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DETERMINATION OF AQUIFERS AND GROUNDWATER CONDITIONS IN KHARTOUM BAHRI AREA, SUDAN

Areej Eltaj Eltip[*1], Ahmed Abdelaziz Ibrahim[2] & Mohammed Adam ginaya[3]

[1,3]Water Resource Engineering Department, College of Water and Environmental Engineering , Sudan
[2]Petroleum Engineering Department, College of petroleum Engineering and Technology, Sudan University of Science and Technology, Sudan

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ABSTRACT

The purpose of this paper is to evaluate the ground water conditions in Khartoum Bahri area using Rock Works Software program based on geological and hydrological data. The study discusses two aquifers upper one has small thickness and not continuous, the Lower one is the Nubian sandstone aquifer and it is the main aquifer in the area. The Lower aquifer in some area is partially confined and at other locations is unconfined or confined. The distribution of the static water levels (SWL) in lower aquifer in all area near the Nile and Blue Nile is near from the surface this illustrates the importance of the Nile and Blue Nile in the recharge. Groundwater in the Lower aquifer in the study area is fit for drinking due to the distribution of the Total Dissolved Solid (TDS) except Elaolyab area records high value.

KEYWORDS: Lithology model, aquifer, ground water conditions, Khartoum Bahri.

1. INTRODUCTION

Groundwater is the most important resource in Sudan**.** About 80% of the inhabitants of Sudan depend on groundwater for their living most of the year [1] [2].

Groundwater obtained from a well is usually safe to drink without treatment, if the well has been properly constructed and maintained but Surface water is more vulnerable to contamination and requires extensive testing and treatment to assure that it is safe to drink [3]**.** The hydrogeological information is very important for the proper design of groundwater well.

The most important aquifer in Sudan is the Cretaceous Nubian sandstone formation. It occupies about 700,000 km^2 from total surface area of the country [4]. The Nubian sandstone covers about 70% of the total surface area of Khartoum state [5].

This study is conducted in Khartoum State. Khartoum region comprises the three towns of Khartoum, Omdurman, Khartoum Bahri and their suburbs. The study area located In Khartoum Bahri area, lies between latitudes 15.7 N to16.08333 N and longitudes 32.57194 E to 32.65 E. Figure (1)

The studied area forms one of the most developed parts in the Sudan and in this area ground water is used for domestic, irrigation and industrial purposes. Bahri area witnessed a steady increase in population. This large numbers of population required additional water supply especially in summer season.

The main objective of this paper is to carry out a Hydrogeology appraisal of groundwater in Khartoum Bahri area. This includes the determination of the general description of lithology nature and aquifers conditions then evaluate their water quality. To achieve the proposed objective the hydrological and lithology data of 32 boreholes were obtained and studied. The investigated boreholes range in depth from 40 to 152 m.

