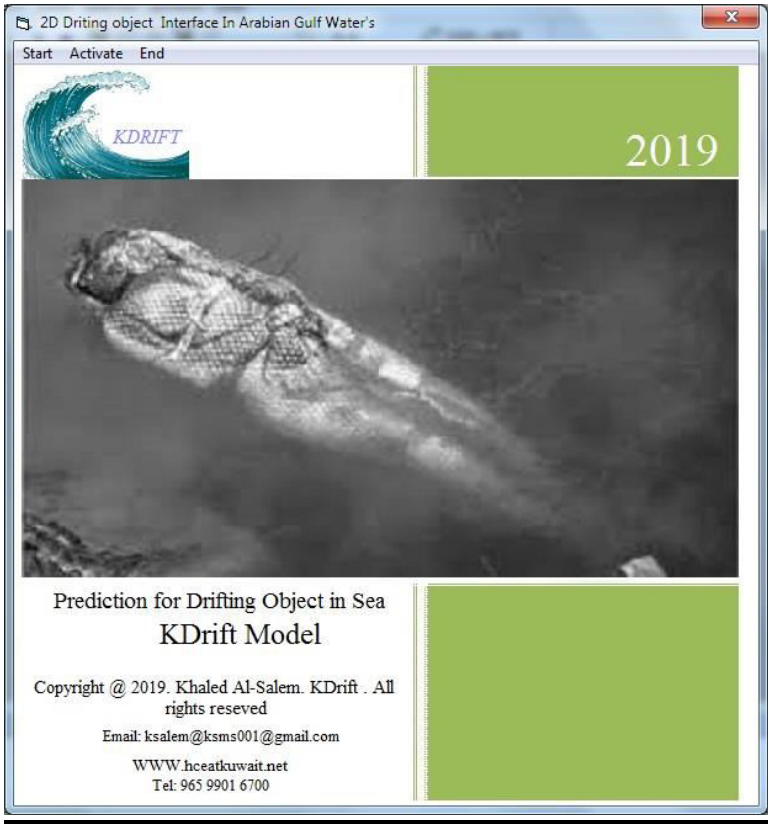
Technical Report



Prediction for Drifting Object in Sea
KDrift Model

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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

$$\begin{aligned} dx_i &= u(x_i, y_i, z_i, t)dt + Rnd_x(i) \\ dy_i &= v(x_i, y_i, z_i, t)dt + Rnd_y(i) \\ dz_i &= w(x_i, y_i, z_i, t)dt + Rnd_z(i) \end{aligned} \qquad [1]$$

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 ($9.8\ m/s^2$). U_S is represent the Stokes Surface drift velocity as follows:

$$u_s = g^{-1}\pi^3 H_S^2 T_p^{-3} \qquad [2]$$

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

$$F_D = \frac{1}{2} C_D \rho V|V| \qquad [3]$$

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

$$F_A = \frac{1}{2} C_a A_c |V_a - V|(V_a - V) \qquad \text{Drift Force relate to wind speed} \qquad [4]$$

$$F_c = \frac{1}{2} C_c A_c |V_c - V|(V_c - V) \qquad \text{Drift Force relate to tidal current} \qquad [5]$$

Equations 4 and 5 combined as shown in Figure 1 will yield as

$$\frac{1}{2} C_a \rho_a A_a |V_a - V|(V_a - V) \quad + \quad \frac{1}{2} C_c \rho_c A_c |V_c - V|(V_c - V) = 0 \qquad [6]$$

Assuming both Reynolds numbers, *Ra,* and *Rc* , to be large, then $\boldsymbol{C_a}$, and $\boldsymbol{C_c}$ are constant. The drift velocity $\boldsymbol{V}$ due to wind speed and tidal current action can be solved easily from equation 6 as:

$$V = \frac{\gamma}{1+\gamma} V_a + \frac{1}{1+\gamma} V_c \qquad [7]$$

Where

$$\gamma = \frac{\gamma_a}{\gamma_c} \quad \text{at} \quad \gamma_a = \sqrt{C_a \rho_a A_a} \quad and \quad \gamma_c = \sqrt{C_c \rho_c A_c}$$

ρ_a Air density: 1.226 kg/m^3 ρ_c Water density: 1025.9 kg/m^3

A_a object area above sea level A_c object area below sea level as shown in Fig 1

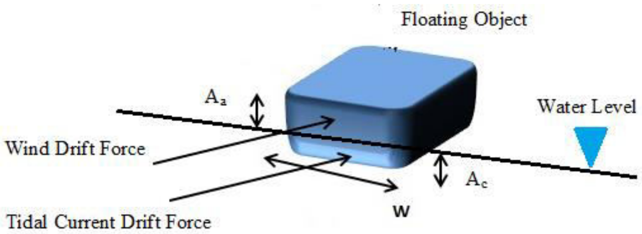
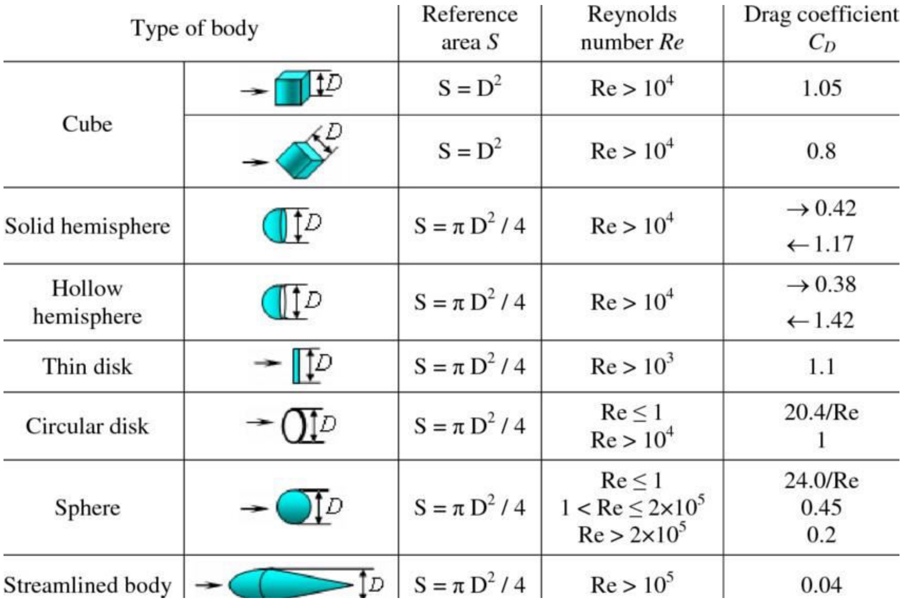


Figure 1

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	→ D	$S = D^2$	$Re > 10^4$	1.05
	→ D	$S = D^2$	$Re > 10^4$	0.8
Solid hemisphere	D	$S = \pi D^2 / 4$	$Re > 10^4$	→ 0.42 ← 1.17
Hollow hemisphere	D	$S = \pi D^2 / 4$	$Re > 10^4$	→ 0.38 ← 1.42
Thin disk	→ D	$S = \pi D^2 / 4$	$Re > 10^3$	1.1
Circular disk	→ D	$S = \pi D^2 / 4$	$Re \leq 1$ $Re > 10^4$	20.4/Re 1
Sphere	→ D	$S = \pi D^2 / 4$	$Re \leq 1$ $1 < Re \leq 2\times10^5$ $Re > 2\times10^5$	24.0/Re 0.45 0.2
Streamlined body	→ D	$S = \pi D^2 / 4$	$Re > 10^5$	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

$$V = V_o - \frac{(V_o - V_c)}{1-\gamma} + \{\left(\frac{V_o - V_c}{1-\gamma}\right)^2 + \frac{\alpha}{1-\gamma^2}\}^{1/2} \qquad [10]$$

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]

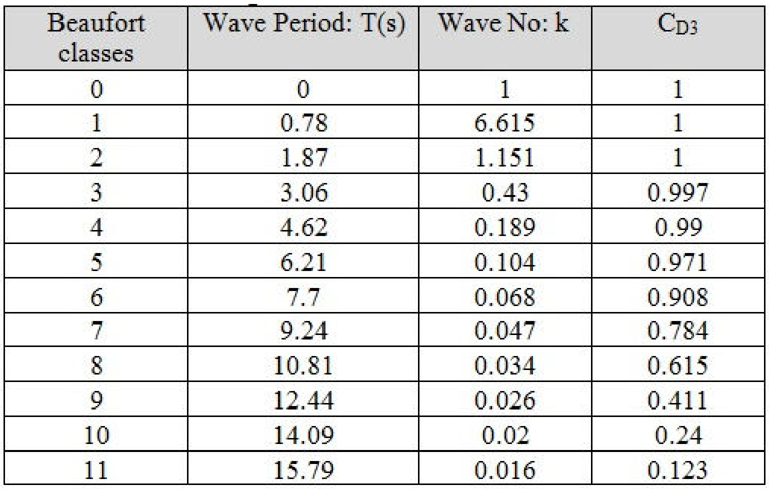
$$V_o = \frac{\gamma}{1+\gamma}V_a + \frac{1}{1+\gamma V_c}V_c$$

$$\propto = \frac{\boldsymbol{C_h G L a^2}}{\boldsymbol{C_c A_c}}$$

For large a, the effect of wave drift is considerable as indicated in equation 6. With small $\propto$, assuming $\propto << |V_o, - V_c|$ 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

Source: Report No.18591.620/TECH_DOC/2 [***Marian***]. https://www.iala-aism.org/wiki/iwrap/images/6/65/Contact_drift.pdf

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

$$V_l = 0.0323(V_a - V_w) \quad [13]$$

Where
V_a *is* Wind speed Drift Velocity, V_w is Tidal Surface Current.

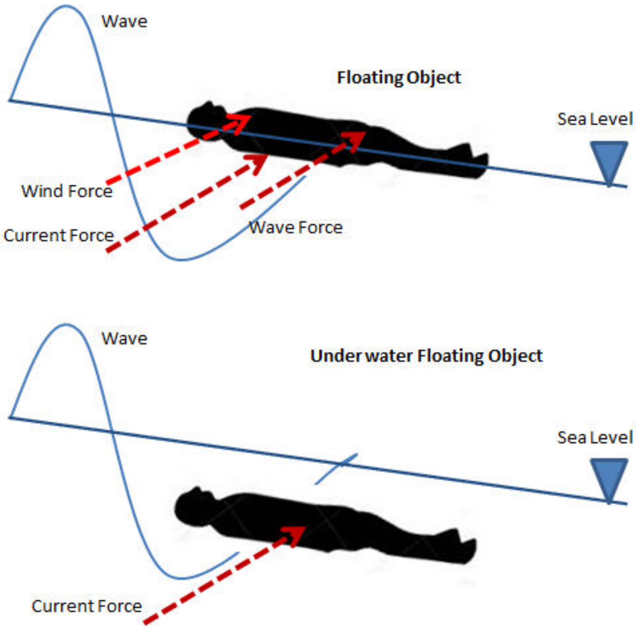


Figure 2. Drift Forces Acted on floating body on water

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).

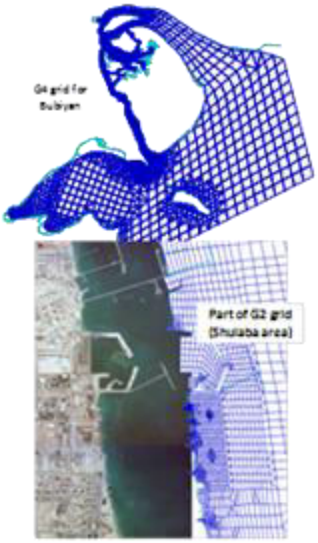


Figure 3. Sample of grids used for Kuwaiti territorial waters

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.

$$H_s(v,\alpha) = \frac{k\sum_{i=1}^{n} C_H H_{si}}{m} \tag{9}$$

where the weighting factor C_H is calculated according to,

$$C_H = 1.0 \quad if \begin{cases} v_{\min} < v < v_{\max} \\ \alpha_{\min} < \alpha < \alpha_{\max} \end{cases} \tag{10}$$

$$C_H = 0.0 \qquad otherwise$$

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),

$$T_m(v,\alpha) = \frac{k\sum_{i=1}^{n} C_T T_{mi}}{m} \tag{11}$$

where the weighting factor C_T is calculated according to,

$$C_T = 1.0 \quad if \begin{cases} v_{\min} < v < v_{\max} \\ \alpha_{\min} < \alpha < \alpha_{\max} \end{cases} \tag{12}$$

$$C_T = 0.0 \qquad otherwise$$

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.

