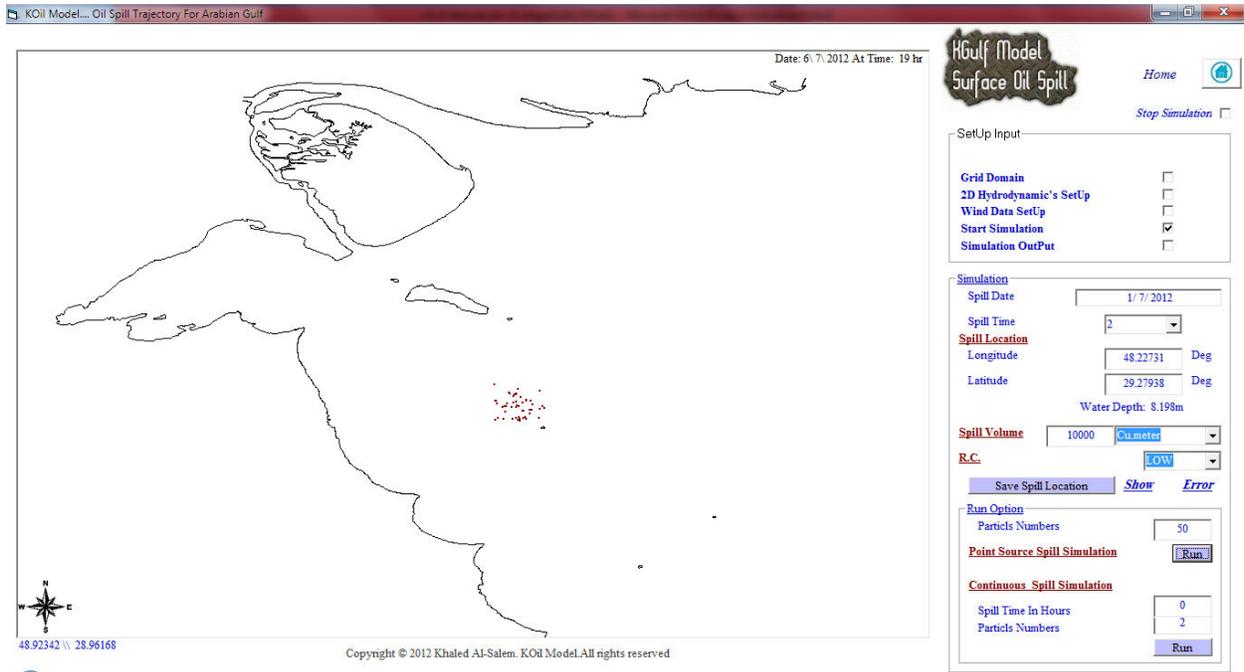
Figure 75
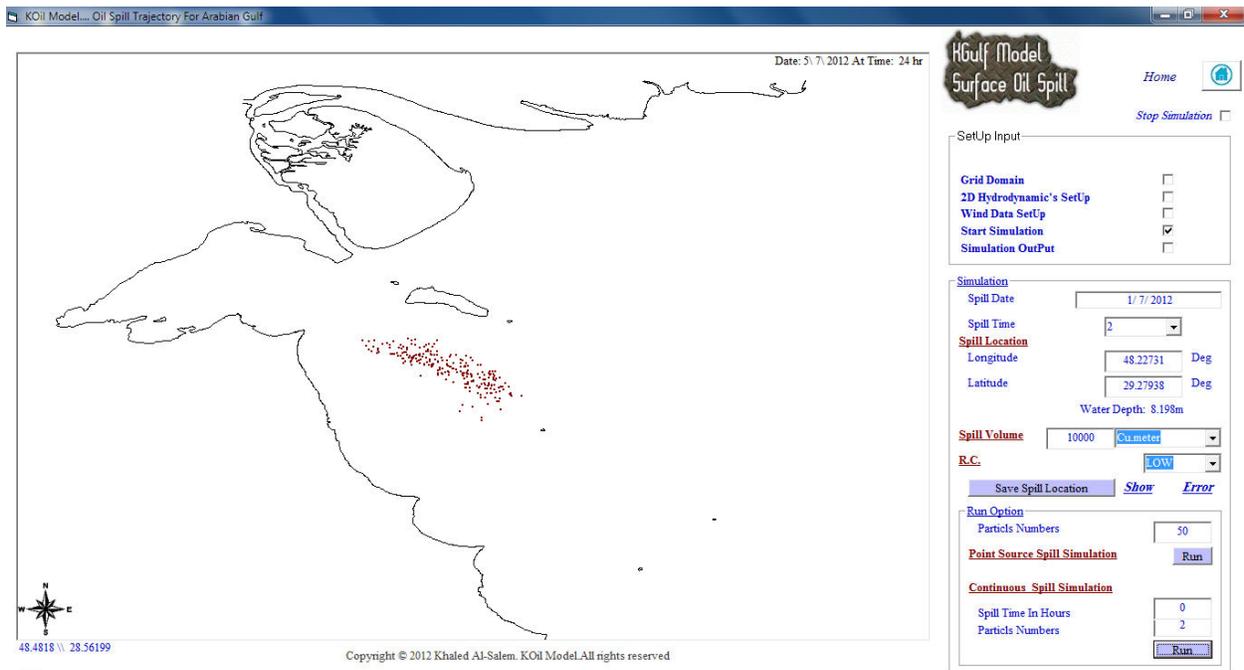
Figure 76

Figure 77

Figure 78

Copyright @ K. Al-Salem - Oil Spill Location on Google Map (KOil 2012)
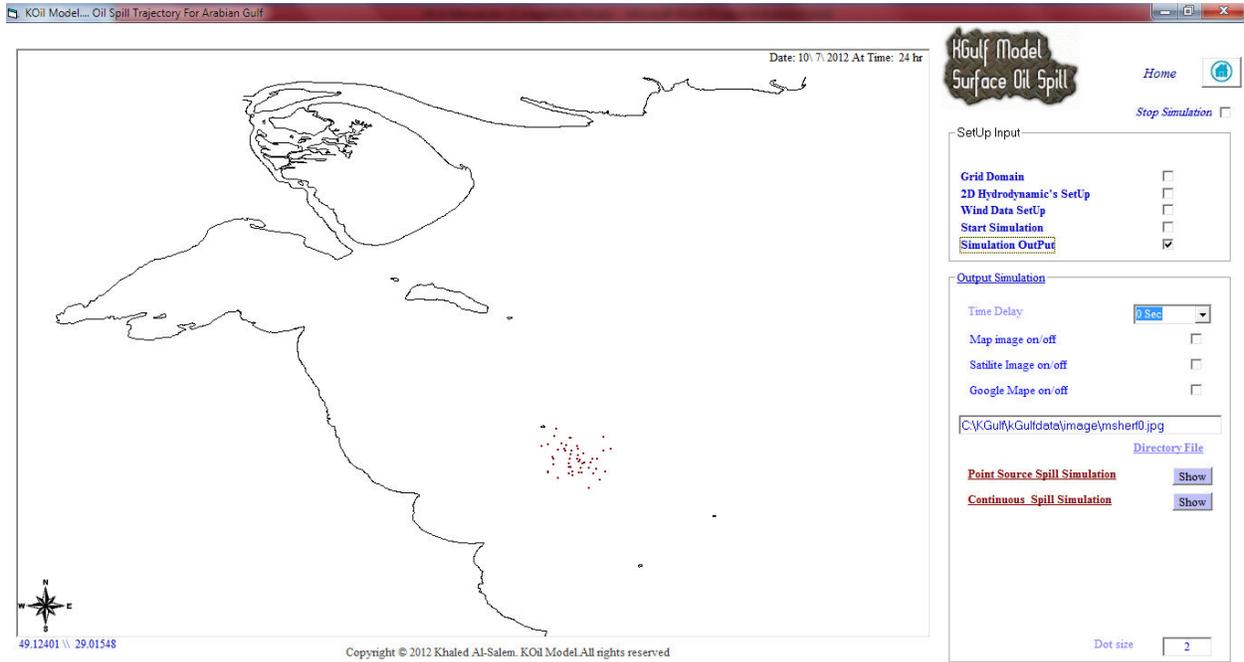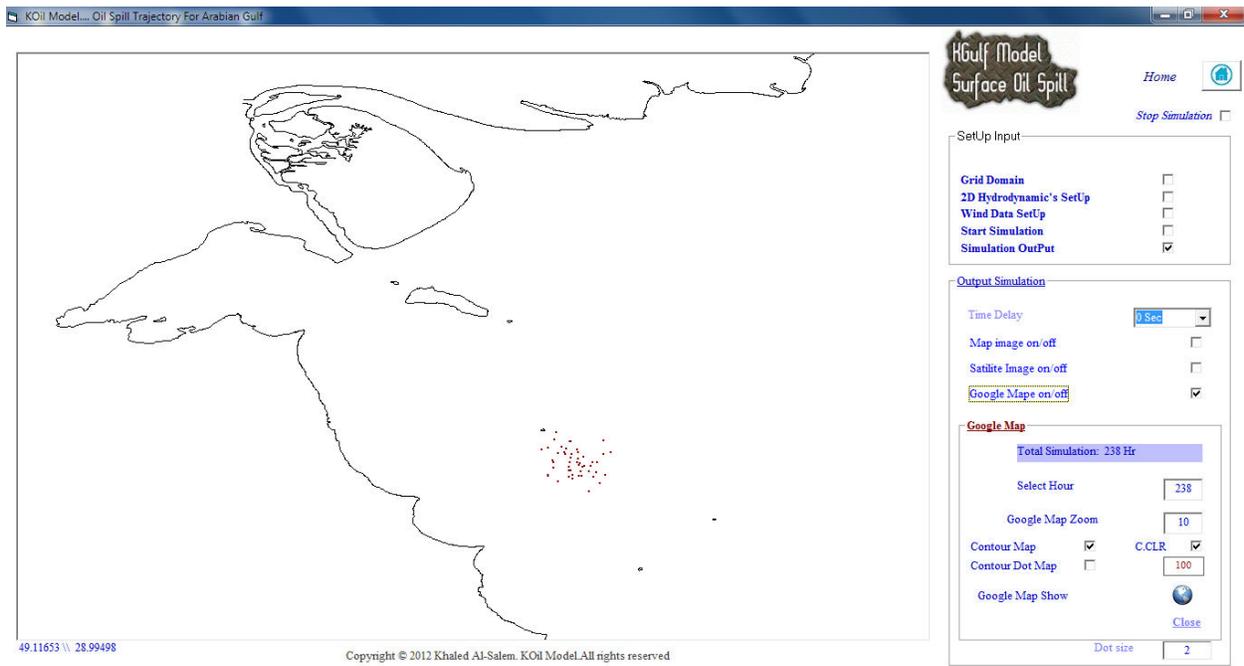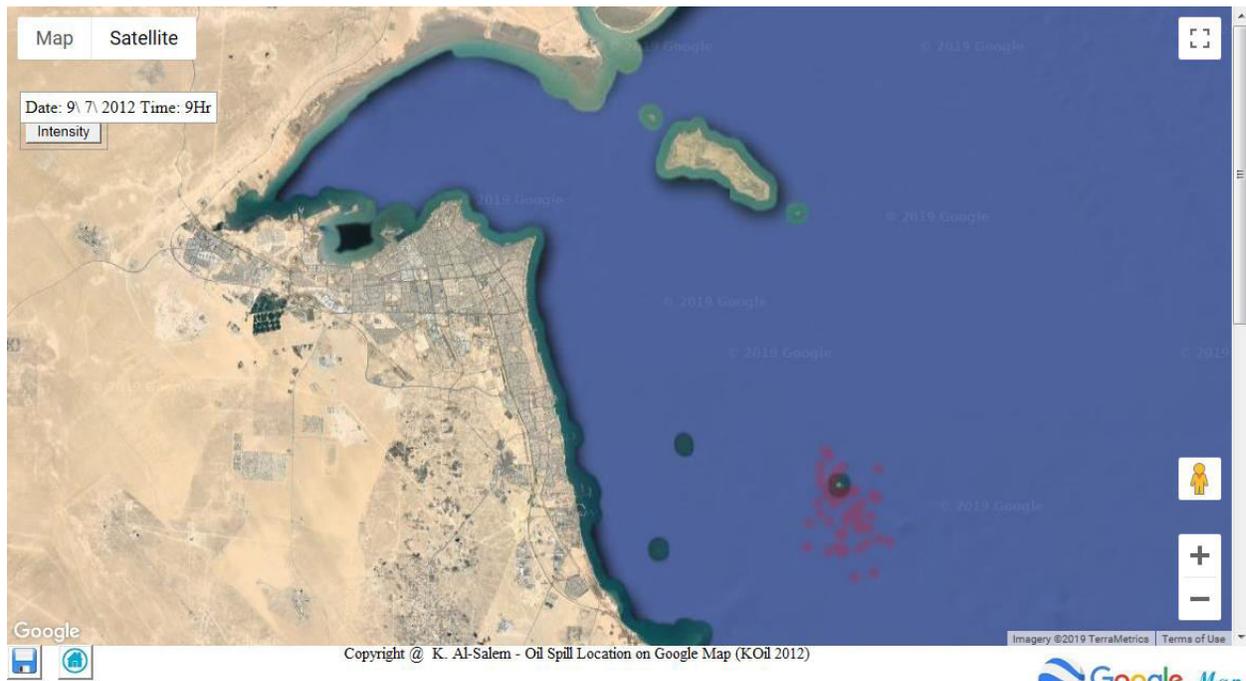
```
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  <head>
  <meta http-equiv='content-type' content='text/html;charset=u
  <meta http-equiv='X-UA-Compatible' content='IE=edge'>

    <title>KOil Model(2012)</title>
    <style>
      #map {
        height: 100%;
      }
      html, body {
        height: 100%;
        margin: 0;
        padding: 0;
      }
      #floating-pane {
        position: absolute;
        top: 10px;
        left: 25%;
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        background-color: #fff;
        padding: 5px;
        border: 1px solid #999;
        text-align: center;
        font-family: 'Roboto','sans-serif';
        line-height: 30px;
        padding-left: 10px;
      }
      #floating-panel {
        background-color: #ffff;
        border: 1px solid #999;
        left: 1%;
        padding: 5px;
        position: absolute;
        top:100px;
        z-index: 5;
      }
      #floating-pane2 {
        background-color: #fff;
        border: 1px solid #999;
        left: 1%;
        padding: 5px;
        position: absolute;
        top:80px;
        z-index: 5;
      }
    </style>
  </head>
  <body>
    <div id='floating-panel'>
      <button onclick='changeOpacity()'>Intensity</button>
    </div>
    <div id='floating-pane2'>
    <textbox id='tv4' >Date: 7\ 2\ 2005 02:00 ?</textbox>
    </div>
    <div id='map'></div>
    <script>
      var map, heatmap;
```

Figure 79

3.3 Back Track Oil Spill for Arabian Gulf [BOil model]
[Al-Salem 2012]   (PC Version)

Methodology

Prior to modeling the transport and dispersion of a typical oil spill processes in estuarine and coastal waters, the hydrodynamic characteristics of the flow fields, such as water elevations and velocity components must be predicted. In the current study, this was predicted by the hydrodynamic model named KGulf, which is used to solve the governing hydrodynamic equations, further details is included in [*Al-Salem*, 2012]. Previously, KGulf model has been successfully validated and widely used for studying the Gulf dynamics as in *Alosairi et al.,* [2011]. In this study, a coarse numerical grid was used, while relatively finer grid was used for Kuwait territorial waters. At each grid points the model provides tidal elevations and most importantly it provides the tidal and wind induced currents that act as the driver for the BOil model.

A Lagrrangian discrete-parcel algorithm is used, in which the oil slick is viewed as a large ensemble of small parcels, see Figure 80. The movement of each parcel is followed and recorded as functions of time relative to a reference grid system fixed in space [*Reddy*, 1997, *Shen* and *Yapa*, 1988, *Shen et al.,* 1987, *Yapa* and *Chowdhary*, 1989, and *Yapa,*1994]. In the Lagrangian discrete-parcel algorithm, the oil slick is divided into a large number of equal masses. These parcels are introduced into the system in case of instantaneous spill at the spill site (x,y) and time (t). Each parcel is then allowed to move with the drift velocity. The water speed s_r and wind speed w_r can be calculated from Equations 1 and 2 respectively.

$$s_r = \sqrt{U_x^2 + U_y^2} \text{ and} \tag{1}$$

$$w_r = \sqrt{W_x^2 + W_y^2} \tag{2}$$

Where U_x and U_y is the velocity components in the *x* and *y* directions, respectively. Similarly for the wind, where W_x and W_y are the wind components in the *x* and *y* directions. The drift velocity, u_i^t and v_r^t, of oil spill takes into account the effects of both, water currents and wind, where it can be calculated by Equations 3 and 4 for the *x* and *y* directions, respectively.

$$u_i^t = U_x + W_x^d \tag{3}$$

$$v_i^t = U_y + W_y^d \tag{4}$$

Where W^d is the drifting speed due to wind that typically varies from 2 to 4% of the wind speed (w_r) [*Schwartzberg*, 1971], for the current study 3% has been used. The component of the velocity due to diffusion of oil slick is calculated by random walk analysis as shown Equations 5 and 6. The computation for oil parcels calculated numerically by integrating the drift velocity at each time interval. For numerical accuracy, sub-time intervals are used for the advection of oil parcels. When the current field is known then turbulent diffusion can possibly be added as random walks *Rnd( )* that have, in general, a Gaussian distribution with dispersion that corresponds to turbulent activity. Therefore, for a particle numbered *i* we get:

$$dx_i = u(x_i, y_i, t)\, dt + Rnd_x(i) \tag{5}$$

$$dy_i = v(x_i, y_i, t)\, dt + Rnd_y(i) \tag{6}$$

It is worth mentioning that Schwartzberg's experiments indicate that the drift has the same direction as the wind but theoretical studies for wind-induced surface current, conducted by *Ekman,* [1905], suggests that the direction of the drift velocity has small deflection to the right or to the left of the wind direction. To overcome the random walk in backtrack simulation of Lagrrangian discrete-parcel algorithm, Monte Carlo Statistical Technique can be applied, as explained in *Binder and Heermann* [2010]. Using Lagrrangian discrete-parcel algorithm analogy in backward time series approach, the path of the center of oil particles were simulated from a given sited location to track were the spill has probably started for *n* number of tests. Then all tests are grouped in defined limits of D_x and D_y with respect the total test completed to generate the probabilities of the final location as shown in Equation 7 and illustrated in Figure 2.

$$P_i = \frac{\Sigma\big((abs(X_{i+1}+X_i)\leq D_x) \text{ and } (abs(Y_{i+1}-Y_i)\leq D_y)\big)}{N} \qquad (7)$$

Where P_i is the probability of particles location, N is total number of simulated tests, i is the location x and y at i test number of total tests N, D_x and D_y is the limit value setup between X and Y location for all simulated tests. The algorithm in Equation 7 is coupled with KGulf to give the source of the oil spill, i.e. B-Oil. The mechanism of the B-Oil model predictions is illustrated in Figure 2. The user of the model would need to set the total number of tests that the model needs to undertake and the diameter of the area where the probabilities may occur (in meters) i.e. D_x and D_y. Based on Equations 7, the probability of test distribution for position of the oil path is estimated by fraction of central practical reaching various locations within selected time intervals based on the number of tests as shown in Figure 80. To elucidate, if the probability indicates 50% at a particular location for 20 tests then this means that half of the tests results (10) occurred in this location. The remaining test would be designated to search for other locations. If probabilities elapsed at a particular location, as shown in Figure 80, then the probability would be accounted for the first probability and not the second one. This modeling technique will be tested and verified in the following section.
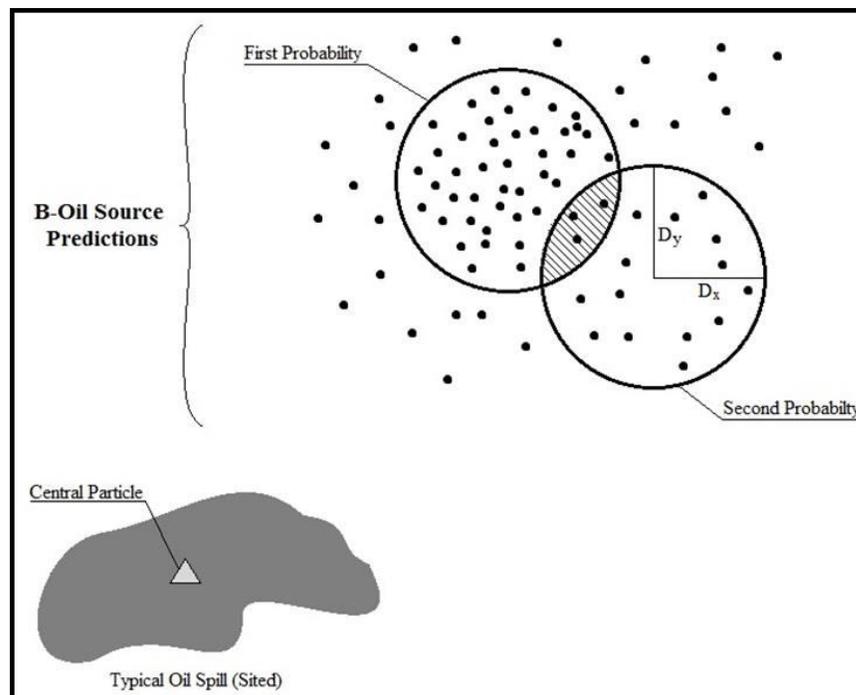
Figure 80

Model simulation Description

User after selected [***OIL SPILL***] in Fig 60.
Figure 81 will display for user two models as:
- o   Oil Spill Trajectory
- o   Back Track Oil Spill.

User must select [***Back Track Oil Spill***] Fig 82 will display to select the following
- ▪   Check [***Limits Domain***] to enter the following
    - Grid Domain [As shown in Fig 83]
    -Domain Map
  Then select [**UPDATE**]
- ▪   Enter [Wind Effect] as following:
    -Constant Wind Speed
    -Variable wind Speed (Read from wind speed file ***WS,Wdirc***]
- ▪   User must check [***Source Info***] to Enter oil spill ***SEEN Location*** as
    -Click On Map
    - Manual Enter Longitude and Latitude then select [**CHK**]
- ▪   Select Hydrodynamic information at [***Start Info***] as follows:
    -Select Oil Spill Seen Date and Time
    -Select Date for Backtrack To.
- ▪   Select information for Lagrrangian discrete-parcel algorithm as
    =Enter [***number Of Test***] for back track simulation test
    =Enter [***Delta***] the probability radius for prediction location

User must select [***Simulate***] in Fig 82 then Fig 84 will display the simulation Results
To display [Location Of Probabilities Table] user must select from Fig 84 *[POST OUTPUT]*.
Figure 85 will display A summary of Back track oil spill Probably of Source Location from all Select Test.
Figure 86 Display A sample Output file select.at [***Store Output File***] as shown in Fig 84
Figure 87 display the back Track Oil Spill with back Ground map of Satellite Image.
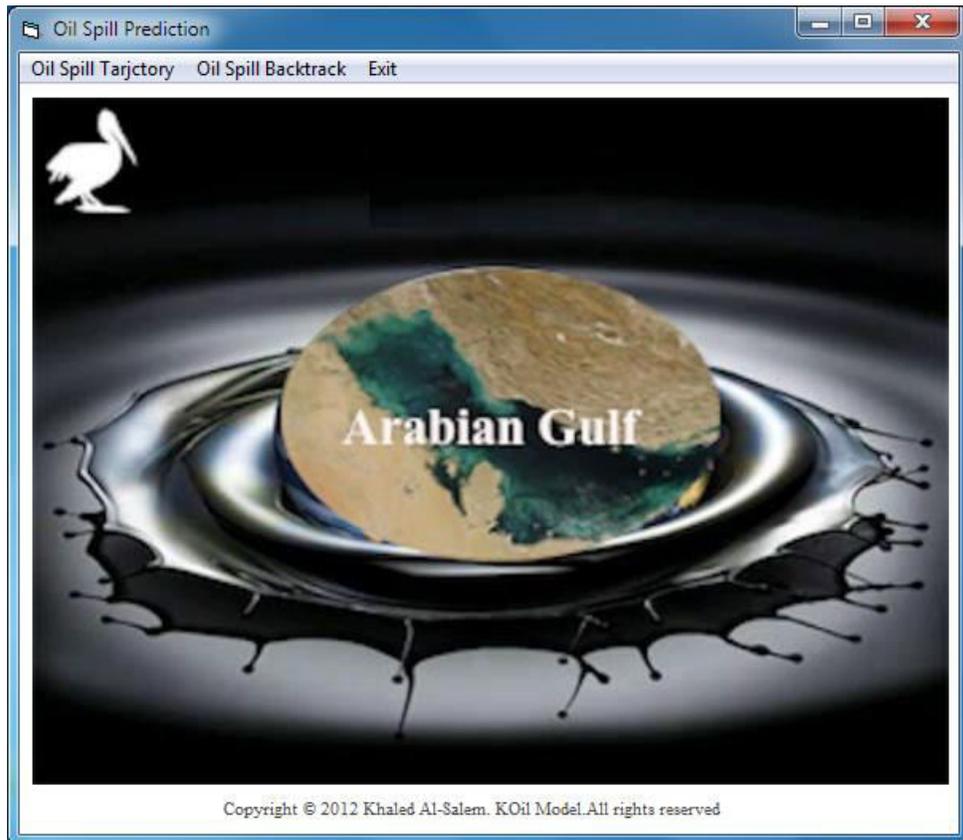
Figure 81
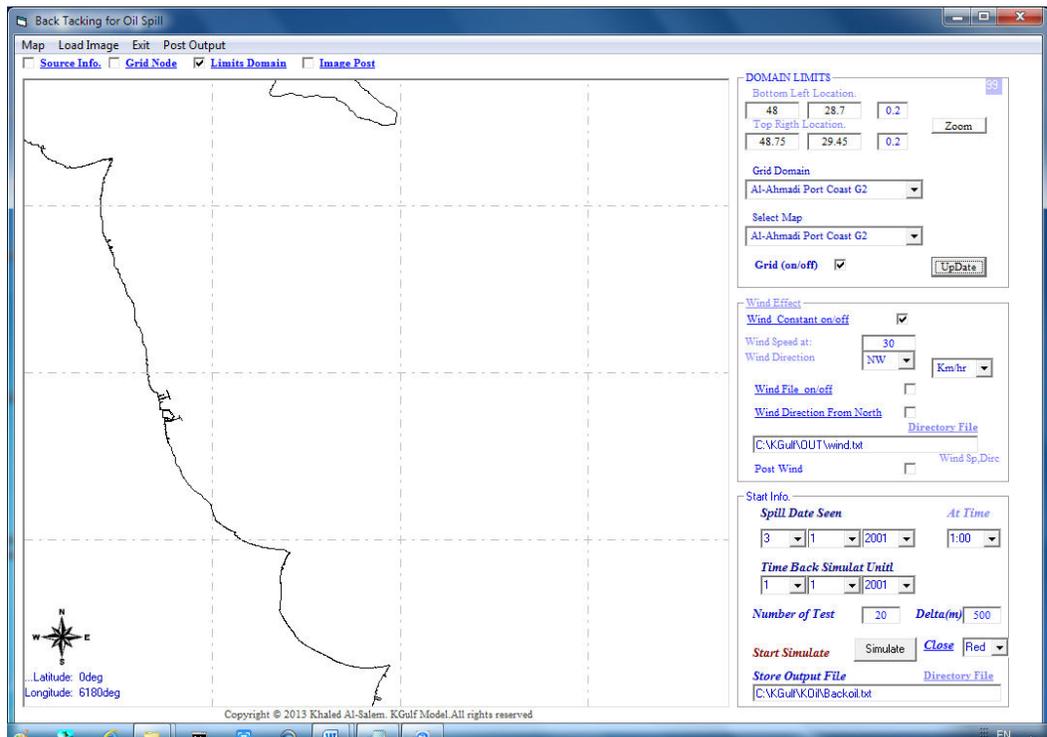
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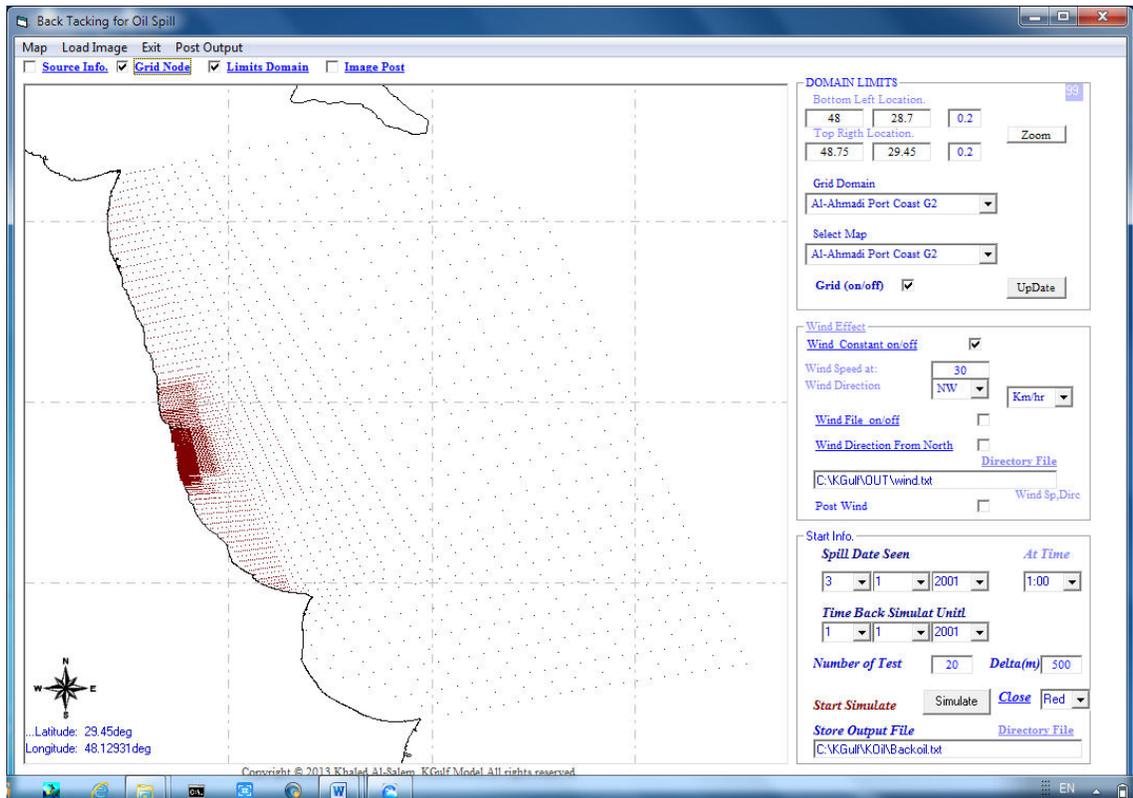
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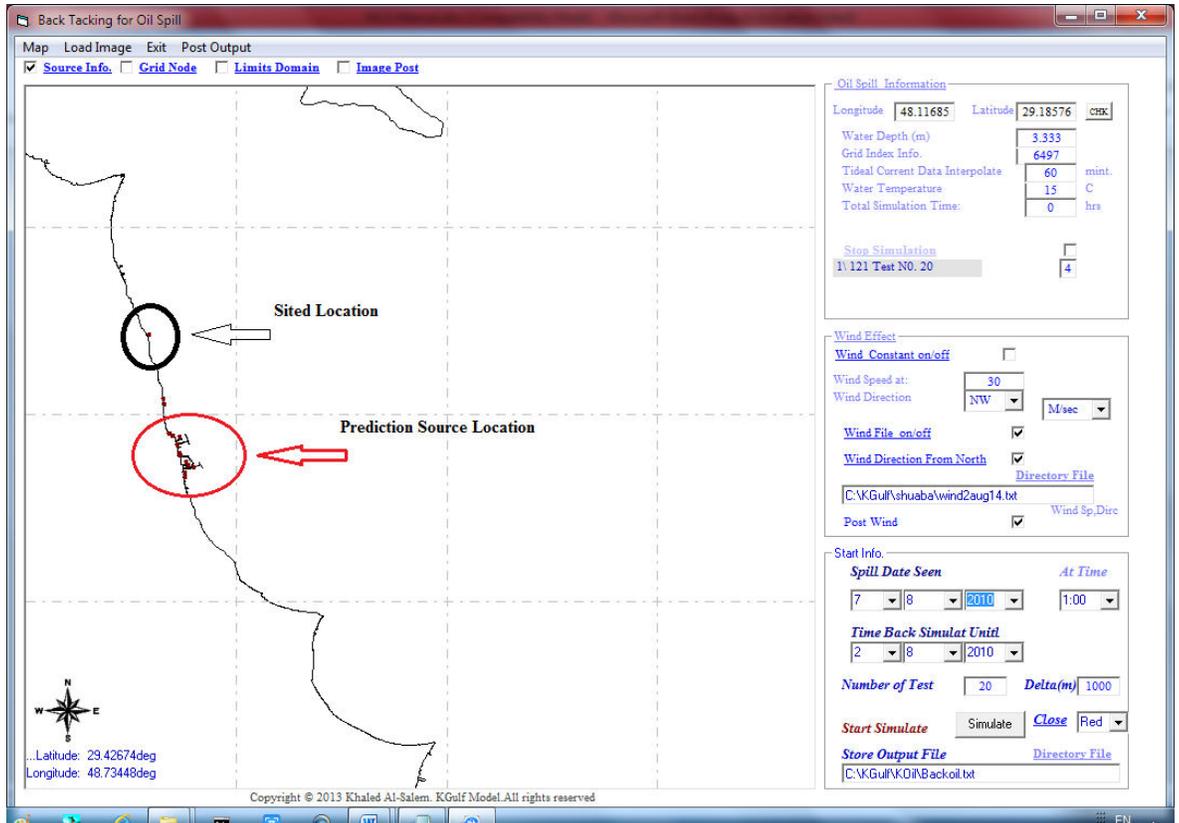
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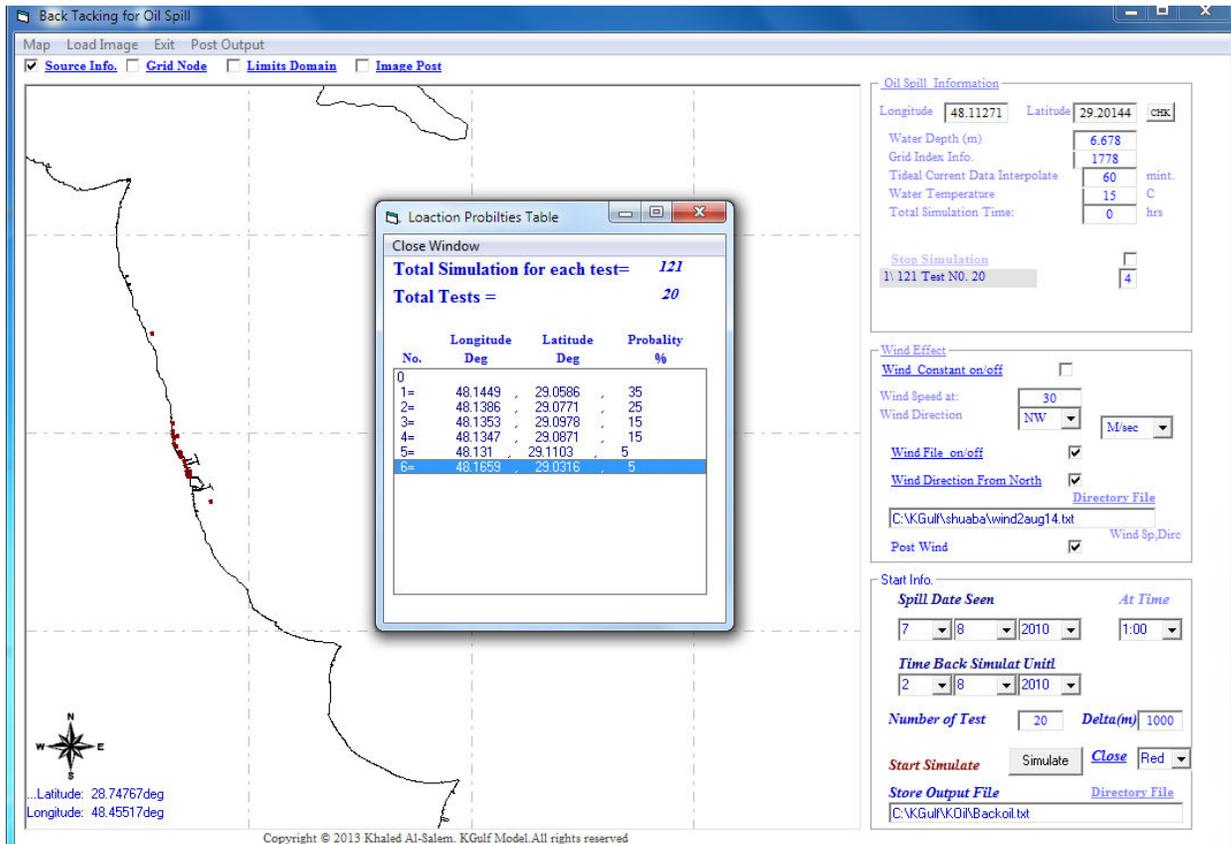
Figure 85
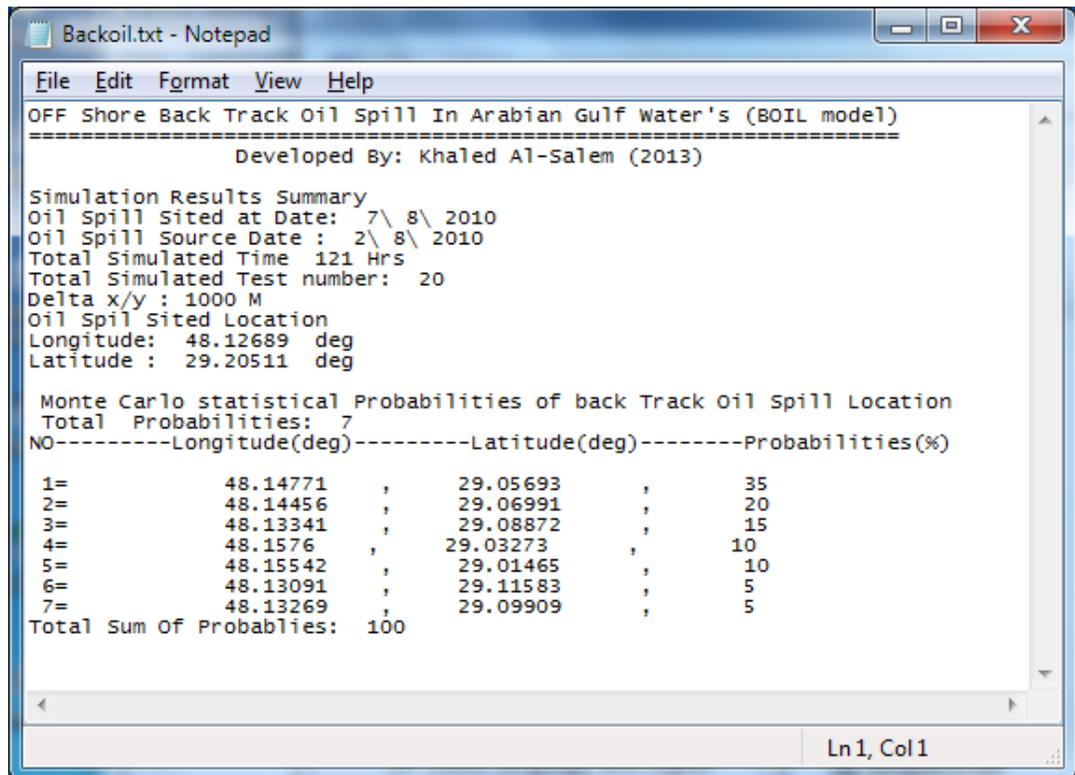
Figure 86
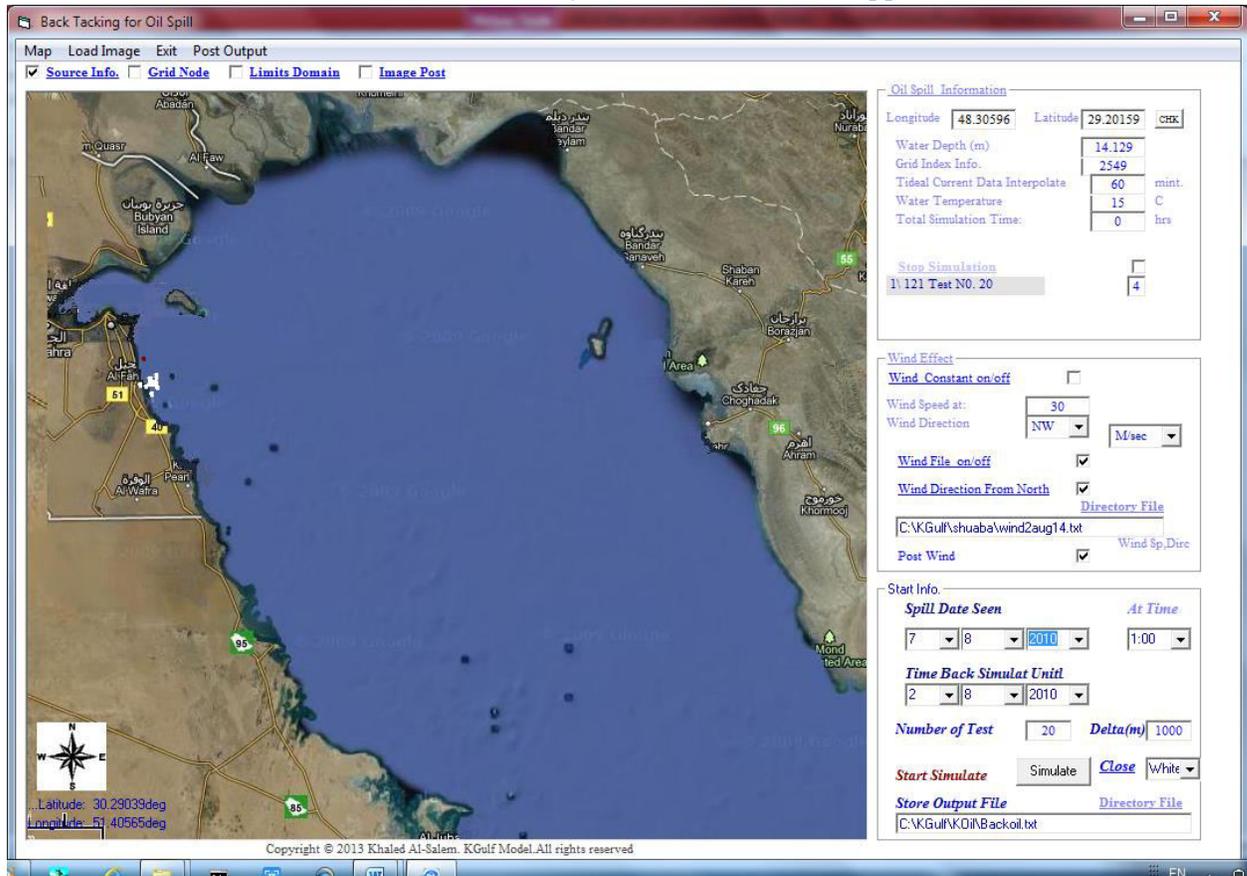
Figure 87

3.4 Under Water Oil Seepage [KSPoil model]
[Dr Yaba 1997]
[Model updated and Interface Developed by Khaled Al-Salem 2010]

Methodology

Governing Equations for Simulating the Plume Dynamics (Phase-1)

   Many oil spill models were developed to predict the trajectory and fate of surface or near surface oil spills (see ASCE, 1996). The KISR oil spill model represents one of such models (Al-Salem and Lo, 1993). Such models are based on the advection/diffusion equation and are thus valid for simulating oil spills on the water surface. For submerged oil spills or underwater natural seepage, the oil behaves as a submerged buoyant jet requiring other model formulations.

   The model described in Yapa and Zheng (1997) provides a model capable of simulating underwater oil spills and is the base for the model developed in this study. The model is a modification of the Lagrangian concept proposed by Lee and Cheung (1990). The model assumes the following:

   • The cross section of the oil jet is round and perpendicular to the trajectory (Fig. 88).
   • The effect of oil viscosity is neglected.
   • The variables used represent average values for the cross section.

- Forced entrainment of ambient fluid occurs from the frontal side of the jet.
- Quasi steady conditions are considered.

A Lagrangian element is defined as a control volume moving along the centerline of the buoyant jet with its local centerline velocity V. The element thickness h and mass m can be calculated from,

$$h = \left|\vec{V}\right|\Delta t \tag{1}$$

$$m = \rho \pi b^2 h \tag{2}$$

where ρ is the local density of the buoyant jet, b is the jet radius (Fig. 88), and Δt is the time step.

Conservation of Mass

The conservation of mass for an oil jet can be written as,

$$\frac{dm}{dt} = \rho_a Q_e - \sum_{i=1}^{n} \frac{dm_i}{dt} - \frac{dm_d}{dt} \tag{3}$$

Where ρ_a is the density of the ambient fluid, Q_e is the volume flux entrained, the second term on the right-hand side represents the dissolution of oil into water, and the last term on the right-hand side represents the mass loss due to turbulent diffusion.

Entrainment

The volume flux entrained Q_e is separated into the shear-induced entrainment and forced entrainment (Frick, 1984 & 1994 and Lee and Cheung, 1990). The shear-induced entrainment Q_s is calculated from,

$$Q_s = 2\pi bh\alpha \left|\left|\vec{V}\right| - V'_a\right| \tag{4}$$

Where V'_a is the projection of V_a in the direction of V, and the entrainment coefficient α is calculated from (Lee and Cheung, 1990),

$$\alpha = \sqrt{2}\,\frac{0.057 + \dfrac{0.554\sin\varphi}{F^2}}{1 + 5\dfrac{V'_a}{\left|\left|\vec{V}\right| - V'_a\right|}} \tag{5}$$

Where φ is the angles between the jet trajectory and the horizontal plane and F is calculated from,

$$F = E\,\frac{\left|\left|\vec{V}\right| - V'_a\right|}{\sqrt{g\dfrac{\Delta\rho}{\rho_a}b}} \tag{6}$$

Where the proportionality constant E is taken to be 2 as recommended by Yapa and Zheng (1997).
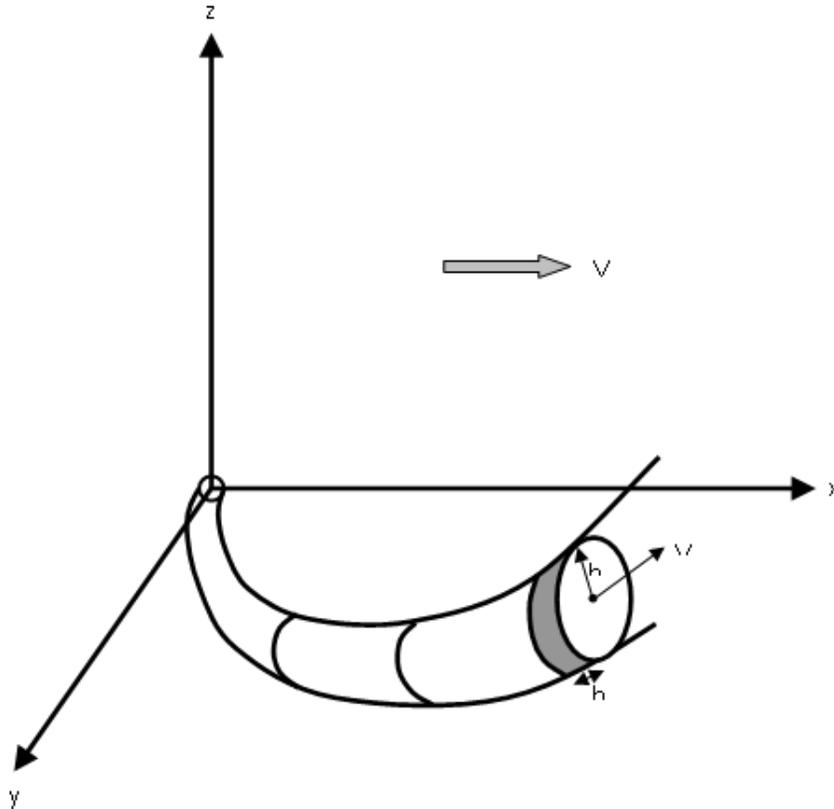
Figure 88. Schematic of the buoyant jet.

The forced entrainment components Q_{fx}, Q_{fy}, and Q_{fz} in the x, y, and z directions are calculated from (Yapa and Zheng, 1997),

$$Q_{fx} = |u_a|\Delta t \left[\pi b \Delta b |\cos\varphi\cos\theta| + 2b\Delta s\sqrt{1-\cos^2\theta\cos^2\varphi} + \frac{\pi b^2}{2}|\Delta(\cos\varphi\cos\theta)| \right] \quad (7)$$

$$Q_{fy} = |v_a|\Delta t \left[\pi b \Delta b |\cos\varphi\sin\theta| + 2b\Delta s\sqrt{1-\sin^2\theta\cos^2\varphi} + \frac{\pi b^2}{2}|\Delta(\cos\varphi\sin\theta)| \right] \quad (8)$$

$$Q_{fz} = |w_a|\Delta t \left[\pi b \Delta b |\sin\varphi| + 2b\Delta s|\cos\varphi| + \frac{\pi b^2}{2}|\Delta(\sin\varphi)| \right] \quad (9)$$

where θ is the angle between the x-axis and projection of the jet trajectory on the horizontal plane, and u_a, v_a, and w_a are the velocity components of the ambient current V_a in the x, y, and z directions respectively..

Finally, the value of Q_e is calculated as the maximum of Q_s or Q_f.

Dissolution

The dissolution term is calculated from the following equation (Yapa, and Zheng, 1997),

$$\frac{dm_i}{dt} = K_i \alpha_i A X_i S_i \qquad (10)$$

Where,

- m_i is the mass of the oil component i (i=1,2,…,n)
- K_r is the mass transfer coefficient of dissolution (m/s)
- α_i is an empirical constant = 0.7 (Rye, 1994)
- A is the area of exposed jet $A = 2\pi bh$
- X_i is the molar fraction of the component i
- S_i is the solubility of the component i (kg/m^3)

This term was neglected in this study (K_r=0.0).

Turbulent Diffusion

The turbulent diffusion term is calculated as,

$$\frac{dm_d}{dt} = \rho_a K_c A \left| \frac{\partial C}{\partial r} \right| \qquad (11)$$

Where,

- m_d is the mass loss due to turbulent diffusion
- K_c is the oil diffusivity
- C is the average (over cross section) oil concentration in the jet

Conservation of Momentum

The conservation of momentum can be written as,

$$\frac{d(m\vec{V})}{dt} = \vec{V_a} \frac{dm}{dt} + m \frac{\Delta\rho}{\rho} g\vec{k} - 2\rho bh C_D \left(\left|\vec{V}\right| - V'_a \right)^2 \frac{\vec{V}}{\left|\vec{V}\right|} \qquad (12)$$

Where C_D is a drag coefficient (taken to be zero thus neglecting the drag force), k is a unit vector in the z direction, and $\Delta\rho = \rho_a - \rho$ (where ρ is the average density of the jet).

Conservation of Heat, Salinity, and Oil Concentration

The conservation of the scalar parameters of the buoyant jet, namely the heat, salinity, and the oil concentration can be written in the from,

$$\frac{d(mC_pT)}{dt} = \left(C_pT\right)_a \frac{dm}{dt} - 2\rho_a \pi bh K_T \frac{\partial(C_pT)}{\partial r} \qquad (13)$$

Where C_p is the specific heat (assumed constant), T is the average temperature of the jet, and K_t is the heat diffusivity.

$$\frac{d(mS)}{dt} = S_a \frac{dm}{dt} - 2\rho_a \pi bh K_S \frac{\partial S}{\partial r} \qquad (14)$$

Where S is the average salinity of the jet, and K_S is the salinity diffusivity.

$$\frac{d(mC)}{dt} = C_a \frac{dm}{dt} - 2\rho_a \pi bh K_C \frac{\partial C}{\partial r} + \sum_{i=1}^{n} \frac{dm_i}{dt} \qquad (15)$$

State Equation

Finally, the density of the buoyant jet is calculated from the state equation describing the variation of the density with temperature, salinity, and concentration of the fluid in the jet.

Discretization of Equations

The above equations were discretized using the finite difference technique as provided in this section.

The mass equation can be discretized as,

$$m_{k+1} = m_k + \rho_a Q_e \Delta t - \sum_{i=1}^{n} \Delta m_i - \Delta m_d \qquad (16)$$

Where the subscript k denotes the time step and the last two terms are calculated from,

$$\Delta m_i = K_i \alpha_i 2\pi b h X_i S_i \Delta t \qquad (17)$$

$$\Delta m_d = \rho_a K_c 2\pi b h \Delta t \frac{C - C_a}{b/2} \qquad (18)$$

The salinity, concentration and temperature can be calculated as follows,

$$S_{k+1} = \frac{m_k S_k + \Delta m_k S_a - 4\pi \rho_a K_S h_k \Delta t (S_k - S_a)}{m_{k+1}} \qquad (19)$$

$$C_{k+1} = \frac{m_k C_k + \Delta m_k C_a - 4\pi \rho_a K_c h_k \Delta t (C_k - C_a) + \sum_{i=1}^{n} \Delta m_i}{m_{k+1}} \qquad (20)$$

$$T_{k+1} = \frac{m_k T_k + \Delta m_k T_a - 4\pi \rho_a K_T h_k \Delta t (T_k - T_a)}{m_{k+1}} \qquad (21)$$

The jet velocities are calculated from the momentum equation,

$$u_{k+1} = \frac{m_k u_k + \Delta m_k u_a}{m_{k+1}} \qquad (22)$$

$$v_{k+1} = \frac{m_k v_k + \Delta m_k v_a}{m_{k+1}} \qquad (23)$$

$$w_{k+1} = \frac{m_k w_k + \Delta m_k w_a}{m_{k+1}} + \frac{\rho_a - \rho_k}{\rho_k} g \Delta t \qquad (24)$$

The location of the jet is calculated from,

$$x_{k+1} = x_k + u_{k+1} \Delta t \qquad (25)$$

$$y_{k+1} = y_k + v_{k+1} \Delta t \qquad (26)$$

$$z_{k+1} = z_k + w_{k+1} \Delta t \qquad (27)$$

The density of the jet can be calculated from the state equation and the thickness and radius of the jet are calculated from,

$$h_{k+1} = \frac{\left| \vec{V}_{k+1} \right|}{\left| \vec{V}_k \right|} h_k \qquad (28)$$

$$b_{k+1} = \sqrt{\frac{m_{k+1}}{\rho_{k+1} \pi h_{k+1}}} \qquad (29)$$

It is important to note that for the first time step, the value of h is taken to be the same as Δs. The orientation of the jet is calculated from,

$$\sin \theta_{k+1} = \frac{v_{k+1}}{Hvel} \qquad (30)$$

$$\cos \theta_{k+1} = \frac{u_{k+1}}{Hvel} \qquad (31)$$

$$\sin \varphi_{k+1} = \frac{w_{k+1}}{\left|\vec{V}_{k+1}\right|} \qquad (32)$$

$$\cos \varphi_{k+1} = \frac{Hvel}{\left|\vec{V}_{k+1}\right|} \qquad (33)$$

Where,

$$Hvel = \sqrt{u_{k+1}^2 + v_{k+1}^2} \qquad (34)$$

Finally, the displacement Δs is calculated from,

$$\Delta s_{k+1} = \vec{V}_{k+1}\Delta t \qquad (35)$$

Governing Equations for Simulating Advection Dispersion (Phase-2)

After the *dynamic phase (Phase 1)*, the oil is considered to have reached *passive phase (Phase 2)*. The oil transport in this phase can be simulated by using advection-diffusion equation. The concentration distribution in the water column can be described by

$$\frac{\partial C_v}{\partial t} + \frac{\partial(uC_v)}{\partial x} + \frac{\partial(vC_v)}{\partial y} + \frac{\partial(wC_v)}{\partial z}$$
$$= \frac{\partial}{\partial x}(D_x \frac{\partial C_v}{\partial x}) + \frac{\partial}{\partial y}(D_y \frac{\partial C_v}{\partial y}) + \frac{\partial}{\partial z}(D_z \frac{\partial C_v}{\partial z}) + \frac{\partial(V_b C_v)}{\partial z} \qquad (36)$$

where C_v = volumetric concentration of oil in the suspended layer; u, v, w = ambient velocity in x, y, z direction; V_b = the buoyant velocity of oil droplets; and D_x, D_y, D_z = diffusion coefficient in x, y, z direction.

For surface oil in a three dimensional (3-D) system, an equation similar to that of two dimensional (2-D) system can be used. The thickness of the surface layer is assumed to be negligible in comparison to the water depth. The equation can be written as

$$\frac{\partial C_s}{\partial t} + \frac{\partial(u_s C_s)}{\partial x} + \frac{\partial(v_s C_s)}{\partial y}$$
$$= \frac{\partial}{\partial x}(D_x \frac{\partial C_s}{\partial x}) + \frac{\partial}{\partial y}(D_y \frac{\partial C_s}{\partial y}) + (V_b C_v - wC_v + D_z \frac{\partial C_v}{\partial z})\bigg|_{z=0} \qquad (37)$$

where C_s = local oil concentration in the surface layer per unit area; u_s, v_s = the components of surface drift velocity in x and y direction; $C_v|_{z=0}$ = local volumetric concentration of oil per unit volume of water in the water layer immediately below the surface oil.

In this model, Lagrangian discrete parcel method is used to simulate the processes described by Eqs. 36 and 37. The Lagrangian discrete-parcel algorithm, oil is represented as an ensemble of a large number of small parcels. Each parcel has a mass and a set of time dependent

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spatial coordinates associated with it. During each time step, all of the oil parcels are displaced according to the drift velocity and a fluctuation component at their respective locations. The fluctuation component represents the turbulent diffusion. Complete details can also be found in Yapa (1994). The corresponding advective velocity is now given by

$$\vec{V}_T = \vec{V}_m + \vec{V}'$$ (38)

where $\vec{V}_T$ = total velocity vector; $\vec{V}_m$ = mean advective velocity, which is equal to ambient velocity $\vec{V}_a$; $\vec{V}'$ = fluctuating component representing the turbulent diffusion. The components of $\vec{V}'$ are given by

$$u_{ran} = \sqrt{\frac{2D_x}{\Delta t}} R_{nx}$$

$$v_{ran} = \sqrt{\frac{2D_y}{\Delta t}} R_{ny}$$ (39)

$$w_{ran} = \sqrt{\frac{2D_z}{\Delta t}} R_{nz}$$

where $u_{ran}, v_{ran}, w_{ran}$ = random walk velocities in x, y, and z directions, respectively; $R_{nx}, R_{ny},$ and R_{nz} = normally distributed random numbers; Δt = time step.

Model simulation Description

User after selected [***OIL SPILL***] in Fig 60.
Figure 81 will display for user two models as:
- o   Oil Spill Trajectory
- o   Back Track Oil Spill.
- o   Under water Oil Seepage

User must select [***under water oil seepage***] Fig 89 will display for user to start [***Start***]
Fig 90 will display to select model input information that described in fig 90 as follows:

- Fig 90 require a number of parameters to input which are describe in the page
- Two important input as [***Time step***] and [***Increment for output of time steps***]
- Input parameters At depth intergrade values option as in:
    - -drop box [***For U from file (3)***] read velocity along Z direction
    - -Drop box [Temperature Type] Read Temperature value along Z
    - -Drop Box [Salinity Type] Read water Salinity value along z
- New Kuwait water map also displayed for user to select the oil seepage location by:
    - -Click On the map to select location
    - -[Select Location] then enter longitude and Latitude location manual.

User must select [**Initial Parameter**] then Fig 91 for the following input as
- A number parameter that describes the Oil JET under water
- The selected Oil seepage location display for user to convert the location as shown Fig 92:
    - Degree --> UTM [***UTM Location***] then click on **LIST**
    - Or UTM --> Degree [Geographical Location] then click on **LIST**

User must select [**Model Parameter**] then Fig 93 for the following input as
- Total Grid in X
- Total Grid in Y

- Total grid in Z

User must Select [*File Option*] on number of option will display as follows:
- Load Input Files
  -Setup files to load per save input data [data input file, initial condition file and parameter file]
  -Load setup files Load pervious saved input data
- Save Input Files
  User must save the input then can start simulate model.
- Model Simulation [Run]
- User select to start simulate the model as shown in Fig 94
- Shows Results
  User must select [Result Shows] to display model results as shown in Fig 95. Which display options for user to select as shown in Figs 96, 97 and 98.
  To adjust the select plot selects [Adjust Scale]
  To Save Plot As image [Save Image]
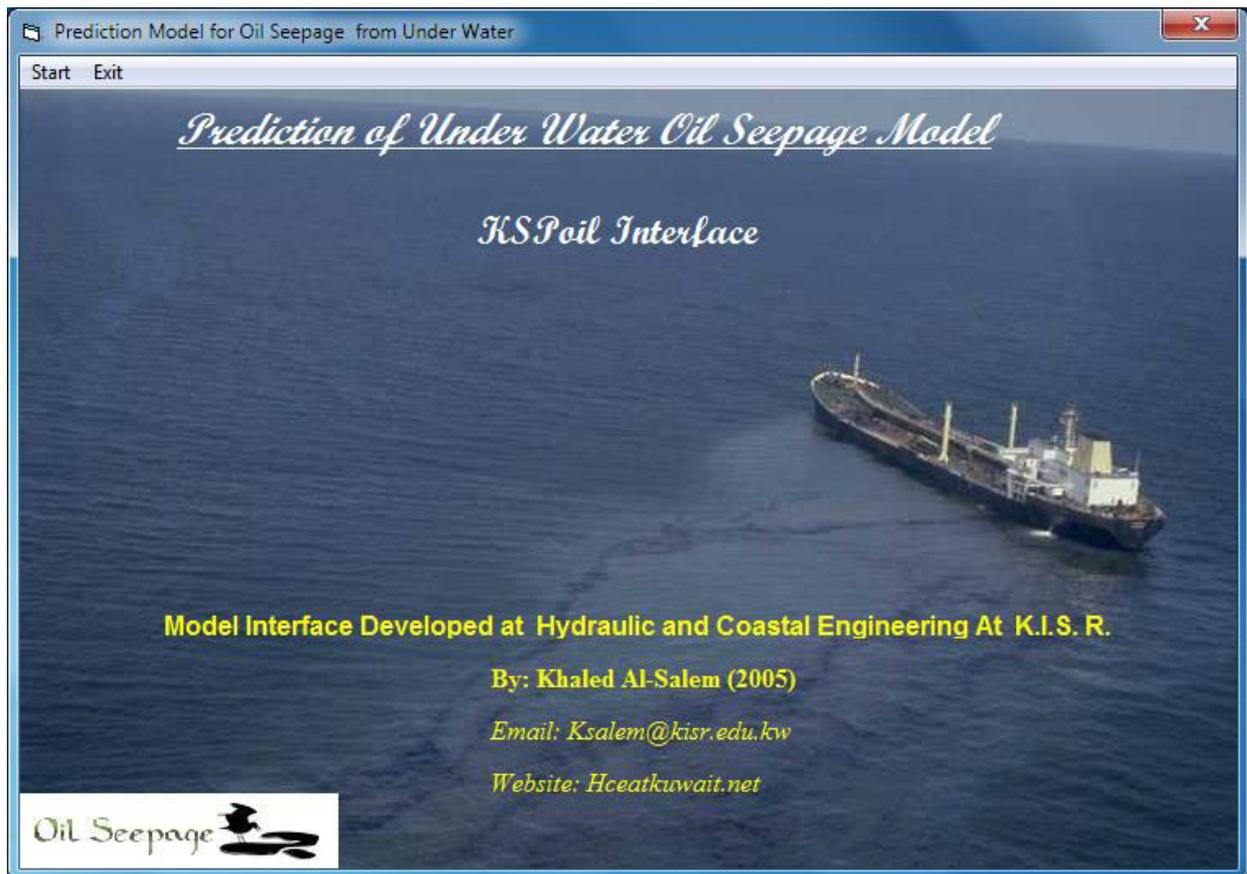
Figure 89

Figure 90
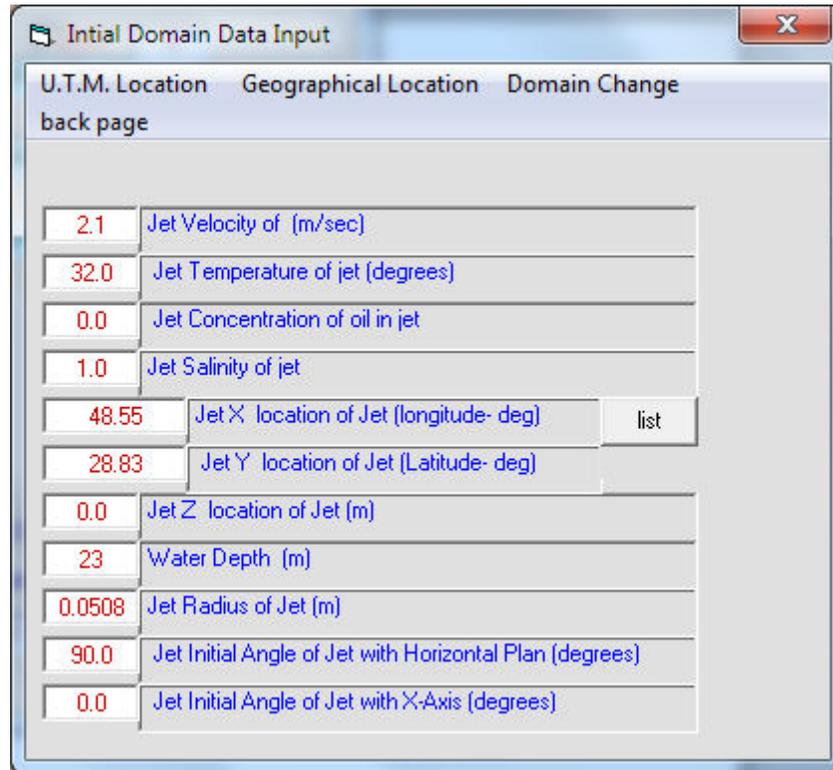
Intial Domain Data Input

U.T.M. Location   Geographical Location   Domain Change

back page

2.1	Jet Velocity of (m/sec)
32.0	Jet Temperature of jet (degrees)
0.0	Jet Concentration of oil in jet
1.0	Jet Salinity of jet
48.55	Jet X location of Jet (longitude- deg)	list
28.83	Jet Y location of Jet (Latitude- deg)
0.0	Jet Z location of Jet (m)
23	Water Depth (m)
0.0508	Jet Radius of Jet (m)
90.0	Jet Initial Angle of Jet with Horizontal Plan (degrees)
0.0	Jet Initial Angle of Jet with X-Axis (degrees)

Figure 91
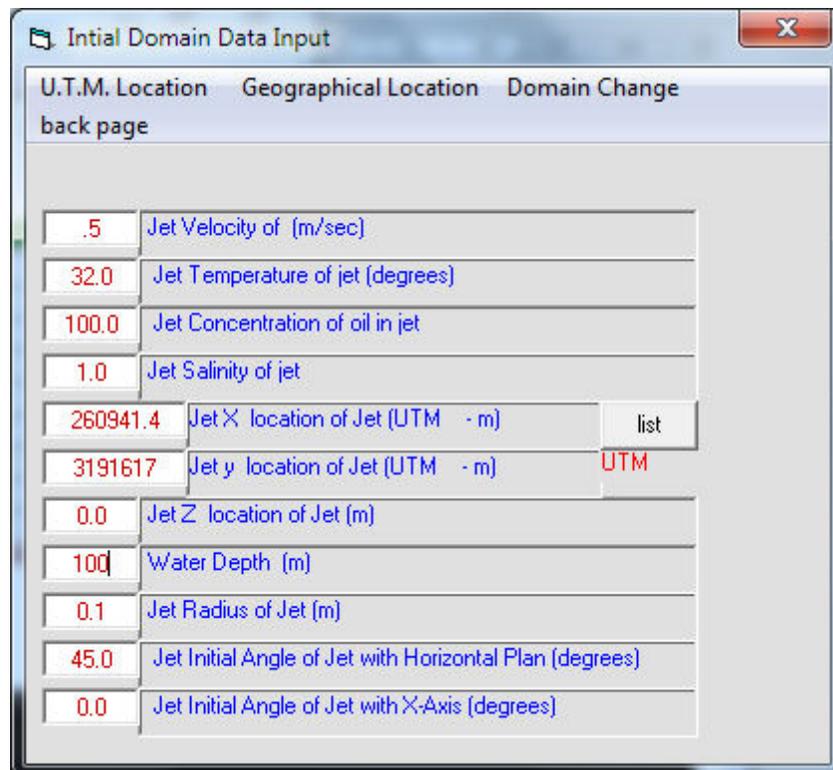
Intial Domain Data Input

U.T.M. Location   Geographical Location   Domain Change

back page

.5	Jet Velocity of (m/sec)
32.0	Jet Temperature of jet (degrees)
100.0	Jet Concentration of oil in jet
1.0	Jet Salinity of jet
260941.4	Jet X location of Jet (UTM - m)	list
3191617	Jet y location of Jet (UTM - m)	UTM
0.0	Jet Z location of Jet (m)
100	Water Depth (m)
0.1	Jet Radius of Jet (m)
45.0	Jet Initial Angle of Jet with Horizontal Plan (degrees)
0.0	Jet Initial Angle of Jet with X-Axis (degrees)

Figure 92

Figure 93

Model Parmeters Input

Back Page

141	IEXT - Total Grid Number along X Direction
141	JEXT - Total Grid Number along Y Direction
214	KEXT - Total Grid Number along Z Direction
150000	ITEND - Total Number Itrations

Figure 94

```
c:\oil-spg\oilseep.exe

Time Step Reduced to  5.0000004E-03
Density of jet = density of ambient    39.28189        32.06534
 76.06601
Density of jet =   1026.738     Density of ambient =   1026.743
End of Model Smulation
```

Figure 95

Outpot Analysis and Plot

Plot Adjust Scale Save Image Back Page

Plot From File(Timeseries.out) ▶

Plot X Direction Vs Z Direction (Ploom)
Plot Time Vs X Direction
Plot Time Vs Y Deriction
Plot Time Vs Z Direction
Plot Time Vs Concentration
Plot Time Vs Oil Density
Plot Z-Direction Vs Concentration
Plot Z-Direction Vs Ploom Area
Edit Timeseries Output File
Map Oil Ploom Tracing

Figure 96

Figure 97

Figure 98

4. Hydraulics Costal Application

power plants, and other projects are being constructed or planned in the near shore area. Such The shorelines of Kuwait extend over a distance of about 500 km. Marinas, harbours, ports, projects require data on the extreme wave conditions for the design of the coastal structures. Yearly average wave conditions are also important for the prediction of the wave induced currents. These currents are important for the prediction of the sediment transport rates in the surf zone. The calculation of the littoral drift is essential for the prediction of the shoreline changes due to any proposed structure in the near shore area. This data will be very important for the design of the future extensions of the water front along the shorelines of Kuwait. The tidal currents are also essential in predicting the fate of any oil spill in the marine environment or in predicting the water quality.

Numerical analysis, area of mathematics and computer science that creates, analyzes, and implements algorithms for obtaining numerical solutions to problems involving continuous variables. Such problems arise throughout the natural sciences, Coastal sciences. To combines numerical analysis, symbolic mathematical computations, computer graphics, and other areas of computer science to make it easier to set up, solve, and interpret complicated mathematical models of the real world.

4.1   Wind/ Wave Perdition For Arabian Gulf [WAM4 Model]

[Hasselmann 1987 , Wamdi group 1988]
[Model Updated and interface Developed by: Khaled AL-Salem 2005]

For most locations, it is difficult to find long-term wave data, essential for the design of any coastal project. Hindcasted wave data are usually used for such purposes. Different wave hindcasting methods are available, ranging from simplistic empirical formulas to complex two-dimensional wave models. Many organizations around the world sell hindcasted data obtained from advanced offshore wave models, e.g., British Met Office (BTO). Many other centers provide wave forecasts based on advanced offshore wave models (e.g., https://www.fnmoc.navy.mil). These forecasts range from global forecasts to local forecasts. The Naval Oceanographic Office in the USA uses the WAM model for forecasting waves in the Arabian Gulf (Johnson et al. 1995).

The Arabian Gulf is almost 900 km long and has a maximum width of about 360 km. The width of the Strait of Hormoz is about 100 km. The Arabian Gulf is predominantly shallow with the bottom sloping gently from the Arabian peninsula into an elongated basin attaining maximum depths of 80 to 100 m close to the more linear and mountainous Iranian coast on the east. Due to the shape of the Gulf as shown in Fig.1, it is sufficient to model the wind waves in the Gulf only with part of the Gulf of Oman.

[Al-Salem. 2005] used a third-generation wind-driven wave model WAM (WAMDI Group, 1988) to model the wind waves in the Arabian Gulf with emphasis on Kuwait's territorial waters. The WAM model is a third-generation ocean wind-wave model. The model is based on the discrete spectral action balance equation that is a generalization of the energy balance equation in the presence of currents. In the model, this balance is formulated for propagation over a sphere using longitude λ and latitude φ coordinates.

$$\frac{\partial N}{\partial t} + \frac{1}{\cos \phi} \frac{\partial}{\partial \phi}\left(\dot{\phi}\ N \cos \theta\right) + \frac{\partial}{\partial \lambda}\left(\dot{\lambda}\ N\right) + \frac{\partial}{\partial k}\left(\dot{k}\ N\right) + \frac{\partial}{\partial \theta}\left(\dot{\theta}\ N\right) = \frac{S}{\sigma} \qquad [1]$$

with short hand notation N for $N(k,\theta)$, which is the wave number action density spectrum of the waves, defined as the energy density divided by the relative frequency σ; S is the source term, and θ is the wave direction.

The left hand side represents the advection term. The first term on the left hand side of the balance equation represents the local rate of change of wave action density. The second and the third terms represent propagation along great circles in geographic space. The fourth term represents shifting of wave number due to time variations in depth and currents. The fifth term represents refraction. The right hand side of the above balance represents the overall effects of the physical processes that add or take energy to or from a given spectral component. The physical processes included in the model are wind-wave interaction (generation), wave-wave interaction (quadruplet), dissipation (white capping), and shallow water bottom dissipation (bottom friction). For the calculation of waves in the surf zone and in shallow water a nearshore wave model with a fine grid should be used to transform the offshore wave roses generated by this study. More details on the model can be found in [Sulisz and Al-Salem (2000), WAMDI Group (1988), and Al-Salem et al. (2005)

[Sulisz and Al-Salem 2000] showed that the use of simple empirical techniques assuming stationary and homogeneous wind fields over the Gulf often results in poor wave predictions. They also verified the ability of the WAM model to predict the wave conditions at three different locations in Kuwait. Their study indicated that the wind data obtained by the ECMWF underestimated the wind speed for some of the storms. This was shown by comparing measured winds at the buoy location with the ECMWF data for these storms. The comparison showed that for the storms with an underestimation in the wave heights, the winds used were lower than the values measured at the buoy as shown by Al-Salem et al. (2005).

The model covers the entire Gulf from the 47.4° until the 56.8° Longitude and 23.8° until 30.5° Latitude with a grid spacing of 0.1°. Fig 2 provides the grid used for the WAM model over the entire Gulf; Fig. 3 provides a closer view for the Kuwait's territorial waters. The bathymetry digitized from the admiralty charts used in Sulisz and Al-Salem 2000] was used. Twenty-five logarithmically distributed frequencies ($f_{n+1} = 1.1 f_n$) with an initial frequency of $f_1 = 0.0505$ Hz were used to represent the wave spectrum. The directional spectrum has a resolution of 15° with 24 directions, which will provide data that can be used for sediment transport calculations. A time step of 5 min was used in the model (Table 1). A new interface was developed for Wind/Wave model By [Al-Salem 2005] named [WAM4 model]. The model description will discuss in next section.
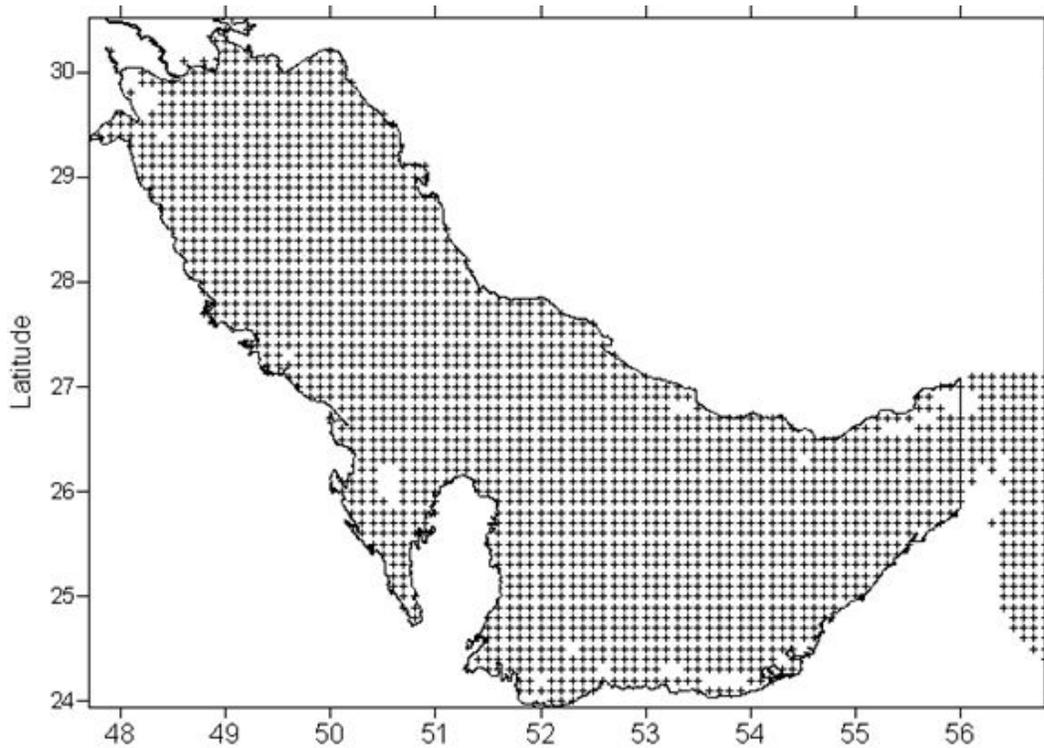
Figure 99. Grid used for the Arabian Gulf WAM model.

Table 1. WAM Model Setup Parameters

Parameter	Value / Range
Spatial grid resolution	0.1^o
Frequency resolution	25 frequencies (starting from 0.0505 Hz)
Directional resolution	15° (24 directions)
Propagation time step	300 s
Source time step	150 s
Output time step	1 h
Time step for wind data	3 h for ECMWF and 6 h for NCEP
Shallow water terms	On
Depth refraction	On
Current refraction	Off

Model simulation Description

Wam4 model interface was rewritten in Visual FORTRAN Coding.

Model Structure

Model path was setup as [C:\Wam4\]
Model divide into 4Section as follows:
- WAM1
- WAM2
- WAM3
- WAM4

Parameter Setup Data file
- Current .Par
- Paramet.Par
- Wind. Par

Model Input/Output Data file Path [C:\Wam4\01-stacj\]
Input domain data file:
- Depth10.dat   [Bathometry data for Arabian Gulf Waters Grid 01.x0.1 deg]
- NW16.dat   [2D wind speed Data created in C.I.S Interface]

Input Setup model simulation files
- PREPROC.in   [Relate WAM1.exe]
- Preset.in   [Relate WAM2.exe]
- Chief.in   [Relate WAM3.exe]
- Pgrid.in   [Relate WAM4.exe]

Simulation Output Path location [C:\WAM4\01-stacj\coarse\]
- [coarse] it a folder inside [01-stacj folder]
- [coarse] Folder should empty at every new simulation [important]
- [coarse] Folder where simulation output file will store in.

Create a folder at path location [C:\WAM4\01-stacj\Fine\]
Output files
- Prepoc2.out   [Relate WAM1.exe]
- Preset.out   [Relate WAM2.exe]
- Chief.out   [Relate WAM3.exe]
- Pgrid.out   [Relate WAM4.exe]

To start new project user must follows as:

- Prepare [**NW16.DAT**] file.
  I.   It is 2D wind speed data over Arabian Gulf Waters. Created from Coastal Information System Interface as shown in Fig 100
  II.   Setup Form Page for NW16.dat file an Fig 101
  III.   A Sample of 2D wind speed data file from NW16.Dat as shown in Fig. 102.
- Prepare input Setup Simulation files as:
  [PREPROC.in] this input file is related to [WAM1.exe] it already setup for Arabian Gulf sample of part of the file shown in Fig 103.

[PRESET.in] this input file is related to [WAM2.exe]. it already setup for Arabian Gulf sample of part of the file shown in Fig 104.But user should input the following data as:

    I.   start date of run (yymmddhhmm)
    II.   timestep on input wind file (seconds)
    III.   time unit s seconds or h hours

[CHIEF..in] this input file is related to [WAM3.exe]. it already setup for Arabian Gulf sample of part of the file shown in Fig 105.But user should input the following data as:

    Input Date and Time

    I. start date of run   (yymmddhhmm)
    II. end   date of run   (yymmddhhmm)

    input selection of output data ****

    I. p   character*1   printer output.. y data are printed, otherwise no output
    II. f   character*1   file output.. y data are written to file, otherwise no output

[PGRID.in] this input file is related to [WAM4.exe]. it already setup for Arabian Gulf sample of part of the file shown in Fig 106.But user should input the following data as:

    Enter output time in fixed intervals
    I. start date of output   (yymmddhhmm)
    II. end date of output   (yymmddhhmm)
    III. data output time step   (second)
    IV. u   = time unit: h = hours, s = seconds

    Enter information for file requests
    I. date of first file name (yymmddhhmm)
    II. file time step (seconds)
    III. u   = time unit: h = hours, s = seconds
    IV. 3 character user id [BEP]

    Enter Information for fields to be printed
    At the end of 50 character print header
    p   = t (true) if print is requested else f (false)

- Simulated data will be display at file name [PGRID.OUT]. A part of sample of Output File shown in Fig 107.

Figure 100

Figure 101

```
  95   68    23.800    30.500    47.400    56.800    1    1
01010000
    3 -2.9 -3.0 -3.1 -3.2 -3.3 -3.3 -3.4 -3.5 -3.6 -3.6 -3.7 -3.7 -3.7 -3.7 -3.8 -3.8 -3.8 -3.8 -3.8 -3.
 -2.9 -3.0 -3.0 -3.1 -3.2 -3.3 -3.4 -3.5 -3.6 -3.6 -3.7 -3.7 -3.7 -3.7 -3.8 -3.8 -3.8 -3.8 -3.9 -3.
 -2.8 -2.9 -3.0 -3.1 -3.2 -3.3 -3.4 -3.5 -3.5 -3.6 -3.6 -3.6 -3.7 -3.7 -3.7 -3.8 -3.8 -3.8 -3.8 -3.
 -2.8 -2.9 -3.0 -3.1 -3.2 -3.3 -3.3 -3.4 -3.5 -3.5 -3.6 -3.6 -3.6 -3.7 -3.7 -3.7 -3.8 -3.8 -3.8 -3.
 -2.8 -2.9 -3.0 -3.0 -3.1 -3.2 -3.3 -3.4 -3.5 -3.5 -3.6 -3.6 -3.7 -3.7 -3.7 -3.8 -3.8 -3.8 -3.8 -3.
 -2.8 -2.9 -3.0 -3.1 -3.1 -3.2 -3.3 -3.4 -3.4 -3.5 -3.5 -3.5 -3.6 -3.6 -3.7 -3.7 -3.7 -3.7 -3.8 -3.
 -2.9 -2.9 -3.0 -3.1 -3.2 -3.2 -3.3 -3.4 -3.4 -3.5 -3.5 -3.5 -3.5 -3.6 -3.6 -3.7 -3.7 -3.7 -3.7 -3.
 -2.9 -3.0 -3.0 -3.1 -3.2 -3.2 -3.3 -3.3 -3.4 -3.4 -3.4 -3.5 -3.5 -3.5 -3.6 -3.6 -3.6 -3.6 -3.6 -3.
 -3.0 -3.0 -3.1 -3.1 -3.2 -3.2 -3.3 -3.3 -3.4 -3.4 -3.4 -3.5 -3.5 -3.5 -3.5 -3.6 -3.6 -3.6 -3.6 -3.
 -3.0 -3.1 -3.1 -3.2 -3.2 -3.2 -3.3 -3.3 -3.3 -3.4 -3.4 -3.4 -3.5 -3.5 -3.5 -3.5 -3.5 -3.5 -3.5 -3.
 -3.1 -3.1 -3.1 -3.1 -3.2 -3.2 -3.3 -3.3 -3.3 -3.3 -3.4 -3.4 -3.4 -3.5 -3.5 -3.5 -3.5 -3.5 -3.4 -3.
 -3.1 -3.2 -3.2 -3.2 -3.2 -3.2 -3.3 -3.3 -3.3 -3.3 -3.3 -3.4 -3.4 -3.4 -3.4 -3.5 -3.4 -3.4 -3.4 -3.
 -3.1 -3.2 -3.2 -3.2 -3.2 -3.2 -3.3 -3.3 -3.3 -3.3 -3.3 -3.3 -3.4 -3.4 -3.4 -3.4 -3.3 -3.3 -3.3 -3.
 -3.1 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.3 -3.3 -3.3 -3.3 -3.3 -3.3 -3.3 -3.3 -3.3 -3.3 -3.2 -3.
 -3.1 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.3 -3.3 -3.3 -3.2 -3.2 -3.2 -3.2 -3.
 -3.1 -3.1 -3.1 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.1 -3.1 -3.1 -3.1 -3.1 -3.
 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.2 -3.2 -3.1 -3.1 -3.1 -3.1 -3.0 -3.
 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.0 -3.0 -3.0 -2.
 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.0 -3.0 -3.0 -3.0 -3.0 -3.0 -2.9 -2.9 -2.
 -3.2 -3.2 -3.2 -3.2 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.1 -3.0 -3.0 -3.0 -3.0 -3.0 -2.9 -2.8 -2.
 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.1 -3.1 -3.1 -3.1 -3.1 -3.0 -3.0 -3.0 -3.0 -2.9 -2.9 -2.
 -3.3 -3.3 -3.3 -3.3 -3.3 -3.2 -3.2 -3.2 -3.2 -3.2 -3.2 -3.1 -3.1 -3.0 -3.0 -3.0 -3.0 -2.9 -2.9 -2.
 -3.3 -3.3 -3.3 -3.3 -3.3 -3.3 -3.3 -3.3 -3.2 -3.2 -3.2 -3.1 -3.1 -3.0 -3.0 -3.0 -3.0 -2.9 -2.9 -2.
 -3.4 -3.4 -3.4 -3.4 -3.4 -3.3 -3.3 -3.3 -3.3 -3.2 -3.2 -3.1 -3.1 -3.0 -3.0 -3.0 -3.0 -2.9 -2.9 -2.
 -3.5 -3.4 -3.4 -3.4 -3.4 -3.4 -3.4 -3.3 -3.3 -3.3 -3.2 -3.2 -3.1 -3.0 -3.0 -3.0 -3.0 -2.9 -2.9 -2.
```

Figure 102

```
        USER INPUT OF PREPROC.           CREATED 19/4/2005
        =======================

        SET-UP OF SWAMP CASE 2 GRID WITH CURRENT REFRACTION AND NEST.

         USER INFORMATION IS BEING READ BY SUB. UIPREP
         WITH THE PRESUMPTIONS THAT:
         1. EVERY LINE STARTING WITH 'C' IS A COMMENT LINE
         2. VALUES ARE PUT IN BELOW POSITIONS INDICATED WITH '-'
            (RIGHT-JUSTIFIED)

   --------------------------------------------------------------------

            **** HEADER OF MODEL RUN   ****

      HEADER   CHARACTER*70   TEXT TO BE PRINTED

 HEADER
 ---------+---------+---------+---------+---------+---------+---------+
  Arabian Gulf   01 grid                    PREPROC VERSION 4.0

             **** FREQUENCY AND DIRECTION GRID ****

      ML          INTEGER*5    NUMBER OF FREQUENCIES.
      KL          INTEGER*5    NUMBER OF DIRECTIONS.
      FR(1)       REAL*10      LOWEST FREQUENCY IN HERTZ.

    ML    KL       FR(1)
 ----- ----- ----------
    25    24 0.05054470

             **** OUTPUT GRID DEFINIONS ****

      XDELLA      REAL      GRID INCREMENT FOR LATITUDE (DEGREE)
      XDELLO      REAL      GRID INCREMENT FOR LONGITUDE (DEGREE)
      AMOSOP      REAL      MOST SOUTHERN LATITUDE IN GRID MATRIX
      AMONOP      REAL      MOST NORTHERN LATITUDE IN GRID MATRIX
      AMOWEP      REAL      MOST WESTERN LONGITUDE IN GRID MATRIX
      AMOEAP      REAL      MOST EASTERN LONGITUDE IN GRID MATRIX

     XDELLA     XDELLO     AMOSOP     AMONOP     AMOWEP     AMOEAP
 ---------- ---------- ---------- ---------- ---------- ----------
       0.10       0.10     23.800     30.500     47.400     56.800
```

Figure 103

```
USER INPUT OF PRESET.            CREATED 19/4/2005
=====================

   USER INFORMATION IS BEING READ WITH THE PRESUMPTIONS THAT:
      1. EVERY LINE STARTING WITH 'C' IS A COMMENT LINE
      2. VALUES ARE PUT IN BELOW POSITIONS INDICATED WITH '-'
         (RIGHT-JUSTIFIED, BUT CHARACTER LEFT-JUSTIFIED)


---------------------------------------------------------------------

         **** HEADER OF MODEL RUN   ****

   HEADER  CHARACTER*70  TEXT TO BE PRINTED

HEADER
---------+---------+---------+---------+---------+---------+---------+
 Arabian Gulf  Stationary wind run            PRESET VERSION 4.0

         **** OPTION FOR INITIAL SPECTRA   ****

   IOPTI    = 0 WIND INDEPENDENT INITIAL VALUES.
            = 1 WIND DEPENDENT INITIAL VALUES AND
                ENERGY EQUAL ZERO IF WINDSPEED IS ZERO
            = 2 WIND DEPENDENT INITIAL VALUES AND
                ENERGY COMPUTED FROM GIVEN PARAMETERS IF
                WINDSPEED IS ZERO.
   ITEST    = 0 NO TEST OUTPUT
            > 0 FOR SUBROUTINE LEVEL
   ITESTB   > 0 FOR BLOCK LEVEL TEST OUTPUT

  IOPTI    ITEST    ITESTB
-------  -------   ------
     2        1        4

         **** PARAMETER OF INITIAL SPECTRUM   ****

   ALPHA    = PHILLIPS' PARAMETER  (NOT USED IF IOPTI = 1)
   FM       = PEAK FREQUENCY (HZ) AND/OR MAXIMUM FREQUENCY
   GAMMA    = OVERSHOOT FACTOR
   SIGMAA   = LEFT PEAK WIDTH
   SIGMAB   = RIGHT PEAK WIDTH
   THETAQ   = WAVE DIRECTION (DEG) (NOT USED IF IOPTI = 1)
   FETCH    = FETCH IN METRES (IF ZERO THEN 0.5 OF THE
              LATITUDE INCREMENT IS USED.)
```

Figure 104

```
       USER INPUT OF CHIEF.              CREATED 19/4/2005
       ====================


       USER INFORMATION IS BEING READ WITH THE PRESUMPTIONS THAT:
        1. EVERY LINE STARTING WITH 'C' IS A COMMENT LINE
        2. VALUES ARE PUT IN BELOW POSITIONS INDICATED WITH '-'
           (RIGHT-JUSTIFIED, BUT CHARACTER LEFT-JUSTIFIED)


   ----------------------------------------------------------------------


       **** HEADER OF MODEL RUN   ****

   HEADER   CHARACTER*70   TEXT TO BE PRINTED

HEADER
---------+---------+---------+---------+---------+---------+---------+
 Arabian  Gulf grid-01 N10                  MODEL VERSION 4.0

           **** PERIOD OF MODEL RUN   ****

    IDATEA    INTERGER*10    START DATE OF RUN   (YYMMDDHHMM)
    IDATEE    INTERGER*10    END   DATE OF RUN   (YYMMDDHHMM)

    IDATEA       IDATEE
 ----------   ----------
 1412300000   1412312100

           **** MODEL TIME STEPS ****

    IDELPRO   INTERGER*7     PROPAGATION TIMESTEP
    IDELT     INTERGER*7     SOURCE TIME STEP
    IDELWO    INTERGER*7     OUTPUT WIND TIMESTEP
    IDELWI    INTERGER*7     TIMESTEP ON INPUT WIND FILE
    U         CHARACTER*1    TIME UNIT  S SECONDS  OR  H HOURS


          ---------   ------------------------------------------------
          DEMAND :    ALL RATIO'S ARE N OR 1/N AND N IS AN INTEGER
          ---------   ------------------------------------------------

IDELPRO U    IDELT U   IDELWO U    IDELWI U
------- -   ------- -  ------- -   ------- -
   300 S       150 S        3 H        3 H
```
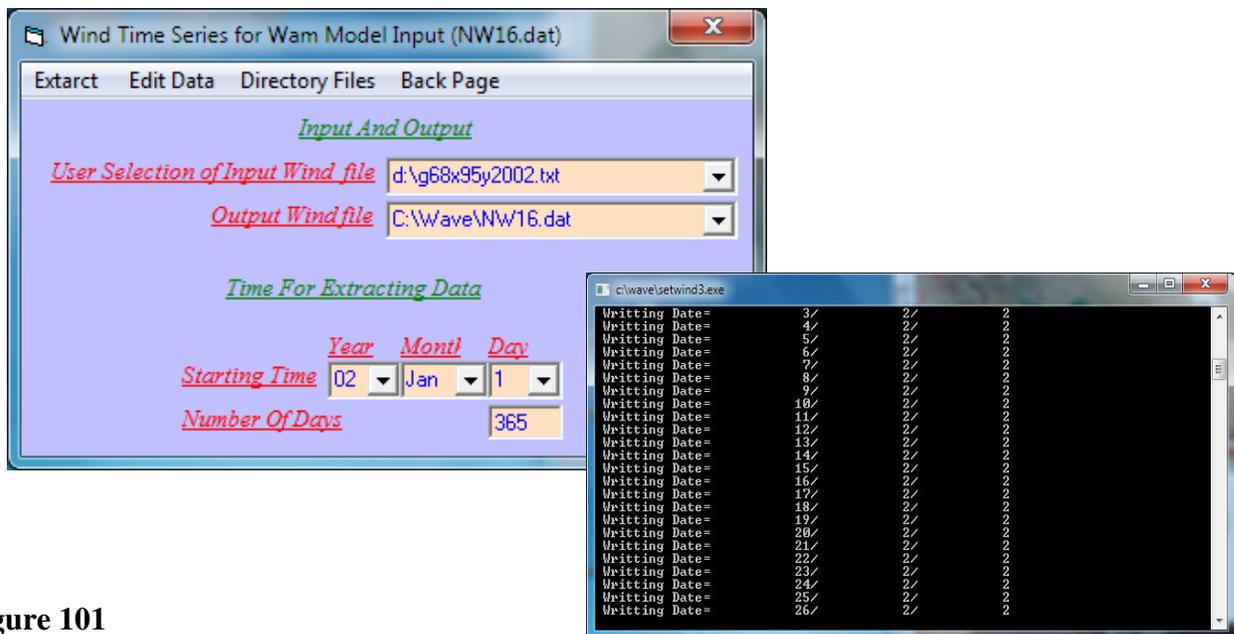
Figure 105

```
           INPUT OF PROGRAM PGRID (PRINT GRID)
           ====================================

           USER INFORMATION IS BEING READ WITH THE PRESUMPTIONS THAT:
             1. EVERY LINE STARTING WITH 'C' IS A COMMENT LINE
             2. VALUES ARE PUT IN BELOW POSITIONS INDICATED WITH '-'
                (RIGHT-JUSTIFIED, BUT CHARACTER LEFT JUSTIFIED)

             **** OUTPUT TIME IN FIXED INTERVALS ****

             IDATEA  = START DATE OF OUTPUT    (YYMMDDHHMM)
             IDATEE  = END DATE OF OUTPUT      (YYMMDDHHMM)
             IDELDO  = DATA OUTPUT TIME STEP   (SECOND)
             U       = TIME UNIT: H = HOURS, S = SECONDS

         IDATEA        IDATEE    IDELDO  U
       ----------    ----------  -------  -
       1712010000   1712312100        1  H

             **** OUTPUT TIME AT SPECIFIED TIMES ****

         SPECIFY A LIST WITH UP TO 100 DATES (YYMMDDHHMM) AND CLOSE THE
         LIST BY 'END       '. IF THE LIST INCLUDES ANYTHING ELSE THAN 'END'
         ALL OUTPUT TIME STEPS SPECFIED ABOVE ARE IGNORED.

     YYMMDDHHMM   YYMMDDHHMM   YYMMDDHHMM   YYMMDDHHMM   YYMMDDHHMM   YYMMDDHHMM
     ----------   ----------   ----------   ----------   ----------   ----------
     END

             **** FILE REQUESTS ****

             IDATEF  = DATE OF FIRST FILE NAME (YYMMDDHHMM)
             IDELFI  = FILE TIME STEP (SECONDS)
             U       = TIME UNIT: H = HOURS, S = SECONDS
             USD     = 3 CHARACTER USER ID
             RID     = 3 CHARACTER RUN  ID (FOR CYBER_205 ONLY)
             FID     = 3 CHARACTER FILE ID (NORMALLY MAP)
             PATH    = 60 CHARACTER PATH (WITHOUT FILE NAME)

         IDATEF    IDELFI  U  USD
       ----------  -------  -  ---
       1712010000        3  H  BEP
```

Figure 106
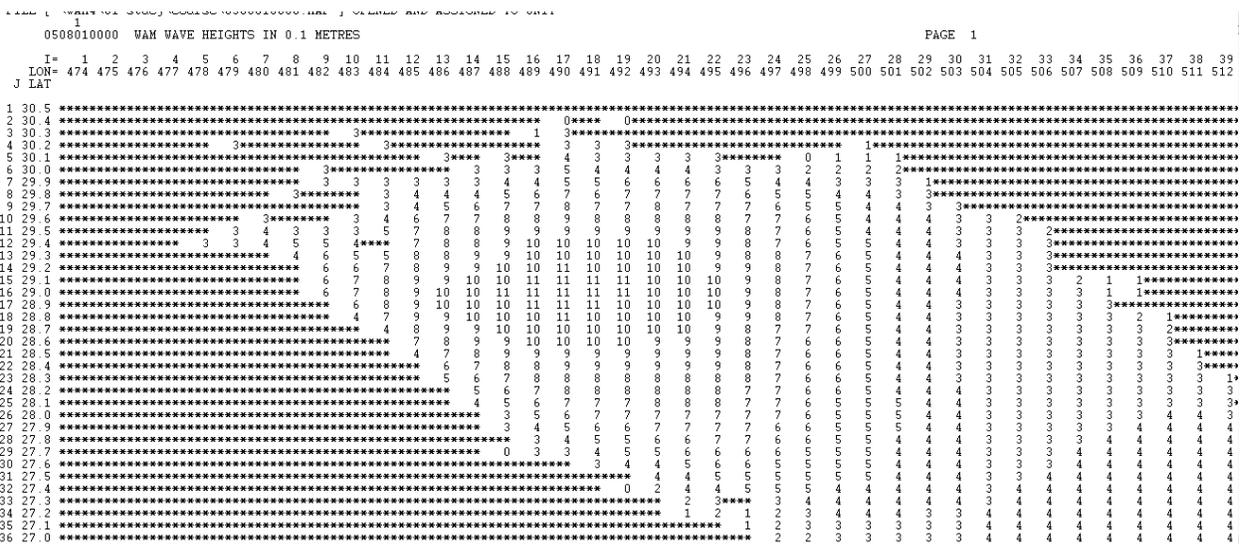
Figure 107

4.2   Prediction of significant wave height using an empirical relation for Kuwaiti territorial waters [KWave Model]

[K. Al-Salem 2005] [Pc version]

Model Methodology

It is well known that wind speed and fetch (depends on wind direction) dominate the generation of water waves in the sea. Apart from this, the water depth, the bathymetry and the location of the point of interest are all important. The wind speed at 10 meter above the sea level, wind direction, and water depth are considered as primary forcing parameters for the present technique.