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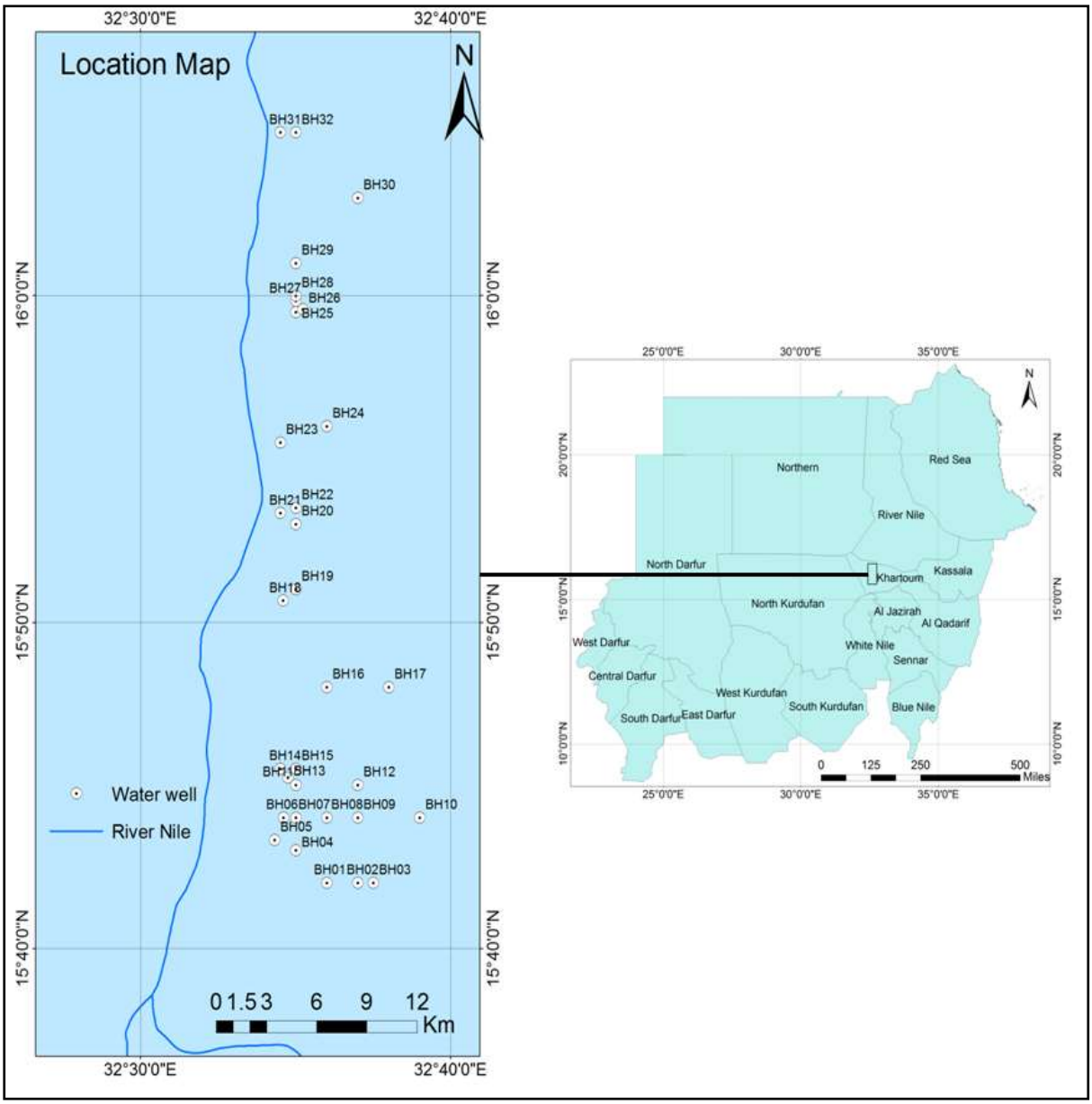

Figure 1. illustrated Location Map

GEOLOGICAL SETTING

The study area is part of the Khartoum sub-basin. That is situated at the northern periphery of the Blue Nile rift basin [6], [7]. Basement Complex is the oldest rock unit cropping out in the study area. Granites and granite gneisses are the main types of rocks forming the basement in the study area[8]. The Nubian (Omdurman) Formation is deposited unconformably over the Basement Complex in study area. The sedimentary sequence of the Nubian Formation comprises sandstones, mudstones and conglomerates. Late Cretaceous (Albian-Cenomanian) age was assigned to Nubian Formation [8]. In the area close to the Nile and east of the Nile the Nubian formation is covered with thin layer (generally less than 5 meters) of superficial deposits. The thickness of the Nubian formation is highly variable [5]. The sediments of the Umm Ruwaba Formation were deposited unconformably over the Basement Complex and the Omdurman Formation and it crops out in small areas east of the Blue Nile and east of the Nile River. In the study area, the Umm Ruwaba Formation is comprised of unconsolidated gravels, sands, silts and clays [8]. Superficial deposits comprise recent deposits of clay, silt, sand