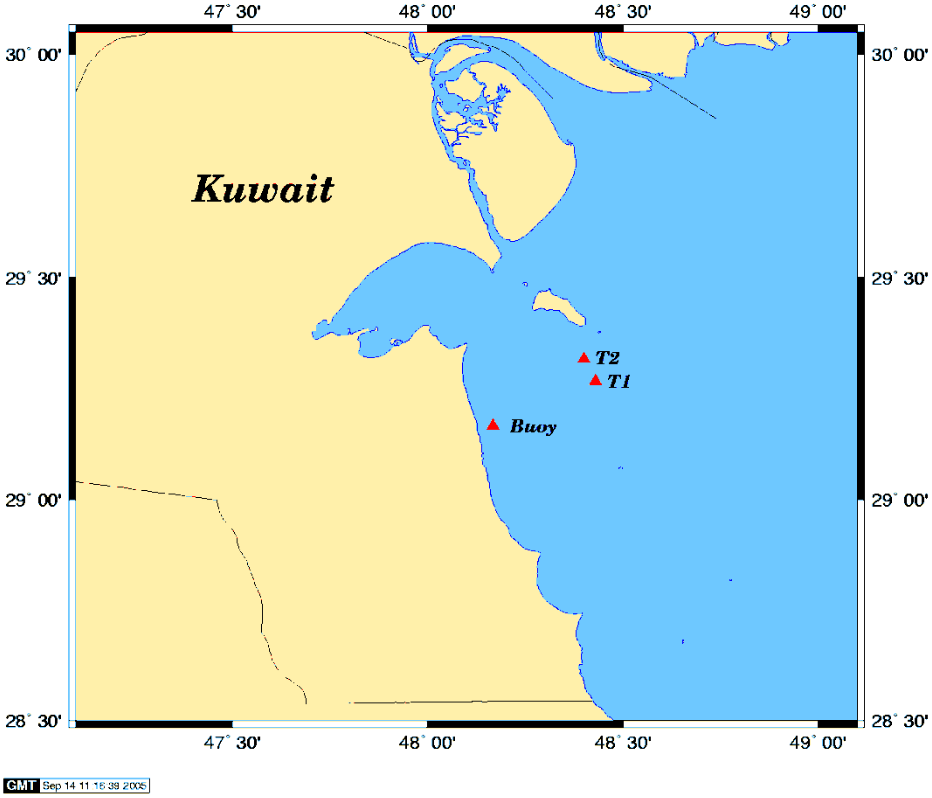
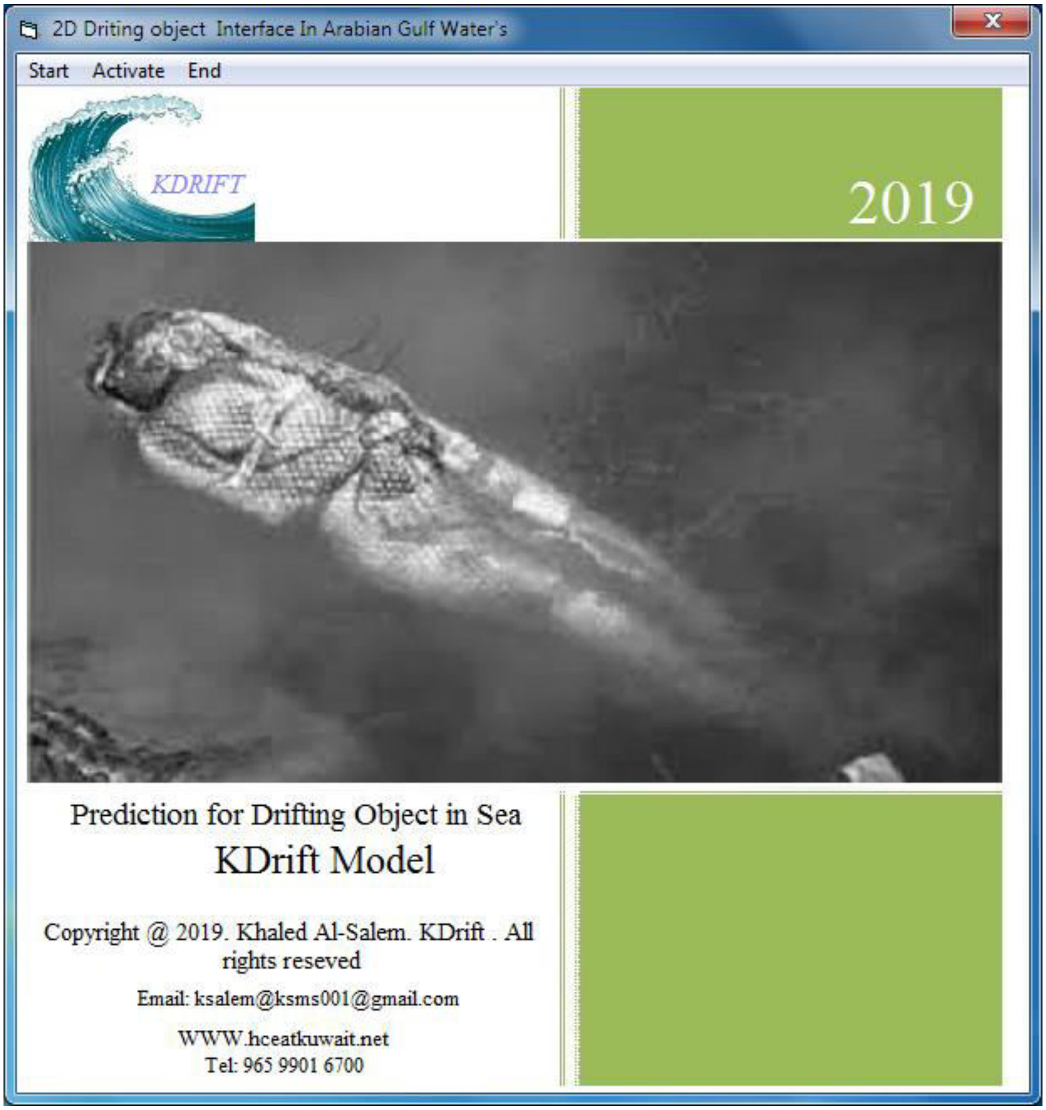


Figure 4. Map of Kuwait showing the locations where measured data was available.

Model Demonstration



Prediction for Drifting Object in Sea
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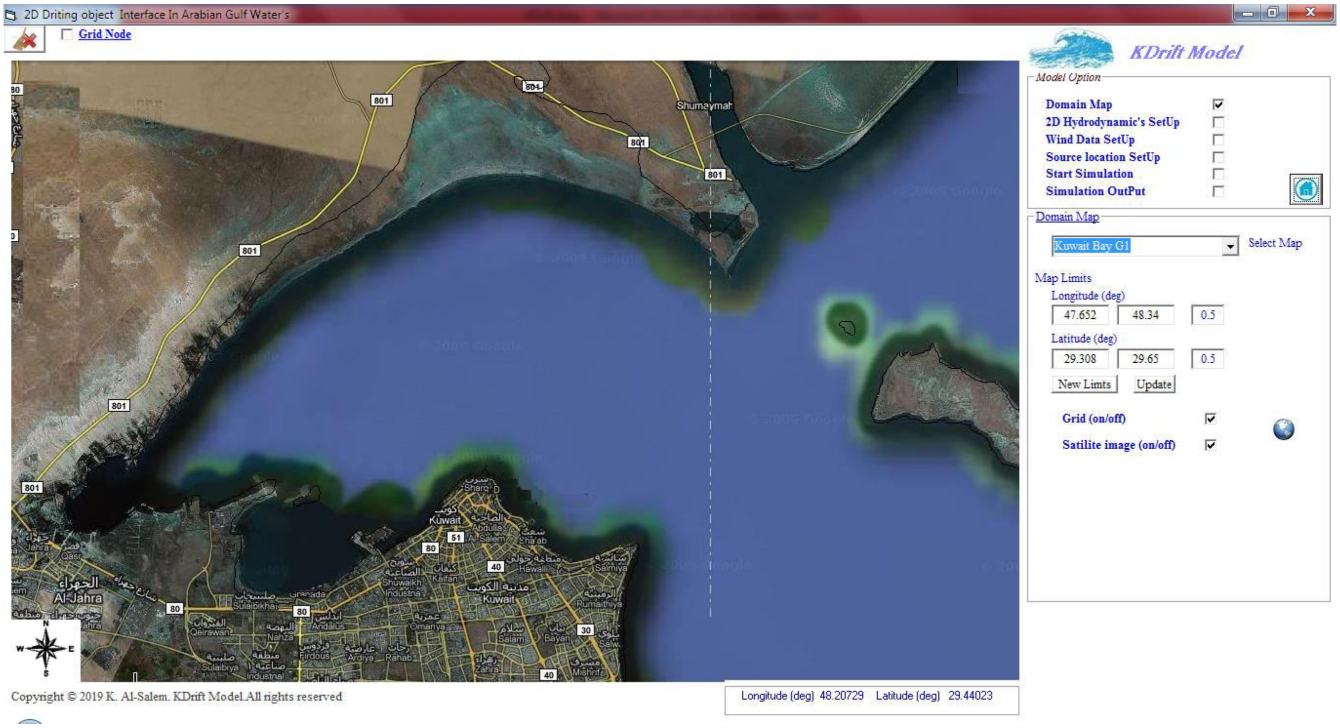
User should Press on Start Fig A1 will display as follows



2D Driting object Interface In Arabian Gulf Water's

☐ Grid Node

Model Option

- Domain Map ☑
- 2D Hydrodynamic's SetUp ☐
- Wind Data SetUp ☐
- Source location SetUp ☐
- Start Simulation ☐
- Simulation OutPut ☐

Domain Map

Select Map: Kuwait Bay G1

Map Limits

Longitude (deg): 47.652 48.34 0.5

Latitude (deg): 29.308 29.65 0.5

New Limts Update

Grid (on/off) ☑

Satilite image (on/off) ☑

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Longitude (deg) 48.20729 Latitude (deg) 29.44023

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

Copyright @ K. Al-Salem - Drift Object on Google Map (KDrift 2019)

Figure A2. Display Selected Image on Google Map

Model Option

Domain Map ☐
2D Hydrodynamic's SetUp ☑
Wind Data SetUp ☐
Source location SetUp ☐
Start Simulation ☐
Simulation OutPut ☐

Hydrodynamic's Time Limit

Start Date: 18 May 2019

End Date: 23 May 2019

Total Simulation Time= 144hr

Time Step: 20 min

SetUp Hydrodynamic's Time
Edit

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Longitude (deg) 49.0379 Latitude (deg) 29.16908

Figure A3. 2D hydrodynamic time setup

2D Driting object Interface In Arabian Gulf Water's

☐ Grid Node

KDrift Model

Model Option

- Domain Map ☐
- 2D Hydrodynamic's SetUp ☐
- Wind Data SetUp ☑
- Source location SetUp ☐
- Start Simulation ☐
- Simulation OutPut ☐

Wind Data Input

Constant Wind Speed ☐

Wind Speed: 0 Km/hr

Wind Direction: NW

File Load Wind Speed (U,Dirc) ☑

M/sec

File Name: C:\KDrift\out\wind.txt (Wind Sp,Dirc)

Wind Direction From North Clockwise ☐

Hceatkuwait.net < RLtime.txt > ☐

Wind Speed SetUp File   Edit

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Longitude (deg) 48.85707   Latitude (deg) 29.16698

Figure A4. Wind Speed Data setup

2D Driting object Interface In Arabian Gulf Water's

☐ Grid Node

KDrift Model

Model Option

- Domain Map ☐
- 2D Hydrodynamic's SetUp ☐
- Wind Data SetUp ☐
- Source location SetUp ☑
- Start Simulation ☐
- Simulation OutPut ☐