All wind wave models such as the WAM model also require the wind speeds and the bathymetry. These types of models however, require spatial and temporal wind data over the water body. The WAM model needs to be applied to the full Arabian Gulf and thus takes considerable computer time. An empirical model [KWave model by Al-Salem 2005] is developed for the Kuwaiti territorial waters to provide an efficient and prediction of wave parameters. This technique can be useful in providing wave conditions from wind data at a single point 1D and 2D. It is expected that the technique can provide good predictions for storm conditions. For swell conditions, it will not provide good results. Due to the relatively small water body of the Arabian Gulf in most cases the wind will not vary considerably over the full Arabian Gulf. For more accurate wave forecasting it is recommended to have a local wind model for the Arabian Gulf to provide data to an operational KWAM model.

To demonstrate the method developed the results for one location is provided. This location is offshore Al-Fintas at longitude E 48.2^o and latitude N 29.1^o in Kuwait's territorial waters as shown in Fig. 108. A wave Buoy was placed at this location for about three years and the data from this buoy were used in the WAM model validation (Al-Salem et al.., 2005). The water depth was 14 m. Equation 1 was used to determine the significant wave height (H_s) for a certain wind speed 'v' class and direction 'α' class.

$$H_s(v,\alpha) = \frac{k\sum_{i=1}^{n} C_H H_{si}}{m} \tag{1}$$

where the weighting factor C_H is calculated according to,

$$C_H = 1.0 \quad if \begin{cases} v_{min} < v < v_{max} \\ \alpha_{min} < \alpha < \alpha_{max} \end{cases} \tag{2}$$

$C_H = 0.0 \qquad otherwise$

where 'n' is the total number of data values available and 'm' is the number of data values with C_H=1.0. The minimum and maximum values for 'v' and 'α' are the limits for each class. K is the constant of 1.2. The wind classes were taken every 1.0 m/s till 20.0 m/s (3.6 km/h to 72 km/h). For the directions a class of 45 degree was used as shown in Table 1. Hourly data for two full years (1993-1994) were used to determine the value of H_s for each 'v' and 'α' class. Table 1 provides the values of H_s for the Fintas location under consideration.
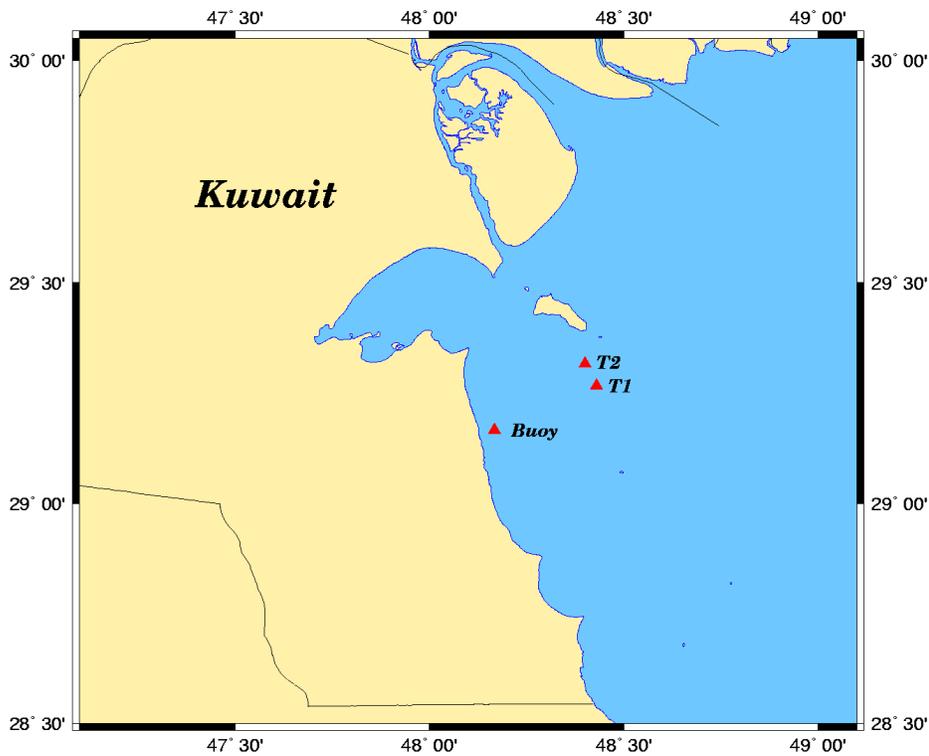
A similar relation was used for the mean wave period (T_m),

$$T_m(v,\alpha) = \frac{k \sum_{i=1}^{n} C_T T_{mi}}{m} \tag{3}$$

where the weighting factor C_T is calculated according to,

$$C_T = 1.0 \quad if \begin{cases} v_{min} < v < v_{max} \\ \alpha_{min} < \alpha < \alpha_{max} \end{cases} \tag{4}$$

$$C_T = 0.0 \qquad otherwise$$

Figure 108. Map of Kuwait showing the locations where measured data was available.

Table 2 provides the values of T_m for the different '*v*' and 'α' classes at the Fintas location. Finally, a similar relation for the wave direction was used to provide a table similar to Tables 1 and 2 for the direction of waves.

Table 1. Coefficients for H$_s$(m) at Al-Fintas.

Dir.	Wind Speed Class (m/s)											
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-20
E	0.107	0.113	0.144	0.193	0.327	0.444	0.559	0.68	0.7	0.967	0	0
NE	0.104	0.133	0.111	0.169	0.311	0.325	0.533	0.667	0.7	0	0	0
N	0.067	0.091	0.158	0.194	0.289	0.442	0.67	0.925	1.067	0	0	0
NW	0.154	0.133	0.147	0.217	0.332	0.48	0.683	0.911	1.146	1.08	0	0
W	0.146	0.115	0.123	0.212	0.33	0.387	0.6	0.9	0.9	0	0	0
SW	0.147	0.112	0.152	0.223	0.386	0.48	0	0.933	0	0	0	0
S	0.145	0.104	0.108	0.176	0.345	0.426	0.561	0.833	0.85	0	0	0
SE	0.085	0.105	0.128	0.192	0.314	0.421	0.535	0.691	0.825	0.99	1.111	0

Table 2. Coefficients for T$_m$(s) at Al-Fintas.

Dir.	Wind Speed Class (m/s)											
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-20
E	2.732	2.822	2.787	2.77	3.009	3.237	3.236	3.38	3.322	3.867	0	0
NE	2.733	2.817	2.714	2.955	3.172	2.85	3.2	3.4	3.3	0	0	0
N	2.75	2.641	2.938	2.884	2.875	3.106	3.833	4.425	4.5	0	0	0
NW	2.958	2.894	2.754	2.851	2.886	3.184	3.691	4.152	4.671	4.187	0	0
W	3.228	2.894	2.804	2.884	2.892	2.94	3.392	3.933	3.933	0	0	0
SW	2.793	2.842	3.005	3.231	3.233	3.18	0	4.9	0	0	0	0
S	2.9	2.77	2.705	2.823	3.124	3.052	3.369	3.833	3.883	0	0	0
SE	2.526	2.604	2.693	2.728	2.838	3.01	3.165	3.417	3.644	3.926	4.089	0

Model simulation Description

KWAVE model was rewritten in Visual FORTRAN and Visual Basic Coding.
Fig 109 shows the main page of the model when it start [KWAVE.EXE]
The model has to option for Wave prediction as:
   i.   Kuwait water
   ii. Arabian Gulf Water

*For Simulation Option 1 [**Kuwait Water**]*
User must select start from fig 109 . Then select [***Kuwait water***]. Then two sub-option will display shown 110 as follows:

I. *[Interactive Mode]*. For interactive run as single run
II. [*Time Serious Mode*]. For variable wind speed data run for sub-option shown 110 as
- o Random Data file
  Read from wind Data file [Wind direction and Wind speed]
  Wind speed in meter and Direction in Degree
  Wind Direction Read From X-Axis counter clock Wise
- o Hindcast Wind Data (1979-2018)
  Wind Data will extract from Coastal Information System [C.I.S.]

If user select *[Interactive Mode]*. Figure 111 will display to enter the following information as
- Location [Lomgitude/Latitude] by two way
  - o Click on the map
  - o Select from dropdown list of locations
- Enter Wind Speed (m)
- Select wind direction from Dropdown list of wind directions

Then user must select [***Run***] to start prediction as shown in Fig 111.
To Display the result user select [***SHOW***] as shown in Fig 111.

If user select [***Time Serious Mode***] and select option [***Random File***] Figure 112 will display for user to input information for prediction as follows:
- Location [Longitude/Latitude] by two way
  - o Click on the map
  - o Select from dropdown list of locations
- Enter Wind Speed file [formatted as (wind direction and wind speed)]

Then user must select [Run] to start prediction as shown in Fig 112.
A new dropdown list will display [***Type of Plot***] as shown in Fig 12. To display the simulation result by Graph as shown in Fig 113 as time serious predicted Parameter plot. And Fig 114 displays the wave height Rose and Frequency of Occurrence table.

If user select [***Time Serious Mode***] and select option [***Hindcast Wind Data (1979-2018)***] Figure 115 will display for user to input information for prediction as follows:
- Select Wind Data file from [CIS Database]
- Select output file name
- Location [Longitude/Latitude] by two way
  - o Click on the map to get location
  - o Select from dropdown list of locations
- Enter Year/Month/Day
- Enter start hour
- Enter number of Days

Then user must select [***Extract Wind Data***] to start prediction as shown in Fig 115.
The extracting process shown at Fig 116.
Then user must select *[Wave Height Prediction]* from Fig 115 to start prediction.
A new dropdown list will display [***Type of Plot***] as shown in Fig 117. To display the simulation result by Graph as shown in Fig 113 as time serious predicted Parameter plot. And Fig 114 displays the wave height Rose and Frequency of Occurrence table.

*For Simulation Option 1 [**Arabian Gulf Water**]*
User must select *[**Start**]* from Fig 109. Then select [**Arabian Gulf water**] Figure 118 will display the Arabian Gulf Map.
The Procedure for Wave Height Prediction will be the same as for *[**Kuwait Waters**]*
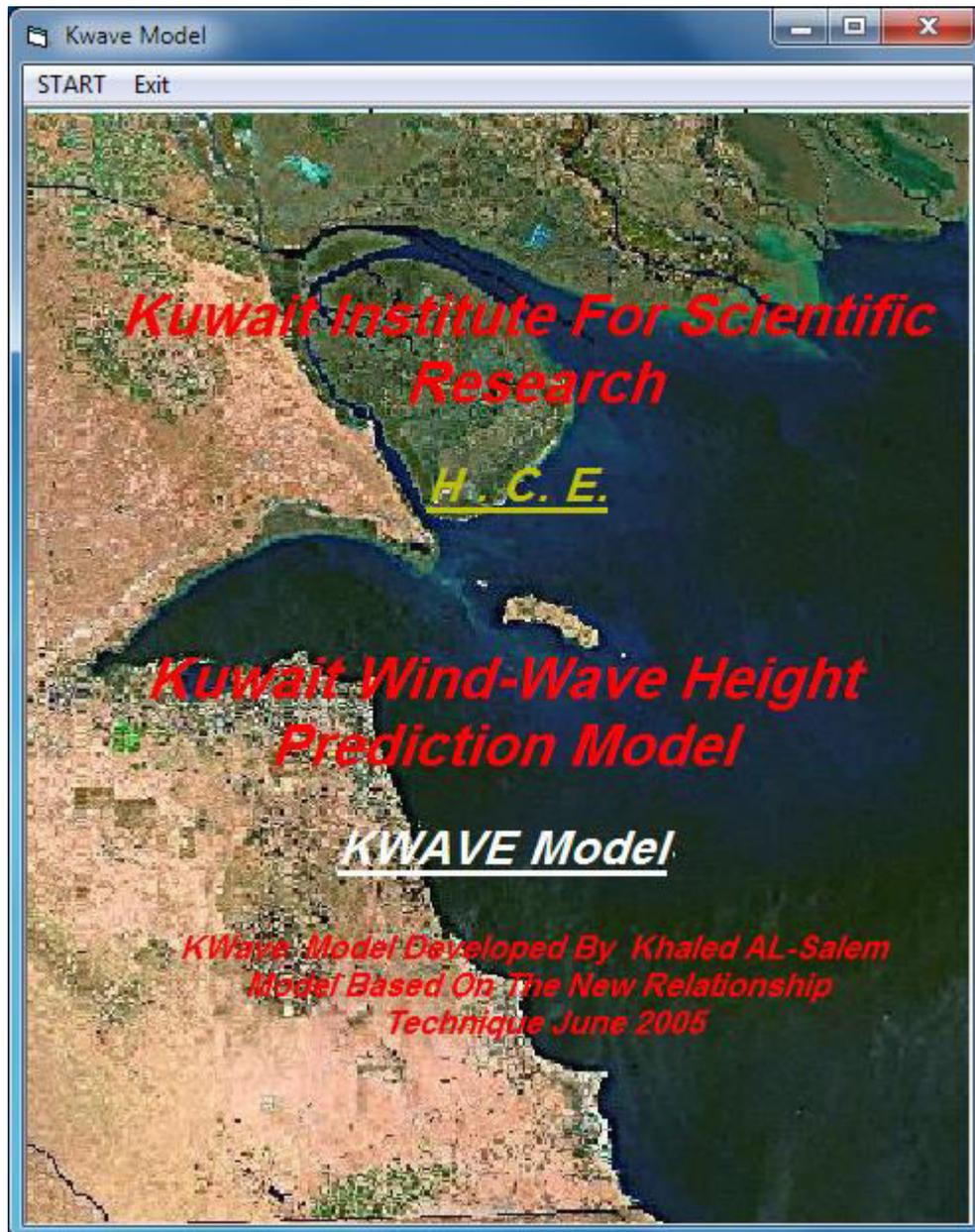
Figure 109
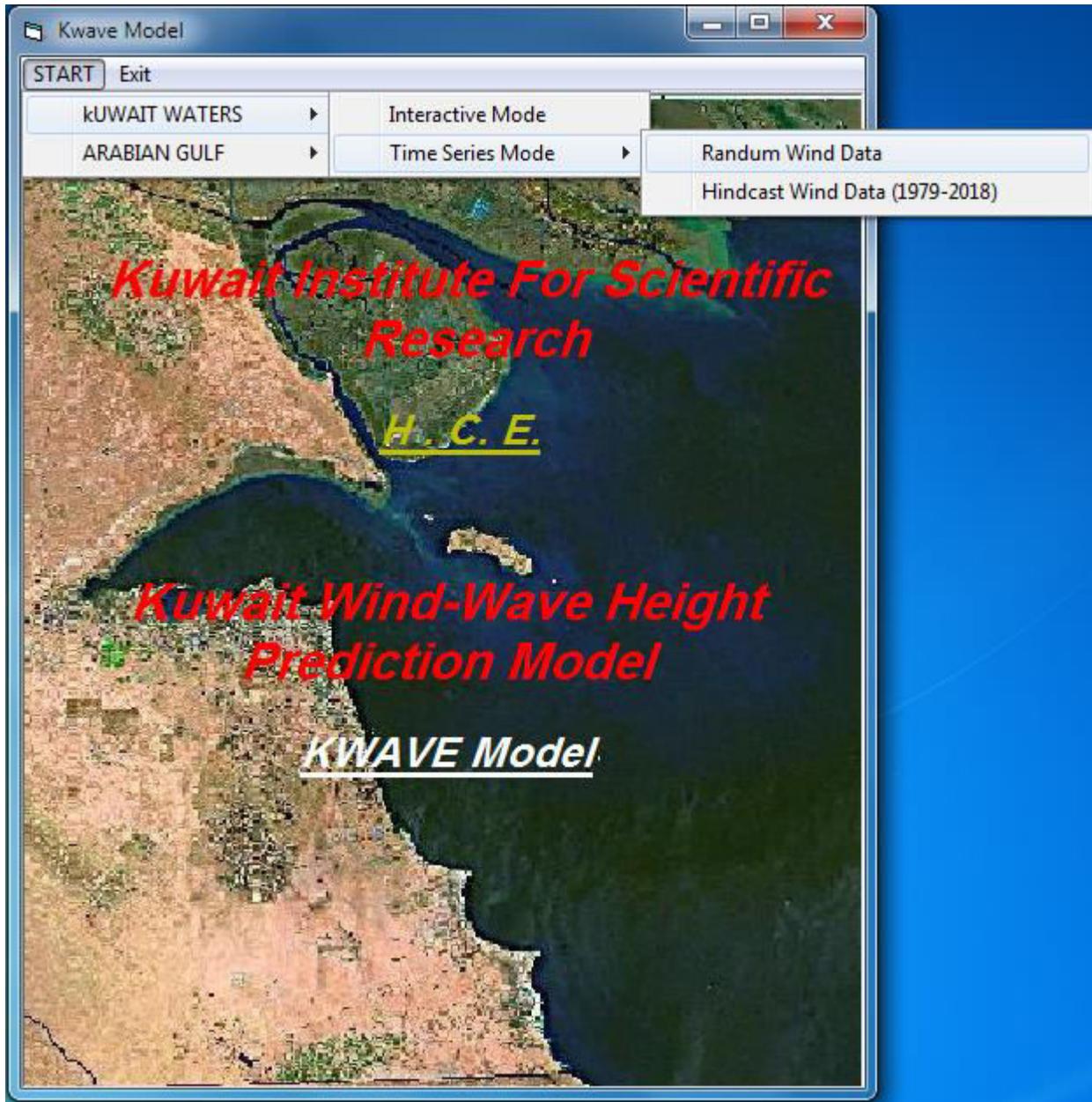
Figure 110
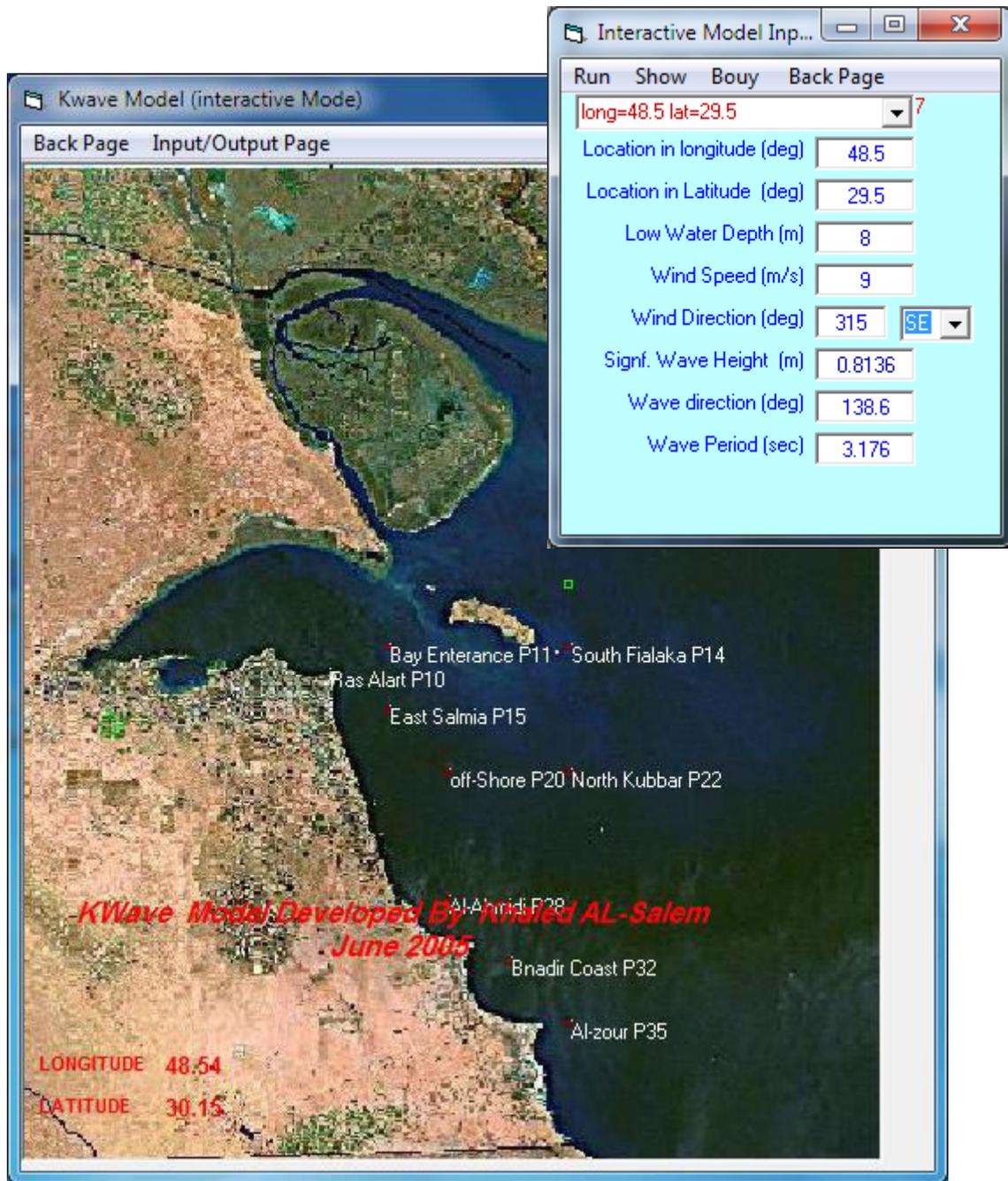
Figure 111
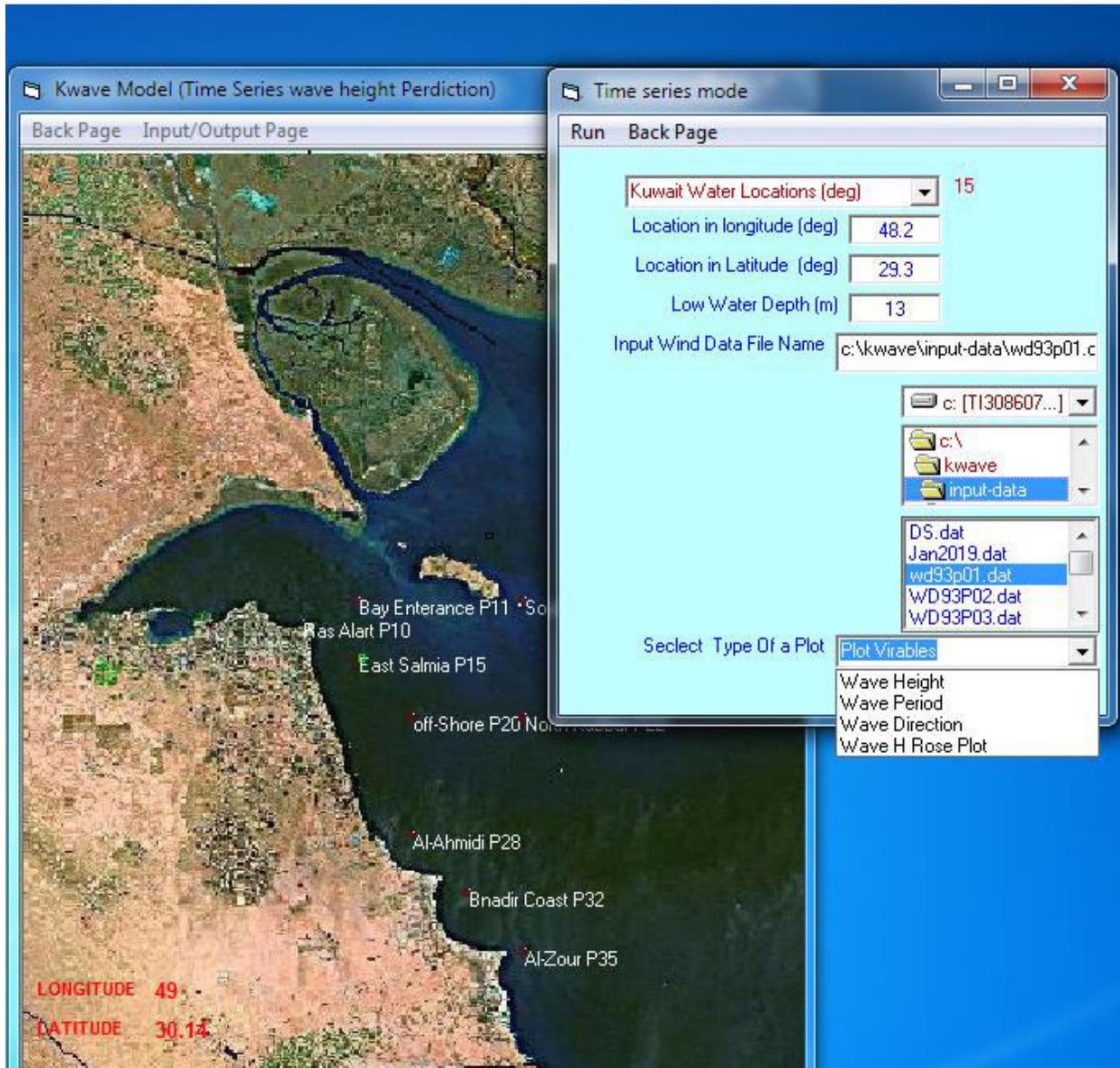
Figure 112
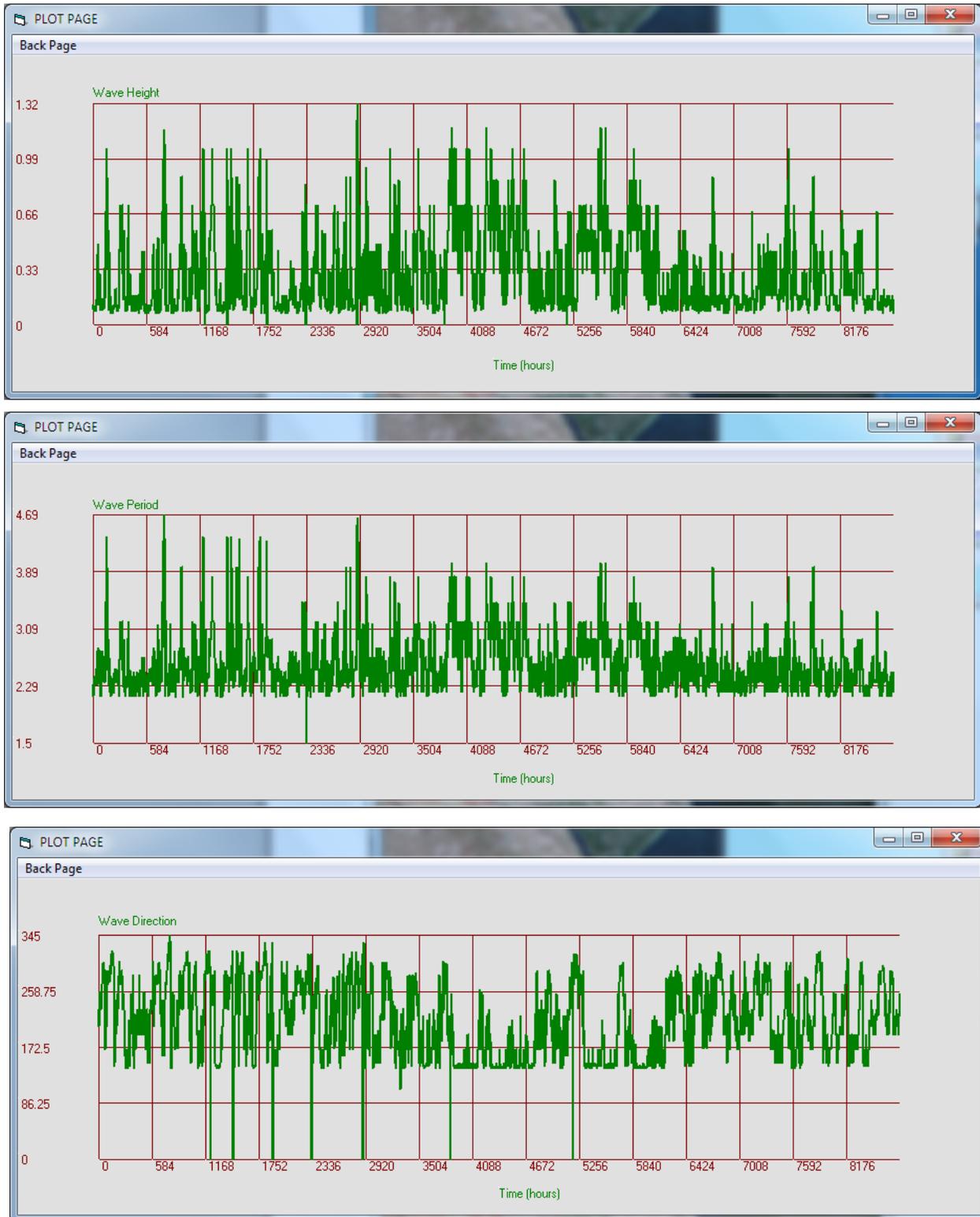
Figure 113
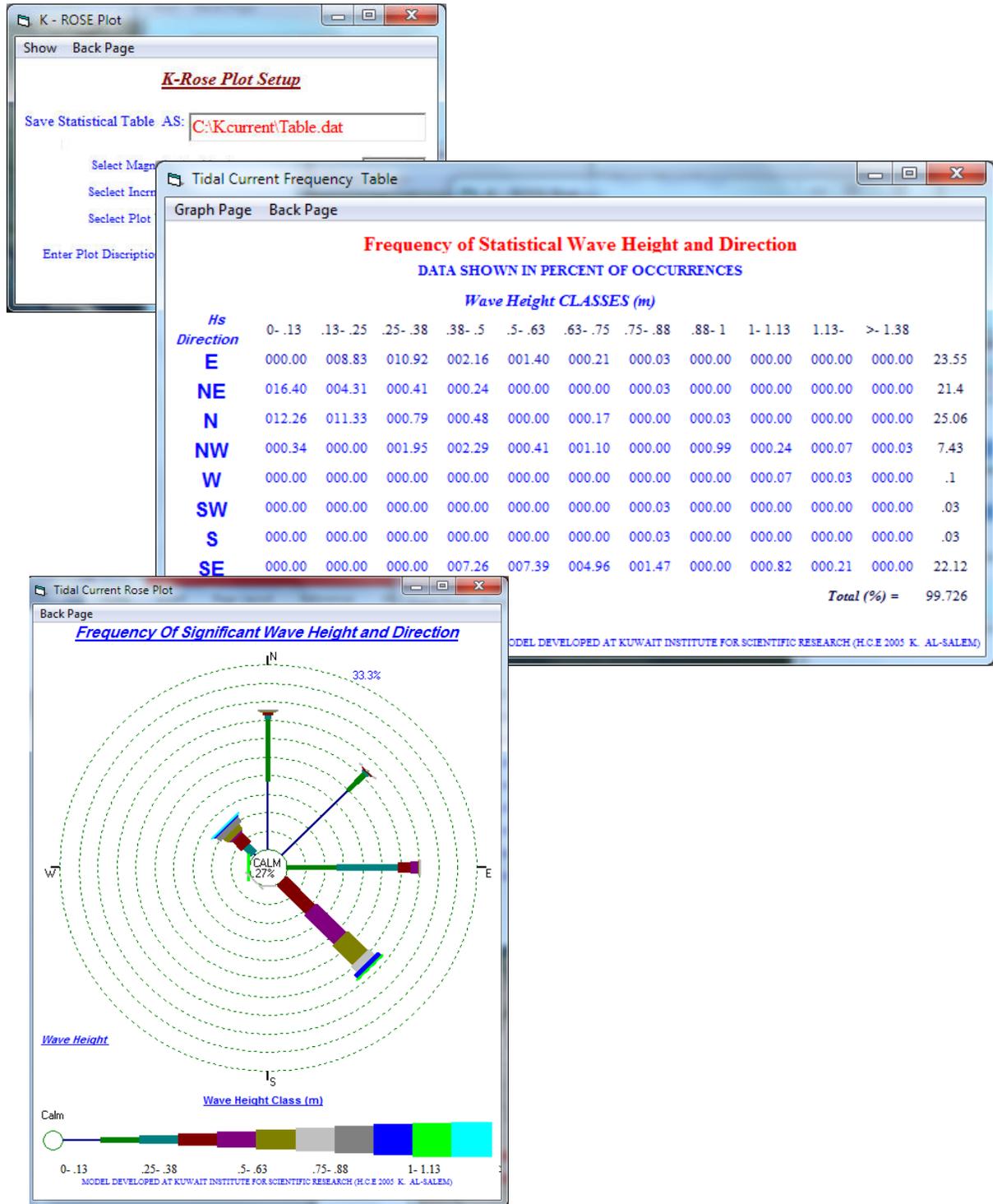
Figure 114
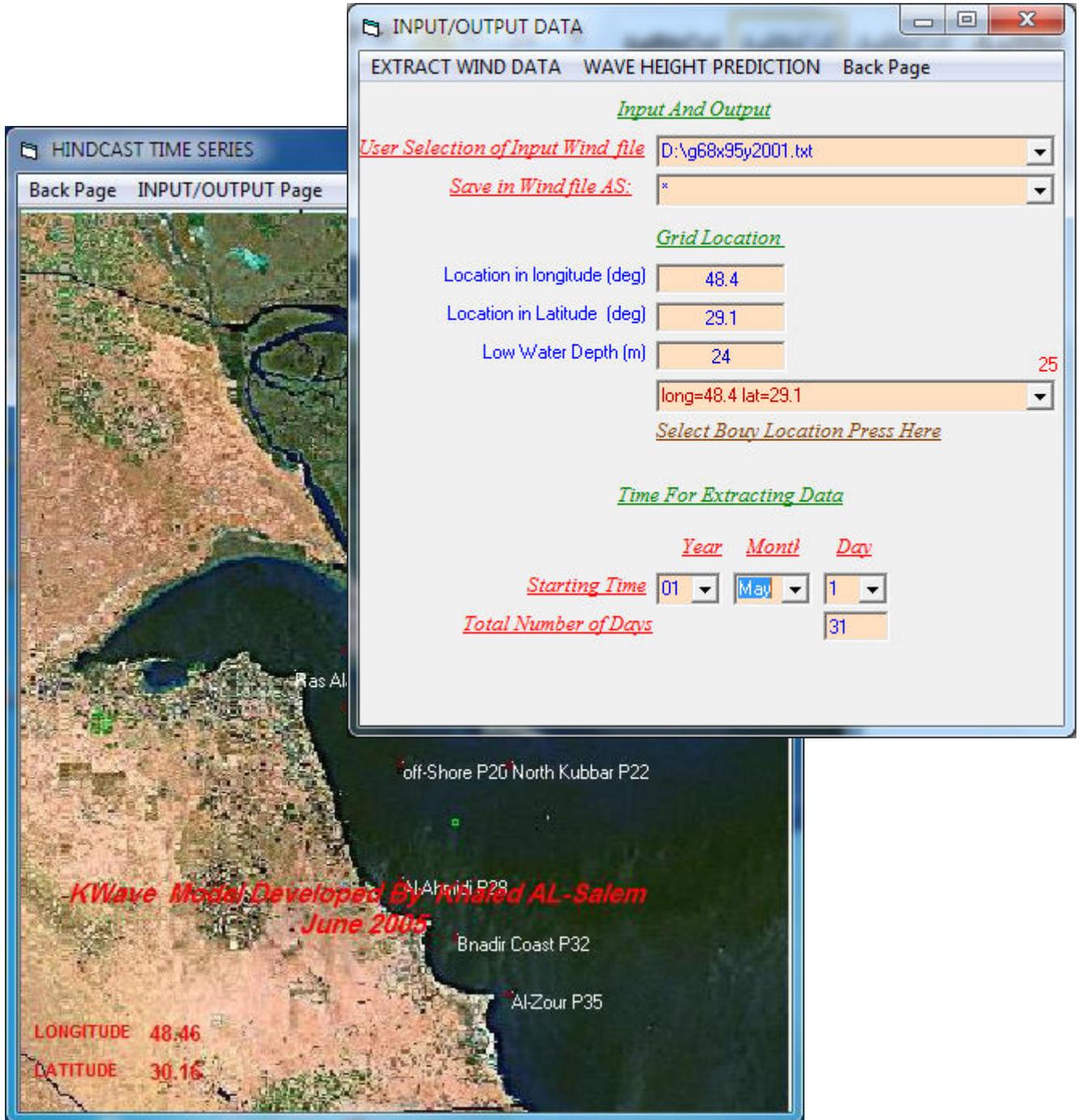
Figure 115
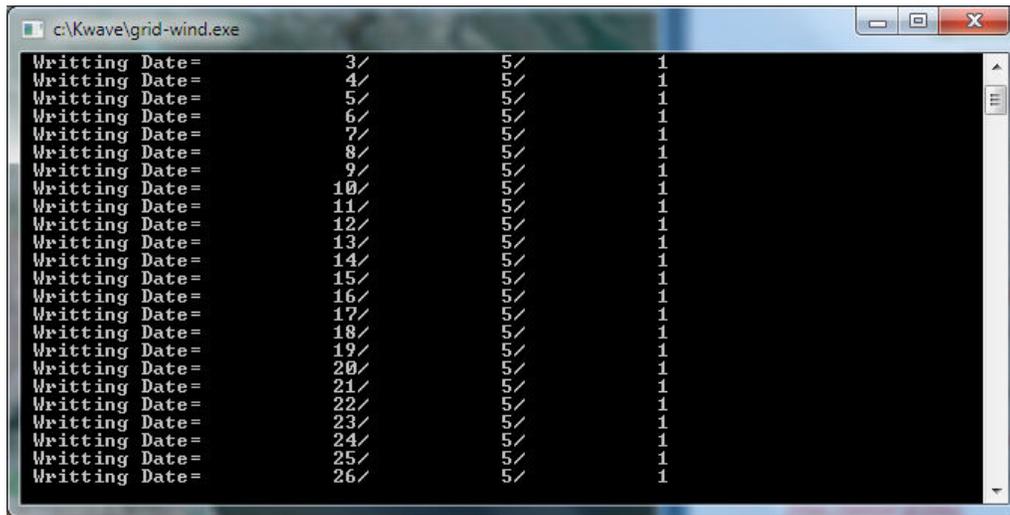
Figure 116
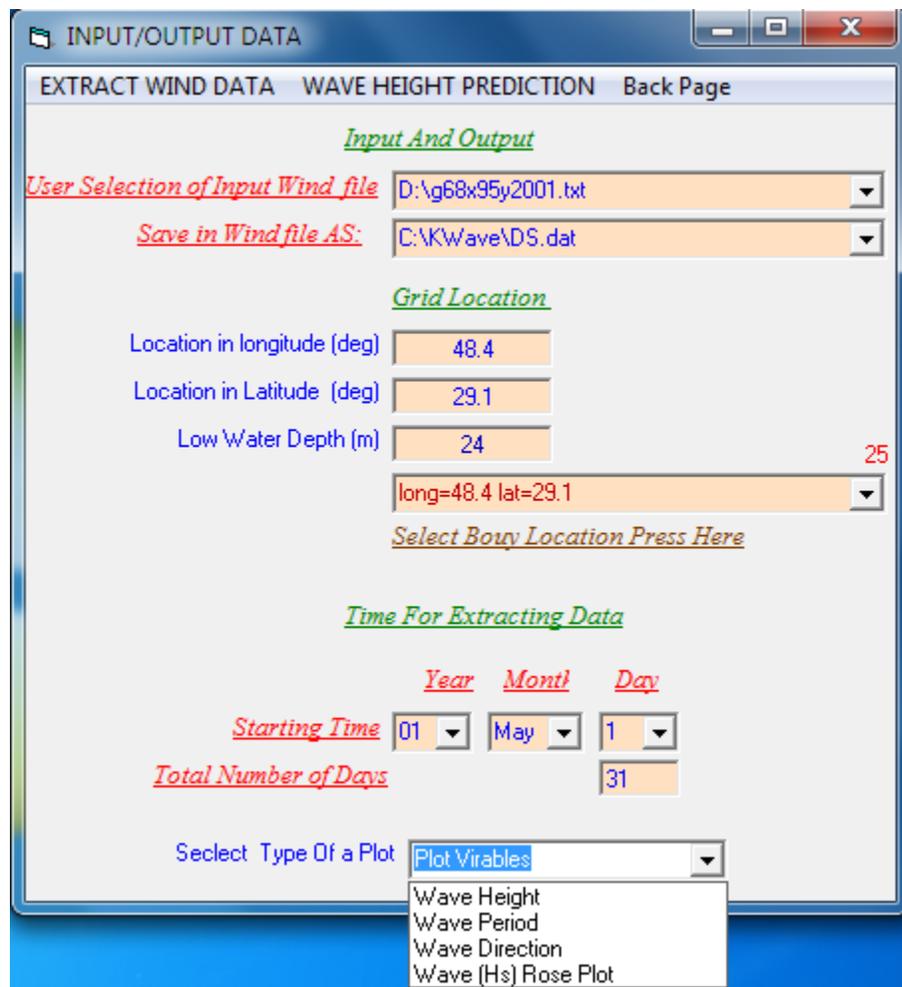
Figure 117
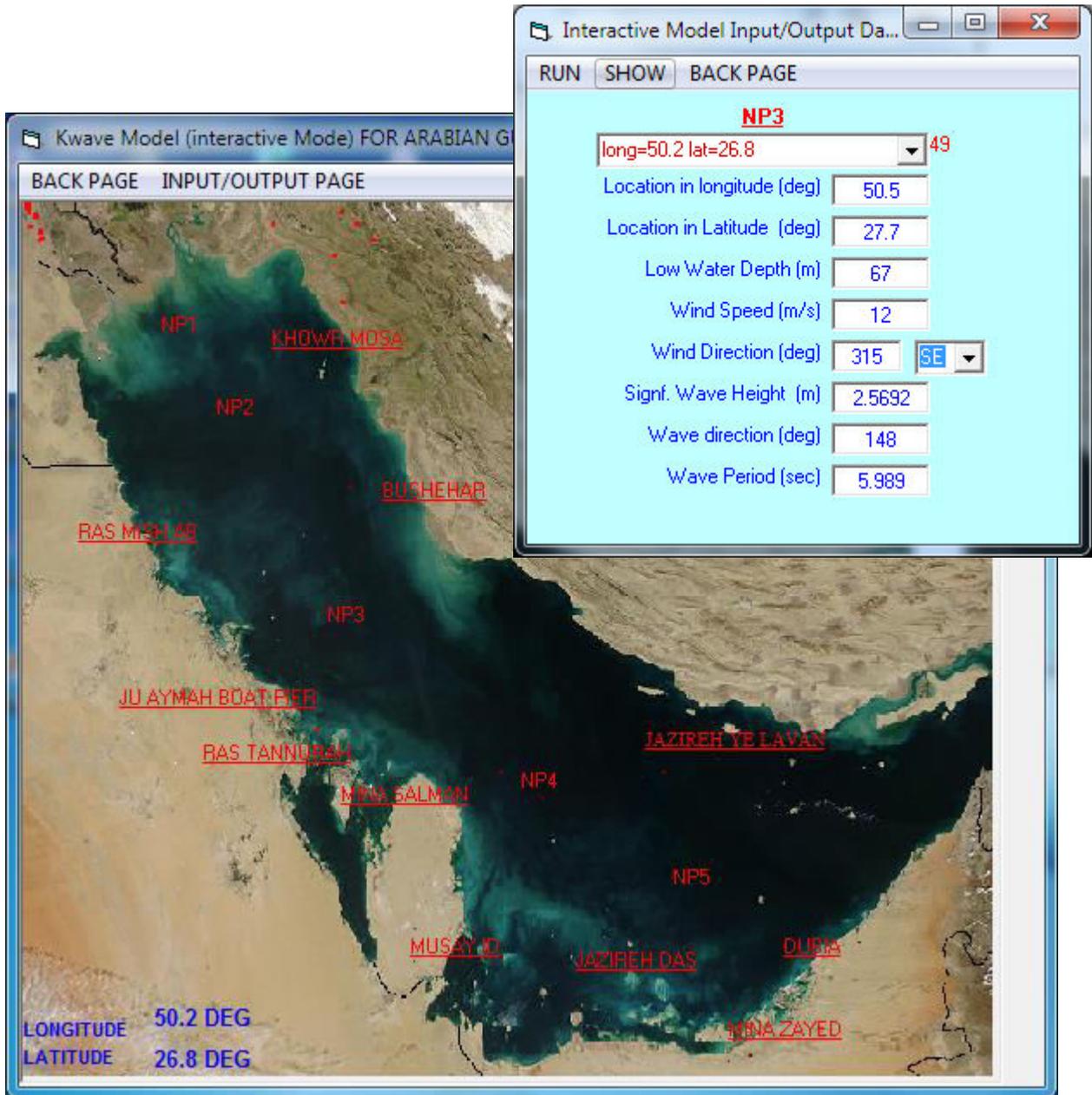
Figure 118

4.3   Design Statistical Threshold Value for Significant Wave Height
[DWave Model]
[K. Al-Salem, M Al-Khaldi 2017] (Pc version)

Model description

Model Wave Database from Jan 1, 1979 To Dec 31, 2015 [Total records: 324336]
Cover All Arabian Gulf Water

To Start the model [🌊] Fig 119 display main page.
 Then user select [Start] Fig 120 will display to user for input Require as follows:

- User have two way to select Location [***Select input File***] as :
  - From Dropdown list
  - Select [***Map***] Arabian Gulf Map will display as Fig 121. Click on map to Select.
- User must select [***Physical TH***] to display the threshold Value as in Fig 120
- User select [***Filter***]. To filter data base on select Threshold vale as shown in Fig 120
- User select Plot button to display Wave height time series plot as shown in Fig 122
- User can display wave statistical distribution as:
  - Gumbel Distribution
  - Weibull Distribution
- To Display Gumbel Distribution Base On Physical Threshold Plot analysis:
  - [BEST FIT] Plot shown in Fig 123
  - [Logarithmic] plot shown in Fig 123. To show Logarithmic System Formulation user must Select [EQU] from figure 123. Figure 124 will display to the system Formulation.
- From Fig 125 user can select [Statistical Threshold] by select [***RUN***] after uset select Max of Threshold Range value.
- To display [***Plot Statistical US***] user must select [***Show***] to display the analysis plot as shown Fig 126. To display Part of sample analysis output data as shown in Fig 127.
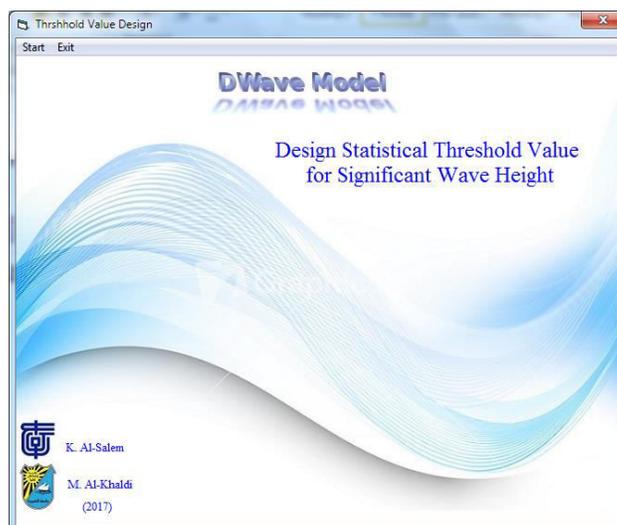
Figure 119

If user select [***Physical TH***] to display the threshold Value as in Fig 120 a new dropdown list will appear [***SELECT***] showing two options as:

- o [Hs] Fig 128 will display Time series for Wave Height for Selected Location.
- o [Tp] Fig 129 will display time series for Wave Periods for Selected Location.
- o From Fig 129 user can select [Spectra Analysis] Option. Frame will display on Fig 129 To select Plot Button to display [Wave Height Spectra Distribution] Analysis plot as shown Fig 130.
- o From Fig 130 user can display the Spectrum Distribution Formulation Option by Select [***EQU***] as shown in Figs 131, 132 and 133.
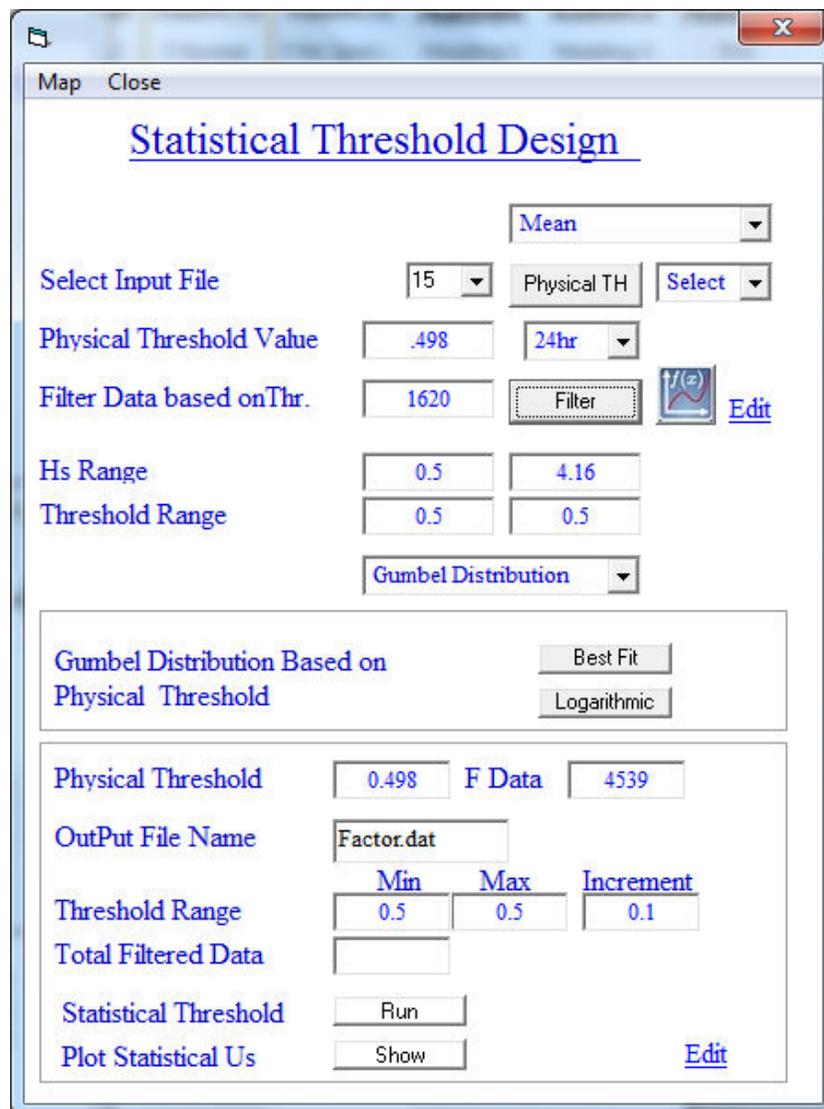
Figure 120
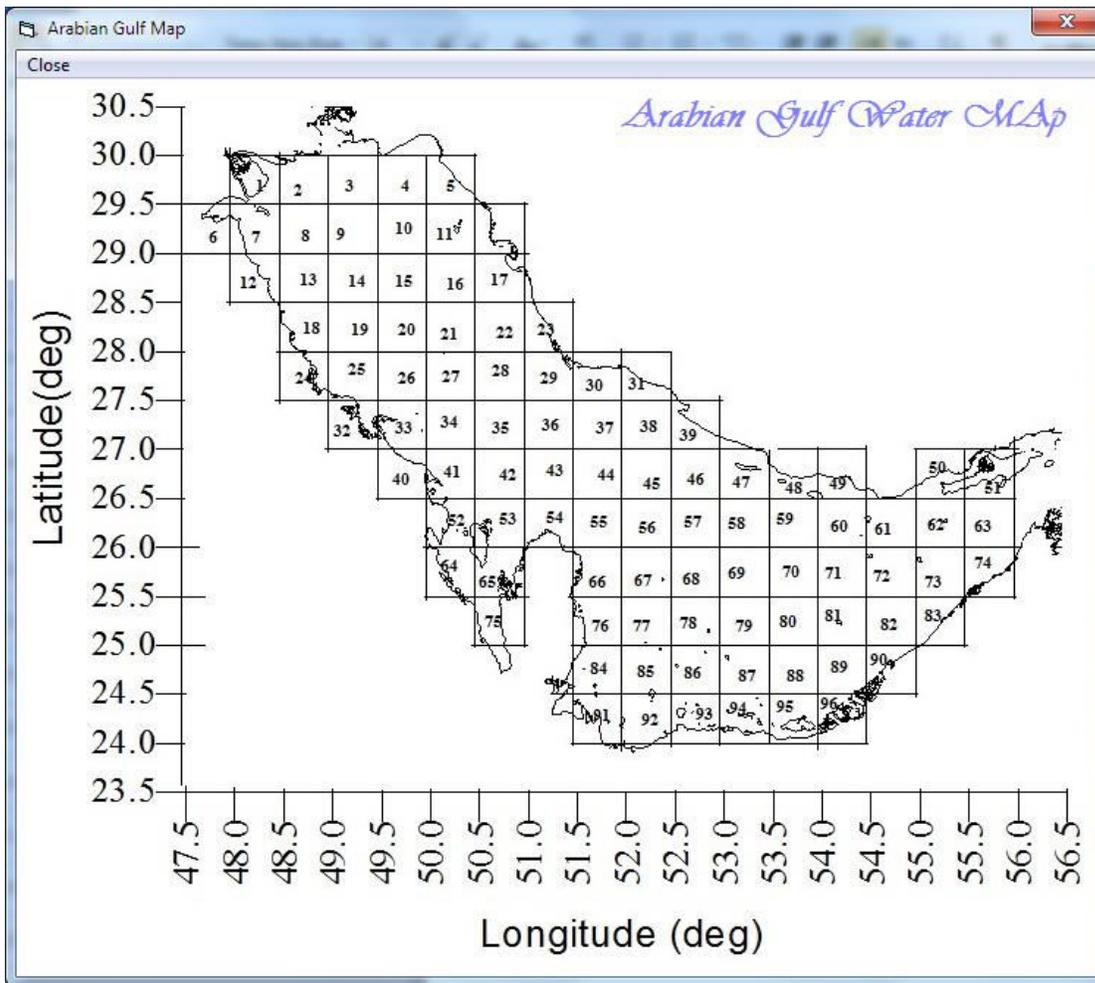
Figure 121
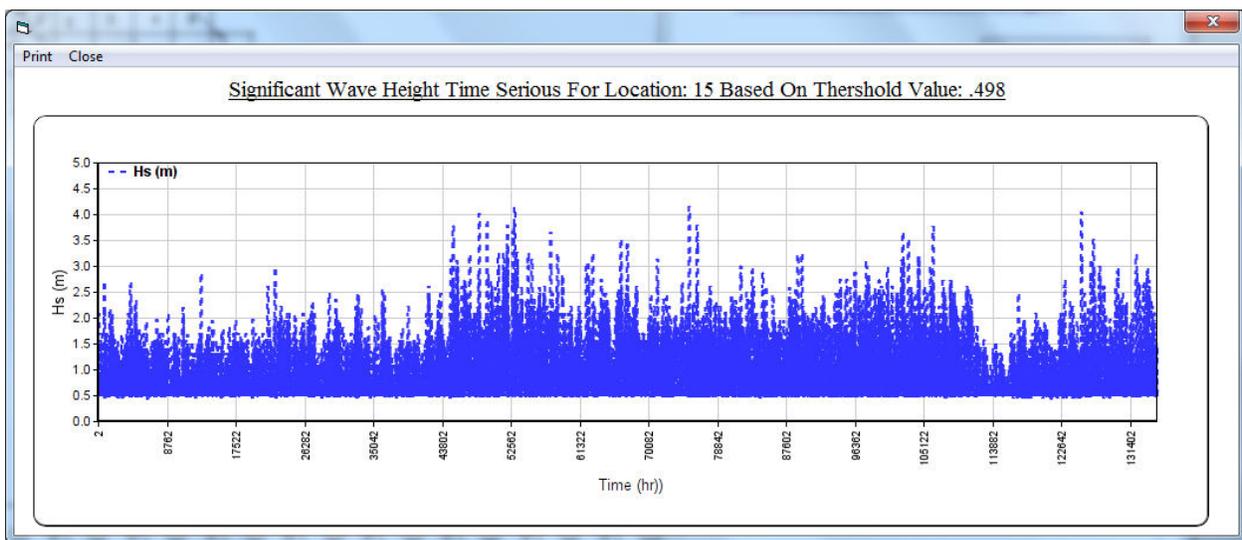
Figure 122
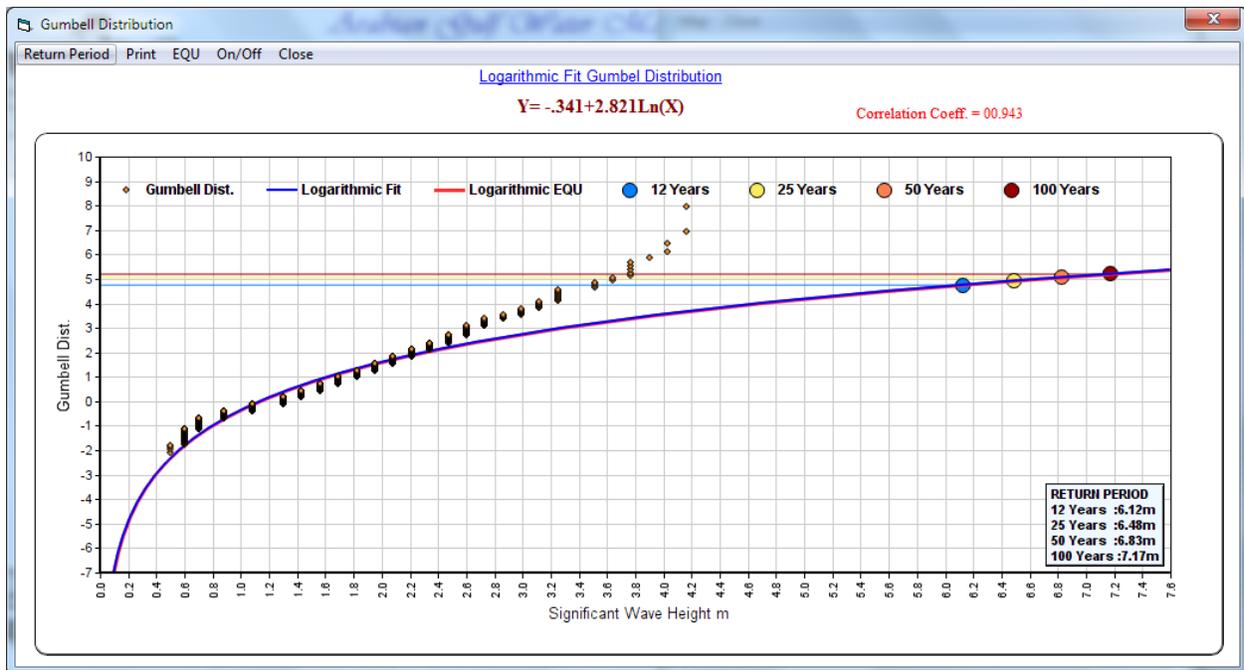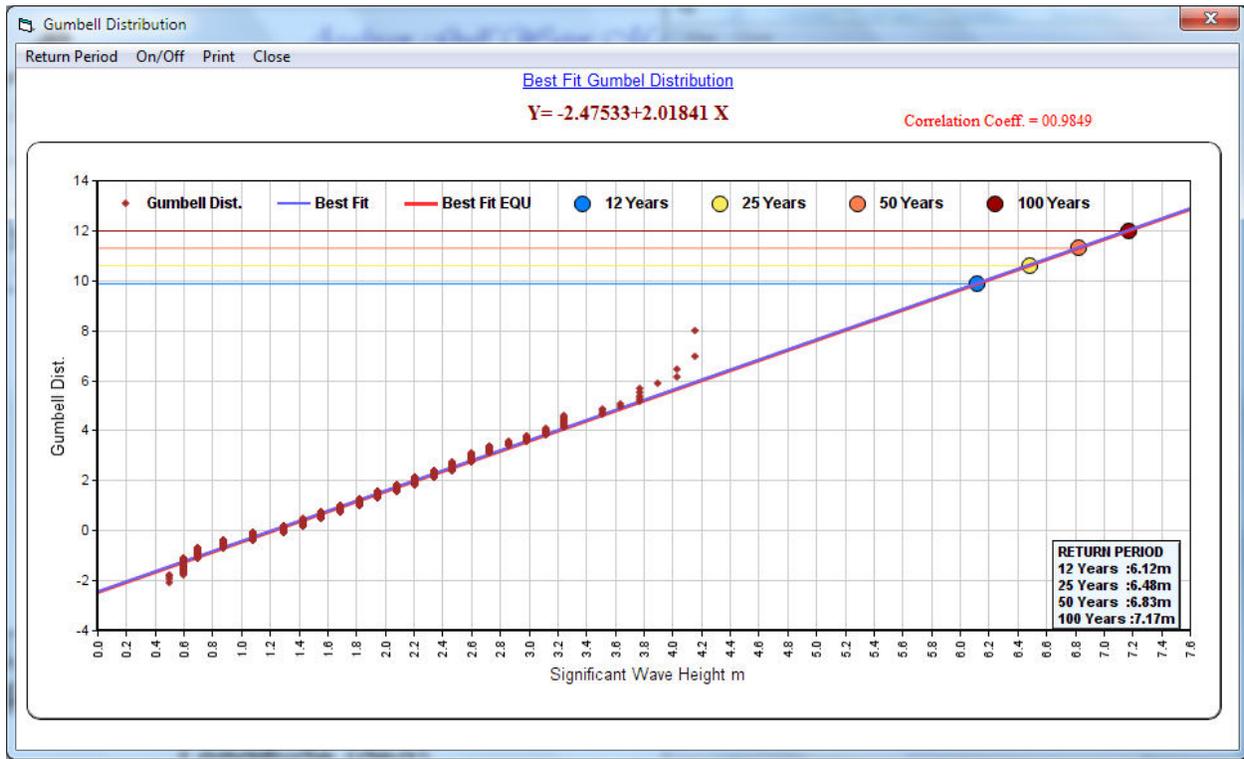
Figure 123
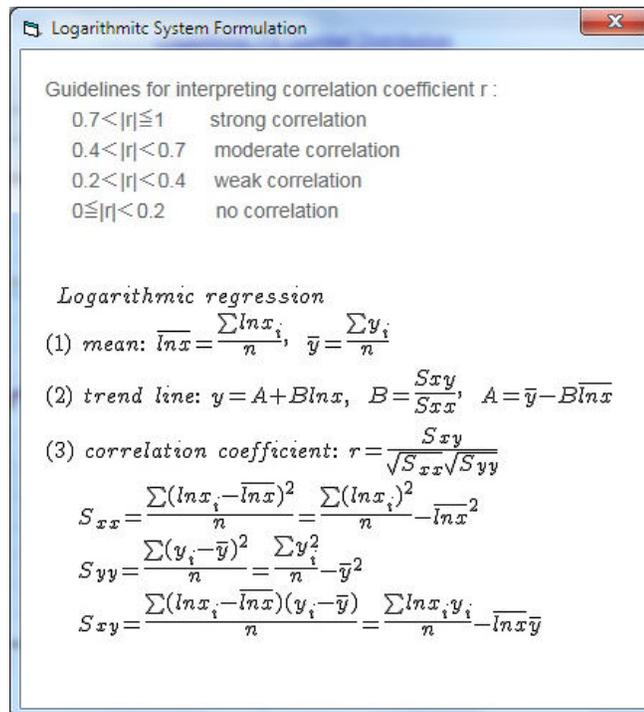
Figure 124

Figure 125

Figure 126

Figure 127

Figure 128

Figure 129

Figure 130

JONSWAP Spectrum Distribution.

The JONSWAP spectrum extends the Pierson-Moskowitz spectrum to including fetch-limited seas. This spectrum is based on an extensive wave measurement program (Joint North Sea Wave Project) carried out in 1968 and 1969 in the North Sea. The JONSWAP (1973) spectrum, received almost instant recognition and became very well-known in international literature. The resulting spectral model is taken as the following form (Hasselmann et al. 1973):

$$S^+(w) = \frac{ag^2}{w^5} Exp\left(\left(-\frac{5}{4} \right) \left(\frac{w_p}{w} \right)^2 \right) \gamma^k$$

Where frequency at peak values of wave period

$$w_p = \frac{2\pi}{T}$$

$$a = \frac{5.061 H_s^2}{T^4} B$$

Where $\gamma = 3.3$ Peak enhancement parameter that describes the degree of peakedness of the spectrum.

$S^+(w)$ JONSWAP spectral density in $\left(\frac{m^2}{rad/_s} \right)$

$B = [1 - 0.287 Ln(\gamma)]$

$k = Exp\left(-0.5 \frac{\left(\frac{w}{w_p} - 1 \right)}{\sigma} \right)^2$

Where:

w Angular frequency (rad/s)

T Wave Period (s)

H_s Significant wave height (m)

$\sigma = 0.07$ $W \leq Wp$ or $\sigma = 0.09$ $W > Wp$

Figure 131

Pierson-Moskowitz Spectra

Pierson-Moskowitz Spectrum Distribution.

The Pierson-Moskowitz spectrum (Pierson and Moskowitz, 1964) is often used as a model spectrum for a fully developed sea, an idealized equilibrium state reached when duration and fetch are unlimited. The mathematical forms of $S^+(w)$ are in terms of the significant wave height, H1/3. (H1/3=ζ m), w Frequency, $g=9.82 \frac{m}{s^2}$. Fetch limitations are displayed in the formulation as follows:

$$S^+(w) = \frac{8.1}{10^3} \frac{g^2}{w^5} e^\propto$$

Where:

$$\propto = -0.032(\frac{g}{\zeta w^2})^2$$

ζ Significant wave height (Hs/3) in meter

$S^+(w)$ Spectral Density $(\frac{m^2}{\frac{rad}{sec}})$

w Angular frequency (rad/sec)

Figure 132

Bertschnider Spectra

Bretschneider Spectrum Distribution.

The ISSC spectrum (also known as Bretschneider or modified Pierson-Moskowitz) is defined as:

$$S^+(w) = \frac{1.25}{4} \frac{w_m^4}{w^5} \zeta^2 e^\alpha$$

Where:

$$\alpha = -1.25(\frac{w_m}{w})^4$$

ζ Significant wave height (m) $(H^{\frac{1}{3}}) = 4\sqrt{M_o}$

w_m Peak frequency: $\frac{2\pi}{T_p}$

T_p Peak period of the spectrum (sec)

The peak period of the spectrum T_p corresponds to the frequency at the mode of the spectral density, the peak frequency w_p:

$$T_{p = \frac{2\pi}{w_p}}$$

Figure 133

4.4 Extreme marine water levels in the Arabian Gulf [KSurge Model]

[Khaled Al-Salem 2011] (Pc version)

The extreme water level at any location is important for the proper design of any coastal structure. For the present project, this is needed for selecting the top level of the breakwater and the level of the land fill. **KSurge model** provides an estimate for the extreme water level at the selected location in Arabian Gulf. According to Kamphuis (2000), there are several types of water level fluctuations and they can be classified according to their return period as:

Short Term:

      I Astronomic Tides
      II Storm Surge
      III Wave setup

Long Term:

      I. Eustatic (Sea) Level Rise
      II. Isostatic (Land) Emergence and Subsidence
      III. Climate Change

This study focus on the short term water level fluctuations.

Astronomic Tides

      Astronomic tides are observed as the periodic falling and rising of the water surface for major water bodies on the earth. Astronomic tides are the result of a combination of forces acting on individual water particles.

      Water level and its change with respect to time have to be measured relative to some specified elevation or datum in order to have a physical significance. In the fields of coastal engineering and oceanography this datum represents a critical design parameter because reported water levels provide an indication of minimum navigational depths or maximum surface elevations at which protective levees or berms are overtopped. It is therefore necessary that coastal datums represent some reference point which is universally understood and meaningful, both onshore and offshore. The following are some of the commonly used datums with respect to tides,

HAT	Highest Astronomical Tide
MHWS	Mean High Water Springs
MHWN	Mean High Water Neaps
MSL	Mean Sea Level
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
LAT	Lowest Astronomical Tide

Storm Surge

      Storms are atmospheric disturbances characterized by low pressures and high winds. A storm surge represents the water surface response to wind-induced surface shear stress and pressure fields. Storm-induced surges can produce short-term increases in water level that rise to an elevation considerably above mean water levels. The water level fluctuation due to storm surge is an increase in water level resulting from shear stress by onshore wind over the water surface . This temporary water level increase occurs at the same time as major wave action and it

is the cause of most of the world's disastrous flooding and coastal damage. During storm surge the water level at a downwind shore will be raised until the slope of the water surface counteracts the shear stress from the wind. Computations of storm surge are carried out using the same depth-averaged two dimensional equations of motion and continuity that are used for tidal computations. In this case wind-generated shear stress is the main driving force. For simple problems, the equations can be reduced to a one-dimensional computation (Kamphuis, 2000).

Wave Setup

Wave setup is the rise in water level at the shoreline induced by the breaking of waves. The wave setup will occur only in the surf zone and is maximum at the shoreline. According to Dean and Dalrymple (1984), the wave setup is about 15% to 19% of the breaking wave height.

Model description

To Start the model [ ] Fig 134 display main page.
 Then user select [Start] Fig 135 will display to user for input Require as follows:
- User must select grid size from Dorpdown list [*Select Grid size*] as :
- User must select [*SHOW*] to display select domain as shown in Fig 136
- To Display Selected Domain by [*G.D.*] as shown in Fig 136

Then user must Check on [*Select Location*] to activate the map for Click Selection for:
- User must select Shallow and deep Location for two way as follows
  - Click on map the two locations
  - Manual Enter the two locations
- User must convert the selected location to Degree by [*CONV*]
- Then user must select [*Wind Path on Google map*]. To Calculate the distance of Wind Path Selected and Display Google Map Icon. And Wind Path will display on Map as shown in Fig 137.
- User can display the Selected wind Path on Google Map by [*Google map Icon*] from Fig 137. Then Fig 138 will display Google map with showing selected wind path [model need internet Access]
- A Part of Sample HTML file was created by the KSURGE model for Google map displaying Wind Path as shown Fig 139.

Then user must start to setup the wind speed path data by select *[SET]* from figure 137.

To show the wind path profile by select [ ]. Then Fig 140 will display for user the wind Profile map.

To Start simulate the extreme water level prediction From Fig 141 user enter the following [*Wind Speed and Units*]

Then select [ ] to start prediction for extreme water level [*based on Mean Sea Level MSL*] as shown in Fig 141.

To display a sample on Output file from storm Surge calculation as shown Fig 142.

By select [ ]

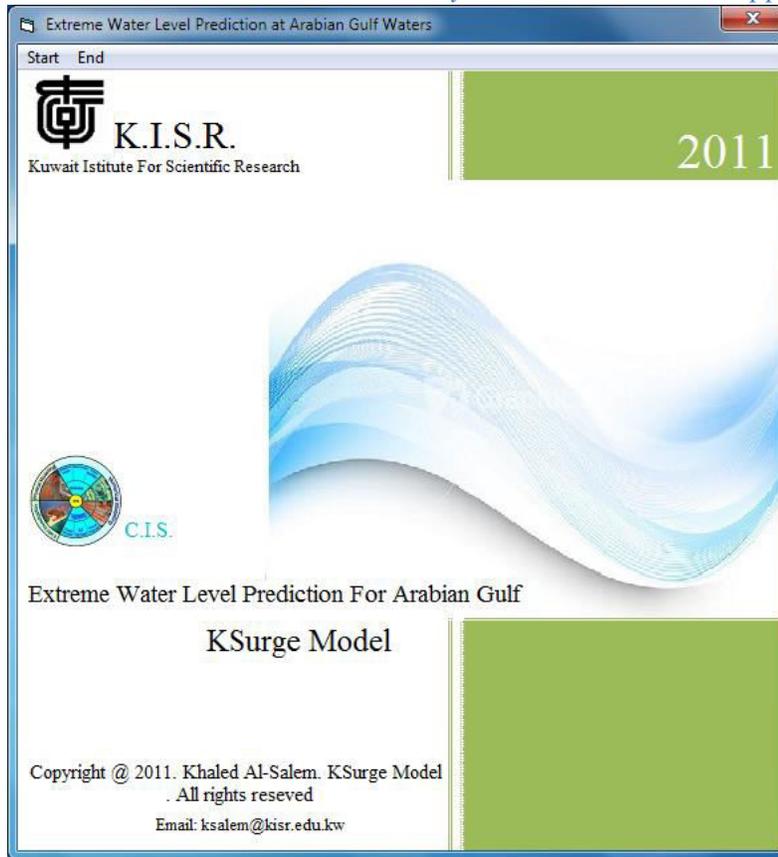To display a sample Final full report of Extreme water level prediction as shown Fig 143 by [ ]
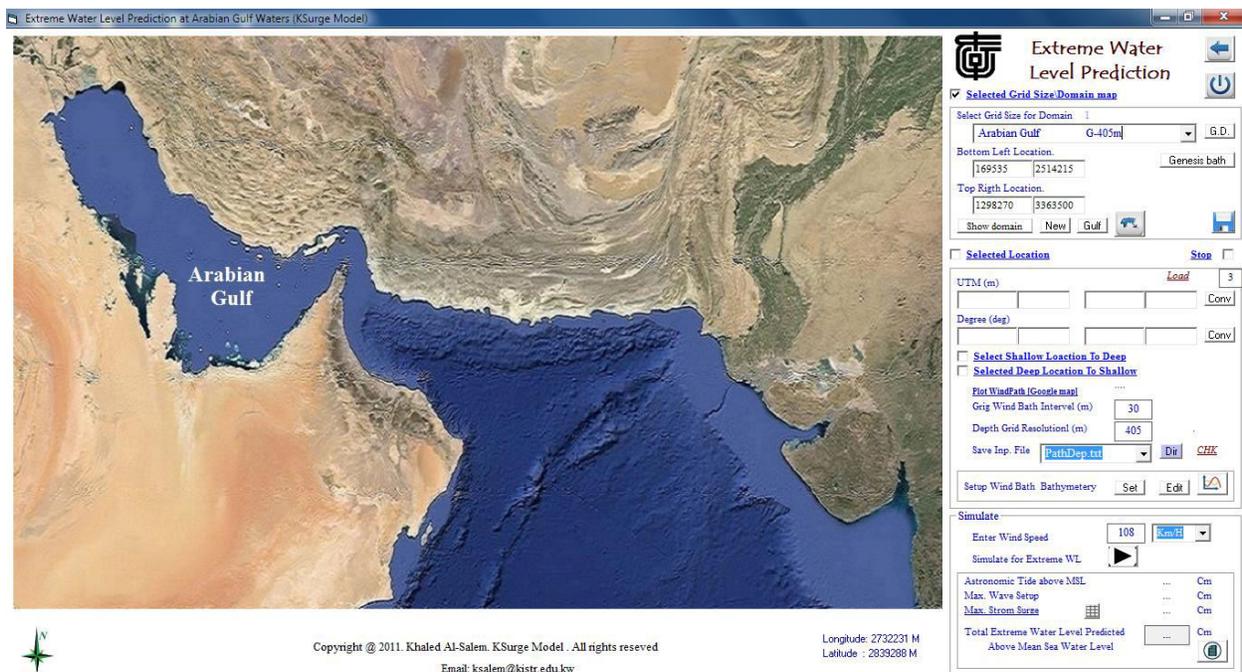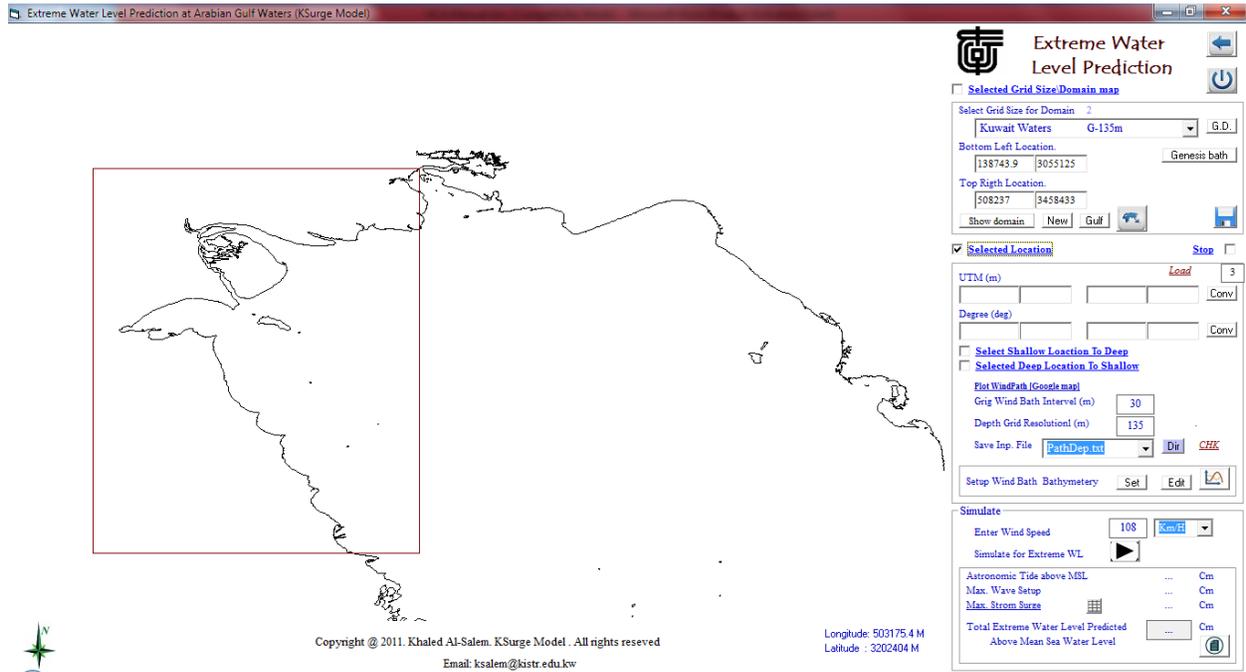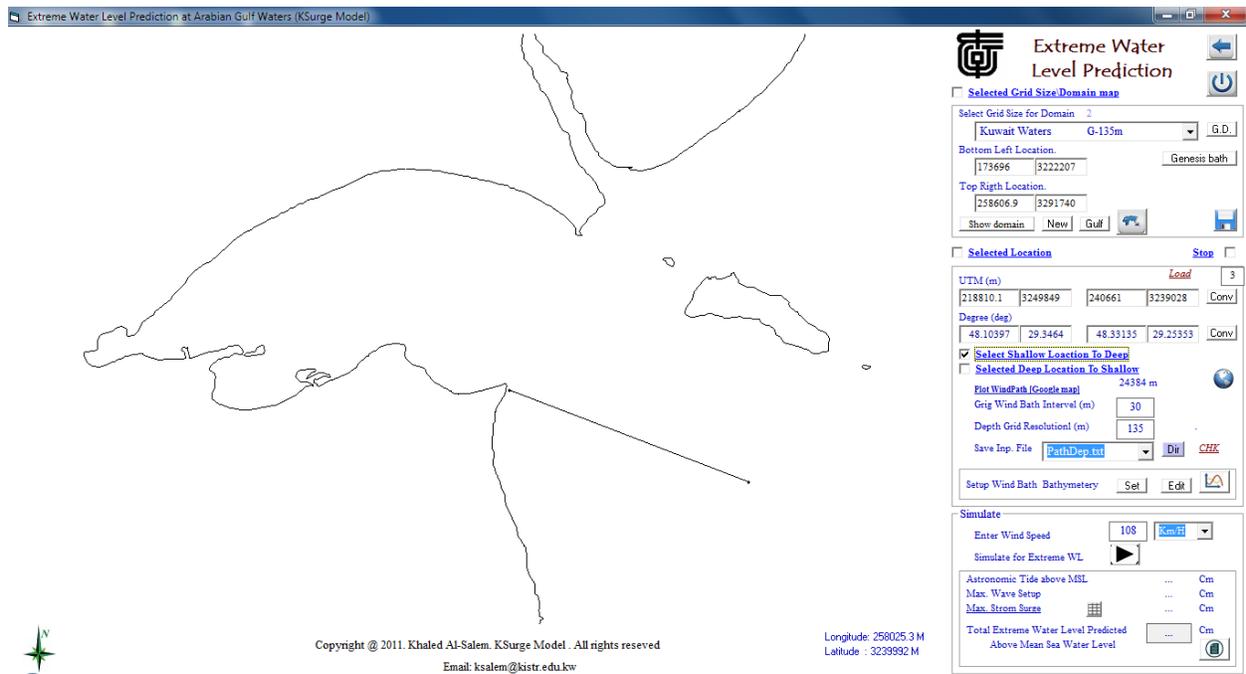

Figure 134

Figure 135

Figure 136

Figure 137

Figure 138

Figure 139

Figure 140

Figure 141

```
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File  Edit  Format  View  Help

                    Table for Storm Surge Wind Bath Data
                          KSurge Model (C.I.S 2011)
                          Dean and Dalrymple (1984)

Wind Speed at (10m) = 108 Km/H
Constant taus =  .00241956
Constant k =  .0000026884
Constant n =  1.27

Max. Storm Surge = 29 (cm)

  No         Longitude      Latitude       Delta X       Water Depth
             (m UTM)        (m UTM)        (m UTM)         (m)
   1         230913.000     3245786        12699.000      -6.2000        Deep Water Loc
  128        218810.000     3249635.000    .000           -15.5000       Shallow Water

Delta-X Interpolation is = 100 m

  No         Delta- x       Water Depth (z)     D Z             Z
             (m)            (m)                 (m)             (m)
   1         12699.000      -6.2000         .0000000000     .0000000000
   2         12600.000      -6.3000         .0049616518     .0049616518
   3         12499.000      -6.3000         .0050217135     .0099833654
   4         12400.000      -6.4000         .0048835156     .0148668810
   5         12299.000      -6.6000         .0048671993     .0197340802
   6         12200.000      -6.4000         .0047708191     .0245048993
   7         12099.000      -6.6000         .0048671993     .0293720986
   8         12000.000      -6.8000         .0046284066     .0340005052
   9         11899.000      -6.8000         .0046524699     .0386529750
  10         11800.000      -6.7000         .0045941221     .0432470971
  11         11699.000      -7.0000         .0046185103     .0478656074
  12         11600.000      -7.2000         .0043676513     .0522332586
  13         11499.000      -7.2000         .0043939993     .0566272580
  14         11399.000      -7.5000         .0042617088     .0608889668
  15         11300.000      -7.6000         .0041073277     .0649962945
  16         11199.000      -7.6000         .0041627362     .0691590307
  17         11100.000      -7.8000         .0040273148     .0731863455
  18         10999.000      -8.1000         .0039794711     .0771658166
  19         10900.000      -8.2000         .0038049477     .0809707643
  20         10799.000      -8.2000         .0038581458     .0848289101
  21         10700.000      -8.5000         .0037138113     .0885427213
  22         10599.000      -8.8000         .0036574330     .0922001543
  23         10500.000      -8.8000         .0035239005     .0957240548
  24         10399.000      -8.9000         .0035747791     .0992988339
  25         10300.000      -9.2000         .0034265551     .1027253890
  26         10199.000      -9.2000         .0034387821     .1061641711

                                    Ln 1, Col 1
```

Figure 142

```
Fout.dat - Notepad                                              [_] [□] [x]

File  Edit  Format  View  Help

                Extreme Water Level Prediction for Arabian Gulf Water's
                        KSurge Model (C.I.S 2011)
                           By: Khaled Al-Salem
                    website address: www.hceatkuwait.net
                    Email address : ksalem@kisr.edu.kw

INTRODUCTION

   The extreme water level at any location is important for the proper design of any coa
This APPs provides an estimate for the extreme water level at the Selected Location in
According to [Kamphuis (2000)], there are several types of water level fluctuations and
classified according to their return period as:
     Short Term:
        I Astronomic Tides
        II Storm Surge
        III Wave setup
        IV Seiche
     Long Term:
        I Eustatic (Sea) Level Rise
        II Isostatic (Land) Emergence and Subsidence
        III Climate Change
This study will focus on the short term water level fluctuations.

Astronomic Tides

   Astronomic tides are observed as the periodic falling and rising of the water surface
Astronomic tides are the result of a combination of forces acting on individual water p
 Water level and its change with respect to time have to be measured relative to some s
have a physical significance. In the fields of coastal engineering and oceanography thi
parameter because reported water levels provide an indication of minimum navigational c
which protective levees or berms are overtopped. It is therefore necessary that coastal
which is universally understood and meaningful, both onshore and offshore. The followir
with respect to tides as:
     HAT       Highest Astronomical Tide
     MHWS    Mean High Water Springs
     MHWN    Mean High Water Neaps
     MSL        Mean Sea Level
     MLWN   Mean Low Water Neaps
     MLWS    Mean Low Water Springs
     LAT       Lowest Astronomical Tide

Storm Surge

   Storms are atmospheric disturbances characterized by low pressures and high winds. A
to wind-induced surface shear stress and pressure fields. Storm-induced surges can proc

                                                           Ln 1, Col 1
```

Figure 143

4.5 Wave Agitation inside Harbor [KHarbor model]
[Al-Salem 1999]   (Pc Version)

Model Methodology

Numerical Method Approach Based on Boundary Element Method for a Harbor of Non-dissipative Boundaries. A brief review of the basic theory, overview of how this theory is implemented is discussed here. The numerical modeling of the problem of wave agitation inside a harbor has gained a lot of attention as numerical modeling can substantially reduce the cost required for conducting feasibility and design studies. All of the basic numerical methods, including the boundary element method and finite element method, finite difference method have been applied to solve the problem. These methods have been applied to solve the governing equation for the problem, which is usually a second-order partial differential equation, namely, the mild-slope equation or the Helmholtz equation with appropriate boundary conditions. The boundary element method has been shown to be an efficient numerical method for the problem of wave agitation and resonance in a harbor, and seems to be an appropriate method to solve the problem numerically. The boundary element method is especially recommended when the water depth is relatively constant or a harbor consists of a basin of constant water depth. Moreover, the application of the boundary element method seems to be indispensable in analyzing the problem of harbor resonance. Finally, the approach based on the boundary element method seems to be irreplaceable when a problem to be solved is urgent and requires a prompt reply.

Water wave agitation in a harbor can be satisfactorily described under the assumption that the fluid is ideal, and the velocity vector possesses a velocity potential function (Hwang and Tuck, 1970). The velocity potential $\Phi(x,y,z,t)$ is assumed in the following form

$$\Phi(x,y,z,t) = \text{Re}\left[-\frac{ig}{\omega} \xi(x,y) \frac{\cosh k(z+h)}{\cosh kh} e^{-i\omega t} \right] \tag{1}$$

where x, y and z are the Cartesian coordinates, t is the time, Re denotes the real part, $i = \left|-1\right|$, g is the gravitational constant, ω is the wave angular frequency, $\xi(x,y)$ is the complex-value free-surface elevation, h is water depth, and k is the wave number.