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and gravel around the river Nile and in big wadis. It also comprises older alluvium, sand dunes, active dunes and Aeolian dunes. These deposits uncomformably cover the basement complex or the Nubian sandstone [5]. See geological map figure (2)

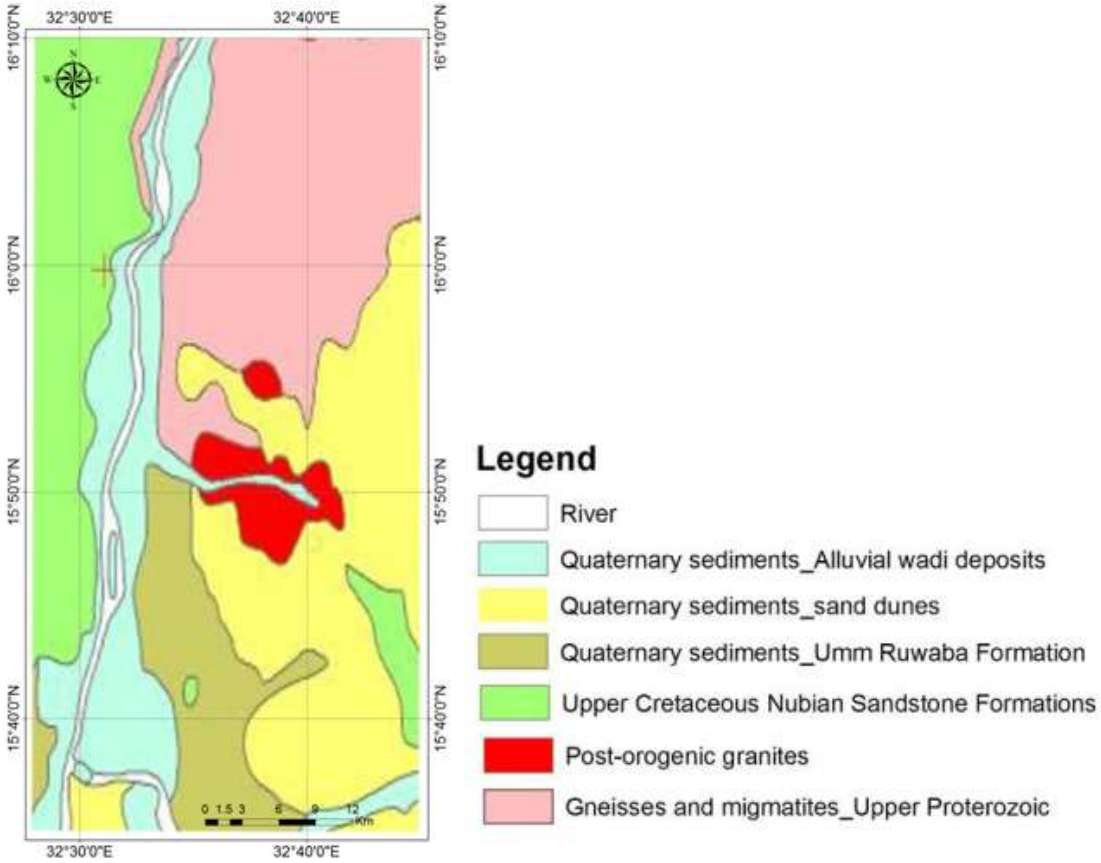

Figure 2. Illustrated Geology of study area (Khartoum Bahri) [9]

GENERAL HYDROGEOLOGY

The Nubian sandstone is the major sedimentary formation. Which covers about 70% of the total surface area of Khartoum state [5]. Due to the existence of mud stone intercalation, more than one aquifer is found in the Nubian sandstone in the studied area [10]. Actually it encloses two Known water zones in the area. These are upper and lower aquifers. The boundaries of the two aquifers cannot be easily located in some parts. The lower aquifer can be tapped at different depths depending on the thickness of separating mudstone layers [5] ,[11].