Source Location

Drift Start Date: 18/ 5/2019

At Time in Day: 0

Dot: 3

Spill Location ☐

Longitude: 48.39508

Latitude: 29.34985

344   Water Depth: 2.825m

Option Of Drift Object: Circular Object

Object

Object Dimension

Diameter [D1 - H] m: 0.5

Diameter [D2 - W] m: 1.0

For Submerge Object [Z0]: 0

Drift Drag Coefficients

Wind Drag Coefficient Cw: 0.45

Current Drag Coefficient Cc: 0.787

Wave Drag Coefficient Cz: 0

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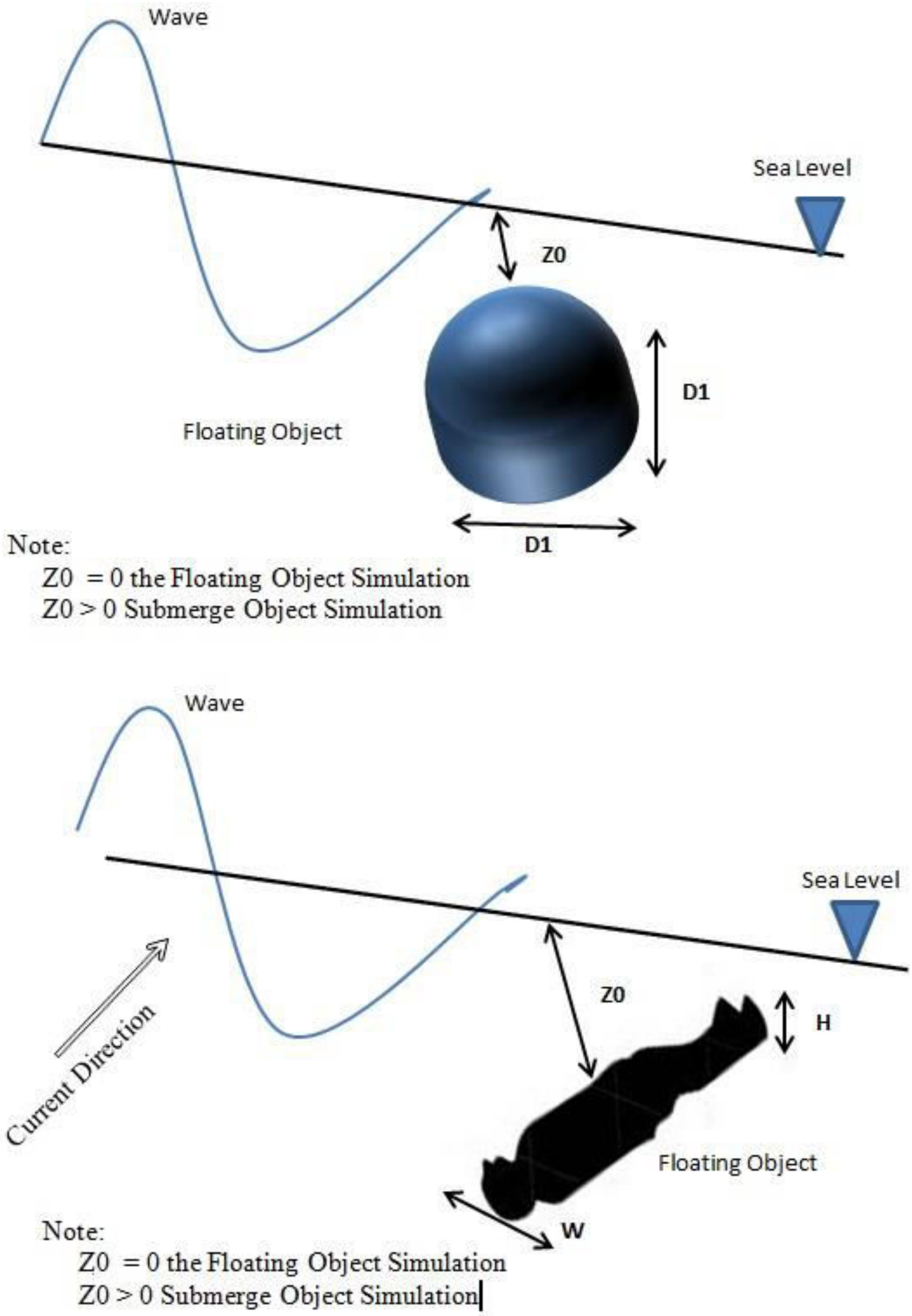
Longitude (deg) 48.86326   Latitude (deg) 29.19535

Figure 5. Object Initial Location And Object Type



Note:
Z0 = 0 the Floating Object Simulation
Z0 > 0 Submerge Object Simulation

Note:
Z0 = 0 the Floating Object Simulation
Z0 > 0 Submerge Object Simulation

Figure A6 Type of Drifted Object in the model

Model Option

Domain Map	☐
2D Hydrodynamic's SetUp	☐
Wind Data SetUp	☐
Source location SetUp	☐
Start Simulation	☑
Simulation OutPut	☐

Model Simulation

Simulation Date 18/ 5/ 2019
Time 12:00 AM

	Longitude	Latitude
Object Location	48.18204	29.3551

Simulation Info.

Drift Location	48.18204	29.3551	
Drift Speed (m/s)	0		
Tidal Current (cm/s)	0	0	
Water Level [m]	-001.0	M.S.L	
Wind Speed (m/s)	0001.2	077.0	
Wave Height (m)	0	0	0
Drift Date	18/ 5/ 2019		
Time	12:00 AM		

Wave height Effect ON / OFF ☑
Show All Loation ☑

START

☑ Lagrangian Moveing Paticals
☐ Leeway Drift
☐ Monte Carlo statistical methods 1

Stop ☐ Time Delay 0 Sec

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Longitude (deg) 48.86574 Latitude (deg) 29.09656

Figure A7. Project simulation Window

Model Option

Domain Map	☐
2D Hydrodynamic's SetUp	☐
Wind Data SetUp	☐
Source location SetUp	☐
Start Simulation	☑
Simulation OutPut	☐

Model Simulation

Simulation Date 18/ 5/ 2019
Time 12:00 AM

	Longitude	Latitude
Object Location	48.18204	29.3551

Simulation Info.

Drift Location	048.24876	029.24549	
Drift Speed (m/s)	000.27		
Tidal Current (cm/s)	033.6	124.1	
Water Level [m]	-000.9	M.S.L	
Wind Speed (m/s)	002.80	230.02	
Wave Height (m)	00.17	071.6	02.9
Drift Date	23/ 5/ 2019		
Time	11:40 PM,		

Wave height Effect ON / OFF ☑
Show All Loation ☑

START

☑ Lagrangian Moveing Paticals
☐ Leeway Drift
☐ Monte Carlo statistical methods 1

Stop ☐ Time Delay 0 Sec

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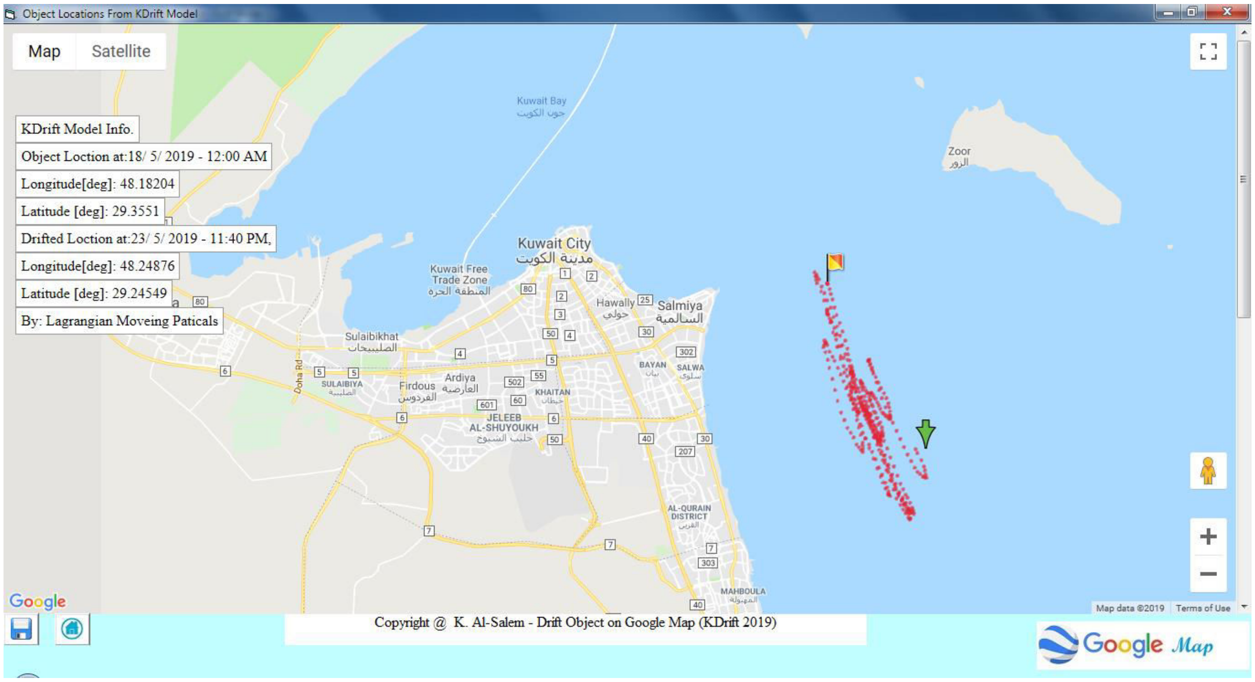
Longitude (deg) 48.86821 Latitude (deg) 28.85379

Figure 8. Drift Object Simulation by Lagrangian Moving Particles theory



KDrift Model Info.

Object Loction at:18/ 5/ 2019 - 12:00 AM

Longitude[deg]: 48.18204

Latitude [deg]: 29.3551

Drifted Loction at:23/ 5/ 2019 - 11:40 PM,

Longitude[deg]: 48.24876

Latitude [deg]: 29.24549

By: Lagrangian Moveing Paticals

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Figure 9. Drift Object Simulation by Lagrangian Moving Particles theory displayed on Google Map

☐ Grid Node

Domain Map ☐
2D Hydrodynamic's SetUp ☐
Wind Data SetUp ☐
Source location SetUp ☐
Start Simulation ☑
Simulation OutPut ☐

Simulation Date	18/ 5/ 2019	
Time	12:00 AM	
	Longitude	Latitude
Object Location	48.18204	29.3551

Simulation Info.

Drift Location	048.23307	029.22539	
Drift Speed (m/s)	000.38		
Tidal Current (cm/s)	048.7	120.8	
Water Level [m]	-001.0	M.S.L	
Wind Speed (m/s)	002.80	230.02	
Wave Height (m)	00.17	067.9	03.0
Drift Date	23/ 5/ 2019		
Time	11:40 PM,		

Wave height Effect ON / OFF ☑
Show All Loation ☑

☐ Lagrangian Moveing Paticals
☑ Leeway Drift
☐ Monte Carlo statistical methods 1

Stop ☐

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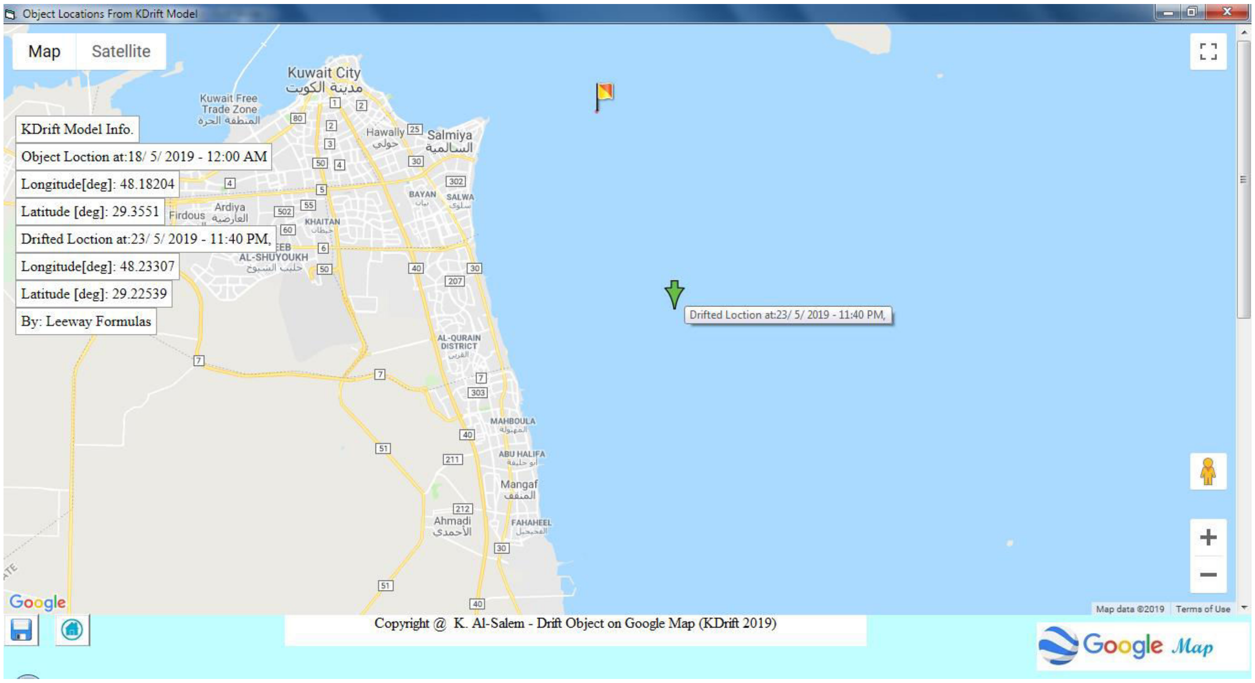
Longitude (deg) 48.86078 Latitude (deg) 28.95153

Figure 10. Drift Object Simulation by Leeway Drift Method



KDrift Model Info.