Since the velocity potential satisfies the Laplace equation, the free-surface elevation has to satisfy equation as follows:

$$\nabla^2 \xi + k^2 \xi + f_2 = 0 \tag{2}$$

Where ∇ is the gradient operator, and the function f_2 is associated with varying water depth. For a constant water depth, Eq. 3 can be reduced to the classical Helmholtz equation:

$$\nabla^2 \xi + k^2 \xi = 0 \tag{3}$$

It is known that numerical integration is usually more stable than numerical differentiation, and often it is convenient to seek the solution of a differential equation in the form of an integral equation (Sulisz, 1987). In particular, it is convenient to seek the solution of Eq. 3 in the form of the integral equation as follows:

$$\int_s \left[\xi \frac{\partial H_0^1(kr)}{\partial n} - \frac{\partial \zeta}{\partial n} H_0^1(kr) \right] dS = 0 \tag{4}$$

Where S is the boundary of a domain, n is the normal to the boundary, H_0^1 is the Hankel Function of the first kind and order 0, and r is the distance between the point on the boundary and a field point. Eq. 4 is solved numerically by discretizing the boundary of a domain (harbor) into N segments.

$$\sum_j \int_{sj} \left[\xi \frac{\partial H_0^1(kr)}{\partial n} - \frac{\partial \zeta}{\partial n} H_0^1(kr) \right] dS_j = \sum_j (I_{ij} + II_{ij}) = 0, i = 1,2,......$$ (5)

Where I_{ij} and II_{ij} denote the first and the second integral, respectively, and implementing boundary condition by imposing at the boundary of a harbor.

$$\frac{\partial \zeta}{\partial n} = 0$$ (6)

Moreover, at the harbor entrance, matching conditions are imposed which require the continuity of a normal component of velocity and continuity of free-surface elevation along the entrance. The procedure leads to a set of simultaneous equation, the solution of which provides the free-surface elevation at any point in the harbor. Since only the boundary of the harbor requires discretization, the procedure is very efficient and can be applied to even a large harbor.

Boundary Condition for Practical Applications. The crucial point in the numerical modeling of wave agitation in a real harbor is the modeling of the wave-absorbing boundary condition. These condition should describe the wave damping associated with wave interaction and reflection at harbor structures and are essential for the proper modeling of wave agitation and resonance in a harbor, as wave field in a harbor is a result of multiple wave reflection from harbor structures (Behrendt, 1985; Dalrymple and Martin, 1996; Melo and Gobbi 1998).

Difficulties in imposing these conditions are due to a lack of details available wave-damping properties for harbor structures and some problems with implementing partially absorbing boundary conditions in a numerical model. The problem with boundary conditions for practical applications can be illustrated by the analysis of partial reflection of oblique incident waves. An elliptic model requires a proper ζ or its normal derivative, or a relation between ζ and its normal derivative at the boundary. Since in general, ζ and its normal derivative are not known at the boundary of a harbor, it is convenient to impose the boundary condition in the form of a relation between ζ and its normal derivative. A relation between ζ and its normal derivatives for the partial reflection of oblique incident plain wave on a straight boundary is expressed as:

$$\frac{\partial \zeta}{\partial n} = ik \frac{1-R}{1+R} \sin \theta_I \zeta,$$ (7)

Where θ_I the angle of incidence and R is the complex-value reflection coefficient. The main problem with the application of Eq. 7 to a harbor agitation problem is related to a lack of information regarding the angle of incidence θ_I, which is known only for the incident wave outside a harbor, and a lack of details regarding R for most harbor structures. Moreover, there is also a problem arising from the application of a formula derived for plain waves to a three-dimensional case, which requires justification.

In addition to the problem with boundary condition inside a harbor, there is also the problem with implementing partially absorbing boundary condition in the exterior domain. A proper solution in the exterior domain is essential to the final solution because the final solution is the result of matching a solution in a harbor and a solution in the exterior domain. The solution

associated with the scattered wave field in the exterior semi-infinite domain bound by collinear coastline may be written in a polar coordinate (r, θ) as follows:

$$\zeta_s = \sum H_q^1(kr)(A_q \cos q\theta + B_q \sin q\theta) \qquad (8)$$

Where H_q^1 is the Hankel function of the first kind and order q, A_q and B_q are constant. For a fully reflective coastline, Eq. 8 can be applied to represent scattered wave field in the exterior domain. However, for a partially reflecting boundary, application of Eq. 8 fails (Xu et al., 1994). This can be illustrated by substituting Eq. 8 into Eq. 7, which results in the relation as follows:

$$\frac{q}{r}B_q + \beta A_q = 0, \theta = 0 \qquad (9)$$

Where β is a constant; Since A_q and B_q are constants and cannot depend on (r), Eq. 9 can be satisfied only if $A_q = 0$ and $B_q = 0$. This implies that the classical approach to the exterior domain cannot be applied for a partially reflecting coastline. In practical applications, the angle of incidence, θ_I is often neglected in the modeling of wave field in a harbor. There are also some attempts to minimize the effect of the lack of information regarding, the angle of incidence by estimating θ_I at the boundaries, applying iterative approaches.

Assessment of Wave Reflection Properties for Harbor Structures. There are basically two methods which can be used to predict reflection properties for harbor structures with relatively small error. The first method is based on the physical modeling of the process of wave interaction with a structure conducted at small, moderate and large scale. The results obtained at different scales can be used to assess scale effects and to predict the reflection properties of harbor structures with a relatively small error. This method requires an access to large wave flume facilities and is both time consuming and expensive. Alternatively, reflection properties for most harbor structures may be assessed using a second method.

This method assesses the reflection properties of harbor structures on the basis of the hydraulic properties of the material used to build a harbor structure and a numerical model for wave interaction with the structure (Sulisz, 1985). Although this method still requires laboratory experiments to assess the hydraulic properties of the material used to build the structure, the experiments are simple, and require only an access to a large perimeter and are conducted only once for each new type of material regardless of structure type or shape. The second method is inexpensive and provides prompt results.

In reality, some feasibility studies for harbor agitation problems are often conducted based on the reflection properties of harbor structure assessed in a very rough manner; namely, on the basis of our individual experience and the material available in the literature. However, this approach possesses a variety of shortcomings due to the lack of reliable information available in literature. For example, the reflection coefficient for normally incident waves and a typical rubble mound breakwater varies from about 0.1 (0.2) for waves of intermediate length to about 0.6 (0.7) for long waves (CERC 1984; Sulisz, 1985). The reflection coefficient is reported to depend on a wide variety of factors including wave length, wave steepness, breakwater width, slope angles, thickness of layers permeability, material used to build the layers, etc. Moreover, the reflection coefficient within and outside the harbor depends also on the angle of incidence (Isaacson et al., 1996, Losada et., al. 1993). The range of the reflection coefficient for a vertical and horizontal composite breakwater is even wider than for a rubble mound breakwater. The

reflection coefficient for normally incident waves varies from about 0.2 to not more than 1 (CERC 1984; Sulisz and NcDougal 1988).

Prediction Of Resonance Effect. An important part of the prediction of wave field in any harbor is the analysis of harbor resonance, which is related to the size and shape of the harbor and the range of incoming wave frequencies (Mei, 1983). The analysis should provide information regarding resonance frequencies as well as the effect of resonance on the wave field inside the harbor. In general, the analysis of harbor resonance requires enormous numbers of calculations and related analysis. The situation is especially complicated for tidal seas, where often an infinite number of resonance frequencies is dealt with some simplification which are possible only for harbors of simple shapes like a rectangular harbor, a circular harbor, etc., where information regarding natural models for circular basin following eigen value solutions may be useful.

$$\zeta = A_{mn} \cos \frac{m\pi x}{b} \cos \frac{n\pi y}{c}, m, n = 0,1,.... \tag{10a}$$

Provided that

$$k = k_{mn} = \left[\left(\frac{m\pi}{b} \right)^2 + \left(\frac{n\pi}{c} \right) 2 \right]^{\frac{1}{2}} \tag{10b}$$

Where the natural periods

$$T_{mn} = \frac{2\pi}{\omega_{mn}} \tag{10c}$$

Are related to k_{mn} via the dispersion relation

Circular Basin:

$$\eta = A_{mn} J_m (k_{mn} r) \cos m\theta \tag{11a}$$

Provided that k_{mn} satisfies

$$J_m (k_{mn} a) = 0, m = 0,1,......,n = 1,2,..... \tag{11b}$$

Where the natural periods

$$T_{mn} = \frac{2\pi}{\omega_{mn}} \tag{11c}$$

are related to k_{mn} via the dispersion relation.

TECHNICAL USER GUIDE
Procedure for Usage of KHarbor Model (Wave Agitation Model inside a Harbor)
Wave Agitation Model (**KHarbor**) is an efficient and easy-to-use wave model. This version is sufficiently user-friendly and can provide the base information for water wave inside harbors. The information provided by this model can be further used to calculate wave forces on structures, stability of breakwaters, sediment/pollutant transport and can be used to assist harbor and coastal protection structure design. In this section of the report, step-by-step instructions are given for use of Wave Agitation Model (Kharbor). The procedure outlined here consists of number of steps which are:

The model can run by select from Figure 144 Start option and then select (Wave Agitation) then Figure 145 will display for user to start.

Figure 144
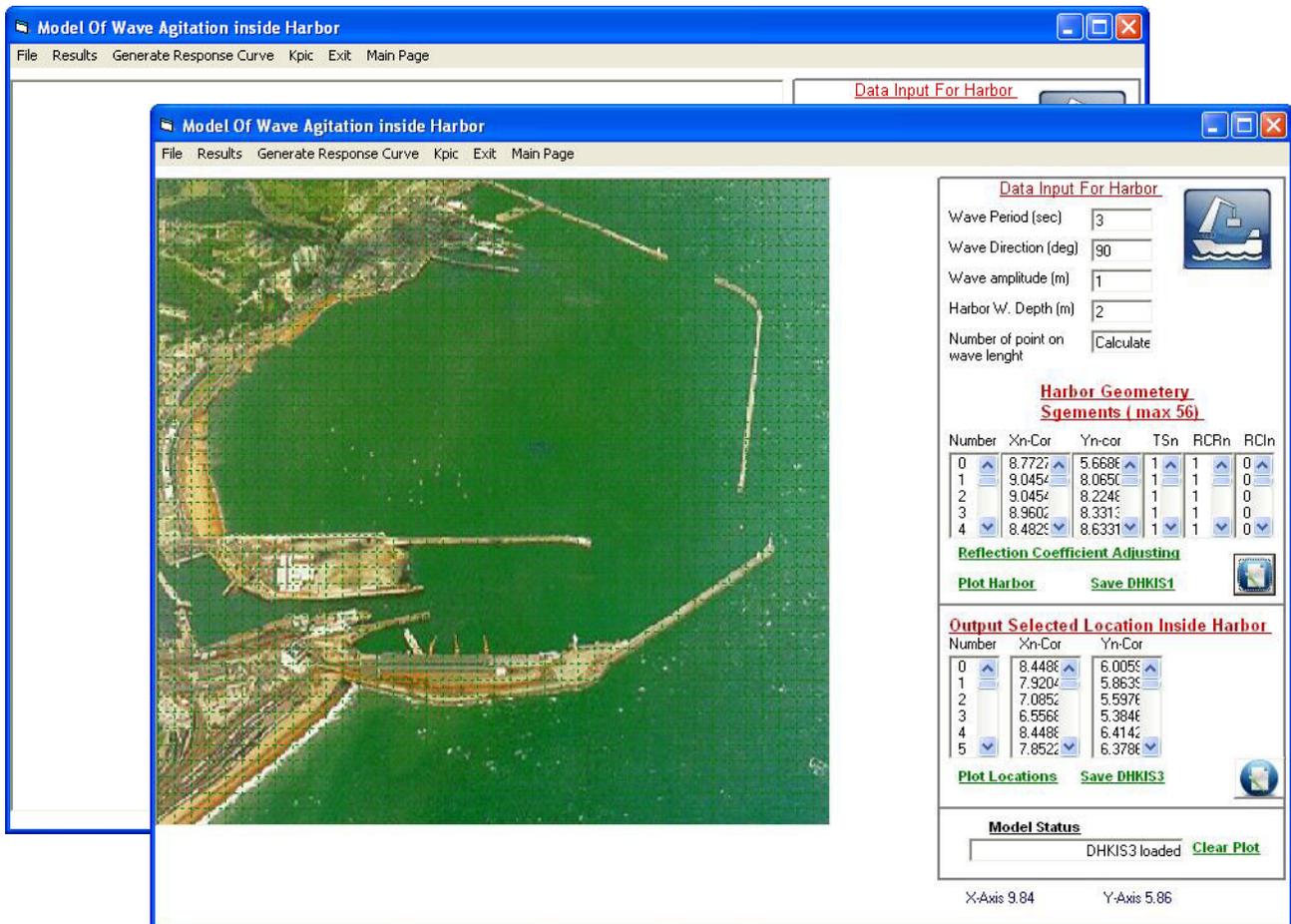
Figure 145

Figure 145 contain some option for user as:

1- Option One : File
   - Load Previous Project Input Data
   - Load Existing Project (Pre-save Input Data)
   - New Project (To start new input Project and Initialize plot Screen)
   - Run (Start simulate for Wave Height prediction inside a Harbor only design wave)
   - Run Time serious (start simulate for Wave Height prediction for variable incidents wave height and direction"

2- Option Two: Results
   - Output List (Show Wave Predicted at select output location)
   - 2D Wave Height Contours Plot (start Kharbnor Graphic Program for 2D Contour presentation)
   - Edit Output (Open output file in text format)
   - Harbor Geometry input 1 and 2 save as (Store input files name)
   - harbor location output 1 and 2 save as (Store output file name)

3- Option three: Generate Response Curve:
   - Select Harbor Data (Input Harbor data and Simulation time)
   - Run (Start simulate for Wave resonance prediction inside a Harbor)
   - Plot Response Curve(start Kharbnor Graphic Program presentation)
   - Edit Output(Open output file in text format)
   - Save Response OutPut

4- Option Four: KPIC
   For Digitize Plot Image for Validation the
   KHarbor Model Output Prediction.

   Procedure for Option Usage as follows:
   Option one
   User has two option to start Kharbor model as
   Load Previous Run input data or user can load Pre-store
   input data as show in Figure 30. User can Input File
   name for Harbor Geometry and Output Location File.

Then User from Figure 145 selects Load files. Figure 146 will
Display.

From Fig 145 user must Initialized the Screen plot scale as
shown in Figure 147.

**Figure 146. Load Input previous
stored data**
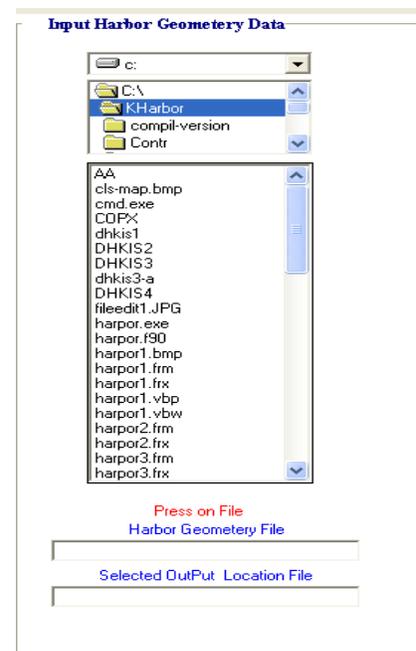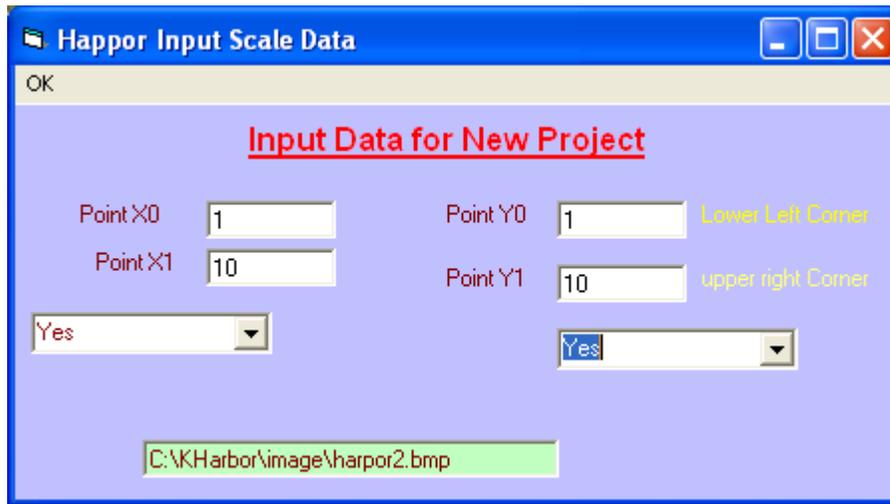
Fig. 147. Initialized load or new project for plot screen

Figure 147 shows for user to input Screen Scale and Load background Harbor Image for digitized the geometry for input and Shown Grid on screen on/off.

Figure 145 shows for user a different project input as :

- Data Input Harbor
  - Incident wave period (sec)
  - Incident Wave Direction (deg)
  - Incident Wave Height/2 (or Wave Amplitude) (m)
  - Harbor Water Depth (m)
- Harbor Geometry Segments (max 56 point)
  - Number
  - X location/y Location
  - TSn: Type of harbor segment (1 for nonentrace 0 entrance)
  - RcRn: Real part on harbor reflection coefficient properties
    - Structure (.1 to 1)
  - RcIn: Imaginary part on harbor reflection coefficient properties
    - Structure (0)
  - User can change RcRn by select Reflection adjusting.
  - User can plot harbor
  - User can edit input data file (DHKIS1) as text file
  - User must save input file (Save DHKIS1)
- Output Location Inside Harbor
  - User enter selected output location.
  - User can plot output location
  - User can edit DHKIS3 location file as text file
  - User must save DHKIS3 location file

Figure 145 user can start simulation for wave height design in
harbor as:
- Select Run
- Figure 148 shows the output prediction wave height.

**Figure 148. Wave height
Output Screen**

Figure 145 user can start time serious simulation for wave height design in
harbor as:
- Select Run Time serious
    Figure 149 will display for user to input incident wave time serious input file
    name and the output file name.
- User must select Run to start simulation.
-
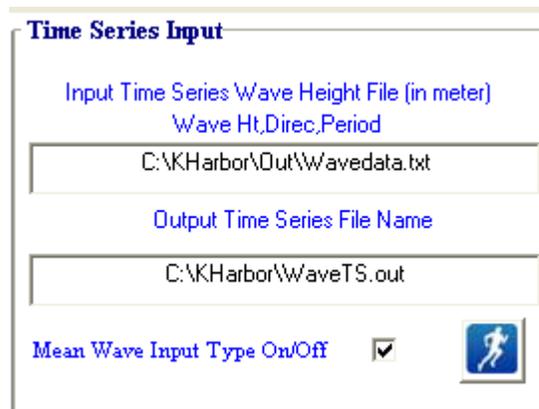
Figure 149. Time Serious Wave height Input Screen

Figure 145. User can Select Result for Present the output as in table as shown in Figure 148.
Or user can start Kharbor 2D Graphics from Figure 145. Figure 150 will display for user to
select what plot type to select.

Next section user will find full procedure description for KHarbor 2D graphic.
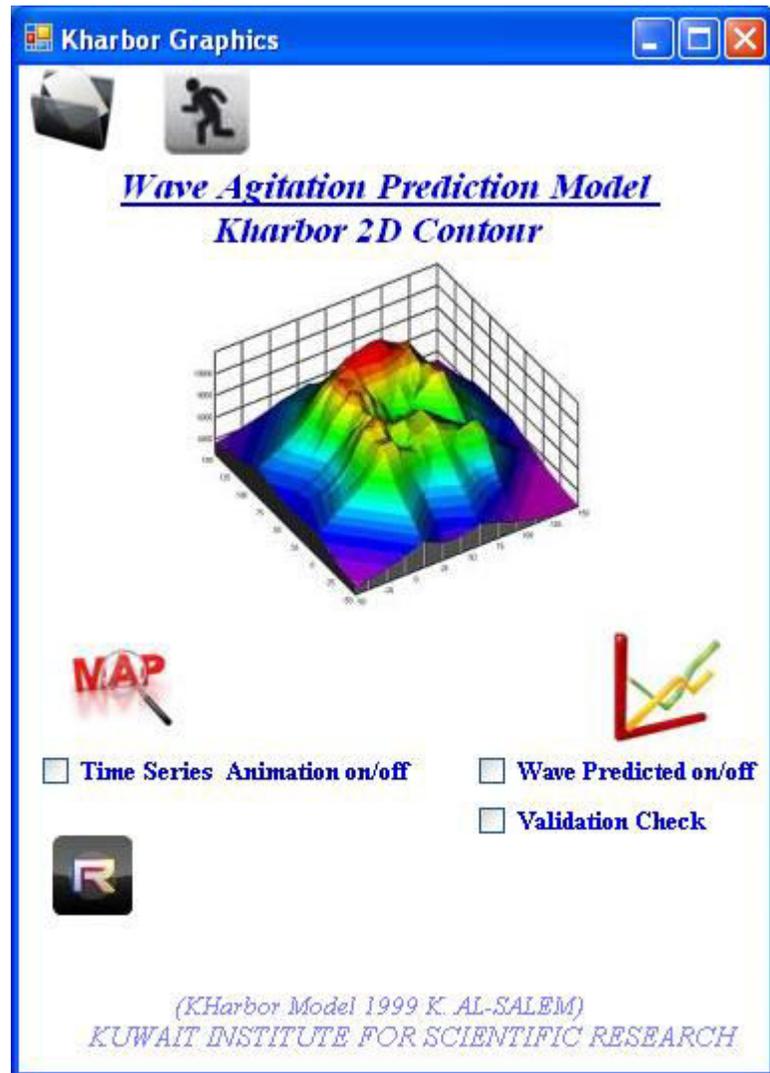
Fig. 150. Kharbor Graphic Screen

Procedure for Studying the Wave Resonance Inside a Harbor

After user setup the harbor geometry and initial wave input then user must select one output inside the harbor to predict the wave resonance data as show in Figure145.
Then user must select only one location inside the harbor to predict the wave resonance data.
Then user select from Figure 145 (Generate Response Curve - Select Data file)
Figure 151 will display for user to enter Harbor Length ,total Simulation Time And time Step.

Then user must select from Figure 145 (Generate Response Curve – Run – Run Time Serious) to start simulation for wave resonance prediction.

Data output presentation:

     From Figure 145 user can present the as the following

- User can start Kharbor 2D Graphics from Figure 145. Figure 151 will display for user to select what plot type to select. Next section user will find full procedure description for KHarbor 2D graphic.
- Edit Output File (results in text format)
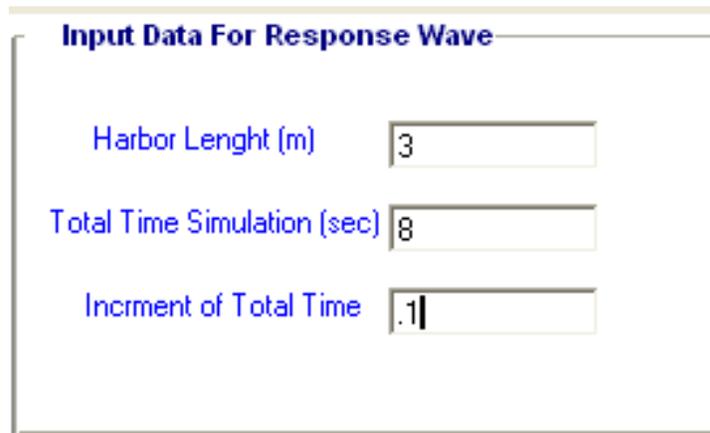
Figure 151. Harbor Data file for Resonance curve prediction screen

Procedure for Kharbor 2D Grsphic Program

Kharbor 2D Graph as shown in Figure 152 is design to present the output from KHarbor Model for:

    -Wave Agiation 2D Contours
    -Wave Agiation Animation 2D Contours
    -Wave Contour in 3D
    -Resonance Curve Line
    -User Selected Output Location Line for Wave Height
    -Superimposed Wave Resonance Line for Validation
    -Wave Refraction/Diffraction Contours
    -Plot wave height prediction from KRD model for
Selected location.
    -Plot time serious Animation contour result from
KRD model
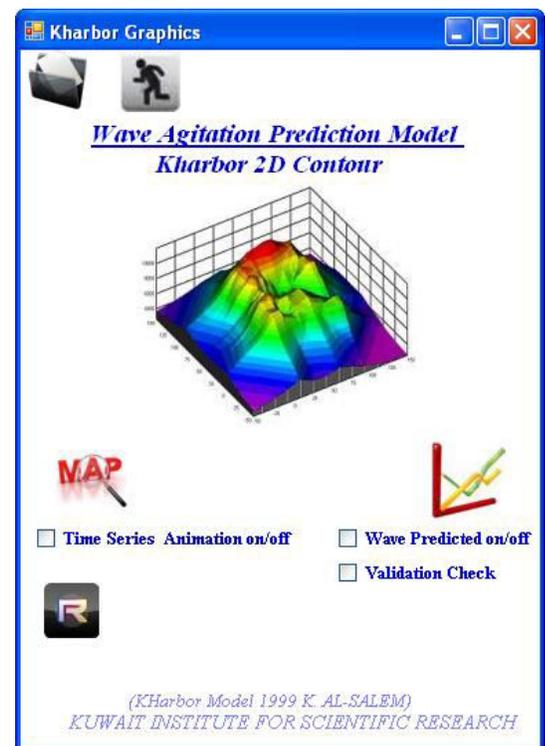
Figure 152. Kharbor Graphic Screen.

Figure 152 shows main screen of Kharbor 2D Graphic Program which have different options as follows:

Map Section

The Map section has two option as

Option 1. Design Wave Height 2D Contour Plot from Wave Agitation model

User must Deselect (time serious animation off or uncheck)   Figure 153 will display for the user with several plot option as follows:
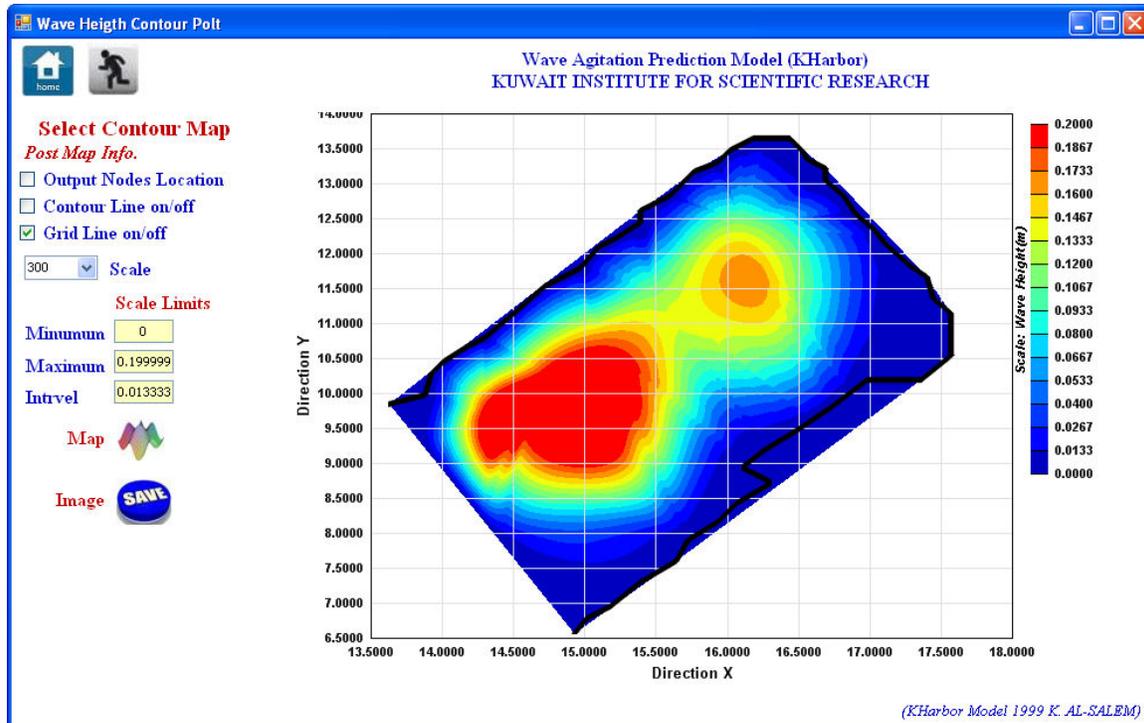
Figure 153. Wave Height Contour Plot Page.

Select Contour Map Option:
1. Post Map information has different check box for:
   To Post Selected Output location on map
   To Show Contour Line on map
   To Show Grid x,y Line on map
2. Scale Legend On/Off or select size.
3. Scale Contour Map as (maximum ,minimum, Interval)
4. To save Image on disk

Option 2. Time serious Animation for Design Wave Height 2D Contour Plot from Wave Agitation model.

User must select (time serious animation On or check) and must enter file name for simulation output as shown in Figure 154.

User must select Map Figure 155 will display for user with several plot option as follows:

1- Plot line for wave height prediction for any selected output location as shown in Figure 156.

2- Plot Animation for 2D wave height contour line for selected output location as shown in Figure 157

3- Plot animation for 3D wave height contour line for selected output location as shown in Figure 158
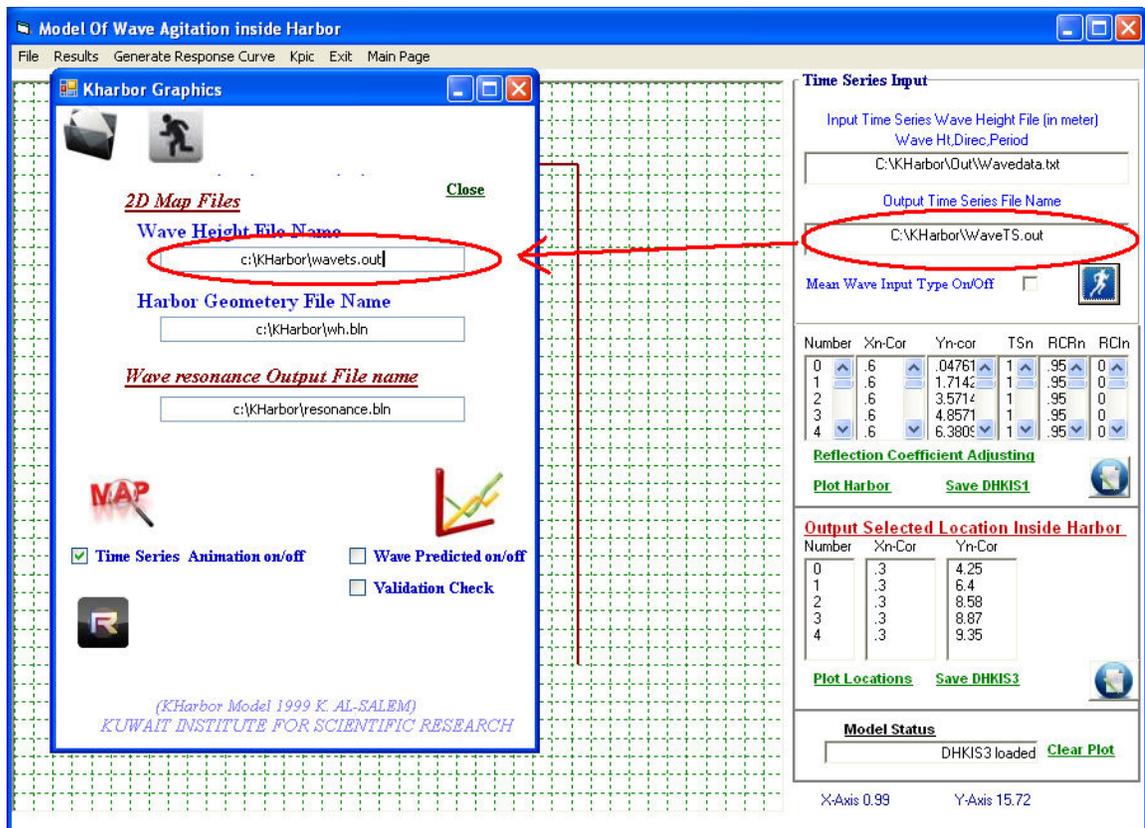
Figure 154. Kharbor Graphic Page.

Figure 155 Time serious Animation for Design Wave Height 2D Contour Page.
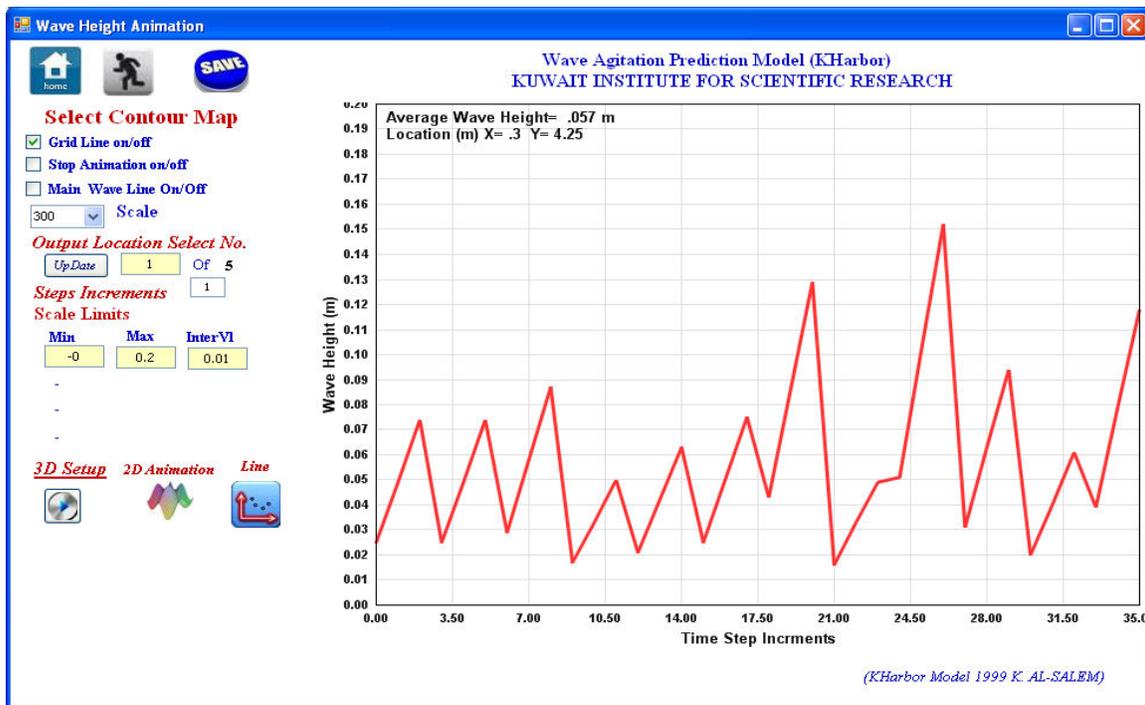
Figure 156. Time serious for Design Wave Height prediction for Location
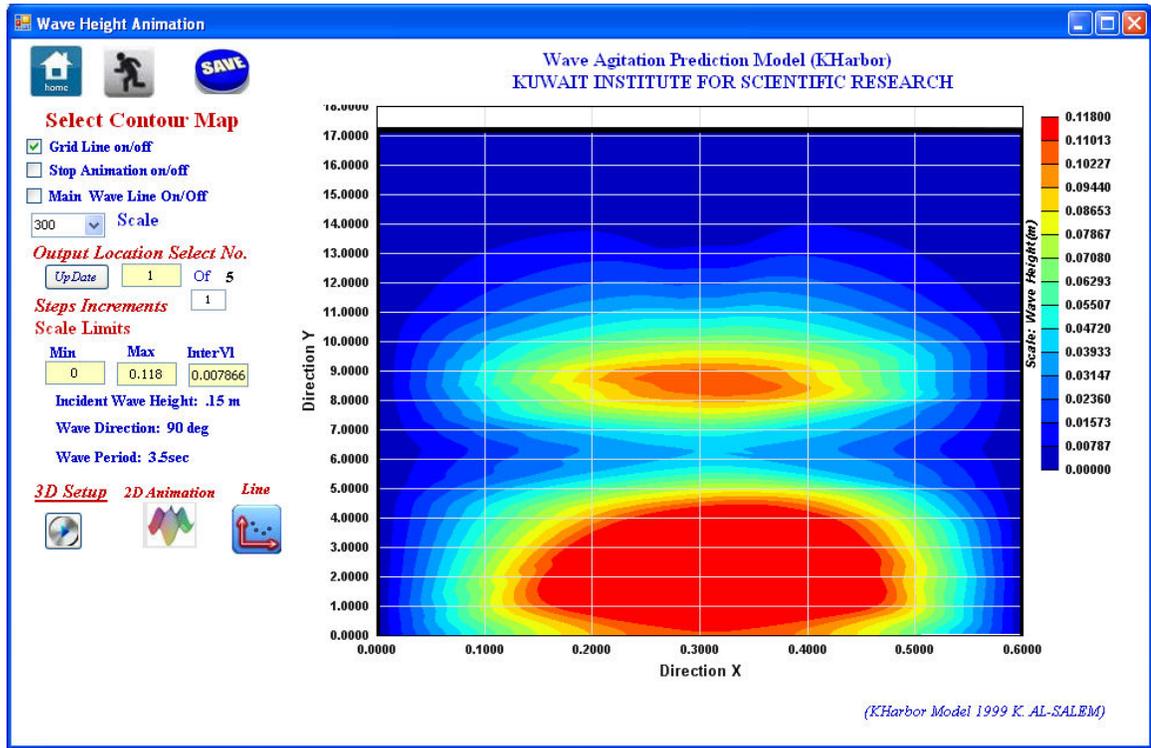
Figure 157. Time serious for Design Wave Height 2D contour prediction .
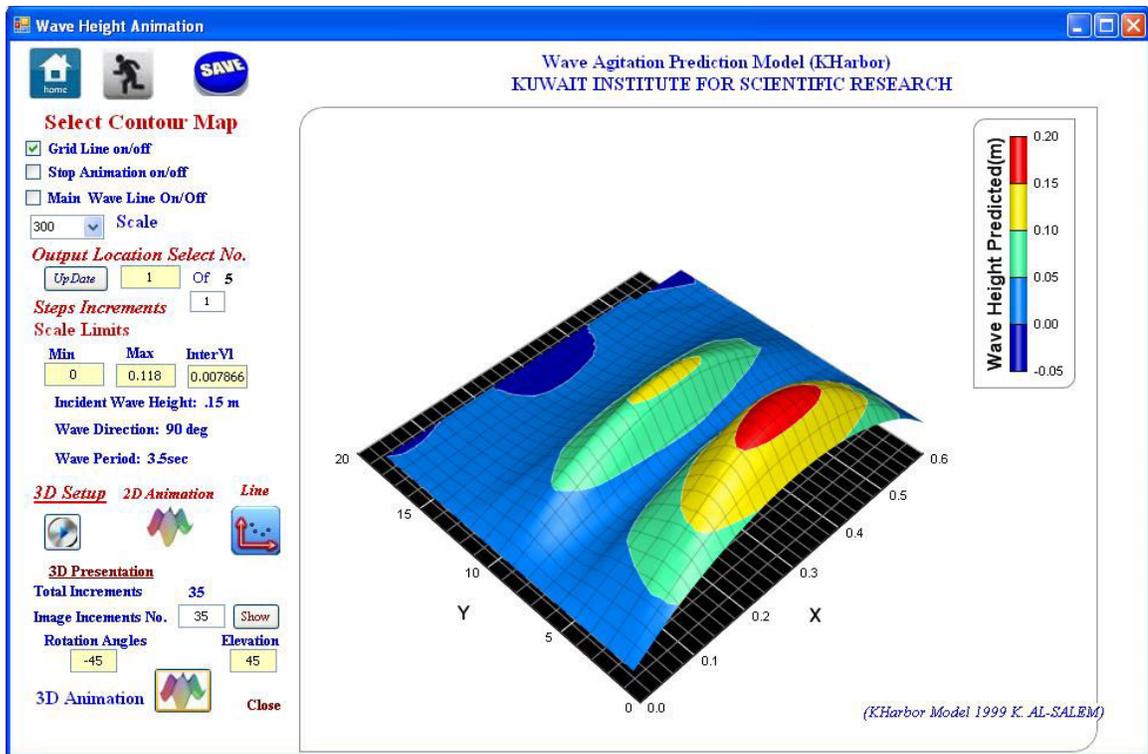
Figure 158. Time serious for Design Wave Height 3D contour prediction.

Wave Resonance prediction Section

To present the wave resonance predicted from [   ] or model by select the above Image from Figure 152. Figure 159 will display.

For plot wave Amplification user must deselect (Wave prediction and Validation Check)

For plot wave height predicted user must select (Wave prediction) and deselect (Validation Check)
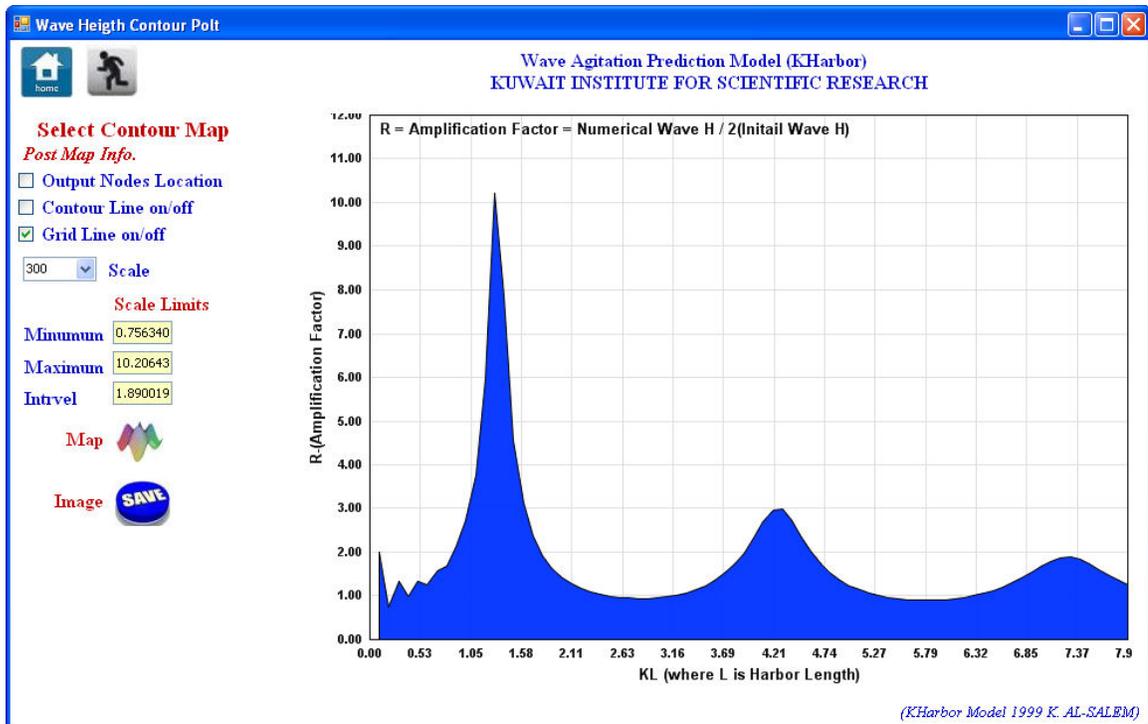
Figure 159. Wave Height Resonance prediction for Selected Location.

Wave Resonance Validation check (KPIC program)

To create data form literature plot for checking the model predicted resonance curve line Userhave two option as:

1- Manual Create data
2- Run KPIC program

Option 1. User can create data manual in text format and save it as

Ndat,1   (Total number data,1)
X1,Y1   (Location X1, Location Y1)
X2,Y2
 -,-
 -,-
Xndat,Yndat

Option 2: Run KPIC program

User can run KPIC program [Fig 160] for Digitizing pre-Saved Plot image as shown in Figure 161. User to start create data from digitalized image must follows the next steps as :

1- Must Setup the plot limits for X-axis and Y-axis
2- Enter Data file name to be save in
3- To collect Each data point for x,y user must click on the image
4- When finished user must check the line
5- At the end user must save the data
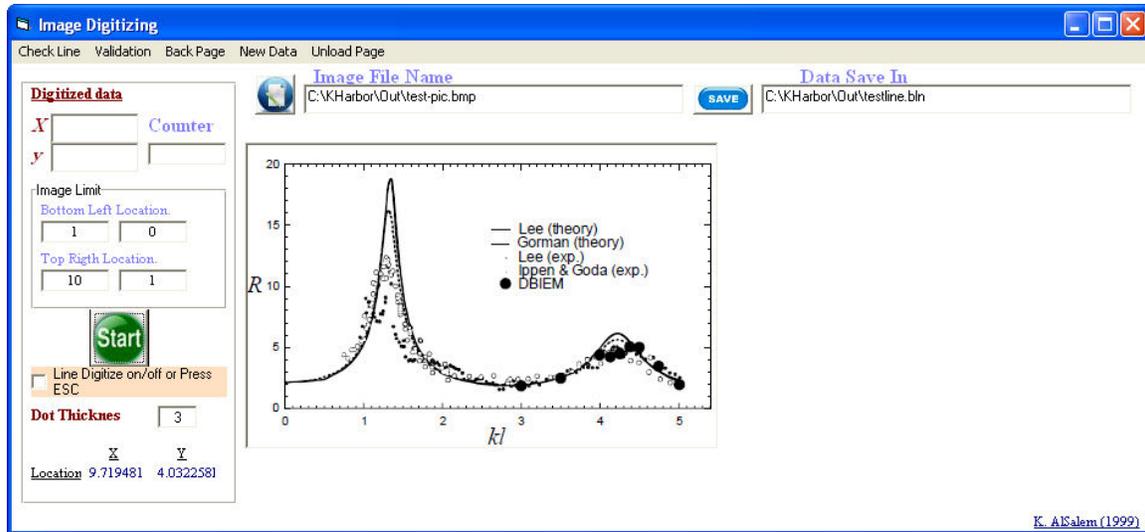
Figure 160. KPIC Program for Digitation Plot line from stored image

For Wave Resonance Validation check:
 User must deselect (Wave prediction) and select (Validation Check) from Figure 161.
User must enter the file name for pre-save digitized data.
User must select ✓ to superimpose plot the two data file for validation As shown in Figure 162.

    For Saving the Image:
        Enter File Name
        Select Save Button

Figure 161. Validation Files.
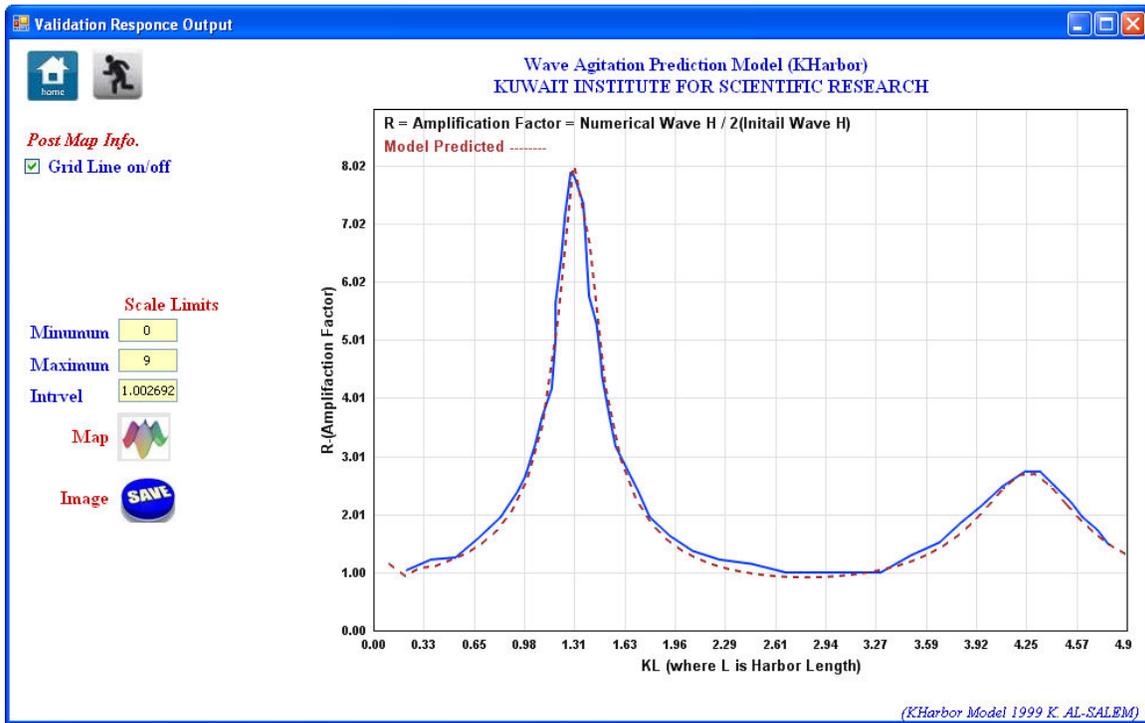
Figure 162. Superimpose plot for Wave Resonance Curves

4.6 Wave Refractions / Diffraction Model [KRDF model]

[J. Kirby, R. Dalrymple   1989]

[Updated and interface developed by: Khaled Al-Salem 1999]   (Pc Version)

Procedure for Usage of KHarbor Model (Wave Refracion\Diffraction Model KRD)

KHarbor Model is an efficient and easy-to-use wave model. This version is sufficiently user-friendly and can provide the base information for water wave inside harbors or around breakwater (K. Al-Salem, 1999). The information provided by this model can be further used to calculate wave forces on structures, stability of breakwaters, sediment/pollutant transport and can be used to assist harbor/coastal protection structure design. In this section of the report, step-by-step instructions are given for use of wave refraction\diffraction Model (Kharbor).

The procedure outlined here consists of number of steps which are:

The model can run by select from Figure 144 [**Start**] option and then select (Wave refraction\diffraction KRD model) then Figure 163 will display for user to start.

Figure 163 contain some option for user to start:

> Option One : File
> - New Project
> - Harbor Geometry
> - Update Data
> - Location Output
> - Add slop Bathymetry to Harbor Geometry
> - Run Wave Design
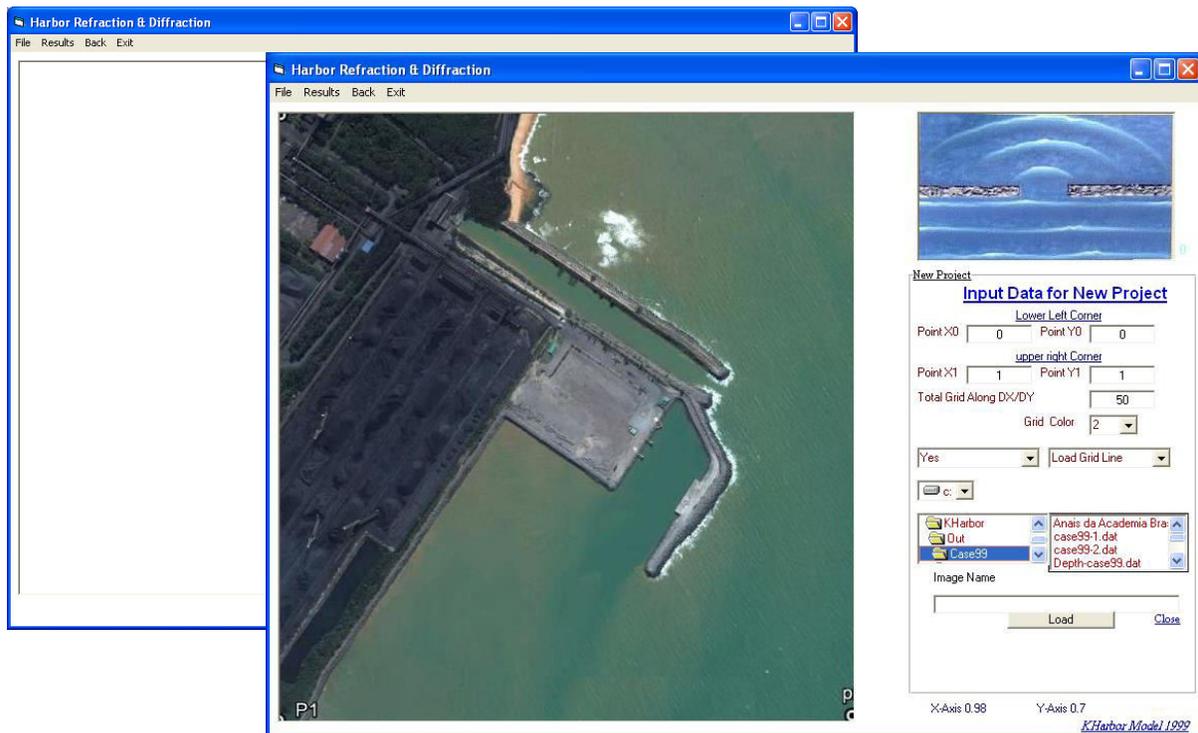
Figure 163. Main Screen for Refraction\Diffraction model (KRD)

New Project:

User can start new Project or setup screen scale for screen plotting and to load pre-saved harbor image for screen digitizing as shown in Figure 164.
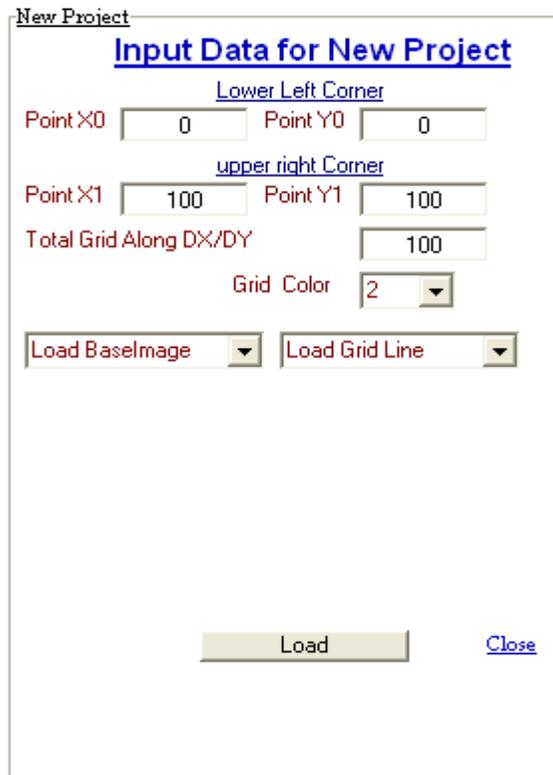
Figure 164. New project screen

<u>*Harbor Geometry:*</u>

User can load pre-save harbor Geometry or to start digitizing the harbor geometry as shown in Figure 165 as follows:

      User can Enter Water depth of the selected domain

      User must enter file name where Harbor Data will save in.

      User must enter file name where domain water depth will be stored in

      User can Plot the Harbor Geometry in screen by select (plot Harbor Ploy)

      Then user must setup domain water depth by select (Depth in)

Figure 165. Harbor Geometry Setup Screen

Add Slop Geo Depth:
To add New Breakwater, user must select
ADD Slop Figure 166 will display for user
to direct him how to enter the data as follows:
User has two options in Figure 166
  o   User can add new bathymetry data
      To the system Domain.
  o   User can Add New breakwater as new
      Depth data to the system domain.
User Can Reload re-save data.
To add data use mouse click on the loaded
Image. When finish user must save data.
And User must select New Depth Save to
enter the selected depth data to the
System domain.
A sample of harbor with new breakwater
Add to the system shown in Figure 167.

Figure 166 BreakWater depth & slop
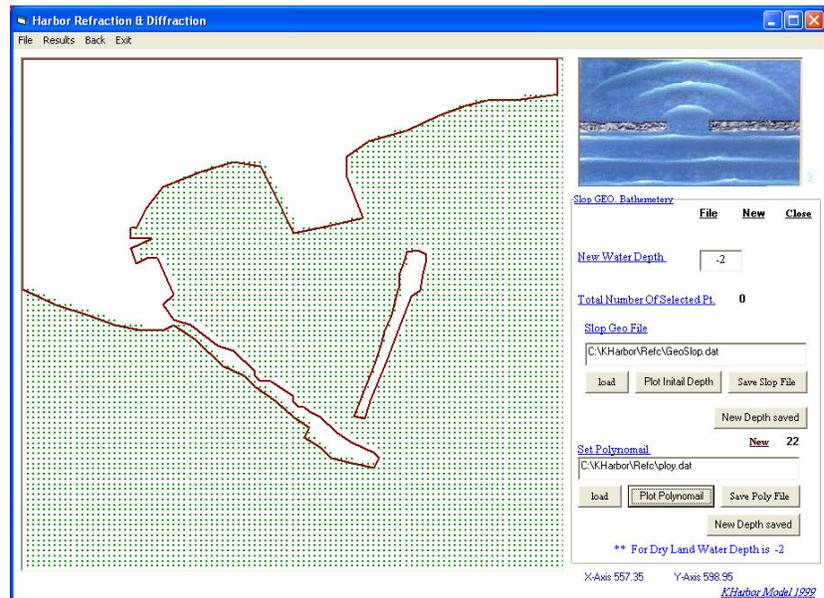
**Figure 167. Sample harbor
with add Break Water**

Update Data:

In this section user should setup (KRD.IN) main input file
for parameter data as shown in Figure 168 as follows:
  Total grids domain dimensions along x and y
  User can select grid spacing at X and Y
  User should Enter:
                Wave Period in sec.
                Wave Amplitude (m) (wave height/2)
                Wave Direction (deg)
  User can select type of domain boundary as :
                Open Boundary Case
                Close Boundary Case

  User can Select time serious case on/off
    If select (Off) only for design wave height
        prediction at selected location.
    If select (On) for time serious wave height
        prediction where user must enter Input
        file name for time serious incident wave
        height in m
User can enter the effect of tidal current on wave
height prediction by select (2D tidal current
Check On). Then user must enter 2d tidal current
files that cover the selected domain grids as in
Ux then Vy data in (m/sec).
User Can Edit (KRD.In) file in text file by select

Figure 168. Updata File Screen

[*Edit*] To save the input user must select (***Update Button***).

Location Output:

User can select output location by three methods as shown in Figure 169 as follows:

        Select location by digitize from screen.

        User Can enter Location In X and Y by <u>edit</u> from the selected file name.

        User can load data from pre-save location data
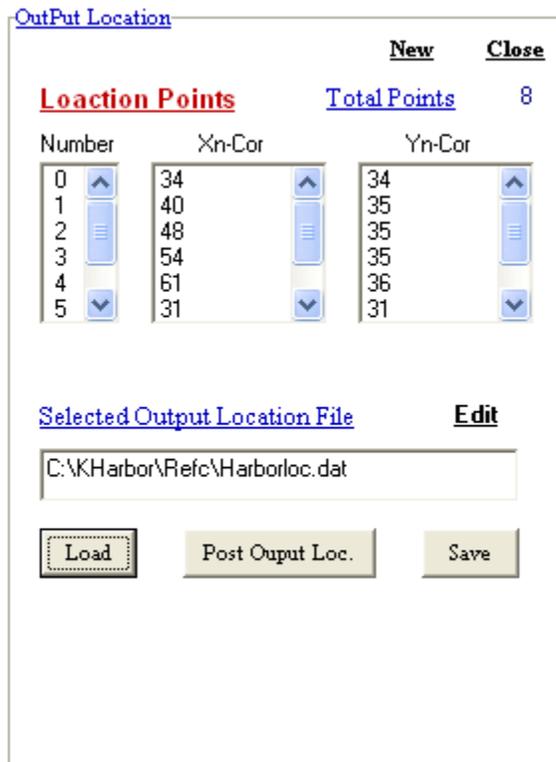
Figure 169. Output Locations Screen.

Add Slop Bathymetry to Harbor Geometry:

In this section user can enter new depth in the select domain as shown in Figure 170 in two methods as:

      - User enters the depth by digitized on the screen.

      - User can Load pre-save data

Then user must save the new depth by select (Save File)

Run Wave Design:

      User can start model simulation

Option Two : Results

-      Edit Output

- 2D output Plot
- Check Water Depth

Edit Output:

User can display the output result for wave height design as in text file

Figure 170. Adding Bathometry Data To Domain Screen.

2D Output Plot:

From Figure 163 User can Select Result for Present the output as to start Kharbor 2D Graphics from Figure 163. Figure 171 will display for user to select what plot type to select. Next section user will find full procedure description for KHarbor 2D graphic.

Procedure for Kharbor 2D Grsphic Program

Kharbor 2D Graph as shown in Figure 171 is design to present the output from KHarbor Model for:
-Wave Agiation 2D Contours
-Wave Agiation Animation 2D Contours
-Wave Contour in 3D
-Resonance Curve Line

-User Selected Output Location Line for Wave Height
-Superimposed Wave Resonance Line for Validation
-Wave Refraction/Diffraction Contours
-Plot wave height prediction from KRD model for Selected location.
-Plot time serious Animation contour result from KRD model
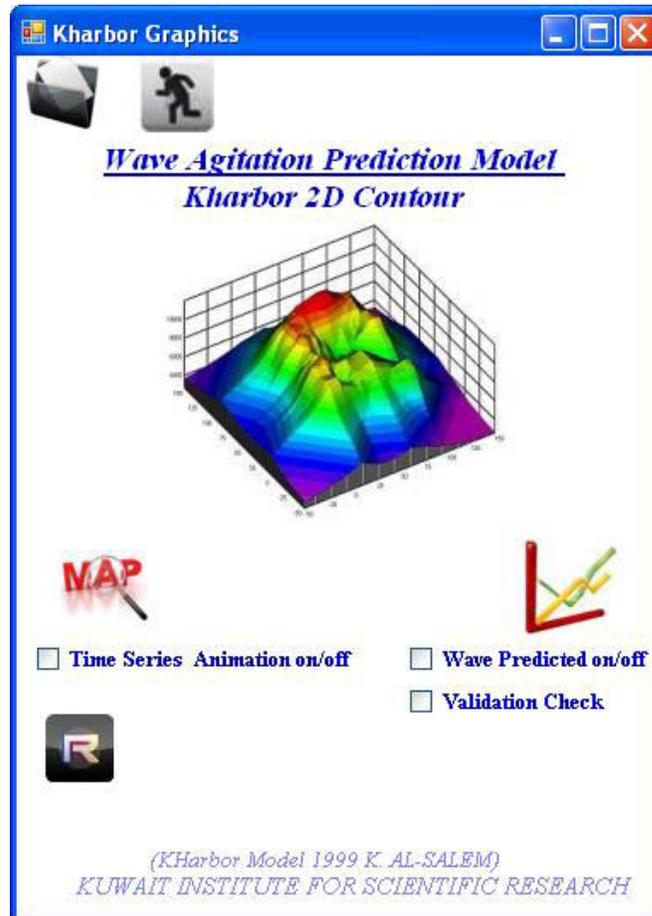
Figure 171. Kharbor Graphic Screen.

Figure 171 shows main screen of Kharbor 2D Graphic Program which have different options as follows:

Map Section
The Map section has two option as
Option 1.
Design Wave Height 2D Contour Plot from Wave Agitation model
User must Deselect (time serious animation off or uncheck)   Figure 172 will display for the user with several plot option as follows:
Select Contour Map Option:
5.   Post Map information has different check box for:

To Post Selected Output location on map
To Show Contour Line on map
To Show Grid x,y Line on map
6.   Scale Legend On/Off or select size.
7.   Scale Contour Map as (maximum ,minimum, Interval)
8.   To save Image on disk
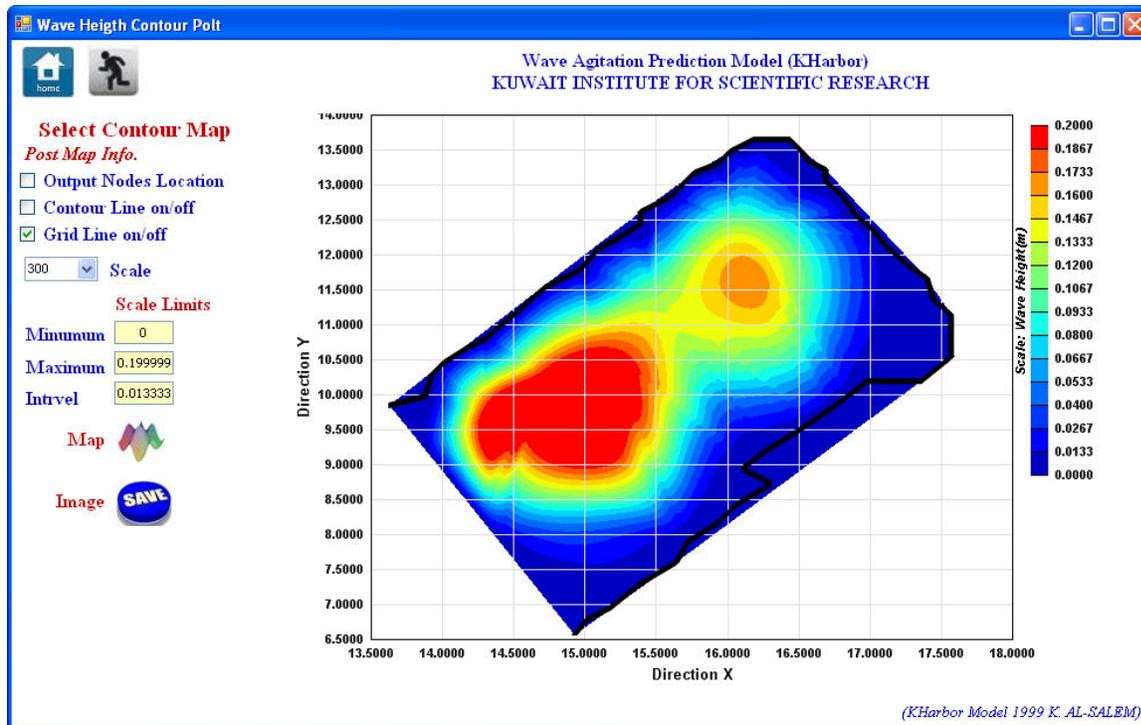
Figure 172. Wave Height Contour Plot Page.

Option 2.
Time serious Animation for Design Wave Height 2D Contour Plot from Wave Agitation model.
User must select (time serious animation On or check) and must enter file name for simulation
output as shown in Figure 173.
User must select Map Figure 174 will display for user with several plot option as follows:

• Plot line for wave height prediction for any selected output location as shown in Figure 175.
• Plot Animation 2D wave height contour line for selected output location shown in Figure 176
• Plot animation 3D wave height contour line for selected output location shown in Figure 177
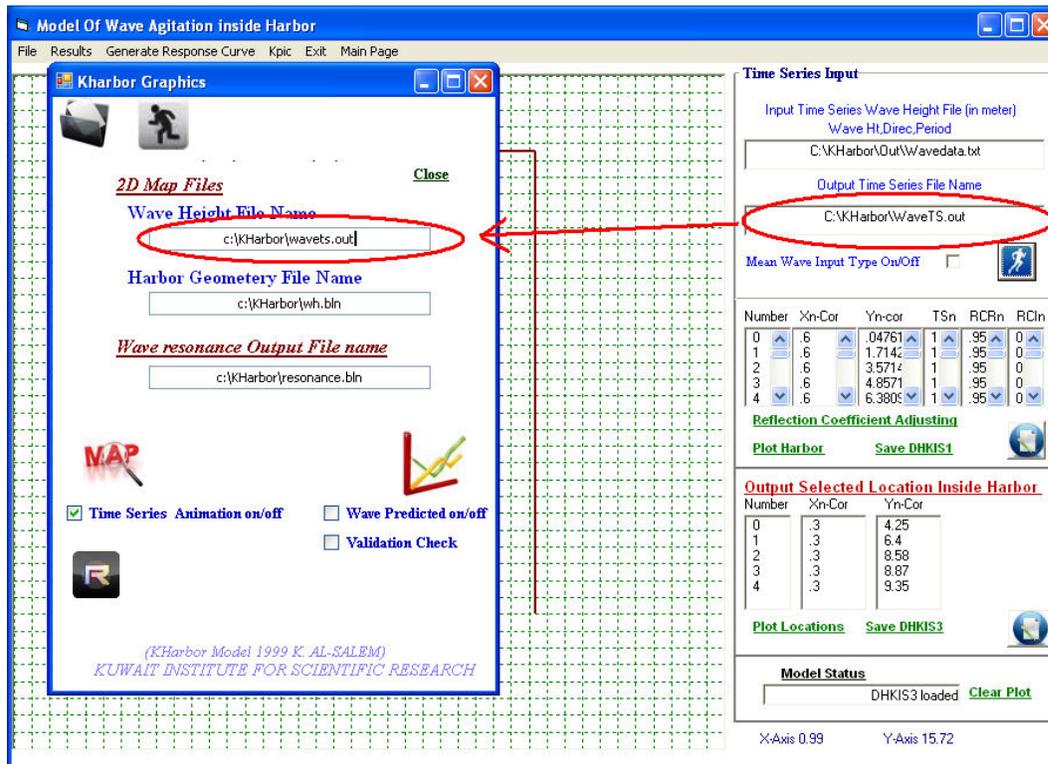
Figure 173. Kharbor Graphic Page.

Figure 174. Time serious Animation for Design Wave Height 2D Contour Page.
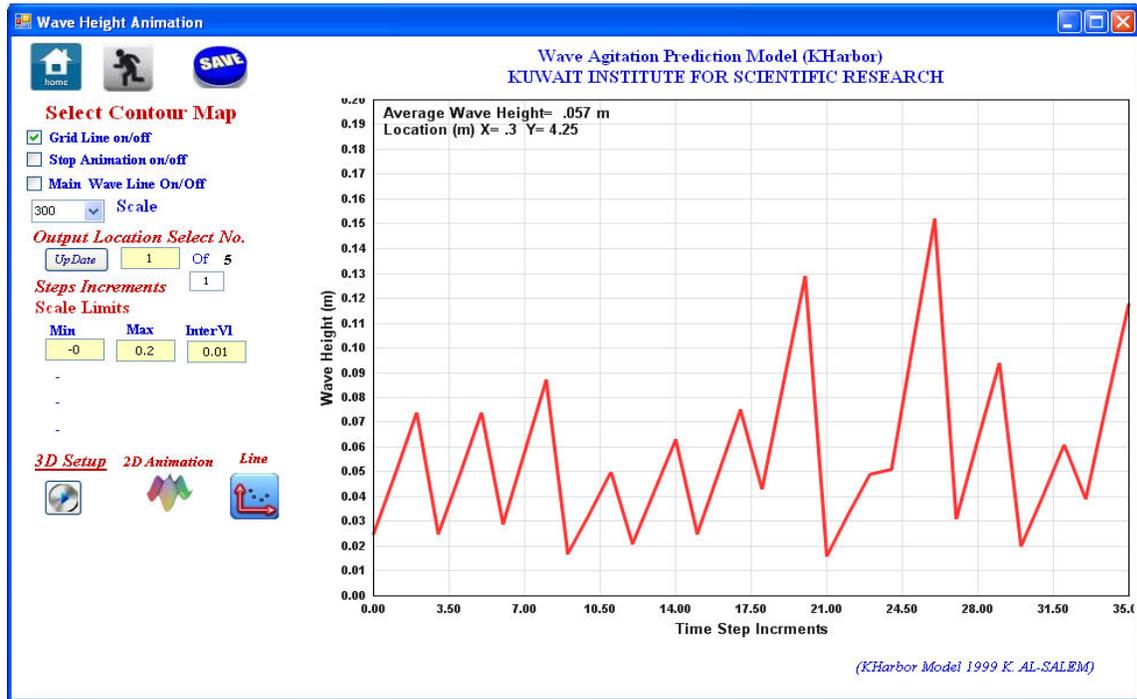
Figure 175. Time serious for Design Wave Height prediction for Location 1.
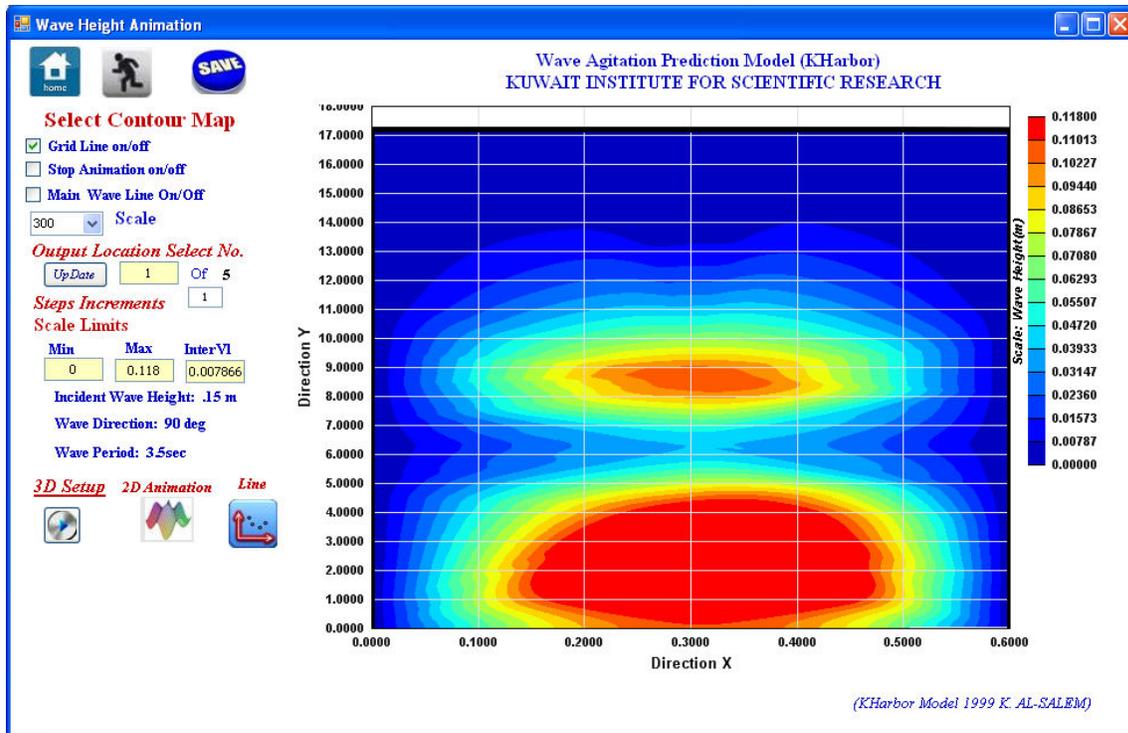
Figure 176. Time serious for Design Wave Height 2D contour prediction
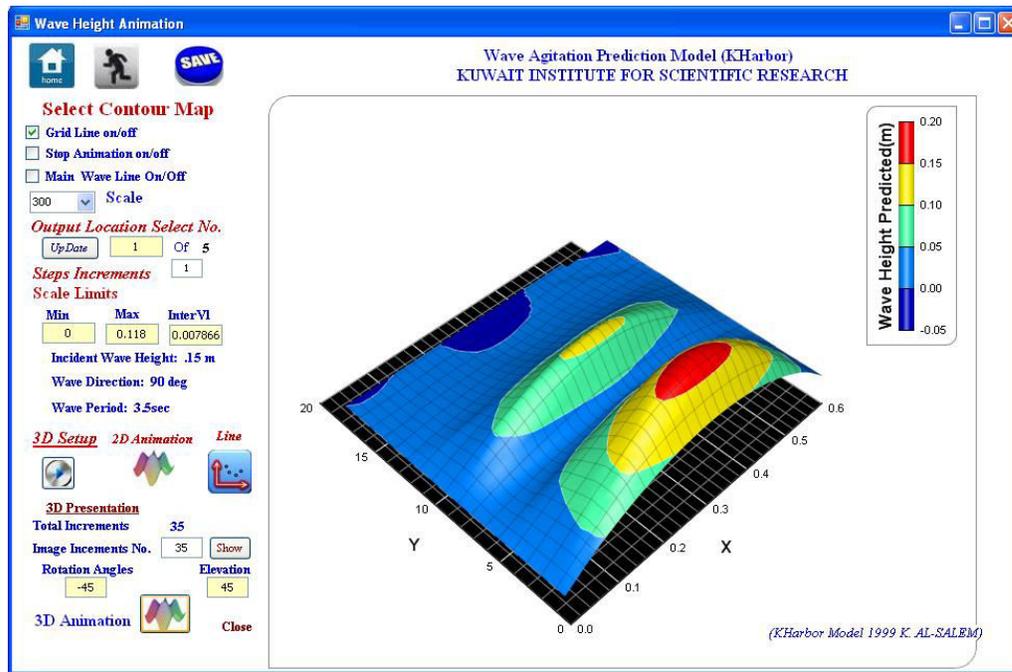
Figure 177. Time serious for Design Wave Height 3D contour prediction.

Wave Resonance prediction Section

To present the wave resonance predicted from Kharbor model by select the above
Image from Figure 171. Figure 178 will display.
For plot wave Amplification user must deselect (Wave prediction and Validation Check)
For plot wave height predicted user must select (Wave prediction) and deselect (Validation Check)
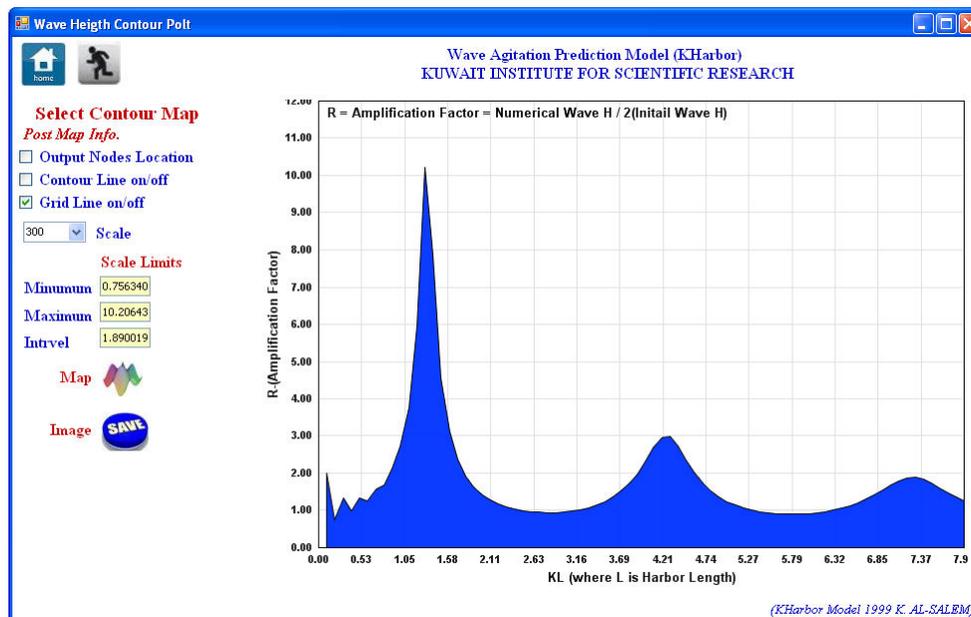
Figure 178. Wave Height Resonance prediction for Selected Location.

Wave Resonance Validation check (KPIC program)

To create data form literature plot for checking the model predicted resonance
curve line User have two option as:

3-	Manual Create data
4-	Run [**KMap program**] See Section 5 Page 197

Option 1. User can create data manual in text format and save it as

	Ndat,1 (Total number data,1)
	X1,Y1 (Location X1, Location Y1)
	X2,Y2
	 -,-
	 -,-
	 Xndat,Yndat

Option 2: Run KPIC program

   User can run KPIC program from Figure 1 or 2 for Digitizing pre-Saved Plot image as shown
in Figure 179. User to start create data from digitalized image must follows the next steps as :

6-	Must Setup the plot limits for X-axis and Y-axis
7-	Enter Data file name to be save in
8-	To collect Each data point for x,y user must click on the image
9-	When finished user must check the line
10-	At the end user must save the data
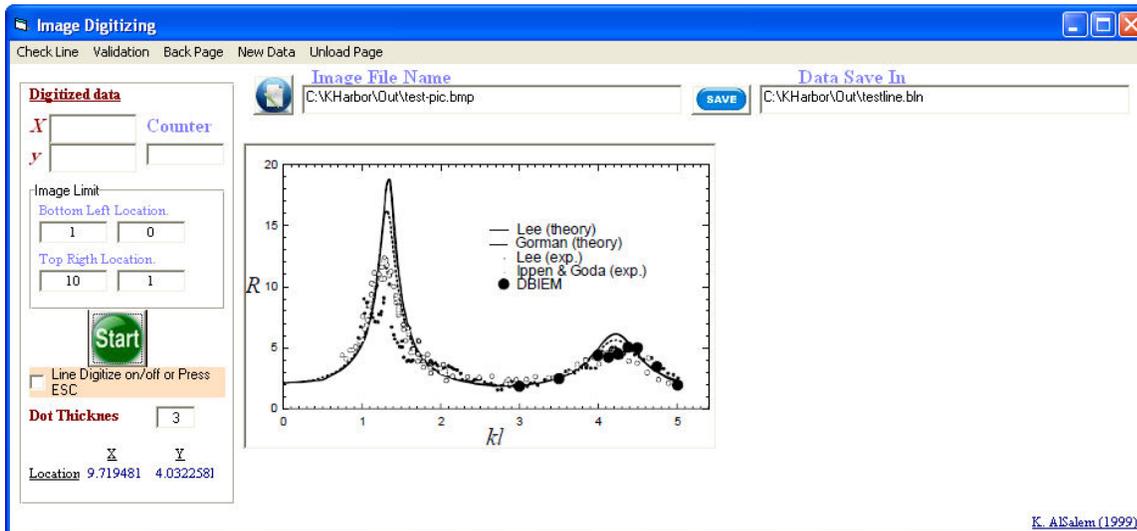
Figure 179. KPIC Program for Digitation Plot line from stored image

For Wave Resonance Validation check:

   User must deselect (Wave prediction) and select (Validation Check) from Figure 180.
   User must enter the file name for pre-save digitized data.

User must select   as in Fig 180
 To superimpose plot the two data file for validation
As shown in Figure 181.

For Saving the Image:
      Enter File Name
      Select Save Button

Figure 180 Validation Files.
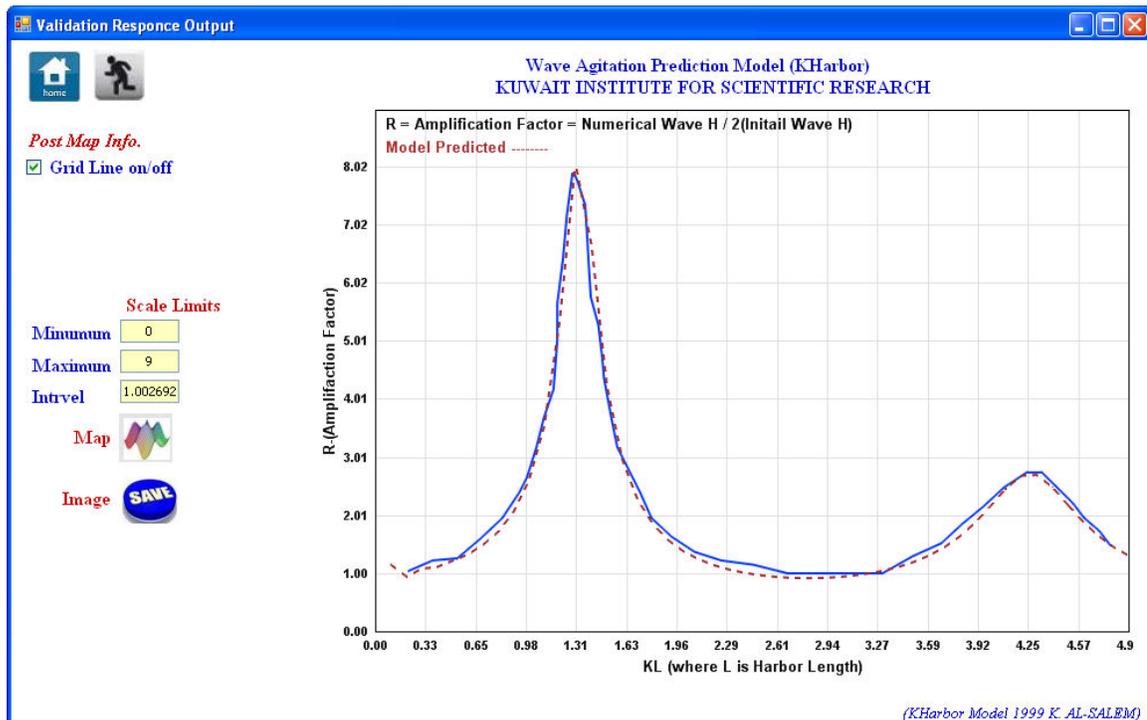
Figure 181. Superimpose plot for Wave Resonance Curves

Refraction/Diffraction

To present the output generated by the Kharbor Model for (refraction/diffraction simulation) is by press on above image to start as shown in Figure 182
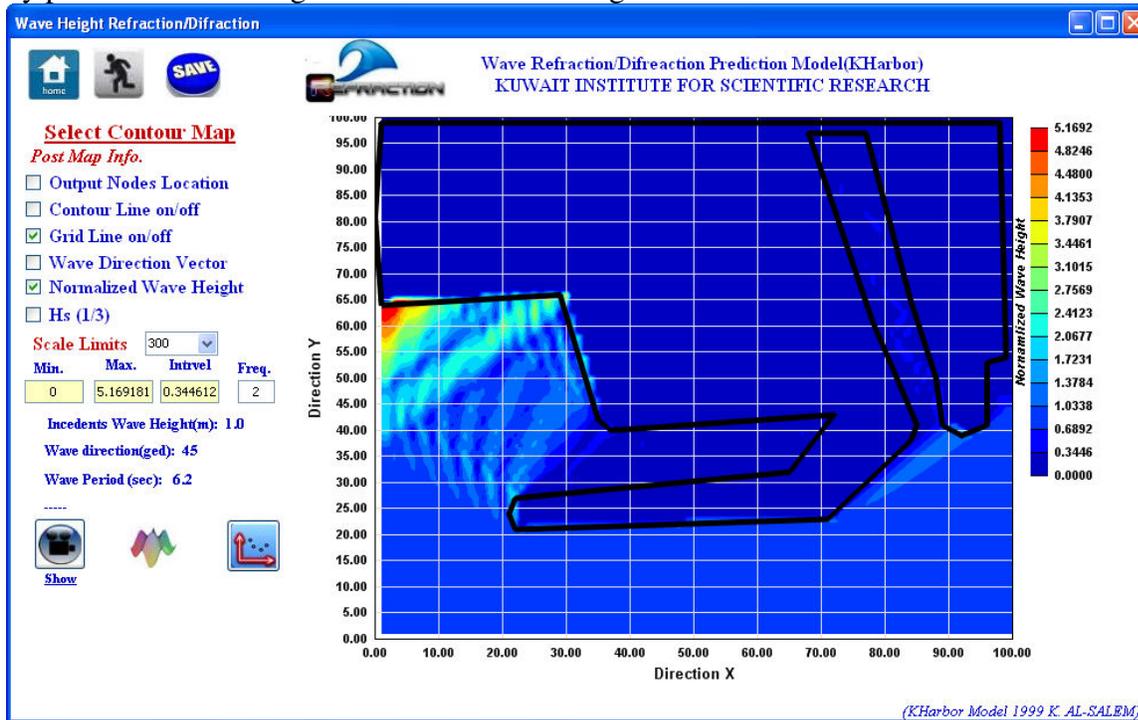
Figure 182. Wave Height refraction/diffraction main page

From Figure 182 user have several option for Present the image output as follows:
- 2D Contour Map as shown in figure 182
- Select Output Wave Height Predicted as Line Plot as shown Figure 183
- 2D Contour Map Animation as shown in Figure 184
- User Save any select Image as (Contour or Line plot)
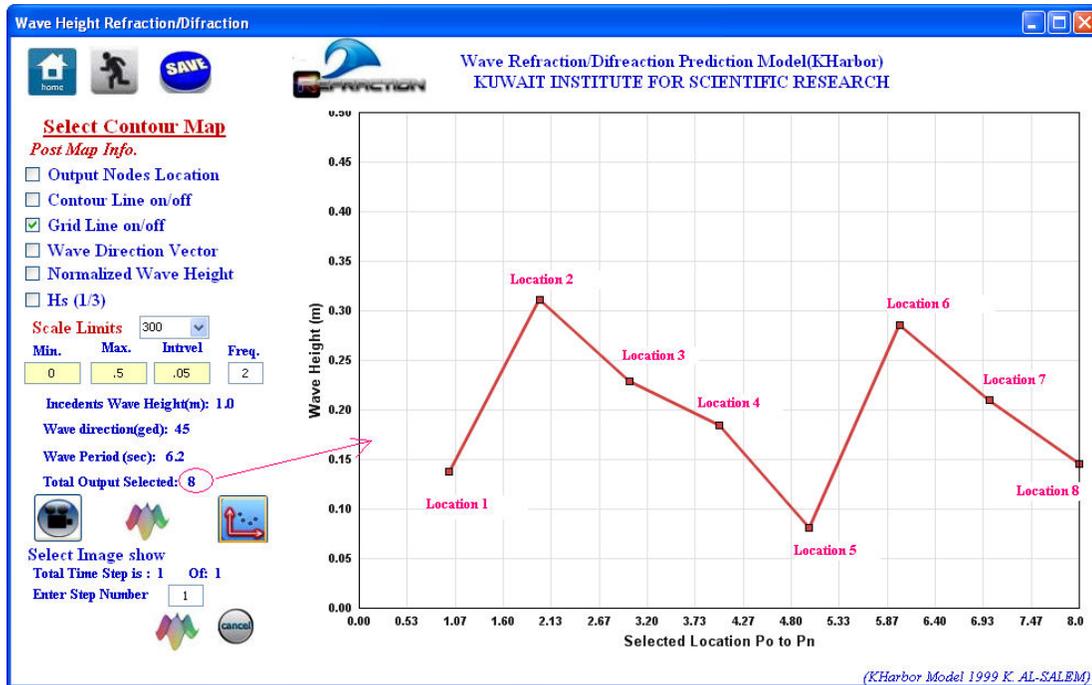
Figure 183. Select Output Wave Height Predicted as Line Plot.
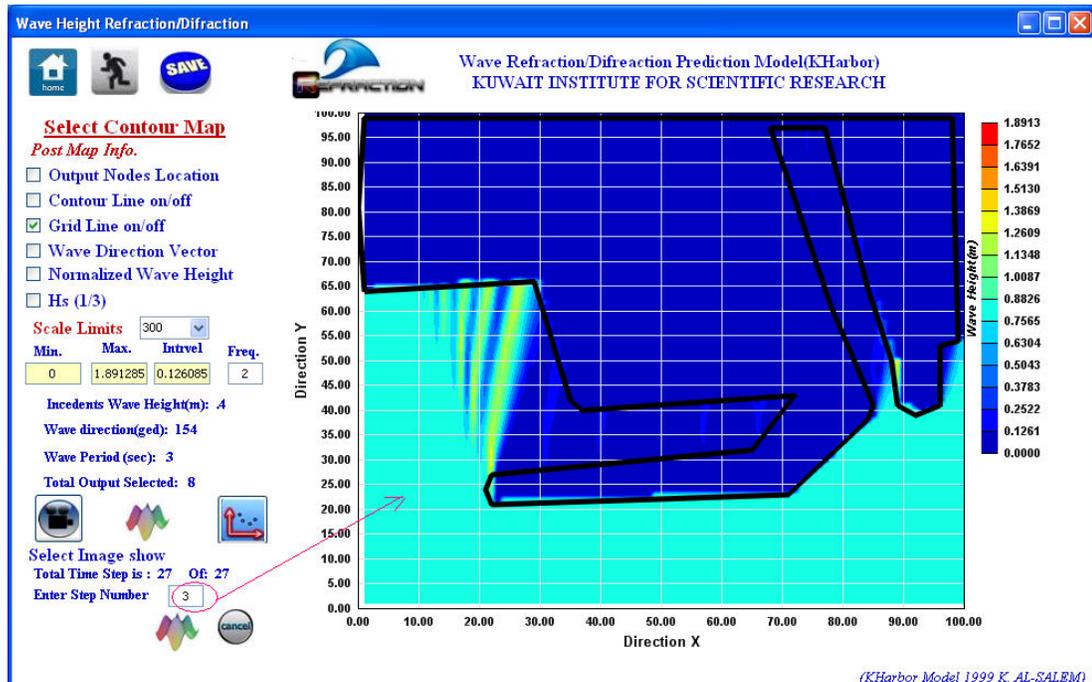
Figure 184. 2D Contour Map Animation

4.7 Awareness System for Tsunami Wave Height in Arabian Gulf , Gulf of Oman and the Arabian Sea Through Smart Mobil Technology and Internet Website by [KUnami Interface model]

[ComCot model developed at Cornell University and Imamura 1996]
[Update and interface developed By: Khaled Al-Salem 2016]
Published at: 3rd International Conference on Environmental Sustainability, Technology and Development (3rd ICESTD),Nov 2016 Kuwait

KUnami Interface developed For Tsunami Wave Height Prediction Based on Comcot Model (Cornell multi-grid coupled tsunami) For Arabian Gulf, Gulf of Oman and Arabian Sea

KUnami interface adopts the setup and organized the input data for simulation Comcot model for tsunami wave prediction that covered the Arabian Gulf, Gulf of Oman and Arabian Sea. Let's user to generate and presents the simulation output in 1D, 2D and 3D graphics; Also to generate 2D and 3D results animation by using the Surfer Software Utilities. . KUnami interface also linked to the internet system for public awareness through webs ide address (http://www.hceatkuwait.net/KUnami/kunami.aspx) and through smart mobile technology. Model were developed in (visual basic 6) were linked to Comcot model in (visual Fortran 90) and Surfer plotting Software using (GS Scripter program).And for internet webside coding were used (Active sever page) and for smart mobile technology coding were used Object-C++.