Water table or artesian conditions in the studied area depend upon the presence of overlying impermeable mudstone horizons [10]. The Nubian sandstone will all its geological and hydrogeological characters is considered to be the principal aquifer in the study area [11]. Also the alluvium deposits of the flood plain provide shallow groundwater sources of limited yields and prone to contamination [11]. Very limited or no recharge from direct precipitation is expected due to the topography, as rainfall runs off quickly towards the Niles [12]. The Nile Rivers are the main source of groundwater recharge in the area [10] [13][8]. figure (3).

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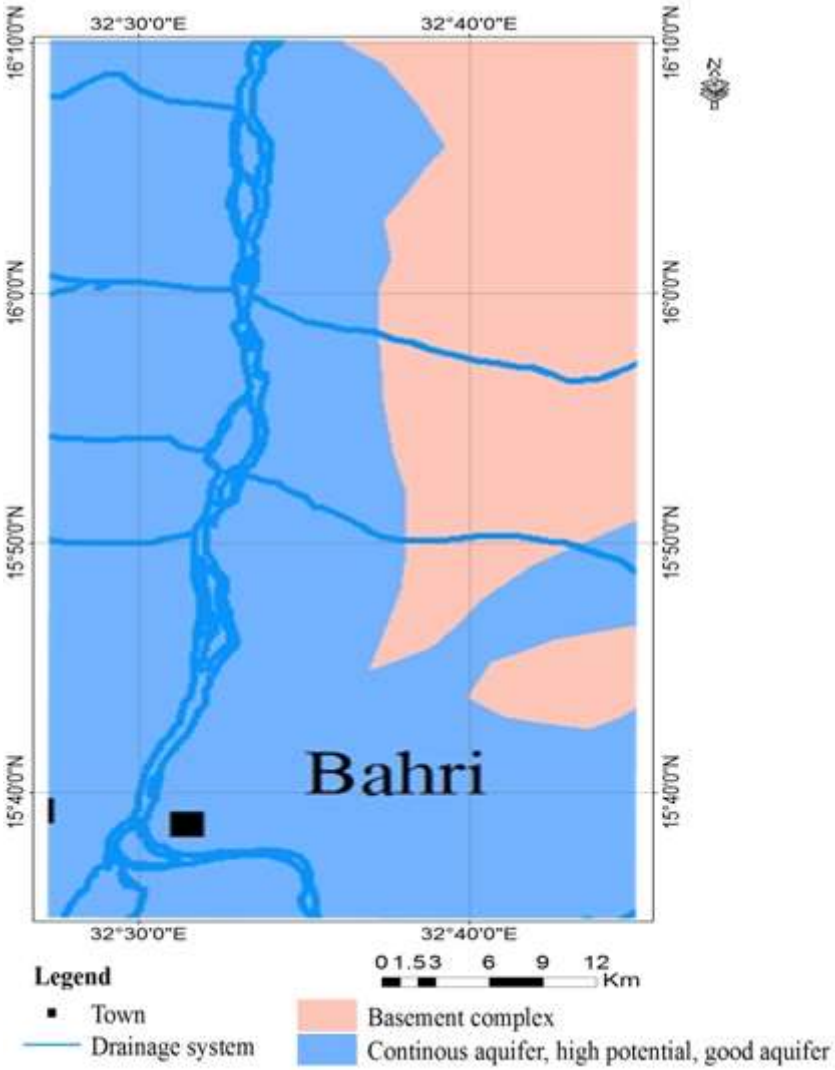

Figure 3. illustrated hydrgeological map of the study area (Khartoum Bahri) [14]

2. MATERIALS AND METHODS

- The Literature review for study area was reviewed, and Hydrogeological inventories was previewed of previous work (Maps, figure, tables...etc).