Object Loction at:18/ 5/ 2019 - 12:00 AM

Longitude[deg]: 48.18204

Latitude [deg]: 29.3551

Drifted Loction at:23/ 5/ 2019 - 11:40 PM,

Longitude[deg]: 48.23307

Latitude [deg]: 29.22539

By: Leeway Formulas

Drifted Loction at:23/ 5/ 2019 - 11:40 PM,

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Figure 11. Drift Object Simulation by Leeway Drift Method displayed on Google Map

☐ Grid Node

Model Option

Domain Map	☐
2D Hydrodynamic's SetUp	☐
Wind Data SetUp	☐
Source location SetUp	☐
Start Simulation	☑
Simulation OutPut	☐

Model Simulation

Simulation Date	18/ 5/ 2019		
Time	12:00 AM		
	Longitude	Latitude	
Object Location	48.18204	29.3551	
Simulation Info.			
Drift Location	048.25061	029.24419	
Drift Speed (m/s)	000.08		
Tidal Current (cm/s)	033.6	124.1	
Water Level [m]	-000.9	M.S.L	
Wind Speed (m/s)	002.80	230.02	
Wave Height (m)	00.17	071.6	02.9
Drift Date	23/ 5/ 2019		
Time	11:40 PM,		

Wave height Effect ON / OFF ☑

Show All Loation ☐

START

☐ Lagrangian Moveing Paticals

☐ Leeway Drift

☑ Monte Carlo statistical methods 20

Stop ☐ Time Delay 0 Sec

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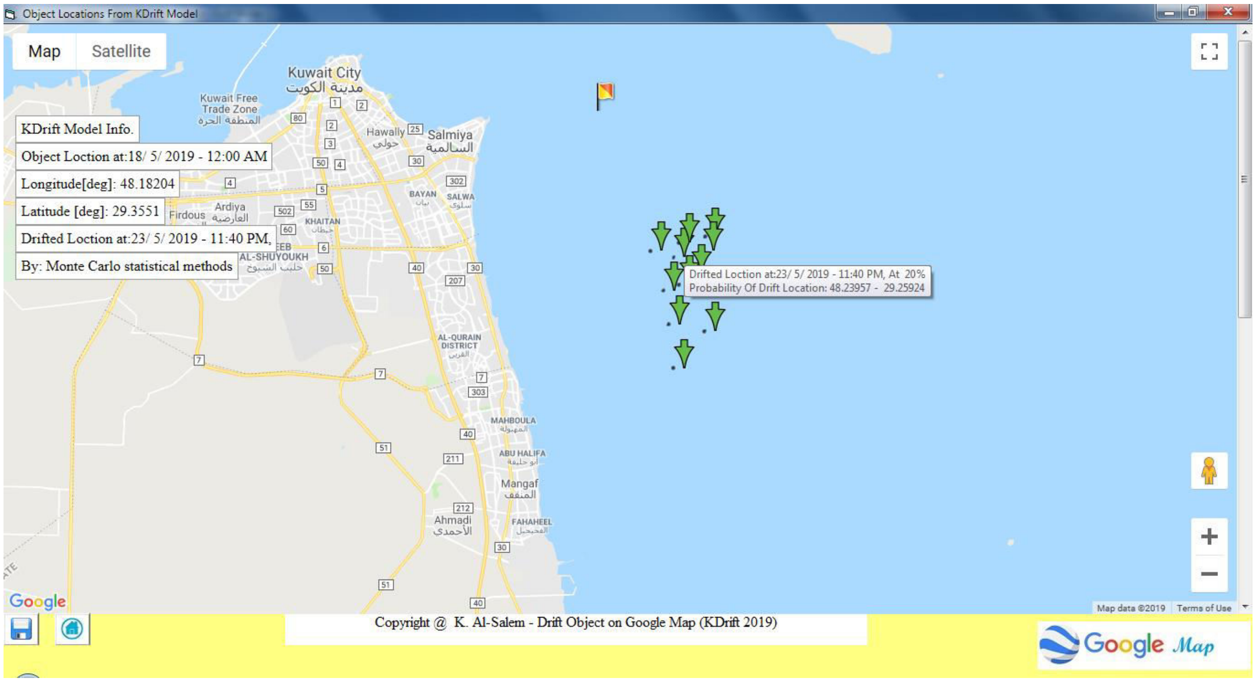
Longitude (deg) 48.86698 Latitude (deg) 28.93787

Figure 12. Drift Object Simulation by Monte Carlo statistical methods

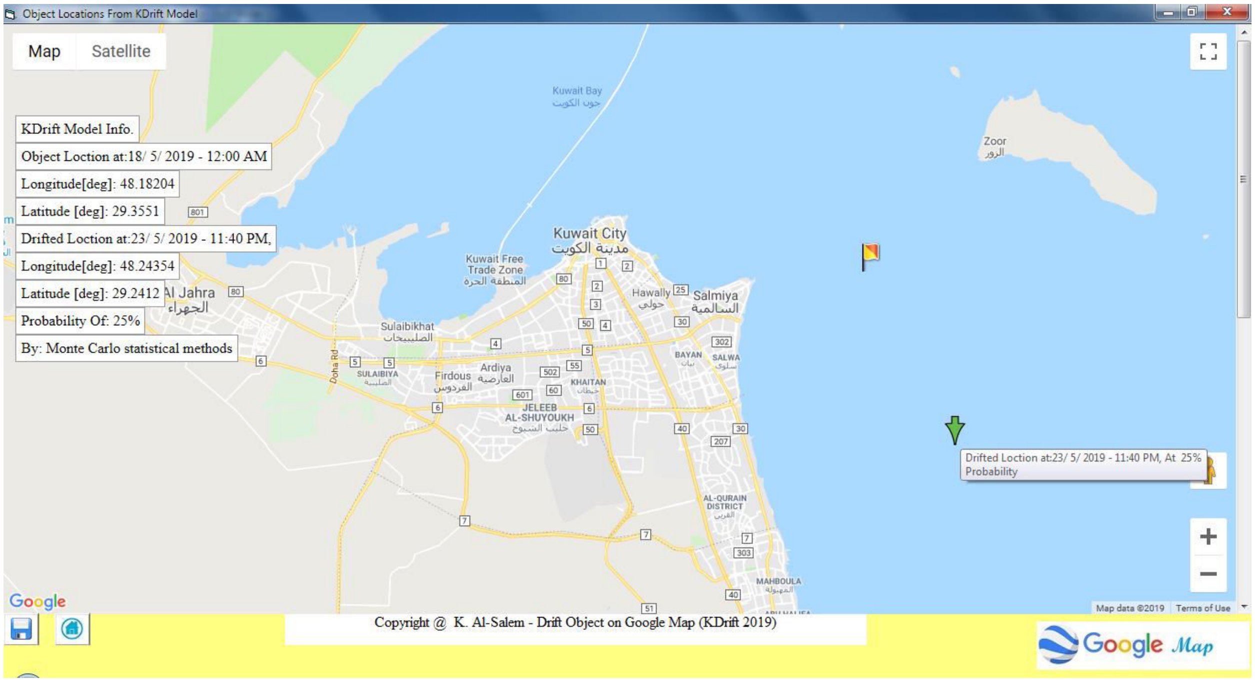


KDrift Model Info.
Object Loction at:18/ 5/ 2019 - 12:00 AM
Longitude[deg]: 48.18204
Latitude [deg]: 29.3551
Drifted Loction at:23/ 5/ 2019 - 11:40 PM,
By: Monte Carlo statistical methods

Drifted Loction at:23/ 5/ 2019 - 11:40 PM, At 20%
Probability Of Drift Location: 48.23957 - 29.25924

Copyright @ K. Al-Salem - Drift Object on Google Map (KDrift 2019)

Figure 13. Drift Object Simulation by Monte Carlo statistical methods display on Google map



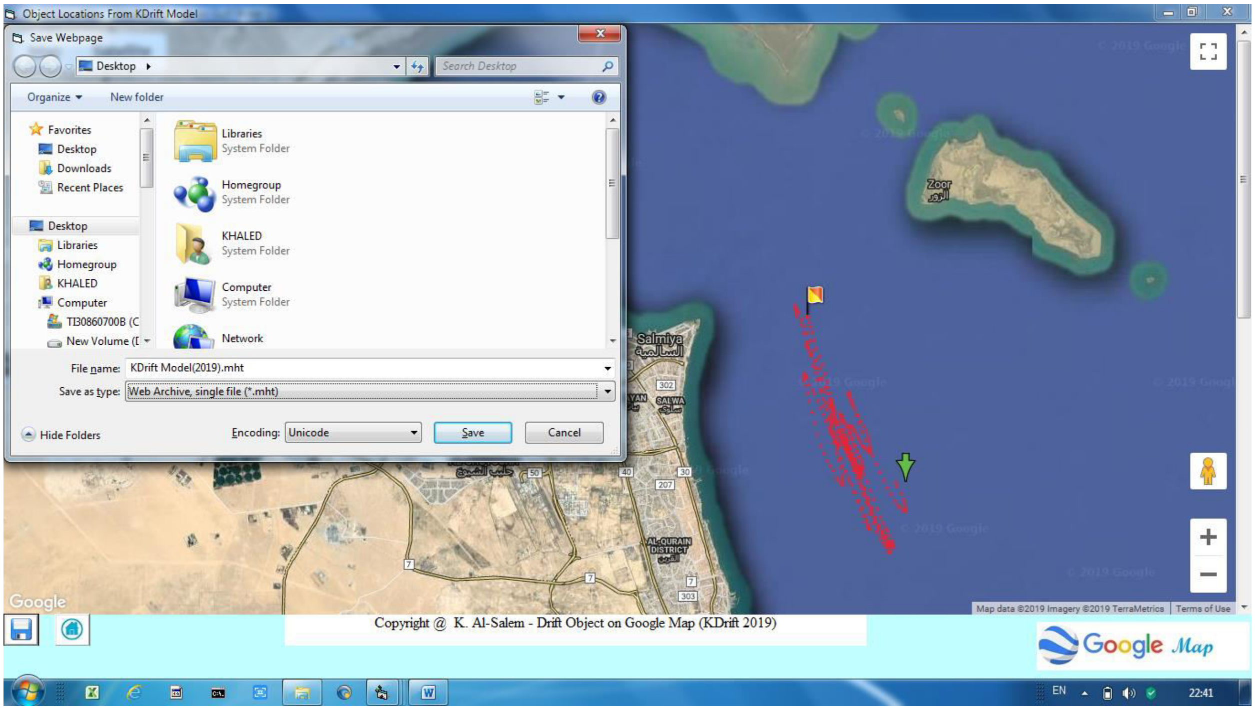
KDrift Model Info.
Object Loction at:18/ 5/ 2019 - 12:00 AM
Longitude[deg]: 48.18204
Latitude [deg]: 29.3551
Drifted Loction at:23/ 5/ 2019 - 11:40 PM,
Longitude[deg]: 48.24354
Latitude [deg]: 29.2412
Probability Of: 25%
By: Monte Carlo statistical methods

Drifted Loction at:23/ 5/ 2019 - 11:40 PM, At 25%
Probability

Copyright @ K. Al-Salem - Drift Object on Google Map (KDrift 2019)

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.