Comcot adopts finite difference schemes to solve Shallow Water Equations. A nested grid system, dynamically coupled up to four regions (which will be referred to as layers) with different grid resolution, is adopted in the model to fulfill the need for tsunami simulations in different scales. Nested grid system means in a region of one grid size, there is one or more regions with smaller grid sizes situated in, which eventually, forms a hierarchy of grids, or grid levels. The region with largest grid size is called 1_{st} level grid and all the grid regions directly nested in the 1_{st} level grid, are called 2_{nd} level grids, so on and so forth. In one grid region, up to 4 sub-level grid regions can be defined. It should be noted that in one grid region, a uniform grid size is adopted in Comcot.

Surfer Software uses GS Scripter program is a basic-like interpreter that loads and executes scripts (also called macros). GS Scripter is automatically installed when you run the Golden Software Setup program. GS Scripter consists of two windows. The GS Scripter Edit window is a standard Windows ASCII text editor that allows you to open, create, edit and save ASCII text files. Scripts are executed from the GS Scripter Edit window. Scripts are text files created within GS Scripter, an Editor window, Windows Notepad, or any ASCII editor of your choice. When a script file is displayed in the GS Scripter Edit window, you can run the script. The operations specified in the script will be carried out. Scripts executed from the GS Scripter Edit window can contain commands necessary to automatically run the Surfer plotting program. .

Files required in KUnami Interface

KUnami main Interface files are included in this package which is:

1. **KUnami**
   KUnami is program developed using Visual basic 6.0 for main control of the interface to allow user to navigate between the model program options.
2. **Kudata**
   Kudata is program developed using Visual Fortran 90 for organizing the main data entry for the Comcot model.

3. **DepX**

   DepX program developed using Visual Basic 6.0 to generate 2D bathymetry interpolation for the sub grids system in Comcot model input data requirement (refined 2D grid system)

4. **FDep**

   5.   FDep is program developed using Visual Fortran 90 for organizing the bathymetry files such as (Layer21-4, Layer31-4 and Layer41-4) in Comcot model main input.

6. **GEBCO**

   Software Interface allows the user to view and access data from GEBCO's gridded data sets of the digital bathymetry Atlas used in forming the sub grid systems.

7. **Sim**

   Sim program is developed using Visual Fortran 90 to run Comcot program from KUnami main interface.

8. **Comcot**

   9.   Comcot is developed using Visual Fortran 90 for tsunami wave simulations and perdiction model.

10. **GSMAC32**

    GS Scripter program complier for Surfer Plotting software Utilities.

11. **KUnami2D**

    KUnami2D is developed using GS Scripter programing for generate a different type of plots and create images for animation. Plot can be 1D, 2D and 3D using Surfer software utilities routine.

Input Files required in KUnami Interface

1. Comcot.CLT

   Main Input data for Comcot model
2. layer01.DEP

   Main bathymetry data file for main grid system in Comcot model
3. layer01_x.DAT, layer01_y.DAT

   Location of main grid system in Longitude and Latitude Direction (degree)

If Sub grid system was activated in Comcot.clt data input, the following has to be included for the activated one

   Layer21.DEP, Layer22.DEP, Layer23.DEP, Layer24.DEP

   A bathymetry data file for Sub grid Level 2 from grid system in Comcot model

   Layer31.DEP, Layer32.DEP, Layer33.DEP, Layer34.DEP

   A bathymetry data file for Sub grid Level 3 from sub grid level 2 system in Comcot model.

   Layer41.DEP, Layer42.DEP, Layer43.DEP, Layer44.DEP

   A bathymetry data file for Sub grid Level 4 from sub grid level 3 system in Comcot model

Input File used in GS Scripter programing for Graphic development for Surfer software files: a

1. AGcoast.BLN: Input file for Coastal line of the main grid system
2. AGBLANK.BLN: Input file for Blanking data uses in Surfer software
3. Gulf2d.DAT: A Control input file for GS Scripter programing to generate Surfer plot [Sample of Data format shown in Appendix Section 4.7]
4. PLV0.LVL: A File for control the contour level in 2D Surfer plot
5. col3d.CLR: A File for control the contour level in 3D Surfer plot

Flow Chart Display for KUnami Interface

Mobile Awareness

Main Page

Input Records Setup Page

Output Setup Page

Setup Animation Images

Remote Presentation

Remote website Awareness

Input data for Output time Extracting

Input Data File for Animation Images for surfer to Creates
Visual Basic code

Main Model Input Visual Basic Code

Run Input format

Start model simulate

Script Surfer Coding
Surfer Generate Single Plot

Script Surfer Coding

Surfer start Generate Images for Animation

Run FORTRAN Format
Input data for model Simulation

Surfer Plot Display

Coverts Images to **Media File**
(GIF , Avi , Mp4)

For Refine and Nest Grid inside Main Grid System (Visual Basic code)

Tsunami Model
ComCot model
Fortran code

Digital bathymetry

Programing Code Used:
1- Visual FORTRAN F90
2-Visual Basic 6.0
3- Script coding For Surfer Utility
4-Active Server Page for web coding
5-Objective-C for Mobile coding

The interface as Tsunami Warning System

As known, the prediction of an earthquake is still not satisfactory with today's technologies, and in fact, for most earthquakes, is unsuccessful. Detection and prediction of tsunamis is only half the work of the system. Of equal importance is the ability to warn the populations of the areas that will be affected. The KUnami warning systems feature lines of communications (such as internet website and smart mobile technology). The awareness system capable of issuing warnings to the general public in less than 15 minutes for known location and initial data input of epicenter and moment magnitude of an underwater quake and the probable tsunami arrival times can be quickly calculated and posted for any selected location from the main domain area in KUnami interface. The internet website address was display the tsunami hazard at website address :(http://www.hceatkuwait.net/KUnami/kunami.aspx) [Al-Salem 2008]. Also it will display on smart mobile system and it will be posted at Apple Store in future.
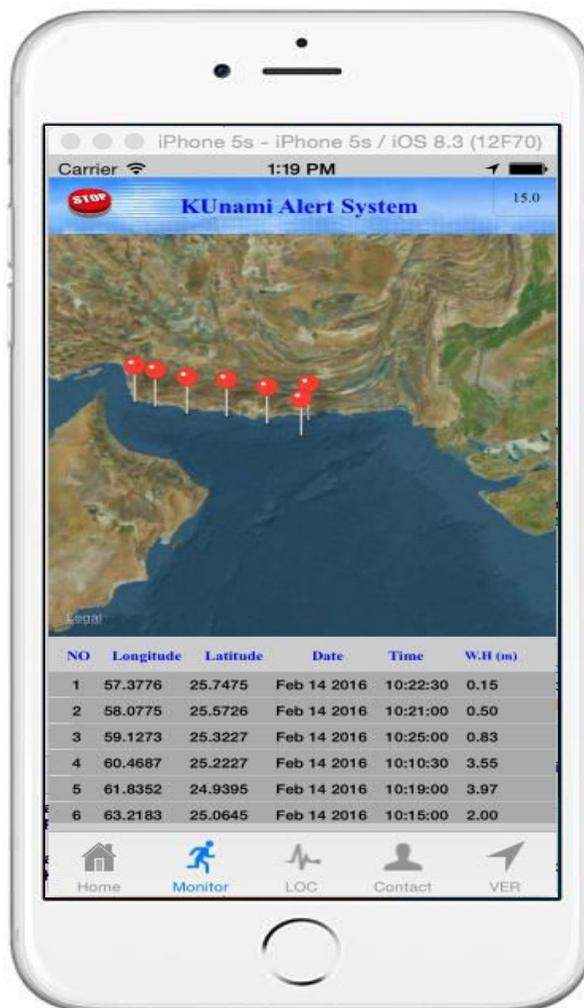
Procedures for using of (The KUnami Interface)

KUnami interface is an efficient and easy-to-use data entry and model simulation. This version is sufficiently user-friendly and can provide the basic information of simulation for tsunami wave prediction. In this section of the report, step-by-step instructions are given for using the model interface.

The procedures outlined here consist of number of steps which can be summarized as:

The model can be run by select the icon ( ) .Figure 185, will display for the user.

User can select the option, which shows a number of selections as follows:

1- To start the new project by setup the input data for Comcot simulation model.

2-Start generate from selected output time step to form Surfer plot in 1D or line plot.

3- Start generate from selected output time step to form Surfer plot in 2D or 3D plot

4. Start generate from selected output time step to form a set on images for Surfer plot in 2D or 3D Animation

Figure 185. KUnami Interface model main page

New project option

If user select to start new project a number of procedure should follows as:

From figure 1 the project input check box should checked then the group option will display for user to start as:

1- The location of the earthquake in longitude and latitude textbox. To select the location user checkbox the ON/OFF as shown in Figure 158 should be activate. Then move the mouse over the Satellite map then click at select location or by enter the location manual then click on the button.

2- Load input Pages as shown in Figure 185.

A- To load the General input parameter is by check on the check box then Figure 186 will display for user to show the type of input data parameter.

Figure 186. Project General Input Parameter

Figure 186 will show for user all earthquake data parameter and simulation time and time step. Also show the total grid dimension for the main system assign. Which cover all Arabian Gulf, Gulf Of Oman and Arabian Sea with grid spacing 30 sec in DX/DY.

Then if user wants to simulate the Comcot model for Wave tsunami prediction for only the system main grid. User can select from Figure 185 **model Simulate** to start the model.

If user want to assign new refined grid inside main grid system user must follow these option as follows:

For level 2nd refined grid user have 4 section to assign as new bathymetry Layer (21, 22, 23 24)
So user must select option checkbox (**Project for 2nd level grid**). Then Figure 3 will display for user.

- In Figure 187 there are 4 sub grid can be used. To Activate the the 2nd level layer is to check the corresponding checkbox.
- If Layer21 activated then go to Figure 185 and select two points on the map to form the refined grid domain. Then the same for the other layer 22,23,24.

- Then from Figure 187 user must select **Sub Grid Dimension** to generate the location index of the sub grid level 2 inside the main grid system and form the total sub grid with the assign ratio also to calculate the dx/dy for the sub grid as shown in Figure 187.

Parameters for 2nd-level grid

Sub Grid Plt   Sub Grid Dimension   Sub Grid Depth Map Scale   Exit

KUnami Model

Configurations for all grids

Parameters for 2nd-level grid	Layer 21 ☐	Layer 22 ☐	Layer 23 ☐	Layer 24 ☐
Run Layer 21 ? (0:Yes, 1:No)	0	1	1	1
Coordinate (0:spherical, 1:cartesian)	0	1	1	1
Governing Eqn. (0:linear, 1:nonlinear)	0	0	0	0
Use Bottom friction ?(only cart,nonlin,0:y,1:n)	1	1	1	1
Manning's relative roughness coef.(bottom fric)	0.013	0.013	0.013	0.013
Output Volume Flux ? (0-Yes, 1-No)	1	1	1	1
Grid Size Ratio of Layer01 to Layer21-4	3	3	3	3
X start	1693	11	11	61
X end	1825	30	30	80
Y start	689	11	11	61
Y end	818	30	30	80
Grid Identification Number (DONNOT CHANGE!!!)	21	22	23	24
Parent Grid's ID Number	1	1	1	1
Nx	399	60	60	60
Ny	390	60	60	60
dx	.002756	.002638	.002638	.002638
dy	.002755	.002638	.002638	.002638
	61.8101912384717	47.7958514492754	47.7958514492754	48.2124489459816
	62.910008629776	47.9541584980237	47.9541584980237	48.3707559947299
	24.7395697101449	19.0916331884058	19.0916331884058	19.5081476811594
	25.8141771014493	19.2499086956522	19.2499086956522	19.6664231884058

Sub Grid Water Depth

Constant   10 M
Read File   C:\KUnami\Out\Data21.dat   Dirc

Figure 187. Project for 2ⁿᵈ Level Grid

- User must select **Sub Grid Depth Map scale** to store information for the 2D Bathymetry interpolate program for later based on the new sub domain of new (NX/NY) as shown in Figure 187.
- To show the new sub grid border line on the map in Figure 1 by selecting **Sub Grid Plt**.
- By default the border color of sub grid 2ⁿᵈ level is **RED**
- There are two important number must user check which are
    - **. Grid indication number must not change**
    - **. Parent Grid ID number if user in 2ⁿᵈ level, then the ID must be 1**

For level 3rd refined grid user have 4 section to assign as new bathymetry Layer (31, 32, 33 34) So user must select option checkbox (**Project for 3rd level grid**). Then Figure 188 will display for user.

- In Figure 188 there are 4 sub grid can be used. To activate the 3rd level layer is to check the corresponding checkbox.
- If Layer31 activated then go to Figure 185 and select two points on the map to form the refined grid domain. But make sure that user select the point inside the 2nd grid level as shown in Figure 190.
- When grid was selected the program generate the location index of the sub grid level 3 inside the 2nd level grid system and form the total sub grid with assign ratio also calculate the dx/dy for the sub grid as shown in Figure 188.
- To show the new sub grid border line on the map in Figure 1 by selecting **Sub Grid Plt**.
- By default the border color of sub grid 3rd level is **Green**
- There are two important number must user check which are
  - **. Grid indication number must no change**
  - **. Parent Grid ID number if user in 3rd level, then the ID must be 2#**
- In this section user can store the input for this grid level information by selecting from Figure 188 **Load/Save Info** . Input/output file information will display in Figure 188 to let user to store or load the grid information.
- Then user must select **Sub grid Depth Map Scale** to calculate sub grid information and store in inf3.dat for 2D bathymetry interpolation program, Will discuss later.

For level 4th refined grid user have 4 section to assign as new bathymetry Layer (41, 42, 43 44) So user must select option checkbox (**Project for 4th level grid**). Then Figure 189 will display for user.

- In Figure 189 there are 4 sub grid can be used. To Activate the 4th level layer is to check the corresponding checkbox.
- If Layer41 activated then go to Figure 185 and select two points on the map to form the refined grid domain. But make sure that user select the point inside the 3rd grid level as shown in Figure 190.
- When grid was selected the program generate the location index of the sub grid level 4 inside the 3rd level grid system and form the total sub grid with assign ratio also to calculate the dx/dy for the sub grid as shown in Figure 189.
- Show the new sub grid border line on the map in Figure 185 by selecting **Sub Grid Plt**.
- By default the border color of sub grid 3rd level is **Blue**
- There are two important number must user check which are
  - **. Grid indication number must no change**
  - **. Parent Grid ID number if user in 4th level, then the ID must be 3#**
- In this section user can store the input for this grid level information by selecting from Figure 189 **Load/Save Info** . Input/output file information will display in Figure 189 to let user to store or load the grid information.
- Then user must select **Sub grid Depth Map Scale** to calculate sub grid information and store in inf4.dat for 2D bathymetry interpolation program, Will discuss later.
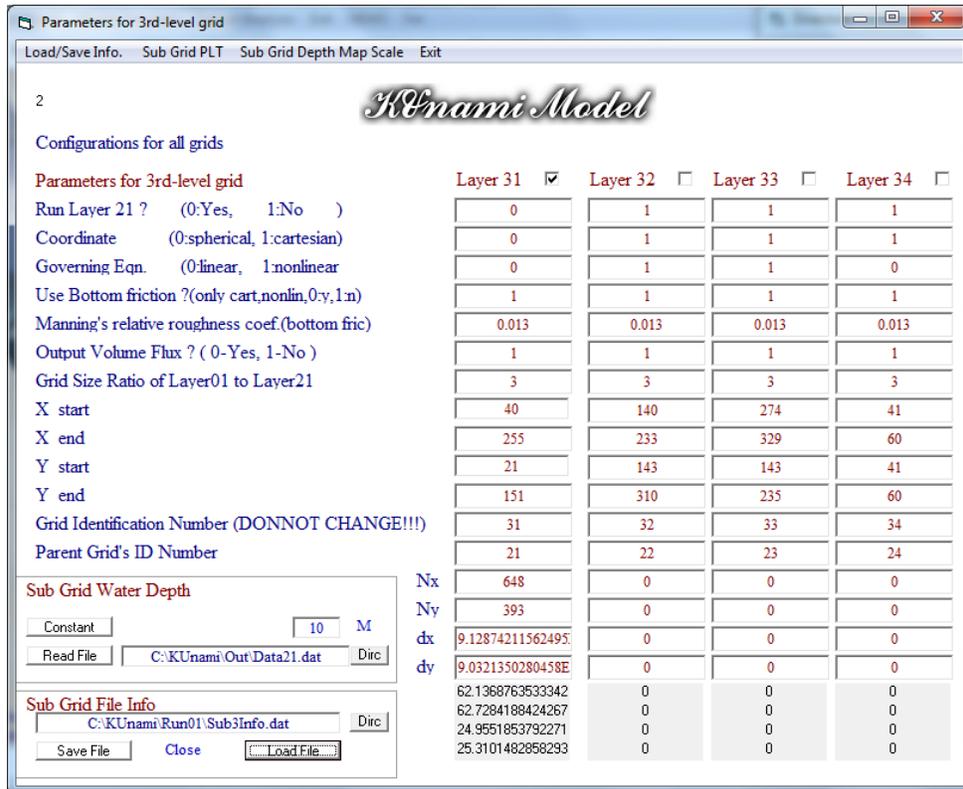
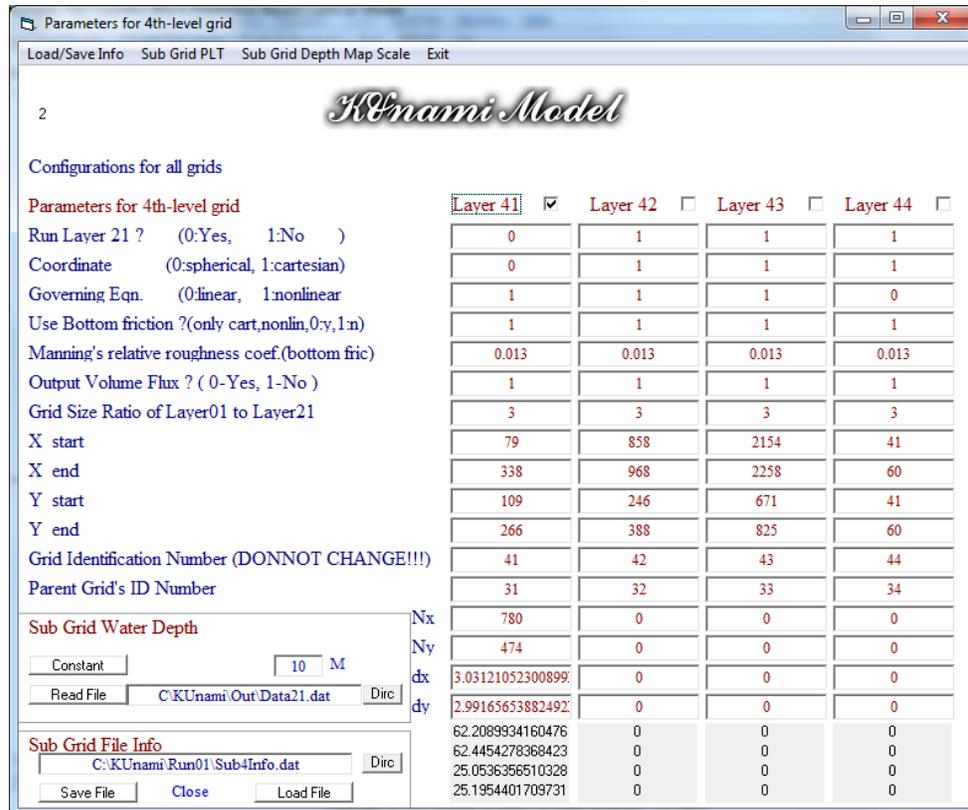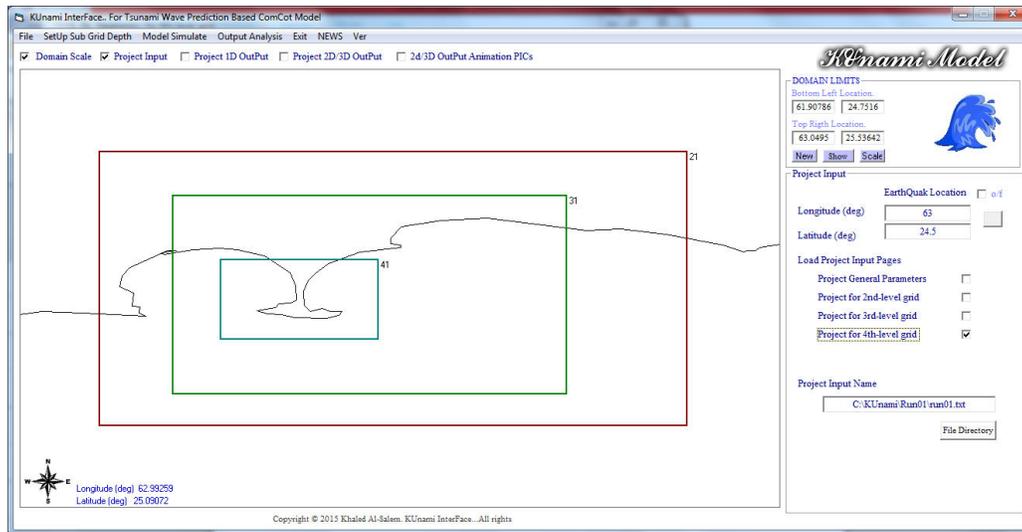**Figure 188. Project for 2rd Level Grid**

Figure 189. Project for 4th Level Grid

Figure 190. Project Sub Grid Level (21,31 and 41)

If user want to include the refined sub grid level inside the system main grid user must select **SetUp Sub Grid Depth** shown in Figure 190 to activate DEPX program for interpolation the 2D bathymetry layer file as shown in Figure 191. There is some step to generate the file as follows:

- User must select the Sub Grid File Info. These default file stored in OUT directory as (for Level 2nd file name inf2.dat and for level 3rd file name inf3.dat and for level 4th file name inf4.dat). Then select Button **Load File** as shown in Figure 191.
- Figure 191 display for user information for the sub grid data dimension and what be the dimension of the bathymetry file collected from Digital atlas bathymetry software as shown in following step.
- User must run **GEBCO program** to generate the bathymetry file by using the map scale shows in Figure 191 (X1,X2 Y1,Y2) as shown in Figure 192. Then the new row/col must match the rows/col in Figure 191.
- Then user must select the file name in **GEBCO Digital Atlas Bathymetry textbox** which just created from GEBCO program.
- Then assign the file layer level name in **Setup Bathymetry for sub grid 2,3 and 4** and corrected path. Then select **Start** to generate the 2D bathymetry interpolation.
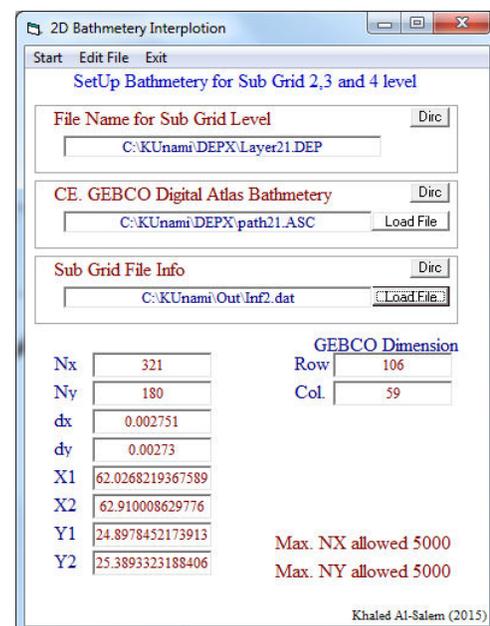
Figure 191. 2D Bathymetry Interpolation Page
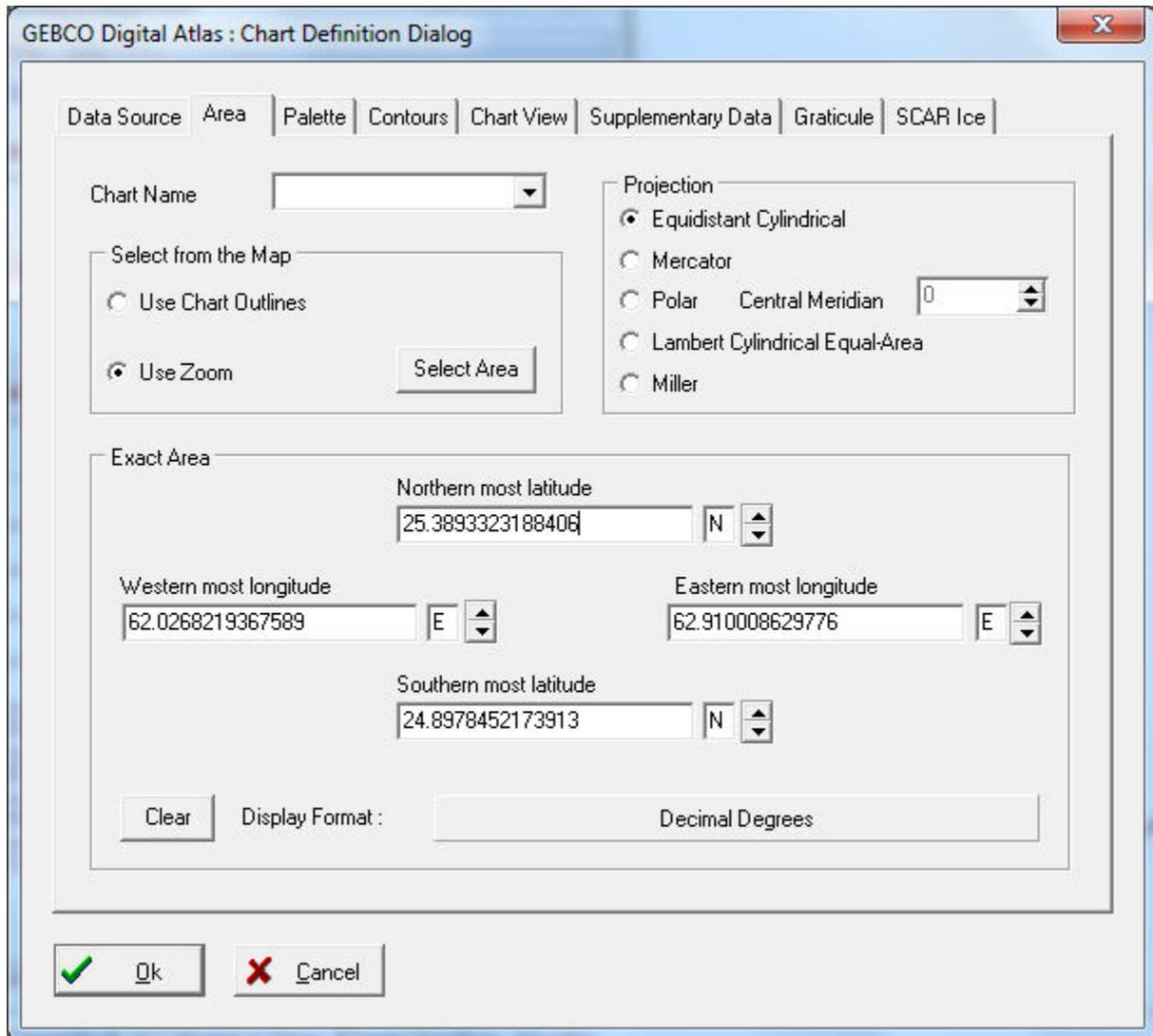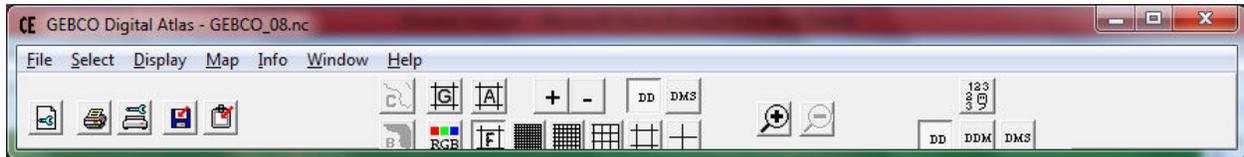
Figure 192. The GEBCO Digital Atlas Bathymetry Program

Then in Figure 193 user must select from File & **Save Project Input**
Figure 193 also shows the grid system and the sub grid levels (2, 3 and4).
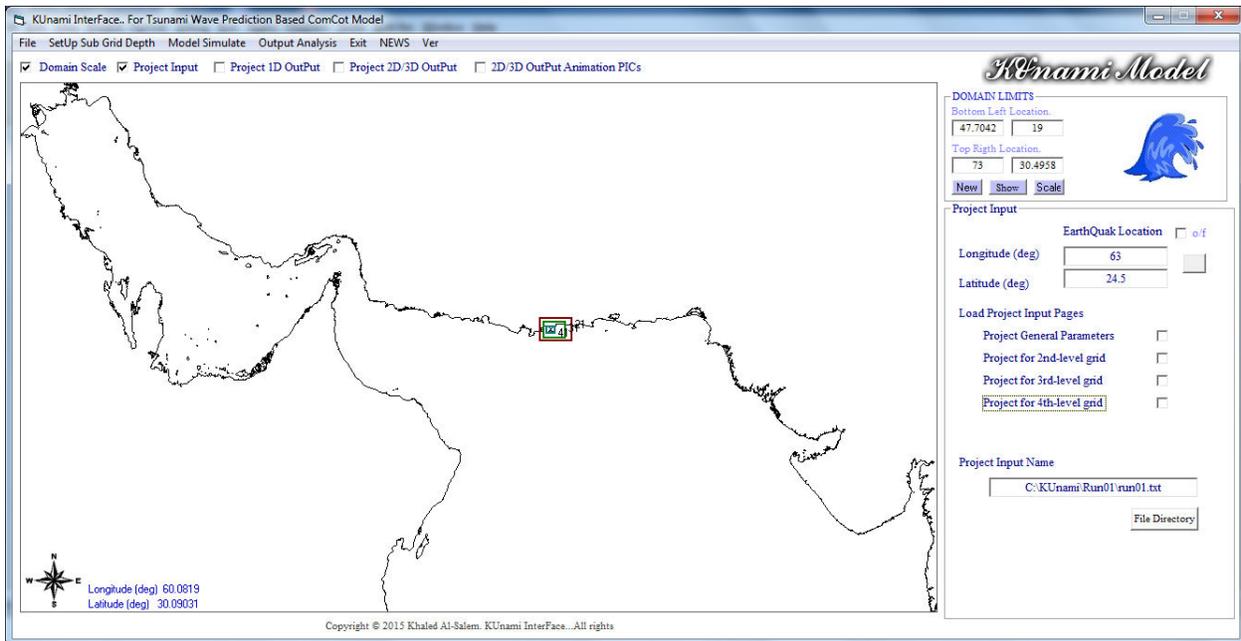
Figure 193. Main Grid System and sub Level grids of (2,3 and 4)

Comcot Model simulation

To start simulate Comcot model for tsunami wave prediction. User must select from Figure 193 **Model simulation.** Then the **Sim** program will activate to run Comcot model as shown in Figure 194.
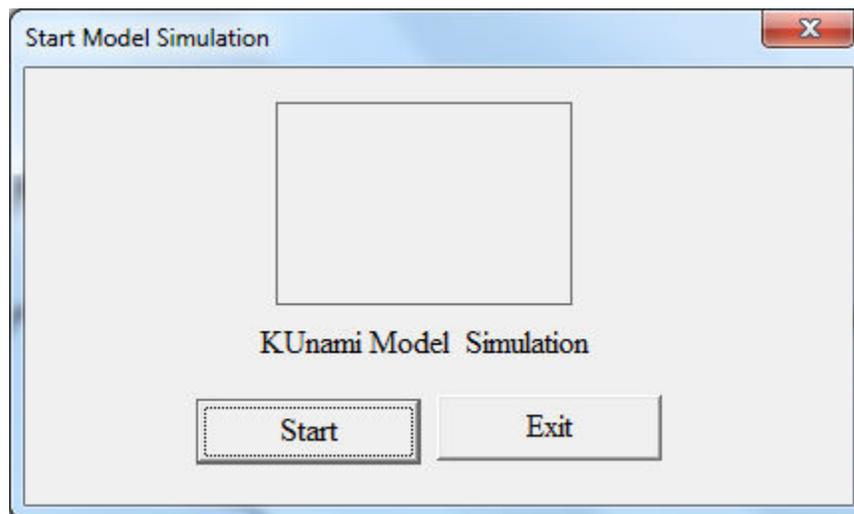
Figure 194. The Sim Program Page.

KUnami Interface Main Grid system Results Personation

Project 1D Output Presentation

From Figurer 195 user should select the checkbox of **Project 1D output,** then Figure 196 will display with a number of inputs for user to select from time serious file to plot and also a drop down list of the grid type now user must select grid 01. Which is the main grid system as follows

1- User can select **Dirc** button to see the output file stored.

2- User should select Start Time and End time and time step for the output files.

3- User must Input the Directory Path for the Input files

4- User must select the output directory location for the converted files.

5- Then user must select **Start** button prepare the output files

6- Then User select the location of plot output file with extension *.bln

Now user ready to select the set of point locations from the map for plotting as

7-User must enter the **Number of Location** then activate the checkbox of On/OFF.

8- Move the mouse over the Map then click on the desire location for all location selected, then When all location is selected the checkbox will turn OFF.

9-User must select **End and Save** button to store the data in the file.

10-To see the location selected (**Edit Location**) button.

Now user ready to extract the data from the input file selected as

11-User Select Extract Data.

12-To See the final plot User must select as

      A- Create Line Plot from KUnami interface System as shown in Figure 195.

      B- Create Line Plot from Surfer Plotting Software.
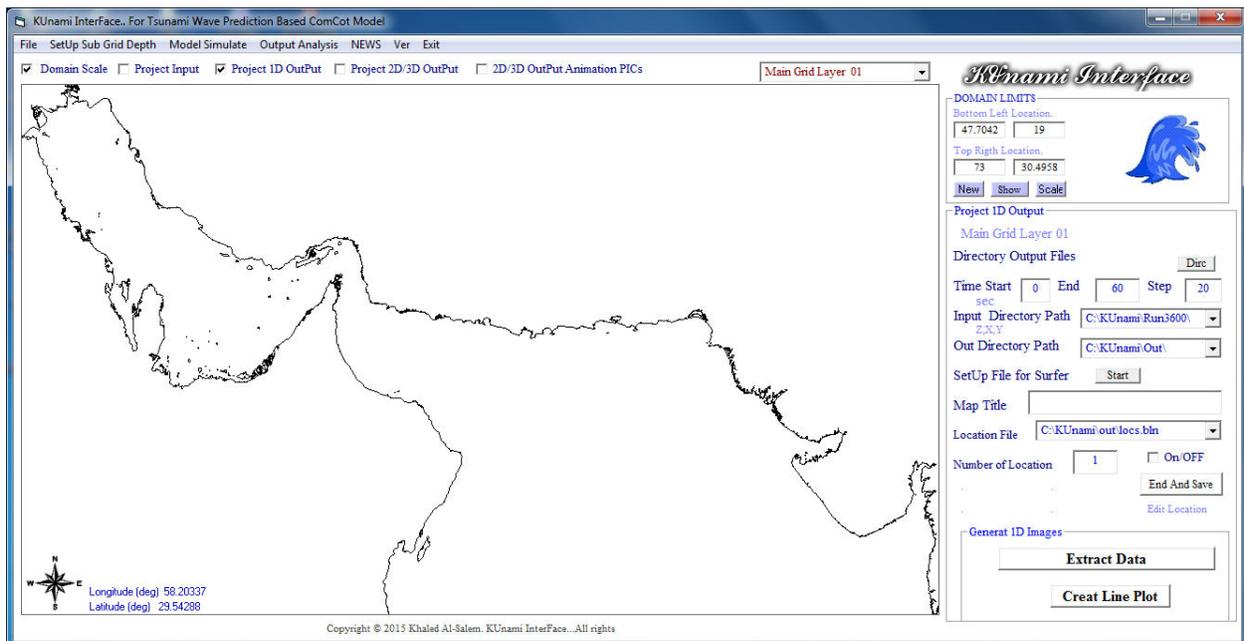
Figure 195. Project 1D output Option
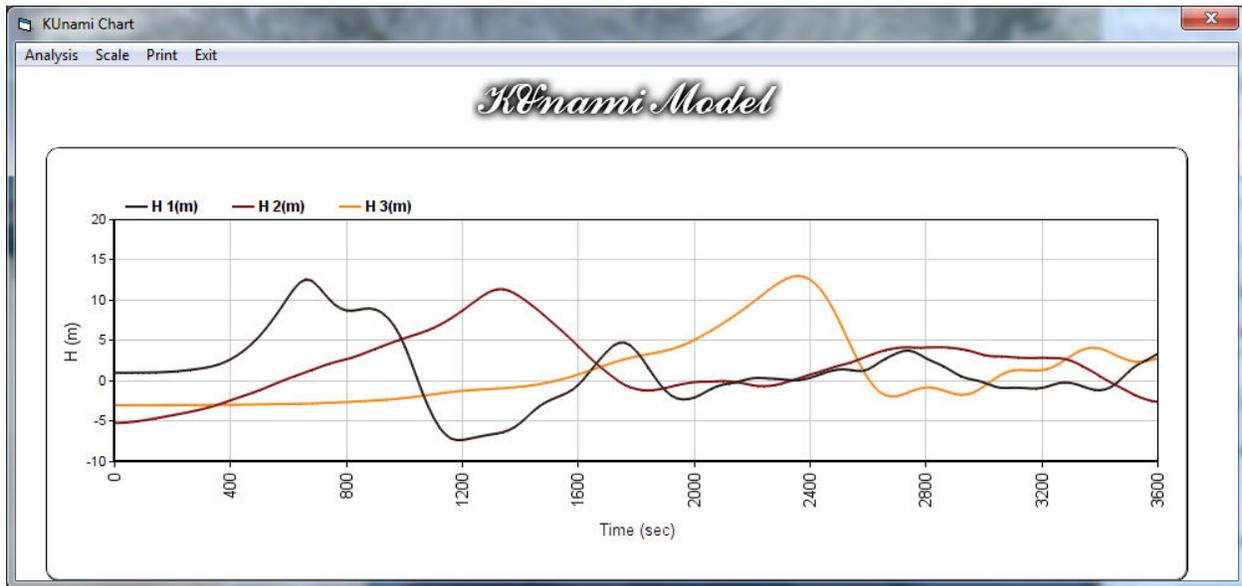
Figure 196. Time serious 1D line for a number of Selected Location for Wave Height.

Data Analysis option for 1D

From Figure 197 user has as option called **Analysis** for calculation the time of maximum wave height occur for each selected location. There a number of input require from user as follow:

1- From Figure 197 user must select Analysis button then Select **Date/Time,** then Figure 197 will display for user to enter Earth Quake Occur Date and Time.

2- From Figure 197 user must select Analysis button then Select **Time of W.H. Max,** then Figure 198 will display for user the Selected location Longitude/Latitude and Date/Time of the maximum wave height occur and the value of the wave height (m)

Figure 198. Text File for a list of Selected Location Output.

Figure 197. Earth Quake Date/Time

Project 2D/3D Output Presentation

In this section user can display an image from selected time step file in two types as:
  1- 2D Image with coast line background or with satellite map background.
  2- 3D Image.
From Figurer 195 user should select the checkbox of **Project 2D/3D Output,** then Figure 199 will display with a number of inputs for user to select but user must select the type of grid domain as shown in the dropbox list as show in Figure 199 and then user must follow the input requirement as follows:
  1- User can select **Dirc** button to see the output model file locations.
  2- User should enter location of the Input file name
  3- User must select Directory Path for the output file
  4- Then user must select **Start** button prepare the output files
  5- Then User selects the contour level file for Surfer software.
  6-User can add text title to Image at MAP plot.

 Now user ready to select Plot type as displayed in Figure 200. For user to Plot 2D image user have two options as
   1-User must select **Create Surfer Plot** (coast line background) as shown in Figure 201
   2- User must select **Create Surfer Plot with Sat. Image** (map background) as shown in
      Figure 202
Or user to select 3D image
  1-User must enter the 3D Color Level file (Default file is col3d.CLR).
  2-User must select **Create Surfer 3D Image** button as shown in Figure 203.
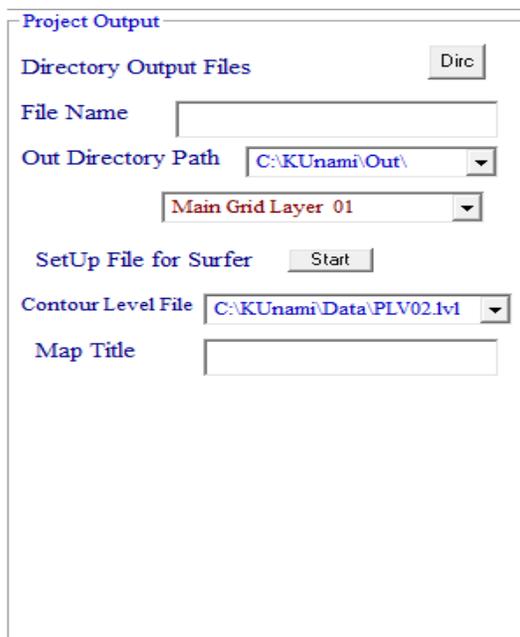
Figure 199. Project Output for 2D/3D Option
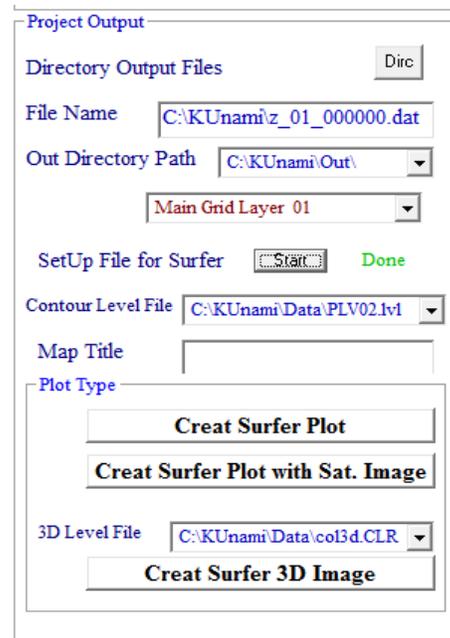
Figure 200. Image Type Selection Option
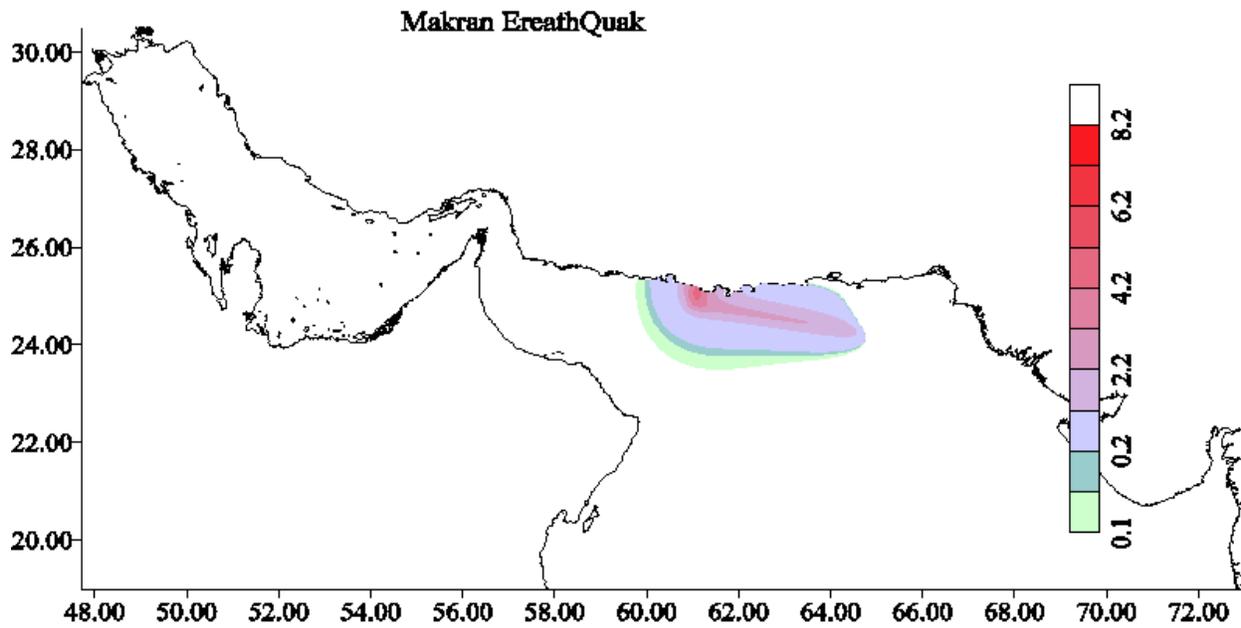
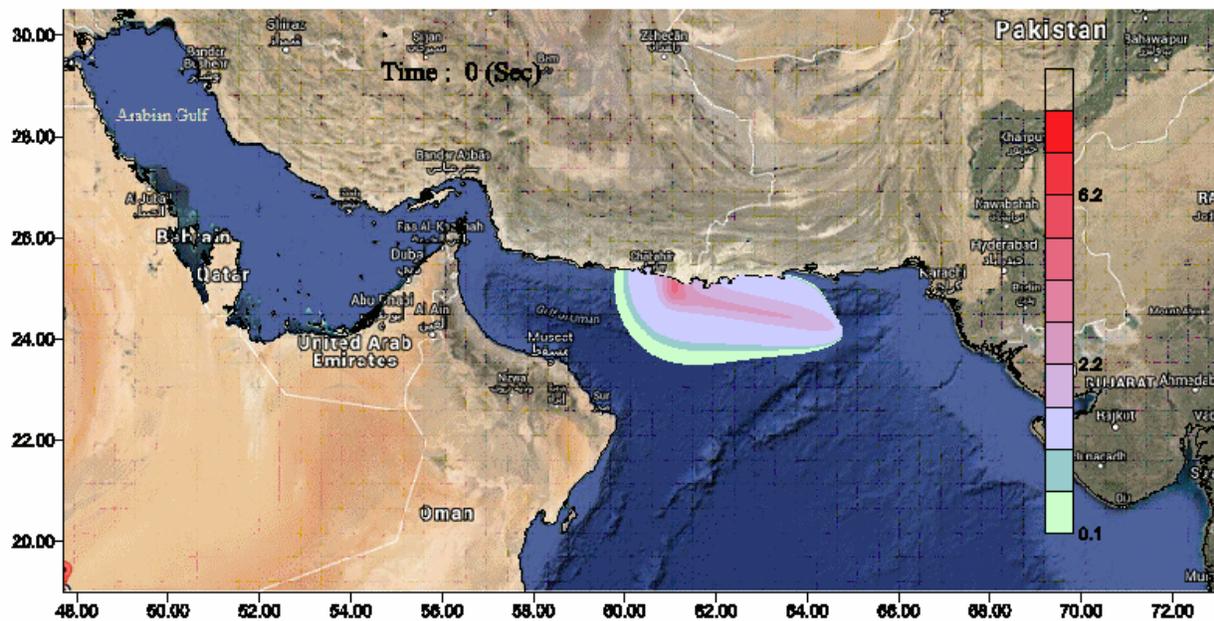**Figure 201. 2D Wave height Contour Plot with Coast line background from Surfer Software**

Figure 202. 2D Wave height Contour Plot with Satellite Map background from Surfer Software

(A)

(B)

Figure 203. 3D Wave height Contour Plot Created by Surfer Software for A at 600 sec and B for 1200 sec.

Project 2D/3D Output Animation Pics

In this section user can create a set of images from selected time step file. From this images user can create a media file by using media program to generate video animation such as:
 -Movie Maker program
 -ImageToGif animation program
 -…….
 -Other program
The two type Animation are follows:
  1- 2D Animation with coast line background or with satellite map background.
  2- 3D Animation.
From Figurer 195 user should select the checkbox of **Project 2D/3D Output Animation PICS,** then Figure 204 will display with a number of input of inputs for user to select but user must select the type of grid domain as shown in the dropbox list as show in Figure 204 and then user must follow the input requirement as follows:
 1- User can select **Dirc** button to see the output model file locations.
 2- User should select start time, end time and time step
 2- User must enter Directory Path input file
 3- User must enter Directory Path output file
 4- Then user must select **Start** button prepare the output files
 5- Then User selects the contour level file for Surfer software.
 6-User can Add text title to Image at MAP plot.

 Now user ready to select Image type for animation as displayed in Figure 205. For user to create 2D images for Animation user have two options as
  1-User must select **Create Surfer Plot with coast line** (background) images
  2- User must select **Create Surfer Plot with Sat. Image** (background) images

Or user to select 3D images for Animation
 1-User must enter the 3D Color Level file (Default file is col3d.CLR) .
 2-User must select **Create Surfer 3D Image** for Animation.

If user used Movie Maker Program from Microsoft to generate Animation file from a set of Images that create from the above option were shown in Figure 206. Which shows the main page of the Movie Maker program with all selected images loaded and ready to compile or generate the animation file.

Figure 204. Project Output for 2D/3D Animation Option

Figure 205. Create Surfer 3D Images for Animation
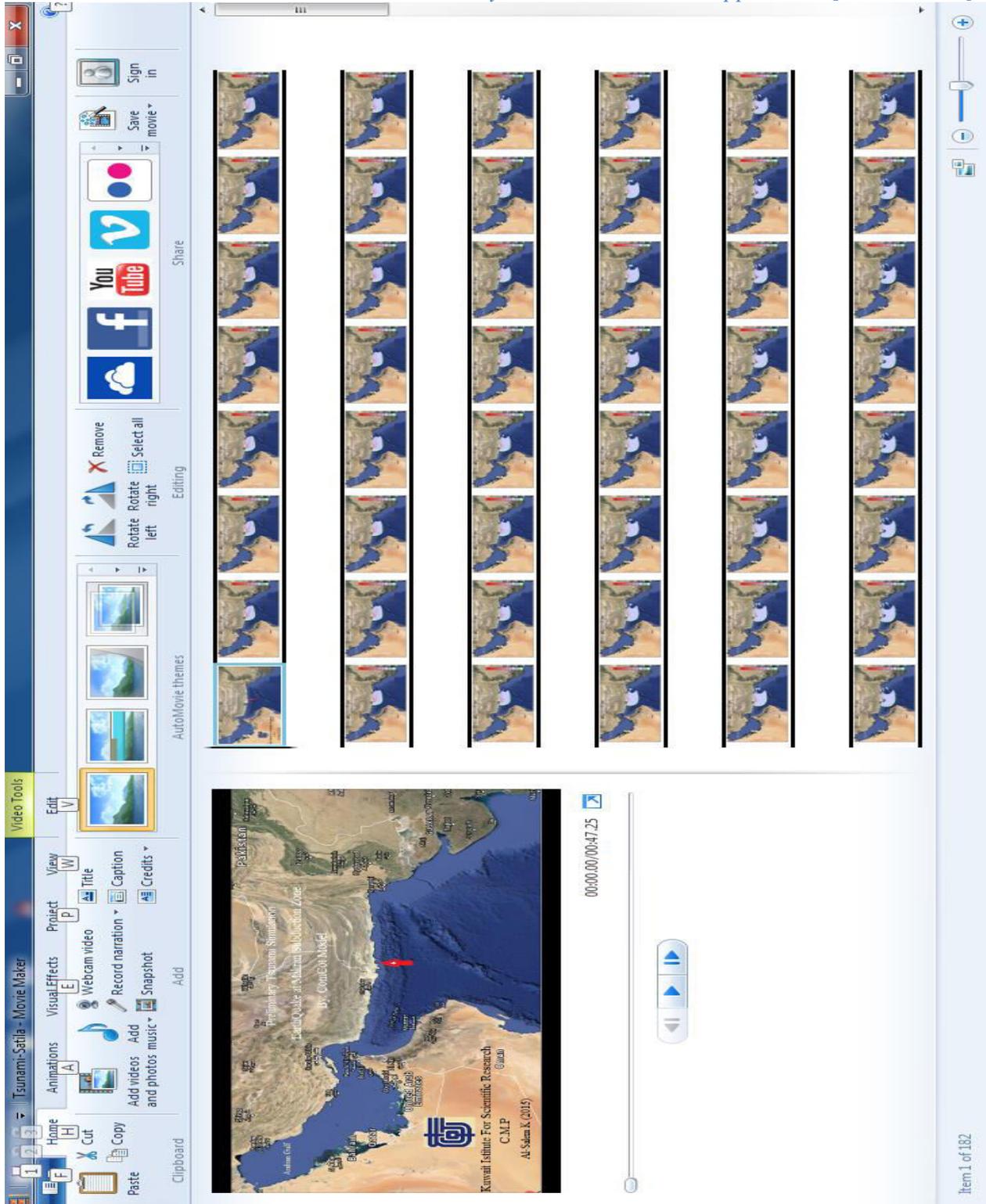
Figure 206. Main Page Of Movie Maker Program With All Selected images Loaded
KUnami Interface Sub Grid system Results Personation

Presentation for results from simulation of ComCot model for Sub grid (refine grid) system require some input from user as follows:

1- Sub Grid 1D Output Presentation for (Layer21 to 44)

From Figure 195 user must select and follow these steps as:
- From the dropbox the Type of sub grid system
- Then base on the sub grid select user must follow as:
- If user select to present sub grid layer (21,22,23,24) user must activate the layer number by select from Figure 207 the   **Sub Grid Dimension** to show and calculate the (NX,NY,DX,DY and the Scale for the sub grid selected) as shown in Figure 207.
- To Show or plot the sub grid user must check the checkbox at the top of layer selected then click on **Sub Grid Plt.**
- If user select to present sub grid layer (31,32,33,34) user must activate the layer number by select from Figure 208 . Then user must select **Load/Save Info** to load the (NX,NY,DX,DY and the Scale for the sub grid selected) as shown in Figure 208
- Same If user select to present sub grid layer (41,42,43,44)
- User can select **Dirc** button to see the output file stored.
- User should select Start Time and End time and time step for the output files.
- User must Input the Directory Path for the Input files
- User must select the output directory location for the converted files.
- Then user must select **Start** button prepare the output files
- Then User select the location of plot output file with extension *.bln
- Now user ready to select the set of point locations from the map for plotting as
- User must enter the **Number of Location** then activate the checkbox of On/OFF.
- Move the mouse over the Map then click on the desire location for all location selected, then
- When all location is selected the checkbox will turn OFF.
- User must select **End and Save** button to store the data in the file.
- To see the location selected (**Edit Location**) button.
- Now user ready to extract the data from the input file selected as

User Select Extract Data.

 To See the final plot User must select as

       A- Create Line Plot from KUnami interface System.

  B- Create Line Plot from Surfer Plotting Software.

Parameters for 2nd-level grid — Sub Grid Plt   Sub Grid Dimension   Sub Grid Depth Map Scale   Exit

K&nami Model

Configurations for all grids

Parameters for 2nd-level grid	Layer 21 ☐	Layer 22 ☐	Layer 23 ☐	Layer 24 ☐
Run Layer 21 ? (0:Yes, 1:No)	1	1	1	1
Coordinate (0:spherical, 1:cartesian)	0	1	1	1
Governing Eqn. (0:linear, 1:nonlinear)	0	0	0	0
Use Bottom friction ?(only cart,nonlin,0:y,1:n)	1	1	1	1
Manning's relative roughness coef.(bottom fric)	0.013	0.013	0.013	0.013
Output Volume Flux ? (0-Yes, 1-No)	1	1	1	1
Grid Size Ratio of Layer01 to Layer21-4	3	3	3	3
X start	1719	11	11	61
X end	1825	30	30	80
Y start	708	11	11	61
Y end	767	30	30	80
Grid Identification Number (DONNOT CHANGE!!!)	21	22	23	24
Parent Grid's ID Number	1	1	1	1
Nx	321	60	60	60
Ny	180	60	60	60
dx	.002751	.002638	.002638	.002638
dy	.00273	.002638	.002638	.002638
	62.0268219367589	47.7958514492754	47.7958514492754	48.2124489459816
	62.910008629776	47.9541584980237	47.9541584980237	48.3707559947299
	24.8978452173913	19.0916331884058	19.0916331884058	19.5081476811594
	25.3893323188406	19.2499086956522	19.2499086956522	19.6664231884058

Figure 207: Activate Layer Sub Grid (21,22,23,24)

Figure 208: Activate Layer Sub Grid (31,32,33,34)

2- Sub Grid 2D/3D Output Presentation for (Layer21 to 44)

From Figure 199 user must select and follow these steps as:
- From the dropbox the Type of sub grid system
- Then base on the sub grid select user must follow as:
- If user select to present sub grid layer (21,22,23,24) user must activate the layer number by select from Figure 207 the **Sub Grid Dimension** to show and calculate the (NX,NY,DX,DY and the Scale for the sub grid selected) as shown in Figure 207.
- To Show or plot the sub grid user must check the checkbox at the top of layer selected then click on **Sub Grid Plt.**
- If user select to present sub grid layer (31,32,33,34) user must activate the layer number by select from Figure 208 . Then user must select **Load/Save Info** to load the (NX,NY,DX,DY and the Scale for the sub grid selected) as shown in Figure 208
- Same If user select to present sub grid layer (41,42,43,44)

Then User must follow same step in [*Project 2D/3D Output Presentation*] for the rest of the selection.

3- Setup Ini Surface Deformation File

Kunami Interface will Simulate the Comcot model by default in one Fault case as shown in Figure 186 by using the parameters for Fault model entry data section. But user want to start the simulation with an initial deformation surface user must follows as:
- From Figure 2 user must select at section (**General Parameters for Simulation**) the **specify ini surface as 1**. This to tell the model the ini-surface data read from file name data.
- From Figure 186 user must select **SetUp INI_Surface Deform File** option. To setup the require input data for creating the ini-surface deform file. Figure 209 will display.
- In Figure 209 shows a number of required data must enter as follows:
  - 1-General fault parameter data for number of events and number of Fault segments and (single as 0 or multi as 1 fault events). User allowed changing.
  - 2-General Domain dimension for number of events and number of domain grid in x and y and grid size in x and y. User not allowed to change.
  - 3-Main Domain Axis its (x,y) data for lower left corner and Top right corner of the main domain grid system for KUnami interface. User not allowed to change.
- Now user ready to enter the fault data by click on **General Input Fault Data** button. Then Figure 210 will display for user to enter the fault data. When finished entry user must save the file as default name (Don't change the file name or save as other name. it must be save as default name).
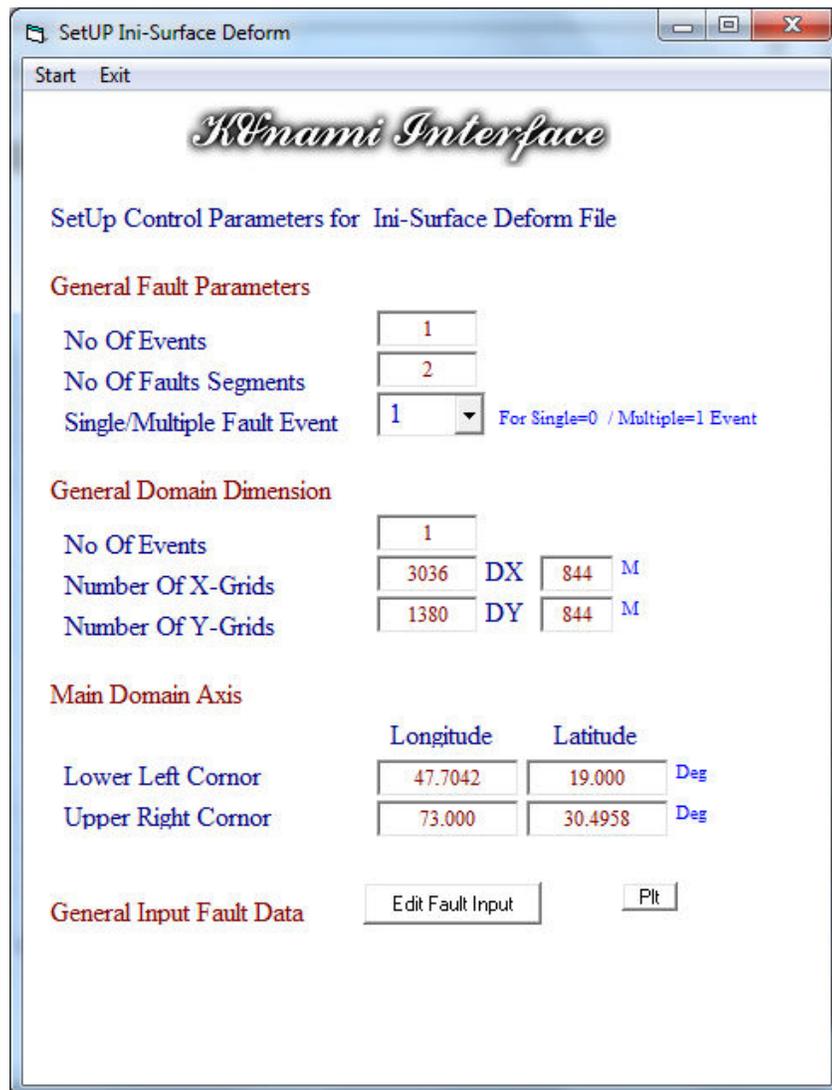
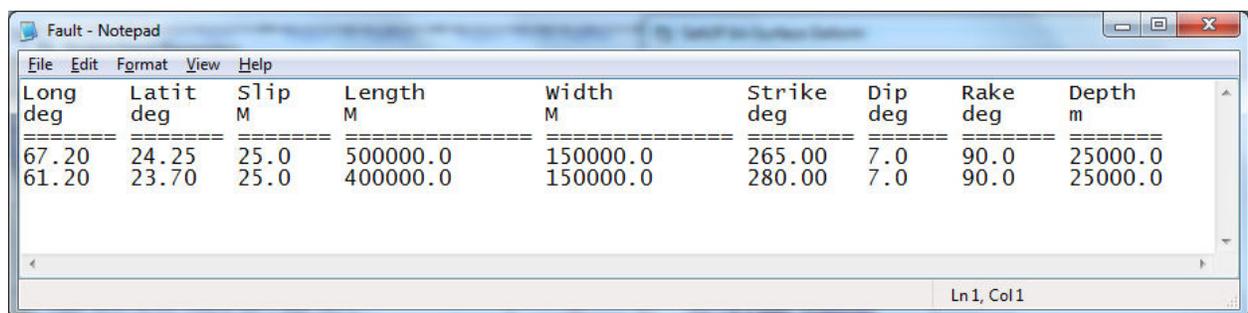**Figure 209: SetUp Ini Surface deformation Page**

Figure 210: Entry Page for Deformation Fault Data

Volume Flux 1D Output Presentation

Volume Flux Presentation for results from simulation of ComCot model for main grid and Sub grid (refine grid) system require some input from user as follows:

From Figure 185 user must select the check box for **Volume Flux 1D Output** then Figure 211 will display to user to follow these steps as:
- From the dropbox the Type of sub grid system
- Then base on the sub grid select user must follow as:
- If user select to present sub grid layer (21,22,23,24) user must activate the layer number by select from Figure 207 the **Sub Grid Dimension** to show and calculate the (NX,NY,DX,DY and the Scale for the sub grid selected) as shown in Figure 207.
- To Show or plot the sub grid user must check the checkbox at the top of layer selected then click on **Sub Grid Plt.**
- If user select to present sub grid layer (31,32,33,34) user must activate the layer number by select from Figure 208 . Then user must select **Load/Save Info** to load the (NX,NY,DX,DY and the Scale for the sub grid selected) as shown in Figure 208
- Same If user select to present sub grid layer (41,42,43,44)
- User can select **Dirc** button to see the output file stored.
- User should select Start Time and End time and time step for the output files.
- User must Input the Directory Path for the Input files
- User must select the output directory location for the converted files.
- Then user must select **Start** button prepare the output files
- Then defualt location of plot output file with extension locVF.bln as shown in Figure 211.
- Now user ready to select the set of point locations from the map for plotting as
- User must enter the **Number of Location** then activate the checkbox of On/OFF.
- Move the mouse over the Map then click on the desire location for all location selected, then
- When all location is selected the checkbox will turn OFF.
- User must select **End and Save** button to store the data in the file.
- To see the location selected (**Edit Location**) button.
- Now user ready to extract the data from the input file selected as
   User Select Extract Data.
 To See the final plot User must select as
> A- Create Line Plot from KUnami interface System as shown in Figure 212.
> B- Create Line Plot from Surfer Plotting Software.
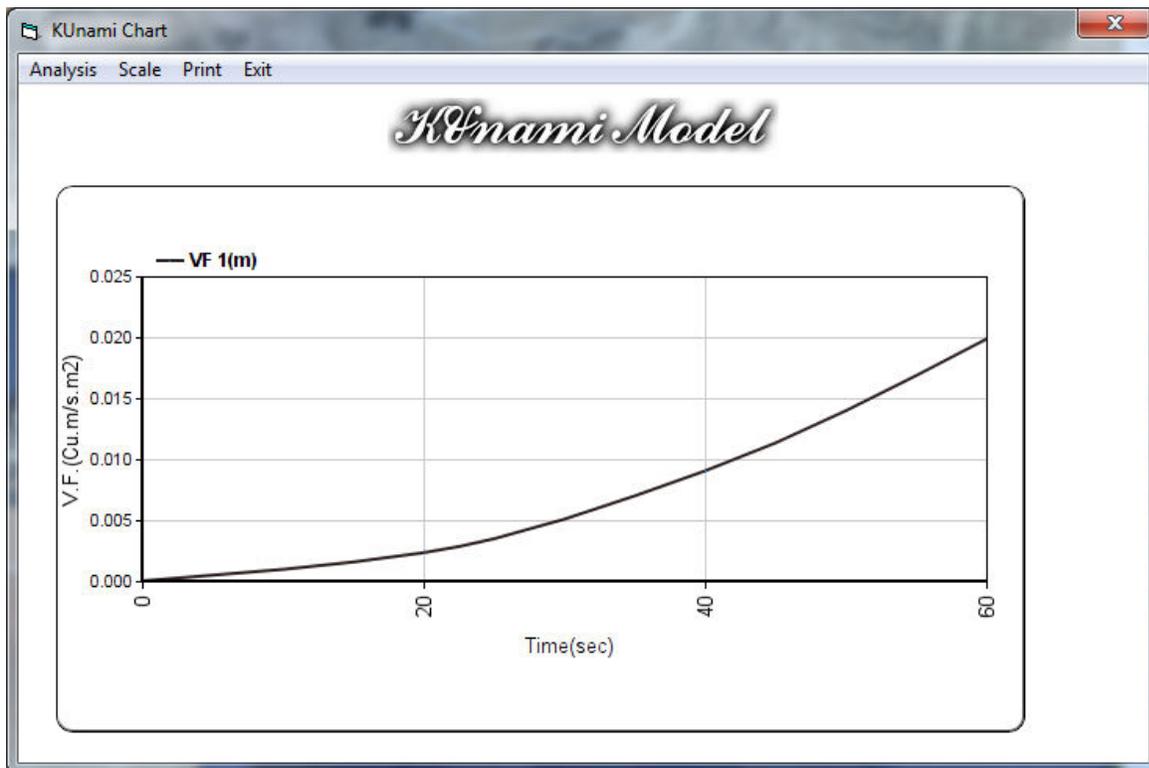
Figure 211. Vulme Flux 1D Outout page

Figure 212. 1D Volume Flux for a selected Location

<u>KUnami Output Presentation at A Remote Website</u>
http://www.hceatkuwait.net/

http://www.hceatkuwait.net/, It's a Remote website hold the KUnami Interface awareness system for a selected location in Arabian Gulf, Gulf of Oman and Arabian Sea waters.
The system will hold the posted awareness data in the system is for 6 hours. The awareness data for selected location will display for user the select as shown in Figure 213.

The system will start at the following website Address:
http://www.hceatkuwait.net/KUnami/KUnami.aspx
Figure 214 will display for user when there are no Tsunami Hazard data post and the system is in standby mode and no posted Pins on the Google map.
Figure 215 will display for user when system received a Tsunami Hazard data at selected location from the operator and the posted location will be on the Google map.

From Figure 215 user can select [icon] to show the time serious data posted for each location as shown in Figure 216 and 217.
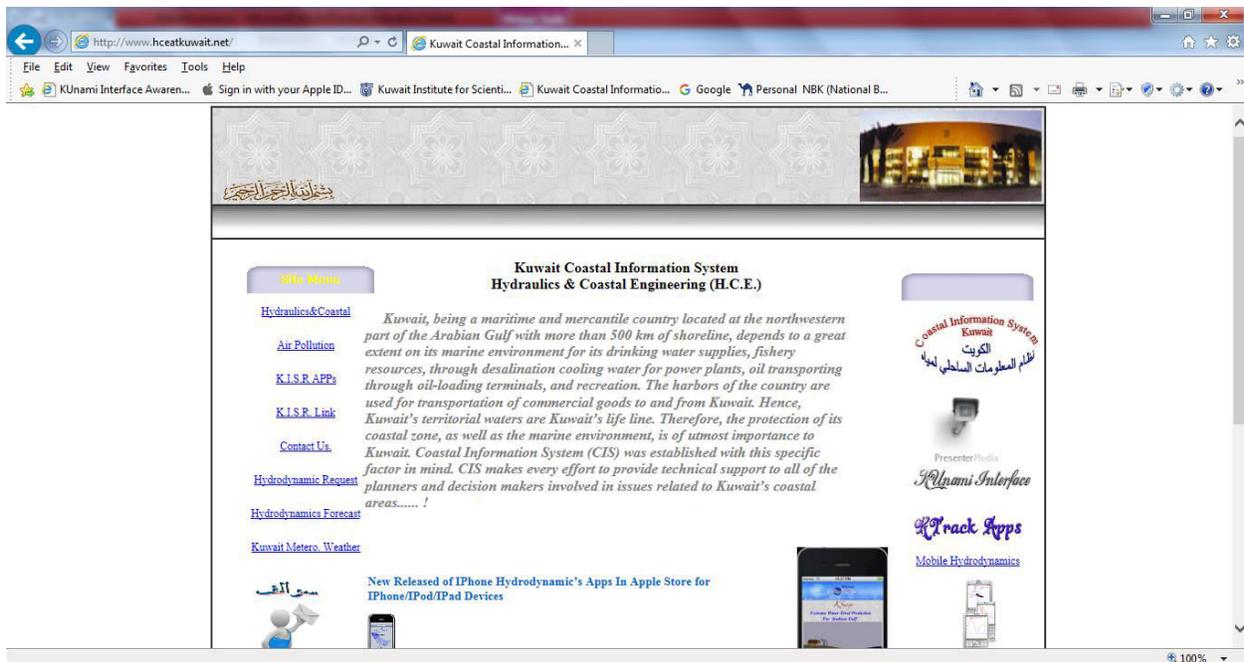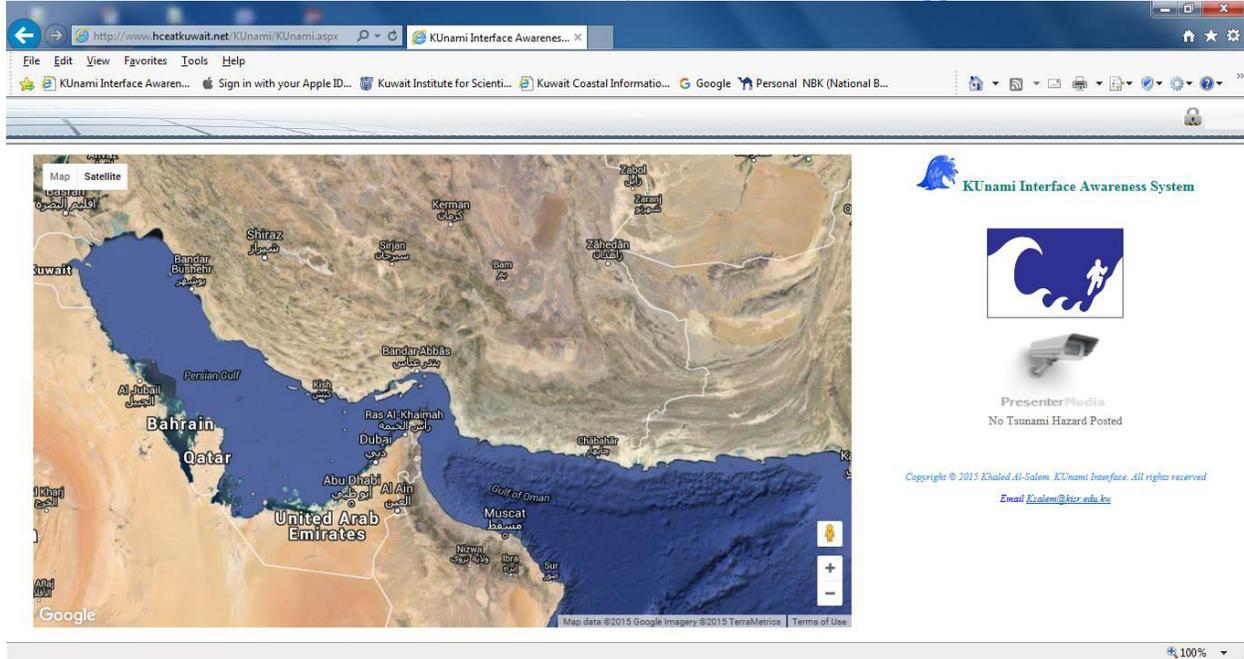

Figure 213. Main Remote Website Page.

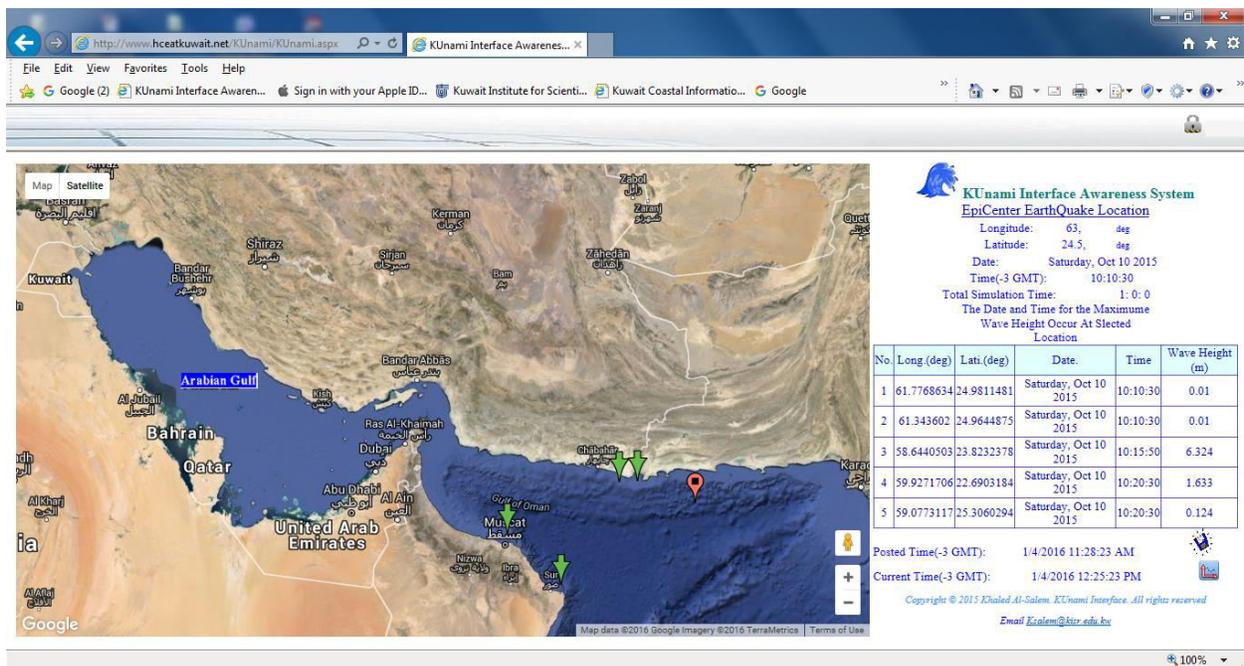**Figure 214. KUnami Interface Remote website (Standby mode)**

Figure 215. KUnami Interface Remote website with awareness hazard data posted

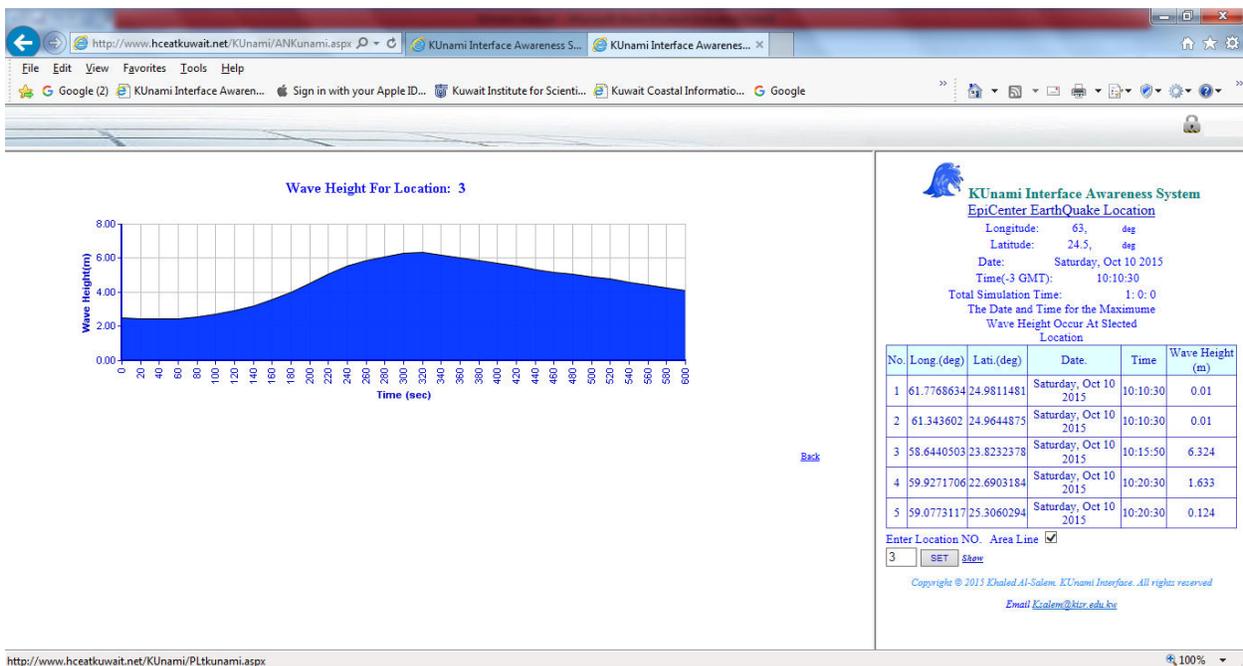**Figure 216. Selection of Time serious Data Location**

Figure 217. KUnami Interface Remote website with Time serious data Plot Posted

KUnami Output Presentation at A Smart Mobile techonolgy [KUnami Apps]

[AL-Salem 2004]   179

[Khaled Al-Salem 2016]

KUnami Apps, It's a mobile apps that hold the KUnami Interface awareness system for selected location in Arabian Gulf, Gulf of Oman and Arabian Sea waters as shown in Figure 218. The system will hold the posted awareness data in the system is for by default a 6 hours or more. The awareness data for selected location will display for user as shown in Figure 220.

The system will start after user select **Monitor button** as show in Figure 219, Figure 219 will stay and display for user when there are no Tsunami Hazard data post and the system is in standby mode and no posted Pins on the Google map.

Figure 220 will display for user when system received a Tsunami Hazard data at selected location from the operator and the posted location will be on the Google map.

From Figure 221 user can select **LOC Bottun** the earth quake information. If user want display the time serious data posted location user must select the following:

    1- Post location number.

    2-Time interval for the plot as(1 for sec, 60 for mint and 3600 for hrs)

Then user must select ⚫ button to show the time serious data posted for each location as shown in Figure 222.

User can send the Tsunami Hazard post data from selection **Contact Button** as shown Figure 223. There are two option for communication which

    1- user can send data by SMS system.

    2-User can send data by Email system as shown in Figure 224
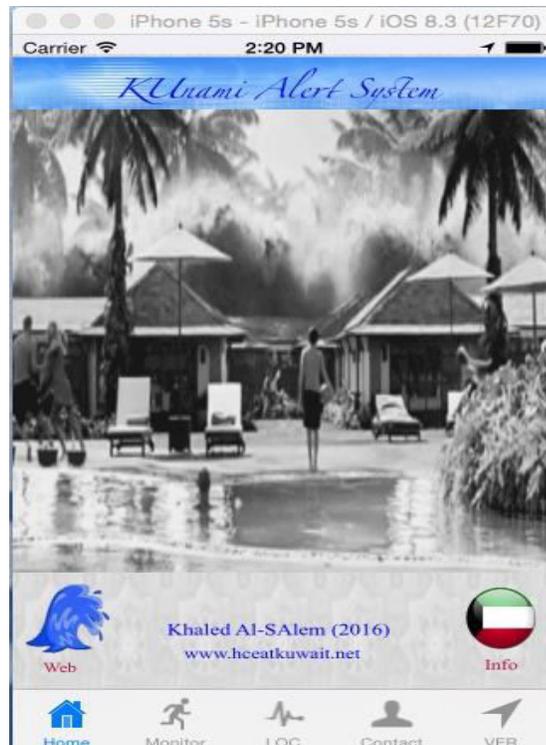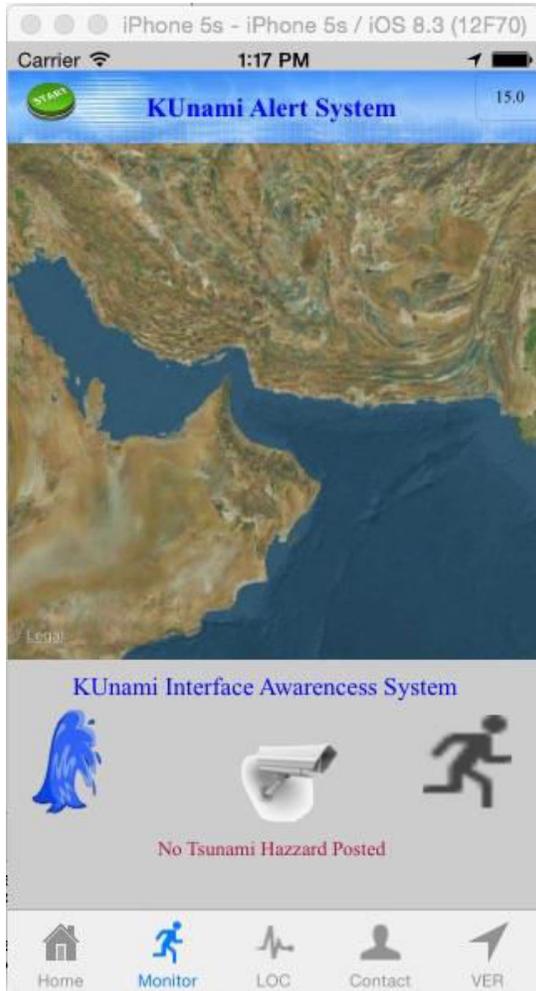

Figure 218. KUnami Apps main Page.

Figure 219. Stand by

Figure 220. Posted Locations

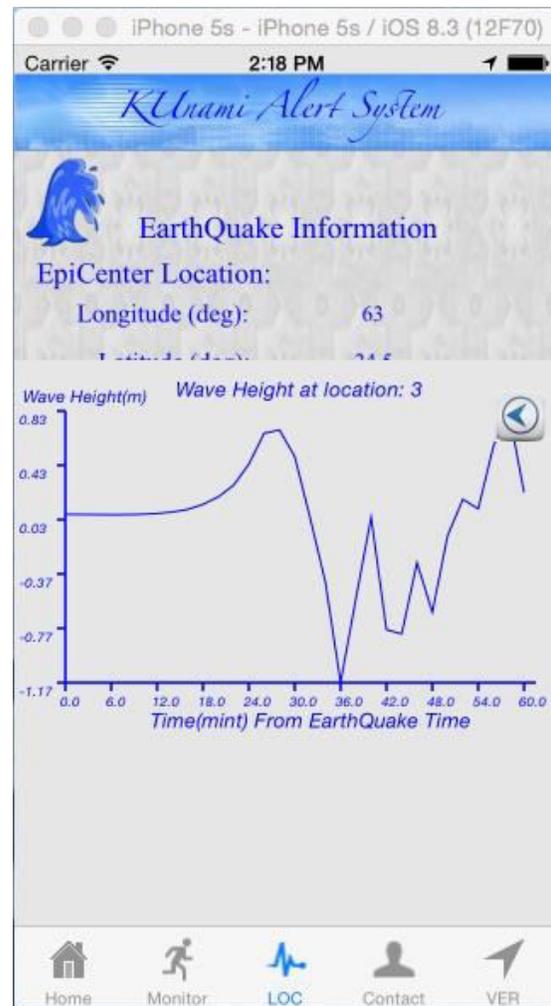**Figure 221. Earth Quake Information**

Figure 222. Plot Time Serious Data for a location

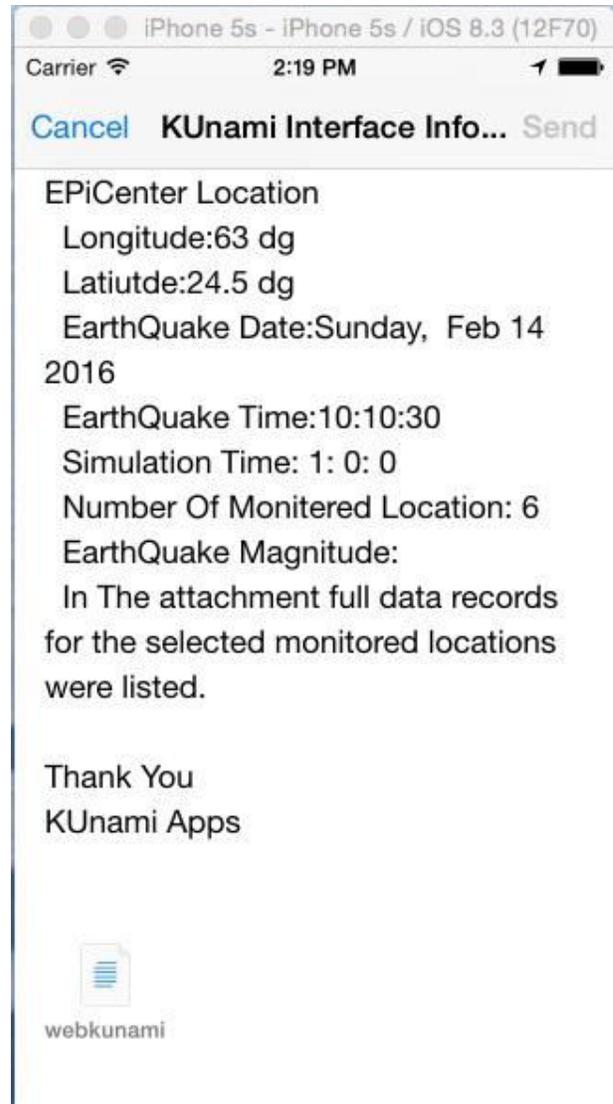**Figure 223. Communication Page**

Figure 224. Email Page

4.8 Gaussian Plume Dispersion [KBlum Model]

[Khaled Al-Salem 2009] [Pc version 1]

Methodology

The Gaussian Plume Model is the most common air pollutant model. It is based on a formula that describes the three-dimensional concentration filed generated by point source under stationary meteorological and emission condition [CE 524. 2011]. The Gaussian plume is visualized in Figure 1. Also Gaussian plume model is the most frequently used atmospheric dispersion model. It is well validated and easy to parameterize. It can be modified to account for different atmospheric stability and surface properties. Gaussian plume dispersion model have a number of fundamental rules has to be followed as:

• Stack gas transported downstream. Concentrations are symmetric about y-axis and z axis.
• Dispersion in vertical direction governed by atmospheric stability
• Dispersion in horizontal plane governed by molecular and eddy diffusion
• x, z, y-axis are oriented to wind direction, vertically upwards and transverse to the wind

By applying the new smart mobile technology to determine the pollutant concentrations beneath an elevated plume involves two main steps; first, the height to which the plume rises at a given downwind distance from the plume source is calculated. The calculated plume rise is added to the height of the plume's source point to obtain the so-called "effective stack height" as shown in Figure 1. The ground-level pollutant concentration beneath the plume at a given downwind distance is predicted using the Gaussian dispersion equation. Second, is the general Gaussian distribution with dispersion that corresponds to the turbulent activity by applying the Lagrangian Plume movement Particles for 3D air concentration dispersion.

Gaussian Plume dispersion modeling

The Gaussian plume model is the most commonly used dispersion model to estimate the concentration of a pollutant at a certain point because of its simplicity. The model describes the transport and mixing of pollutants. Gaussian plume dispersion equation has been derived from basic advective/diffusive equation describing the transfer and diffusion of pollutants from instantaneous point [Khare , 2002 and CE 524. 2011]. The concentration of pollutants (C) at location (x, y, z) from a continuous elevated point source with an effective height of H is given in following equation [1]:

$$C(x,y,z) = \frac{Q}{2\pi\sigma_y\sigma_z\bar{u}} \exp\left(-\frac{(y-y_s)^2}{2\sigma_y^2}\right) \times \left[\exp(-\frac{(z-z_p)^2}{2\sigma_z^2}) + \exp(-\frac{(z+z_p)^2}{2\sigma_z^2})\right]. \qquad [1]$$

Where, Q is the source emission rate, given in mass per second, u is the mean wind velocity, and y and z are the Gaussian plume standard deviations in the horizontal (crosswind) and vertical directions. The coordinate y refers to the crosswind horizontal direction, and y_s is the source coordinate in that direction. The coordinate z refers to the vertical coordinate and z_p is the plume height above ground. Where, σ_y, σ_z are the y direction plume standard deviation and , z direction plume standard deviation Concentration distributions from a continuous point source of effective height H as explain in Gaussian Plume Equation [Seinfeld, 1975], Where

C: downwind concentration
Q: pollution source emission rate

U: average wind speed

σy, σz: y and z direction plume standard deviation

x: position in the x direction or downwind direction

y,z: position in the y and z direction

H: effective stack height

Plume contaminant concentration at ground level can be written as:

$$C(x,y,0) = \frac{Q}{\pi u \sigma_y \sigma_z} e^{-\frac{y^2}{2\sigma_y^2}} e^{-\frac{H^2}{2\sigma_z^2}} \qquad [2]$$

Where the plume Effective stack height can calculate as follows:

The plume rise as referred as (ΔH) in equation [3].

$$\Delta H = d\left(\frac{V_s}{U}\right)^{1.4}\left(1 + \frac{\Delta T}{T_s}\right) \qquad [3]$$

Where, d is inside stack diameter (m), V_s is stack velocity and U is wind velocity in (m/sec), T_s is temperature of the effluent (K) , $\Delta T = T_s - T$ (ambient temperature in K) and $h_{physical}$ if the stack height in meter. Where the effective stack height H can be calculated as:

$$H = h_{physical} + \Delta h$$

Lagrangian Plume Movement Particles

Lagrangian particles dispersion mathematically follows pollution plume particles as the particles move in the atmosphere and also uses a moving frame of reference as the particles moves from their initial location. The particles movement calculates the air pollution dispersion by computing the trajectories of a large number of the pollution plume particles. The motion of the particles is known as a random walk process [Druxler, 1998], [Sutton, 1932] and [Peter 1994]. It looks at the subsequent coordinates (trajectories) of a number of individual property particles that are advected (transported) by wind. When the wind field is known then we may add diffusion as random walks $Rnd()$ that have in general Gaussian distribution with dispersion that corresponds to turbulent activity as shown in Figure 2. The Lagrangian discrete parcel algorithm shown in equation [4] will be used to predict the pollutant trajectory in air. For a particle numbered i we get:-

$$dx_i = u(x_i, y_i, z_i, t)dt + Rnd_x(i) \qquad [4]$$
$$dy_i = v(x_i, y_i, z_i, t)dt + Rnd_y(i)$$
$$dz_i = w(x_i, y_i, z_i, t)dt + Rnd_z(i)$$

Though the method contains a number of heuristic elements, it has all the advantages of a Gaussian plume dispersion and Lagrangian formulation. It is shown that it is possible to formulate and apply Gaussian plume dispersion and a Lagrangian moving partials which is able to recover the classical formulations for plume rise in the environment and to accommodate more recent Eulerian formulations in a turbulent environment. Moreover, the method offers excellent possibilities to include the turbulent characteristics of the plume's environment [Pasquale 2002].

These facts make it attractive for various practical applications. Some examples and Apps results validation will be given to illustrate.

Model Descriptions

Model was rewritten to calculate the air Pollution over UM-ALHaiman City from from Multi-Source system location.

To start model user must select [   ] Fig 225 will display for user to inter a number of require information as shown Fig 226 as follows:

User check box [Plot Parameter] to show wind on simulation map

User check box [Stability Info] to select the stability type

User check box [Source Info] to select source location and source parameters and activation

Then user must prepare Wind Data by select [Extract wind Data] Fig 227 will display for user to inter the shown information to extract wind data from Costal information System Database[CIS].

Then user must interpolate wind data by [Wind file] to interpolate wind data. Data will store in a default wind data name [Windhr.dat] used in simulation.

Then user select [Start] to start simulation.