-The hydrological and lilhology data of 32 boreholes were studied. The borehole data include: locations, latitudes, longitudes, elevations, lithological Data, well designs, static water levels (SWL), total dissolved solids (TDS), well yield, electrical conductivity (EC) and PH (table1). Borehole data were obtained from Information Centre of Groundwater and Wadis Directorate - Ministry of Water Resources and Electricity, Khartoum, Sudan.

- The Rock works Software Program was used to create project for 32 wells in study area. And lithology data was entered in the program to generate Lithology model figure (4) and Lithology cross sections Figures (6, 8, 10) to Show lithology nature and aquifers of study area. The cross sections locations shown in figures (5, 7, 9). The RockWorks Software Program Using for the sub-surface visualization and modeling (2D and 3D logs, cross sections, fence diagrams, Lithology models, solid models, stratigraphic models, structure maps, etc.) [15].

- Arc GIS Software Program was used to construct contour maps for elevation, SWL, TDS, EC and PH for these 32 well to show their distributions for the aquifer in the study area.

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Table 1. The well data used in the Study

Bore	Location	Longitude	Latitude	Total Depth	Elevation	Screen Depth		S.W. L	S. W. L	Yield	TD	PH	EC
						Top	Botto	From Surface	a.s.l				
		Decimal Degree	Decimal Degree	m	m	m	m	m	m	m^3/h	mg/L		µS/c
BH01	EL HALFAYA	32.6	15.7	105	384.20	88.5	94.5	22	362.20	50	-	-	-
BH02	UMM DUREIWA	32.61666	15.7	98.8	384.70	-	-	22	362.70	31	335	7.9	-
BH03	UMDUREWEIA NORTH	32.625	15.7	117.9	386.00	79.3	109.8	23	363.00	29	300	7.9	400
BH04	AL DOUROSHAB	32.58333	15.71666	128.1	384.00	79.3	91.5	27.1	356.90	40.91	335	8.1	608
BH05	EL DUROSHAB(AL	32.57194	15.72194	105.2	383.20	83.8	96	26.5	356.70	13.6	412	7.2	588
BH06	E DROUSHAB NORTH	32.57666	15.73333	137.2	383.50	73.2	85.4	24.1	359.40	27.3	417	7.3	596
BH07	ELDROSHAB	32.58333	15.73333	132.6	381.50	91.5	114.3	22	359.50	16	210	8.2	380
