Hydrodynamic Analysis for Burulus Lake before & after Radial Channel Construction

Ahmed Hany, Fatma Akl, Mona Hagras Ahmed Balah , Abdel Mohsen Elmongey

Abstract— **Egypt has numerous lakes (wetlands) with different types in depths and shapes. Burulus, one of the main lakes, is the second largest coastal lakes and wetland in Egypt. Recently, the Egyptian Government has made great efforts for the rehabilitation and restoration of the northern lakes and wetlands in attempt to improve their environmental conditions and restore their economic value. Among these efforts is Burullus Lake Rehabilitation Project, which has started in 2018 covering the inlet and the eastern part of the lake and aims to improve the water quality and fish production in the lake mainly by enhancing water exchange between the lake and the sea through dredging and side protection works.**

Mike software was used as 2D model to check the hydraulic parameter before and after the recent constructed project in Burulus lake..

***Index Terms*—Burulus, Mike 2D, Radial Channel, Hydrodynamic**

I. Introduction

Burullus lake is the second largest lakes of the Egyptian northern lakes with area 420 km2 along the Mediterranean coast; water depth varies from 0.4m to 2.0 m at the Boughaz El-Burg inlet location. Figure 1[1].

Figure 1:Burulus lake Location

Ministry of Environment Egyptian Environmental Affairs Agency (EEAA) aims to create new projects in order to protect Burulus lake. One of these projects is the use of Radial Channel which was constructed at the sea inlet location at the north side of the lake entrance. Paper in hand represents the comparison between hydrodynamic main parameters before and after radial channel construction.[2]

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II. Methodology

A. Input Data

- Bathymetric data:

Bathymetric data means information about the depths and shapes of underwater terrain for Burulus lake. Bathymetric data was divided into: before 2019 and data after 2019 which present the recent rehabilitation project. Rehabilitation works is the execution of the radial channels in 2019 at the inlet region. The work includes the widening and deepening of the lake inlet (Bughaz) to an average depth of 5.0 m in addition to the dredging of three radial channels for about 1.0 km downstream of the inlet with 100.0 m width. Below, two figures reflect both bathymetric available data before and after year 2019.Figure 2 and Figure 3

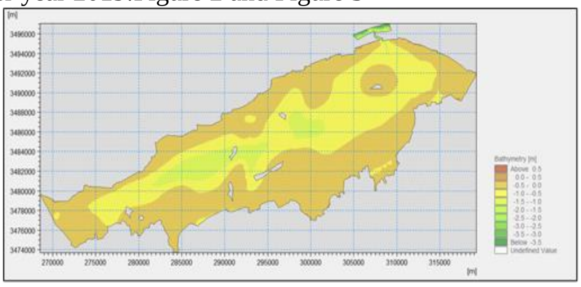

Figure 2:Bathymetric data before year 2019

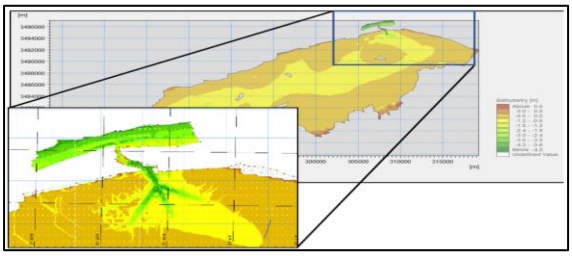

Figure 3:Bathymetric data after year 2019

- Source of inlet discharge:

Many inlets drain within Burulus lake boundary were observed mainly at the southern side of the lake. It is worth to note that only eight drains were draining into the lake. Figure 4 [1]

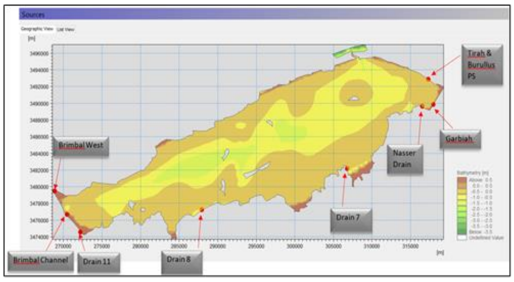

Figure 4:Existing drain sources

It is noticed that Burullus Drain records highest value in one month/year about 38 m3/sec; such drain is a collector drain from other lateral drains . The water body of Lake Burullus receives agricultural drainage from many main drains, they are, from east to west; Brimbal west , Brimbal Channel , Drain 11 , Drain 8 , drain 7 , Nasser Drain , Garbiah and Tirah & Burulus PS. The average annual water discharge from these drains and Brimbal channel is 3.77 $\times 10^6$ m3 and 1.94 $\times 10^6$ m3, respectively. Figure 5 [3].