File name: KDrift Model(2019).mht
Save as type: Web Archive, single file (*.mht)
Encoding: Unicode

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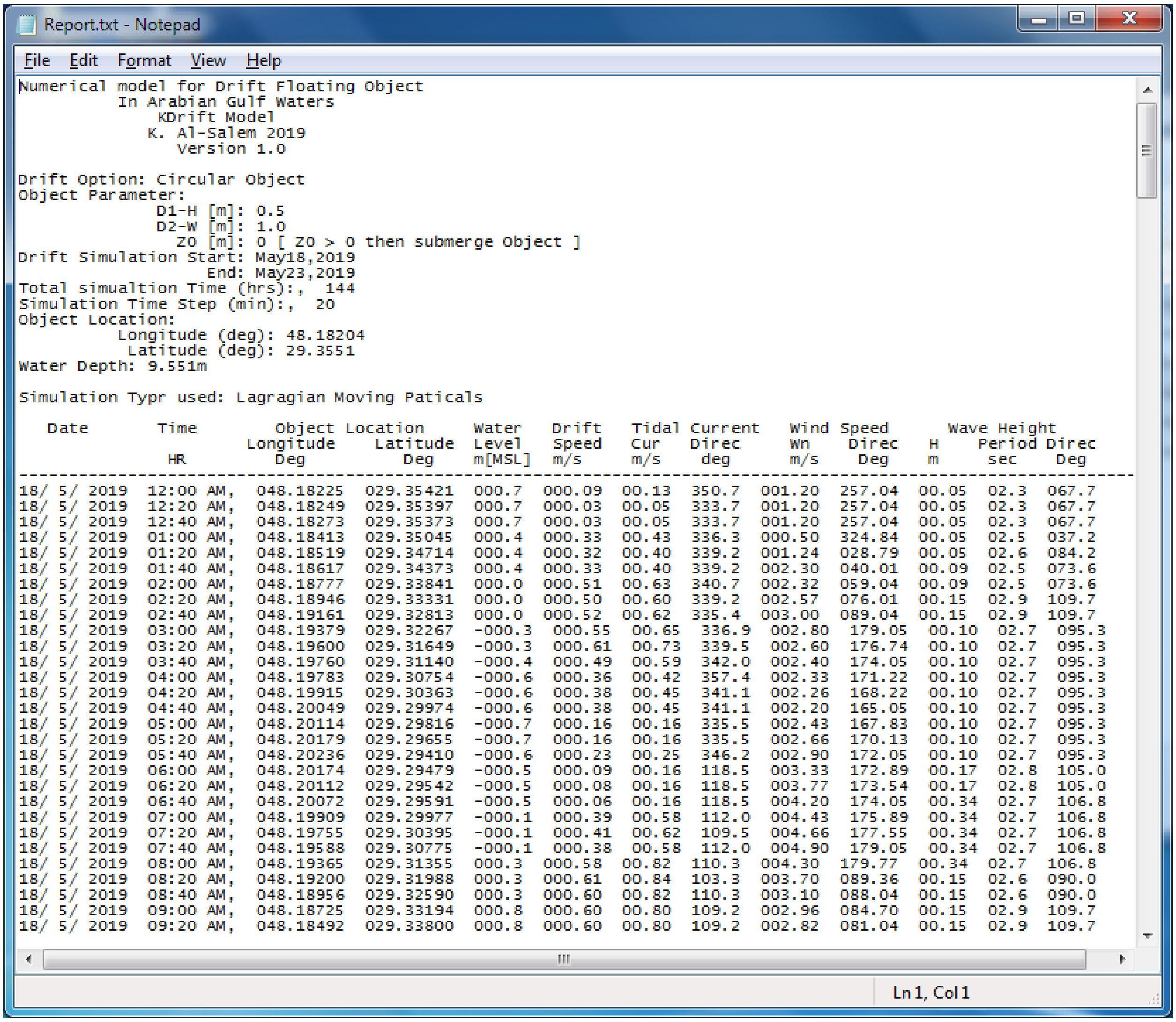
Figure 14. To Save HTML file for the select Simulation from Google Map Option.

```
<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..



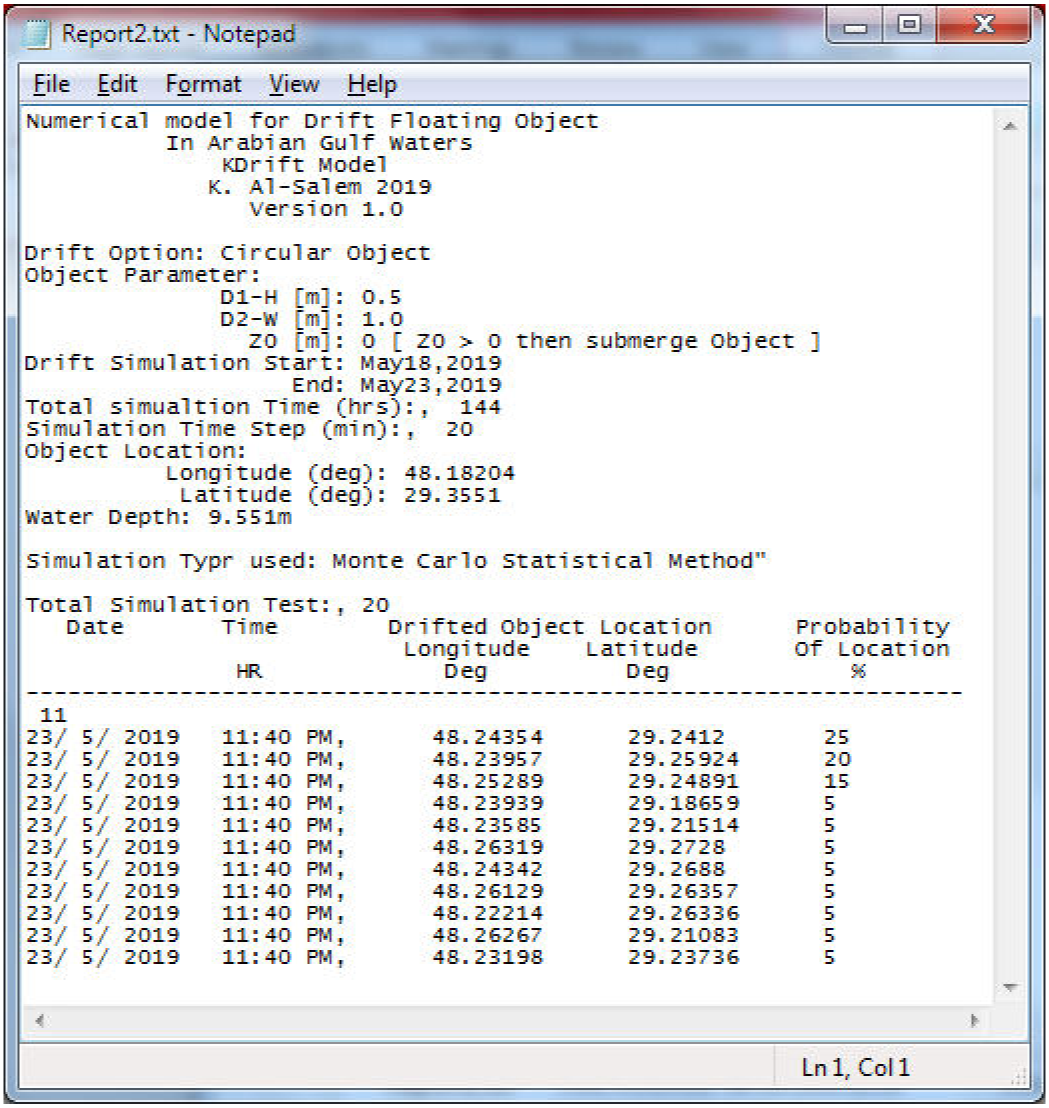
```
Numerical model for Drift Floating Object
          In Arabian Gulf Waters
              KDrift Model
             K. Al-Salem 2019
                Version 1.0

Drift Option: Circular Object
Object Parameter:
              D1-H [m]: 0.5
              D2-W [m]: 1.0
                Z0 [m]: 0 [ Z0 > 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
```

Figure 16. Display Drift Object Result file by Lagrangian Moving Particles theory or Leeway Drift Method