BH08	ELDURASHAB SOUTH	32.6	15.73333	125	384.30	76.2	112.8	23	361.30	14	300	7.7	500
BH09	UMM DIRAWA	32.61666	15.73333	97.4	384.30	80.2	90.4	22	362.30	46	-	8.9	472
BH10	ELAOLYAB(2)	32.65	15.73333	61	390.20	48.8	54.9	26.6	363.60	16.36	522	8.4	745
BH11	UM ALGORA WEST	32.58333	15.75	106.7	381.30	61	91.5	18	363.30	25	304	7.2	435
BH12	EL ZAKIAB	32.61666	15.75	106.7	384.30	74.7	99.1	19	365.30	34.1	360	7.5	515
BH13	UMM ELGOURA WEST	32.57916	15.75388	106.7	383.30	73.2	91.5	20.6	362.70	32.7	453	7	647
BH14	EL KASR EL GADID	32.575	15.75833	79.3	382.00	39	49.7	29	353.00	23	435	7.2	622
BH15	UMM EL GORA WEST	32.58333	15.75833	106.7	382.70	62.5	94.5	18	364.70	25	385	7.8	550
BH16	EL TIBNA	32.6	15.8	67	383.00	54.9	61	-	-	-	-	-	-
BH17	ABO SEDIR NORTH	32.63333	15.8	152.4	388.80	134.2	146.3	116.5	272.30	16.36	277	7.2	504
BH18	AL FAKI	32.57638	15.84416	61	380.20	36.6	48.8	14.4	365.80	18.2	-	7.7	-
BH19	EL KHILALA	32.58333	15.85	77.7	380.70	60.9	71.3	13	367.70	40	300	7.8	44
BH20	EL KABBASHI	32.58333	15.88333	75.6	381.50	60.4	66.2	2	379.50	80	320	8.4	370
BH21	KABBASHI	32.575	15.88888	73.1	379.30	58.5	63.6	-	-	-	-	-	-
BH22	EL KABBASHI2	32.58333	15.89166	67.1	381.50	53.4	58.5	13	368.50	40	370	7.5	450
BH23	EL SAGGAI EL BATALAB	32.575	15.925	56.4	379.50	35.1	47.3	11	368.50	11	476	7.2	680
BH24	EL TUMANAT	32.6	15.93333	48.7	388.20	18.5	47.1	-	-	-	-	-	-
BH25	DEIM ABU FRAWAH	32.58333	15.99166	80	380.70	64	78	7	373.70	60	240	8	330
BH26	ABO TELEH	32.58722	15.99305	61	381.50	51.8	57.9	25.6	355.90	34.09	286	7.4	408
BH27	ELNAYA	32.58333	15.99722	61	379.80	-	-	9	370.80	80	-	-	-
BH28	WAWISSI(2)	32.58333	16	45.7	380.00	33.5	39.6	22.9	357.10	29.2	264	7.8	377
BH29	NORTHERN AREA	32.58333	16.01666	44.2	377.20	27.4	39.6	20	357.20	11	317	7.2	446
BH30	ELKUNGER	32.61666	16.05	40.9	394.10	28.7	40.9	20	374.10	33	135	8	355
BH31	WAWOSSI ELSHEIK	32.575	16.08333	53.4	376.00	24.4	30.5	8.5	367.50	24.79	170	7.7	320
BH32	WAWESEE	32.58333	16.08333	45.7	376.70	28.9	39.6	-	-	-	-	-	-