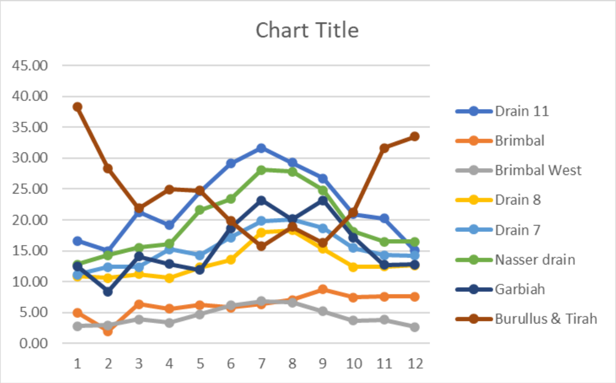

Figure 5:Discharge drains values

- Precipitation Data:

Precipitation data were collected from the main responsible authorities in Egypt (Egyptian metrological authoritiy - http://ema.gov.eg/).

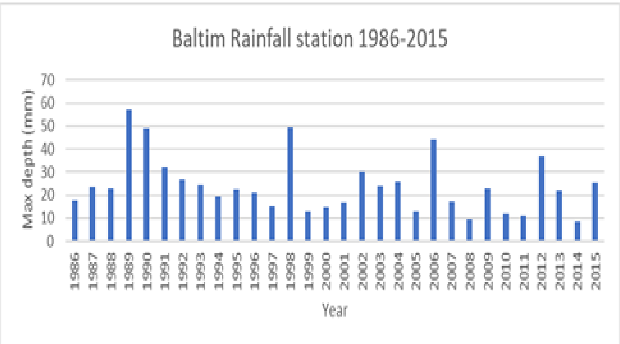

Figure 6: The Max. Daily Rainfall for Baltim rainfall station (1986-2015)

Most precipitation falls in January, with an average of 47.1 mm. Baltim Rainfall Station was chosen because it is close to the Burulus lake. The records cover about 30 years, which are sufficient for statistical analysis for periods of higher frequency. Data from this station were collected between 1986 and 2015. the maximum value recorded during this period is 57.3 mm, which was recorded in 1989.Figure 6.

- Evaporation Data:

Several methods were used to obtain the evaporation rate for years 2011 and 2012 respectively (for example) The MK deviations are scattered around the zero level (zero error level), with both positive and negative errors, being the best evenly scattered over the two years 2011 & 2012. The HM deviations are scattered above the zero level (overestimated) for all two years. The DK, PT, PM and JH deviations are scattered below the zero level (under estimated) for all two years. Figure 7 [4],[5].