To show any concentration over UM ALHaiman city while simulation in Running by check [Um Al-Haiman Conce] as shown in 228

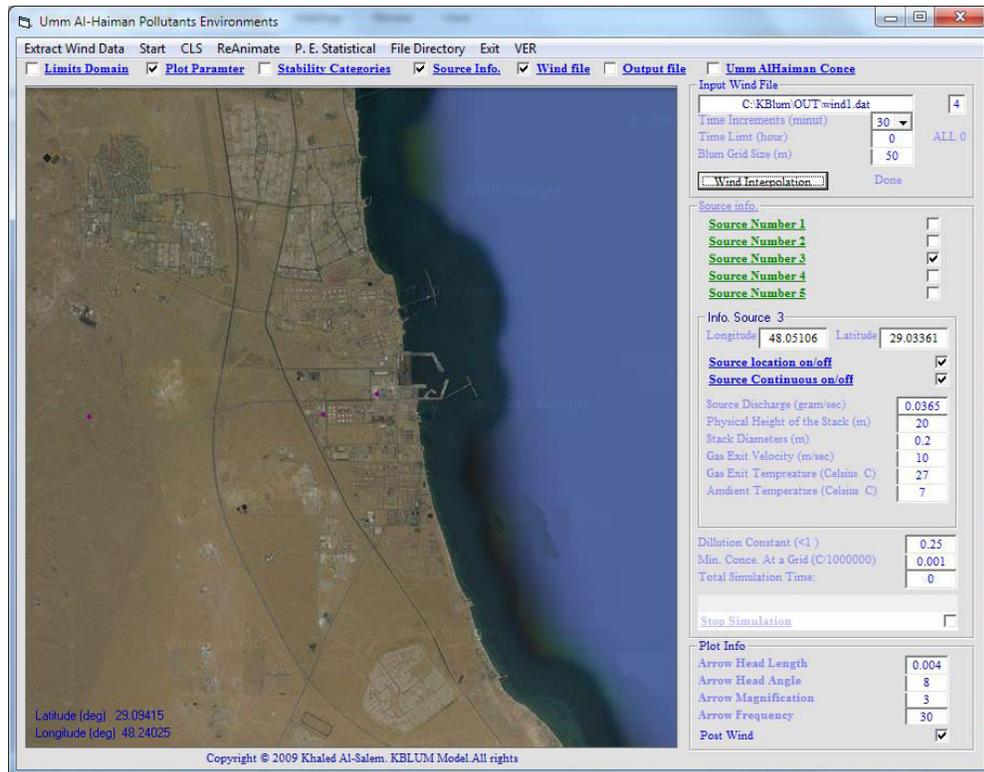Fig 229 display final analysis of concentration Over Um ALHaiman city.
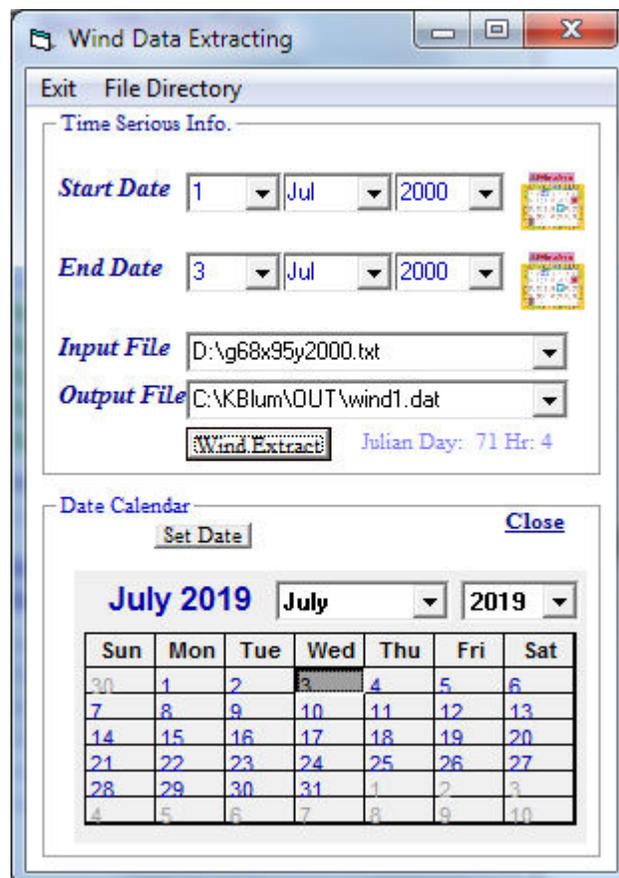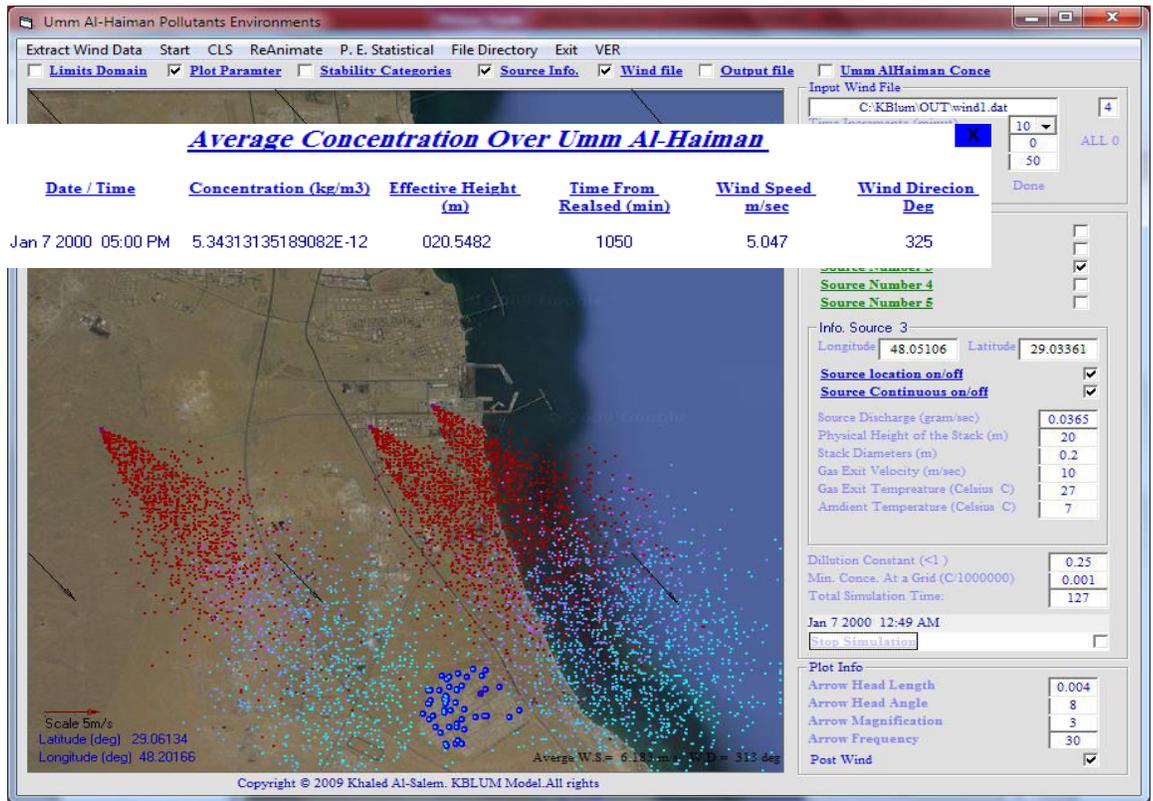

Figure 225

Figure 226

Figure 227

Figure 228

Figure 229

4.9 Gaussian Plume Dispersion [KPlume Model]
[Khaled Al-Salem 2013] [Pc version 2]

Model Descriptions

Model was rewritten to calculate the air Pollution over North of Arabian Gulf from Multi-Source system location.

To start model user must select [   ] Fig 230 will display for user to inter a number of require information same KBlum model Version 1.

Then Fig 231 will display The Plume trajectory analysis
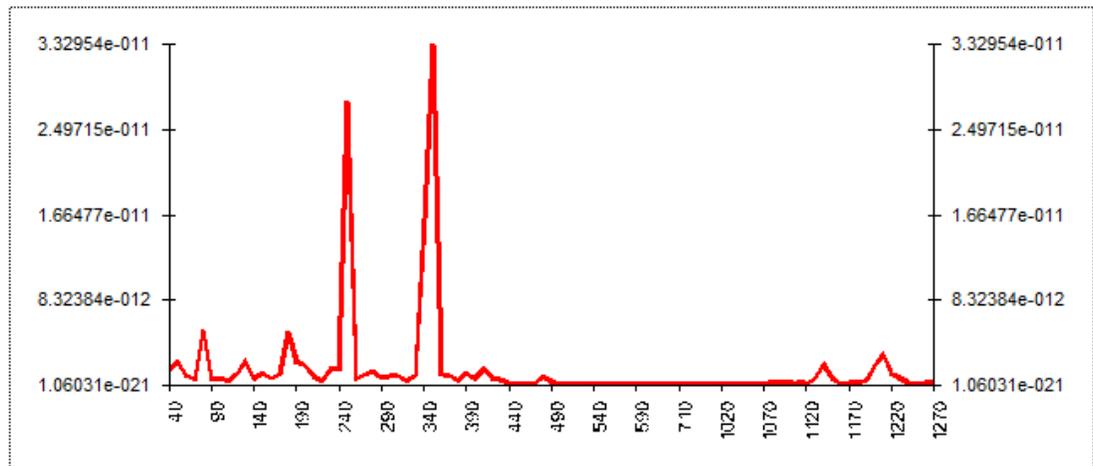
Figure 230

Figure 231

5. Hydraulics Costal Tools

Computational hydraulics is an applied science aiming at the simulation by computers of various physical processes involved in sea. As the current state-of-the-art hydraulic marine models are becoming increasingly complex numerical model. The following tools programs are to carry out numerical experiments in designing and testing Nature-Based Solutions and presenting output tools. Moreover, these tools will work on more applied and/or detailed modeling

.

5.1 1D/2D Output Presentation On Google Map [KGMap Model]
[Khaled Al-Salem 2018]

Google Maps has been around for a while, but too many people are unaware of the full extent of the services that the service can afford.
[KGMap model] uses Google map utilities to presents a simulated 1D/2D output result from different model in Costal Information System Interface on Satellite image.
[This model Need Internet Connection]

Model Discription
To demonstrate how to run the model is by select [**KGMap**] Fig 232 [1D/2D output presentation by Google Map] will display Main Page of KGMap.
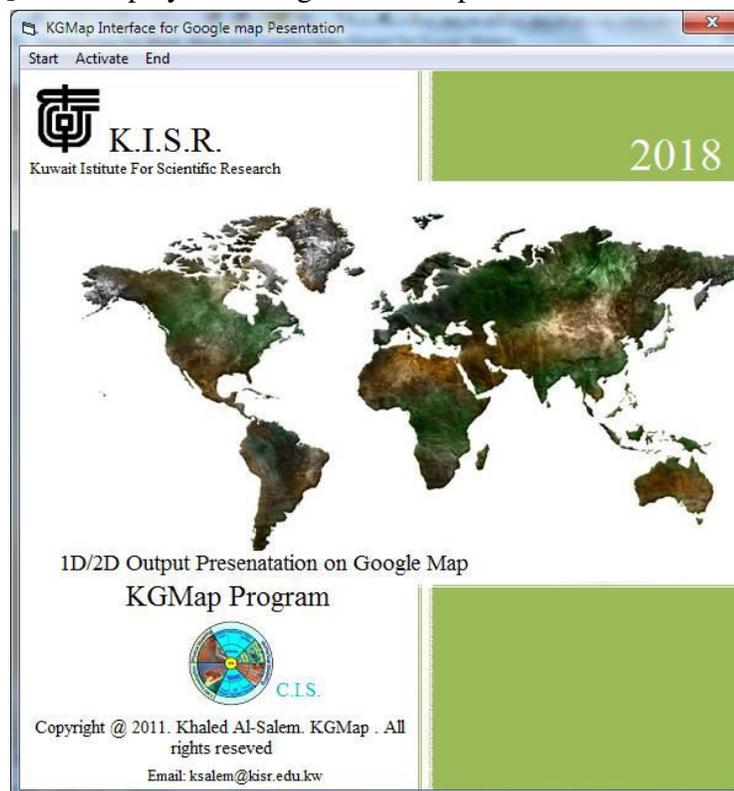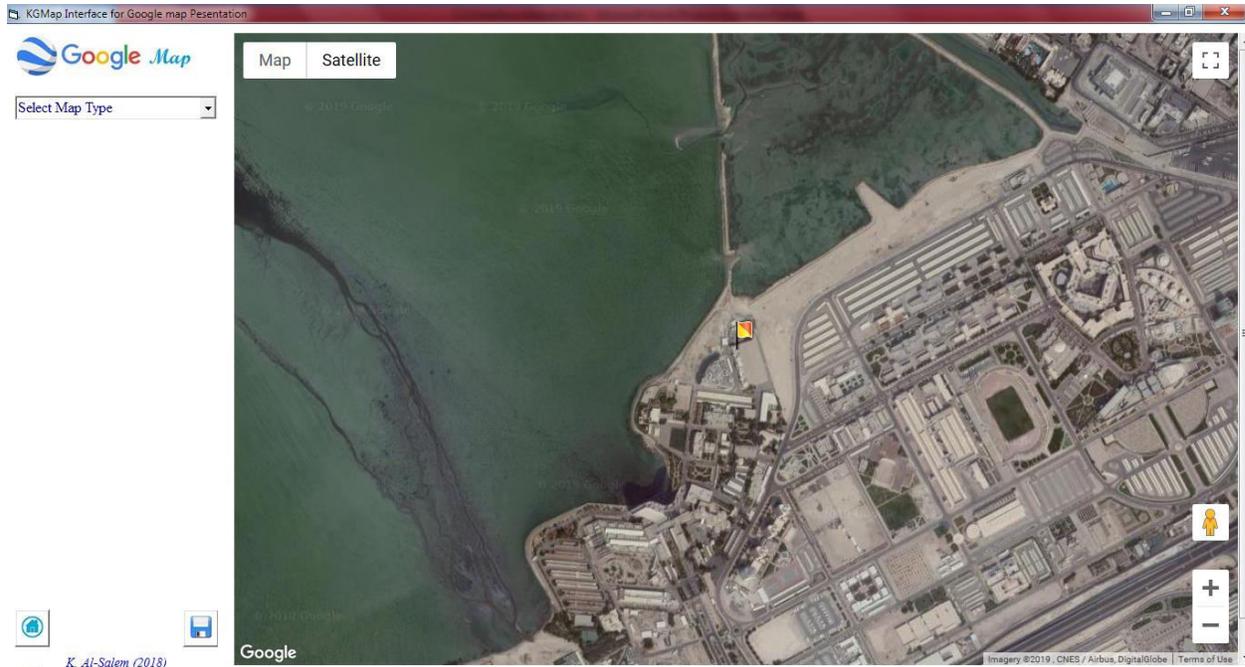

Figure 232

From Fig 232 user must select [*Star*t]. Fig 233 will display a map of KISR on Google map with a number of options user should select from dropdown list as follow:

1. *1D Map*
2. *2D Map*
3. *My office*
4. *File Optimizing*

Figure 233

Sub_option 1

If user select [*1D map*] as shown in Fig 234 a number of information require to enter as follows:
User must select data format as:

        X,Y data
        X,Y,Z data

User must select [*input file name*]

User allow to set the Google map Zooming by select from dropdown list in *[Map zoom Fator]*

Then to show the data on Google map by Select [*Display Google Map*] Fig 235 will display for user the data place on Google Map and Map Center Location [Longitude/Latitude in Degrees].

To Export or print the image map user must select [*SAVE*] a new Frame will appear as shown in Fig 236 for user to Select the following:

- *Print Image*
- *Save AS HTML file [To create HTML file for present Google map as standalone file]*
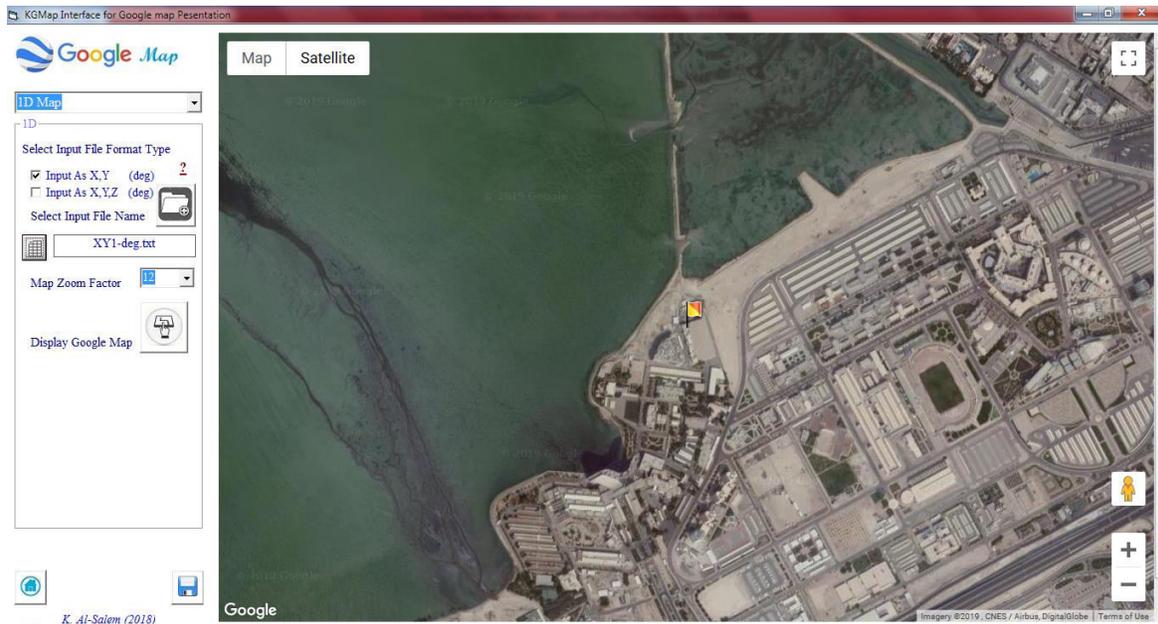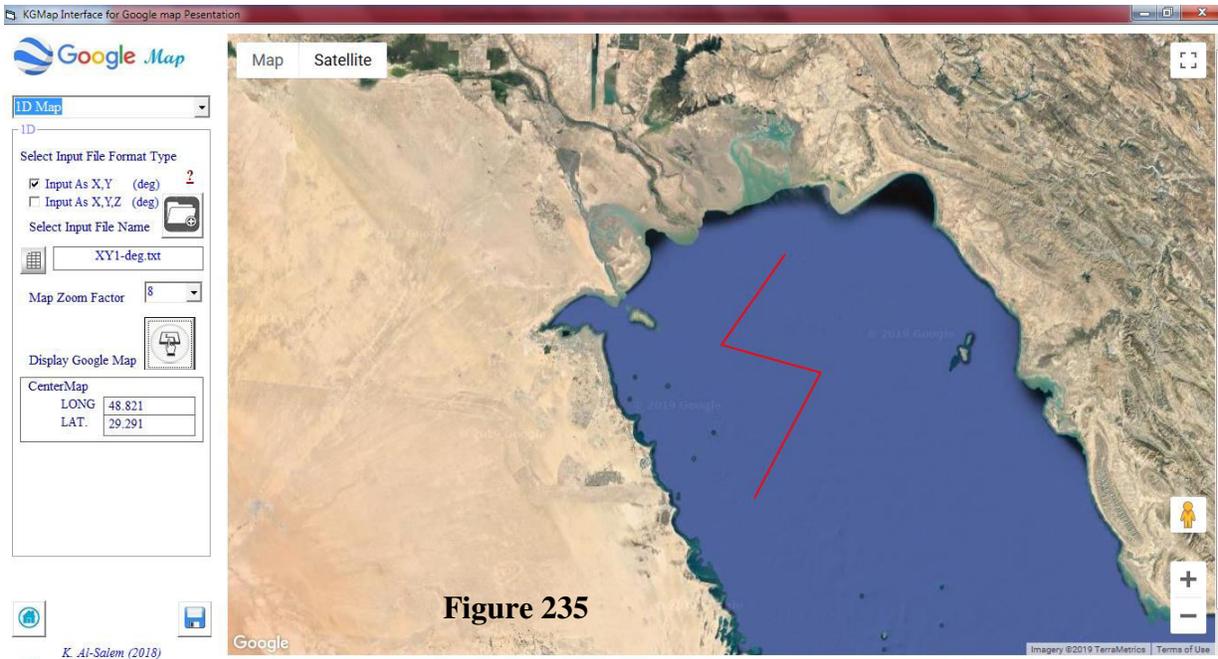
Figure 234

Figure 235

Figure 236

Sub_option 2

If user select [*2D map*] as shown in Fig 233 a number of information require to enter as follows:
User must select data format as:

> X,Y data
> X,Y,Z data
> Input as 2D

User must select [*input file name]*.
User allow to set the Google map Zooming by select from dropdown list in *[Map zoom Fator]*
User must select [Minimum Data] as follow:

> Manual Enter the minimum data values by CHECK ON
> Model calculate the minimum value by   CHECK OFF

To convert the input from UTM to Degree user Check On [in main data was in UTM] Fig 237
Then user must Select [*LOAD*] to start setup the data for Google map presentation.
To show the data on Google map user have check on of the following:

- Contour Map as shown in Fig 238
- Contour Dot Map as shown in 239

To Export or print the image map user must select [*SAVE*] a new Frame will appear as shown in Fig 237 for user to Select the following:

- *Print Image*
- *Save AS HTML file [To create HTML file for present Google map as standalone file]*

Sample of HTML file AUTO-created from KGMap model list below.
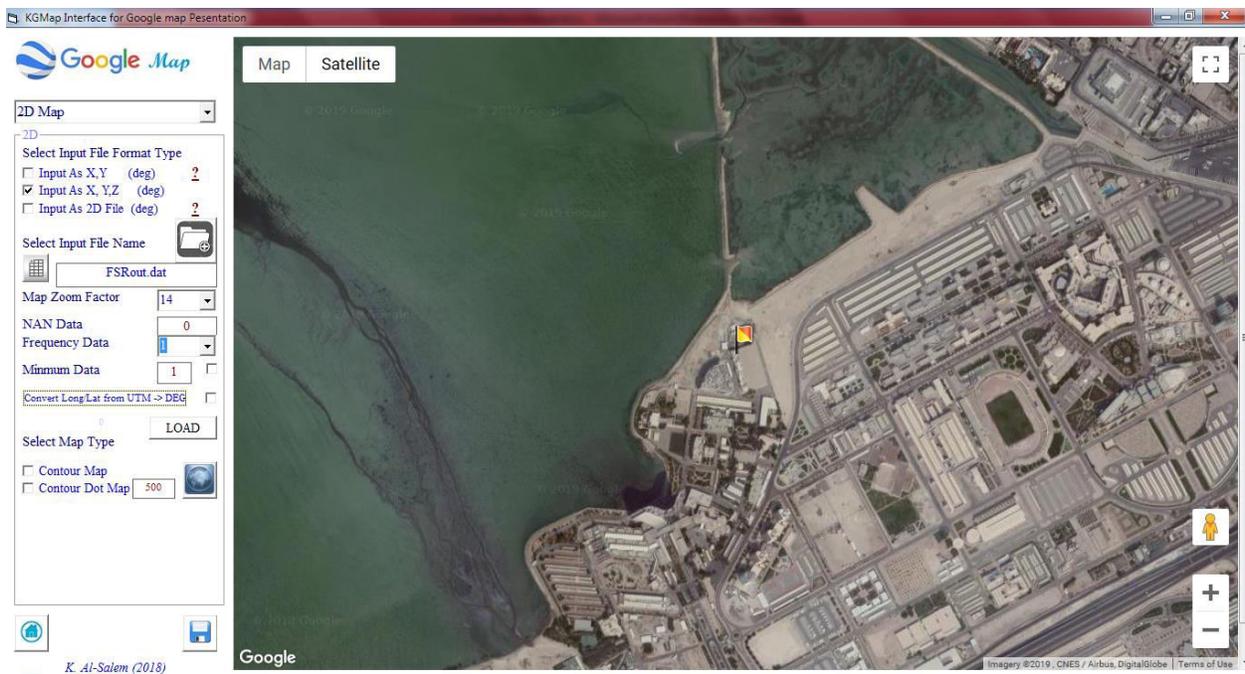
Figure 237

Figure 238
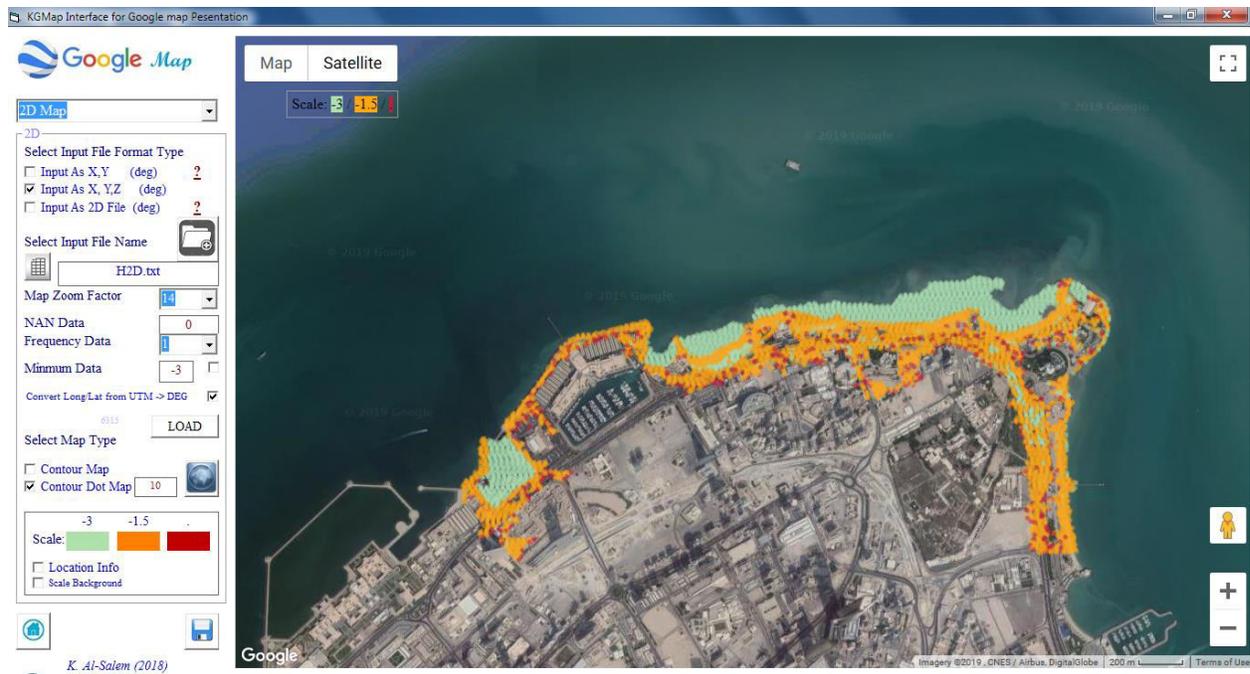
Figure 239

Sample of HTML file Created from KGMap model

```
<!DOCTYPE html>
<html>
<head>
<meta http-equiv="content-type" content="text/html;charset=utf-8"/>
<meta http-equiv="X-UA-Compatible" content="IE=edge">

  <title>C.I.S.</title>
  <style>
   #map {        height: 100%;
   }
   html, body {
     height: 100%;
     margin: 0;
     padding: 0;
   }
  </style>
</head>
  <script>
   function initMap() {
     var map = new google.maps.Map(document.getElementById("map"), {
       zoom:8,
       center: {lat: 29.291,lng: 48.821},
       mapTypeId: "satellite"
     });
     var flightPlanCoordinates = [
       new google.maps.LatLng(29.772,49.214),
       new google.maps.LatLng(29.291,48.821),
       new google.maps.LatLng(29.142,49.431),
       new google.maps.LatLng(28.467,49.027)
     ];
     var flightPath = new google.maps.Polyline({
       path: flightPlanCoordinates,
       geodesic: true,
       strokeColor: "#FF0000",
       strokeOpacity: 1.0,
       strokeWeight: 2
     });
     flightPath.setMap(map);
   }
  </script><script src="http://maps.googleapis.com/maps/api/js?key=AIzaSyBG5W9UEomYpNK38QmpobKVRk6YKZ4ICy0"
type="text/javascript">
</script>
<body onload="initMap()"  >
<div id="map" ></div>
<br clear="all"/>
<br/>

</body>
</html>
```

Sub_Option 4

File optimizing it is Toole to reduce the file data records since we are dealing with internet option with Google maple it not except large number of data to plot on Google map.

If user select [***File Optimized***] as shown in Fig 240 a number of information require to enter as follows:

User must select data format as:

X,Y data

X,Y,Z data

User must select [*input file name]*

User must select *[Output file name]*

User must select [*First line Ndata On/OFF*]

User must select the approximate minimum value [Select big –value if water example -100]

User allow to select [*Frequency Data]* that will user select how much the will reduce.

Then user must select [*Update*]. A number of information will appear in Fig 161 as follows:

- *Updated Recodes*
- *Original Records*
- *Min- Z value*
- *Max Z Value*

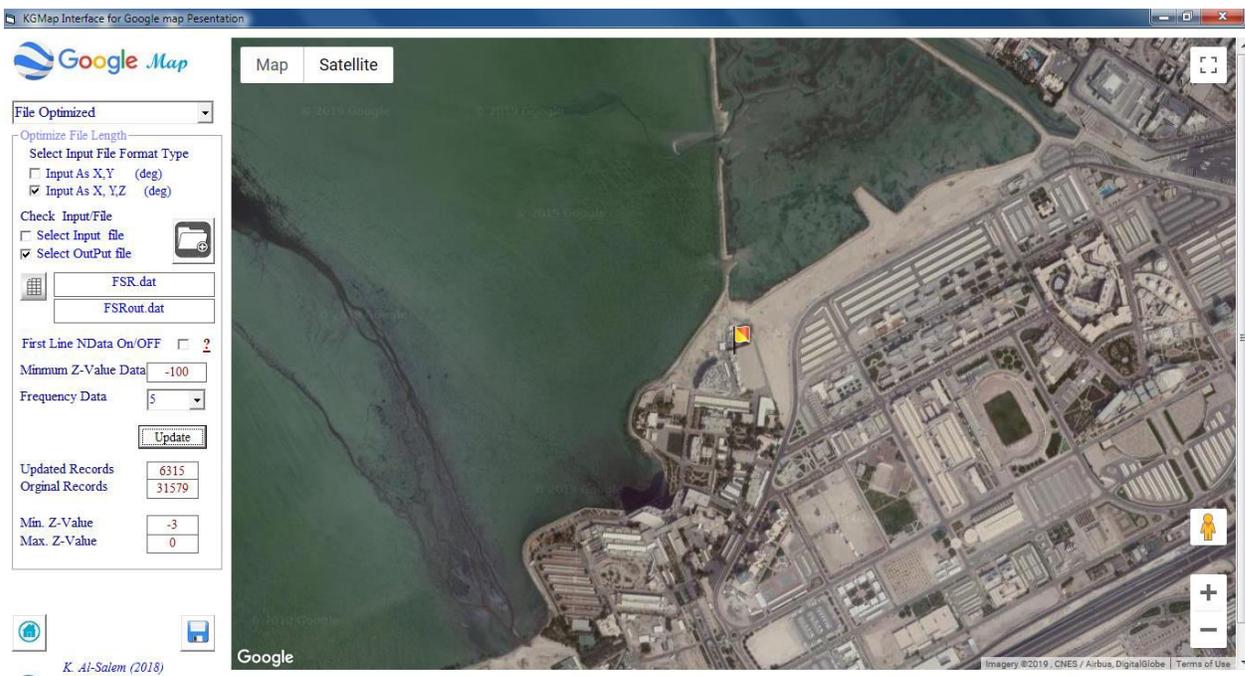**Then that new create output File should use in Sub-Option 1 or 2 Google map Presentation**

Figure 240

5.2 Create Map File for RMA10 /KHarbor [KMap program]
[Khaled Al-Salem 2010]

Model Description

KMap program it is numerical tool for seting up an input data from the following model:
- RMA10 model
- KHarbor model
- A bathymetry data for a request
- KSurge model

To Run the program user must select [*KMap*] a Fig 241 will display

Then user Select [*File*] a number of option will display for the following:
- Digitize MAP . Figs 242 and 243 will display for Coastline and Bathymetry Digitize
- RMA-R10. Fig 244 and 245 will display for user to create R10 file for RMA10 model
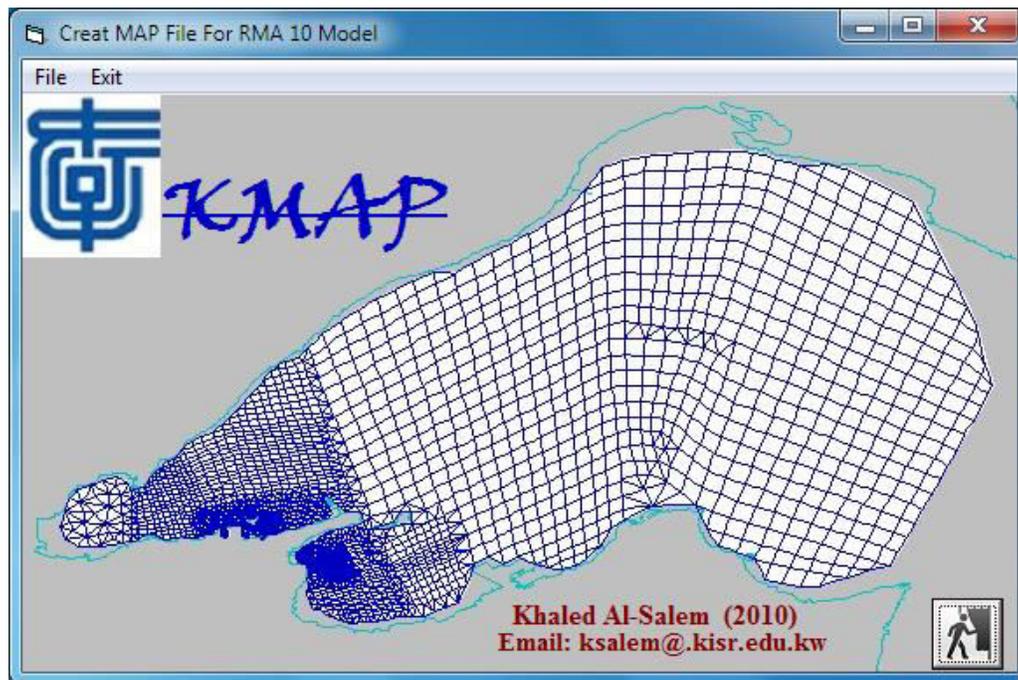- EOMAP. Fig 246 will display for user to extract 2D bathymetry and topography data .
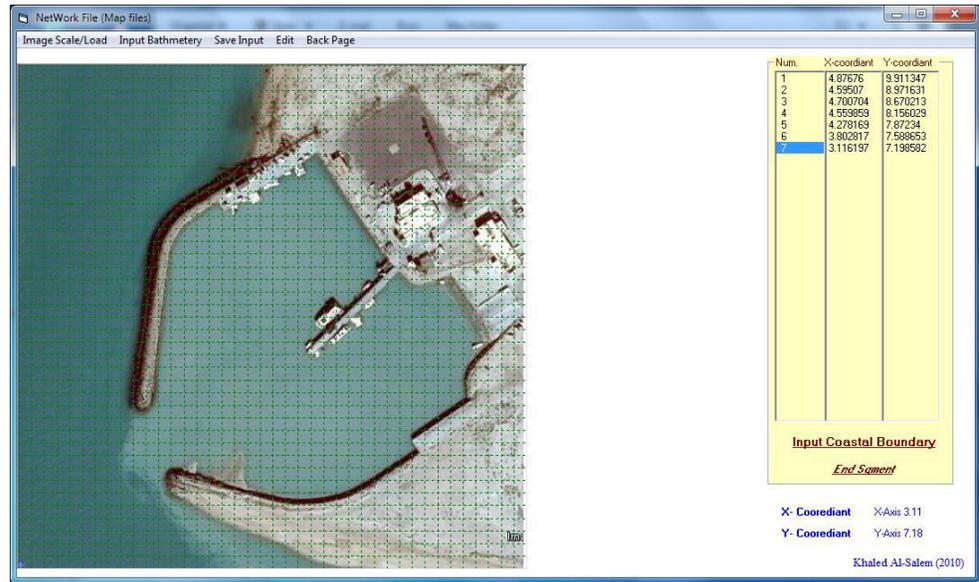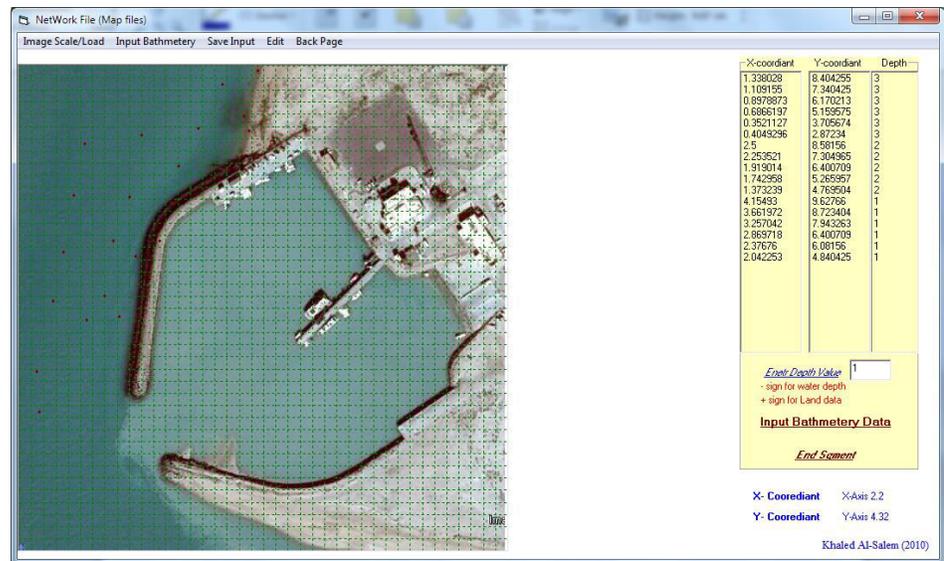

Figure 241
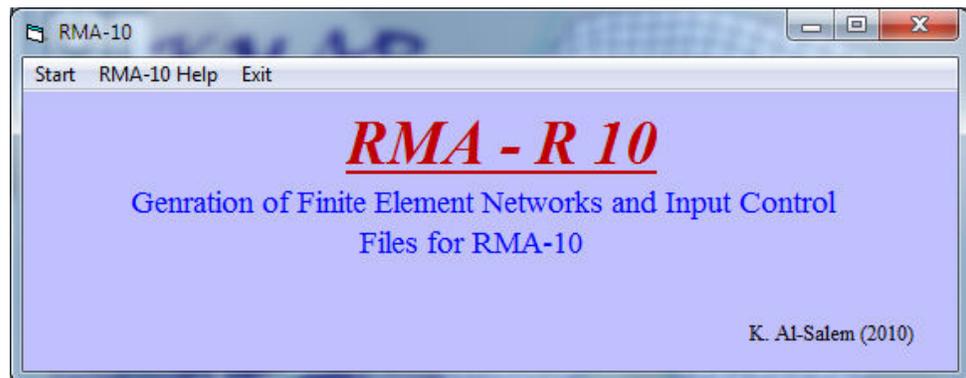
Figure 242
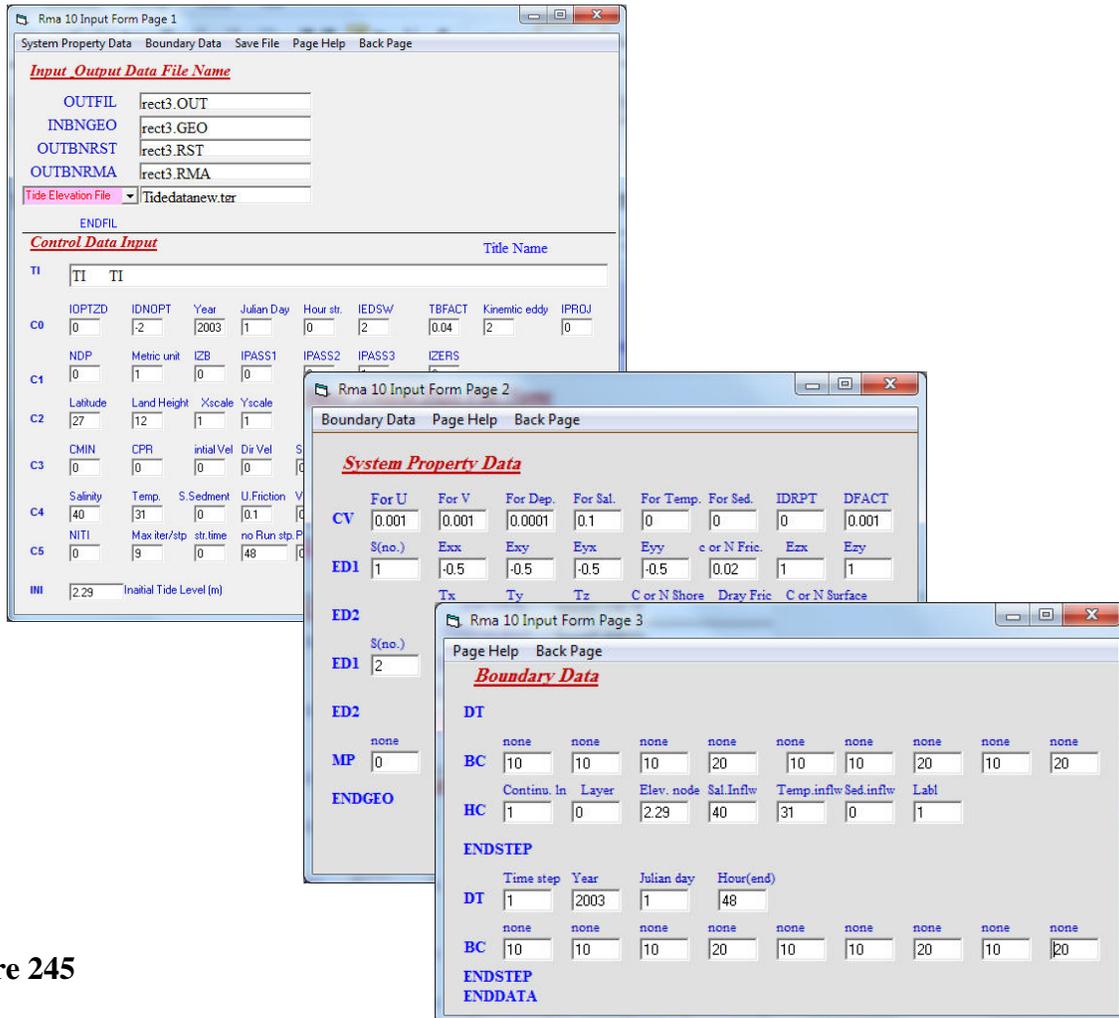
Figure 243

Figure 244
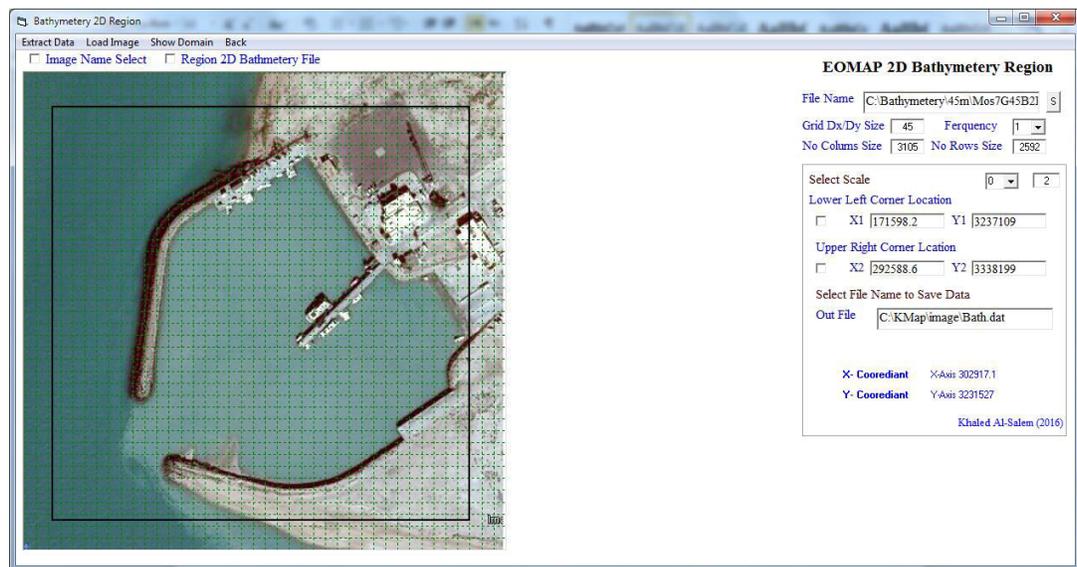
Figure 245

Figure 246

5.3 Geographical Conversion Model [KUtm Program]

[*Khaled Al-Salem 2009*]

KUtm program it is conversion tools for the following:
  I. Map information
      o Point on map conversion as shown in Fig 247
      o Find map distance and conversion as shown in Fig 248
  II. Data Conversion as shown in Fig 249
      o Geographical to UTM
      o UTM To Geographical
      o Geographical To KUDAMS/KTM

Figure 247

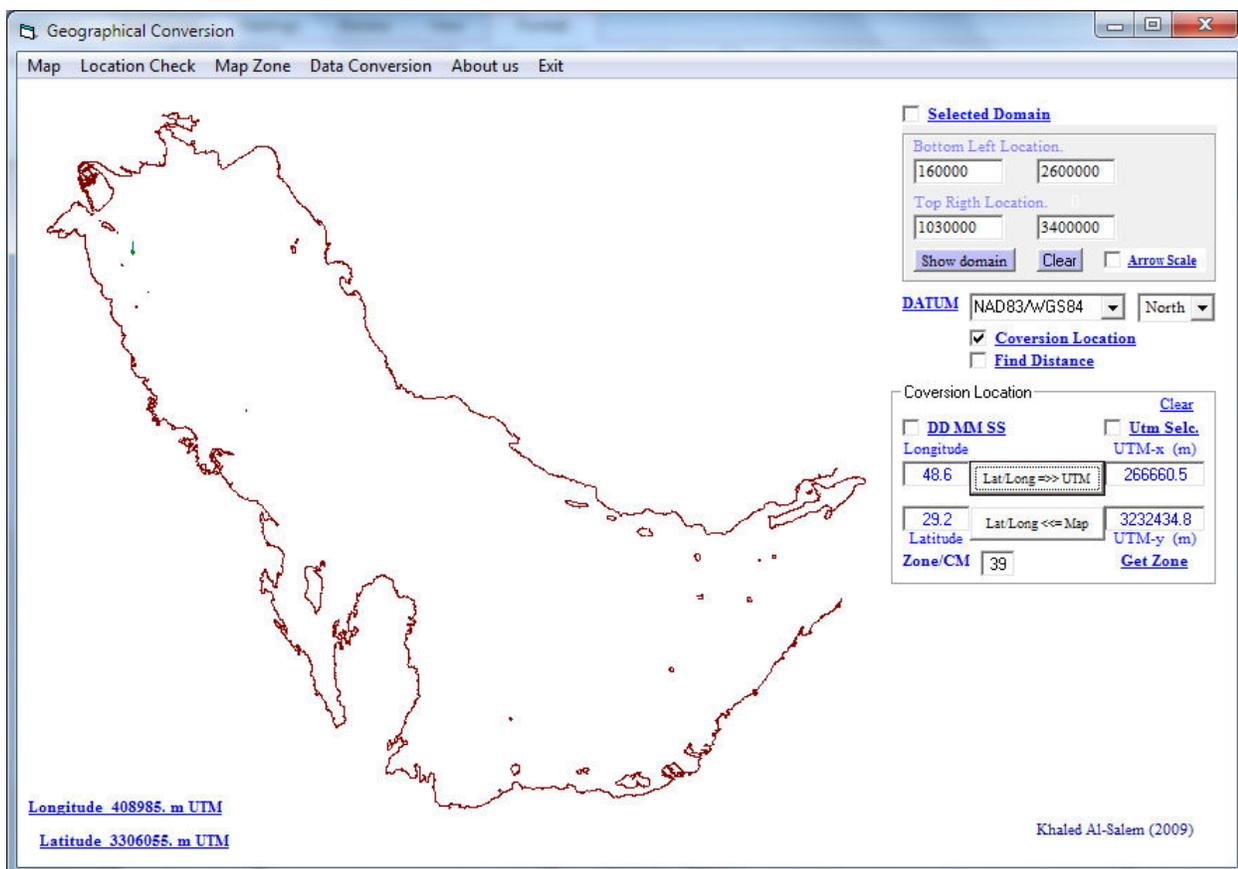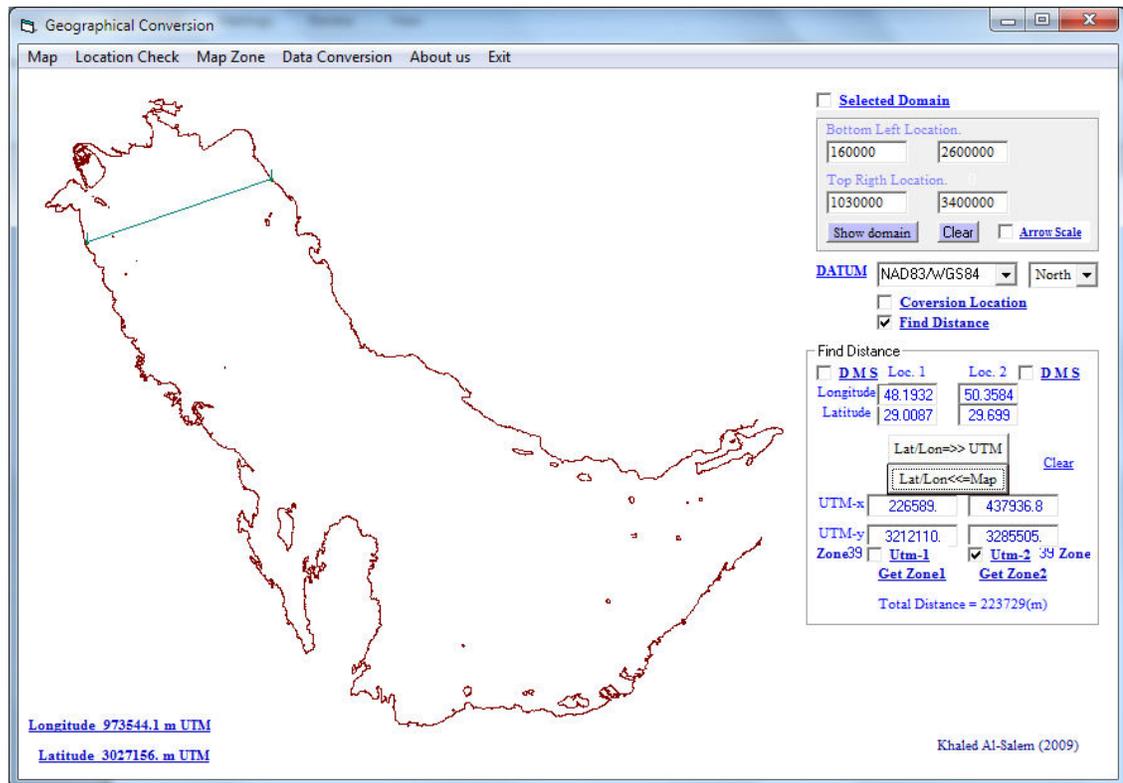**Figure 248**
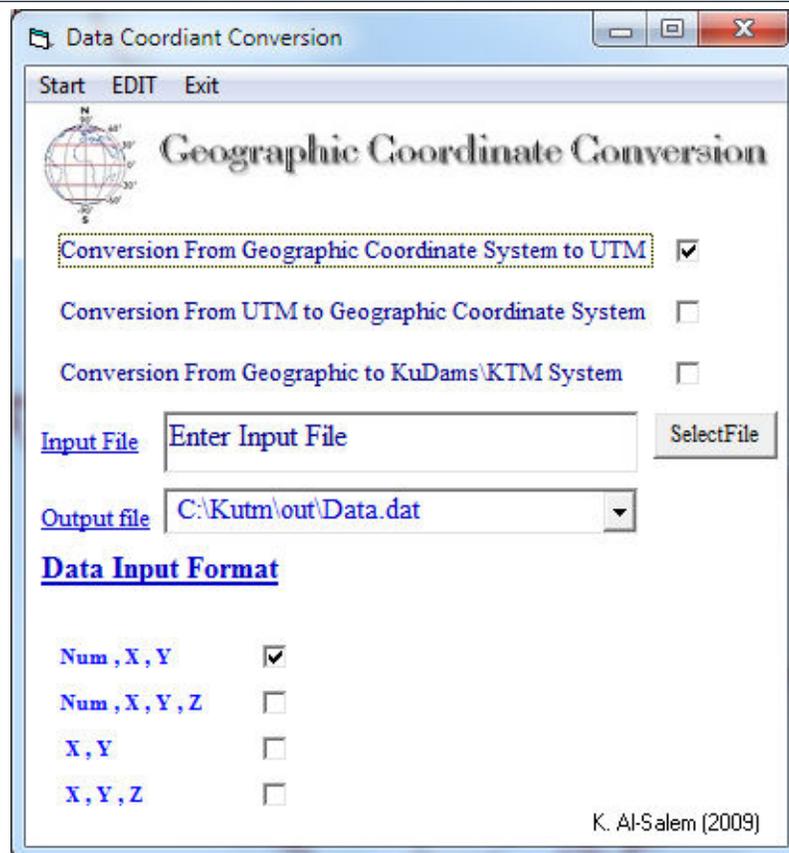
Figure 249

6. Hydraulics Costal Engineering application On Smart Devices [Mobil application]

[Khaled Al-Salem 2007-2017]

Hydraulics Costal engineering application was developed on Smart Devices for the following:
[KGulf Apps 2D, 2011] hydrodynamic prediction for Arabian Gulf
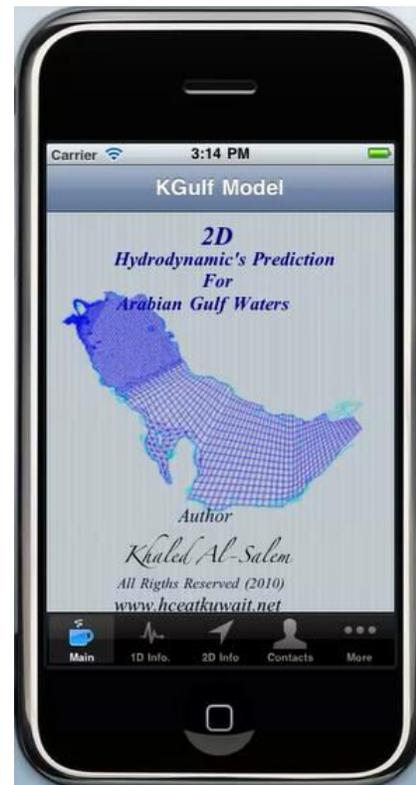
[KTide Apps 2010] For Water level Prediction for Kuwait and Arabian Gulf Water
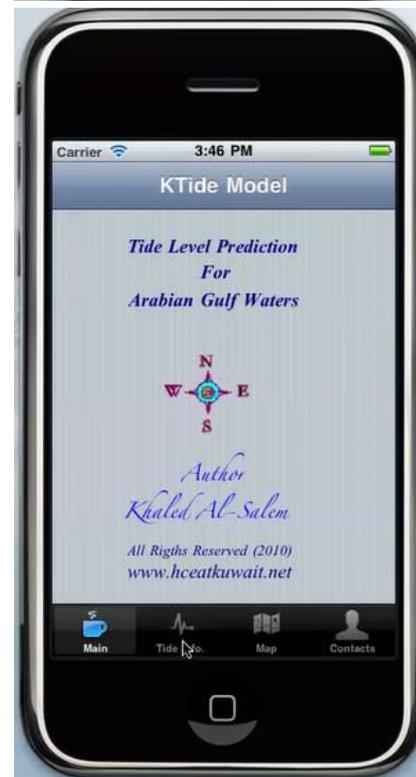
[Q8CIS Apps 2011] For Global Water level Prediction and
1D Hydrodynamic For Arabian Gulf waters
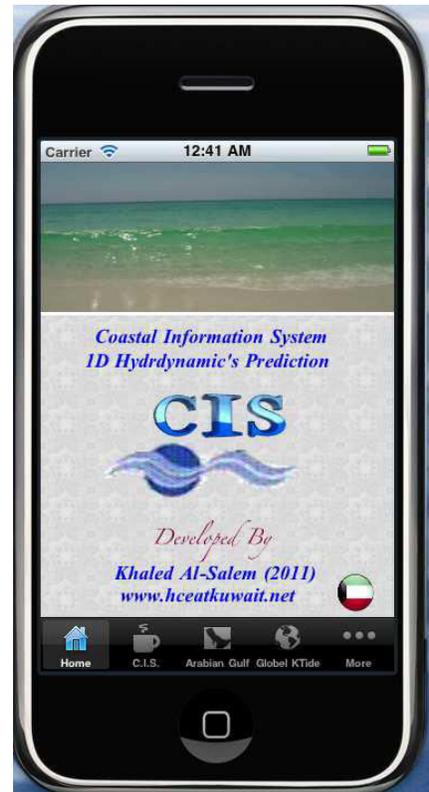
[KBrod Apps 2012] For Online Broadcast for
hydrodynamic and Met Forecast for GCC and Kuwait

[KForc Apps 2011] For Kuwait Waters Hydrodynamic Forecast

[KSurge Apps 2011] For Extreme water Level Prediction
for Arabian Gulf
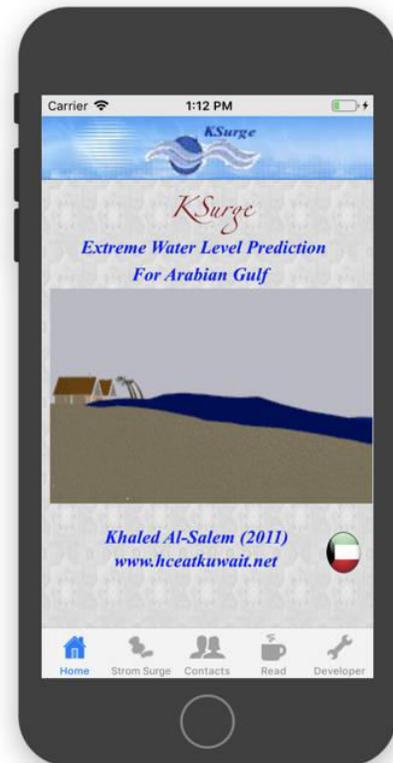
[KOil Apps 2011] For Oil Spill Trajectory Prediction in Arabian Gulf waters

[BOil Apps 2013] For Back Track Oil Spill In Arabian Gulf
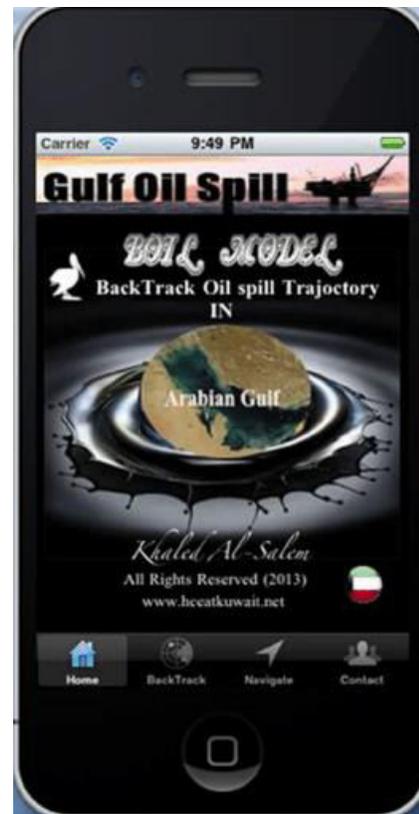
[KUnami Apps 2016] For Tsunami Warning
  System
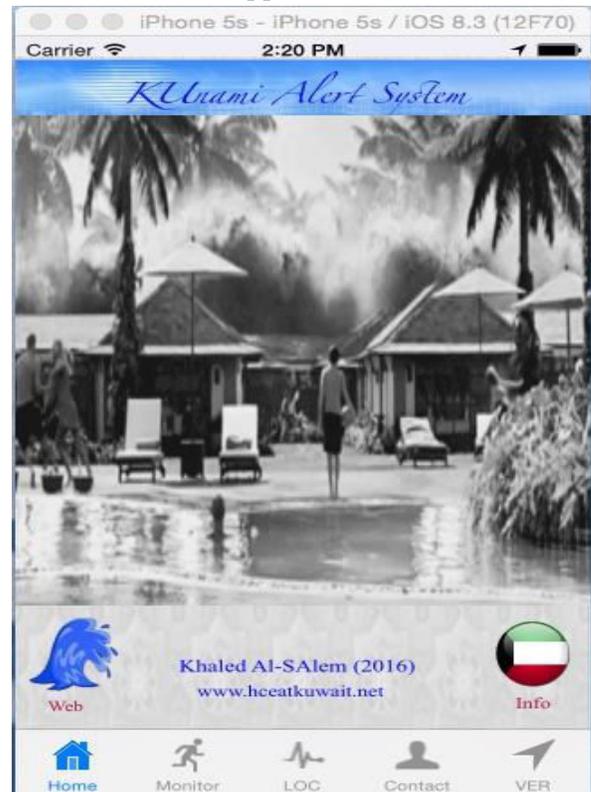
[KPlume Apps 2011] For Gaussian Plume Dispersion
application

[KTrack Apps 2013] for Record Geographical Location and online track location

7. Hydraulics Costal Engineering application on [http://www.hceatkuwait.net/web_pas/main.aspx]

[Khaled Al-Salem 2006]

Hceatkuwait.net it is a remote website for Hydrodynamic Prediction and Forecast for Arabian Gulf and Kuwait Waters numerical models

Hydrodynamic Predictions System for Kuwait Territorial Waters

The System will provide useful information to scientists, engineers and the general public on the hydrodynamic conditions in the Kuwaiti territorial waters. One of the main purposes is to provide online daily hydrodynamic forecasting of some of the important oceanographic parameters of Kuwaiti coastal waters and the Arabian Gulf.

Kuwait RealTime Hydrodynamic Virtual Monitoring System (Khydro System)

Khydro system was developed by (Al-Salem K., 2008) for hydrodynamic virtual monitoring in real-time for Kuwaiti territorial waters, it is an efficient and easy-to-use system. Although more advanced features are anticipated to evolve in the future, this version is sufficiently user-friendly and can provide and displays highly detailed output of hydrodynamics virtual monitoring information in real-time for Kuwait Water's.

Digital Hydrodynamics' Forecast for Kuwait Water's (DHF system)

DHF is an Operational forecast systems provide hourly nowcasts and short-term (one day) forecasts that are updated every 24 hours of water levels and currents, wave height, wave period, wind speed and air temperature. Because these predictions are based on a hydrodynamic model, they are considered to be computer-generated forecast guidance. System developed by (Alsalem K., 2009)

Global Tide Level Prediction Model (Global KTide Model)

Global KTide model was developed by (Al-Salem K., 2011) for Global Water Level Prediction. This version is sufficiently user-friendly and can provide the base information for water tide elevation for Global Regions (Asia, Africa, Europe, North America and South America). The information provided by this model can be further used to calculate sediment/pollutant transport and used as input for tidal circulation models.

Kuwait Tide Level Prediction Model (Ktide Model)

Tide model Model was developed by (Al-Salem K., 2004) for Kuwaiti territorial waters and the Arabian Gulf, it is an efficient and easy-to-use model. Although more advanced features are anticipated to evolve in the future, this version is sufficiently user-friendly and can provide the base information for water tide elevation for Kuwaiti Waters and the Arabian Gulf. The information provided by this model can be further used to calculate sediment/pollutant transport and to predict the tidal circulation for Kuwait waters and Arabian Gulf.

Arabian Gulf 2D Tidal Current and Water Level Prediction Model (KGulf Model)

New Version of Combined 2D Tidal Current and Tide Level Predictions for Kuwait and Arabian Gulf Water. Named as KGulf Model (developed by Al-Salem K., 2009) using the tidal constituents for tidal current and water Level in the x (east) and y (north) directions were calculated for total wet grids of 3692 nodes which covers all Arabian Gulf Waters.

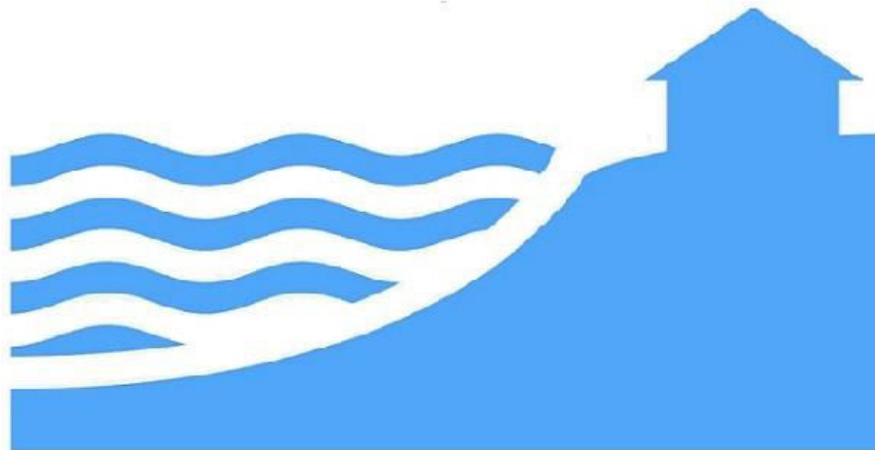### Kuwait Tidal Current Prediction Model (Kcurrent Model)

Technical Report

KSED

2020

ANNUAL LONGSHORE SEDIMENT TRANSPORT

KSED Model

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All right reserved
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Annual Long shore Sediments Transport
For
Kuwait and Arabian Gulf Waters

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Tel: 965 9901 6700

Oct. 2020

ABSTRACT

Annual longshore sediment transport rate and its cross-shore distribution in the surf zone are essential to many coastal engineering and science studies. Practical engineering applications such as beach response in the vicinity of coastal structures, beach-fill evolution and re-nourishment requirements, and sedimentation rates in navigation channels all require accurate predictions of longshore sediment transport rates. Formula proposed by Kamphuis (1991), which includes wave period, a factor that influences breaking, gave good estimates. Examination of the cross-shore distribution of longshore sediment transport indicates that there are three distinct zones of transport: the incipient breaker zone, the inner surf zone, and the swash zone, with each zone contributing a different fraction to the total transport rate. Transport in the incipient breaker zone was influenced by breaker type, transport in the inner surf zone was controlled by depth, and transport in the swash zone showed dependencies on wave height and, in particular, wave period. Swash zone transport was found to have a significant contribution to the total transport rate. Arguably the most widely used model for estimating total longshore sediment transport rate is the "CERC" formula (Shore Protection Manual, 1984). The model was based on the assumption that the total longshore sediment transport rate is proportional to longshore energy flux.

INTRODUCTION

The prediction of reliable estimates of longshore sediment transport is of considerable practical importance in coastal engineering. An example is the evaluation of sediment budgets for coastal areas with and without structures (breakwaters, groins). Another example is the long-term stability of beach protections and beach nourishments. Most research on longshore transport has concentrated on sand sized sediment, but research on longshore transport along gravel/shingle beaches, which are quite common along mid- and high-latitude (formerly glaciated) parts of the world, has been very limited.

The most widely used formula for longshore transport (LT) is the CERC equation (Shore Protection Manual, US Army Corps of Engineers, 1984). This method is based on the principle that the longshore transport rate (LT, incl. bed load and suspended load) is proportional to longshore wave power P per unit length of beach; LT=K P, with K=calibration coefficient. The CERC formula has been calibrated using field data from sand beaches. The CERC formula does not account for particle size and beach slope. It is only valid for sandy conditions. Sediment transport occurs in two ways:

1. Bed load transport, where particles roll or move in small jumps in a small layer close to the bed.
2. Suspended load transport, where particles are suspended in the water without contact with the bed. Bed load transport typically occurs for low bed shear stresses, obviously still above the critical value, while suspended load occurs with higher bed shear stresses.

In coastal waters the sediment transport processes are strongly affected by the high-frequency waves introducing oscillatory motions acting on the particles. The high-frequency (short) waves generally act as sediment stirring agents; the sediments are then transported by the mean current.

THEORETICAL ANALYSIS

In coastal waters the sediment transport processes are strongly affected by the high-frequency waves introducing oscillatory motions acting on the particles. The high-frequency (short) waves generally act as sediment stirring agents; the sediments are then transported by the mean current. Field experience over a long period of time in the coastal zone has led to the notion that storm waves cause sediments to move offshore while fair-weather waves and swell return the sediments shorewards. During conditions with low non-breaking waves, onshore-directed transport processes related to wave-asymmetry and wave-induced streaming are dominant, usually resulting in accretion processes in the beach zone. During high-energy conditions with breaking waves (storm cycles), the beach and dune zone of the coast are attacked severely by the incoming waves, usually resulting in erosion processes. For practical reasons the suspended transport in coastal waters will be subdivided into current-related and wave-related transport components. The net annual longshore transport (in m3 per year) of sand, gravel or shingle at the beach based on an annual offshore wave climate as input (total 365 days including days without wind H=0). The angle of the wave propagation vector is defined with respect to the north, see Figure 1, this direction differs 180 degrees from the direction from which the waves are coming. Similarly, the angle of the shore normal is also defined with respect to the north. Refraction theory is used to determine the nearshore wave climate. Three longshore transport formulas as [CERC, Kamphuis and van Rijn] will be used in KSED program for prediction of Annual longshore sediments transport.
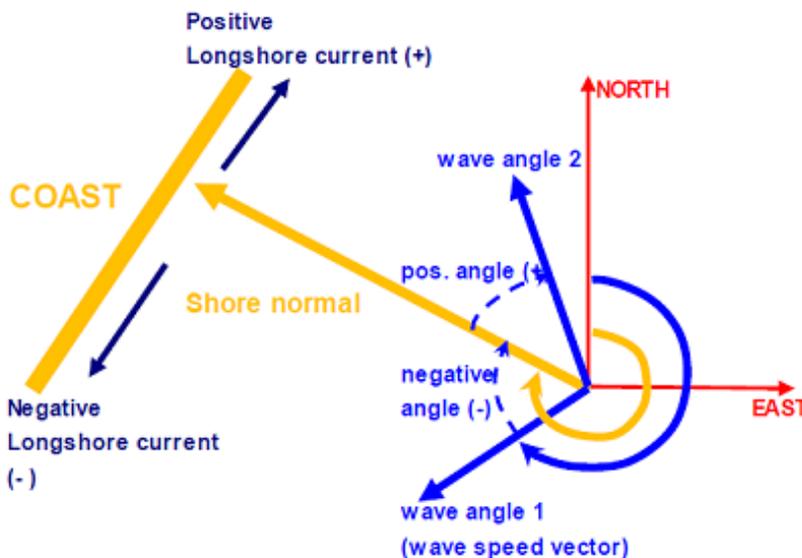

Figure   1   Definition of the angle of wave propagation with respect to the coast.

The Kamphuis (1991) method is given by:

$$Q_{t-mass} = 2.33\rho_s/(\rho_s - \rho)(T_p)^{1.5}(tan\beta)^{0.75}(d_{50})^{-0.25}(H_{s,br})^2[\sin(2\theta_{br})]^{0.6}$$

Where:
Q_{t-mass}= longshore sediment (dry mass in kg/s)
$H_{s,br}$=significant wave height at breaker line (m);
θ_{br}=wave angle at breaker line (°)
d_{50}=median particle size in surf zone (m)
$tan\beta$ = beach slope
T_p = peak wave period
 p= porosity factor (0.4).
The modified Kamphuis (Mil-Homens et al., 2013) method is given by:

$$Q_{t-mass} = 1.5\rho_s/(\rho_s - \rho)(T_p)^{0.89}(tan\beta)^{0.86}(d_{50})^{-0.69}(H_{s,br})^{2.75}[\sin(2\theta_{br})]^{0.5}$$

In CERC formula (Shore Protection Manual, 1984) the model, based on the assumption that the total longshore sediment transport rate is proportional to longshore energy flux, is given as:

$$Q_{t,mass} = 0.023(1 - p)\rho_s g^{0.5}(\gamma_{br})(H_{s,br})^{\frac{5}{2}}[\sin(2\theta_{br})]$$

Using:
p = porosity = 0.4
ρs = 2650 kg/m^3
γbr = breaking coefficient = 0.8
$$Q_{t,mass} = 128(H_{s,br})^{\frac{5}{2}}[\sin(2\theta_{br})]$$

with:
$Q_{t,mass}$ = longshore transport rate (dry mass, in kg/s),
$H_{s,br}$ = significant wave height at breaker line;
θ_{br} = wave angle at breaker line (between wave crest line and coastline; or between wave
        Propagation direction and shore normal direction).
The coefficient 128 has dimensions and $H_{s,br}$ is in meters. The most important parameters are the wave height and the wave angle. The second equation is a rather crude formula, not showing any influence of the particle diameter and the beach/surf zone slope. Therefore, the CERC-formula is only valid for a narrow range of conditions as represented by the calibration data. The formula is most valid for sandy ocean coasts.

   Formula of Van Rijn (2014) is given, which is a simple general expression for the computation of longshore transport of sand, gravel, and shingle (0.1 to 100 mm). The effects of additional currents due to tide and wind are included. The longshore sediment transport according to Van Rijn (2014) is:

$$Q_{t,mass} = 0.00018 K_{swell} \rho_s g^{0.5} (tan\beta)^{0.4} (d_{50})^{-0.6} (H_{s,br})^{3.1} [\sin(2\theta_{br})]$$

With:

K_{swell} = Swell factor.

The above equation includes the effect of swell waves. Low-period swell waves in the range of 1 to 2 m produce significantly larger transport rates (factor 1.5) compared to wind waves of the same height (H_{rms} = H). This effect can to some extent be taken into account by using a correction factor to the longshore transport rate, if the percentage of swell waves (in terms of wave height) of the total wave height record is known. Herein, it is proposed to use a swell factor, as follows:

$$K_{swell} = 1.5 \left(\frac{p_{swell}}{100}\right) + 1 \left(1 - \frac{p_{swell}}{100}\right) = 0.015\, p_{swell} + (1 - 0.01\, p_{swell})$$

With:

p_{swell} = percentage of low-period swell wave heights of the total wave height record (about 10% to 20% for sea coasts and 20% to 30% for ocean coasts). Some values are: K_{swell} =1.05 for p_{swell} =10%; K_{swell} =1.1 for p_{swell} =20% and K_{swell} =1.5 for p_{swell} =100%. If swell is absent (or unknown), then K_{swell} = 1. The equation can also be expressed, as:

$$Q_{t,mass} = 0.0006 K_{swell} \rho_s (tan\beta)^{0.4} (d_{50})^{-0.6} (H_{s,br})^{2.6} [V_{wave}]$$

Where

$$V_{wave} = 0.3 (gH_{s,br})^{0.5} (sin2\theta_{br})$$

with:

V_{wave} = wave-induced longshore current velocity (m/s) averaged over the cross-section of the surf zone based on the work of Bagnold (1963) and Komar (1979).

This equation is linear in velocity. Additional velocities in the surf zone due to tide and wind can be simply taken into account by schematizing the tidal period in two blocks, as follows

$$V_{total} = V_{wave} + 0.01p_1V_1 + 0.01p_2V_2$$

Where

V_1= representative velocity in positive longshore direction due to wind and tide.

V_2= representative tidal velocity in negative longshore direction due to wind and tide.

p_1= percentage of time with positive flow (about 50%).

p_2= percentage of time with negative flow (about 50%).

The peak longshore velocities in the surf zone due to wind and tide are approximately in the range of 0.1 m/s for micro-tidal to 0.5 m/s for macro-tidal conditions. Generally, there is a slight asymmetry in the wind-generated velocities in the main wave (wind) direction. Using this approach, a slight asymmetry in the velocities due to wind and tide (V_1 larger than V_2 or reversed) can be taken into account.

The effect is zero in fully symmetric tidal flow (p_1 = 50%, p_2 = 50%, V_1 = -V_2).

KSED Model Demonstration
Internet Version
Website: WWW.hceatkuwait.net\Web_pas\KSED\KSed.aspx

User must login to website address at: WWW.hceatkuwait.net\Web_pas\KSED\KSed.aspx
Then Figure 1 will display the main KSED website page on internet as follows:
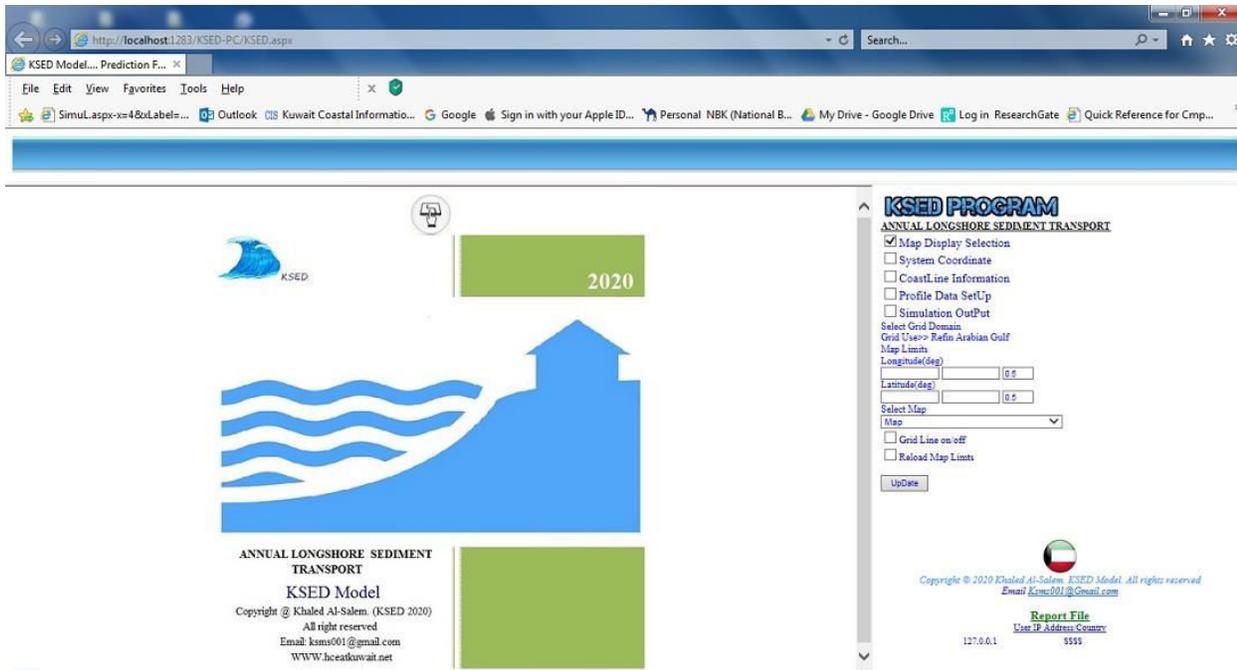

Figure 1. KSED model Website main Page.

MAP Display Selection
User should display the Arabian Gulf/Kuwait Coast map by select [Map Display Selection
Check box] from Figure 1 then a number of option will display as:
1. Selection of Different coast map of Arabian Gulf Water from [**DropBox**]
2. Check for Display X/Y axis grid line as check box[**Check On/ Uncheck OFF**]
3. If user want to reload the previous map select check on the Chekbox for [**Reload Map**]

Then from Figure 1 user must select { **UPDATE** }Button to Load and store data the selection
Then new button for Display the map will show as [**MAP SHOW**] as shown in Figure 2

System Coordinate Information
 User from Figure 1 check on [**System coordinate CheckBox**] Figure 3 will display for user to
set The coastal line information as follows
1. Coastline Reference Coordinate
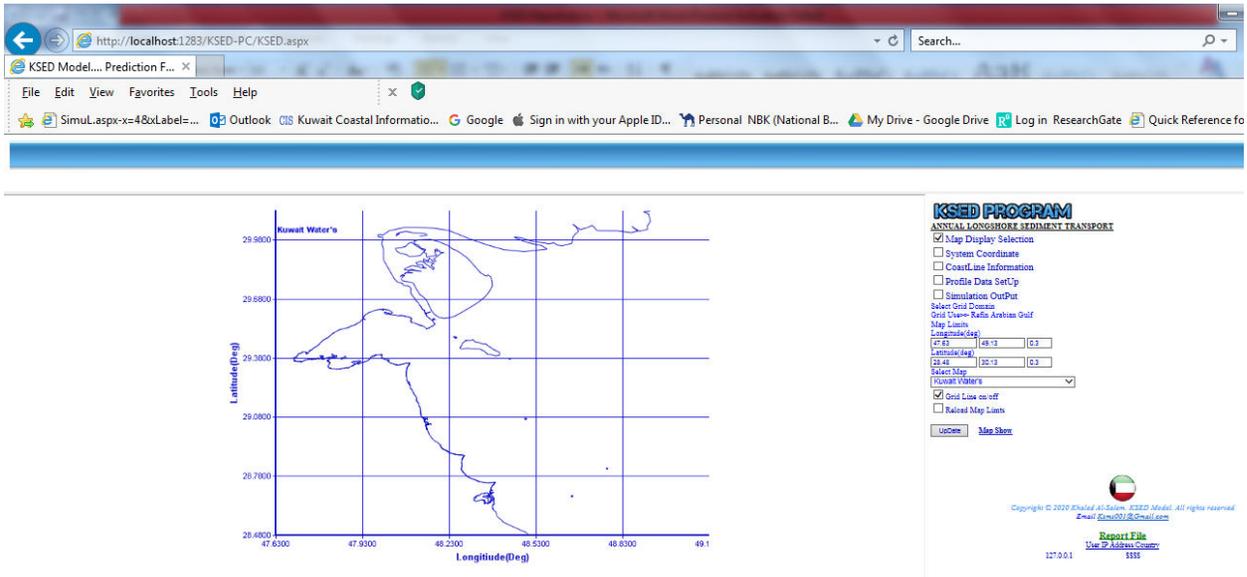2. Origin Coordinate
3. Coastline System Orientation

Figure 2. Map Display

In this setup user should select the coastline parameters data as follows
- The Upper/Lower corner data are the coastline reference map
- Origin coordinate is points close to coastline were to calculation the Azmith Angle as shows in Figure 3.
- Enter the [**Coastline Angle From North**] is the angle axis of shoreline orientation from TURE North as discussed and display in Figure 3.Figure 4 display how to calculate the Azmith angle for north.
- Enter the [**Axis-L**:] is the axis shoreline length (just for display on map for user)
- Shoreline Data should be entered as formatted data(x,y) in meters. To display a sample discussed data user select [ ] info button Figure 4 will display to data format.
- Coastline data can be upload as file to the system But for security this option can be done only by Operator [ksms001@gmail.com]. Send data to upload for user work.

User can display the coastline and the orientation of the axis by select [ ] as shown in Figure 5. Also user can update the coastline data select [ ].

Last option in this section is to assign the entered data to select profile location. A profile location is a location at coastline where the beach profile will collect to find the BEACH SLOPE angle. In KSED model can be assign up to 5 profiles location. From [**Setup Profile**] a droplist of 5 profile to select as shown in Figure 3. But user can Manually enter profile data will be discussed next sections.
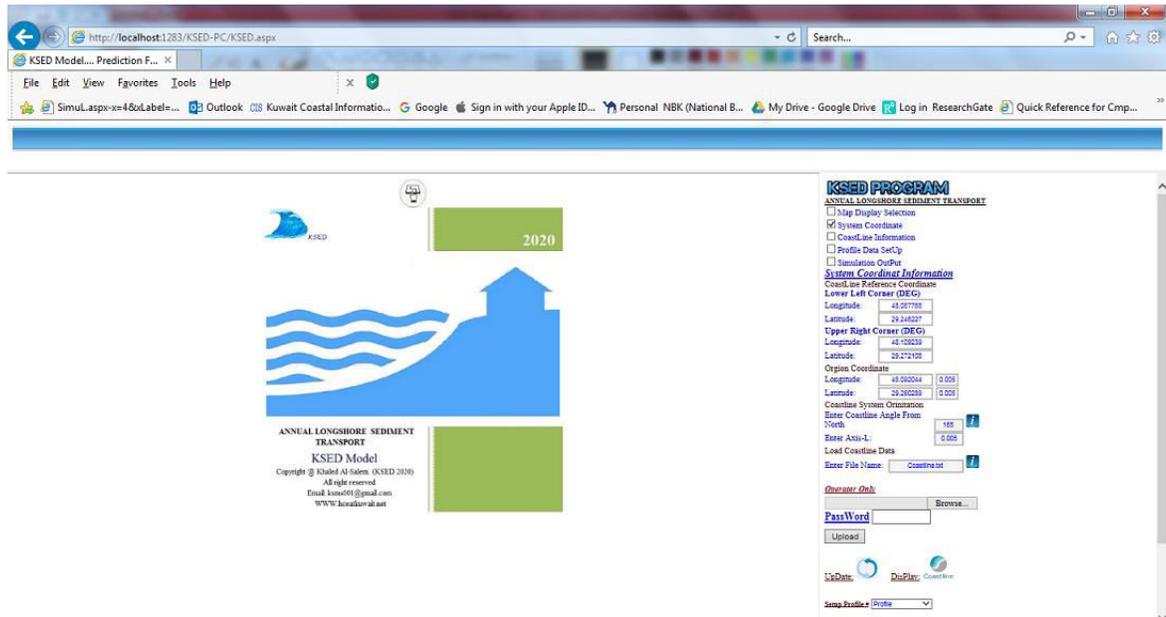
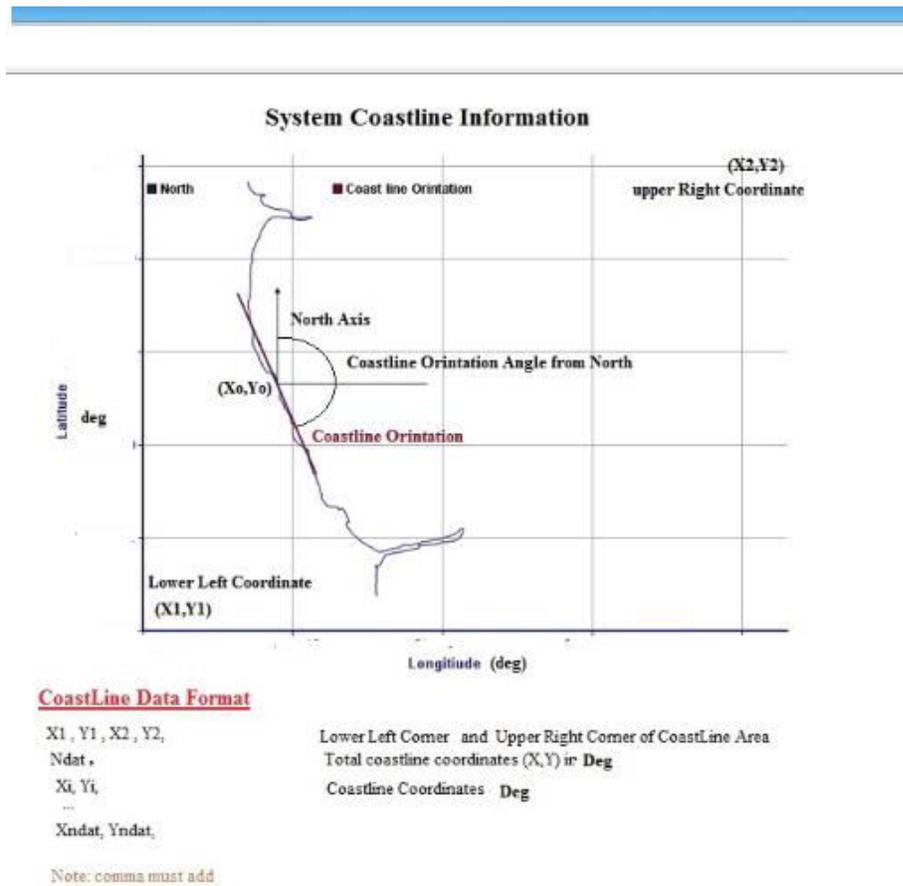**Figure 3. System Coordinate Information for Selected Coastline**
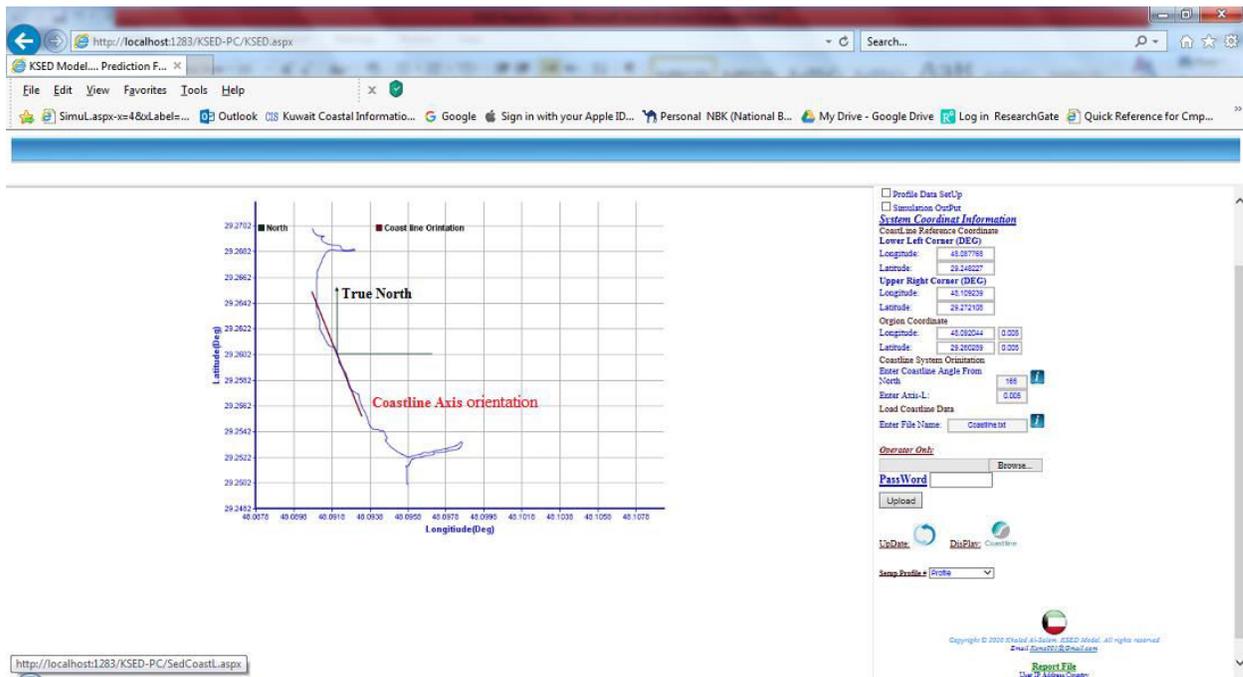

Figure 4

Figure 5. Coastline Axis Orientation Display

Coast Line Information

From Figure 3 user should check on [**Coast Line Information**] Check box to display the selected coastal parameters for sediment and Longshore currents as shown in Figure 6 for the following:

- Sediment Density.
- Bulk density of sand bed.
- Percentage of mud in bed (range of 0 to 20%).
- Percentage of offshore swell waves (H>1m, T>10s).
- Positive Tidal current vel. (50% of time).
- Negative Tidal current vel. (50% of time).
  (Tidal velocities are only applied in method Van Rijn)

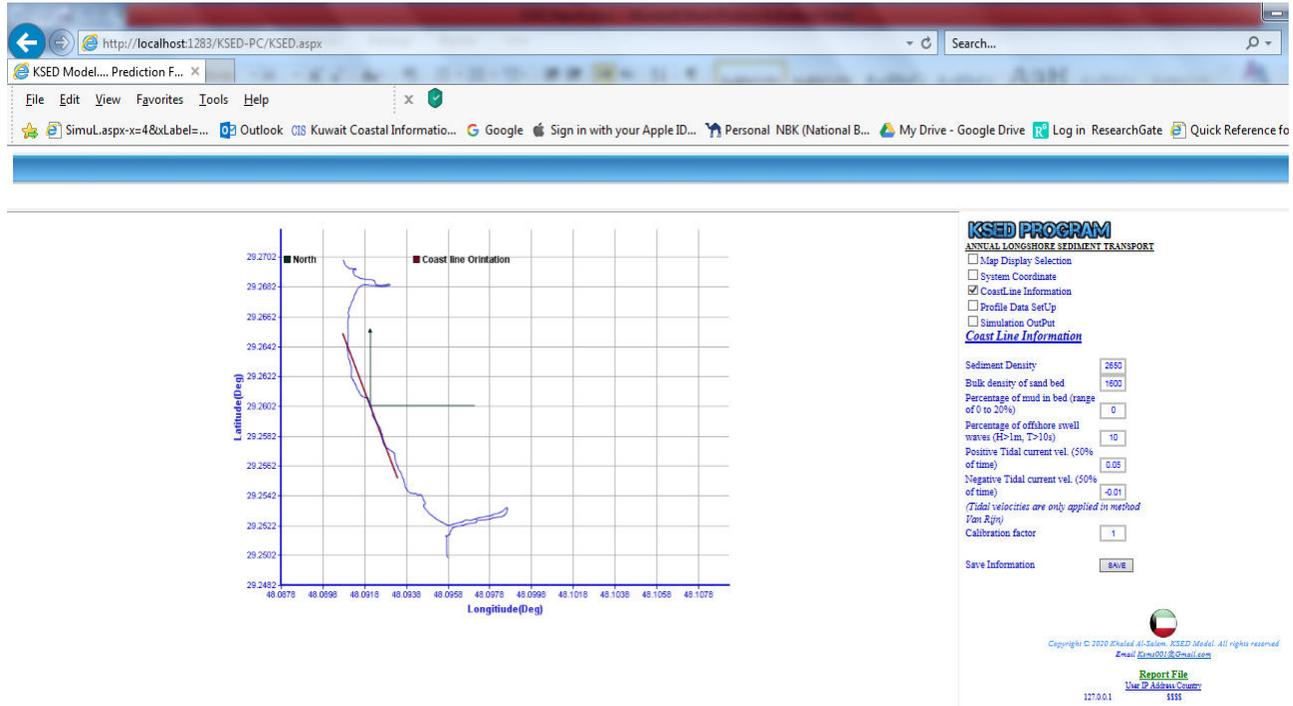Then user must save the data. The system will load the file in simulation later.