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3. RESULTS AND DISCUSSION

From Lithology model figure (4) and Lithology cross sections (A-A‘, B-B‘ and C-C‘) figure (6, 8, 10) consequently there are two aquifers in study area upper aquifer and Lower aquifer. The upper one has small thickness and not continuous, the Lithological description of this aquifer consists on the gravels, sands, silts and clays (Umm Ruwaba Formation) and Superficial deposits see figures (4, 6,8, 10) this upper one nearest from the surface and their water subject to the contamination due to directly Rainwater infiltration to the soil or seepage well.

Lower aquifer it includes mainly Nubian sand stone formation and is the main one. The Lower aquifer in some area is partial confined and in others is unconfined (one aquifer) or confined due to presence of clay or mud stone layers. In cases of unconfined and partial confined need sealing in design well and drilling far away to prevent water from pollution by seepage. From cross sections figures (6, 8, 10) the Lithological description of the main Nubian aquifer consists sand (fine medium to coarse) and gravely sand and geologically its good characterizes to store and transmit water.

In northern part of the study area the basement depth in range 40 to 60 m see Lithology model figure (4) and cross section B-B‘ figure (8)

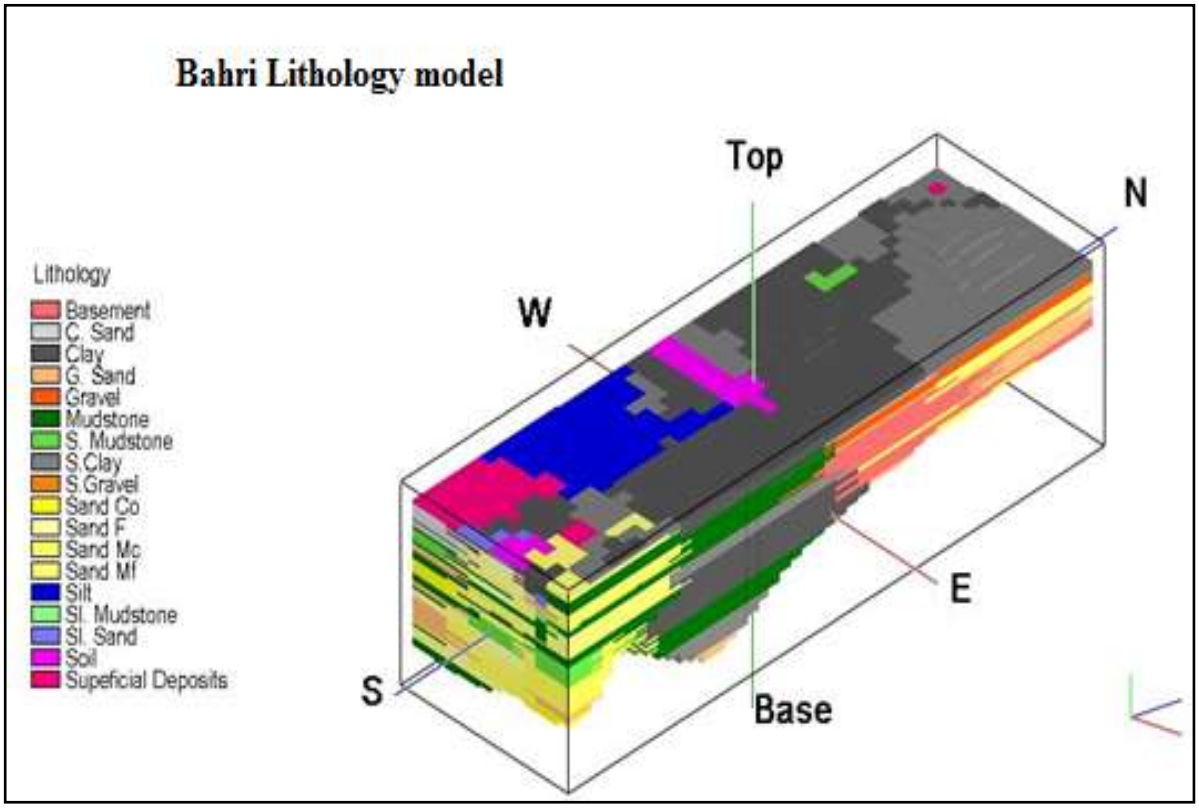

Figure 4. illustrated Bahri Lithology model

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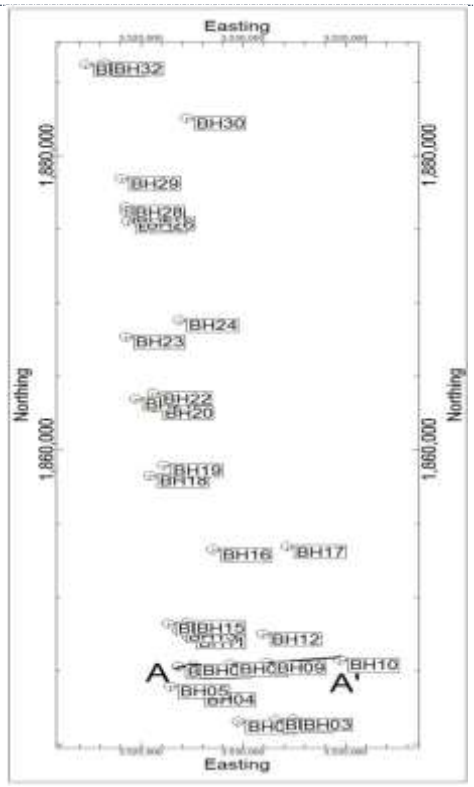