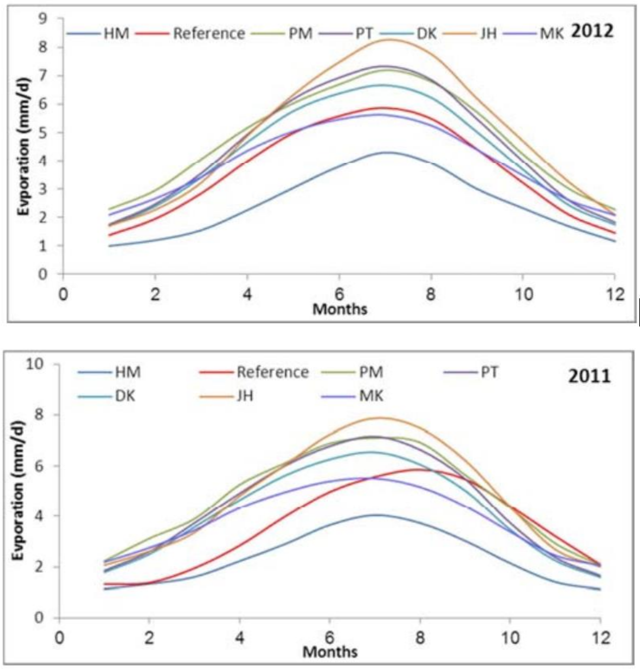

Figure 7: Different between six methods-estimated of evaporation (with reference evaporation (mm/d) during 2011&2012)

- Wind forcing:

The predominant wind in the Burulus lake area strikes generally from the western direction; sometimes changes its direction to north or north – west. Actually, it may also strikes from the south-west during winter. The current wind speed is between 1 and 16 Knots. Wind speed more than 16 Knots is less frequent. While wind speed more than 27 Knots is very rare and is confined mostly in winter months. There is direct effect of the increased wind speed on the general hydrography of the lake.

As for the sea water into the lake through the Boughaz (Sea inlet) , the volume of which depends on the wind velocity duration . Turbulence of water may occur because of increasing of wind velocity.

Also, the wind movements play an important role in the distribution of salinity in the lake. In case of easter winds, the fresh water drains cover most of the lake, and they decrease the salinity to a large extent. The northern winds drive water southerly and the salinity increases even next to drains. Figure 8 [6], [7]

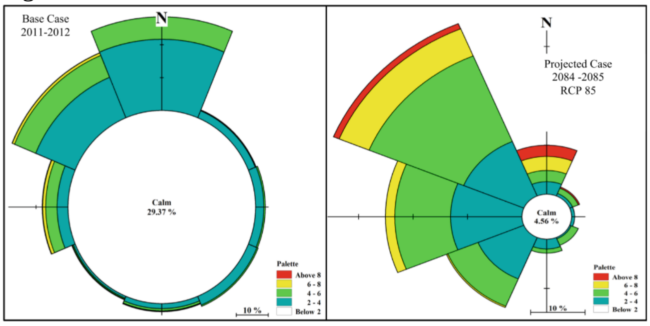

Figure 8: Wind rose in Burulus lake

B. Analysis stage:

Analysis stage in burulus case study will be limited to the below items:

- Mesh Analysis:

Two meshes were built including appropriate selection of the area to be modelled, adequate resolution of the bathymetry, flow, wind and wave fields under consideration and definition of codes for open and land boundaries. The resolution in the geographical space must also be selected with respect to stability considerations.
One of these two meshes were generated at the sea & inlet lake (Boghaz), as this inlet was very tight, hence, the mesh was decreased to represent the hydrodynamics changes. Figure 9.
Inlet width is 100.0m approximately and the maximum width of mesh is about 20.0m to allow the flow to run smoothly to the lake.

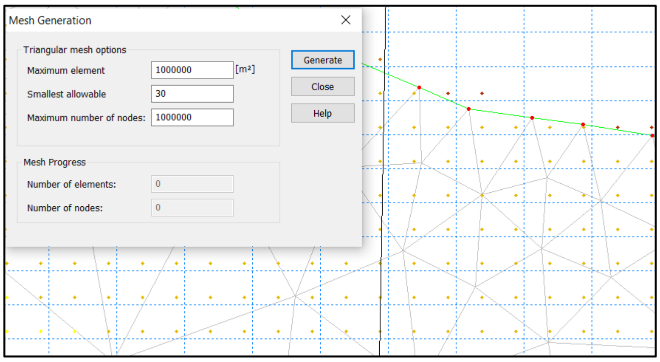

Figure 9: Mesh generation at the burulus lake

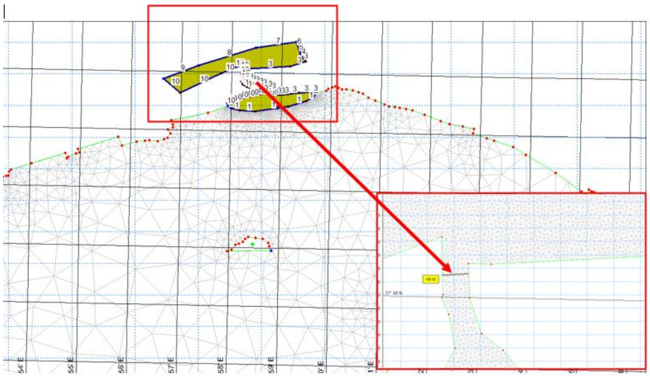

Figure 10: Mesh Size and inlet width at Bughaz

- Boundary Conditions:

Boundary conditions was used based on water level to be variable in time and constant along boundary; in this case with water level varying in time but constant along the boundary, prepared data file contains the water level at the open sea location (red marked boundary) Figure 11.

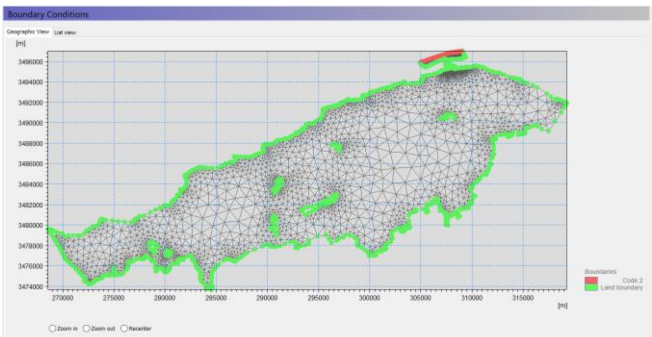

Figure 11: Boundary Conditions shows land boundaries and sea boundaries

Water levels was inserted as boundary conditions at the open sea boundary which is varying in time, with a time step one-hour. Maximum water level was recorded on 10th of April and the min level was on 11th of the same month. Figure 12.

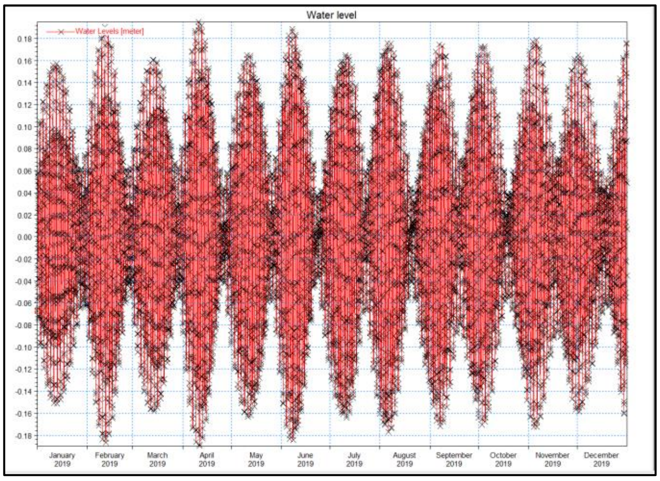

Figure 12: Water levels at open sea location

III. Results

Two scenarios were setup first scenario with the old state at inlet sea while the other one represents the radial channels.
Two points were chosen to check the hydrodynamic condition results for each scenario. Such two points were allocated one at the inlet, the other point at the middle of burulus lake to check the impact of radial channels on the middle of the lake. Figure 13.

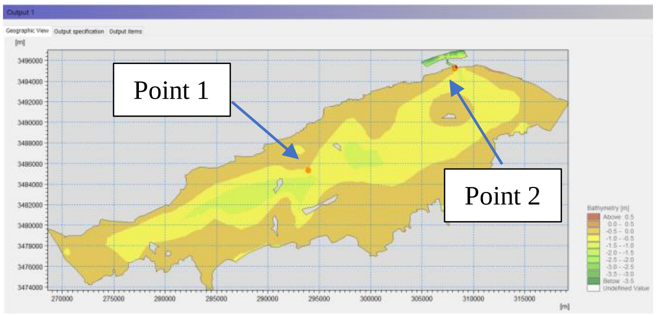

Figure 13: Output result locations

Point 1 results concerning velocities, show that in case of old condition before construction of radial channels, the maximum velocity is 0.9m/s. in January and decreases to 0.2 m/s, February and then 0.9m/s at the end of the year. For the same point 1 and after the construction of radial channels, velocities were reduced from February to April reaching 0.08 m/s and then became at the same value as the old condition case (up to 0.2m/s), then large drop in velocities were observed reaching 0.05 m/s.
Point 1 results shows decreasing in velocities specially form February to April and from august to the end of the year.
The velocities in first months decrease as the flow at sources of drains had a low value, however at the middle of the year the sources of flow have high values and the velocities show higher values.