Figure 6

LONGSHORE SEDIMENT TRANSPORT

From Figure 6 user must check [**LongShore Sediment Transport**] checkbox Figure 7 will display for user to continue setup calculation sediment transport process.

In this section user must enter profile data and number of profiles to be simulated or can be reload from previous run as follow:

- User should enter Number of Profile location to be simulated
- From Droplist user select a profile parameter to be open to update data as shown in Figure 8

    Data each profile selected as:

    Profile 1
    1. Slope surf zone (slope from waterline to depth)tanB
    2. Shore Normal angle to North (deg)
    3. Sediment Size (D50) (m
    4. Offshore wave water Depth (Ho) (m

    Profile Location
    - Longitude
    - Latitude:

To find the profile slop angle for selected beach location slope of the surf zone is by select option
[ ] . From Figure 9 user calculated the slope of the surf zone of selected beach profile by the
following:

1. User must enter data of the beach profile by:
   - Enter number of Point as [NO ,]
   - Enter X,Y point for beach profile as [NOx , NOy ,] in meter
   - Note: a **comma** must follows each number
2. Or user can copy and passed the data in the text area

3. User must select [ ] to calculate the Profile Slop in Degree and the best fit
   line equation display at Figure 9.
4. User must get the slop angle to select Profile no.

Or user can Reload data from Previous Run by select **[Reload previous profile data]**

When all data profile are entered user must select [**Load Wave Index Data**] to load
Wave height, period and direction data recorded for each profile location from the database of
KSED model system and analysis the wave data for KSED model simulation.

To start simulation user must enter [ASSIGN PASSWORD] the select [Run]
To display the result user must checkbox [**Simulation Output**] From Figure 8. Figure 10 will
display for user a number of options to select as follows:

OutPut Simulation Display

1. Display Report File
   To display simulation output file as shown in Figure 11

2. Download Report File
   To download simulation output file

Plot Simulation Display
   - Calculation Methods [Motheds ▼]
     Select a simulation method to plot Annual GROSS sediment transport and Net
     Annual sediments transport as Bar graph as shown in Figure 12
   - Display==>>
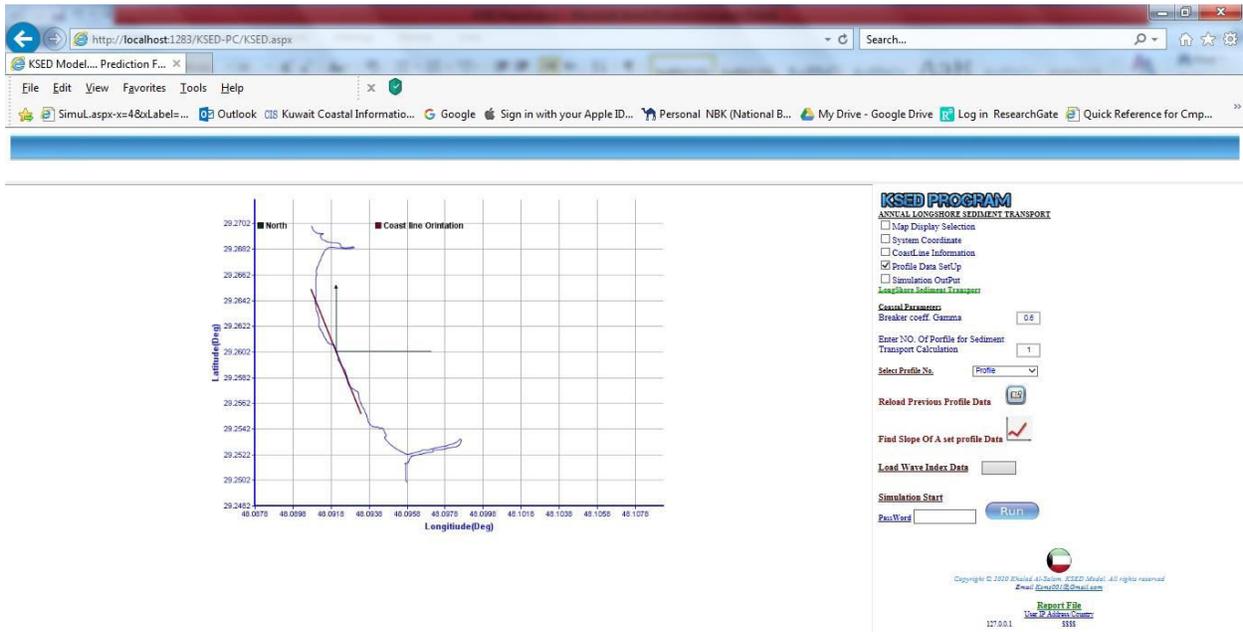   To display a select Plot as shown in Figure xxx
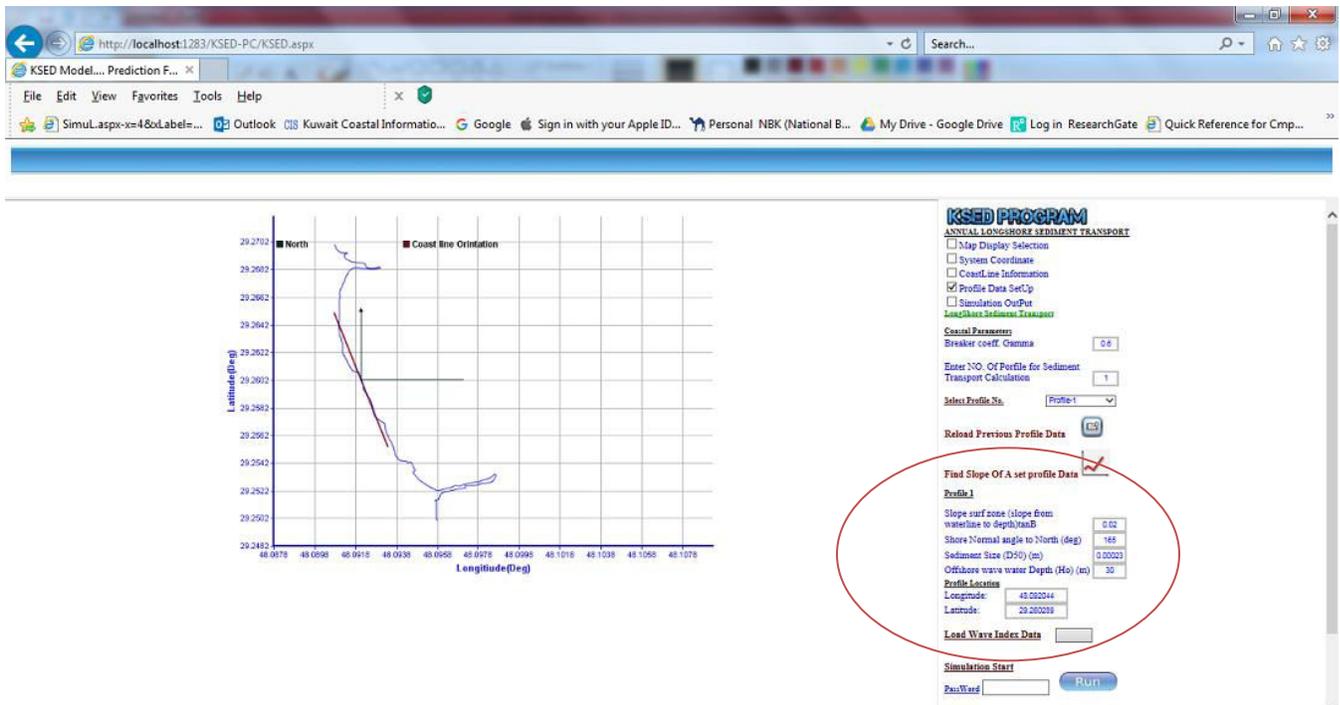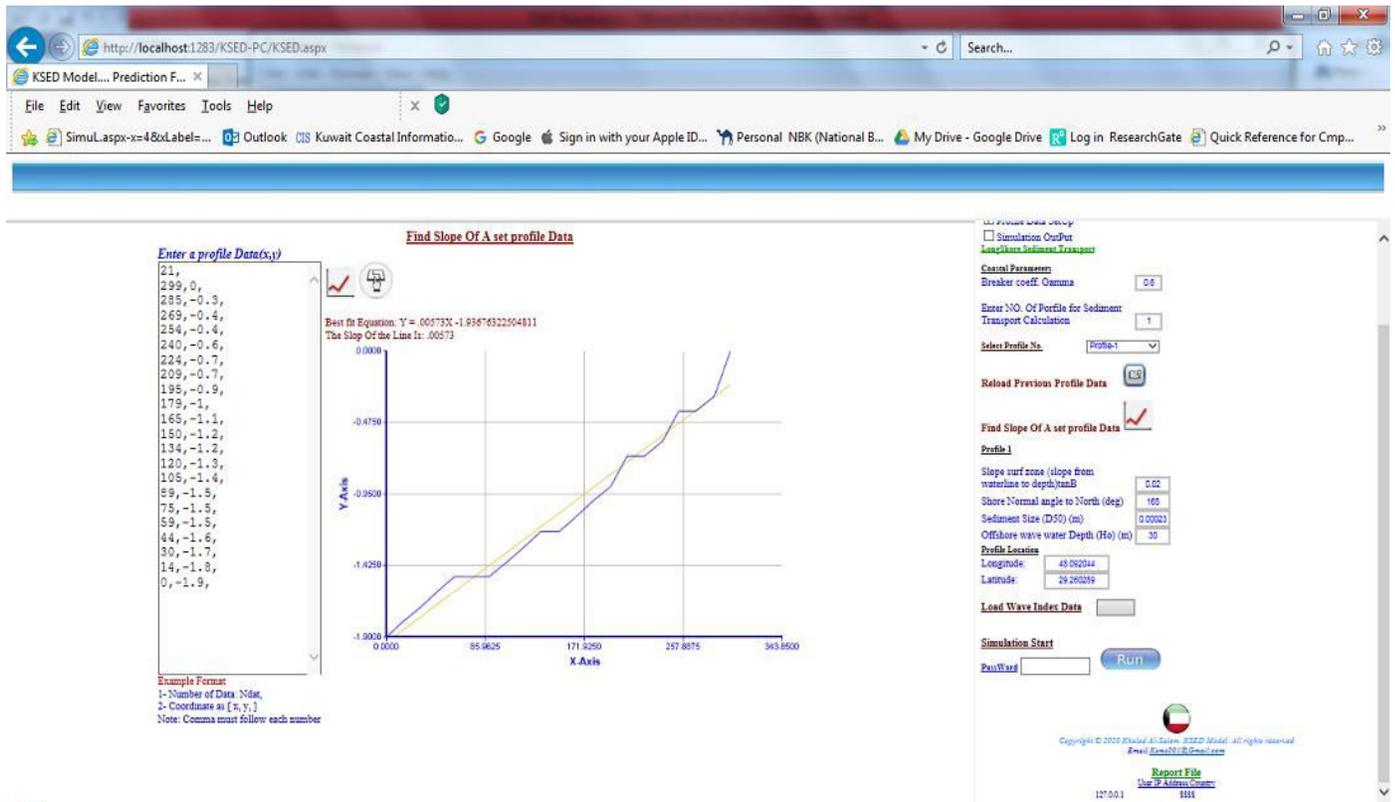

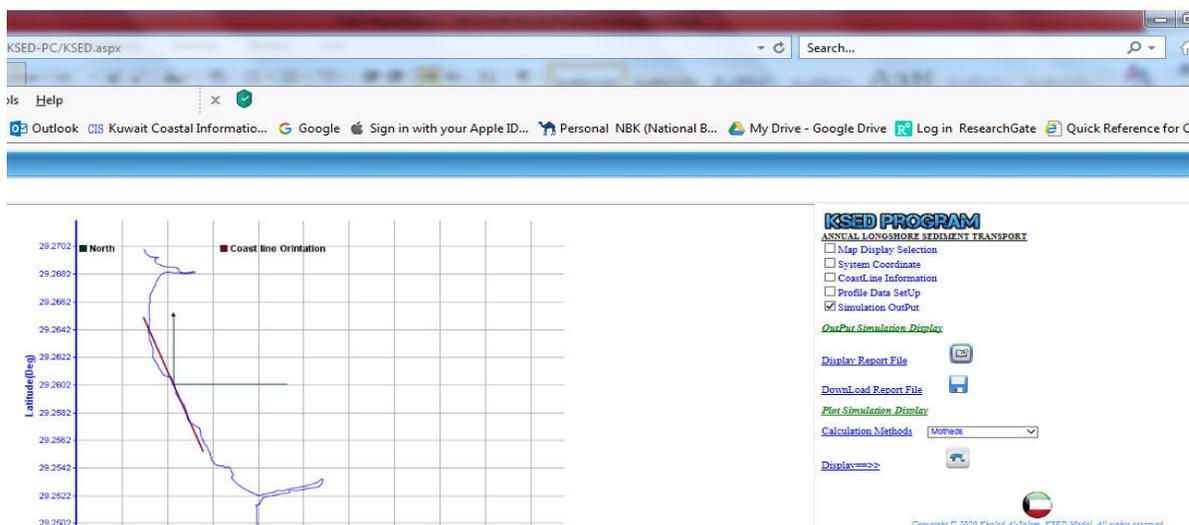**Figure 7**

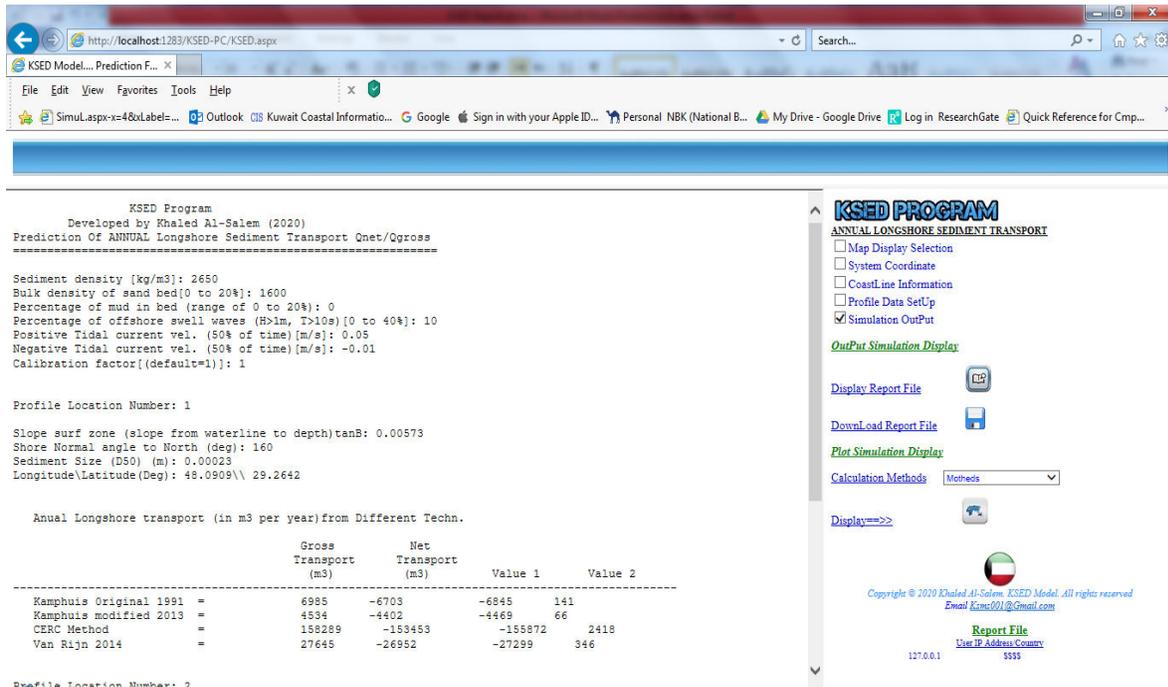**Figure 8**

Figure 9

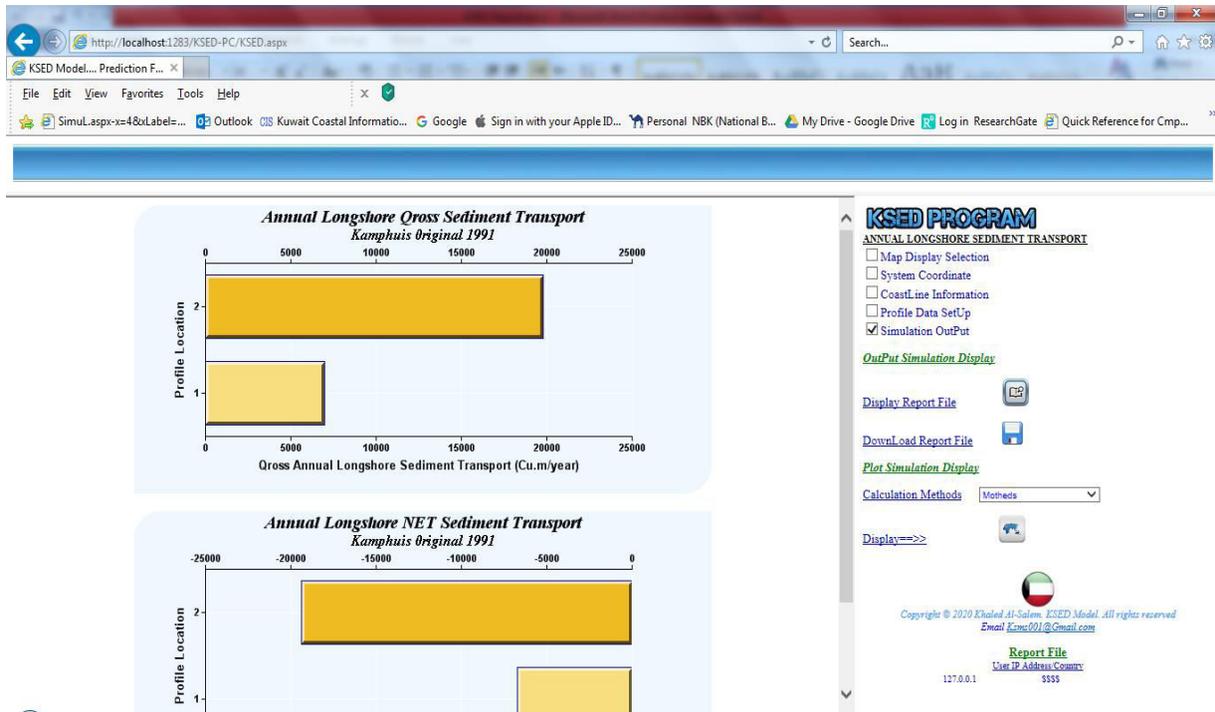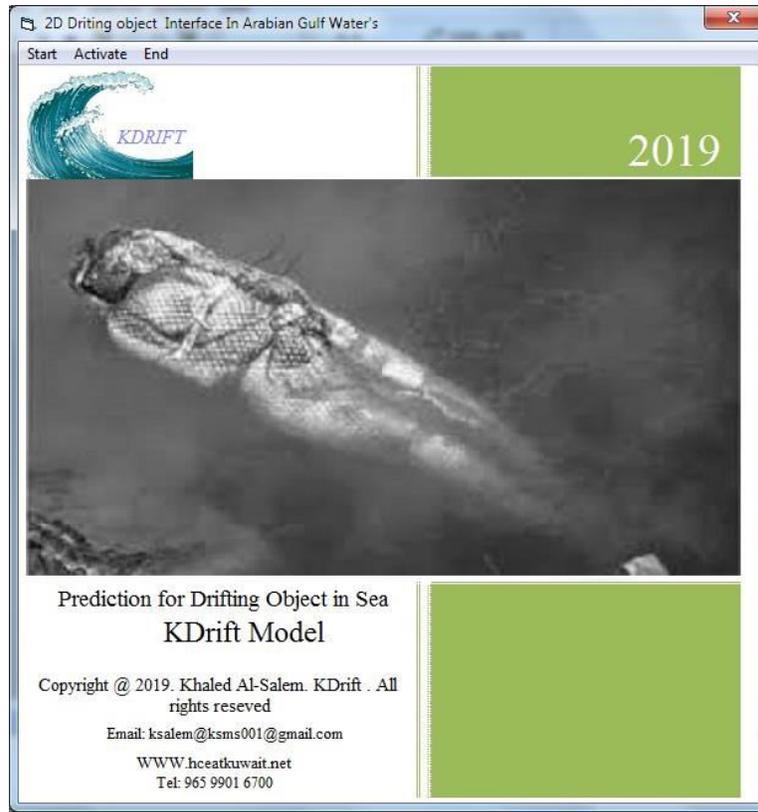**Figure 10**

Figure 11

Figure 12

Technical Report

**Numerical model for Drift Floating Object
In Kuwait and Arabian Gulf Waters**

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Oct 2019

ABSTRACT

Search for and rescue of persons or floating Object in distress on the high seas requires the capability to accurately predict the position of the survivors or to locate the object. The current approach used to predict the drift is based on an empirical correlation between wind speed and search object motion derived from available field data [like 2D tidal current and wave height]. Prior to this study, no drift data were available for persons or floating object in sea, which are widely used in distress situations. In an effort to help mitigate these uncertainties, [Al-Salem 2019] developed a mathematical model to predict the drift of object, person in sea and life raft for given environmental conditions. Subsequently, the model was simplified for operational use in search and rescue mission planning for disabled boats and drifting life rafts.

INTRODUCTION

Many factors affect the drift of life rafts, disabled boats or a person at sea. Successful Search and Rescue missions, therefore, depend on human intelligence, on intuition and insight gained frommany years at sea, and on tools developed for the task. Since 1944, numerous efforts have beenmade to investigate the effects of surface current (Tomczak, 1964; James, 1966; and Meyer et al., 1967) and wind velocity (Pingree, 1944; Chapline, 1960; Hufford and Broida, 1974; Morgan etal., 1977; Morgan 1978, Scobie and Thompson, 1979; Osmer, Edwards, and Breitler, 1982; andNash and Willcox, 1985) on drifting objects. Drift motion is defined as the movement of the search object through water, caused by the action of the wind on the exposed surfaces of the object (National Search and Rescue Manual, 1991). As a vector quantity referenced to the local wind, tidal current, directions and wave height may be expressed in terms of drift speed and angle also wave height will be considered. The rate of a drifting object refers to the ratio of the drift speed of the object to the local surface wind speed, tidal current and wave height. The study has provided a better understanding of the dynamical processes of drifting objects in the Sea. A reliable drift prediction model has been developed to expected the result in improved efficiency in search and rescue missions. This report covers the work carried out in the study.

THEORETICAL ANALYSIS

Drifting objects in Sea are very complex technical systems, controlled by general mathematical models analysis of performances for floating objects requires detailed knowledge of its dynamics. The basis of the general mathematical model is analysis of conditions and energetic balances, prevailing during moving of object throughout the water. On the basis of known relations of hydrodynamics and floating object in the ambient water, A general mathematical model of dynamics of floating object is reached. By solving an obtained system of complex equations within a time unit, actual condition of floating object in space has been provided. The aim of the model is to predict the probable drifted area or path of an object or (drown body) in sea after certain order of time. The drifting is due wave, current and wind action.

In This study a number technical of theoretical solution will be apply for develop a drift floating object in Arabian Gulf waters as:

Lagrangian Movements of Particles

A Lagrangian discrete-parcel algorithm is used. In this algorithm, the floating object is viewed as a large ensemble of small parcels. It looks at the subsequent coordinates (trajectories) of a number of individual fluid or fluid property particles that are adverted (transported) by currents, Wind Speed and Wave height action. When the hydrodynamics field is known then we may add turbulent diffusion as random walks $Rnd(\ )$ that have in general Gaussian distribution with dispersion that corresponds to turbulent activity. For a particle numbered i we get

$$dx_i = u(x_i, y_i, z_i, t)dt + Rnd_x(i)$$
$$dy_i = v(x_i, y_i, z_i, t)dt + Rnd_y(i)$$
$$dz_i = w(x_i, y_i, z_i, t)dt + Rnd_z(i)$$

[1]

Where
(u,v) represent drift velocity related to wind speed, tidal current and wave height. To compute the wave drift velocity we applied the surface Stokes drift formula using significant wave height *Hs*, period *Tp and g* is gravity (*9.8 m/s²*). U_S is represent the Stokes Surface drift velocity as follows:

$$u_s = g^{-1}\pi^3 H_s^2 T_p^{-3}$$

[2]

LeeWay theory for Object Drift in Water

Forces exerted on a solid body when fluid flows around it or when it moves through a fluid are termed the drag and the lift, depending on whether the force is parallel to the motion or at right angles to it. The general expression of the drag force F_D is

$$F_D = \frac{1}{2}C_D\rho V|V|$$

[3]

where C_D is the drag coefficient, ρ is the density of the fluid, A is the cross-sectional area of the body perpendicular to the direction of the flow, and V, is the velocity of the fluid relative to that of the drifting body. The primary forces acting on a drifting object are wind forcing and current retardation. A steady drift velocity V is achieved when the forces balance, as expressed by

$$F_A = \frac{1}{2}C_a A_c |V_a - V|(V_a - V)$$ Drift Force relate to wind speed [4]

$$F_c = \frac{1}{2}C_c A_c |V_c - V|(V_c - V)$$ Drift Force relate to tidal current [5]

Equations 4 and 5 combined as shown in Figure 1 will yield as

$$\frac{1}{2}C_a\rho_a A_a |V_a - V|(V_a - V) + \frac{1}{2}C_c\rho_c A_c |V_c - V|(V_c - V) = 0$$

[6]

Assuming both Reynolds numbers, *Ra,* and *Rc* , to be large, then C_a, and C_c are constant. The

drift velocity V due to wind speed and tidal current action can be solved easily from equation 6 as:

$$V = \frac{\gamma}{1+\gamma} V_a + \frac{1}{1+\gamma} V_c \qquad\qquad [7]$$

Where

$$\gamma = \frac{\gamma_a}{\gamma_c} \quad at \quad \gamma_a = \sqrt{C_a \rho_a A_a} \quad and \quad \gamma_c = \sqrt{C_c \rho_c A_c}$$

ρ_a Air density: 1.226 kg/m³ $\qquad$ ρ_c Water density: 1025.9 kg/m³

A_a object area above sea level A_c object area below sea level as shown in Fig 1
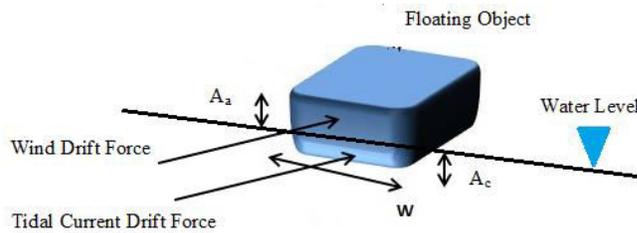

Figure 1

C_a Drag Coefficient for Wind speed on Floating Object as shown in table 1.

Table 1. Drag coefficient for Wind speed C_a

Type of body		Reference area S	Reynolds number Re	Drag coefficient C_D
Cube	⬜	$S = D^2$	$Re > 10^4$	1.05
	◇	$S = D^2$	$Re > 10^4$	0.8
Solid hemisphere	◖	$S = \pi D^2 / 4$	$Re > 10^4$	→ 0.42 ← 1.17
Hollow hemisphere	◖	$S = \pi D^2 / 4$	$Re > 10^4$	→ 0.38 ← 1.42
Thin disk	▯	$S = \pi D^2 / 4$	$Re > 10^3$	1.1
Circular disk	⬭	$S = \pi D^2 / 4$	$Re \leq 1$ $Re > 10^4$	20.4/Re 1
Sphere	●	$S = \pi D^2 / 4$	$Re \leq 1$ $1 < Re \leq 2\times10^5$ $Re > 2\times10^5$	24.0/Re 0.45 0.2
Streamlined body	⬯	$S = \pi D^2 / 4$	$Re > 10^5$	0.04

Source: Elsayed S. Aziz 2008. Conference American Society for Engineering Education, 2008

Wave Effect

Hufford and Broida (1974) reported that drift object appears to increase up to about 15% with increasing sea state. The relationship has not yet been quantitatively established, however. This section contains a simple derivation to account for the wave effect on drift. The wave drift force can be expressed by

$$F_h = \frac{1}{2} C_h \rho_w g L \left(\frac{H}{2}\right)^2 \qquad \text{Drift Force relate to wave height} \qquad [8]$$

where C_h denotes the wave drift coefficient, g is the acceleration due to gravity (9.8 m/s^2), L is a Characteristic length of the drifting objects, and $\frac{H}{2}$ is the wave amplitude which is equal to one half the wave heights. The force acts in the direction of the wave propagation. The wave drift coefficient in a regular wave pattern is a function of the frequency of the incoming waves and may reach a value of order 1 in some cases. Including the wave drift force in the balance equation 6, and assuming that the wind, current, and wave forces act in the same direction as shown in Fig 2, we obtain the following:

$$\frac{1}{2} C_a \rho_a A_a (V_a - V)^2 + \frac{1}{2} C_c \rho_c A_c (V_c - V)^2 + \frac{1}{2} C_h \rho_w g L \left(\frac{H}{2}\right)^2 = 0 \qquad [9]$$

This quadratic equation can be solved to yield

$$V = V_o - \frac{(V_o - V_c)}{1-\gamma} + \left\{ \left(\frac{V_o - V_c}{1-\gamma}\right)^2 + \frac{\alpha}{1-\gamma^2} \right\}^{1/2} \qquad [10]$$

V_o is the solution of equation 6 when $H/2 = 0$ and C_h is the Drag coefficient for wave height as shown in table 2; thus, [11]

$$V_o = \frac{\gamma}{1+\gamma} V_a + \frac{1}{1+\gamma V_c} V_c$$

$$\alpha = \frac{C_h G L a^2}{C_c A_c}$$

For large a, the effect of wave drift is considerable as indicated in equation 6. With small α, assuming $\alpha \ll |V_o, - V_c|$ equation 6 can be reduced to yield

$$V = V_o + \frac{1}{2} \left(\frac{\alpha}{(1+\gamma)(V_o - V_a)} \right) \qquad [12]$$

Table 2. Drag coefficient for Wave Height C_h

Beaufort classes	Wave Period: T(s)	Wave No: k	C_{D3}
0	0	1	1
1	0.78	6.615	1
2	1.87	1.151	1
3	3.06	0.43	0.997
4	4.62	0.189	0.99
5	6.21	0.104	0.971
6	7.7	0.068	0.908
7	9.24	0.047	0.784
8	10.81	0.034	0.615
9	12.44	0.026	0.411
10	14.09	0.02	0.24
11	15.79	0.016	0.123

A theoretical analysis and laboratory experiments were investigate the drift and leeway characteristics can be simplified to leeway expression, developed from theoretical considerations, indicated that the leeway velocity should be directly proportional to the difference between the true wind velocity at the drift object and the true current at the object. This relationship should hold over a wide range of wind speeds. The leeway velocity, V, was estimated to by

$$V_l = 0.0323(V_a - V_w)$$
[13]

Where
V_a *is* Wind speed Drift Velocity, V_w is Tidal Surface Current.
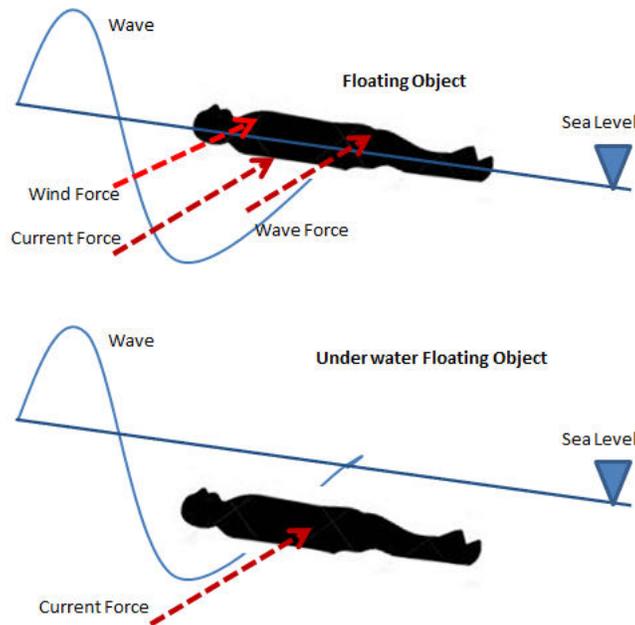
Figure 2. Drift Forces Acted on floating body on water

1D/2D Hydrodynamics prediction model [KGulf Model]

Hydrodynamic models (HD) represent the core of any simulation for flow field, water quality, erosion and siltation, and morphological studies. HD models vary from fully three dimensional (3D) to simpler one dimensional (1D) models. For such models they may differ in the choice of the numerical grid, the discretization method, the time difference scheme, the solution technique, and the treatment of boundary conditions. Finite difference models using Cartesian grids require the application of several nested models in order to model a certain area with a fine grid. Finite element models have the advantage that an unstructured grid can be used thus providing fine grid resolution in the areas of interest only. But the disadvantage with this method is that the computation takes much time for simulation. Many researchers have modeled the Arabian Gulf (e.g., Blain, 2000; AlHajri et

al., 1997, Chu et al., 1988, and Proctor et al. 1994). It is essential for Kuwait to have its own HD model for the Arabian Gulf. Lo and Al-Salem (1999) attempted to develop such a model for the Kuwait Institute for Scientific Research (KISR) by setting up two models. The two models they used however were based on the finite difference technique and thus require the use of nested models to provide a finer grid resolution in the Kuwaiti territorial waters. A new Tidal Current prediction technique is developed for hind-cast, now-cast and forecasting of Tidal current conditions over the Kuwaiti territorial water and the Arabian gulf. It is an interactive online model (K. Al-Salem ,2012). The computer simulation time required for this model technique for Tidal Current history prediction in very little. The present technique is validated with RMA 10 model and with measured field data. The model is named as KGulf model .In this study, the KGulf model is setup to predict the water level variations and the currents induced by tides. The grid resolution is finer in the Kuwaiti territorial waters in order to get accurate useful data for Kuwait. A snap shot of grid system used in KGulf model as shown in Fig. 1. The KGulf model is a two dimensional (2D) and is based on the calculated grid constituents values, which is stored and linked as database to the model. The model is capable of simulating 2D tidal current and water level at any selected grid inside the Arabian Gulf waters starting from the year 1970 to 2035 with hourly output results (K. Al-Salem ,2012).
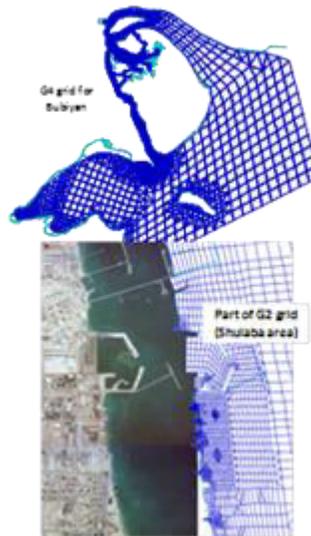
Figure 3. Sample of grids used for Kuwaiti territorial waters

Prediction of Significant Wave Height using an Empirical Relation for Kuwaiti Territorial Waters [Al-Salem 2009]
It is well known that wind speed and fetch (depends on wind direction) dominate the generation of water waves in the sea. Apart from this, the water depth, the bathymetry and the location of the point of interest are all important. The wind speed at 10 meter above the sea level, wind direction, and water depth are considered as primary forcing parameters for the present technique. All wind wave models such as the WAM model also require the wind speeds and the bathymetry. These types of models however, require spatial and temporal wind data over the water body. The WAM model needs to be applied to the full Arabian Gulf and thus takes

considerable computer time. In this study an empirical model is developed for the Kuwaiti territorial waters to provide an efficient and prediction of wave parameters. This technique can be useful in providing wave conditions from wind data at a single point 1D and 2D. It is expected that the technique can provide good predictions for storm conditions. For swell conditions, it will not provide good results. Due to the relatively small water body of the Arabian Gulf in most cases the wind will not vary considerably over the full Arabian Gulf. For more accurate wave forecasting it is recommended to have a local wind model for the Arabian Gulf to provide data to an operational WAM model. To demonstrate the method developed the results for one location is provided. This location is offshore Al-Fintas at longitude E 48.2^o and latitude N 29.1^o in Kuwait's territorial waters as shown in Fig. 4. A wave Buoy was placed at this location for about three years and the data from this buoy were used in the WAM model validation (Al-Salem et al.., 2005). The water depth was 14 m. Equation 9 was used to determine the significant wave height (H_s) for a certain wind speed 'v' class and direction 'α' class.

$$H_s(v,\alpha) = \frac{k\sum_{i=1}^{n} C_H H_{si}}{m} \qquad (9)$$

where the weighting factor C_H is calculated according to,

$$C_H = 1.0 \quad if \begin{cases} v_{min} < v < v_{max} \\ \alpha_{min} < \alpha < \alpha_{max} \end{cases} \qquad (10)$$

$$C_H = 0.0 \qquad otherwise$$

where 'n' is the total number of data values available and 'm' is the number of data values with C_H=1.0. The minimum and maximum values for 'v' and 'α' are the limits for each class. K is the constant of 1.2. The wind classes were taken every 1.0 m/s till 20.0 m/s (3.6 km/h to 72 km/h). For the directions a class of 45 degree was used. Hourly data for two full years (1993-1994) were used to determine the value of H_s for each 'v' and 'α' class. A similar relation was used for the mean wave period (T_m),

$$T_m(v,\alpha) = \frac{k\sum_{i=1}^{n} C_T T_{mi}}{m} \qquad (11)$$

where the weighting factor C_T is calculated according to,

$$C_T = 1.0 \quad if \begin{cases} v_{min} < v < v_{max} \\ \alpha_{min} < \alpha < \alpha_{max} \end{cases} \qquad (12)$$

$$C_T = 0.0 \qquad otherwise$$

In this study a wave model [**KWave**] was developed by [Al-Salem 2009] to predict the wave conditions from local wind records will be used. The model was validated and calibrated using data from a two dimensional WAM model for the Arabian Gulf and a measured data recodes
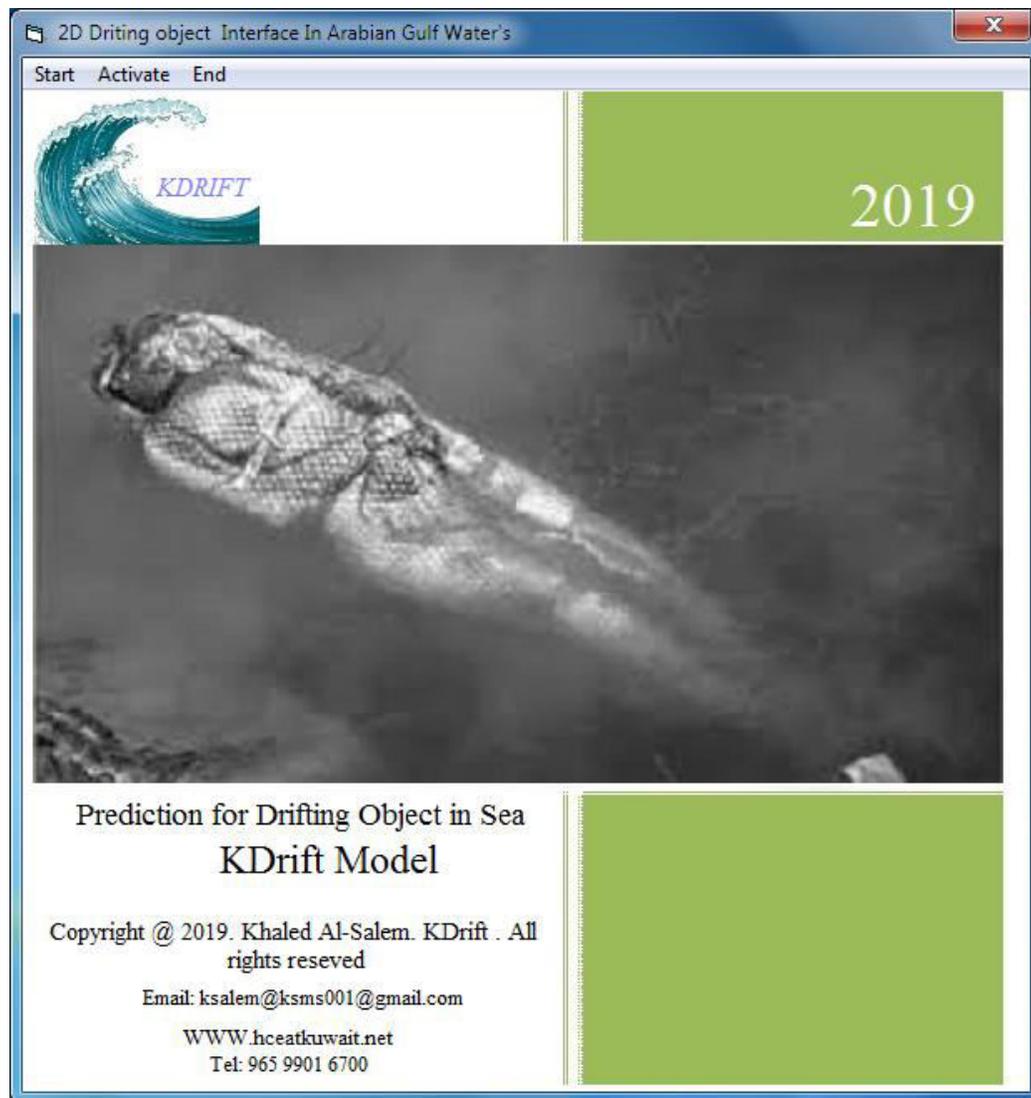
from the Bouy deployed at al-Fintas coast in Arabian Gulf. The KWave model was shown to provide good results for the wave height, period and direction.
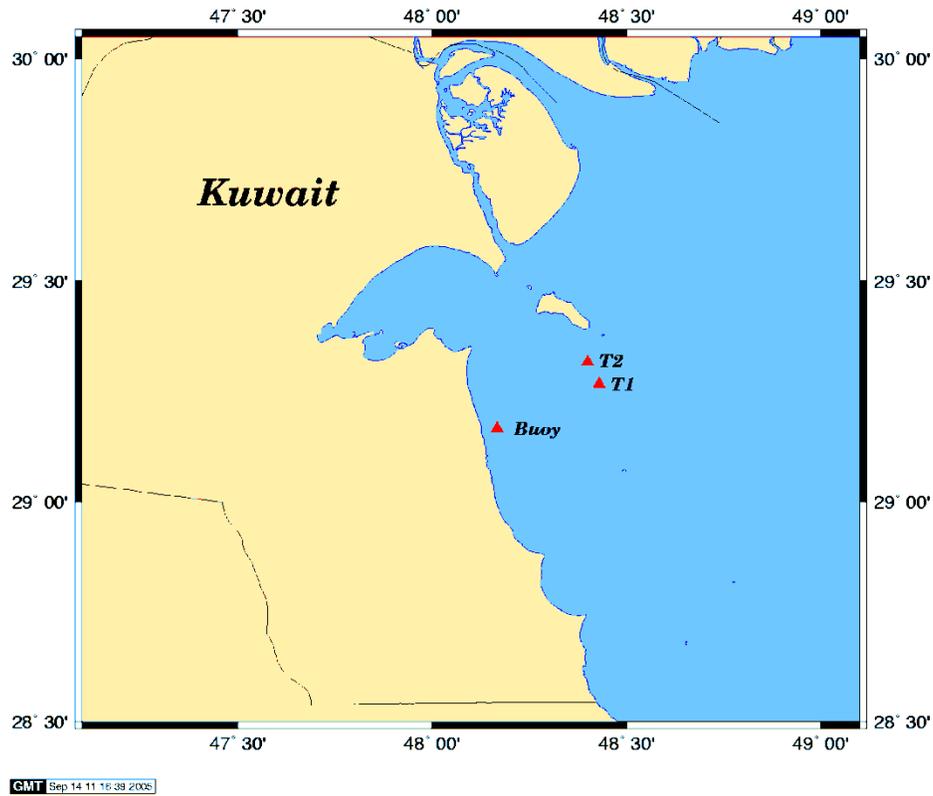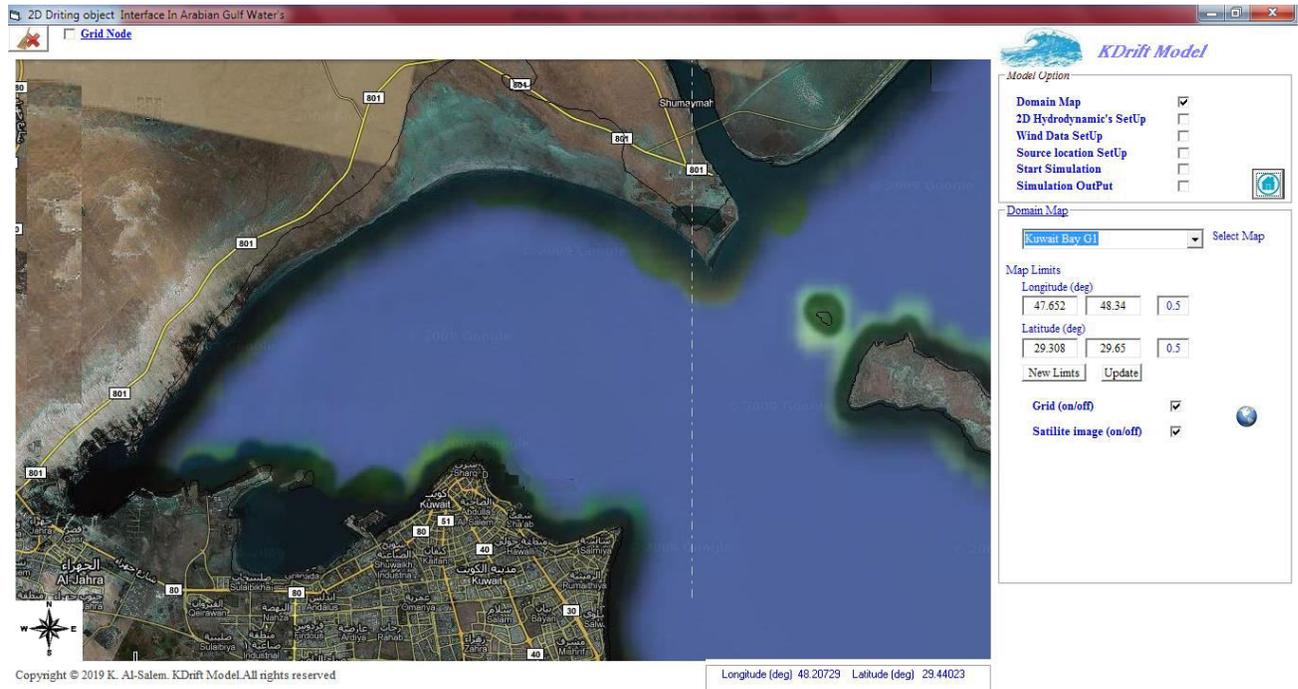

Figure 4. Map of Kuwait showing the locations where measured data was available.

KDrift Model Demonstration
[PC Version]

[Internet Version => http://www.hceatkuwait.net/web_pas/kdrift/kdrift.aspx]

User should Press on Start Fig A1 will display as follows

Figure A1

Figure A1 display a number of model Options for user to setup new project as follows:

1. Domain Map; Option for user to select the display main map by dropdown list of pre-saved satellites image map of Kuwait water. User can select { } image to display the selected map on Google map [*Internet require*] as shown In Fig A2

2. 2D hydrodynamic Setup; Option for user to setup Start and end Time for hydrodynamics prediction [2D Tidal current and water level] .And user can select simulation time step in (min) as shown in Fig A3.

3. Wind Data Setup. This option allow user to load wind data to the simulation as shown in Fig A4 by following:
   - Constant Wind Speed and wind Direction
   - Variable Wind Speed and wind Direction in two ways

   1- Load Wind data From Pre-saved File as {Wind speed/Direction}

   2-Load online Wind Speed Data from Remote website address [hceatkuwait.net]. Data stored for coming 6 days.

4. Source Location Setup; Option to enter the object Location and Type Of Object for simulation As shown in Fig A5. Figure A6 shows the type on Object to be simulated.

5. Start Simulation; Option to start project simulation by three different theories as shown in Fig A7 for follows:
   - Lagrangian Moving Particles theory [Result show in Fig A8]

Figure A9 display result on Google Map

- Leeway Drift Method [Result show in Fig A10]

Figure A11 display result on Google Map

- Monte Carlo statistical methods [Result show in Fig A12]

Figure A13 display result on Google Map

6. Simulation Output; to display the result and reanimate the simulation for the following:
- Reanimate the Drift object simulation
- Display The simulation output Files as shown in Fig A16 and A17

Figure A2. Display Selected Image on Google Map

Figure A3. 2D hydrodynamic time setup

Figure A4. Wind Speed Data setup

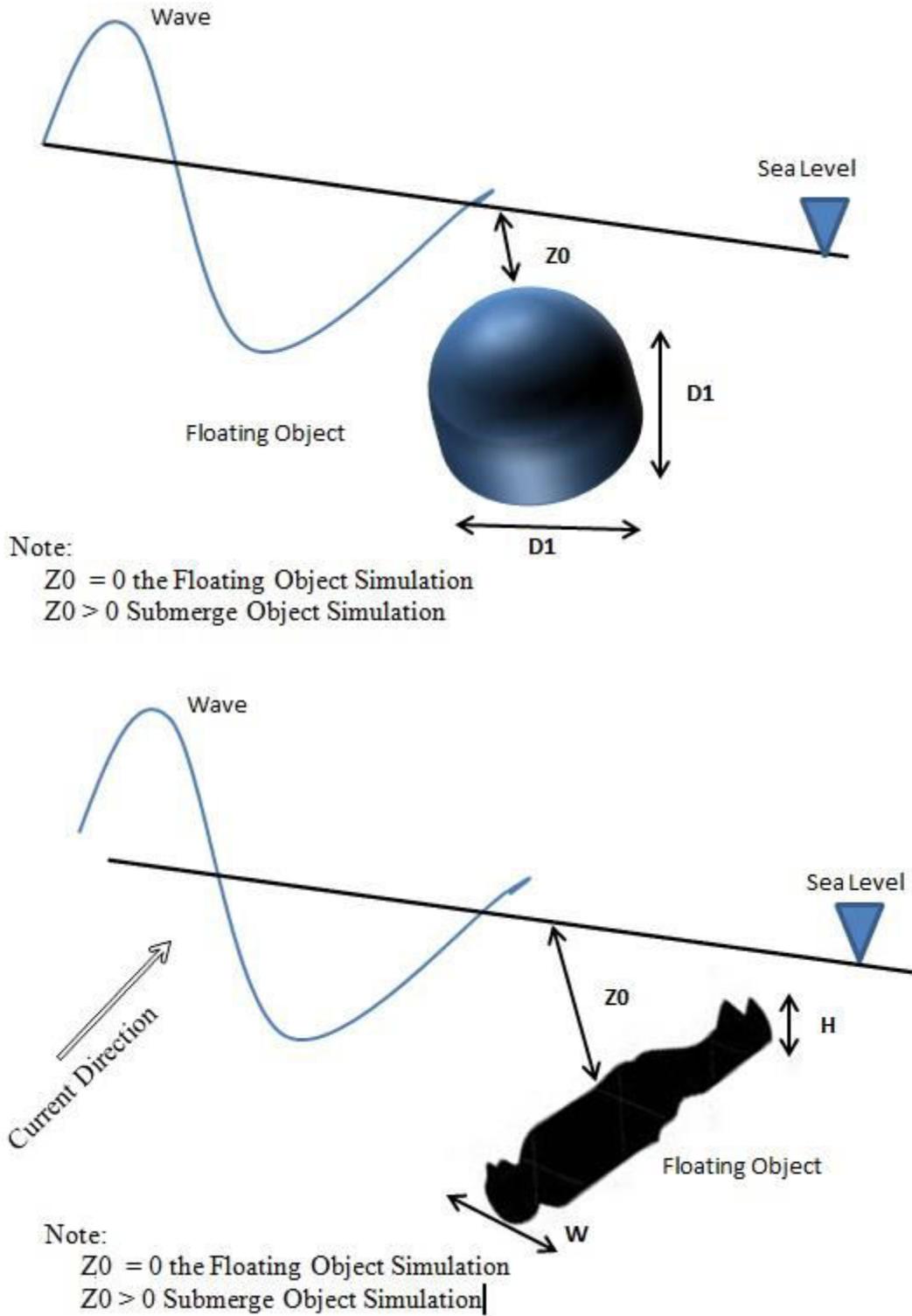
Figure 5. Object Initial Location And Object Type

Wave

Sea Level

Z0

D1

Floating Object

D1

Note:
  Z0 = 0 the Floating Object Simulation
  Z0 > 0 Submerge Object Simulation

Wave

Sea Level

Z0

H

Current Direction

Floating Object

W

Note:
  Z0 = 0 the Floating Object Simulation
  Z0 > 0 Submerge Object Simulation

Figure A6 Type of Drifted Object in the model

Figure A7. Project simulation Window

Figure 8. Drift Object Simulation by Lagrangian Moving Particles theory
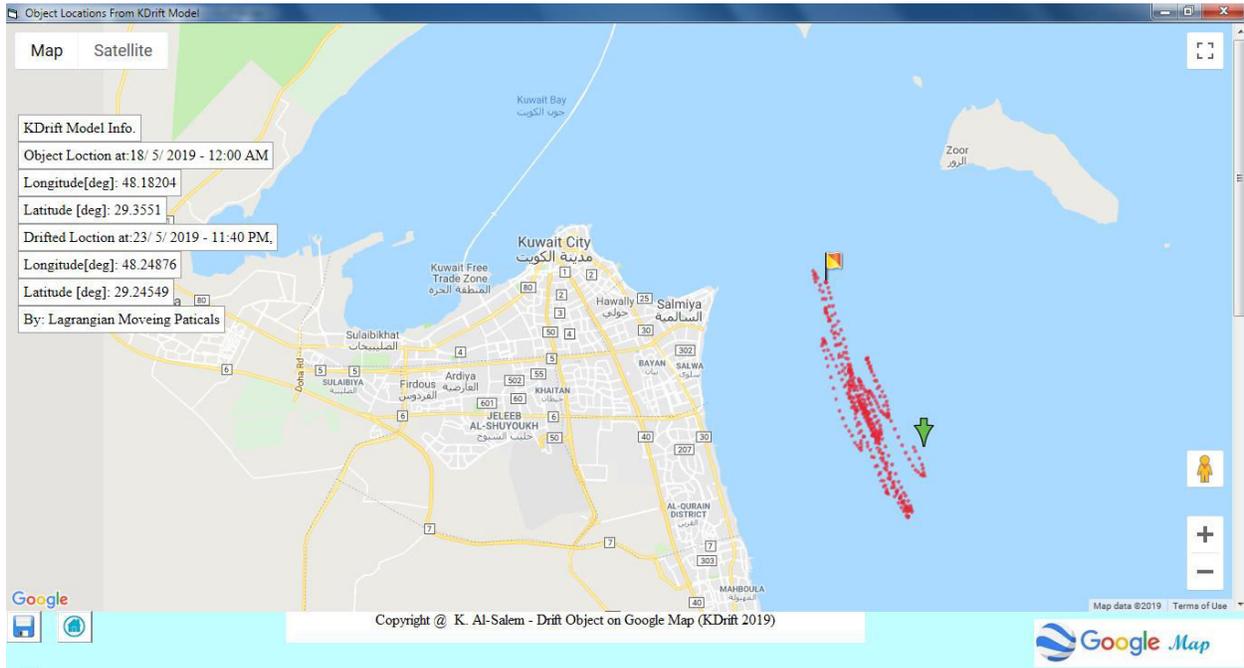
Figure 9. Drift Object Simulation by Lagrangian Moving Particles theory displayed on Google Map

Figure 10. Drift Object Simulation by Leeway Drift Method
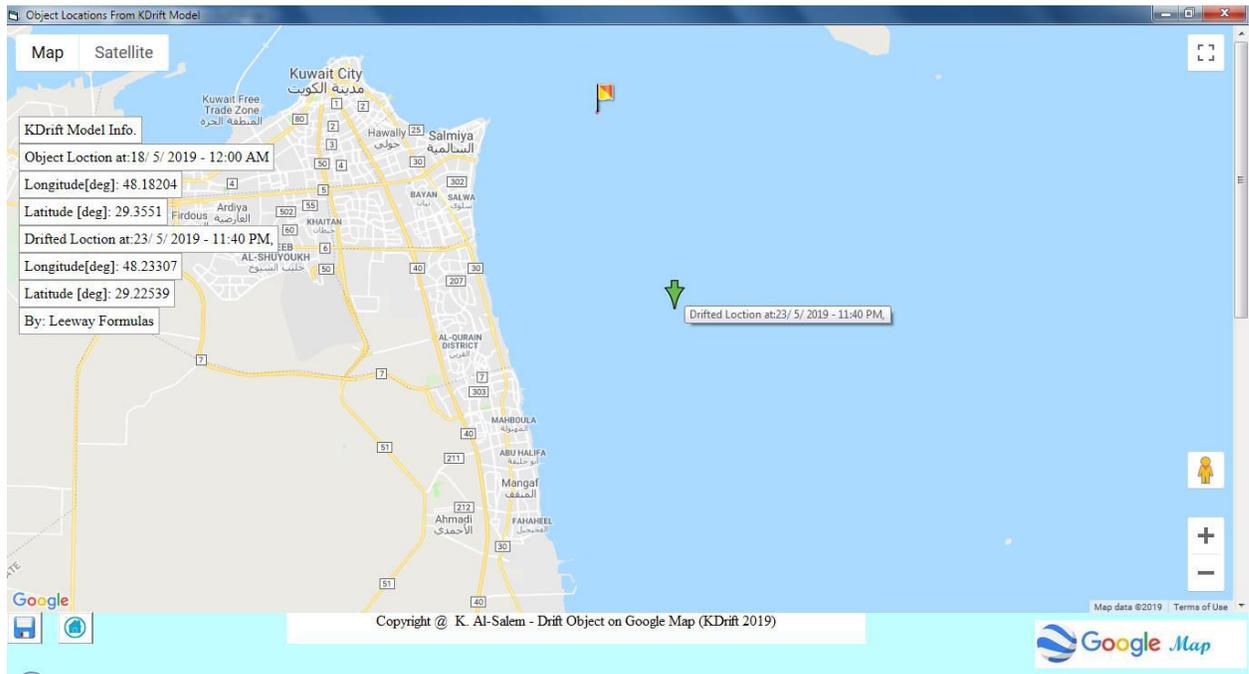
Figure 11. Drift Object Simulation by Leeway Drift Method displayed on Google Map

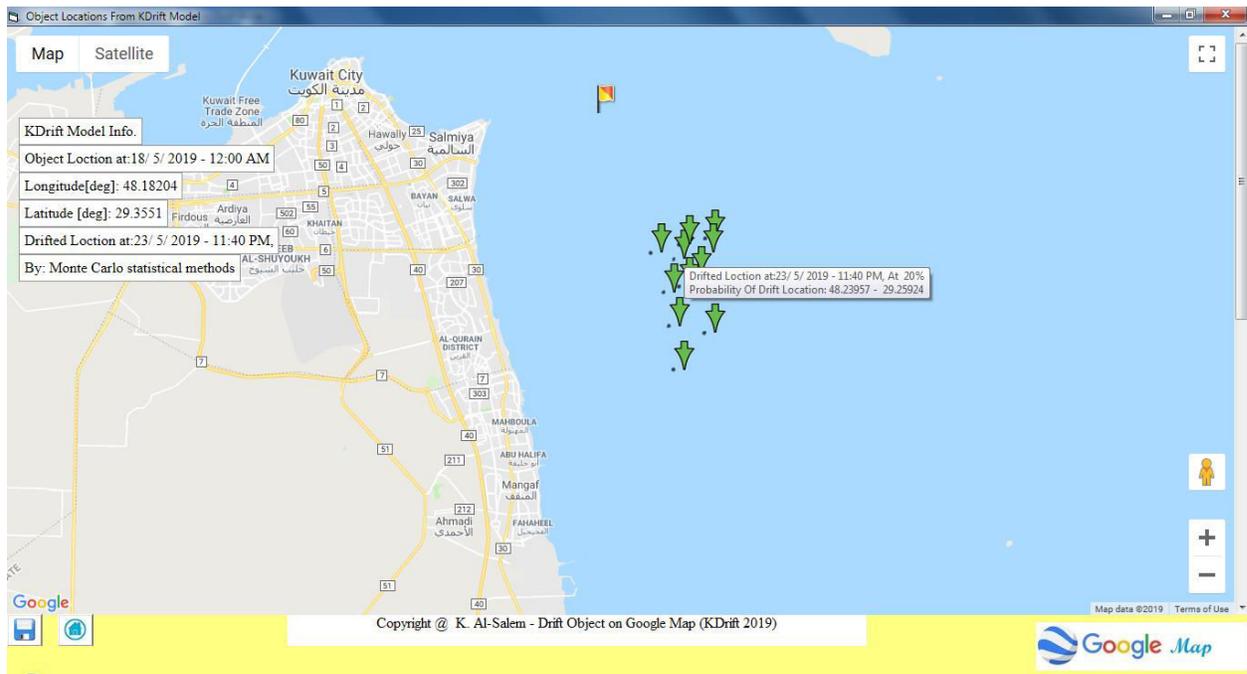**Figure 12. Drift Object Simulation by Monte Carlo statistical methods**

Figure 13. Drift Object Simulation by Monte Carlo statistical methods display on Google map
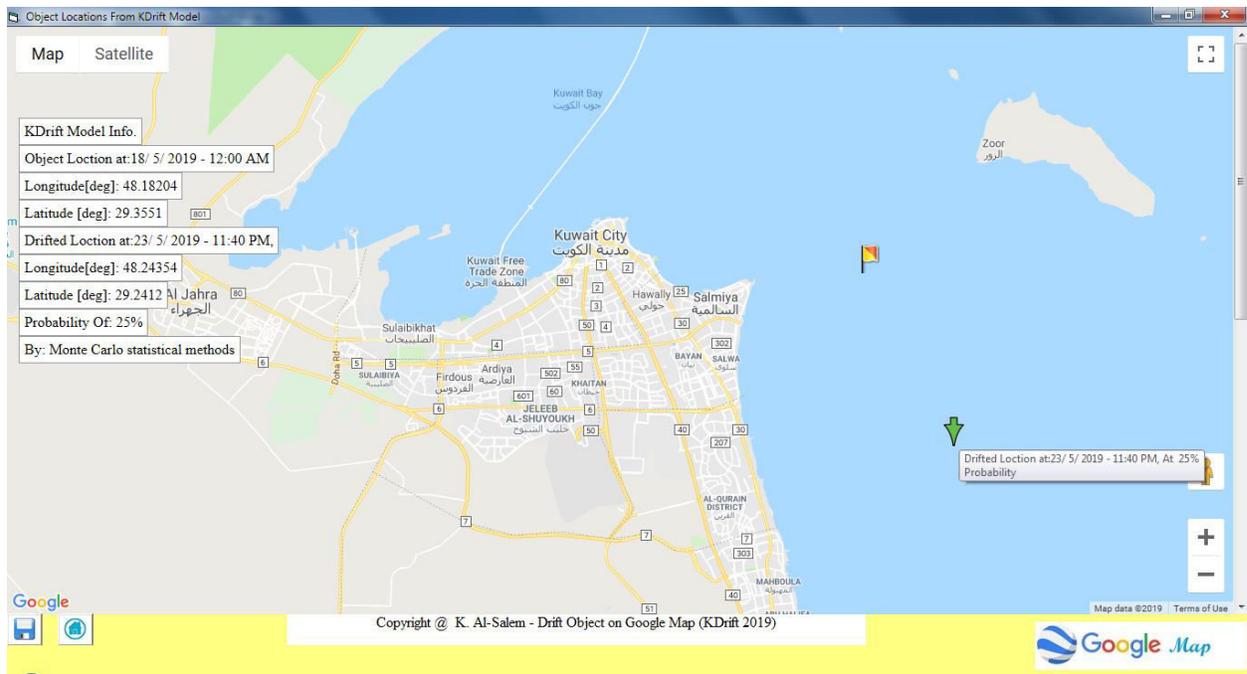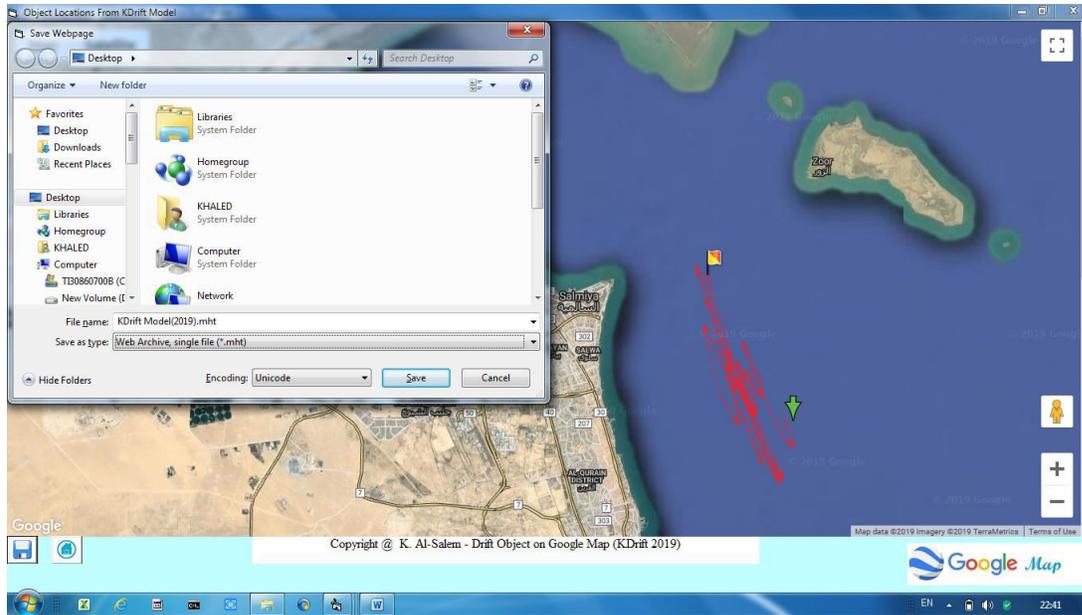

Figure 13. Display Highest Prbability of Drift Object by Monte Carlo statistical methods display on Google map

To Create HTML file for the select Simulation as shown in Fig A14. Figure A15 displays a part on the HTML file create by KDrift Model to Redisplay the Drift Result.

Figure 14. To Save HTML file for the select Simulation from Google Map Option.

```
<head>
 <meta http-equiv='content-type'
content='text/html;charset=utf-8'/>
 <meta http-equiv='X-UA-Compatible' content='IE=edge'>
 <title>KDrift Model(2019)</title>
 <style>
 #map {
  height: 100%;
 }
html, body {
 height: 100%;
margin: 0;
padding: 0;
}
    #floating-pantit {
      background-color: #fff;
      border: 1px solid #999;
      left: 1%;
      padding: 5px;
      position: absolute;
```

Figure 15. A Snap of a part of HTML Created by KDrift model..

Report.txt - Notepad

File   Edit   Format   View   Help

```
Numerical model for Drift Floating Object
        In Arabian Gulf Waters
            KDrift Model
          K. Al-Salem 2019
            Version 1.0

Drift Option: Circular Object
Object Parameter:
            D1-H [m]: 0.5
            D2-W [m]: 1.0
            ZO [m]: 0 [ ZO > 0 then submerge Object ]
Drift Simulation Start: May18,2019
                   End: May23,2019
Total simualtion Time (hrs):,  144
Simulation Time Step (min):,  20
Object Location:
        Longitude (deg): 48.18204
        Latitude (deg): 29.3551
Water Depth: 9.551m

Simulation Typr used: Lagragian Moving Paticals

   Date        Time        Object Location    Water   Drift   Tidal Current   Wind Speed       Wave Height
                        Longitude  Latitude   Level   Speed    Cur   Direc    Wn    Direc    H    Period Direc
                HR         Deg        Deg     m[MSL]   m/s     m/s    deg     m/s    Deg     m      sec    Deg
--------------------------------------------------------------------------------------------------------------
18/ 5/ 2019  12:00 AM,   048.18225  029.35421  000.7  000.09  00.13  350.7  001.20  257.04  00.05  02.3  067.7
18/ 5/ 2019  12:20 AM,   048.18249  029.35397  000.7  000.03  00.05  333.7  001.20  257.04  00.05  02.3  067.7
18/ 5/ 2019  12:40 AM,   048.18273  029.35373  000.7  000.03  00.05  333.7  001.20  257.04  00.05  02.3  067.7
18/ 5/ 2019  01:00 AM,   048.18413  029.35045  000.4  000.33  00.43  336.3  000.50  324.84  00.05  02.5  037.2
18/ 5/ 2019  01:20 AM,   048.18519  029.34714  000.4  000.32  00.40  339.2  001.24  028.79  00.05  02.6  084.2
18/ 5/ 2019  01:40 AM,   048.18617  029.34373  000.4  000.33  00.40  339.2  002.30  040.01  00.09  02.5  073.6
18/ 5/ 2019  02:00 AM,   048.18777  029.33841  000.0  000.51  00.63  340.7  002.32  059.04  00.09  02.5  073.6
18/ 5/ 2019  02:20 AM,   048.18946  029.33331  000.0  000.50  00.60  339.2  002.57  076.01  00.15  02.9  109.7
18/ 5/ 2019  02:40 AM,   048.19161  029.32813  000.0  000.52  00.62  335.4  003.00  089.04  00.15  02.9  109.7
18/ 5/ 2019  03:00 AM,   048.19379  029.32267  -000.3 000.55  00.65  336.9  002.80  179.05  00.10  02.7  095.3
18/ 5/ 2019  03:20 AM,   048.19600  029.31649  -000.3 000.61  00.73  339.5  002.60  176.74  00.10  02.7  095.3
18/ 5/ 2019  03:40 AM,   048.19760  029.31140  -000.4 000.49  00.59  342.0  002.40  174.05  00.10  02.7  095.3
18/ 5/ 2019  04:00 AM,   048.19783  029.30754  -000.6 000.36  00.42  357.4  002.33  171.22  00.10  02.7  095.3
18/ 5/ 2019  04:20 AM,   048.19915  029.30363  -000.6 000.38  00.45  341.1  002.26  168.22  00.10  02.7  095.3
18/ 5/ 2019  04:40 AM,   048.20049  029.29974  -000.6 000.38  00.45  341.1  002.20  165.05  00.10  02.7  095.3
18/ 5/ 2019  05:00 AM,   048.20114  029.29816  -000.7 000.16  00.16  335.5  002.43  167.83  00.10  02.7  095.3
18/ 5/ 2019  05:20 AM,   048.20179  029.29655  -000.7 000.16  00.16  335.5  002.66  170.13  00.10  02.7  095.3
18/ 5/ 2019  05:40 AM,   048.20236  029.29410  -000.6 000.23  00.25  346.2  002.90  172.05  00.10  02.7  095.3
18/ 5/ 2019  06:00 AM,   048.20174  029.29479  -000.5 000.09  00.16  118.5  003.33  172.89  00.17  02.8  105.0
18/ 5/ 2019  06:20 AM,   048.20112  029.29542  -000.5 000.08  00.16  118.5  003.77  173.54  00.17  02.8  105.0
18/ 5/ 2019  06:40 AM,   048.20072  029.29591  -000.5 000.06  00.16  118.5  004.20  174.05  00.34  02.7  106.8
18/ 5/ 2019  07:00 AM,   048.19909  029.29977  -000.1 000.39  00.58  112.0  004.43  175.89  00.34  02.7  106.8
18/ 5/ 2019  07:20 AM,   048.19755  029.30395  -000.1 000.41  00.62  109.5  004.66  177.55  00.34  02.7  106.8
18/ 5/ 2019  07:40 AM,   048.19588  029.30775  -000.1 000.38  00.58  112.0  004.90  179.05  00.34  02.7  106.8
18/ 5/ 2019  08:00 AM,   048.19365  029.31355  000.3  000.58  00.82  110.3  004.30  179.77  00.34  02.7  106.8
18/ 5/ 2019  08:20 AM,   048.19200  029.31988  000.3  000.61  00.84  103.3  003.70  089.36  00.15  02.6  090.0
18/ 5/ 2019  08:40 AM,   048.18956  029.32590  000.3  000.60  00.82  110.3  003.10  088.04  00.15  02.6  090.0
18/ 5/ 2019  09:00 AM,   048.18725  029.33194  000.8  000.60  00.80  109.2  002.96  084.70  00.15  02.9  109.7
18/ 5/ 2019  09:20 AM,   048.18492  029.33800  000.8  000.60  00.80  109.2  002.82  081.04  00.15  02.9  109.7
```

Ln 1, Col 1

Figure 16. Display Drift Object Result file by Lagrangian Moving Particles theory or Leeway Drift Method
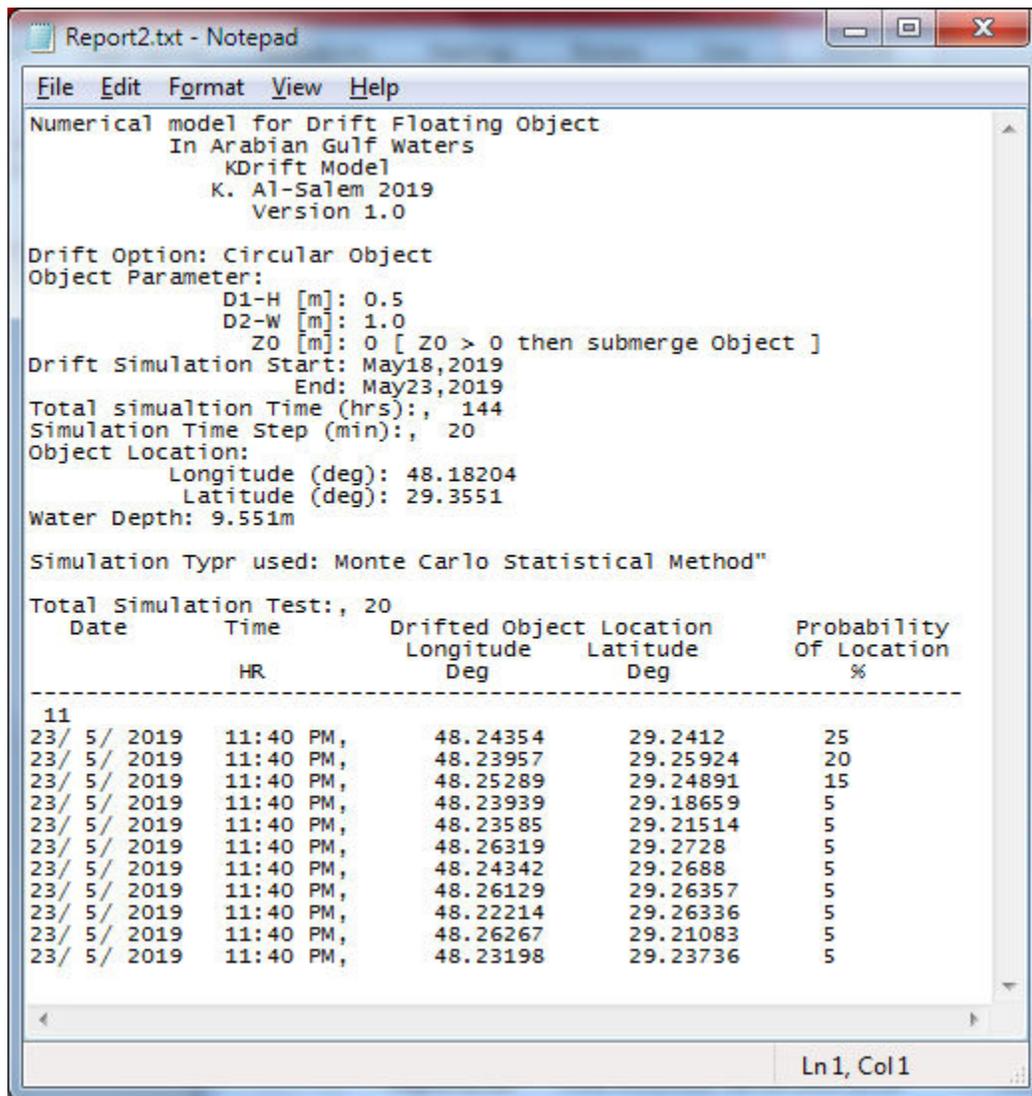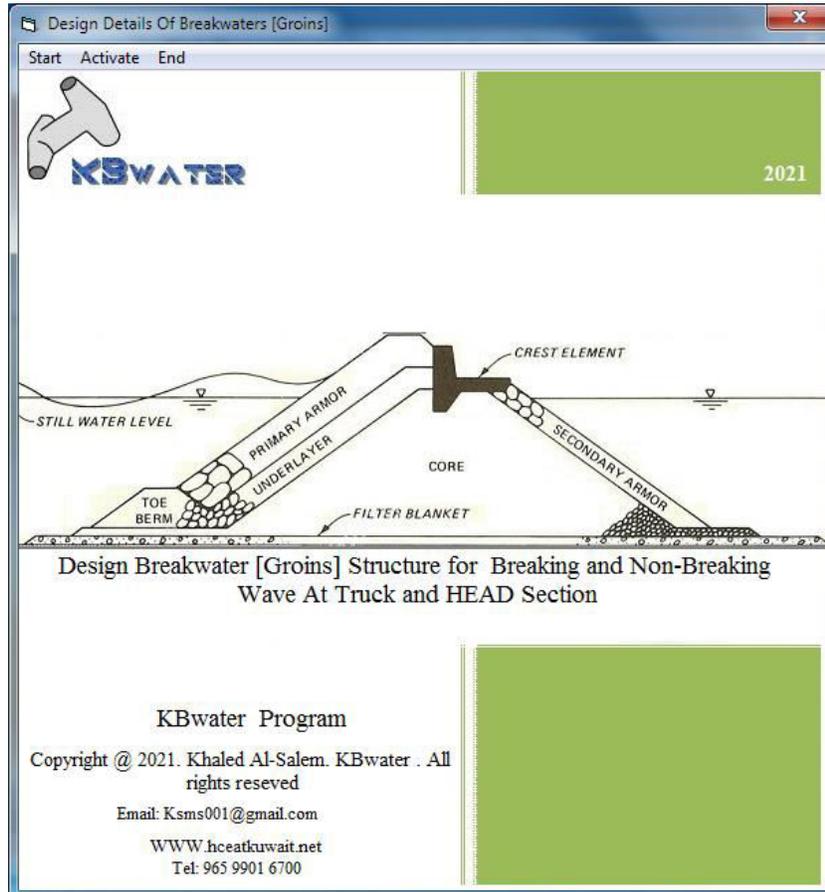
```
Report2.txt - Notepad                                    _  □  X

File  Edit  Format  View  Help
Numerical model for Drift Floating Object
        In Arabian Gulf Waters
            KDrift Model
        K. Al-Salem 2019
            Version 1.0

Drift Option: Circular Object
Object Parameter:
            D1-H [m]: 0.5
            D2-W [m]: 1.0
            ZO [m]: 0 [ ZO > 0 then submerge Object ]
Drift Simulation Start: May18,2019
            End: May23,2019
Total simualtion Time (hrs):,  144
Simulation Time Step (min):,  20
Object Location:
        Longitude (deg): 48.18204
        Latitude (deg): 29.3551
Water Depth: 9.551m

Simulation Typr used: Monte Carlo Statistical Method"

Total Simulation Test:, 20
    Date          Time        Drifted Object Location      Probability
                            Longitude    Latitude         Of Location
                  HR          Deg          Deg                %
    -------------------------------------------------------------------
  11
23/ 5/ 2019   11:40 PM,    48.24354     29.2412            25
23/ 5/ 2019   11:40 PM,    48.23957     29.25924           20
23/ 5/ 2019   11:40 PM,    48.25289     29.24891           15
23/ 5/ 2019   11:40 PM,    48.23939     29.18659           5
23/ 5/ 2019   11:40 PM,    48.23585     29.21514           5
23/ 5/ 2019   11:40 PM,    48.26319     29.2728            5
23/ 5/ 2019   11:40 PM,    48.24342     29.2688            5
23/ 5/ 2019   11:40 PM,    48.26129     29.26357           5
23/ 5/ 2019   11:40 PM,    48.22214     29.26336           5
23/ 5/ 2019   11:40 PM,    48.26267     29.21083           5
23/ 5/ 2019   11:40 PM,    48.23198     29.23736           5

                                                    Ln 1, Col 1
```

Figure 17. Display Prbability of Drift Object Result file by Monte Carlo statistical methods

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KBwater *Technical Report*

Design Breakwater [Groins] Structure for Breaking and Non-Breaking Wave At Truck and HEAD Section

DETAILES DESIGN PRINCIPLES OF BREAKWATERS

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Jan. 2021

Introduction

Breakwaters are structures constructed on coasts as part of coastal management or to protect an anchorage from the effects of both weather and longshore. Breakwater is the oldest coastal structure used by human being. A thorough knowledge of the basics of the dynamics of waves, currents, tides, cyclones, storm surges and its influence on the breakwater in terms of disturbing actions, scours and response are essential for a successful deign of breakwater.

Breakwaters are basically classified as

- o Rubble mound Breakwaters and Vertical breakwaters

- o Composite Breakwaters (Horizontally composite and Vertically Composite)

- o Floating breakwaters and Special type of breakwaters.

Rubble mound breakwaters are built using natural rubbles *Figure 1* and they are good energy dissipaters.
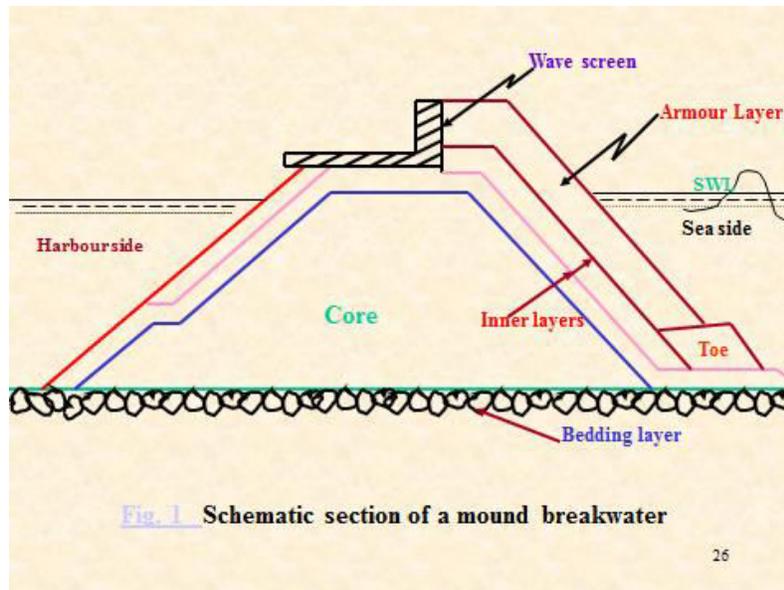
Figure 1. Schematic section of a rubble mound breakwater.

Many different concrete shapes have been developed as armor units for rubble structures. The major advantage of concrete armor units is that they usually have a higher stability coefficient value and thus permit the use of steeper slopes or a lighter weight of armor unit. This advantage has particular value when quarrystone of the required size is not available. Some of the prominent concrete armor units are shown in *Figure.2* including rubble in Fig. 5a.
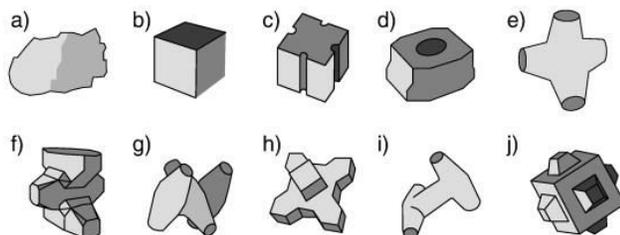
Figure 2. Some artificial armor units (b. Cube; c. Antifer; d. HaroR; e.Tetrapod; f.

Accropode; g. Core-loc; h. XblocR; i. Dolos; and j. CubipodR.

The rubble structure is normally composed of a bedding layer and a core of quarry run stone covered by one or more layers of large stones and an exterior layer or layers of quarrystone (armor) or concrete armor units. Typical rubble mound cross sections are shown in *Figure 3* (Source: Shore Protection Manual, 1984). This breakwater is exposed to wave actions on one side (Seaside) and intended to allow minimal wave to the lee-side. Breakwaters of this type are usually designed with crests elevated such that overtopping occurs only in very severe storms.
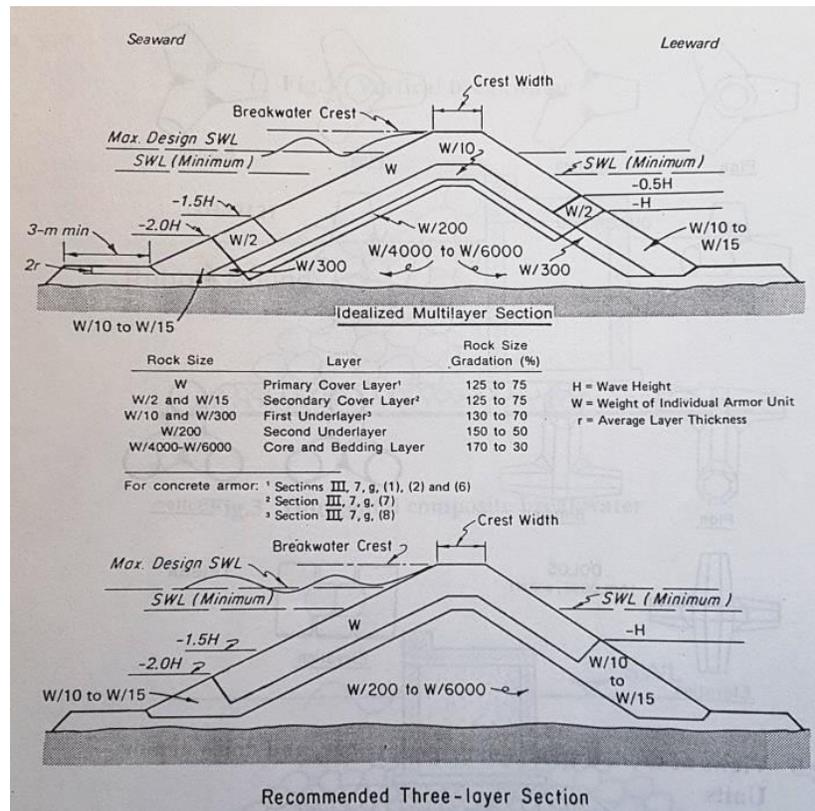
Figure 3.Rubble mound Section for save wave exposure with zero tp moderate overtopping Conditions

Methodology of design breakwaters [groins] structure

The rubble structure is normally composed of a bedding layer and a core of quarry run stone covered by one or more layers of large stones and an exterior layer or layers of quarrystone (armor) or concrete armor units.   This breakwater is exposed to wave actions on one side (Seaside) and intended to allow minimal wave to the lee-side. Breakwaters of this type are usually designed with crests elevated such that overtopping occurs only in very severe storms. If it is exposed for substantial wave action from both sides (Example: outer portions of jetties). The recommended cross section takes into account some of the practical problems involved in constructing submerged features. According to this principle, the size of pore at any layer must be smaller than the size of the inner material so that the inner material should not be finding its way to escape out due to the dynamic activity of the waves.

WEIGHT OF THE PRIMARY LAYER

The stable weight of the armor stone, W is estimated by using Hudson formula.

$$W = w_r H^3 / (K_D (S_r-1)^3 \cot \theta) \hspace{3cm} (1)$$

Where

w_r : *unit weight of armor unit (N/m^3)*
H : *design wave height at the structure (m)*
K_D : *Stability Coefficient*
(Varies with the shape of the armor units, roughness of the armor unit surface, sharpness of edges, degree of interlocking obtained in placement) (Refer Table 1)
S_r : *Specific gravity of the armor unit, relative to the water at the structure (w_r / w_w)*
W_w : *Unit weight of water (N/m^3)*
θ : *Angle of structure slope measured from horizontal in Degrees*

Eqn.1. is intended for conditions when the crest of the structure is high enough to prevent major overtopping. The slope of the cover layer can be partly determined on the basis of stone sizes economically available. Cover layer slopes steeper than 1 V: 1.5 H is not recommended. Eqn.1 determines the weight of armor unit of nearly uniform size. For graded riprap armor stone, the eqn. is modified as

$$W_{50} = w_r H^3 / (K_{RR} (S_r-1)^3 \cot \theta) \hspace{3cm} (2)$$

Where W_{50} is the weight of the 50% size in the gradation. The maximum weight of graded rock is 4.0 W_{50} and the minimum is 0.125 W_{50}. K_{RR} is a stability coefficient for angular, graded riprap and is shown in Table 1. These values allow for 5% damage as shown in Table 2. Use of graded riprap cover layers is generally more applicable to revetments than to breakwaters or jetties. A limitation for the use of graded riprap is that the design wave height should be less than about 1.5 m. For waves higher than 1.5 m, it is usually more economical to use uniform-size armor units as specified by eqn.1.

WEIGHT OF THE FIRST UNDERLAYER AND SECONDARY COVER LAYER

= W/10 to W/15

WEIGHT OF CORE AND BEDDING LAYER

= W/200 to W/6000

Gradation Layers Details Table shown in Table 3

CREST ELEVATION

Select the crest elevation such that overtopping of water is allowed only 2% of the time during a storm.

$Ru_{2\%} /H_s = 0.83 \xi_p$ for $\xi_p < 2$

Consider H_s = Maximum wave height / (2% of 90%)

= 0.78 X Hs/(1.8)

ξ_p = Surf Similarity parameter

= $\tan \theta / (H_s /L_{0p})^{1/2}$

As a first approximation, run-up height can be predicted using the above eqn.

$Ru_{2\%}$ = 0.83 X ξ_p X Hs

Which mean that crest elevation of the structure is at $Ru_{2\%}$ (m), then only 2% of the waves during a storm will overtop the breakwater.

CREST WIDTH

The minimum crest width, B should be equal to the combined width of three armor units (n=3).

i.e.   B   = $n k_\Delta (W/w_r)^{1/3}$

Where

B   =   Crest width (m)

n   =   No. of stones (n=3 is recommended minimum)

k_Δ =   layer coefficient (1.02 from Table 4)

Use crest width of B m in order to facilitate movements of machines and trucks during construction recommend (B <= 4m)

ARMOUR LAYER THICKNESS, r

$$R = n k_\Delta (W/w_r)^{1/3}$$

Where

n   =   No. of stones (n=2 is recommended)

k_Δ =   layer coefficient (1.02 from Table 4)

W   =   Weight of armor unit in primary cover layer, Tons

w_r =   Unit weight of armor unit, Ton/m^3

TOE BERM FOR COVER LAYER STABILITY

Weight of the stone   =   W/10

Width of the toe Berm   =   3 r,

Where :   r   = $k_\Delta (W/w_r)^{1/3}$

Height of the Berm   =   2r

UNDERLAYER THICKNESS

Thickness of the under layer   =   2 r,

Where: r   = $k_\Delta (W/w_r)^{1/3}$

Table 1. Suggested K_D values for use in determining armor unit weight
(Shore Protection Manual)

No- Damage Criteria and Minor Overtopping							
Armor Units	N^{III}	Placement	Structure Trunk K_D^{II}		Structure Head K_D		Slope
			BW	NBW	BW	NBW	Cot θ
QUARRYSTONE Smooth rounded Smooth rounded Rough angular	2 >3 1	Random Random Random^{IV}	1.2 1.6 IV	2.4 3.2 2.9	1.1 1.4 IV	1.9 2.3 2.3	1.5-3 V V
Rough Angular	2	Random	2.0	4.0	1.9 1.6 1.3	3.2 2.8 2.3	1.5 2.0 3.0
Rough Angular Rough Angular Parallelepiped^{VII}	>3 2 2	Random Special^{VI} Special^{I}	2.2 5.8 7.0 – 20.0	4.5 7.0 8.5 – 24.0	2.1 5.3 ---	4.2 6.4 ---	V V
TETRAPOD & QUADRIPOD	2	Random	7.0	8.0	*5.0* *4.5* *3.5*	6.0 5.5 4.0	1.5 2.0 3.0
TRIBAR	2	Random	9.0	10.0	*8.3* *7.8* *6.0*	9.0 8.5 6.5	1.5 2.0 3.0
DOLOS	2	Random	15.8^{VIII}	31.8^{VIII}	*8.0* 7.0	*16.0* *14.0*	2.0^{IX} 3.0
MODIFIED CUBE	2	Random	6.5	7.5	---	*5.0*	V
HEXAPOD	2	Random	*8.0*	9.5	*5.0*	*7.0*	V
TOSKANE	2	Random	11.0	22.0	---	---	V
TRIBAR	1	Uniform	12.0	15.0	*7.5*	*9.5*	V
QUARRYSTONE ((K_{RR}) Graded Angular	---	Random	2.2	2.5	---	---	

BW   : Breaking Wave
NBW : Non Breaking Wave

Table 2. $H/H_{D=0}$ as a function of cover-layer damage and type of armor unit [I].