```
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
```

Figure 17. Display Prbability of Drift Object Result file by Monte Carlo statistical methods

Appendix

Case for Predicted Location of Drifted Drown Person in Kuwait water
By KDrift Model
Khaled Al-Salem [2019]

Accident Location:

Oil Al-AReiq Al-Durrah Kuwait #8

Forwarded

تاريخ الفقدان يوم الجمعة 18-5-2018
تاريخ الحصول على الجثمان 25-5-2018
مكان الفقدان ارياق الدرر ريق دي 8
مكان رؤية الجثمان جنوب غرب الريق ب
200 متر تقريباً

2:06 PM

Forwarded

28° 57.240' N
49° 5.445' E

2:06 PM

Approx. date

Events as shown in Fig 1

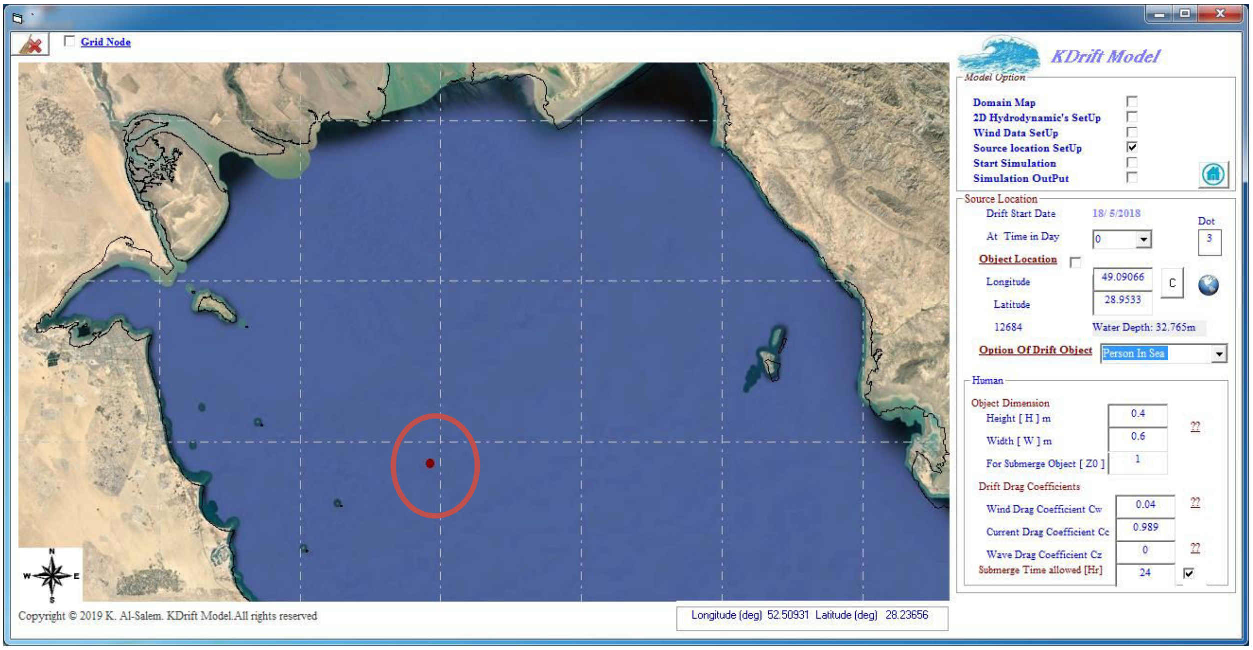
May 18 2018 Friday
Time 4: pm
Longitude= 49° 5.445' E
Latitude = 28° 57.24' N
Water depth : 35.902m

Found date

May 25 2018 Friday
Longitude: ????
Latitude : ????

Wind Data Record file:

May 18, 2018 To May 31, 2018
Name: HrWind18-20-2018.txt
Used file: w2018.txt Hourly Data



Domain Map ☐
2D Hydrodynamic's SetUp ☐
Wind Data SetUp ☐
Source location SetUp ☑
Start Simulation ☐
Simulation OutPut ☐

Source Location
Drift Start Date 18/ 5/2018
At Time in Day 0
Dot 3
Object Location ☐
Longitude 49.09066
Latitude 28.9533
12684
Water Depth: 32.765m
Option Of Drift Object Person In Sea

Human
Object Dimension
Height [H] m 0.4
Width [W] m 0.6
For Submerge Object [Z0] 1
Drift Drag Coefficients
Wind Drag Coefficient Cw 0.04
Current Drag Coefficient Cc 0.989
Wave Drag Coefficient Cz 0
Submerge Time allowed [Hr] 24 ☑

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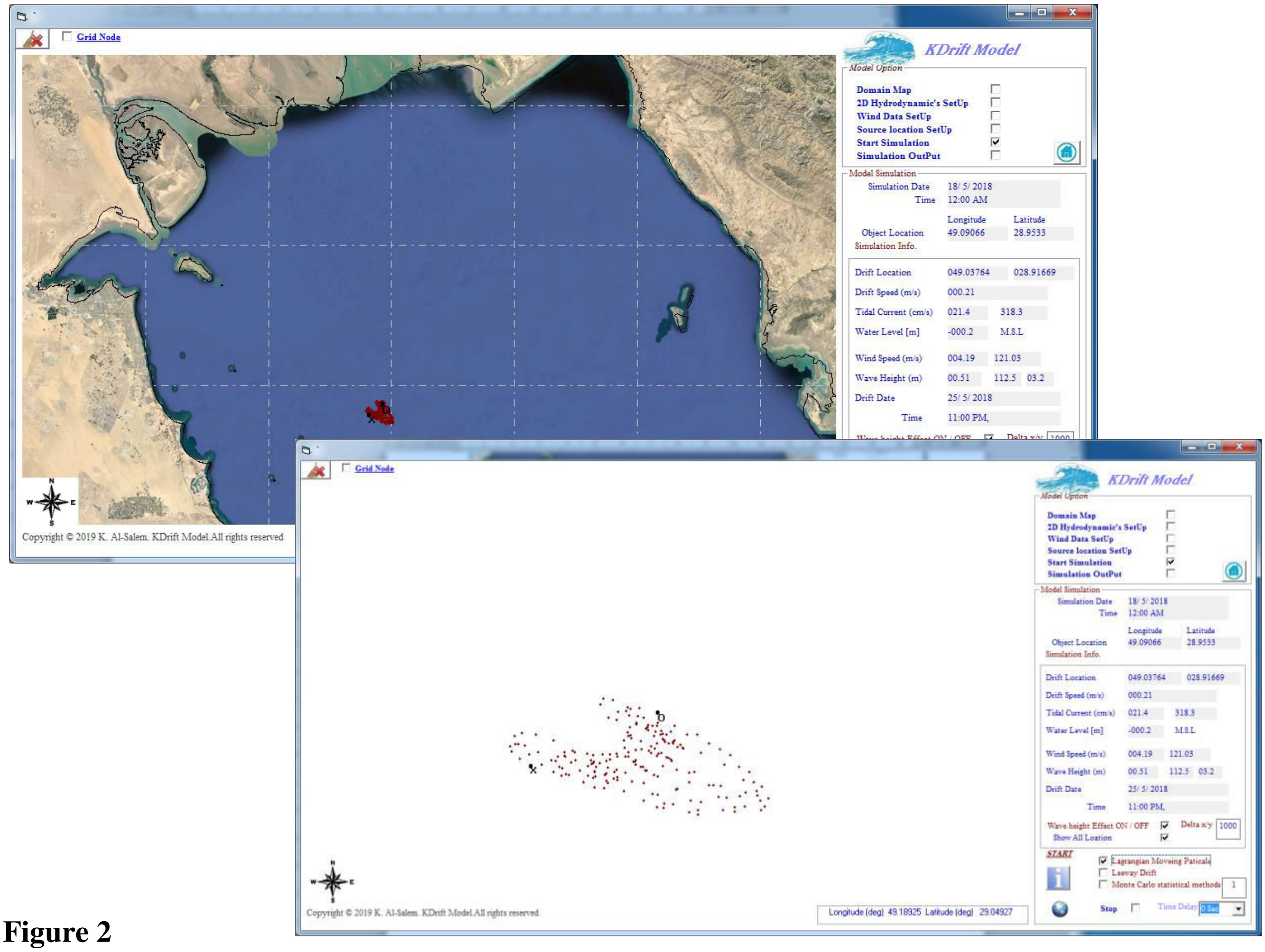
Longitude (deg) 52.50931 Latitude (deg) 28.23656

Figure 1. Accident Location in Kuwait Water

Figure 2 shows Object drift prediction From May 18 2018 to May 25 2018
Figure 3 Show Object drift prediction on Google Map.
List of Simulation output File List at the end .



Model Simulation

Simulation Date: 18/ 5/ 2018
Time: 12:00 AM

	Longitude	Latitude
Object Location	49.09066	28.9533

Simulation Info.

Drift Location: 049.03764 028.91669
Drift Speed (m/s): 000.21
Tidal Current (cm/s): 021.4 318.3
Water Level [m]: -000.2 M.S.L
Wind Speed (m/s): 004.19 121.03
Wave Height (m): 00.51 112.5 03.2
Drift Date: 25/ 5/ 2018
Time: 11:00 PM,

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Model Simulation
Simulation Date: 18/ 5/ 2018
Time: 12:00 AM
Object Location: Longitude 49.09066 Latitude 28.9533
Simulation Info.
Drift Location: 049.03764 028.91669
Drift Speed (m/s): 000.21
Tidal Current (cm/s): 021.4 318.3
Water Level [m]: -000.2 M.S.L
Wind Speed (m/s): 004.19 121.03
Wave Height (m): 00.51 112.5 03.2
Drift Date: 25/ 5/ 2018
Time: 11:00 PM,

Wave height Effect ON / OFF ☑ Delta x/y: 1000
Show All Loation ☑

Longitude [deg] 49.18925 Latitude [deg] 29.04927

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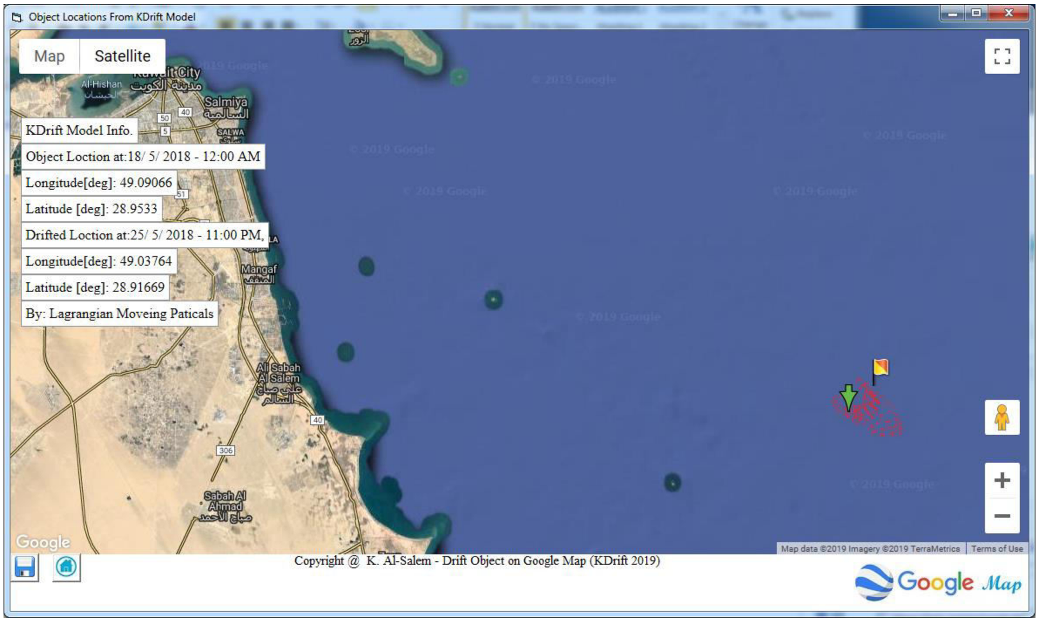
Figure 2



KDrift Model Info.
Object Loction at:18/ 5/ 2018 - 12:00 AM
Longitude[deg]: 49.09066
Latitude [deg]: 28.9533
Drifted Loction at:25/ 5/ 2018 - 11:00 PM,
Longitude[deg]: 49.03764
Latitude [deg]: 28.91669
By: Lagrangian Moveing Paticals

Copyright @ K. Al-Salem - Drift Object on Google Map (KDrift 2019)

Figure 3

```
Numerical model for Drift Floating Object
        In Arabian Gulf Waters
            KDrift Model
           K. Al-Salem 2019
              Version 1.0

Drift Option: Person In Sea
Object Parameter:
            D1-H [m]: 0.5
            D2-W [m]: 1.0
              Z0 [m]: 0 [ Z0 > 0 then submerge Object ]
Drift Simulation Start: May18,2018
                 End: May25,2018
Total simulation Time (hrs.):,  192
Simulation Time Step (min):,  60
Object Location:
        Longitude (deg): 49.09066
         Latitude (deg): 28.9533
Water Depth: 32.765m