Deepening of the lake inlet (radial channel) make the depth increase up to -5.0 m has anoticeable impact on decreasing the velocities. Figure 14[8]

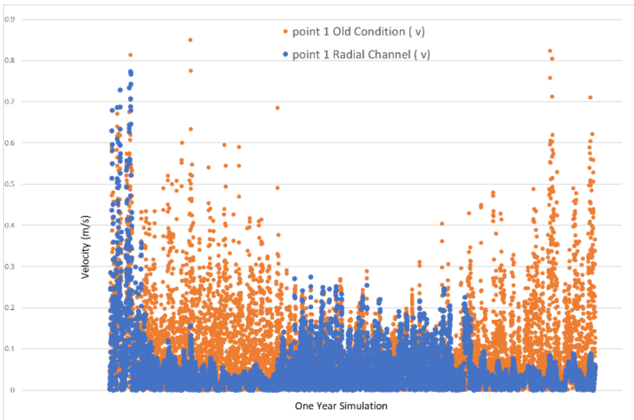

Figure 14: Velocities comparison between old &Radial channel conditions (point 1)

<u>Point 2</u> was a critical point located at the entrance of the recent constructed radial channel to check the main hydrodynamic parameter (velocity). On the contrary of point 1 the first month of the year (Jan) represents low velocities about 0.2 m/s then for the next three months (Feb, March and April), velocities are almost the same of about 0.6m/s.At the middle of the year velocities change rapidly ,then at the end of the year velocities become almost the same, reaching 0.6m/s.

As point 2 , allocated nearest to the entrance of the lake , the impact of the wave height on the velocities was observed for the old condition's situation. Deepening of the entrance by construction the radial channels had reduces the velocities as shown below.Figure 15 [9].

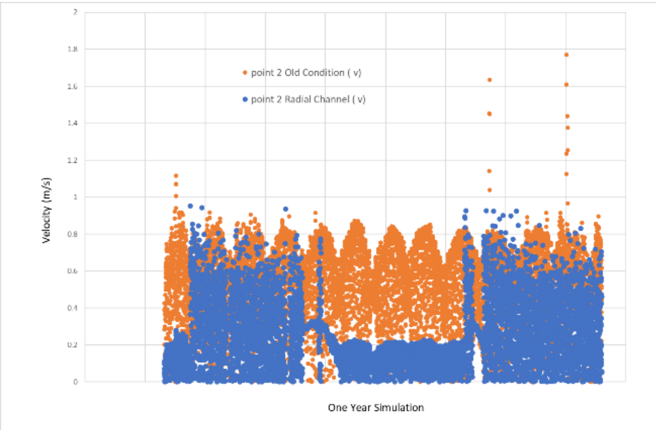

Figure 15: Velocities comparison between old &Radial channel conditions (point 2)

IV. CONCLUSION

Recent projects were constructed on burulus lake in order to enhance both water quality and the hydrodynamics performance. One of these projects is radial channels which were constructed at the inlet of the lake.

Mike 21 software was used to simulate two scenarios checking the hydrodynamic result, one represents the old conditions and the other after constructing three radial channels with depths ranged from -2.0 to -5.0m.

It was noticed that the velocities along burulus lake were decreased generally along the year. These results emphasize that deepening lakes or some portions of the lakes, does not improve the hydrodynamic conditions, generally other parameters can improve the hydrodynamic conditions such as; decreasing the inlet width by a suitable percentage depending on local condition or adding more than one inlet to the lakes to increase the flushing time or decreasing the inlet width.

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