Unit		Damage (D) in Percent						
		0 - 5	5 -10	10-15	15-20	20-30	30-40	40-50
Quarrystone (Smooth)	$H/H_{D=0}$	1.00	1.08	1.14	1.20	1.29	1.41	1.54
Quarrystone (Rough)	$H/H_{D=0}$	1.00	1.08	1.19	1.27	1.37	1.47	*1.56*[II]
Tetrapods & Quadripods	$H/H_{D=0}$	1.00	1.09	1.17[III]	1.24[III]	1.32[III]	1.41[III]	1.50[III]
Tribar	$H/H_{D=0}$	1.00	1.11	1.25[III]	1.36[III]	1.50[III]	1.59[III]	*1.64*[III]
Dolos	$H/H_{D=0}$	1.00	1.10	*1.14*[III]	*1.17*[III]	1.20[III]	*1.24*[III]	*1.27*[III]

[I] *Breakwater Trunk, n=2, random placed armor units, non breaking waves, and no overtopping conditions*
[II] *Values in italics are interpolated or extrapolated.*
[III] *Caution: Tests did not include possible effects of unit breakage. Waves exceeding the design wave height conditions by more than 10% may result in considerably more damage than the values tabulated.*

Table.3. Rock-size gradation as a percent of the rock size

LAYER	ROCK SIZE	GRADATION (%)
Primary Cover Layer	W	75 to 125
Secondary Cover Layer	W/2 and W/15	75 to 125
First Under layer	W/10 and W/300	70 to 130
Second Under layer	W/200	50 to 150
Core and Bedding Layer	W/4000 to W/6000	30 to 170

Table 4.Layer Coefficient and Porosity for various armor units

Armor Unit	n	Placement	Layer Coefficient k_Δ	Porosity (P) in %
Quarrystone (Smooth)	2	Random	1.02	38
Quarrystone (Rough)	2	Random	1.15	37
Quarrystone (Rough)	>3	Random	1.10	40
Cube (modified)	2	Random	1.10	47
Tetrapod	2	Random	1.04	50
Quadripod	2	Random	0.95	49
Hexapod	2	Random	1.15	47
Tribar	2	Random	1.02	54
Dolos	2	Random	1.00	63
Tribar	1	Uniform	1.13	47
Quarrystone	graded	Random	----	37

KBwater Model Demonstration
Internet Version
Website: WWW.hceatkuwait.net\KBwater\kbw.aspx

User must login to website address at: *WWW.hceatkuwait.net\KBwater\kbw.aspx*
Then Figure 4 will display the main KBwater website page on internet as follows:
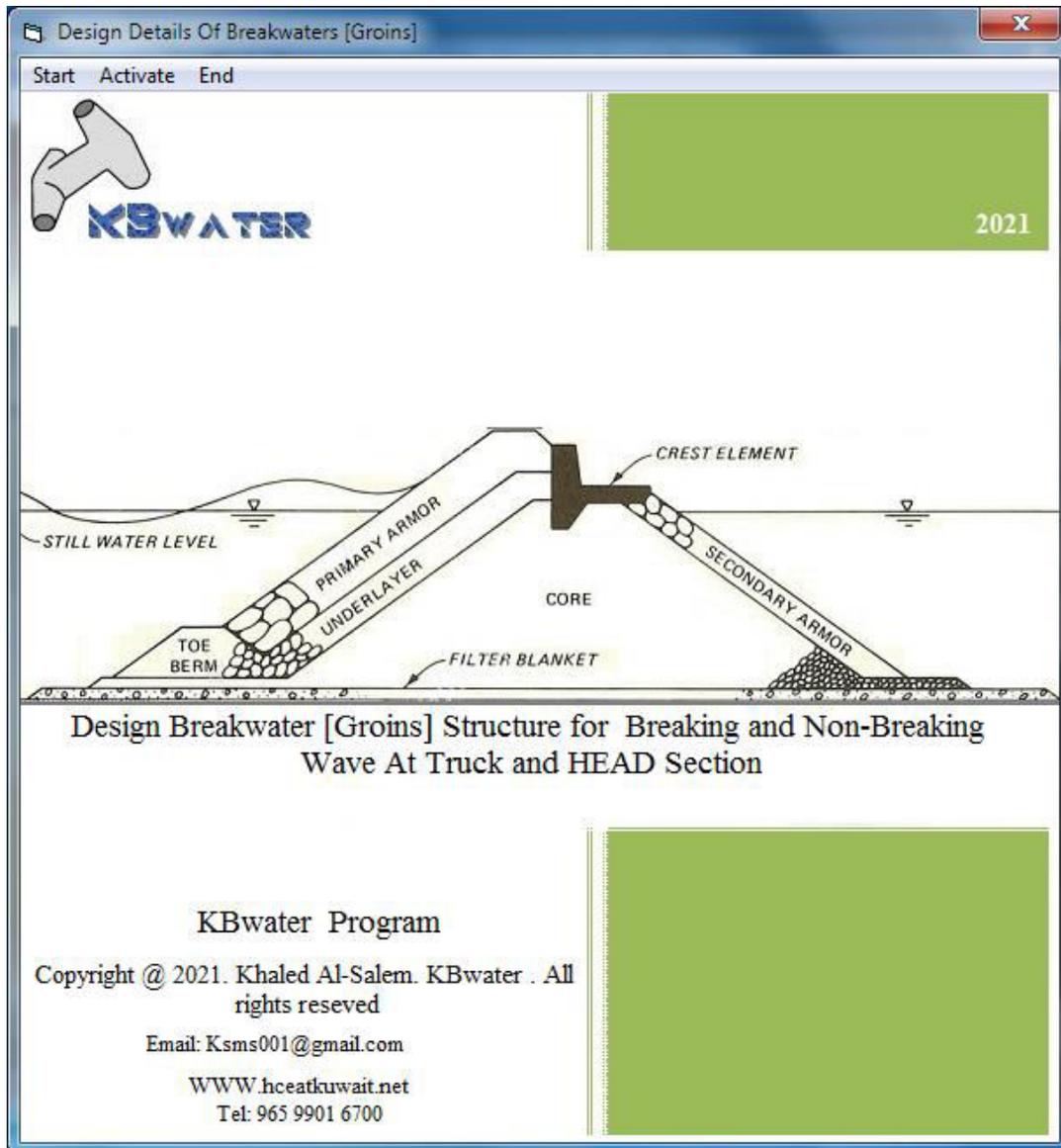
Figure 4

User must select [⬡] to start the model for new project. Figure 5 will display for new project setup.

Figure 5 display for user to setup structural design for breakwater for the following Section

1- Design Breakwater section
- o Trunk Section of Breakwater as shown in Figure 10 [On the Right Of Figure 5]
- o Head Section of Breakwater as shown in Figure 10 [On Left of Figure 5]

2- Type of wave to design
- o Breaking Wave
- o Non-Breaking Wave

User must enter the following Parameter of the design as
1. Design Depth [m] D
2. Design Wave Height [m] [Extreme wave height] Hs
3. Design Corresponding wave periods [sec] Pr

The from these model will decided the design based on [Breaking and NON-breaking] as followings:

$$Hs > 0.78D \ \ [Breaking \ wave \ design]$$

as shown in Figure 6 after user select [*Press-Check Case*].

4. Select Armor type [From Drop list]

5. Select Layer Coefficient [Ka] by two ways:

   - From Armor type selection

   - From select [*Table Ka*] manual enter value.

6. Armor units weight [KN/m3 Or Tons]

7. Select structure trunk[Kd] by select [*Table Kd*] manual enter value

8. Select Breakwater Slop as V-vertical direction and H Horizontal direction

HEAD SECTION SAME WAY OF DATA PARAMETER INPUTS

When all Data input for Trunk and Head section of breakwater are done user must enter [An ACESS CODE].
User can get ACESS CODE from Developer at [Ksms001@Gmail.com].

Figure 7 will display for user a complete structural design of the breakwater.
From Figure 7 user can display the Cross section of breakwater structural design detail in graphically by select the [check box] next to each section the design?

Then select map icon [   ] to display the cross section of the breakwater as shown in:
- Figure 8 TRUNK Cross section of breakwater

- Figure 9 HEAD Cross section of breakwater

A sample project Report display at the end for user by Selecting from Figure 7 Icon[   ].
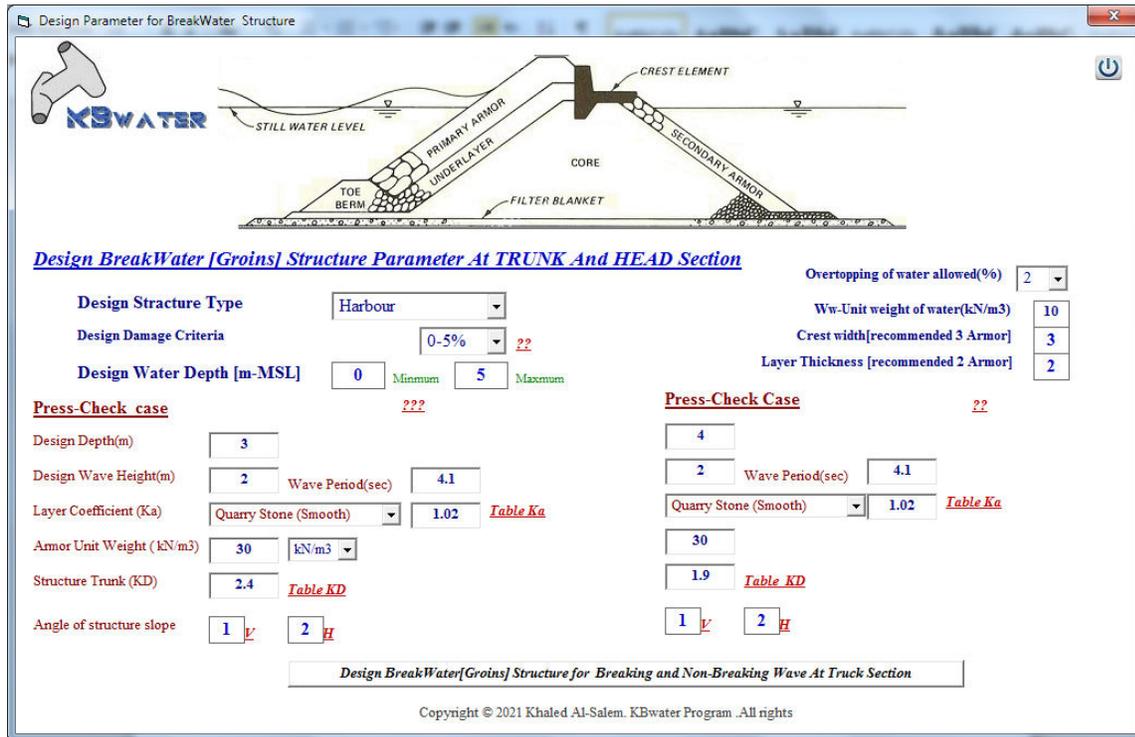
Figure 5
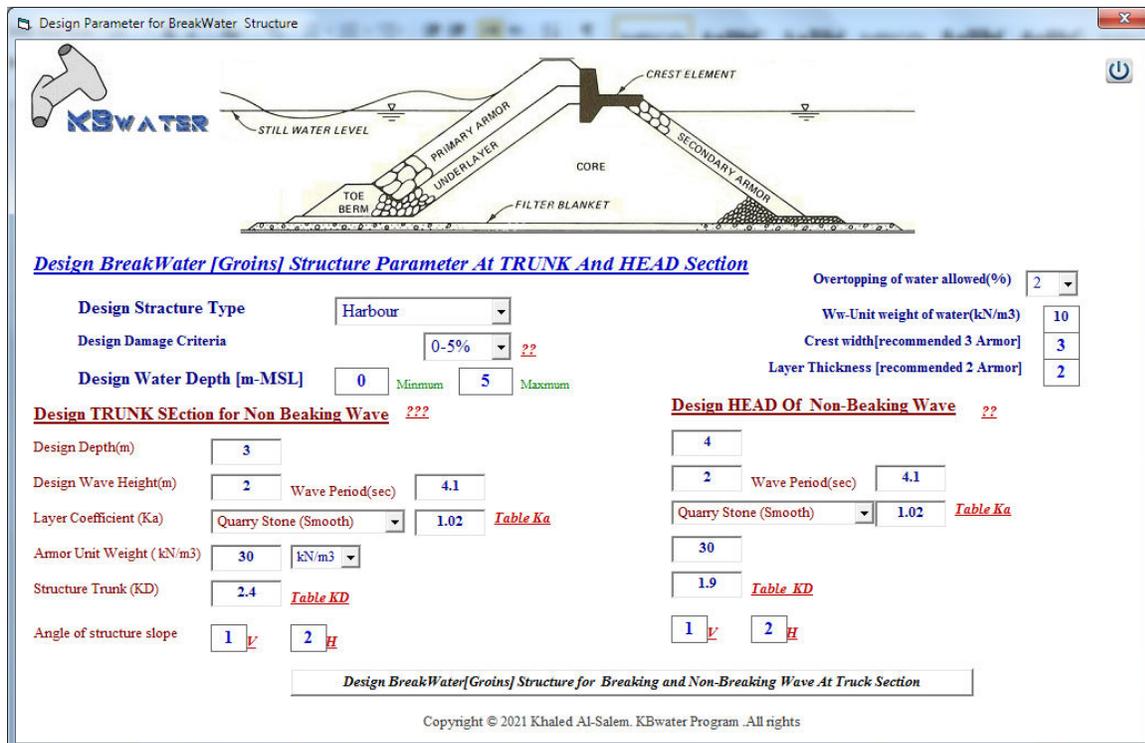
Figure 6

Design Sheet for WEIGHT OF ARMOR UNIT at Structure Trunk of BreakWater

Design Details Sheet

For BreakWater [Groins] Structure at Trunk Section

WEIGHT OF ARMOR UNIT for Breakwater Trunck Section

WEIGHT OF ARMOR UNIT Breakwater HEAD Section

Design Armor Units weight (K-Tons) — 6 — (K-Tons)

Weight of the First Under Layer and Secondary Cover Layer — W/10 to W15 — 0.6 — .4 — (K-Tons)

Weight of Core and Bedding Layer — W/200 to W/6000 — 0.03 — .001 — (K-Tons)

8 — (K-Tons)
0.8 — .5333 — (K-Tons)
0.04 — .0013 — (K-Tons)

Armour Details

GRADATION DETAILS ??

Layer	Rock Size (K-Tons)	GRADATION (%)
Primary Cover Layer	W 6	125 To 75% 7.5 to 4.5
Secondary cover Layer , First under Layer	W/10 To W/15 .6 To .4	130 To 70% .78 to .28
Core and Bedding Layer	W/200 To W/6000 .03 To .001	170 To 30% .051 to .0003

GRADATION DETAILS ??

Layer	Rock Size (K-Tons)	GRADATION (%)
Primary Cover Layer	W 8	125 To 75% 10 to 6
Secondary cover Layer , First under Layer	W/10 To W/15 .8 To .5333	130 To 70% 1.04 to .37331
Core and Bedding Layer	W/200 To W/6000 .04 To .0013	170 To 30% .068 to .00039

BreakWater Details

TOE BERM FOR COVER LAYER STABILITY

Crest Elevation [r-m]   2   only 2% of the waves during a storm will overtop the breakwater.

Crest Width [B-m]   2   Armour units Recommend used (n=3) for facilitate movements of machines

Armour Layer Thickness   1   r-(m) Recommended # Armour unit n=2

TOE BERM FOR COVER LAYER STABILITY

Stone Weight [Kn]   0.6   Width Toe Berm [m]   2   Height of the Berm [m]   1.255

Underlayer Thickness [r-(m)]   1.255

Design Damge Wave = 2m   Damge Criteria = 0.5%

BreakWater Details

Crest Elevation [r-m]   3   only 2% of the waves during a storm will overtop the breakwater.

Crest Width [B-m]   2   Armour units Recommend used (n=3) for facilitate movements of machines

Armour Layer Thickness   1   r-(m) Recommended # Armour unit n=2

TOE BERM FOR COVER LAYER STABILITY

Stone Weight [Kn]   0.8   Width Toe Berm [m]   1   Height of the Berm [m]   0.609

Underlayer Thickness [r-(m)]   0.609

Design Damge Wave = 2m   Damge Criteria = 0.5%

Figure 7

Figure 8
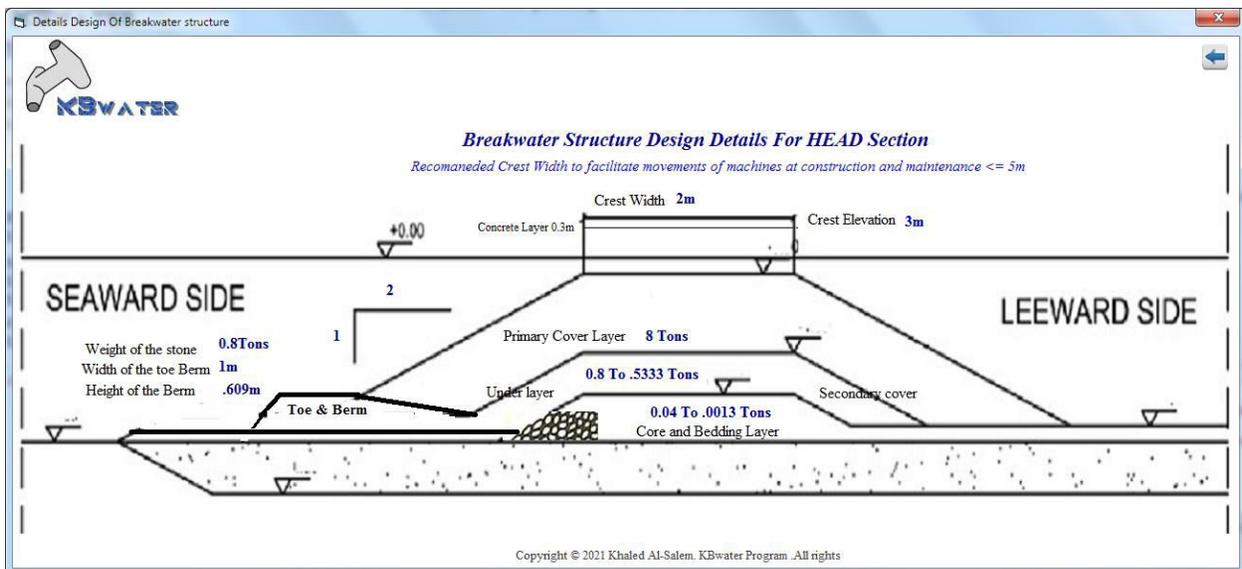
Figure 9
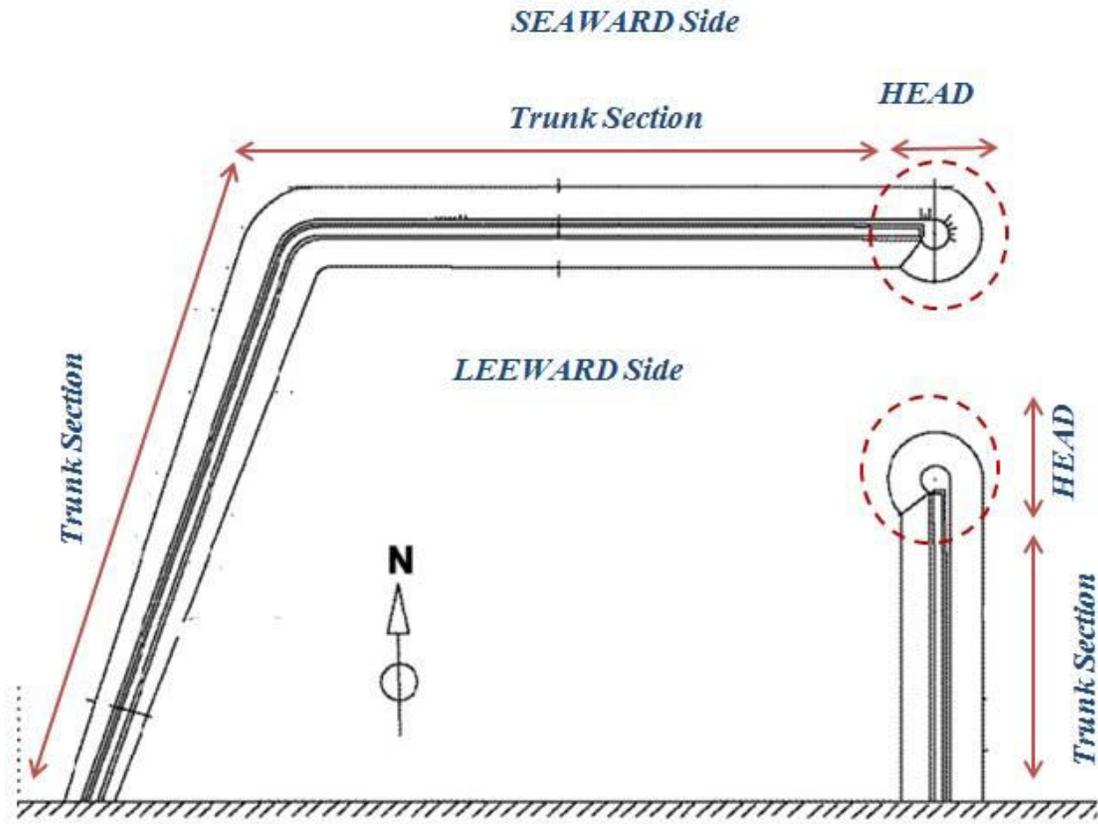
Figure 10

DETAILS DESIGN FOR BREAKWATERS STRUCTURE

KBWater Model
:Khaled Al-Salem (2021)
Email: Ksms001@Gmail.com
WWW.hceatkuwait.net
Phone:(965) 99016700

   Basically the weight of the stable armor stone/artificial unit is first estimated in the design.
Then the weight of the stones in the inner layers and core needs to be estimated.
The weights and sizes of the inner layers and core need to be selected based on the inverse filter principle.
According to this principle, the size of pore at any layer must be smaller than the size of the inner material
so that the inner material should not be finding its way to escape out due to the dynamic activity of the
waves.

Details Design Breakwater Parameter

Breakwater Parameters Inputs

   Breakwater Slow-Depth (m)   : 0
   Breakwater Deeper-Depth (m)   : 5
   Overtopping of Water Allowed(%)   : 2
   Unit Weight of Water(Kn/m3)   : 10
   Crest width [Recommended use n Amours   : 3
   Layer Thickness [Recommended used n Amours]: 2
   Selected Damage Criteria(%)   : 0-5%

Parameter Selected For TRUNK SECTION As shown In Figure 10
==

   Design TRUNK Section for Non Breaking Wave as shown in Figure 6
   Selected Depth For Breakwater TRUNK Section(m)   : 3
   Selected Significant Wave Height [Used Extreme Wave H](m): 2
   Selected Wave Period(sec)   : 4.1
   Selected Layer Type   : Quarry Stone (Smooth)
   Layer coefficient (Ka)   :1.02
   Selected Armor Unit Weight [kN/m3]   : 30
   Selected Structure TRUNK (KD)   : 2.4
   Selected Angle Of Structure Slop: V   :1m and H:2m

Details stone Layer and Breakwater information Design For Construction at TRUNK Section

Layer Design Selected For TRUNK SECTION As shown In Figure 7.
Armor Details
   Design Armor Units weight [W](Tons)   : 7
   Secondary cover Layer , First under Layer [W/10 => W/15](Ton)   : 0.6 => .4
   Weight of the First UnderLayer and Secondary Cover Layer[W/200 => W/6000](Ton): 0.03 => .001

Table For GRADATION DETAILS

Layer	Rock Size(K-Ton)	GRADATION(%)
Weight of Core and Bedding Layer	W	75% to 125%
	6	7.5 to 4.5
Secondary cover Layer , First under Layer	W/10 => W/15	70% to 130%
	0.6 => .4	.78 to .28
Core and Bedding Layer	W/200 => W/6000	30% to 170%
	0.03 => .001	.051 to .0003

BREAKWATER DETAILS
   Crest Elevation[m]   : 2   Note: only 2% of the waves during a storm will overtop the breakwater.
   Crest Width[m]   : 2   Note: Armor units Recommend used (n=3) for facilitate movements of machines
   Amour Layer Thickness [m]: 1   Note: r-(m) Recommended # Armor unit n=2

TOE BERM FOR COVER LAYER STABILITY
   Stone Weight [Kn]   : 0.6
   Width Toe Berm [m]   : 2
   Height of the Berm [m]   : 1.25590203030453
   Underlayer Thickness [r-(m)]: 1.25590203030453
Wave Height Damaged Criteria
   Design Damage Wave = 2m
   Damage Criteria = 0-5%

Figure 8 display Cross Section of Breakwater Details Design for TRUNK Section

Parameter Selected For HEAD SECTION As shown In Figure 10
==

   Design HEAD Of Non-Breaking Wave as shown in Figure 6
   Selected Depth For Breakwater Head Section(m)   : 4
   Selected Significant Wave Height[Used Extreme Wave H](m): 2
   Selected Wave Period(sec)   : 4.1
   Selected Layer Type   : Quarry Stone (Smooth)
   Layer coefficient (Ka)   :1.02
   Selected Armor Unit Weight [kN/m3]   : 30
   Selected Structure TRUNK (KD)   : 1.9
   Selected Angle Of Structure Slop: V   :1m and H:2m

Details stone Layer and Breakwater information Design For Construction at HEAD Section
----

Layer Design Selected For HEAD SECTION As shown In Figure 7.
Amour Details
   Design Armor Units weight [W](Tons)   : 8
   Secondary cover Layer , First under Layer [W/10 => W/15](Ton)   : 0.8 => .5333
   Weight of the First UnderLayer and Secondary Cover Layer[W/200 => W/6000](Ton): 0.04 => .0013

Table For GRADATION DETAILS

Layer	Rock Size(K-Ton)	GRADATION(%)
Weight of Core and Bedding Layer	*W*	*75% to 125%*
	8	*10 to 6*
Secondary cover Layer , First under Layer	*W/10 => W/15*	*70% to 130%*
	0.8 => .5333	*1.04 to .37331*
Core and Bedding Layer	*W/200 => W/6000*	*30% to 170%*
	0.04 => .0013	*.068 to .00039*

BREAKWATER DETAILS
   Crest Elevation[m]   : 3   Note: only 2% of the waves during a storm will overtop the breakwater.
   Crest Width[m]   : 2   Note: Armor units Recommend used (n=3) for facilitate movements of machines
   Amour Layer Thickness [m]: 1   Note: r-(m) Recommended # Armor unit n=2

TOE BERM FOR COVER LAYER STABILITY
   Stone Weight [Kn]   : 0.8
   Width Toe Berm [m]   : 1
   Height of the Berm [m]   : 0.609471045531774
   Underlayer Thickness [r-(m)]: 0.609471045531774
Wave Height Damaged Criteria
   Design Damage Wave = 2m
   Damage Criteria = 0-5%

Figure 9 display Cross Section of Breakwater Details Design For HEAD Section

PREDICTION OF LONGSHORE CURRENTS AND SEDIMENT TRANSPORT
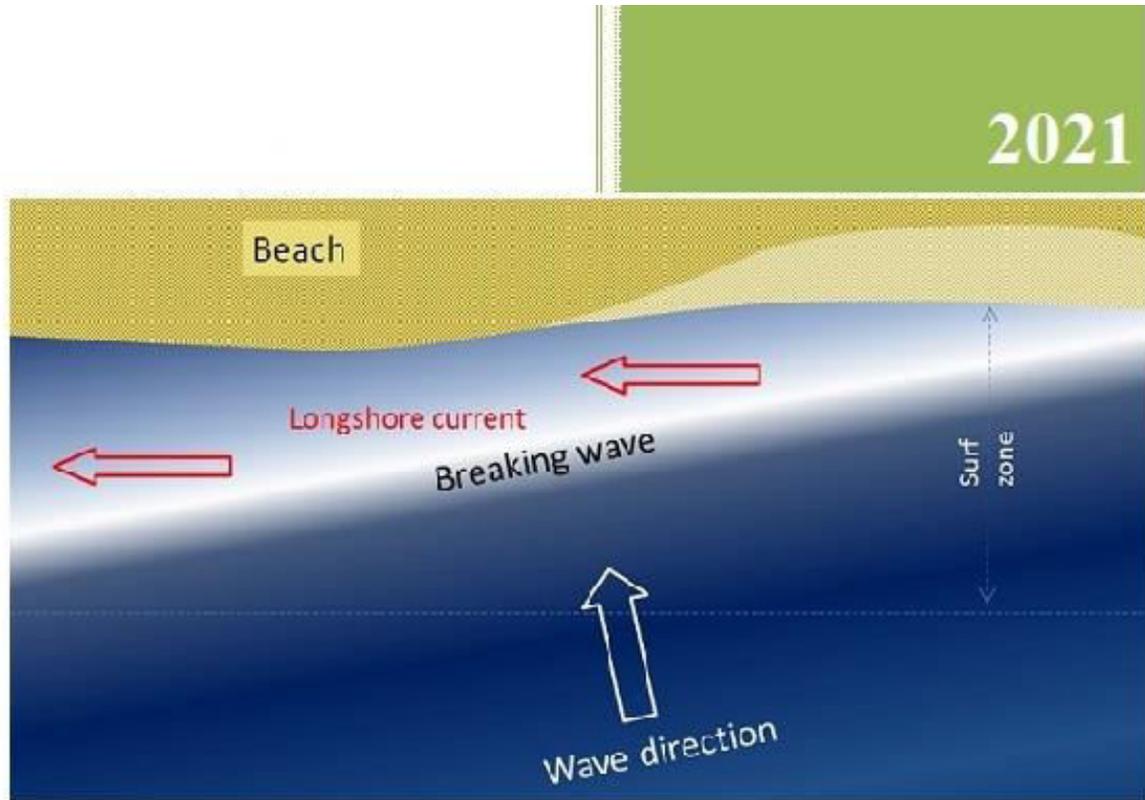
PREDICTION OF LONGSHORE CURRENTS AND SEDIMENT TRANSPORT

· **KLSC Program**

Costal Information System [C.I.S.]
Jan 2021

Introduction

Breaking waves approach a straight coastline at an oblique angle, they induce a longshore current in the surf zone. The current acts somewhat analogous to beach line, transporting sediment mobilized by the breaking waves, and confined to a zone with a width of two to three times the width of the surf zone. The prediction of such longshore currents and the associated sediment transport is of prime importance for coastal engineers. The purpose of this study is to present a numerical model of longshore current in combination with some of the known formulae for predicting sediment transport which can be used for engineering purposes. Breaker wave Types as shown in Figure 1 shows the slope of the lower beach depends on the type of waves (in beaches of uniform composition).

- ☐ Spilling Breaker: Gentle beach slope, waves break far from shore and surf gently rolls over the front of the wave.
- ☐ Plunging Breaker: Moderately steep beach slope, less steep wave, slightly longer period, wave curls over forming a tunnel until the wave breaks.
- ☐ Surging Breaker: Steep beach slope, low wave of long period, doesn't actually break, wave rolls onto the beach.
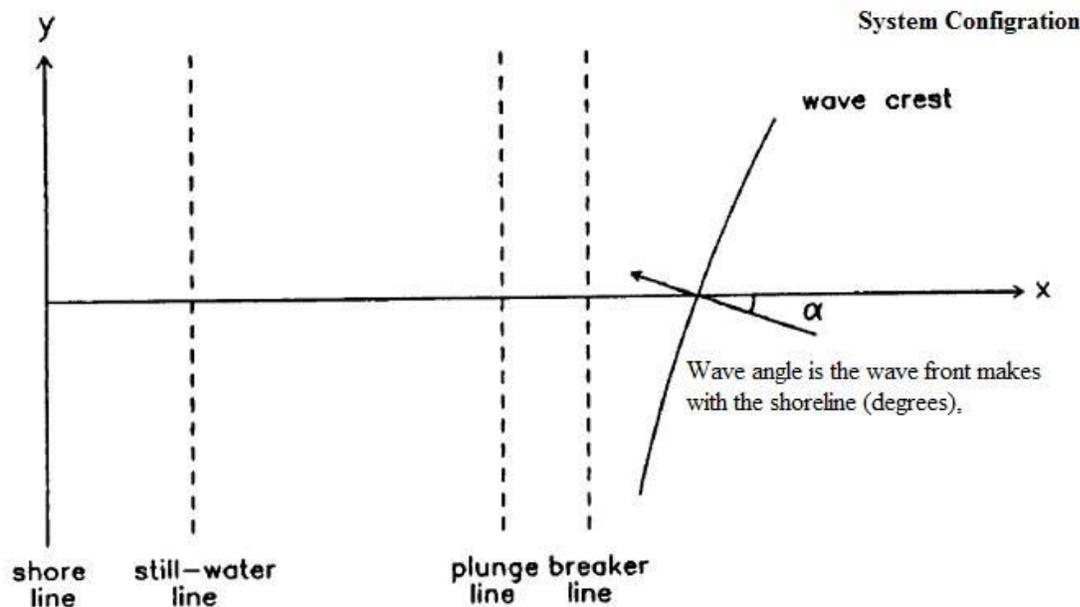
Figure 1. illustrative of Breaker wave Types.

.
Longshore Current:
Sand moves to or from the beach in an onshore-offshore direction, but it also moves along the shoreline ("longshore"). This longshore sand transport is referred to as longshore drift as shown in Figure 2. The longshore current moves the sand along the beach. At a particular time, the longshore drift of the sand by the longshore current may be in either direction along the beach. Over the course of a year and at most locations, the volume of sand moved in one direction will exceed the amount moved in the opposite direction. The difference in the amounts of longshore drift between the two directions over a period of one year is called the annual net longshore drift. The longshore current, the movement of water along the shoreline, is caused by
- ☐ Waves approaching at an angle to the shoreline.

☐ Tidal currents.

☐ Wind pushing water along the beach.
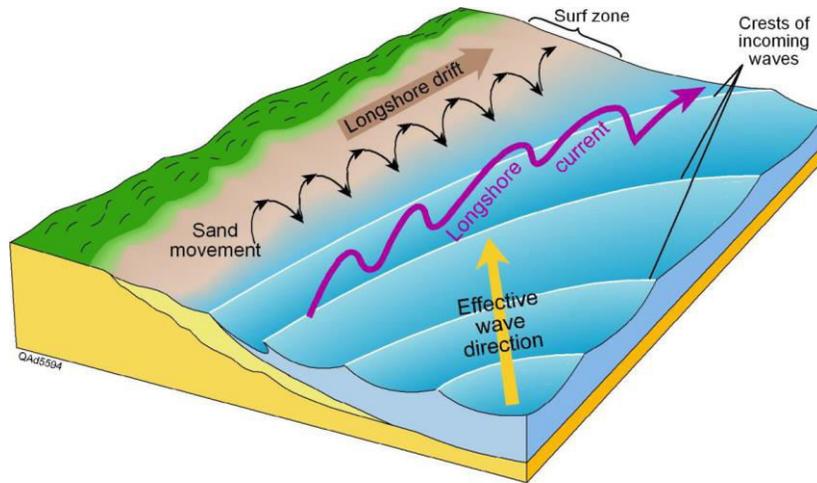
Figure 2. illustrative of longshore current.

Methodology

A numerical model for the steady-state profile of the longshore current induced by regular, obliquely incident, breaking waves will be presented. The wave parameters must be given at an arbitrary depth. A rapid convergent numerical algorithm is described for the solution of the governing equation. This model is solved using a nonlinear bottom friction law in which the friction coefficients are a function of the bottom roughness which is computed at each point using an empirical formula. The predicted current profiles are combined with some of the known formulae for sediment transport computations. According to the generally employed assumptions in longshore current modeling as:

☐ Longshore uniformity in waves and bottom topography.

☐ Negligible bottom friction in the cross-shore direction.

☐ Applicability of linear-wave theory.

the vertically integrated, time-averaged momentum equations for nearshore water motion (Mei, 1983) become as follows:

$$\rho g d \frac{dn}{dx} = -\frac{dS_{xx}}{dx}$$

$$\frac{d}{dx}\left[A_h d \frac{dV}{dx}\right] - \frac{\tau_{by}}{\rho} = \frac{1}{\rho}\frac{dS_{xy}}{d_x}$$

Where

o   the cross-shore *X* component and for the longshore *Y* component respectively as shown in Figure 2.

o ρ is the water density,

o   g the acceleration resulting from gravity.

o $d = h + \eta$ the mean water depth.

- o h Still water depth,
- o η Elevation of the free surface above the still water level,
- o A_h the eddy viscosity coefficient,
- o V the longshore current velocity
- o τ_{by} Bottom frictional stress.
- o S_{xx} and S_{xy} Radiation stress components are given by the following:

$$S_{xx} = E[n(cos^2\alpha + 1) - \frac{1}{2}]$$

$$S_{xy} = \frac{\sin(\alpha)}{C} F_x$$

Where

C is the phase velocity of waves

$n = \frac{1}{2} + (kd/Sh2kd)$

α *is the that wave front with the shoreline*

$E = \frac{1}{2}\rho g H^2$ is the energy density of the waves per unit area

H is the wave height in meter

$k = 2\pi/L$ wave number

L wavelength

$C = \sqrt{gd}(1 - \frac{d}{L_0})$ as $\frac{d}{L_0} \leq 0.36$

OR

$C = \frac{gT}{2\pi} = C_0$ as $\frac{d}{L_0} \geq 0.36$

T is the wave period (sec)

L_0 *wavelength at deep water* [*o for deep water values*]

The specific assumptions of this study as following:

- o Constant beach slope.
- o Proportionality between the wave height and the mean water depth in the surf zone $H=\lambda d$.
- o Negligible wave set-down offshore of the plunge line X_p.
- o Applicability of the shallow water approximation η=1, cos α =1 and $C = \sqrt{gd}$

The mean water surface displacement can be integrated to obtain

$\eta = Ks(X_p - X)$ Where $K = (1 + \frac{8}{3\gamma^2})^{-1}$

λ breaker index

s beach slope.

For X=X_s then $X_s = KX_p$ where X_s *is* the line of maximum wave set-up as shown in Figure 3.

Where Plunge line $X_p = X_b - 3H_b$ [H_b *breaking wave height*]

The breaker zone width $X_b = \frac{d_0}{s} + X_s$ where d_0 depth at breaking [$d_0 = H_b/\gamma$]. Figure 3 display the definition sketch for coordinate system and nearshore region parameters.
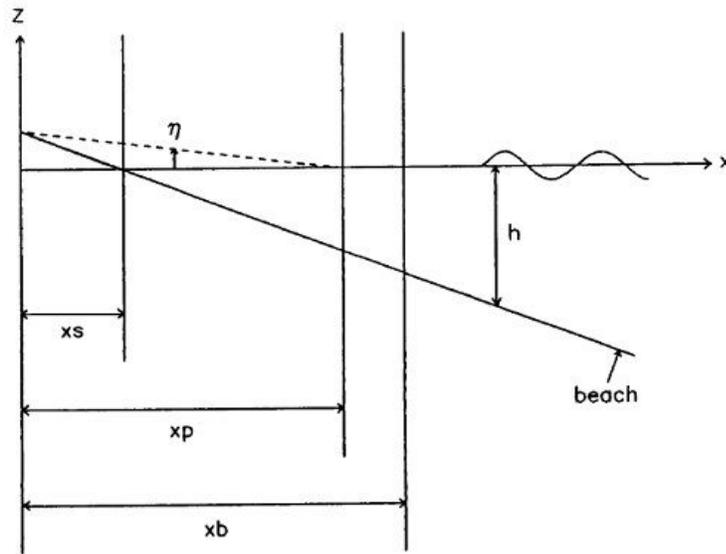
Figure 3. Definition sketch for coordinate system and nearshore region

Under the combined action of waves and currents the time-averaged bottom friction in longshore direction can be expressed as

$$\frac{\tau_{by}}{\rho} = \frac{1}{8} F \frac{1}{T} \int_0^T [V^2 + 2\xi u_m V \sin\alpha \cos\omega t + (\xi u_m)^2 \cos^2 \omega t]^{1/2} * (V + \xi u_m \sin\alpha \cos\omega t) \, dt$$

Where

$\omega = \frac{2\pi}{T}$ Angular frequency

u_m maximum orbital velocity near the bottom

$\xi = 2[\frac{F_w}{F}]^{1/2}$ where F_w Jonsson friction coefficient F Darcy-Weisbach friction coefficient

By solving the longshore current numerically the square wave approximation introduced by Nishimura (1988) is used the time-averaged bottom friction in longshore direction becomes:

$$\frac{\tau_{by}}{\rho} = \frac{1}{8} F \left(Z + \frac{z^2 \sin^2 \alpha}{Z} \right) V$$

Where

$$Z = \frac{1}{2} [(V^2 + z^2 + 2zV \sin\alpha)^{\frac{1}{2}} + (V^2 + z^2 - 2zV \sin\alpha)^{1/2}$$

$$z = (\frac{2}{\pi}) \xi u_m$$

The friction coefficients F_w

$F_w = \exp[-5.977 + 5.213(\frac{r}{a_b})^{0.194}$ for $\frac{r}{a_b} \leq 0.63$

or

$F_w = 0.3$ for $\frac{r}{a_b} > 0.63$

$$F = 8[2.5 Ln \frac{12d}{r}]^{-2}$$

Where

$a_b = u_m/\omega$ is the horizontal water particle excursion at the bottom

r equivalent diameter of the roughness elements as $r = 190D\sqrt{(\theta - 0.05)} + 8\frac{n_r^2}{\gamma_r}$

γ_r ripple length

η_r ripple height

D mean sediment grain diameter

$\theta = \frac{1}{2}F_w\psi$ so-called skin friction Shields parameter

F_w Jonsson friction coefficient $r = 2.5D$

$\psi = \mu_m^2[(s-1)gD]$ is mobility parameter

s relative sediment density $[s = \rho_s/\rho$ where ρ_s sediment density]

To simulate the appropriate breaker index for random waves [Thornton, Wu, and Guza (1984)] presented criteria for random breaking waves based on field and laboratory data for the following:

$\gamma_s = 0.603 + 2.147s\,(30.685s - 5.192)[\frac{H_{os}}{L_0}]$ Based on significant wave height

Where the correlation coefficient is 0.99.

For a Rayleigh wave height probability distribution, the relationship between significant wave height and root-mean square wave height is $H_s = \sqrt{2}H_{rms}$,

where H_{rms} is $root - mean$ $square$ $wave$ $height.$ Then γ_{rms} breaker index based on root-mean square wave height as as follows:

$\gamma_{rms} = \dfrac{\gamma_s}{\sqrt{2}}$

When the input conditions are those at the breaker line a simple predictive formula is used to estimate the deep water wave height prior to determining the breaker index (Larson and Kraus, 1989).

$H_{bs} = 0.53H_{0s}[\frac{H_{os}}{L_0}]^{-0.24}$

where,

H_{bs} is the $significant$ $breaking$ $wave$ $height$ at $breaker$ $line$
H_{0s} is the $significant$ $breaking$ $wave$ $height$ at $deep$ $water$

A new numerically program was developed to solve the prediction of Longshore current and sediments transport. The program will be called [**K.L.S.C. model**] using the above formulation for longshore current prediction. The user will request to input the following parameters:

- The significant wave height (Hs in meters) or the root-mean square wave height (Ha ..... in meters).
- The angle of the wave front makes with the shoreline (degrees)
- The wave period (seconds) as shown Figure 1.
- The depth in which wave measurements were made (meters). If the wave conditions are not at the breaker line.
- The beach slope.
- The mean sediment diameter (D in millimeters).
- The particle diameter D90 if it available (10% by weight exceeded in size, millimeters) which is not strictly necessary for the program to be run.
- The sediment density (kilogram per cubic meter).

With these parameters the program computes the following:

o LongShore current [m/s]
o Sediment transport distributions rate in [m^3/s and m^3/day]

Discussion Result and Model validation process

Case 1: Computed longshore current distribution for Thornton and Guza (1986, 1989-4 Feb) Data and compared with KLSC model result using the input wave parameters list in Table 1. In [*Model results*] shows the simulation output for sediments transport rate and Figure 4 display the computed longshore current distribution from Thornton and Guza (1986, 1989) and KLSC model (AL-Salem K. 2021) shows satisfying agreements.

Table 1 Model input parameters

Root-mean square wave height	0.52 m
Significant wave height	0.735m
Wave period	14.2 sec
The wave front makes with the shoreline (α in degrees) see Figure 1	7.8^0
Beach slope [1 : 26]	0.038
Mean sediment diameter D_{50}	0.23 mm
Sediment density	2650 kg/ m^3
if the wave conditions are not at the breaker [Depth in which wave measurements were made]	At Breaker D> no need

Thornton and Guza (1989) Field Measurements of 4 February (Slope from Profile 0.038)

Distance from Shoreline (m)	Depth (m)
10.39	0.52
13.39	0.65
16.45	0.78
19.41	0.89
22.21	1.01
25.34	1.16
28.26	1.24
31.31	1.34
34.46	1.42
38.58	1.56
43.16	1.7
60.62	2.37
72.42	3.03
84.16	3.79

Data Source: https://erdc-library.erdc.dren.mil/jspui/bitstream/11681/4585/1/13150.pdf
"Dredging Research Program: NMLONG: Numerical Model for Simulating the Longshore Current. Report 1. Model Development and Tests"

Model results:

```
KLSC Program
Prediction Of Longshore Current and Sediment Transport
Developed By Khaled; Al-Salem(2021)
Email: Ksms001@gmail.com
www.hceatkuwait.net
Tel:964 9901 6700
============================================================

Parameter Wave Input:
Input Wave Type          =Root-Mean Square Wave Height
Wave Height(m)           = 0.76
Wave Angle(deg)          = 7.8
Wave Period(sec)         = 14.2
Beach Slope              = 0.038
Mean sediment Diameter(mm) = 0.23
Simulation Condition at The Beaker Line =YES
Is the sediment diameter D90 available =NO
D90[mm] = 0
Sediment Density[ kg/cub.m ]  = 2650


Parameter Simulated:
Root-mean square wave height at the breaker line=  0.76
Angle of incidence of wave at the breaker line=  7.8
Period of wave =  14.2


The Breaker zone width[m]                 = 45.0422385050969
The distance from shoreline to plunge line[m]  = 42.7622385050969
The distance from shoreline to still-water[m]  = 3.40529669304591
The depth at breaking Wave[m]             = 1.58220378885794
Breaker index                            = 0.480342674788171
Vo[m/s]                                   = 1.16510770909339
Mean longshore current velocity[m/s]      = 0.437607942872251


Sediment transport (m3/sec And  m3/Day)


                                m3/sec        m3/Day
Adapted Engelund-Hansen formula = .00199       172
Watanabe formula                 = .01177      1017
CERC formula                     = .02242      1936
```
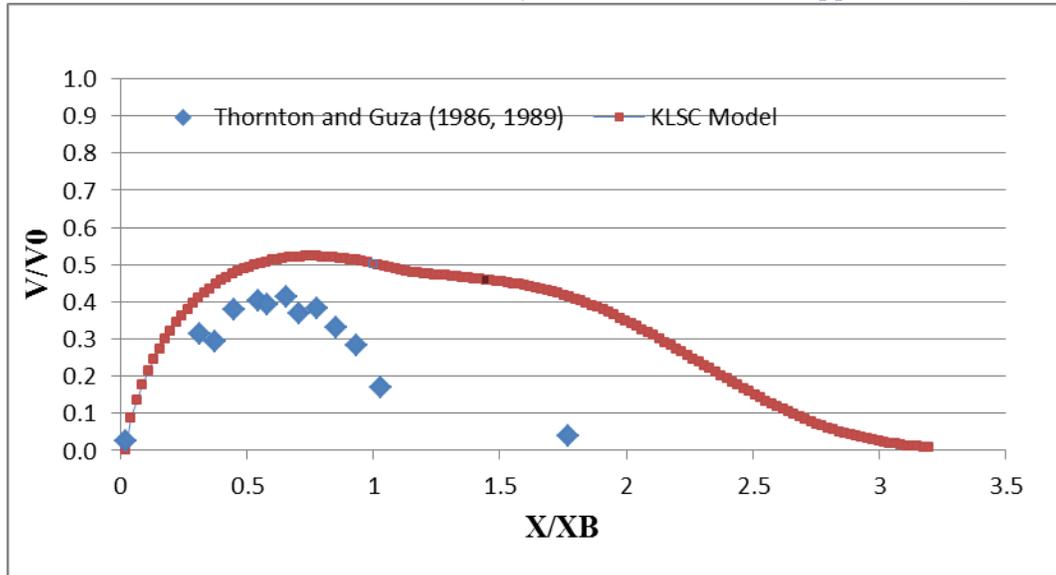
Figure 4. Computed longshore current distribution for Thornton and Guza (1986, 1989 data Feb.4) and KLSC model (AL-Salem K. 2021).

***Case 2*:** Computed longshore current distribution for [Thornton and Guza (1986-89) -3 Feb)] Data and compared with KLSC model result using the input wave parameters list in Table 2. Figure 5 display the computed longshore current distribution from Thornton and Guza (1986-Feb. 3 data) and KLSC model (AL-Salem K. 2021) shows satisfying agreements.

Table 2 Model input parameters [Thornton and Guza (1986) -3 Feb)]

Root-mean square wave height	0.55 m
Wave period	14.3 sec
The wave front makes with the shoreline (α in degrees) see Figure 1	7.8^0
Beach slope [1 : 28]	0.035
Mean sediment diameter D_{50}	0.23 mm
Sediment density	2650 kg/ m^3
if the wave conditions are not at the breaker [Depth in which wave measurements were made]	At Breaker D> no need

Data Source: https://apps.dtic.mil/dtic/tr/fulltext/u2/a408263.pdf
"Dredging Research Program: NMLONG: Numerical Model for Simulating the Longshore Current. Report 1. Model Development and Tests"
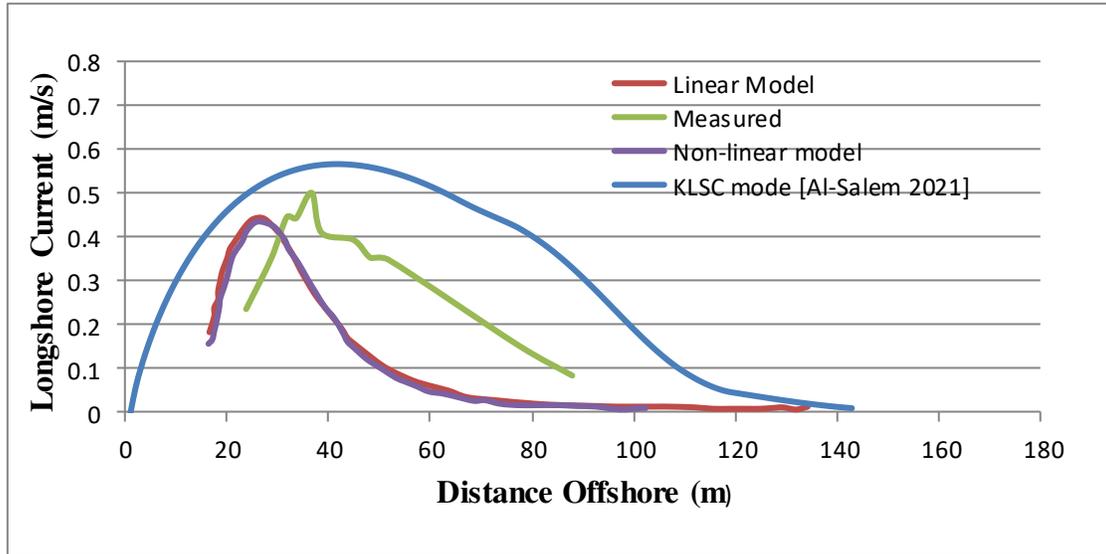
Figure 5. Computed longshore current distribution for Thornton and Guza (1986, 1989 Data Feb.3) and KLSC model (AL-Salem K. 2021).

Case 3. Input Data used from Report of:
 "A SIMPLE GENERAL EXPRESSION FOR LONGSHORE TRANSPORT OF SAND, GRAVEL AND SHINGLE". Leo C. van Rijn. [https://www.leovanrijn-sediment.com/papers/Longshoretransport2013.pdf].

Comparison of measured and predicted with computed longshore transport predicted from KLSC model for coarse-grained beaches (0.68-1 mm) shows in Table 3 for coarse-grained beaches more than 7-19mm predicted zero transport. All computed transport rates of the measured values, predicted and KLSC model prediction as shown in Table 3. The new longshore transport formula used in KLSC model yields rather good results compared to laboratory experiments and predicted with small irregular waves and shingle type sediment under a very steep slope of 1 to 1.5.From table 2 KLSC model show a good agrements with field sites measurements and laboratory experiments data.

Conclusion
    A numerical modeling system called KLSC was developed [Al-Salem 2021] that has the capability to calculate the longshore current and sediments transport rate trough beach profile. The calculated longshore current is time-averaged and depth-integrated. A major practical restriction on the modeling system is the requirement of longshore uniformity, meaning that the beach topography and wave conditions should be uniform alongshore.The three Cases calculation components of the modeling system were verified separately. The longshore current and sediments transport calculation was verified with data from small-scale laboratory experiments involving regular wave's incident at an angle to the beach. the longshore current calculation was verified with laboratory measurements and two field data sets.

Table 3. Longshore transport data of coarse-grained field sites, laboratory experiments and Predicted from KLSC model [al-Salem 2021]

Field and laboratory data	*Input wave parameters*					Q_{t-max}		
	D50	**Tan(β)**	*Hs*	*α*	*Tp*	*Mea-Sured*	*Pred-icted*	*KLSC model*
	mm		*m*	*deg*	*sec*	*(kg/s)*	*(kg/s)*	*(kg/s)*
Onslow beach, NC,USA(Wang,1998)	2.25	0.094	0.85	12	6	5.3	5.5	8.3
Canaveral beach, FL,USA(Wang,1998)	0.9	0.115	0.65	9	3.5	2.4	3.4	3.7
Melbourne beach, FL,USA(Wang,1998)	1.5	0.158	0.7	2.5	3.5	0.75	1.02	0.62
Lido Key beach, FL,USA(Wang,1998)	0.68	0.105	0.53	14	3.7	4.9	3.2	4.02
Redington beach, FL,USA(Wang,1998)	0.85	0.125	0.5	8.4	4.5	1.9	1.5	1.45
Redington beach, FL,USA(Wang,1998)	0.9	0.026	0.45	19.2	4.5	1.05	1.21	2.5
Indian Rocks, FL,USA(Wang,1998)	1.38	0.191	0.27	10	2.8	0.35	0.21	0.6
Indian Rocks, FL,USA(Wang,1998)	1.29	0.152	0.2	8.2	3.8	0.25	0.073	0.12
Cape Thompson(Moore and Cole 1960)	1	0.091	1.66	25	5.5	67	133	346
Lab. Exp. Ir. Waves G-H; Burcharth 1988	19	0.2	0.13	15-30	1.8-2.5	0.005	0.01	0-0

D50 particle size; **tanβ** beach/surf zone slope; *Hs,* significant wave height at breaker line;

α wave angle to shore normal at breaker line; *Tp* peak wave period,

[Q(m^3/sec) => 739 Q (kg/sec)]

Q-predicted from KLSC model used based [Watanabe formula]

Data source:[https://www.leovanrijn-sediment.com/papers/Longshoretransport2013.pdf].

K.L.S.C. Model Demonstration
PREDICTION OF LONGSHORE CURRENTS AND SEDIMENT TRANSPORT
[Al-Salem K 2021]
PC Version
Website version: WWW.hceatkuwait.net\KLSC\KLSC.aspx

User can run the KLSC model from CIS interface under [Hydrodynamics sub]. Then Figure A1 will display the main KLSC main page as follows:
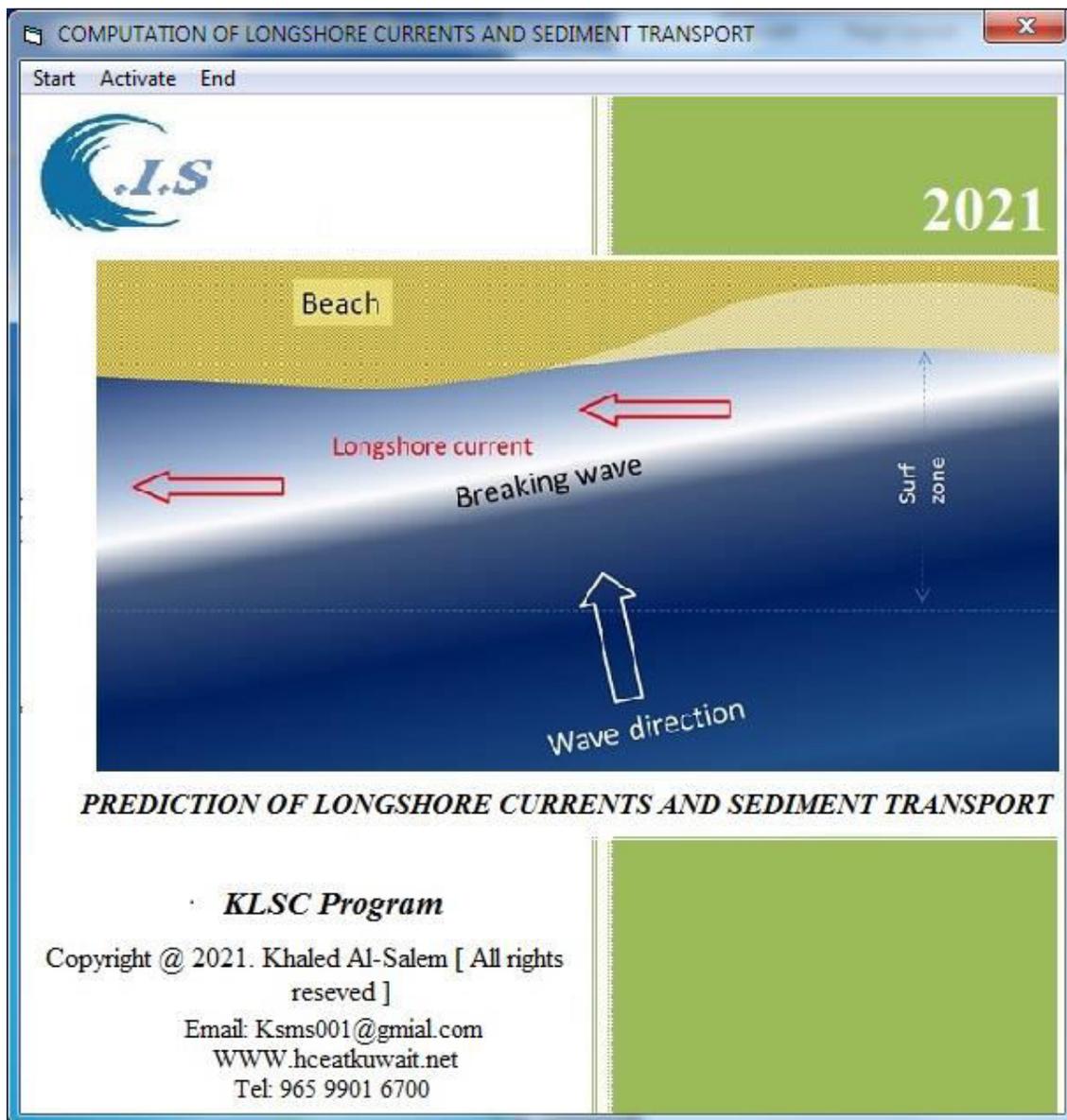
Figure A1

User must select Start to Run. Then Figure A2 will display for user to select a number of options:
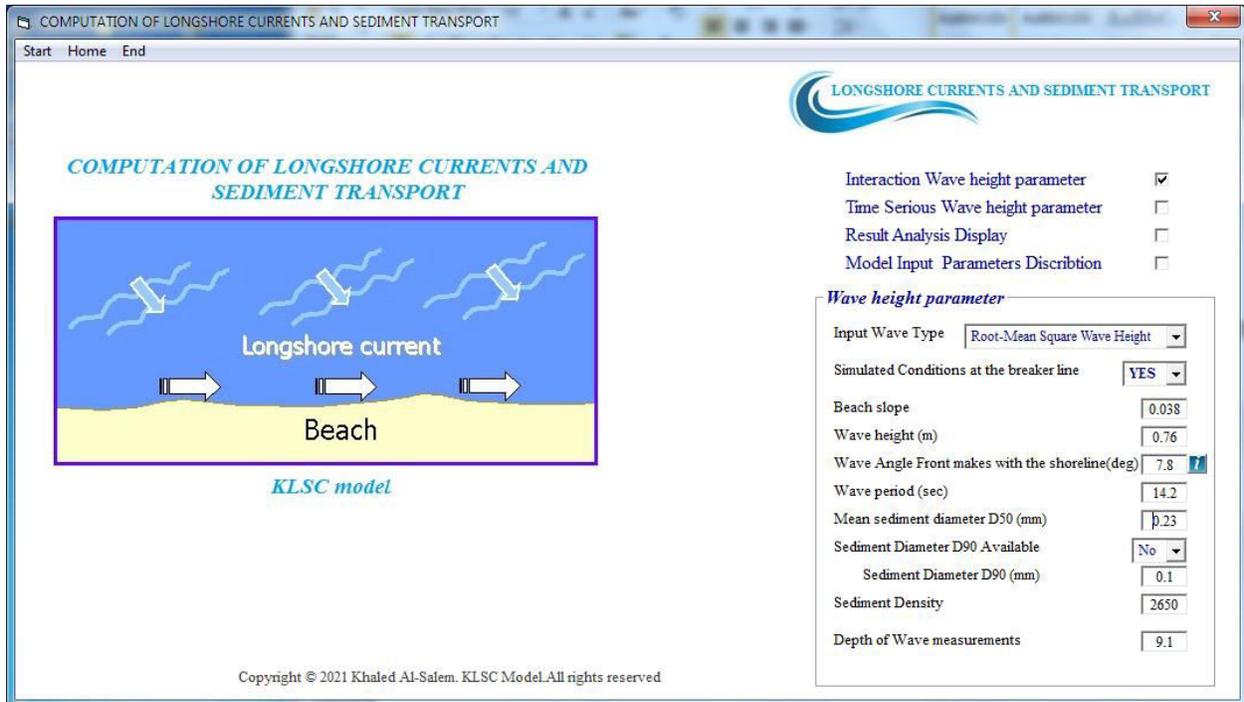
Figure A2

Figure A2 display a number of option for user to select as follows:

- o   Interactions Wave height parameter check box

If user check in this option shows in Figure A2.

Then a wave parameter Screen will display as in figure A2. Showing The Wave input parameter need to Run as follows:

1. Type of wave height [meter] as

    - Significant wave height [H_s]

    - Root mean Square Wave height [H_{rms}].

2. Select the Condition for simulation at Breaker Line [Yes Or No].

3. Beach Slope

4. Wave Height [m]

5. Wave Angle Front makes with the shoreline [deg] as shown in Figure 1

6. Wave period [sec]

7. Mean sediment diameter D_{50} [mm]

8. Sediment Diameter D_{90} Available [Yes Or No]

9. If Yes then in Value of D_{90} [mm]

10. Sediment Density $[\frac{kg}{m^3}]$

11. Depth of Wave measurements [m] [if Condition for simulation Not at Breaker Line]

- o   Time Serious Wave height parameter check box

Then a wave parameter Screen will display as in figure A2. Showing The Wave input parameter need to Run as follows:

1. Type of wave height [meter] as

- Significant wave height [H_s]

- Root mean Square Wave height [H_{rms}].

2. Select the Condition for simulation at Breaker Line [Yes Or No].
3. Input Wave Height and Period Data File
4. Beach Slope

5. Wave Angle Front makes with the shoreline [deg]
6. Mean sediment diameter D$_{50}$ [mm]
7. Sediment Diameter D$_{90}$ Available [Yes Or No]
8. If Yes then in Value of D$_{90}$ [mm]
9. Sediment Density [$\frac{kg}{m^3}$]
10. Depth of Wave measurements [m] [if Condition for simulation Not at Breaker Line]

o Result analysis display

To display the simulation graphically

o Model input Parameters Discretion

Is user select Option 1 for [***Interactions Wave height parameter checkbox***]

After user entered wave data parameter then select [***Start***]. Two options will display for user. Then user select [***Interaction Wave height parameter***] start simulated the model as shown in Figure A3.
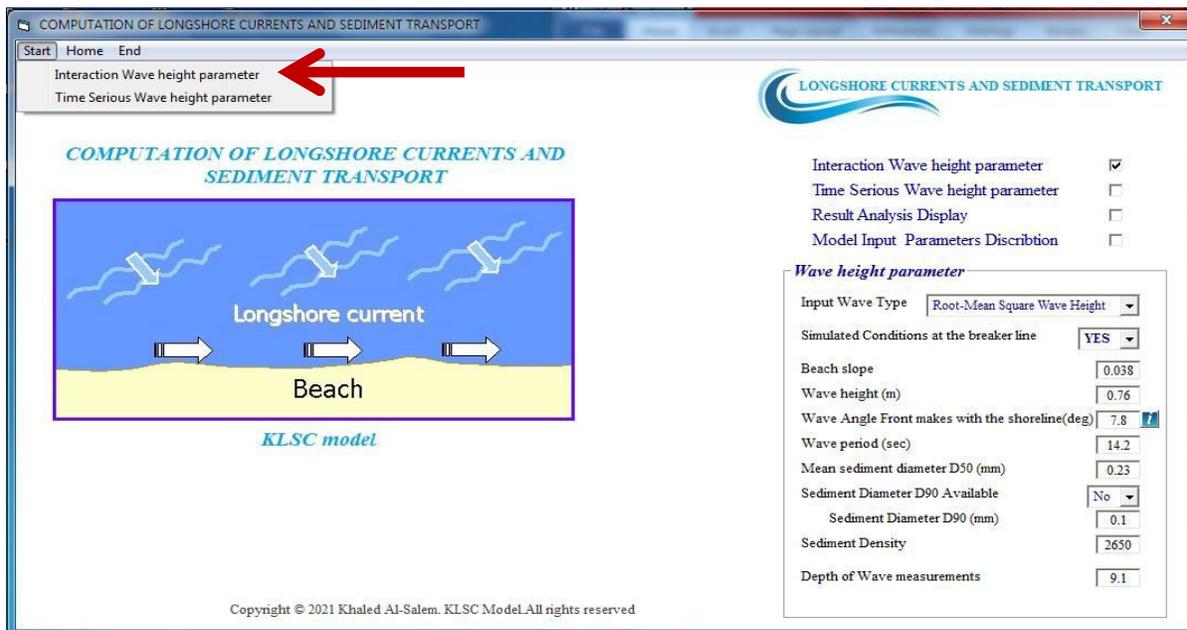
Figure A3

After simulation Done. Use must select [***Result Analysis Display option***] shown in Figure A3. Figure A4 will display for user. In Figure A4 two display options user must select one from Droplist. By default option will be selected for [***Interactions Wave height parameter***] simulation case.
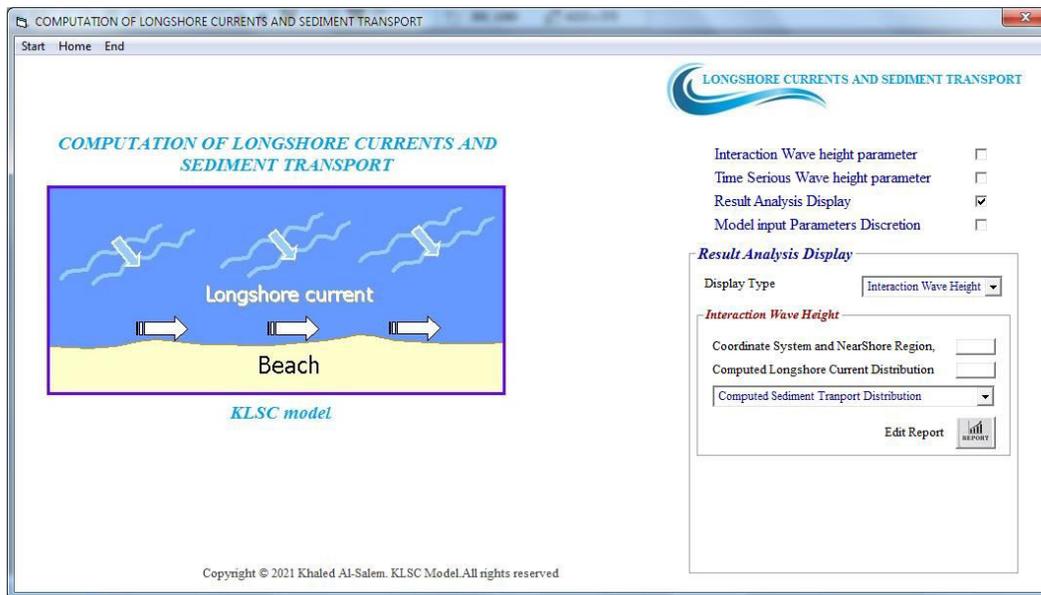
Figure A4

User have a number of result display option as follows:

1. Display [Coordinate System and NearShore Region] as shown in Figure A5
2. Computed Longshore Current Distribution as shown in Figure A6
3-Sediments transport from CoastLine to Breaker Zone offshore based on Different Formula displayed in Figure A7.

- BiJker formula
- Adapted Engelund-Hansen formula
- Watanabe formula

4. Display the simulation Report [EDIT REPORT] as show in Figure A8
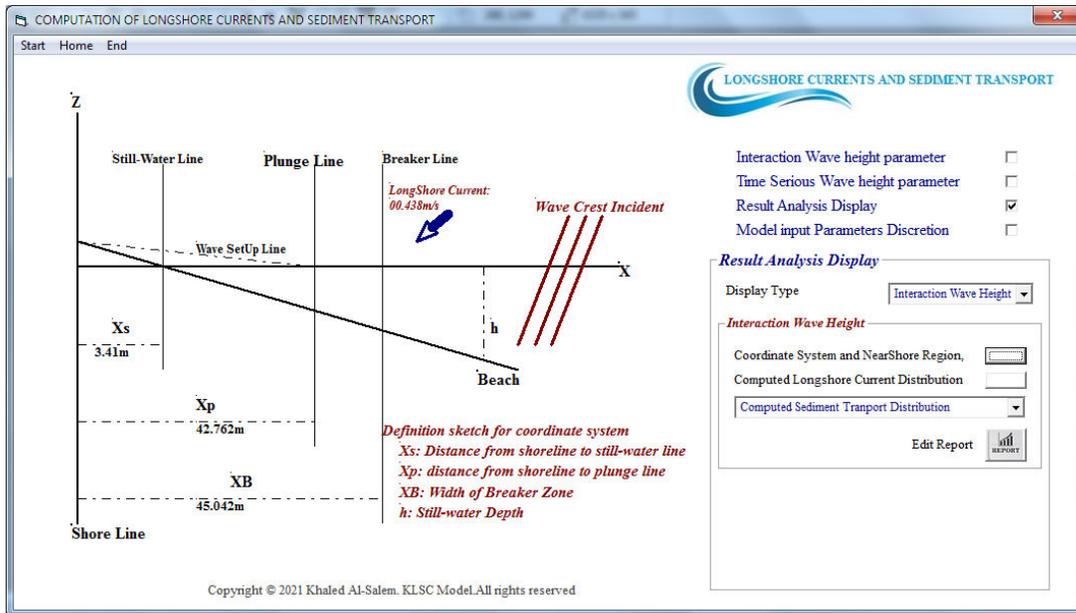
Figure A5
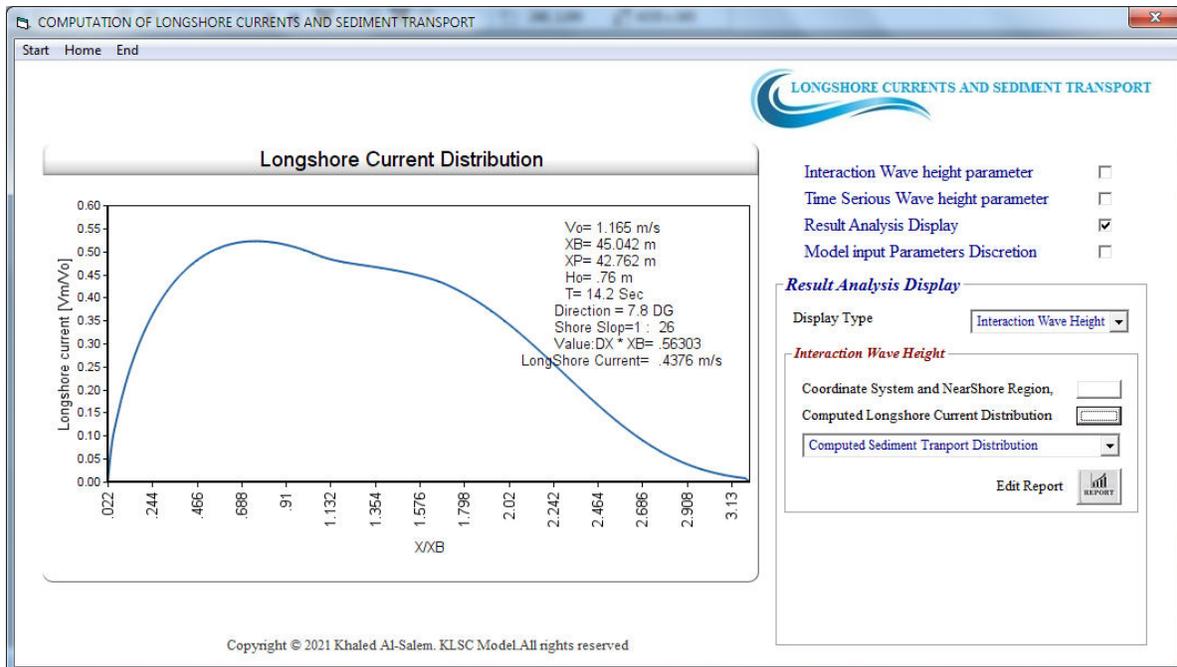
Figure A6
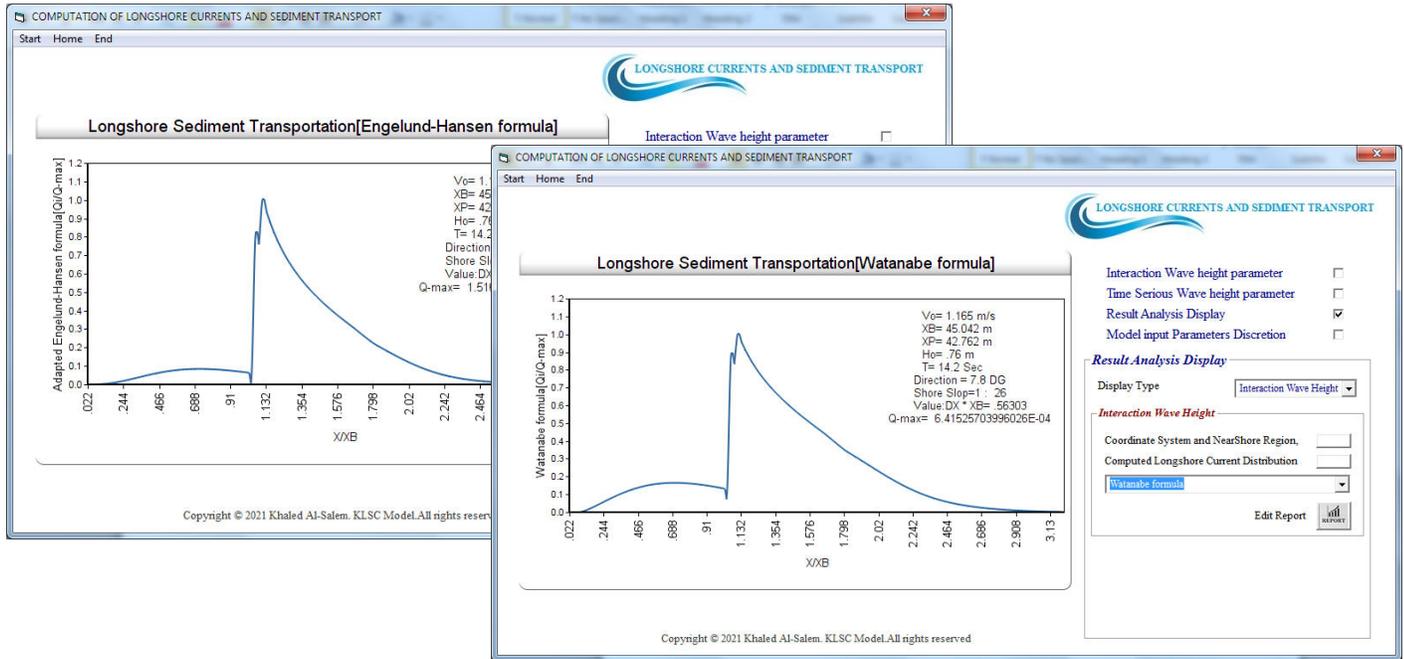
Figure A7
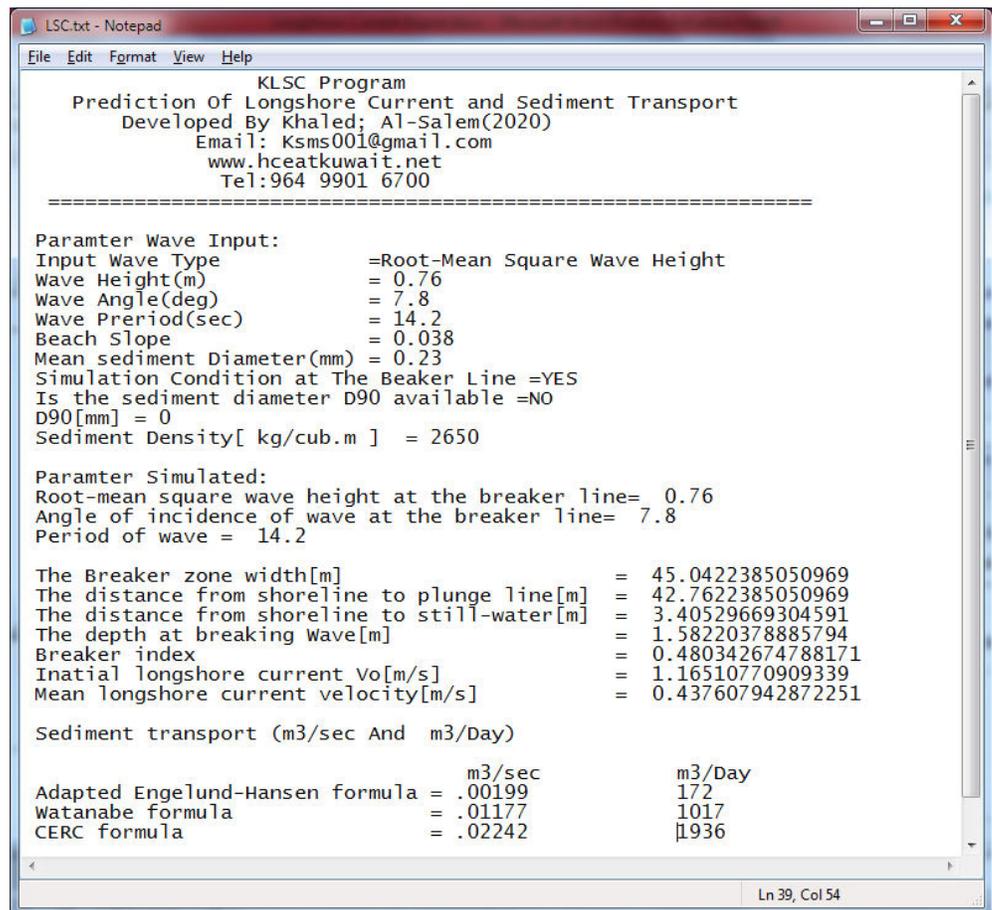
Figure A8

<u>*Is user select Option 2*</u> for [***Time Serious Wave height parameter checkbox***]

   After user entered wave data parameter then select [***Start***] as shown in Figure A9.
   Then user select [***Time Serious Wave height parameter***] start simulated the model as shown in
   Figure A9.

After simulation Done. Use must select [***Result Analysis Display option***] shown in Figure A9.
Figure A10 will display for user. In Figure A10 two display options for user must select one
from Droplist. User must select for [***Time Serious Wave height parameter***] simulation case.
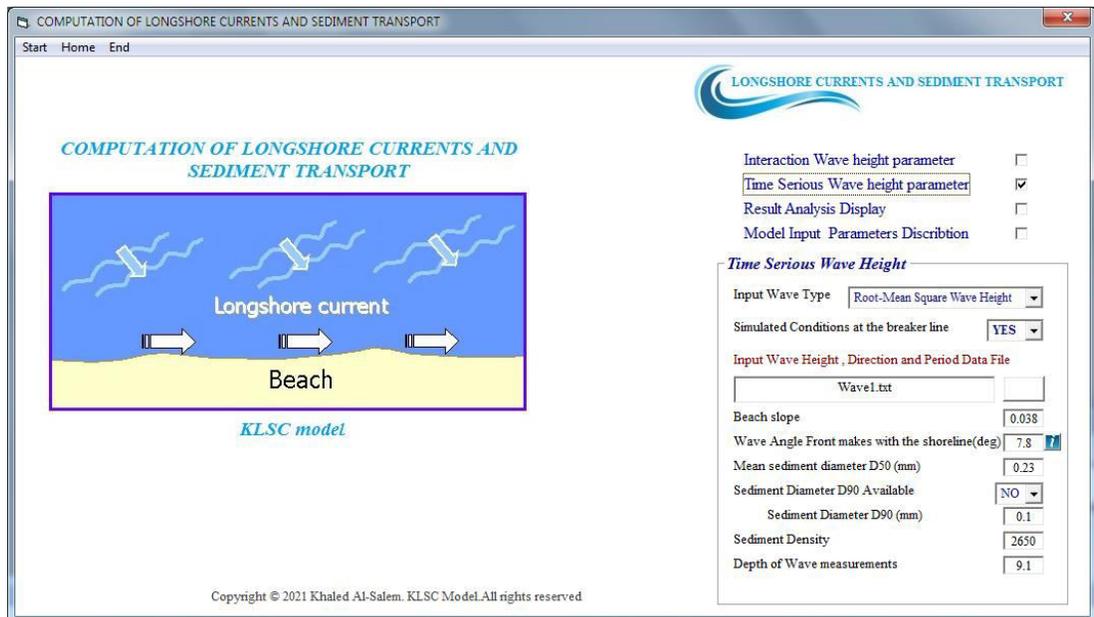
Figure A9
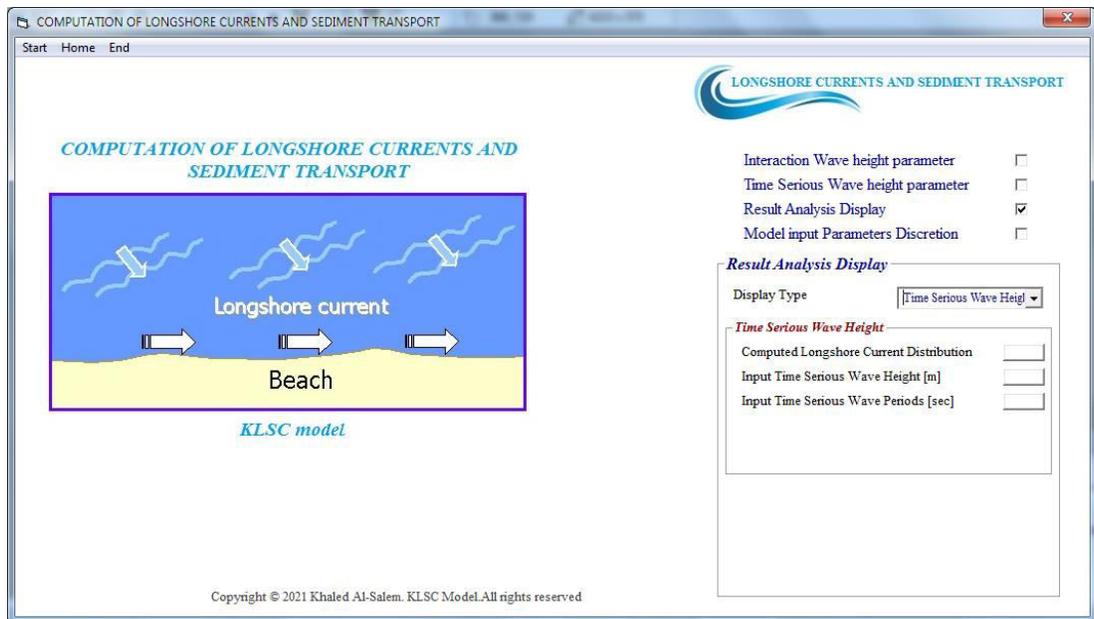
Figure A10

User have a number of result display option as follows:

1. Computed Longshore Current Distribution as shown in Figure A11
2- Input Wave heights data   as shown in Figure A12
3- Input Wave Periods data   as shown in Figure A13
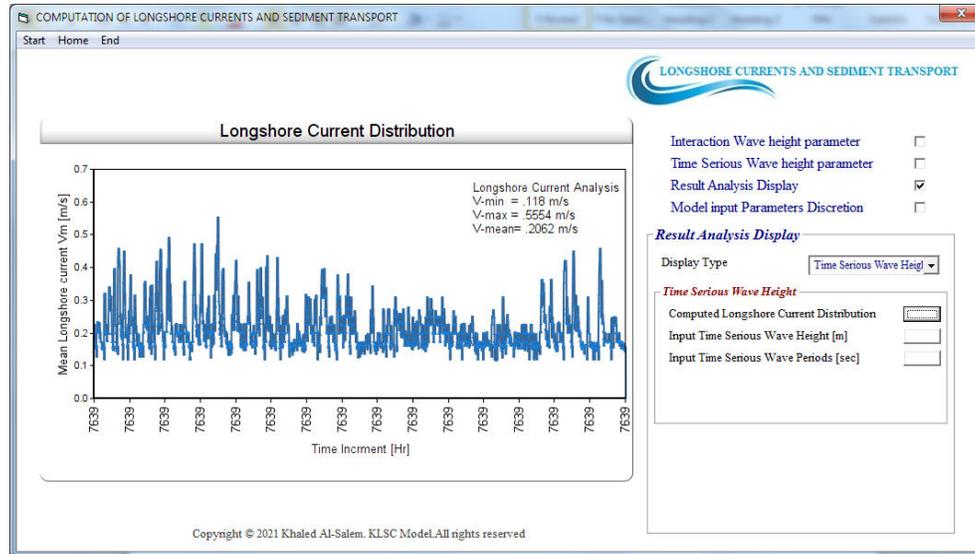
Figure A10
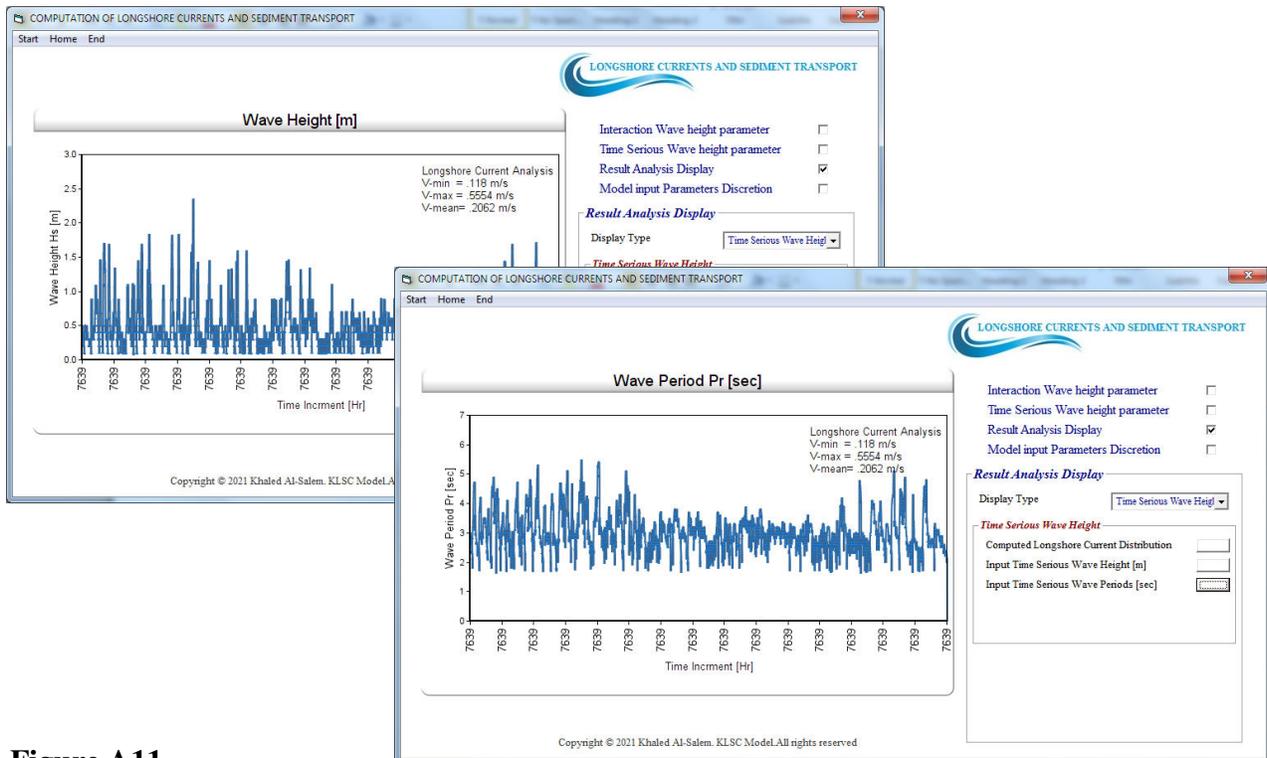
Figure A11

Technical Report
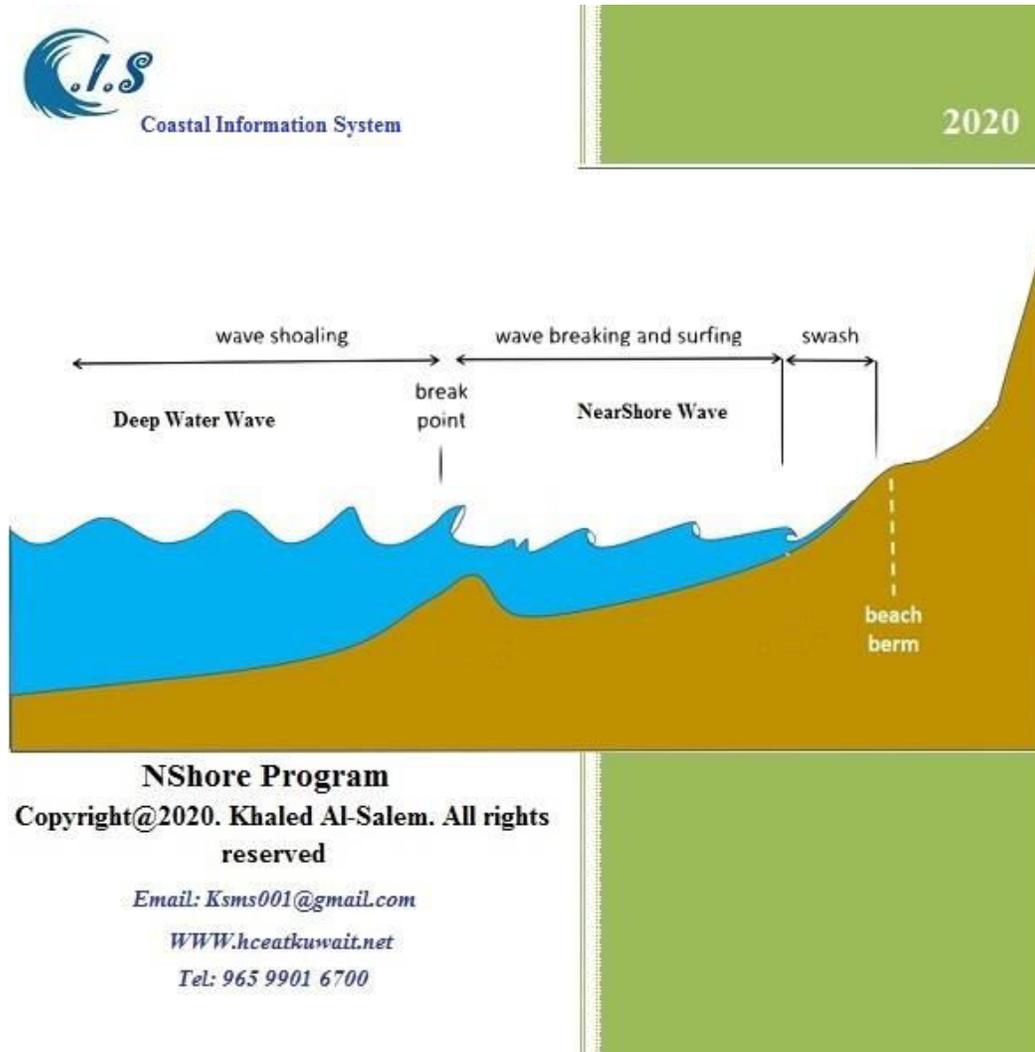
Prediction of NearShore Wave Height Conditions for Irregular Deep Water Waves Height

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Website: WWW.hceatkuwait.net\Nshore.aspx
Tel: 965 9901 6700
2022

ABSTRACT

NShore model presents state-of-the-art NearShore wave height prediction from irregular deep water wave height techniques developed by [Al-Salem K. 2022] based on Goda (1975a, 1975b). Methods for estimating nearshore irregular wave height conditions for the case of continuously shallowing bottom contours, given the bottom slope and offshore wave height characteristics, are presented. The methods are based on the work of Goda (1975a, 1975b) and Goda, Takayama, and Suzuki (1978). NShore model was developed for running in two operation system [PC version and Internet version at website address WWW.hceatkuwait.net].