Simulation Typr used: Lagragian Moving Particles

  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/ 2018  12:00 AM,  049.08309  028.95599  000.2  000.25  00.25  160.5  003.41  213.02  00.30  03.3  067.4
18/ 5/ 2018  01:00 AM,  049.07920  028.95539  000.2  000.12  00.12  188.8  003.15  207.01  00.30  03.3  067.4
18/ 5/ 2018  02:00 AM,  049.07883  028.95118  000.3  000.13  00.13  264.9  003.11  207.01  00.30  03.3  067.4
18/ 5/ 2018  03:00 AM,  049.08166  028.94591  000.2  000.18  00.19  331.7  003.06  207.01  00.30  03.3  067.4
18/ 5/ 2018  04:00 AM,  049.08584  028.94217  000.2  000.17  00.17  311.8  004.02  222.02  00.44  03.1  049.1
18/ 5/ 2018  05:00 AM,  049.08987  028.94035  000.1  000.14  00.14  294.2  003.98  223.02  00.27  03.1  065.9
18/ 5/ 2018  06:00 AM,  049.09219  028.94082  000.1  000.07  00.07  011.5  003.94  223.02  00.27  03.1  065.9
18/ 5/ 2018  07:00 AM,  049.09040  028.94392  000.2  000.11  00.11  120.1  005.55  236.03  00.60  03.2  056.3
18/ 5/ 2018  08:00 AM,  049.08471  028.94958  000.4  000.25  00.25  135.2  005.53  236.03  00.60  03.2  056.3
18/ 5/ 2018  09:00 AM,  049.07800  028.95654  000.6  000.30  00.30  134.0  005.51  236.03  00.60  03.2  056.3
18/ 5/ 2018  10:00 AM,  049.07199  028.96169  000.8  000.24  00.25  139.5  005.20  231.02  00.58  03.2  056.7
18/ 5/ 2018  11:00 AM,  049.06782  028.96250  000.8  000.13  00.13  169.1  005.18  232.02  00.58  03.2  056.7
18/ 5/ 2018  12:00 PM,  049.06686  028.95838  000.8  000.13  00.13  256.8  005.16  232.02  00.58  03.2  056.7
18/ 5/ 2018  01:00 PM,  049.07023  028.94964  000.6  000.29  00.29  338.9  004.77  226.02  00.41  03.1  054.3
18/ 5/ 2018  02:00 PM,  049.07839  028.93734  000.3  000.46  00.46  326.4  004.71  227.02  00.44  03.1  049.1
18/ 5/ 2018  03:00 PM,  049.09046  028.92370  000.0  000.56  00.56  318.5  004.65  228.02  00.44  03.1  049.1
18/ 5/ 2018  04:00 PM,  049.10395  028.91222  -000.4  000.55  00.55  310.4  004.76  221.02  00.44  03.1  049.1
18/ 5/ 2018  05:00 PM,  049.11708  028.90342  -000.7  000.49  00.49  303.8  004.69  222.02  00.44  03.1  049.1
18/ 5/ 2018  06:00 PM,  049.12758  028.89887  -000.9  000.35  00.35  293.4  004.62  223.02  00.44  03.1  049.1
18/ 5/ 2018  07:00 PM,  049.13223  028.89973  -000.9  000.15  00.15  010.5  005.55  211.01  00.60  03.2  056.3
18/ 5/ 2018  08:00 PM,  049.13089  028.90572  -000.9  000.19  00.19  102.6  006.22  208.01  01.20  05.9  107.0
18/ 5/ 2018  09:00 PM,  049.12491  028.91630  -000.7  000.37  00.38  119.5  006.92  205.01  01.20  05.9  107.0
18/ 5/ 2018  10:00 PM,  049.11683  028.92838  -000.5  000.45  00.45  123.8  003.41  225.02  00.27  03.1  065.9
18/ 5/ 2018  11:00 PM,  049.10722  028.93812  -000.2  000.42  00.42  134.7  004.00  217.02  00.27  03.1  065.9
19/ 5/ 2018  12:00 AM,  049.09786  028.94407  000.0  000.34  00.34  147.6  004.64  211.01  00.44  03.1  049.1
19/ 5/ 2018  01:00 AM,  049.09069  028.94633  000.2  000.23  00.23  162.6  001.82  303.97  00.16  02.8  019.8
19/ 5/ 2018  02:00 AM,  049.08675  028.94481  000.2  000.13  00.13  201.0  002.03  311.97  00.19  02.8  013.3
19/ 5/ 2018  03:00 AM,  049.08660  028.94106  000.3  000.12  00.12  267.7  002.27  317.97  00.19  02.8  013.3
19/ 5/ 2018  04:00 AM,  049.08922  028.93694  000.2  000.15  00.15  327.4  002.29  270.04  00.20  03.0  035.1
19/ 5/ 2018  05:00 AM,  049.09343  028.93407  000.1  000.16  00.16  304.3  002.32  277.96  00.20  03.0  035.1
19/ 5/ 2018  06:00 AM,  049.09706  028.93319  000.1  000.12  00.12  283.5  002.39  285.96  00.20  03.0  035.1
19/ 5/ 2018  07:00 AM,  049.09774  028.93433  000.2  000.04  00.04  059.1  003.65  238.03  00.27  03.1  065.9
19/ 5/ 2018  08:00 AM,  049.09446  028.93825  000.3  000.16  00.16  129.9  003.95  232.02  00.27  03.1  065.9
19/ 5/ 2018  09:00 AM,  049.08858  028.94421  000.5  000.26  00.26  134.7  004.31  226.02  00.44  03.1  049.1
19/ 5/ 2018  10:00 AM,  049.08238  028.95053  000.6  000.27  00.27  134.5  003.80  265.04  00.27  03.0  029.4
19/ 5/ 2018  11:00 AM,  049.07755  028.95429  000.7  000.19  00.19  142.1  003.88  258.04  00.24  02.9  033.1
19/ 5/ 2018  12:00 PM,  049.07401  028.95359  000.8  000.11  00.11  191.1  004.03  250.03  00.44  03.1  356.5
19/ 5/ 2018  01:00 PM,  049.07352  028.94839  000.7  000.16  00.16  264.7  005.42  291.96  00.61  03.2  350.4
19/ 5/ 2018  02:00 PM,  049.07802  028.93959  000.5  000.31  00.31  332.9  005.50  293.96  00.59  03.2  338.6
19/ 5/ 2018  03:00 PM,  049.08695  028.92706  000.2  000.48  00.48  324.5  005.59  295.96  00.59  03.2  338.6
19/ 5/ 2018  04:00 PM,  049.09873  028.91404  -000.2  000.54  00.54  317.8  004.32  288.96  00.47  03.1  359.3
19/ 5/ 2018  05:00 PM,  049.11227  028.90382  -000.5  000.52  00.52  307.0  004.39  291.96  00.47  03.1  359.3
19/ 5/ 2018  06:00 PM,  049.12497  028.89623  -000.8  000.46  00.46  300.8  004.47  293.96  00.46  03.1  347.7
19/ 5/ 2018  07:00 PM,  049.13382  028.89334  -001.0  000.29  00.29  288.0  003.10  275.95  00.27  03.0  029.4
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19/ 5/ 2018  08:00 PM,  049.13697  028.89502  -001.0  000.11  00.11  028.1  003.08  270.95  00.27  03.0  029.4
19/ 5/ 2018  09:00 PM,  049.13437  028.90265  -000.9  000.25  00.25  108.8  003.09  266.04  00.27  03.0  029.4
19/ 5/ 2018  10:00 PM,  049.12906  028.91299  -000.7  000.36  00.36  117.2  002.49  297.97  00.19  02.8  013.3
19/ 5/ 2018  11:00 PM,  049.12095  028.92441  -000.4  000.43  00.43  125.4  002.37  291.96  00.20  03.0  035.1
20/ 5/ 2018  12:00 AM,  049.11208  028.93205  -000.3  000.36  00.36  139.3  002.29  285.96  00.20  03.0  035.1
20/ 5/ 2018  01:00 AM,  049.10297  028.93809  000.0  000.34  00.34  146.5  002.67  341.99  00.20  02.9  029.9
20/ 5/ 2018  02:00 AM,  049.09620  028.94007  000.1  000.22  00.22  163.7  002.94  342.99  00.20  02.9  029.9
20/ 5/ 2018  03:00 AM,  049.09291  028.93872  000.3  000.11  00.11  202.3  003.22  344.99  00.32  03.0  023.5
20/ 5/ 2018  04:00 AM,  049.09292  028.93525  000.3  000.11  00.11  359.9  002.20  318.98  00.19  02.8  013.3
20/ 5/ 2018  05:00 AM,  049.09526  028.93207  000.2  000.12  00.12  323.6  002.42  323.98  00.19  02.8  013.3
20/ 5/ 2018  06:00 AM,  049.09889  028.92982  000.2  000.13  00.13  301.7  002.66  326.98  00.19  02.8  013.3
20/ 5/ 2018  07:00 AM,  049.10158  028.92882  000.2  000.09  00.09  290.2  002.16  285.96  00.20  03.0  035.1
20/ 5/ 2018  08:00 AM,  049.10101  028.92899  000.2  000.02  00.02  163.3  002.19  288.96  00.20  03.0  035.1
20/ 5/ 2018  09:00 AM,  049.09721  028.93205  000.3  000.15  00.15  141.2  002.23  291.96  00.20  03.0  035.1
20/ 5/ 2018  10:00 AM,  049.09193  028.93797  000.5  000.25  00.25  131.8  002.61  275.95  00.20  03.0  035.1
20/ 5/ 2018  11:00 AM,  049.08646  028.94305  000.6  000.23  00.23  137.2  002.62  278.96  00.20  03.0  035.1
20/ 5/ 2018  12:00 PM,  049.08172  028.94529  000.7  000.16  00.16  154.7  002.64  280.96  00.20  03.0  035.1
20/ 5/ 2018  01:00 PM,  049.07901  028.94318  000.6  000.11  00.11  217.8  003.52  269.04  00.27  03.0  029.4
20/ 5/ 2018  02:00 PM,  049.07931  028.93757  000.6  000.17  00.17  357.0  003.52  270.95  00.27  03.0  029.4
20/ 5/ 2018  03:00 PM,  049.08394  028.92821  000.4  000.32  00.32  333.6  003.53  273.95  00.27  03.0  029.4
20/ 5/ 2018  04:00 PM,  049.09272  028.91669  000.1  000.45  00.45  322.6  002.81  260.04  00.20  03.0  035.1
20/ 5/ 2018  05:00 PM,  049.10402  028.90558  -000.3  000.49  00.49  314.5  002.79  263.04  00.20  03.0  035.1
20/ 5/ 2018  06:00 PM,  049.11602  028.89580  -000.6  000.48  00.48  309.1  002.77  266.04  00.20  03.0  035.1
20/ 5/ 2018  07:00 PM,  049.12711  028.88912  -000.8  000.40  00.40  301.0  002.44  231.02  00.21  03.0  064.7
20/ 5/ 2018  08:00 PM,  049.13402  028.88682  -000.9  000.23  00.23  288.4  002.81  222.02  00.21  03.0  064.7
20/ 5/ 2018  09:00 PM,  049.13564  028.88946  -001.0  000.10  00.10  058.5  003.23  216.02  00.27  03.1  065.9
20/ 5/ 2018  10:00 PM,  049.13257  028.89702  -000.8  000.25  00.25  112.1  001.45  272.95  00.13  02.7  036.0
20/ 5/ 2018  11:00 PM,  049.12654  028.90719  -000.6  000.36  00.37  120.7  001.52  252.03  00.13  02.7  036.0
21/ 5/ 2018  12:00 AM,  049.11851  028.91761  -000.4  000.41  00.41  127.7  001.76  235.03  00.19  03.0  055.5
21/ 5/ 2018  01:00 AM,  049.10881  028.92590  -000.2  000.39  00.39  139.5  002.65  345.99  00.20  02.9  029.9
21/ 5/ 2018  02:00 AM,  049.10015  028.93126  000.0  000.31  00.31  148.3  002.98  346.99  00.20  02.9  029.9
21/ 5/ 2018  03:00 AM,  049.09372  028.93309  000.2  000.21  00.21  164.2  003.30  348.99  00.32  03.0  023.5
21/ 5/ 2018  04:00 AM,  049.09028  028.93211  000.3  000.11  00.11  195.8  002.04  320.98  00.19  02.8  013.3
21/ 5/ 2018  05:00 AM,  049.08957  028.92887  000.3  000.10  00.10  257.7  002.31  325.98  00.19  02.8  013.3
21/ 5/ 2018  06:00 AM,  049.09105  028.92539  000.2  000.12  00.12  337.0  002.60  329.98  00.19  02.8  013.3
21/ 5/ 2018  07:00 AM,  049.09424  028.92290  000.2  000.13  00.13  307.9  002.19  273.95  00.20  03.0  035.1
21/ 5/ 2018  08:00 AM,  049.09623  028.92138  000.2  000.08  00.08  307.4  002.18  271.95  00.20  03.0  035.1
21/ 5/ 2018  09:00 AM,  049.09537  028.92205  000.2  000.03  00.03  141.8  002.18  270.95  00.20  03.0  035.1
21/ 5/ 2018  10:00 AM,  049.09211  028.92553  000.3  000.15  00.15  133.2  002.15  279.96  00.20  03.0  035.1
21/ 5/ 2018  11:00 AM,  049.08788  028.93043  000.4  000.20  00.20  130.8  002.14  277.96  00.20  03.0  035.1
21/ 5/ 2018  12:00 PM,  049.08353  028.93388  000.5  000.17  00.17  141.6  002.13  275.95  00.20  03.0  035.1
21/ 5/ 2018  01:00 PM,  049.07960  028.93558  000.5  000.13  00.13  156.6  002.42  303.97  00.19  02.8  013.3
21/ 5/ 2018  02:00 PM,  049.07670  028.93410  000.5  000.10  00.10  207.0  002.88  315.97  00.19  02.8  013.3
21/ 5/ 2018  03:00 PM,  049.07691  028.92915  000.4  000.15  00.15  357.6  003.44  323.98  00.29  02.9  013.8
21/ 5/ 2018  04:00 PM,  049.08133  028.92099  000.2  000.29  00.29  331.5  002.26  248.03  00.20  03.0  035.1
21/ 5/ 2018  05:00 PM,  049.08908  028.91085  000.0  000.39  00.39  322.6  002.11  267.04  00.20  03.0  035.1
21/ 5/ 2018  06:00 PM,  049.09842  028.90094  -000.3  000.42  00.42  316.6  002.19  285.96  00.20  03.0  035.1
21/ 5/ 2018  07:00 PM,  049.10879  028.89256  -000.6  000.41  00.41  308.9  005.17  214.02  00.60  03.2  056.3
21/ 5/ 2018  08:00 PM,  049.11792  028.88704  -000.8  000.33  00.33  301.1  005.63  211.01  00.60  03.2  056.3
21/ 5/ 2018  09:00 PM,  049.12282  028.88577  -000.9  000.16  00.16  284.5  006.11  208.01  01.20  05.9  107.0
21/ 5/ 2018  10:00 PM,  049.12290  028.88871  -000.8  000.09  00.09  088.3  002.78  199.01  00.17  02.8  072.0
21/ 5/ 2018  11:00 PM,  049.11957  028.89542  -000.7  000.23  00.23  116.4  003.30  196.01  00.27  02.9  084.1
22/ 5/ 2018  12:00 AM,  049.11390  028.90385  -000.6  000.31  00.31  124.0  003.83  194.01  00.27  02.9  084.1
22/ 5/ 2018  01:00 AM,  049.10596  028.91284  -000.4  000.37  00.37  131.5  002.24  169.05  00.17  02.8  072.0
22/ 5/ 2018  02:00 AM,  049.09656  028.92040  -000.2  000.37  00.37  141.3  002.24  169.05  00.17  02.8  072.0
22/ 5/ 2018  03:00 AM,  049.08779  028.92584  000.1  000.32  00.32  148.2  002.24  168.05  00.17  02.8  072.0
22/ 5/ 2018  04:00 AM,  049.08148  028.92750  000.2  000.20  00.20  165.3  000.98  156.04  00.21  03.1  071.2
22/ 5/ 2018  05:00 AM,  049.07852  028.92635  000.3  000.10  00.10  201.2  000.98  156.04  00.21  03.1  071.2
22/ 5/ 2018  06:00 AM,  049.07850  028.92338  000.3  000.09  00.09  269.7  000.98  155.04  00.21  03.1  071.2
22/ 5/ 2018  07:00 AM,  049.08106  028.91985  000.2  000.13  00.14  324.0  000.39  250.03  00.14  02.8  026.7
22/ 5/ 2018  08:00 AM,  049.08466  028.91634  000.2  000.16  00.16  314.2  000.38  282.96  00.14  02.8  026.7
22/ 5/ 2018  09:00 AM,  049.08609  028.91392  000.2  000.09  00.09  329.3  000.47  308.97  00.12  02.7  059.0
22/ 5/ 2018  10:00 AM,  049.08551  028.91383  000.2  000.02  00.02  189.4  001.95  246.03  00.19  03.0  055.5
22/ 5/ 2018  11:00 AM,  049.08365  028.91604  000.3  000.09  00.09  130.2  001.88  252.03  00.13  02.7  036.0
22/ 5/ 2018  12:00 PM,  049.08055  028.91969  000.3  000.15  00.15  130.4  001.82  259.04  00.13  02.7  036.0
22/ 5/ 2018  01:00 PM,  049.07725  028.92329  000.3  000.15  00.15  132.5  004.38  256.04  00.47  03.1  359.3
22/ 5/ 2018  02:00 PM,  049.07365  028.92527  000.4  000.13  00.13  151.2  004.27  264.04  00.47  03.1  359.3
22/ 5/ 2018  03:00 PM,  049.07083  028.92466  000.4  000.09  00.09  192.1  004.25  272.95  00.47  03.1  359.3
22/ 5/ 2018  04:00 PM,  049.07066  028.92101  000.3  000.11  00.11  267.4  003.82  221.02  00.27  03.1  065.9
22/ 5/ 2018  05:00 PM,  049.07338  028.91443  000.1  000.22  00.22  337.5  003.38  228.02  00.27  03.1  065.9
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22/ 5/ 2018  06:00 PM,  049.07981  028.90607  -000.1  000.33  00.33  322.4  003.00  237.03  00.27  03.1  065.9
22/ 5/ 2018  07:00 PM,  049.08861  028.89780  -000.3  000.37  00.37  313.2  006.34  185.00  00.73  03.4  105.2
22/ 5/ 2018  08:00 PM,  049.09700  028.89063  -000.6  000.34  00.34  310.5  007.32  184.00  00.94  03.7  099.8
22/ 5/ 2018  09:00 PM,  049.10399  028.88546  -000.7  000.27  00.27  306.4  008.30  184.00  01.12  03.9  096.9
22/ 5/ 2018  10:00 PM,  049.10756  028.88395  -000.8  000.12  00.12  292.9  003.40  098.01  00.24  02.9  069.2
22/ 5/ 2018  11:00 PM,  049.10758  028.88697  -000.8  000.09  00.09  089.7  004.38  097.01  00.42  03.0  101.9
23/ 5/ 2018  12:00 AM,  049.10466  028.89348  -000.7  000.22  00.22  114.2  005.36  095.01  00.72  03.6  114.7
23/ 5/ 2018  01:00 AM,  049.09892  028.90156  -000.5  000.31  00.31  125.4  002.31  077.03  00.18  02.8  064.9
23/ 5/ 2018  02:00 AM,  049.09070  028.90988  -000.3  000.36  00.36  134.7  002.30  078.03  00.18  02.8  064.9
23/ 5/ 2018  03:00 AM,  049.08154  028.91759  -000.1  000.37  00.37  140.0  002.29  079.03  00.18  02.8  064.9
23/ 5/ 2018  04:00 AM,  049.07392  028.92303  000.1  000.29  00.29  144.5  001.28  058.02  00.14  02.7  074.2
23/ 5/ 2018  05:00 AM,  049.06755  028.92498  000.3  000.21  00.21  163.0  001.25  060.02  00.14  02.7  074.2
23/ 5/ 2018  06:00 AM,  049.06366  028.92404  000.3  000.12  00.12  193.5  001.23  062.02  00.14  02.7  074.2
23/ 5/ 2018  07:00 AM,  049.06286  028.92073  000.3  000.10  00.11  256.4  001.60  349.99  00.17  02.8  032.1
23/ 5/ 2018  08:00 AM,  049.06484  028.91622  000.3  000.15  00.15  336.4  002.27  352.99  00.20  02.9  029.9
23/ 5/ 2018  09:00 AM,  049.06907  028.91155  000.2  000.19  00.20  317.7  002.94  354.99  00.20  02.9  029.9
23/ 5/ 2018  10:00 AM,  049.07222  028.90810  000.1  000.14  00.14  317.5  001.02  243.03  00.19  03.0  055.5
23/ 5/ 2018  11:00 AM,  049.07366  028.90740  000.1  000.05  00.05  295.9  000.94  282.96  00.14  02.8  026.7
23/ 5/ 2018  12:00 PM,  049.07381  028.90937  000.1  000.06  00.06  085.8  001.27  313.97  00.16  02.8  019.8
23/ 5/ 2018  01:00 PM,  049.07265  028.91259  000.1  000.11  00.11  109.7  003.62  217.02  00.27  03.1  065.9
23/ 5/ 2018  02:00 PM,  049.06991  028.91592  000.2  000.13  00.13  129.5  003.42  219.02  00.27  03.1  065.9
23/ 5/ 2018  03:00 PM,  049.06640  028.91865  000.2  000.14  00.14  142.2  003.23  222.02  00.27  03.1  065.9
23/ 5/ 2018  04:00 PM,  049.06387  028.91960  000.2  000.08  00.08  159.3  003.76  194.01  00.27  02.9  084.1
23/ 5/ 2018  05:00 PM,  049.06300  028.91802  000.1  000.06  00.06  241.2  003.52  195.01  00.27  02.9  084.1
23/ 5/ 2018  06:00 PM,  049.06432  028.91326  000.1  000.15  00.15  344.6  003.27  196.01  00.27  02.9  084.1
23/ 5/ 2018  07:00 PM,  049.06914  028.90680  -000.1  000.25  00.25  323.2  005.63  095.01  00.72  03.6  114.7
23/ 5/ 2018  08:00 PM,  049.07646  028.89998  -000.3  000.31  00.31  312.9  006.59  094.01  01.05  04.4  132.1
23/ 5/ 2018  09:00 PM,  049.08474  028.89359  -000.5  000.32  00.32  307.6  007.54  093.01  01.28  04.8  140.0
23/ 5/ 2018  10:00 PM,  049.09038  028.88907  -000.5  000.22  00.22  308.6  003.06  116.02  00.30  02.9  086.7
23/ 5/ 2018  11:00 PM,  049.09320  028.88836  -000.7  000.09  00.09  284.1  003.94  110.02  00.24  02.9  069.2
24/ 5/ 2018  12:00 AM,  049.09333  028.89148  -000.7  000.10  00.10  087.6  004.85  106.02  00.42  03.0  101.9
24/ 5/ 2018  01:00 AM,  049.09073  028.89740  -000.6  000.20  00.20  113.8  003.05  073.03  00.24  02.9  069.2
24/ 5/ 2018  02:00 AM,  049.08499  028.90528  -000.4  000.30  00.30  126.1  003.01  076.03  00.24  02.9  069.2
24/ 5/ 2018  03:00 AM,  049.07726  028.91244  -000.3  000.33  00.33  137.3  002.97  080.03  00.18  02.8  064.9
24/ 5/ 2018  04:00 AM,  049.06922  028.92029  000.0  000.35  00.35  135.7  002.43  054.02  00.18  02.7  056.7
24/ 5/ 2018  05:00 AM,  049.06115  028.92525  000.2  000.29  00.29  148.4  002.33  057.02  00.18  02.7  056.7
24/ 5/ 2018  06:00 AM,  049.05505  028.92721  000.3  000.20  00.20  162.2  002.24  061.02  00.18  02.7  056.7
24/ 5/ 2018  07:00 AM,  049.05165  028.92633  000.4  000.11  00.11  194.6  003.02  023.01  00.30  03.2  080.7
24/ 5/ 2018  08:00 AM,  049.05165  028.92371  000.4  000.08  00.08  270.0  003.60  019.00  00.32  03.0  023.5
24/ 5/ 2018  09:00 AM,  049.05456  028.91945  000.3  000.16  00.16  325.6  004.20  016.00  00.46  03.1  007.8
24/ 5/ 2018  10:00 AM,  049.05806  028.91397  000.2  000.20  00.20  327.4  000.94  340.99  00.17  02.7  008.0
24/ 5/ 2018  11:00 AM,  049.06146  028.91011  000.0  000.16  00.16  318.7  001.55  347.99  00.17  02.8  032.1
24/ 5/ 2018  12:00 PM,  049.06359  028.90888  000.0  000.08  00.08  299.8  002.17  351.99  00.20  02.9  029.9
24/ 5/ 2018  01:00 PM,  049.06455  028.90996  000.0  000.04  00.05  047.9  003.09  248.03  00.27  03.0  029.4
24/ 5/ 2018  02:00 PM,  049.06424  028.91274  000.0  000.09  00.09  096.5  002.95  257.04  00.20  03.0  035.1
24/ 5/ 2018  03:00 PM,  049.06154  028.91663  000.0  000.15  00.15  124.7  002.88  267.04  00.20  03.0  035.1
24/ 5/ 2018  04:00 PM,  049.05643  028.92061  000.1  000.20  00.20  142.2  002.90  204.01  00.21  03.0  064.7
24/ 5/ 2018  05:00 PM,  049.05196  028.92314  000.1  000.16  00.16  150.5  002.46  209.01  00.21  03.0  064.7
24/ 5/ 2018  06:00 PM,  049.04900  028.92338  000.1  000.09  00.09  175.4  002.04  216.02  00.21  03.0  064.7
24/ 5/ 2018  07:00 PM,  049.04810  028.92049  000.0  000.09  00.09  252.7  005.70  101.02  00.72  03.6  114.7
24/ 5/ 2018  08:00 PM,  049.04958  028.91614  -000.1  000.14  00.14  341.2  006.69  099.01  01.05  04.4  132.1
24/ 5/ 2018  09:00 PM,  049.05343  028.91094  -000.2  000.20  00.20  323.5  007.68  098.01  01.28  04.8  140.0
24/ 5/ 2018  10:00 PM,  049.05967  028.90588  -000.4  000.25  00.25  309.0  002.82  113.02  00.18  02.7  074.5
24/ 5/ 2018  11:00 PM,  049.06427  028.90236  -000.5  000.18  00.18  307.3  003.77  107.02  00.24  02.9  069.2
25/ 5/ 2018  12:00 AM,  049.06822  028.90200  -000.6  000.12  00.12  275.3  004.74  104.02  00.42  03.0  101.9
25/ 5/ 2018  01:00 AM,  049.06990  028.90518  -000.5  000.11  00.11  062.1  002.20  049.02  00.18  02.7  056.7
25/ 5/ 2018  02:00 AM,  049.06859  028.91097  -000.4  000.18  00.18  102.8  002.22  048.02  00.18  02.7  056.7
25/ 5/ 2018  03:00 AM,  049.06382  028.91867  -000.3  000.28  00.28  121.8  002.23  048.02  00.18  02.7  056.7
25/ 5/ 2018  04:00 AM,  049.05599  028.92642  -000.1  000.34  00.34  135.3  001.41  011.00  00.17  02.8  032.1
25/ 5/ 2018  05:00 AM,  049.04720  028.93421  000.1  000.36  00.36  138.5  001.43  011.00  00.17  02.8  032.1
25/ 5/ 2018  06:00 AM,  049.03966  028.93836  000.2  000.27  00.27  151.2  001.46  011.00  00.17  02.8  032.1
25/ 5/ 2018  07:00 AM,  049.03382  028.93916  000.4  000.18  00.18  172.3  002.53  311.97  00.19  02.8  013.3
25/ 5/ 2018  08:00 AM,  049.03091  028.93695  000.5  000.11  00.11  217.1  002.83  318.98  00.19  02.8  013.3
25/ 5/ 2018  09:00 AM,  049.03239  028.93181  000.4  000.16  00.17  343.9  003.16  323.98  00.29  02.9  013.8
25/ 5/ 2018  10:00 AM,  049.03682  028.92474  000.3  000.26  00.26  327.9  001.16  292.96  00.16  02.8  019.8
25/ 5/ 2018  11:00 AM,  049.04227  028.91752  000.1  000.28  00.28  322.9  001.38  308.97  00.16  02.8  019.8
25/ 5/ 2018  12:00 PM,  049.04695  028.91296  -000.1  000.20  00.20  314.2  001.68  319.98  00.16  02.8  019.8
25/ 5/ 2018  01:00 PM,  049.05050  028.91013  -000.1  000.14  00.14  308.6  000.76  196.01  00.16  02.8  038.2
25/ 5/ 2018  02:00 PM,  049.05220  028.91147  -000.2  000.07  00.07  038.3  000.32  222.02  00.16  02.8  055.7
25/ 5/ 2018  03:00 PM,  049.05064  028.91513  -000.2  000.12  00.12  113.1  000.34  320.98  00.12  02.7  059.0
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25/ 5/ 2018  04:00 PM,  049.04620  028.92082  -000.2  000.22  00.22  128.0  002.27  102.02  00.18  02.8  064.9
25/ 5/ 2018  05:00 PM,  049.04072  028.92605  -000.1  000.23  00.23  136.3  001.79  105.02  00.16  02.8  086.5
25/ 5/ 2018  06:00 PM,  049.03519  028.93047  000.0  000.22  00.22  141.4  001.31  110.02  00.16  02.8  086.5
25/ 5/ 2018  07:00 PM,  049.03110  028.93162  000.0  000.13  00.13  164.3  004.91  101.02  00.42  03.0  101.9
25/ 5/ 2018  08:00 PM,  049.02888  028.93022  000.0  000.08  00.08  212.2  005.50  100.02  00.72  03.6  114.7
25/ 5/ 2018  09:00 PM,  049.02956  028.92682  000.0  000.11  00.11  348.6  006.10  099.01  01.05  04.4  132.1
25/ 5/ 2018  10:00 PM,  049.03303  028.92186  -000.1  000.19  00.19  325.0  003.68  125.03  00.30  02.9  086.7
25/ 5/ 2018  11:00 PM,  049.03764  028.91669  -000.2  000.21  00.21  318.3  004.19  121.03  00.51  03.2  112.5
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