INTRODUCTION

Waves are often irregular in height, period, and direction with some or most of the waves breaking or near the point of breaking during extreme wave conditions. Procedures for predicting design wave conditions for irregular waves are not discussed in the Shore Protection Manual (SPM) (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977). Much of the information in this report are supplements state-of-the-art irregular wave prediction techniques developed by Goda (1975a, 1975b) and suggested by Goda, Takayama, and Suzuki (1978). Easy-to-use methods for estimating nearshore wave height, angle of approach, and resulting water level setup for irregular waves are presented. The methods are intended for open sections of the coast with continuously shallowing depth contours. Wave setup due to narrow band frequency spectra and surf beat is considered but other forms of wave-wave and wave current interaction and spectral shape factors have been neglected. Design curves and examples of estimating the nearshore significant wave height are also available in Seelig (1979).

The transformation and attenuation of waves propagating from deep water to a beach is a problem of considerable difficulty because of a lack of field data and a poor theoretical understanding of the complex wave deformation process. The methods presented in this report are empirical in nature with the physics of the actual problem only partially understood. The results, based on laboratory and limited field data, are considered promising enough to recommend their application in selected field calculations. The results of calculations should be carefully examined to assure that the basic assumptions of the method have will be violated.

THEORETICAL ANALYSIS

The directional spreading of a wave energy model suggested by Goda, Takayama, and Suzuki (1978) is used to predict the refraction coefficient and refracted wave height for the nearshore point of interest. The height is then used, as input to the surf zone wave height distribution model developed by Goda (1975a, 1975b) to estimate the nearshore wave conditions and setup. The input information necessary for the application of these prediction techniques includes the deep water significant wave height, wave period of peak energy density and dominant wave direction,

the directional spreading of wave energy parameter, S*, beach slope, and water depth at the point of interest.

The confused sea state in deep water may be described as the sum of wave simultaneously moving in various directions. As this wave move toward the coast, the waves with the largest angles between their crest and the bottom contours refract the most, so that nearshore waves appear to be less confused. The reason for the directional spreading of wave energy in refraction Calculations for the case of straight parallel bottom contours are discussed in this section as:

- **Wave Refraction Analysis.**

Refraction calculations are based on the energy-weighted superposition of refraction coefficients obtained from linear theory. If E_i and K_{Ri} are the wave energy and refraction coefficient, respectively, for a wave direction, i, then the composite refraction coefficient for waves from several simultaneous directions is taken as

$$K_R = \sqrt{\frac{\sum_{i=1}^{N} E_i K_{Ri}^2}{\sum_{i-1}^{N} E_i}} \qquad [1]$$

where
N is the number of wave directions

The use of equation [1] in the calculation is to obtain a better estimate of refraction coefficients for irregular waves then would be obtained if a single value of the refraction coefficient obtained from linear theory were used.

Calculation of refraction coefficients and nearshore wave direction angles using the design curves as in Fig 1 requires the dominant deep water parameter conditions as
- wave direction angle, α_0 ,
- Type of deep water wave condition S_*.
- Deep water wave period T_s
- Shallow water location depth d
- Acceleration due to gravity g=9.8 m^2/s

E_i is the density of wave energy in a given direction, i.
Longuet-Higgins, Cartwright, and Smith (1963) suggest the following density function for wave energy:

$$E_\theta = K[cos\frac{\theta}{2}]^2 \, S_* \qquad [2]$$

where
θ = wave direction angle with respect to the dominant deep water direction, α_0 (Fig. 2; note that
    α_0 is measured from a line perpendicular to the shoreline)
K = a constant used to define the total wave energy

E_θ = the density of wave energy in a given direction, θ

S_* = a parameter that defines the variation of energy level with wave direction. Smaller values of S_* yield higher amounts of directional spreading of wave energy. Goda, Takayama, and Suzuki recommend the values of S_* in Table 1 for design purposes.

Table 1. Recommended values of S_*.

S_*	Wave condition
4	Wind waves
12	Swell (short-to-moderate decay distances)
37	Swell (moderate-to-long decay distances)
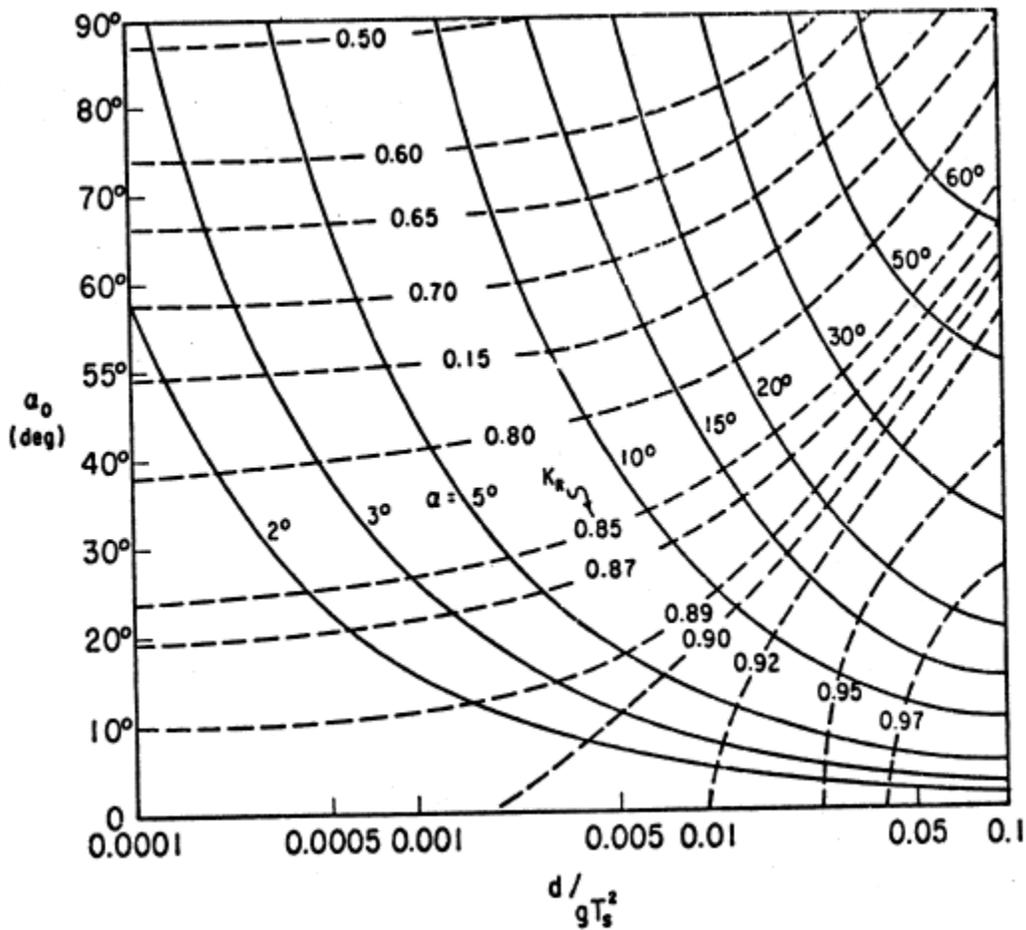
Figure 1. Design Curve for Wave Refraction For $S_* = 4$
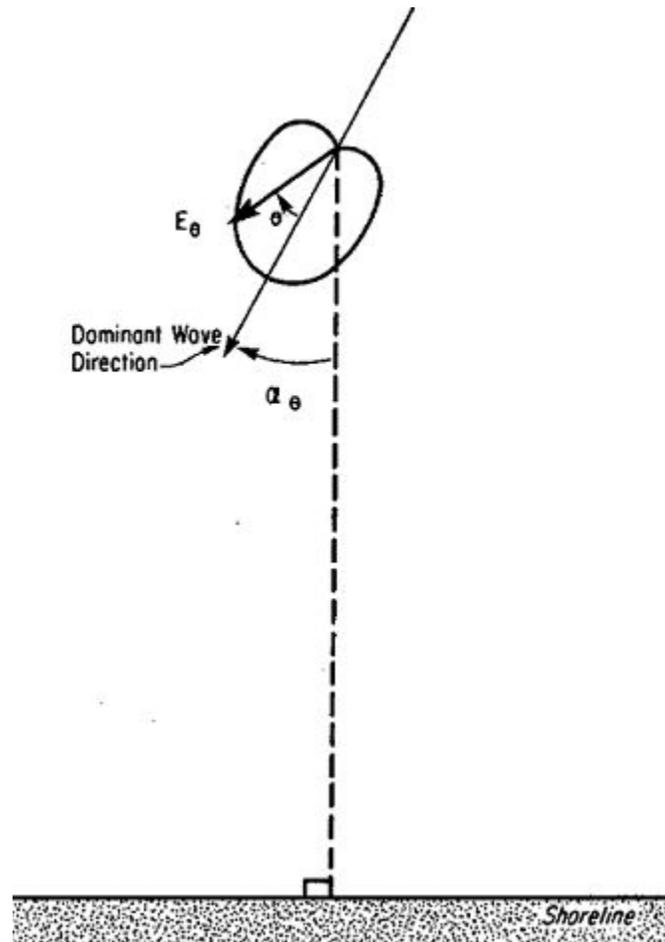
Figure 2. Wave refraction including directional spreading of wave energy

- **NEARSHORE WAVE BREAKIN ANALYSIS**

Goda (1975a, 1975b) developed a nearshore wave height prediction model for irregular waves that accounts for wave breaking, nonlinear wave shoaling, irregular wave setup, and surf beat. Surf beat is the longer period component of water level oscillation. Goda assumed that the deep water significant wave height, H_0, and the average period of the significant waves, T_s, are known or can be estimated. The wave heights are assumed to have a Rayleigh distribution in deep water and this distribution is used to characterize wave heights as the waves move into shallower water until a depth is reached where the waves begin breaking. Goda's approach allows the broken waves to reform at a lower height, so that the wave height.
Distribution is no longer described by the Rayleigh distribution. As the waves move into shallower water the nonlinear method developed by Shuto (1974) is used to estimate wave shoaling coefficients. Shuto's method of calculating shoaling coefficients usually gives somewhat higher waves than would be predicted using the conventional linear shoaling method.

Nonlinear shoaling is consistent with the observed behavior of waves in shallow water and is conservative when compared to linear shoaling. The offshore beach profile is assumed to be represented by a straight plane surface. Dissipation of wave energy by bottom friction is usually very small for typical sand beaches; therefore, bottom dissipation is neglected. Wave setup or setdown and surf beat are related to the wave breaking process and are accounted for. The radiation stress of the waves progressing toward the shore causes wave setup which can either increase or decrease the local water depth; a decrease is often referred to as setdown. Setdown occurs seaward of the breaker zone and setup occurs shoreward from the point where a significant number of the waves break. Surf beat is the longer period component of water level oscillation (periods from 20 seconds to several minutes) due to longer period irregularities in wave action. The magnitude of the surf beat is amplified in shallow water. Figure 3 shows the conditions used in this model.
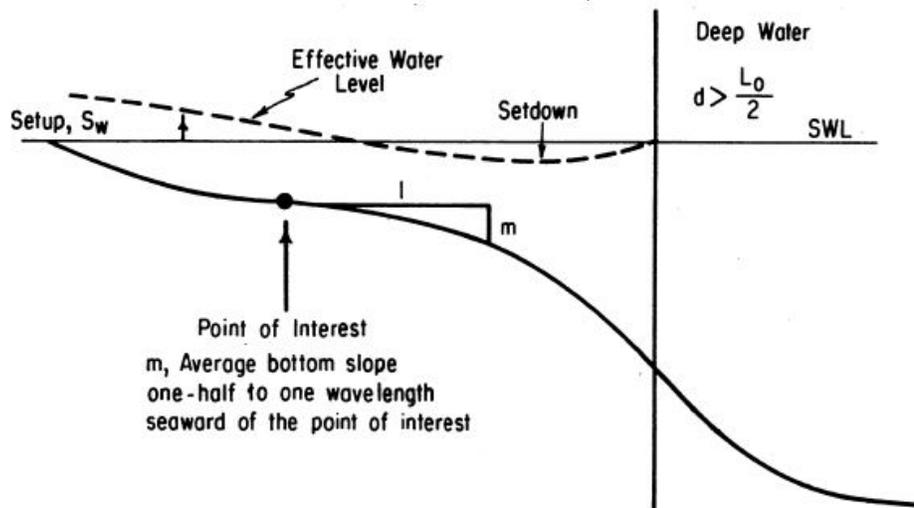
Figure 3. Definition.

The equivalent deep water wave height, H_0' is determined from

$$H_0' = K_R \, H_0 \qquad\qquad [3]$$

where H_0 is defined as the deep water significant wave height H_0' should also include diffraction or any other loss coefficients if they are significant.

The shallow water wave height condition parameters prediction by using a design curves obtained from Goda's analytical model (Seelig, 1978). The design curve described the five variables in the nearshore zone as:

(a) The maximum wave height, H_i, defined as the mean of the highest 1% of the waves.

(b) the significant wave height, H_s , defined as the mean of the highest one-third waves (the significant wave height is approximately equal to four times the root-mean-square (rms) surface elevation of a water level record).

(c) The root-mean-square (rms) wave height, H_{rms}.

(d) The mean wave height $\ddot{H}$.

(e) the wave setup, S_w

All of these variables are divided by the deep water significant wave height. The five variables are corresponded to the ordinate versus the ratio of the local Stillwater depth, **d**, to the deep water significant wave height, H'_0, on the abscissa. The design curves data is available for each wave steepness and for each **beach Slope [S].**

The ratio of the local Stillwater depth, $= \dfrac{d}{(gT^2)}$

The Offshore Wave Steepness H'_0/L_0

Depth-to-Height Ratio d/H'_0

Where

L_0 Deepwater wavelength $= 1.56\, T_s^2$

d water depth at the point of interest

All design curve for all deep water wave types S* were converted to A Database linked to [NShore model – AL-Salem 2022].

To evaluate the nearshore parameters in NShore model, use the Design curves having the offshore slope, m, and offshore wave steepness (H'_0/L_0) closest to the values of interest. Enter the value of $/H'_0$, and select the curve of the parameter of interest. Five dimensionless parameters option can be predicted are presented as:

1. $\dfrac{S_w}{H'_0}$ Wave Setup / equivalent deep water wave height

2. $\dfrac{H_{rms}}{H'_0}$ Root-mean-square wave height / equivalent deep water wave height

3. $\dfrac{\bar{H}}{H'_0}$ Mean wave height / equivalent deep water wave height

4. $\dfrac{H_S}{H'_0}$ Significant wave height or average of the highest one-third waves / equivalent

     Deep water wave height

5. $\dfrac{H_1}{H'_0}$ Average of the highest 1-percent waves / equivalent deep water wave height

DISCUSSION RESULT AND MODEL VALIDATION PROCESS

Data source from Goda (1975a, 1975b) developed a nearshore wave height prediction model for irregular waves that accounts for wave breaking nonlinear wave shoaling, irregular wave setup by [NShore model].

Wave Refraction analysis

GIVEN

The wave period, $T_s = 10$ seconds

The Dominant deep water wave angle $\alpha_0 = 40°$

The Significant wave height, H_0 = 2.0 meters.
Wave condition selected [S∗] is wind/wave data
Beach slop [1 /100] 0.01
Shallow water depth 1.0 m

SOLUTION for K_R [refraction coefficient]
Run NShore model at interactive option as shown in Fig 4 shows
Input Deep water and Shallow water parameters then [RUN}
The wave refraction K_R = 0.80
The angle of nearshore wave energy vector α = 5.0°.
The deep water equivalent wave height [H'_0] is 1.6 m as shown in Equation 3.
Significant wave height at shallow water selected H_s = 0.747 m

Figure 4. NShore model interactive option page with [H_0:2m T_0:10sec A_0:40⁰]

Nearshore Wave Heights and Water Level Parameters

GIVEN

The wave period, T_s = 14 seconds

The Dominant deep water wave angle $\alpha_0 = 0°$

The Significant wave height, H_0 = 3.0 meters.

Wave condition selected [S*] is wind/wave data

Beach slop [1 /100] 0.01

Shallow water depth 6.0 m

SOLUTION for H_s

Run NShore model at interactive option as shown in Fig 5 shows

The wave refraction KR = 0.97

The angle of nearshore wave energy vector α = 2.0°.

The deep water equivalent wave height [$\boldsymbol{H_0'}$] is 2.91 m as shown in Equation 3.

Significant wave height at shallow water selected H_s = 3.611 m
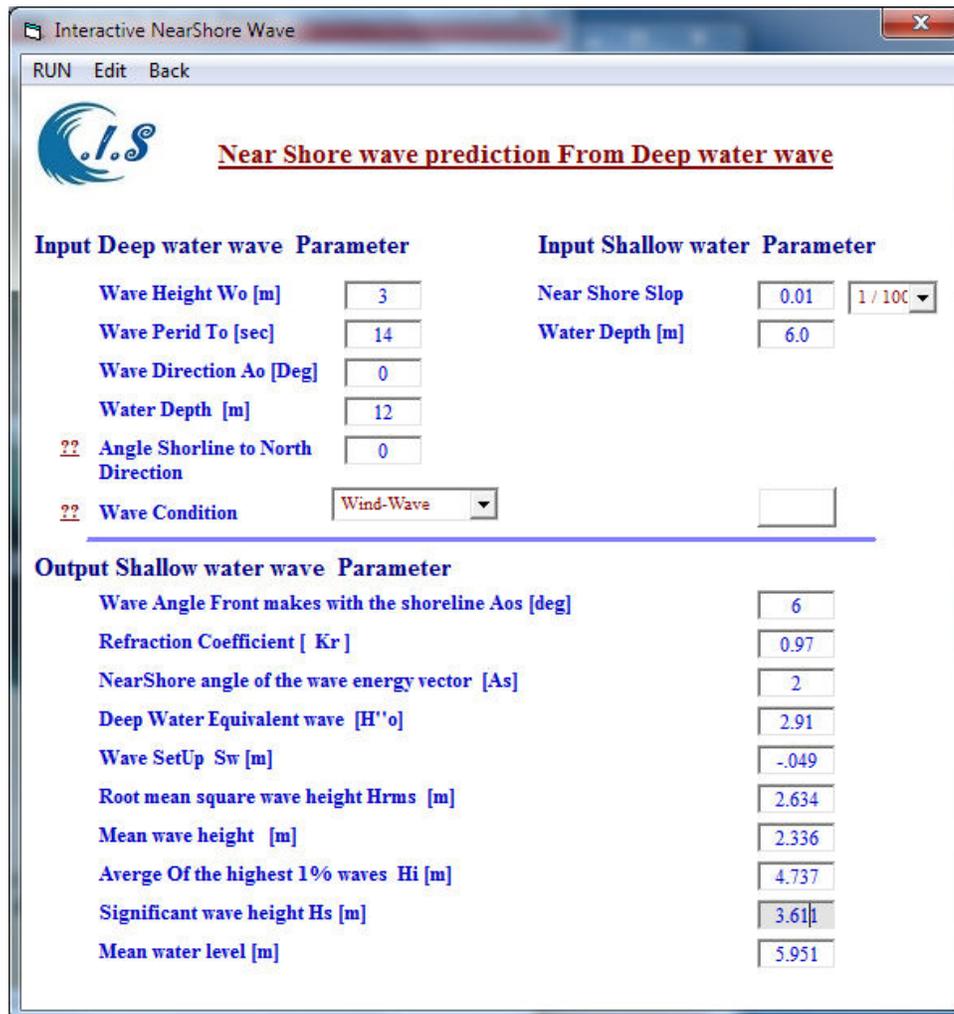
Figure 5. NShore model interactive option page with [H_0:3m T_0:14sec A_0:0°]

Sensitivity Analysis for NearShore wave height prediction for a selected Deepwater condition.

Data source from Goda (1975a, 1975b) to develop a nearshore wave height prediction.

In any given design situation the quality of the input information may vary. An important question to ask when predicting nearshore wave conditions is How sensitive are the predicted conditions to errors of uncertainty in the input parameters. The sensitivity of the predicted nearshore significant wave height to input parameters is illustrated below with an examples. A reference condition is chosen and nearshore significant wave heights are estimated. Each of the input parameters is then systematically varied and the results compared to the reference condition.

Case 1

The reference condition was selected to have the following input parameters:

H_0 = Deep water significant wave height (5.15 meters)

H_0' = Deep water equivalent wave height 5.0 m as shown in Equation 3.

T_0 = Wave period (10 seconds)

d = Nearshore water depths (1.0 to 3 meters)

s = Beach Slope (1/100)

From the reference condition the predicted nearshore significant wave height is slightly less than the deep water wave height for water depth of 1, 3 and 5 meters due to wave setdown as shown in Table 2 from God (1975a, 1975b) and Result predicted from NShore model [AL-Salem 2022].

Table 2. NShore model interactive option page to predict H_s with Reference Parameters
[H₀:5.15m H_0':5m T₀:10sec A₀:0° and beach slop 1/100] no refraction.

	Goda (1975a, 1975b) Model data			[AL-Salem 2022] NShore Model			
Stillwater depth (m)	1.0	3.0	5.0	1.0	3.0	5.0	
Reference d/H_0'	0.2	0.6	1.0	0.2	0.6	1.0	
Condition							
Reference value	0.96	2.1	3.2	.994	2.187	3.204	*Fig-6*
Variation							
Water 1 m deeper	1.6	2.7	3.8	1.620	2.614	3.645	*Fig 7*
1/20 slope	1.3	2.6	3.9	1.286	2.726	3.710	*Fig 8*
H_0' = 6m	0.9	2.2	3.3	1.158	2.110	3.217	*Fig 9*
H_0' = 4m	0.9	2.1	3.1	0.797	2.082	3.101	*Fig 10*
α_0 = 45°, S* = 4	0.9	2.0	3.1	0.995	2.174	3.206	*Fig 11*
T_0 = 6 sec	0.8	1.9	2.8	0.984	1.878	2.835	*Fig 12*
T_0 = 18 sec	1.1	2.3	3.5	1.252	2.356	3.829	*Fig 13*

The predicted height decreases in shallow water to a value of 0.96 meter in a 1-meter water depth (still-water level). Systematic variations are made from the reference condition and from the resulting predicted nearshore wave heights given in Table 2. Comparisons with the reference

condition and NShore model [Al-Salem 2022] were displayed in Table 2. Figures 6 to 13 display NShore model result with varying input parameter condition showing a good agreement with [Goda (1975a, 1975b)].
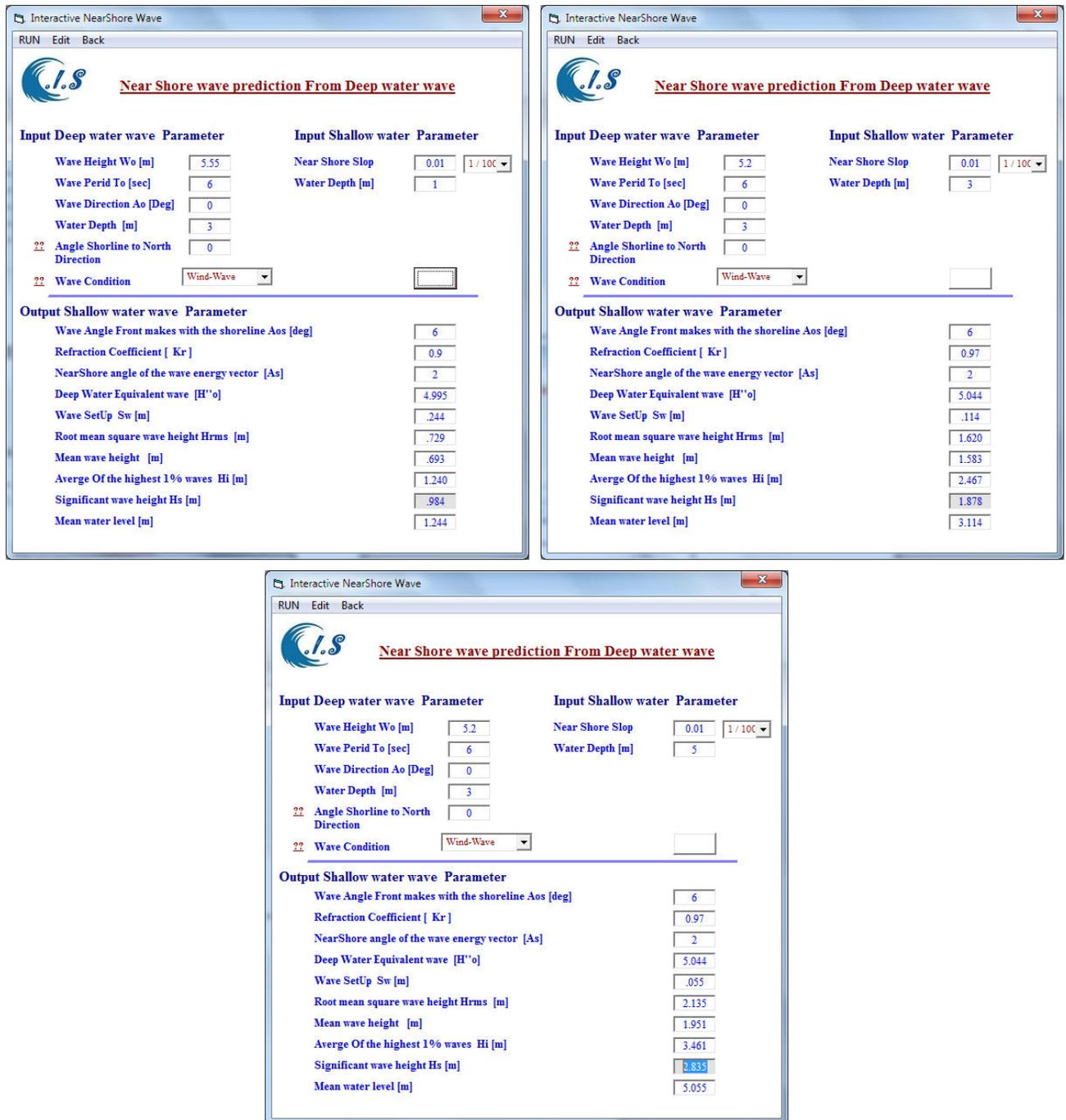

Figure 6. NShore model interactive option page with [H_0:5.15m T_0:10sec A_0:0° at water depth d= 1,3,and 5] beach slop [1/100]

Figure 7. NShore model interactive option page with [H$_0$:5.15m T$_0$:10sec A$_0$:0° at water depth d= 2,4,and 6] beach slop [1/100]
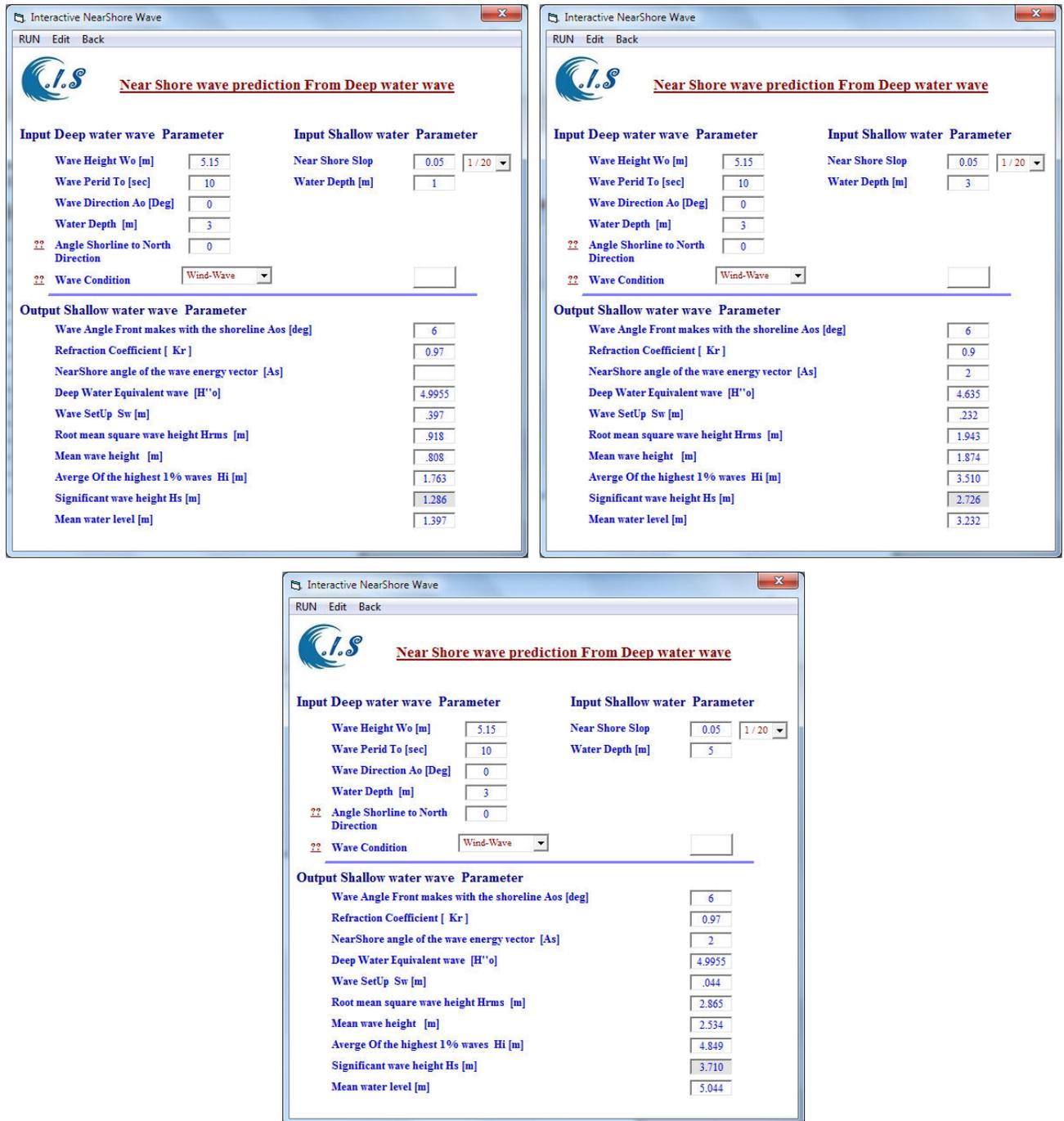
Figure 8. NShore model interactive option page with [H$_0$:5.15m T$_0$:10sec A$_0$:0° at water depth d= 1,3,and 5] beach slop [1/20]
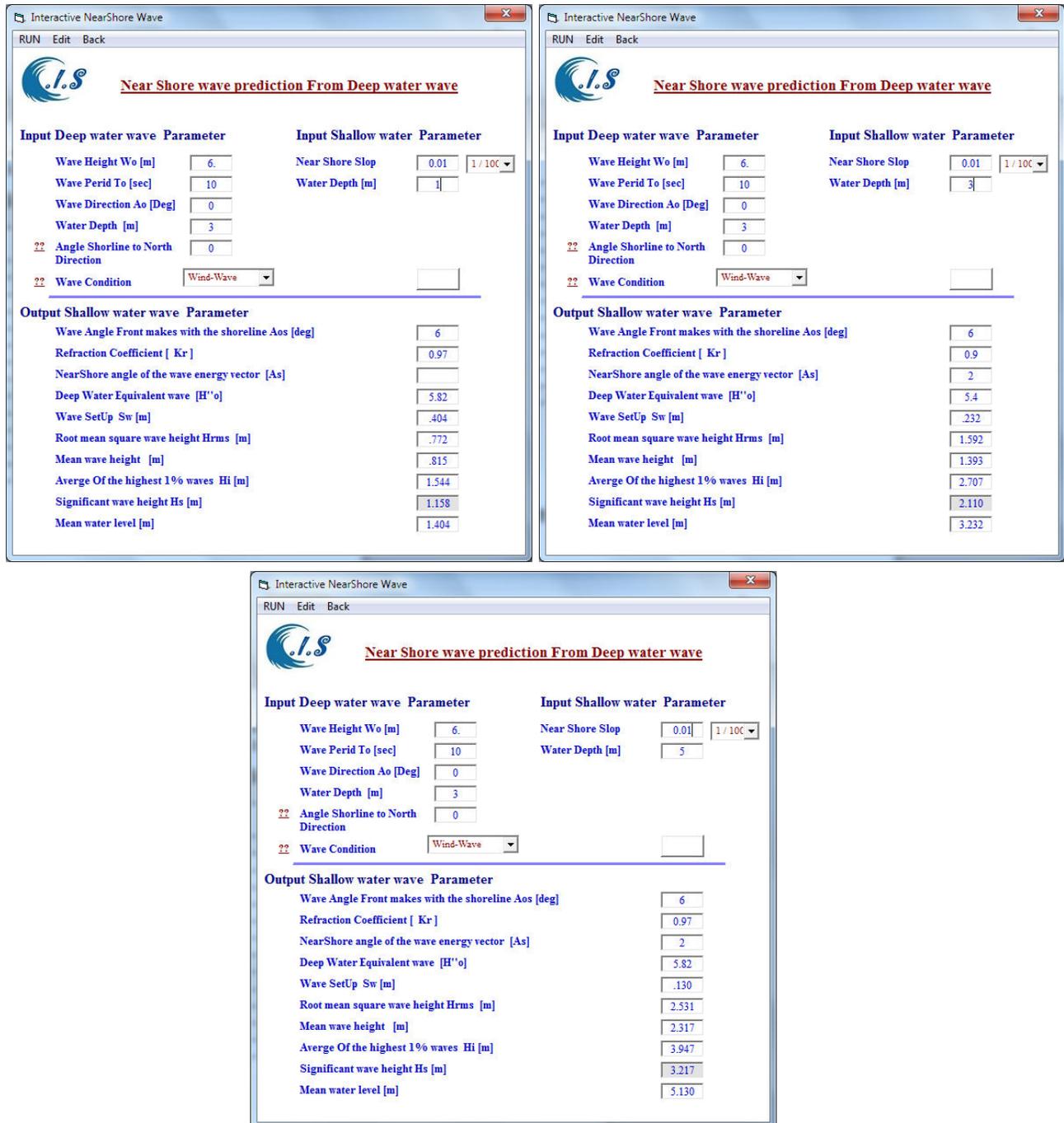
Figure 9. NShore model interactive option page with [H₀:6.1m T₀:10sec A₀:0° at water depth d= 1,3,and 5] beach slop [1/100] H_0': 6m

Figure 9. NShore model interactive option page with [H_0:6.1m T_0:10sec A_0:0° at water depth d= 1,3,and 5] beach slop [1/100] H_0': 6m
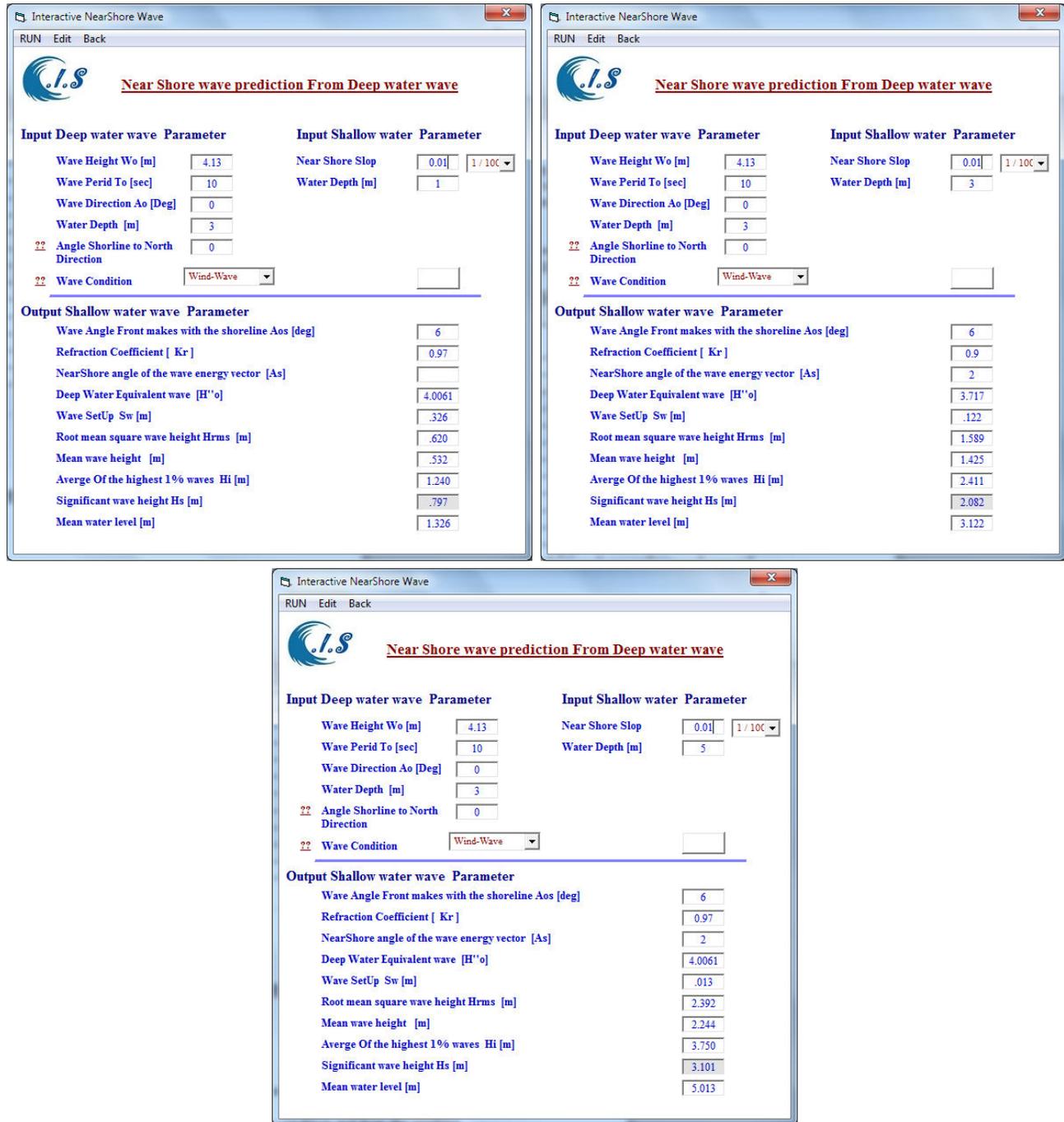
Figure 10. NShore model interactive option page with [H$_0$:4.13m T$_0$:10sec A$_0$:0° at water depth d= 1,3,and 5] beach slop [1/100] H'_0: 4m
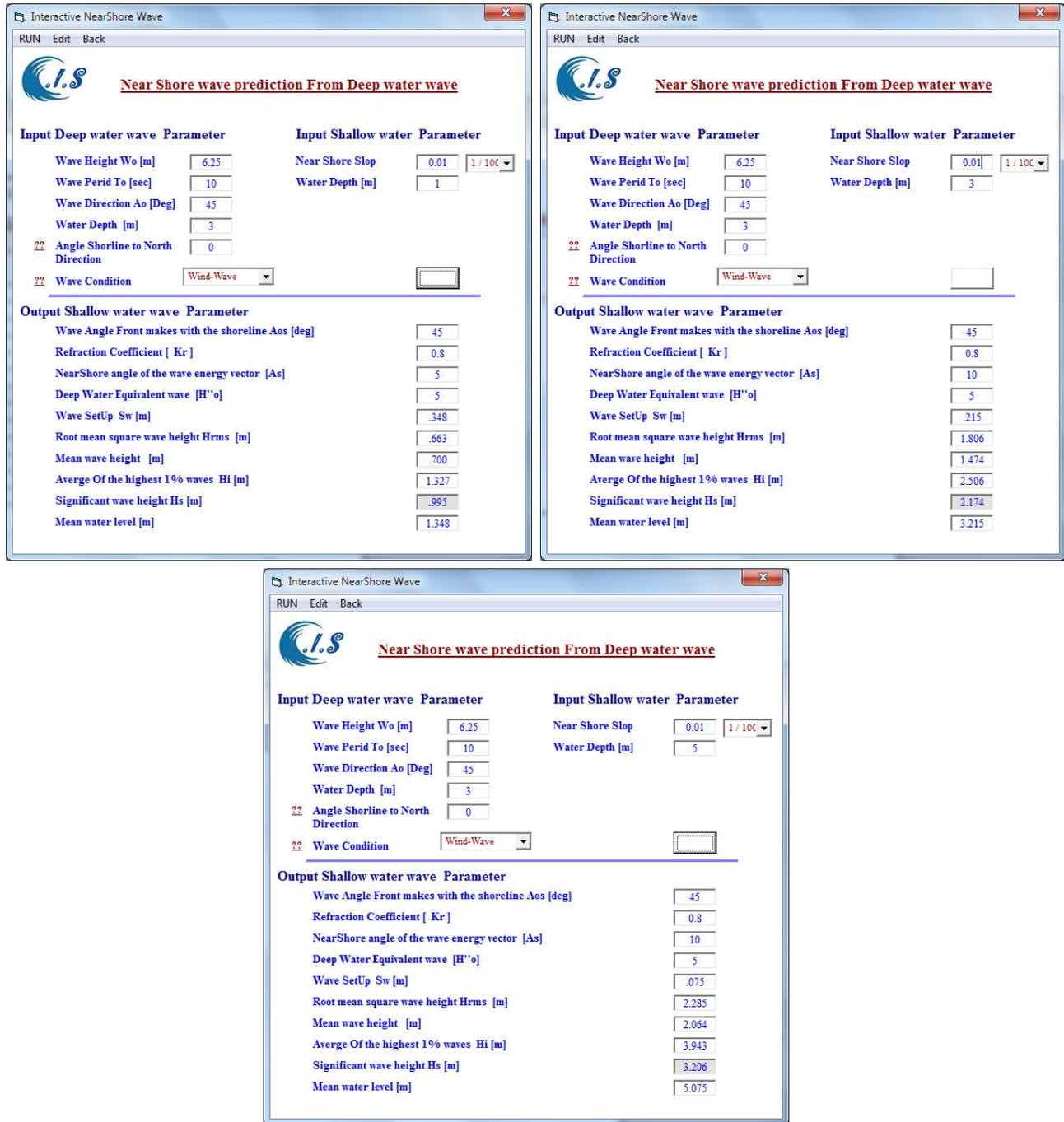
Figure 11. NShore model interactive option page with [H$_0$:6.25m T$_0$:10sec A$_0$:45° at water depth d= 1,3,and 5] beach slop [1/100] H'_0: 5m

Figure 12. NShore model interactive option page with [H$_0$:5.2 m T$_0$:6 sec A$_0$:0° at water depth d= 1,3,and 5] beach slop [1/100] H'_0: 5m

Figure 13. NShore model interactive option page with [H_0:5.2 m T_0:18 sec A_0:0° at water depth d= 1,3,and 5] beach slop [1/100] H'_0: 5m

Case 2

Data source from Goda (1975a, 1975b) to develop a nearshore wave height prediction.
The 13 September 1978 storm, a wave gage 2,250 meters beyond the end of the pier was used to record offshore wave height and period. Radar images were used to estimate dominant wave

direction. Predicted tides and a profile survey of 8 September 1978 were used to determine water depth along the pier. Deep-water wave input parameter as follows:

- Wave hight H_0 = 1.66 m
- Wave Period T_0 = 4.52 sec
- Wave direction α_0 = 50^0
- Wave condition S_* = Wind-Wave [4]
- Beach slop s = 1 / 80

Table 3 and Figure 14 shows nearshore wave conditions. Observed and predicted wave height [Goda (1975a, 1975b)] compared to wave predicted from NShore model [Al-Salem 2022] at the FRF, 13 September 1978 shows a good agreements.

Table 3. NShore model interactive option page to predict H_s with Reference Parameters [H_0:5.15m H'_0:5m T_0:10sec A_0:0° and beach slop 1/100] no refraction.

		Observed Wave Conditions	Goda (1975a, 1975b)	Al-Salem 2022
Distance from Shore line	Shallow Water depth d	Observed wave height H_s	Predicted Wave Height H_s	NShore model Wave Height H_s
	m	m	m	m
1.05068	1.24	0.981651	0.770642	0.852
2.348578	4.76	1.146789	1.211009	1.321
4.239802	5.68	1.082569	1.165138	1.321
6.613102	7.11	1.183486	1.192661	1.331
9.925835	9.33	1.422018	1.256881	1.372

Predicted, observed and NShore model wave heights are similar for most of the wave profile as shown in Fig 14, with the observed wave height in the shallowest water higher than predicted and NShore. Results show that the local significant wave height is primarily controlled by nearshore depth

Figure 14. Observed and predicted wave height at the FRF, 13 September 1978 from Goda (1975a, 1975b) compared with Nshore model [Al-Salem 2022] for prediction of shallow wave at deffernt water depth
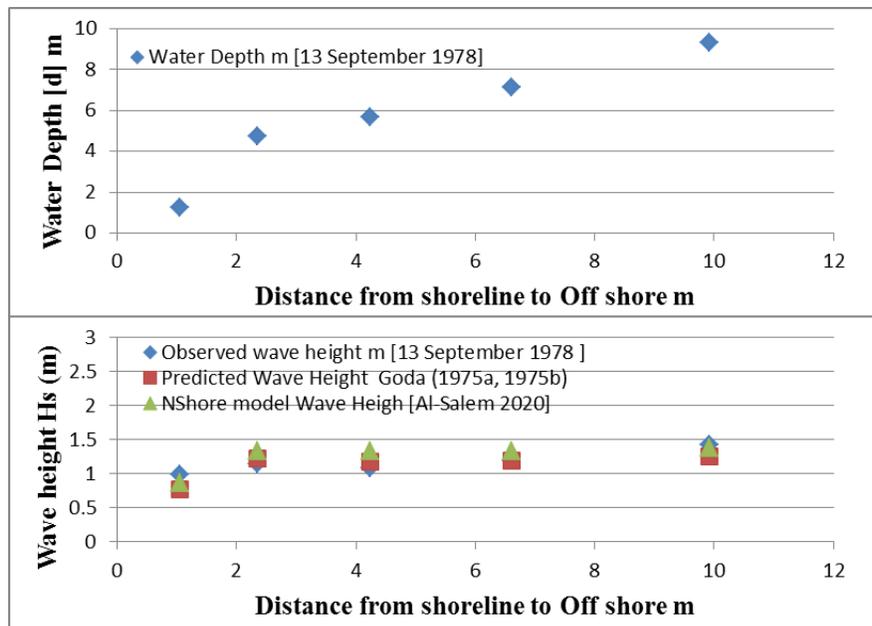
Case 3

Data source from Goda (1975a, 1975b) to develop a nearshore wave height prediction.

GIVEN:

Figure 15 display deep wave height condition.

. Deep-water wave input parameter as follows:

- Wave height H_0 = 2.41 m
- Wave Period T_0 = 6.9 sec
- Wave direction α_0 = 60^0
- Wave condition S_* = Wind-Wave [4]
- Beach slop s = 1 /100
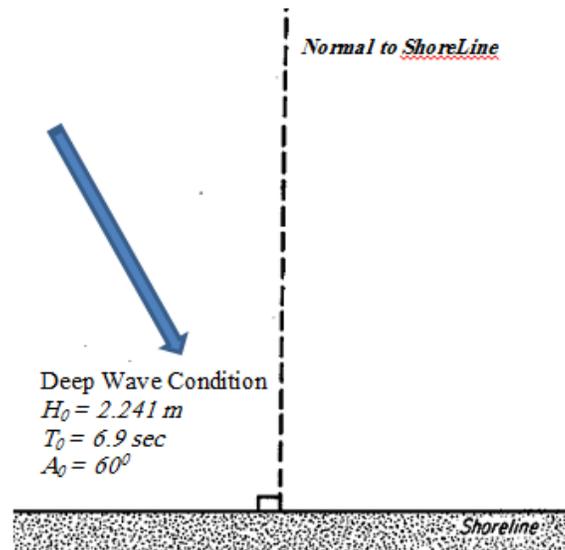
Figure 15. Deepwater Wave Condition

Table 4. NShore model interactive option page to predict H_s with Reference Parameters [H_0:2.41m T_0:6.9sec A_0:60° and beach slop 1/100]

	Goda (1975a, 1975b)			NShore model [Al-Salem 2022]		
Water Depth d_{swl} m	K_R	H_0' m	H_s m	K_R	H_0' m	H_s m
0.5	0.69	1.66	0.43	0.70	1.687	0.435
1.0	0.69	1.67	0.620	0.70	1.687	0.696
2.0	0.70	1.68	1.28	0.70	1.687	1.268
3.0	0.70	1.69	1.69	0.75	1.8075	1.825
4.0	0.71	1.70	1.75	0.75	1.8075	1.905
6.0	0.72	1.74	1.72	0.75	1.8075	1.825

Results show that the local significant wave height is primarily controlled by depth. In this Case,wave direction, refraction effects, and wave period are relatively unimportant input parameters. Table 4 shows has good agreement with [Goda (1975a, 1975b)] and NShore model

[Al-Salem 2022] . Figure 16 display sample result for water depth d_{swl} 2.0 m. Figure 17 shows a good agreement of nearshore wave height prediction between NShore and Goda.

Figure 16. NShore model interactive option page with [H_0:2.41 m T_0:6.9 sec α_0:60° at water depth d_{swl} :2.0m] beach slop [1/100]
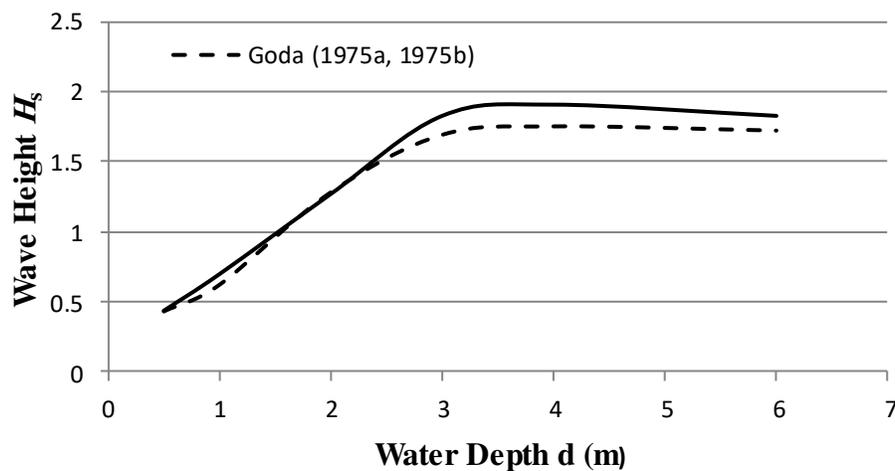
Figure 17. Comparison of Nearshore Wave height H_s predicted from NShore model to Goda (1975a, 1975b)

CONCLUSION

The NShore numerical model for prediction nearshore wave height by applying the methods developed by Goda (1975a, 1975b) and suggested by Goda, Takayama, and Suzuki (1978) for predicting nearshore irregular wave conditions for the case of continuously shallowing bottom contours have been presented in forms convenient for designers. The NShore model was presented by two operation system As PC version and Website version at web dress
[http:\\www.hceatkuwait.net\NShore.aspx].
A sensitivity analysis as shown in case 3 of the methods shows the relative importance of the input parameters on the predicted nearshore wave height. Comparison with observed wave height changes and prediction wave height were presented at [Goda (1975a, 1975b)   ] and NShore model [AL-Salem 2022] at case 2 for data source from FRF, 13 September 1978 shows a good agreements.

REFERNCE

Al-Salem k. and Al-Rashed A. 2022. "Prediction of NearShore Wave Conditions From Irregular Deep water Waves (NShore model)". Website address:
http://www.hceatkuwait.net/NShore.aspx.

GODA, Y., "Deformation of Irregular Waves Due to Depth-Controlled Wave Breaking*". Report of the Port and Harbour Research Institute,* Japan, Voi. 14, No.3, Sept. 1975a, pp. 60-106 (in Japanese).

GODA, Y., "Irregular Wave Deformation in the Surf Zone," *Coastal Engineering in Japan,* Voi. 18, 1975b, pp. 13-26.

GODA Y., TAKAYAMA, T., and SUZUKI, Y., "Diffraction Diagrams for Directional Random Waves," *Proceedings of the 16th Conference on Coastal Engineering,* Port and Harbour Research Institute, Japan, 1978.

NShore Model Demonstration
P.C. Version

NShore model was developed based Coastal information system C.I.S. [Al-Salem 2005] for PC version as shown in Figure P1.
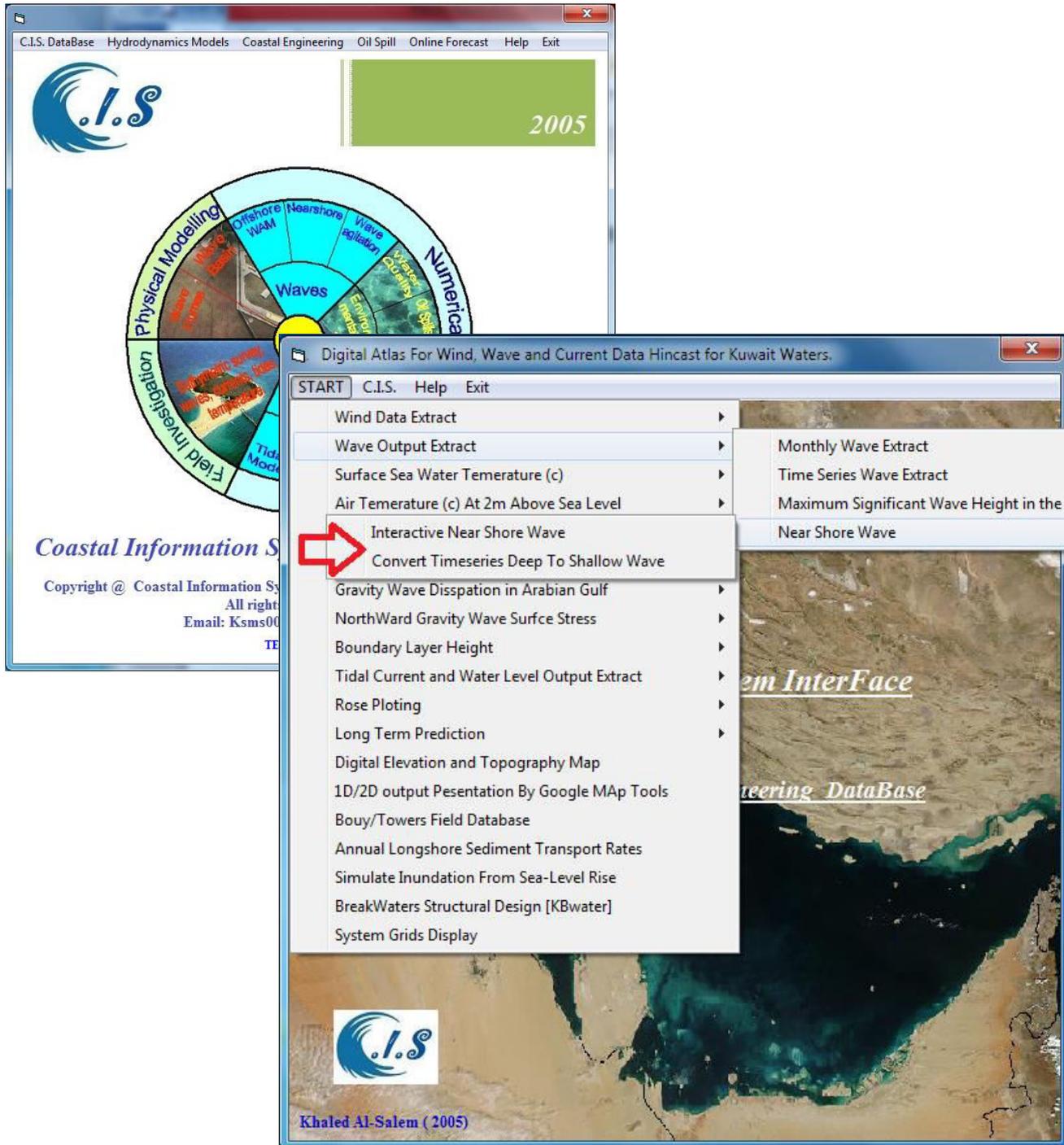
Figure P1. Coastal information system C.I.S

From Figure P1 user can run NShore model by select from drop list at [**Near shore wave**].
Then a new drop list will display as shown in Figure P1 to show that there are two options to run the model which are:

- Interactive NearShore Wave height
- Convert Timeseries Deep water wave height To Shallow Wave height

Option 1 [Interactive NearShore Wave]

If user selects option 1 then new page will display as shown in Figure P2.
Then user must input The Deep water wave height Condition as follows:

- Deep water wave Height m
- Deep water Wave Period sec
- Deep water Wave Angle deg
- Angle of Shoreline with respect to True North direction deg. [See Fig 15]
- Beach Slop s
- Shallow water depth [Interest depth location] m
- Wave Condition [For This version used *Wind-Wave*]

Figure P2

When all input data was entered as shown in Figure P3 user can select [RUN] to start the model.
Figure P3 display the output simulation.
Figure P4 display the output file created by the model

Figure P3

Figure P4

Option 2: Convert Timeseries Deep To Shallow Wave

If user selects option 2; this option was linked to Costal information System CIS database [AL-Salem 2005] for extraction Deep water wave height, direction and period data to do that is by the following steps:
1. Use deep water wave data file extracted from CIS
2. Use Created deep water wave data file by user [H_0, T_0, α_0]

For using option 1 for creating Deep water wave Condition file from CIS user must follows:
- Run CIS interface as shown in Fig P1 then select
  WAVE OUTPUT EXTRACT
  TIME SERIES WAVE EXTRACT
- Figure P5 for user input require parameter as shown in Fig P5 as
  Start Time / End time
  Deep water location [Longitude/Latitude]
  Then run Extract data

- Then user must select EXPORT FILE to create Deep water wave file by select [NEARSHORE] button.
- Then the wave data file will transfer to NShore model by a default name [Wave1.txt) as display in Figure P6
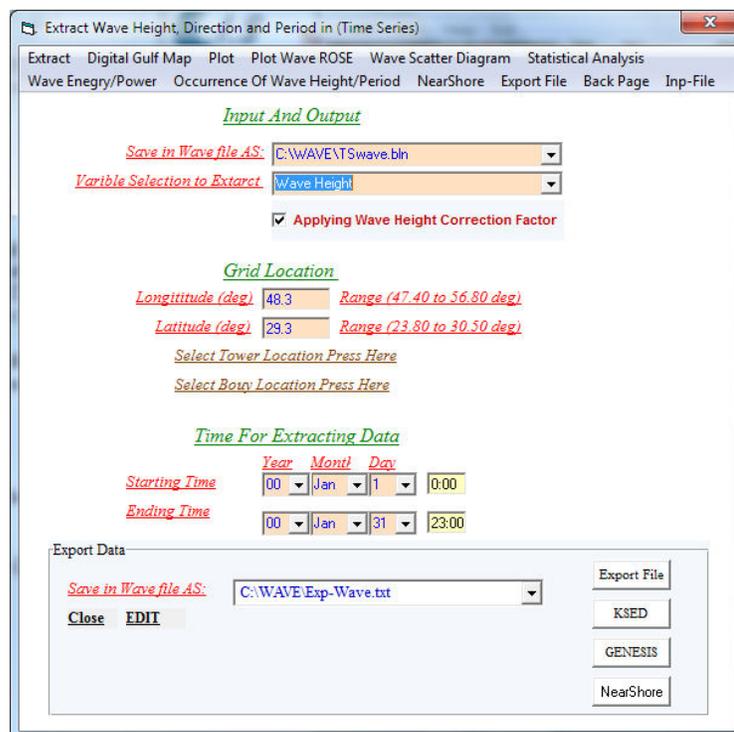- Figure P7 display sample of deep water wave height created by CIS interface
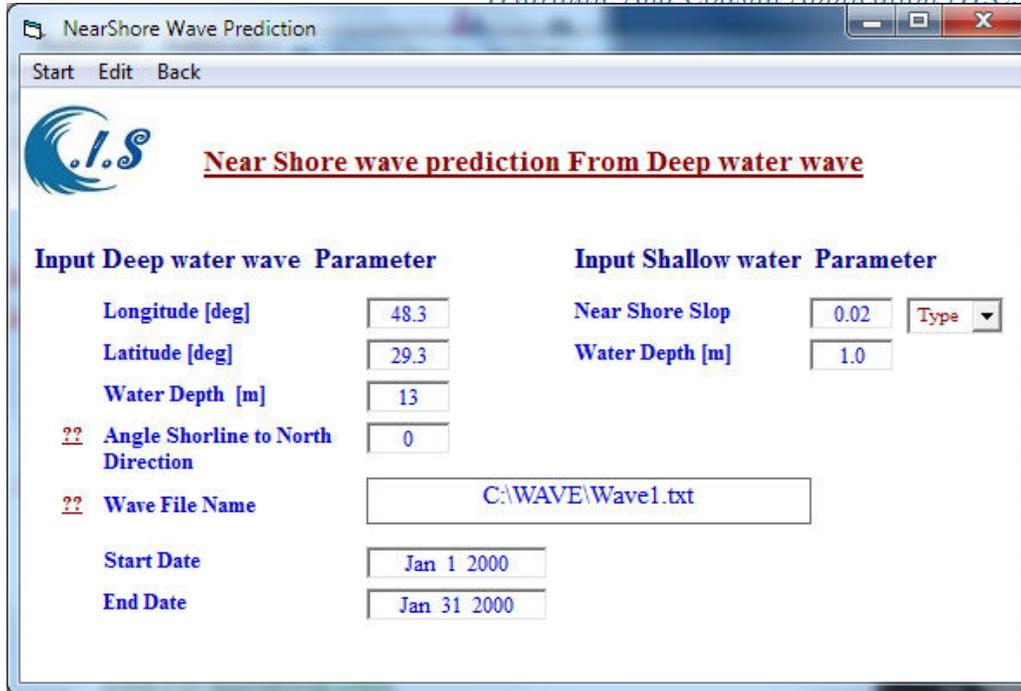

Figure P5
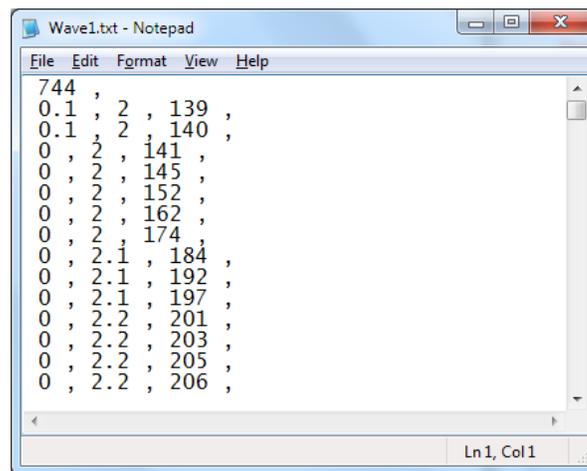
Figure P6

Figure P7

For using Option 2 for creating Deep water wave height Condition file must follows:
- Cerate text file data format must follow:
  - Number of data records ,
  - Deep water wave height , Wave periods , Wave direction ,
- A comma after each number is a must
- Then user must enter the created file Path and name in the [Wave file name] as shown in Fig P6.

After deep water wave file name entered, then user must input the following as in Figure P6:

  o Input Deep water wave parameter
Longitude of Deep water location
Latitude of Deep water location
Deep water Depth [not use in Calculation]
Angle of Shoreline to True North [See Figure 15]
  o Input Shallow water Parameter
Beach Slop
Water Depth at interested location [*d*]
  o Input Wave File name
  o Input Start Time
  o Input End Time

When all input data was entered as shown in Figure P6 user can select [**START**] to start the model.
Figure P8 display the output file created by the model

```
                          C.I.S.
          Coastal Information System DataBase
    PREDICTION OF NEARSHORE WAVE CONDITIONS FROM IRREGULAR
                  DEEP WATER WAVES

               [ Al-Salem K. 2005 ]
             Email: Ksms001@Gmail.com
               Tel  : 965 99016700
               WWW.hceatkuwait.net


    Time Serious for Significant wave height and Periods Data Records
    Selected Grid Location:
    Longitude:   48  18.00E
    Latitude :   29  18.00N
    Deep Water Depth: 1.0
    Date From: Jan  1  2000
    Date To  : Jan  31  2000

    Input Shallow water  Parameter
    Near Shore Slop    : 0.02
    Shallow Water Depth: 1.0

    Total Time Records:  744  Hours
    Wave Direction Measured From North Clockwise

    Discribtion of Parameters for Nearshore Conditions
    Ho    : Deepwater Significant Wave Height
    To    : Wave Period
    Ao    : Wave Direction
    Shore : ShoreLine Orintation angle from North
    Normal: Normal direction of wave to shore line
    KR    : Wave Refraction Coefficient
    As    : Angle of Nearshore Wave Energy Vector
    H'o   : DeepWater Equivalent Significant Wave Height
    Sw    : Wave SetUp
    Hrms  : Root-Mean-Square Wave Height
    Hs    : Significant Wave Height at Select Water Depth [Shallow]
    MWL   : Mean water level
                  Calculation of Nearshore Wave Heights and Water Level Parameters.

    Ho     To    Ao     Shore  Normal  KR     As     H'o      Wave    Hrms    Hs      MWL
    m      sec   deg    Orint  Shore   Coefi  deg    m        SetUp   m       m       m
    00.10  02.00 139.0  00.00  180.00  0.600  03.00  00.060   00.000  00.044  00.064  001.000
    00.10  02.00 140.0  00.00  180.00  0.600  03.00  00.060   00.000  00.044  00.064  001.000
    00.00  02.00 141.0  00.00  00.00   0.000  00.00  00.000   00.000  00.000  00.000  000.000
    00.00  02.00 145.0  00.00  00.00   0.000  00.00  00.000   00.000  00.000  00.000  000.000
    00.00  02.00 152.0  00.00  00.00   0.000  00.00  00.000   00.000  00.000  00.000  000.000
    00.00  02.00 162.0  00.00  00.00   0.000  00.00  00.000   00.000  00.000  00.000  000.000
    00.00  02.00 174.0  00.00  00.00   0.000  00.00  00.000   00.000  00.000  00.000  000.000
    00.00  02.10 184.0  00.00  00.00   0.000  00.00  00.000   00.000  00.000  00.000  000.000
    00.00  02.10 192.0  00.00  00.00   0.000  00.00  00.000   00.000  00.000  00.000  000.000
    00.00  02.10 197.0  00.00  00.00   0.000  00.00  00.000   00.000  00.000  00.000  000.000
    00.00  02.20 201.0  00.00  00.00   0.000  00.00  00.000   00.000  00.000  00.000  000.000
    00.00  02.20 203.0  00.00  00.00   0.000  00.00  00.000   00.000  00.000  00.000  000.000
```
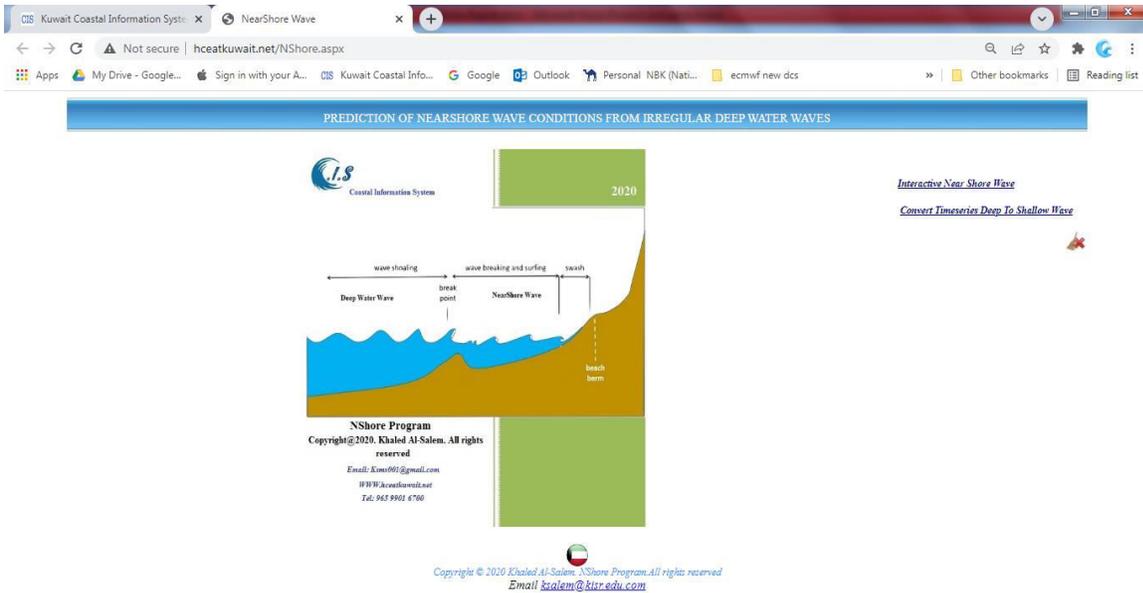
Figure P8
NShore Model Demonstration
Internet Version
Website: http://www.hceatkuwait.net\NShore.aspx

User must login to website address at: http://www.hceatkuwait.net\NShore.aspx
Then Figure V1 will display the main NShore model website page on internet as follows:

Figure V1

Figure V1 to shows that there are two options to run the model which are:
- Interactive NearShore Wave
- Convert Timeseries Deep To Shallow Wave height

Option 1 [Interactive NearShore Wave]

If user selects option 1 then new page will display as shown in Figure V2.
Then user must input The Deep water wave height Condition as follows:
- Deep water wave Height m
- Deep water Wave Period sec
- Deep water Wave Angle deg
- Angle of Shoreline with respect to True North direction deg.
- Beach Slop s
- Shallow water depth [Interest water depth location] m
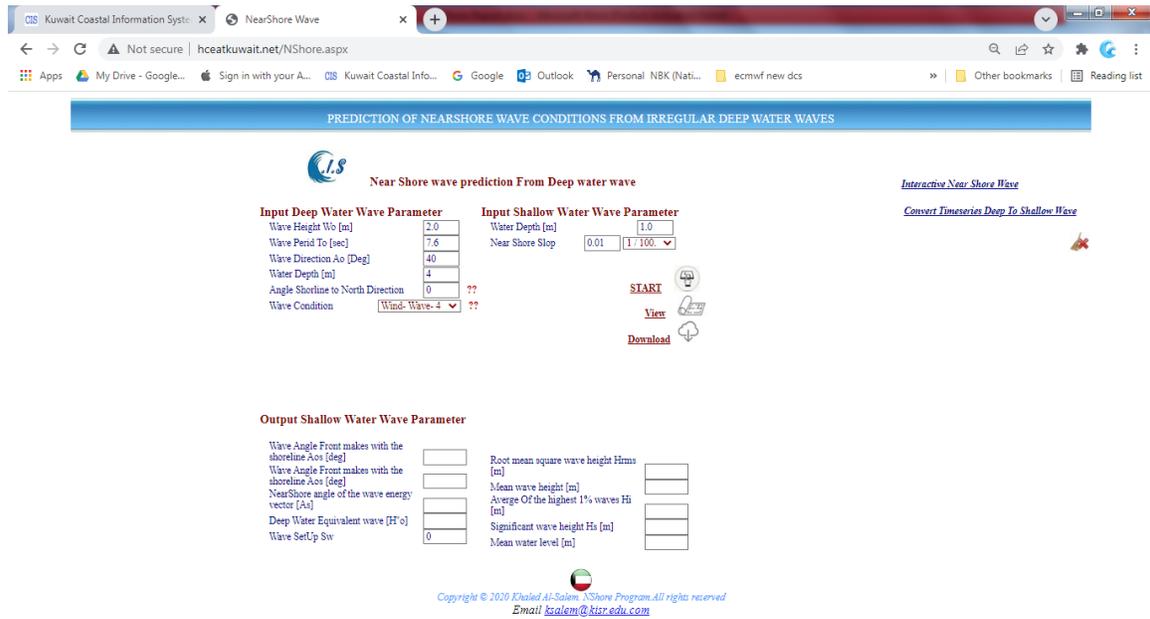- Wave Condition [For This version used *Wind-Wave*]

Figure V2

When all input data was entered; User can select [**START**] to start the model.
Figure V3 display the output simulation.
From Figure V3 user can do the following:

- View the output file created by the model as shown in Figure V4
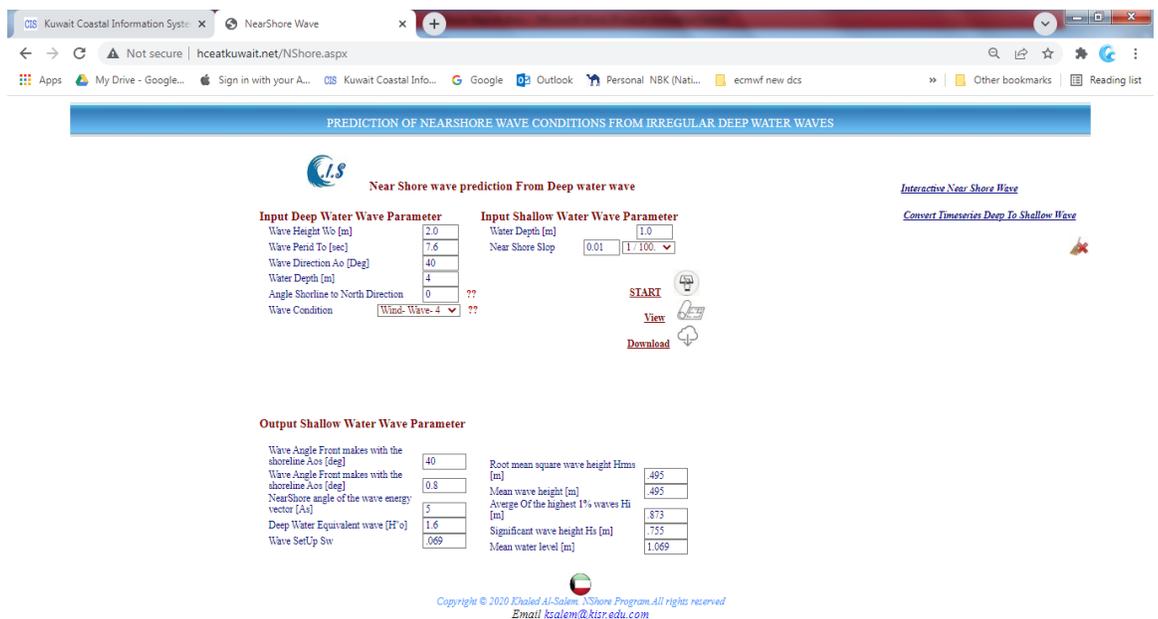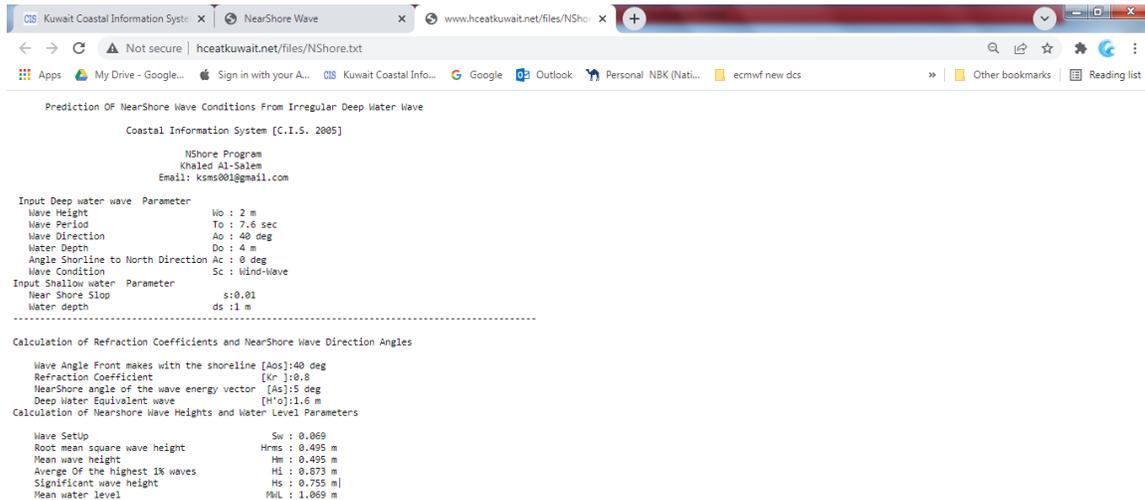
- Download output file created by model

Figure V3

Figure V4

Option 2: Convert Timeseries Deep To Shallow Wave

If user selects option 2 as shown in Figure V5;

This option user can prediction nearshore wave height data from time series deep-water wave height data file. The data file can be entered or created by the following:

      [1] Use deep water wave data file extracted from Costal information System CIS database [AL-Salem 2005].

[2] Use Created deep water wave height data file by user as follows:

  Ndat,   Total records,

  [H_0, T_0, α_0]   Wave height , period , direction ,

[3] User can used pre-saved deep wave height data file by select [***Default Sample Deep Water Wave Data*** *]* as shown in Figure V6.

For using option 1 for creating Deep water wave Condition file from CIS user must follows:

Run CIS interface as shown in Fig P5 then select

      WAVE OUTPUT EXTRACT

      TIME SERIES WAVE EXTRACT

Then open the file created. User must copy the all data then pass in Data container as shown in Figure V6.

For using option 2 for creating Deep water wave Condition file by user must do following:

      File data enter format as shown in Figure V6:

          [1] Number of Data: **Ndat ,**

          [2] Coordinate as [**H_o , T_o , α_o ,**]

Note: Comma must follow each number

Note: Maximum Wave Data 8784 records

User can Update the input wave height data file by select [***Load data***]

Then user must save the data file by select [SAVE data]

User input require parameter for both options as shown in Fig V6 as

Water depth ***d*** [at interested location]
Beach slop ***s***
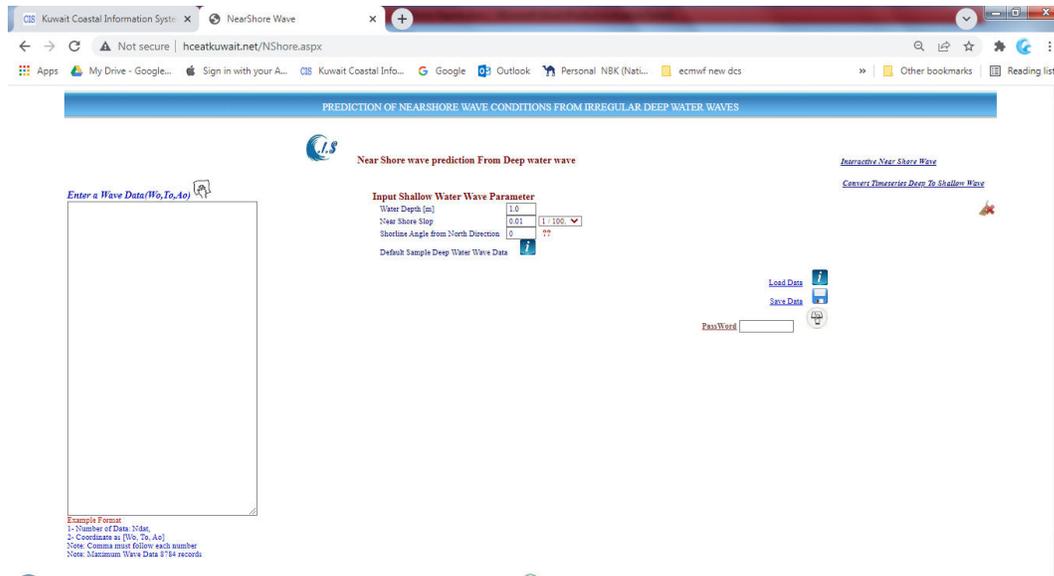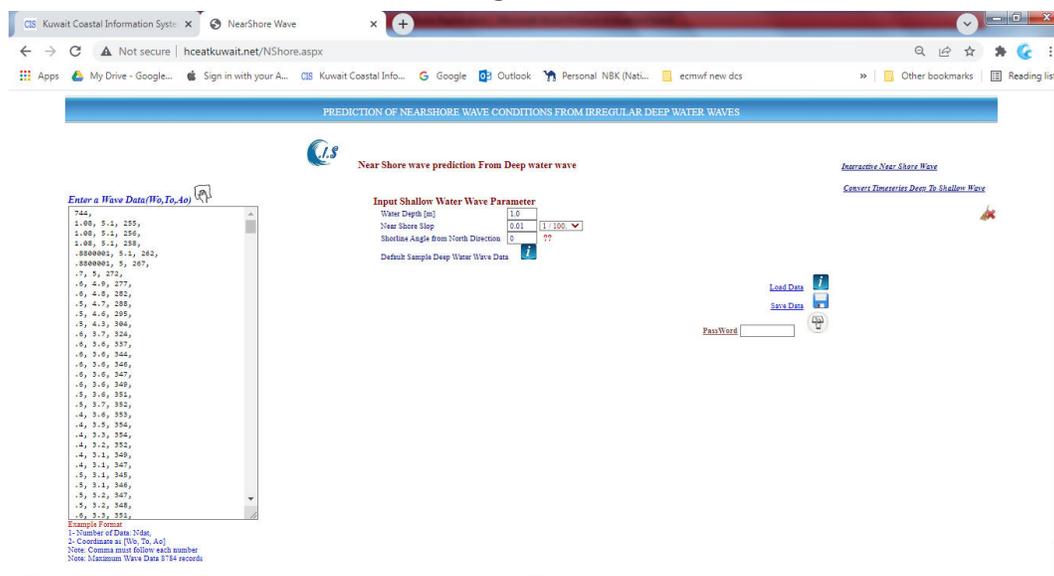Shore line Angle from Normal direction ***θ***

Figure V5

Figure V6

When all input parameters were entered as shown in Figure V6.

Then user must enter his access code at [**PASSWORD**] to start run the model by select [Run icon   ].

Figure V7 will display for user to select from **Output Shallow Water Wave** view options follows:

- View simulation data file   [Snapshot from output file shown in Figure V8].

  [*User must refresh or reload page to update view file it is internet issue*]

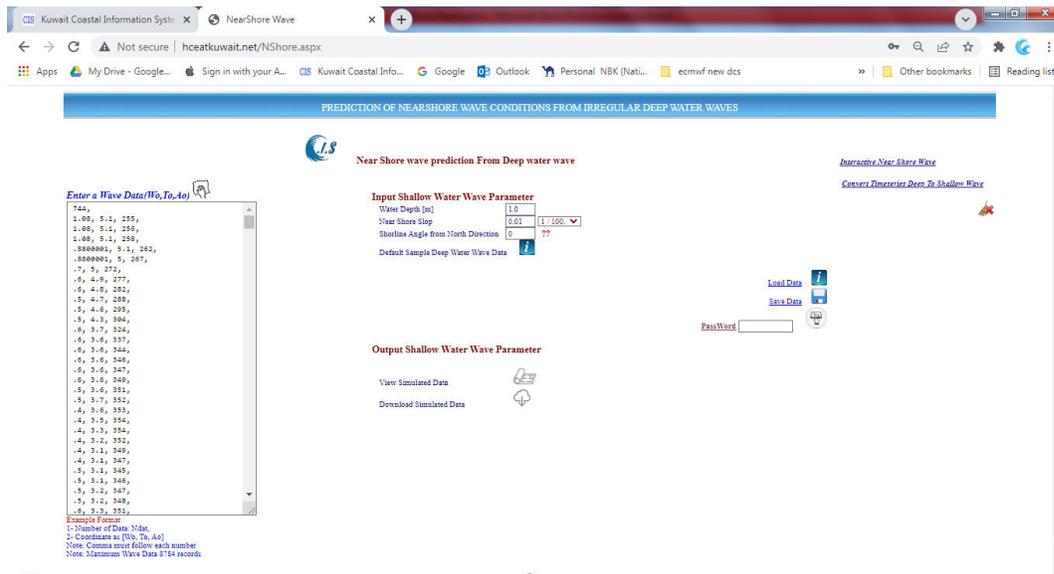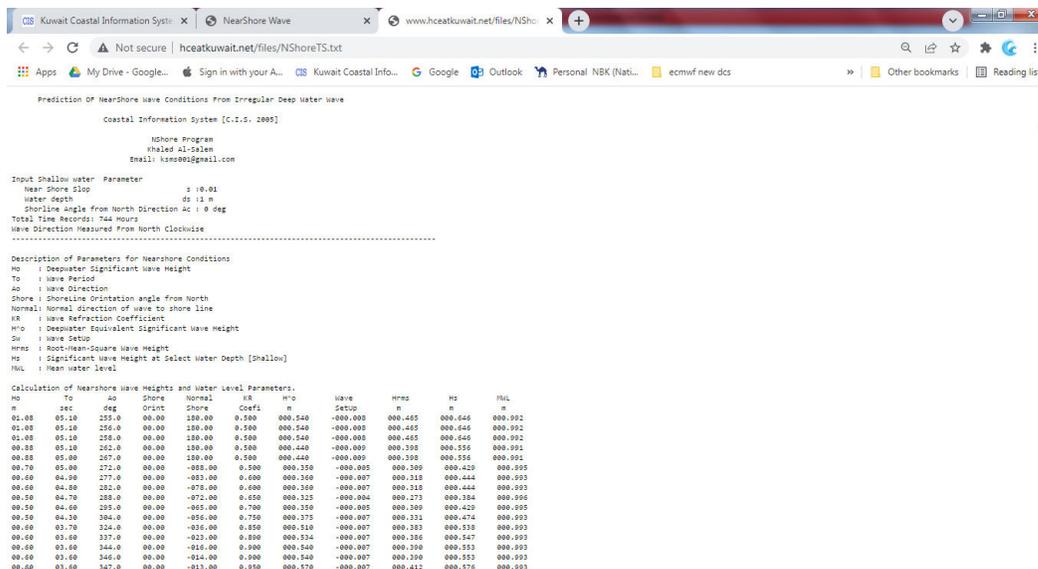- Download simulation data   [Snapshot from output file shown in Figure V8]

Figure V7

Figure V8

Appendix

Section 2.1

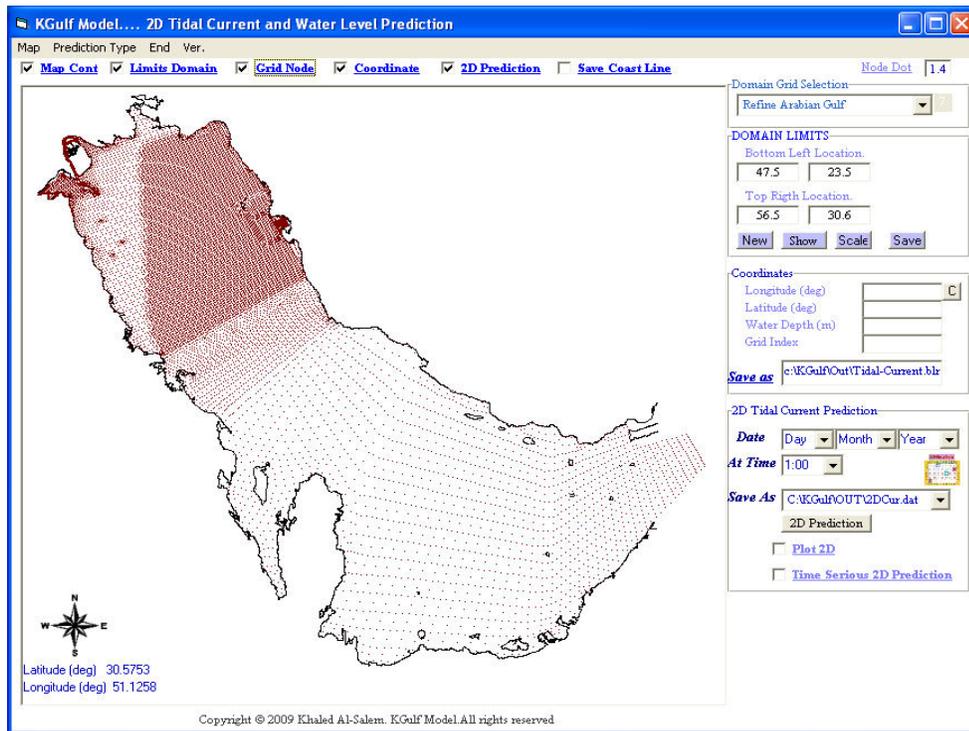Figure A1
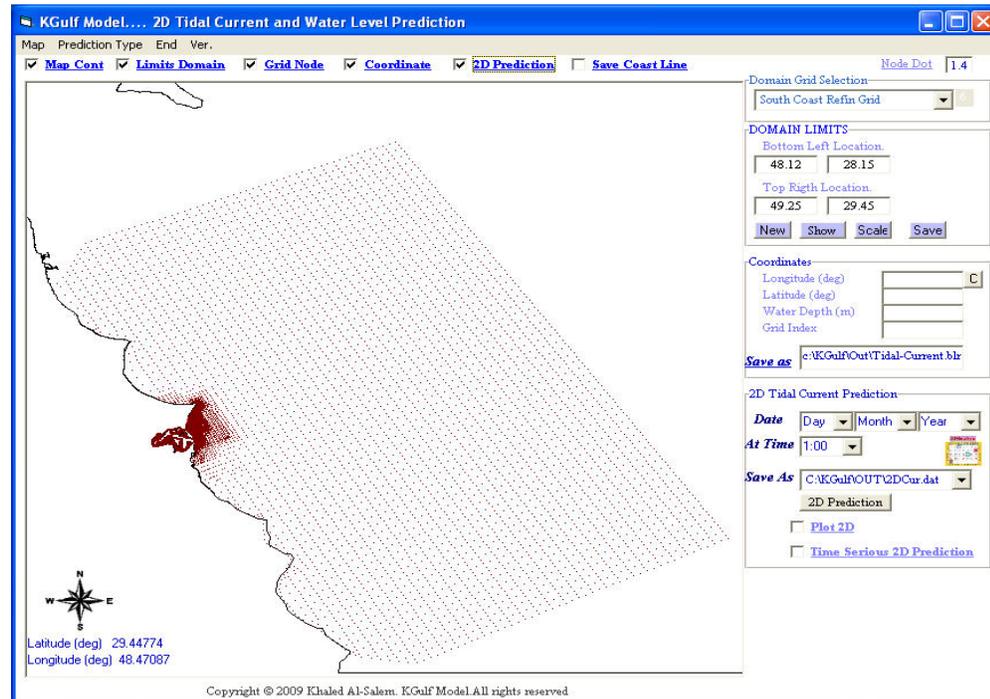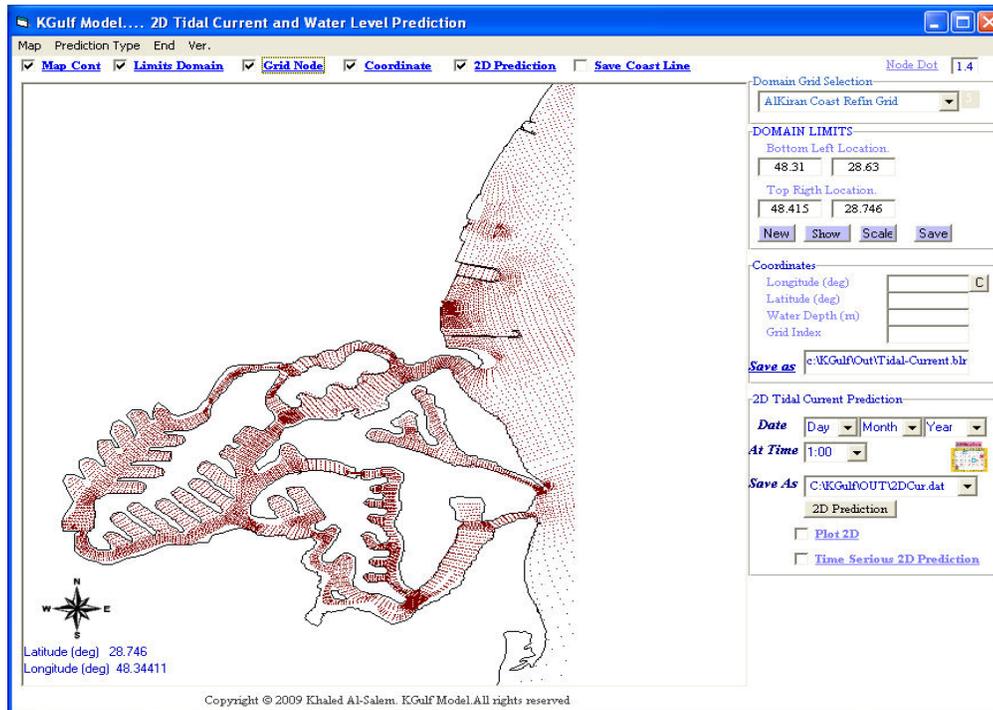

Figure A2

Figure A3

Section 4.7

Important Note for Bathymetry Data
Extremely important to make sure that in water depth file, bathymetry (water area) data takes positive sign and topographical (Land area) data takes negative sign.

GS Script Data Input Format From KUnami Interface

The Data are:

Parameters Value	Parameters Value Description
C:\KUnami\Out\filedat.dat	Input data file for plot
C:\KUnami\Out\filegrd.dat	Input Grid file Name Which will create from Surfer Software
C:\KUnami\Out\filebmp.dat	Input Image file Name Which will create from Surfer Software
C:\KUnami\Data\AGcoast.bln	Input Coast Line file Name for Surfer Software
C:\KUnami\Data\AGBLANK.bln	Input Blanking file Name for Surfer Software
C:\KUnami\Data\PLV02.lvl	Input 2D Contour level file Name for Surfer Software
C:\KUnami\Data\col3d.CLR	Input 3D image contour file Name for Surfer Software
3	Total Time
0	Start Time
40	End Time
20	Time Step

0	Type of back ground 0 for coast line 1 for satile image background
Title plot	Plot Title
47.7042	Domain Scale X1
73	Domain Scale X2
19	Domain Scale Y1
30.4958	Domain Scale Y2
2	For 2D plot is 2 and 3D is 3
1	Animation control 1 on 0 off
3036	Total domain Dimension Ny
1380	Total domain Dimension Nx

Volume Flux

In fluid dynamics, the volumetric flux is the rate of volume flow across a unit area (m3·s-1·m-2). Volumetric flux = liters/(second*area). The density of a particular property in a fluid's volume, multiplied with the volumetric flux of the fluid, thus defines the Advective flux of that property. The volumetric flux through a porous medium is often modeled using Darcy's law.