Figure5. illustrated cross section (A-A') location

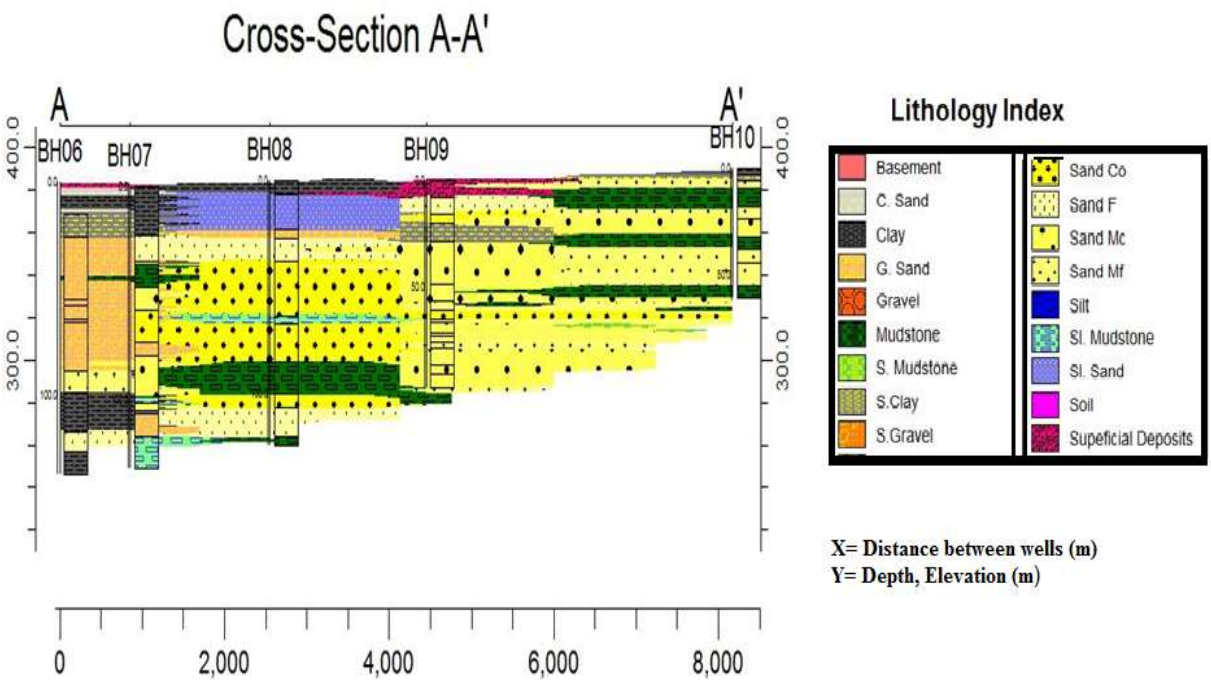

Figure. 6. illustrated Cross section A-A'

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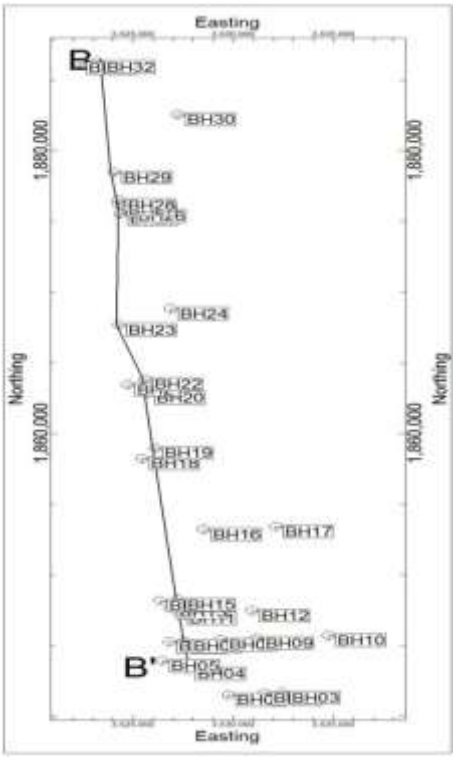

Figure7. illustrated cross section (B-B') location

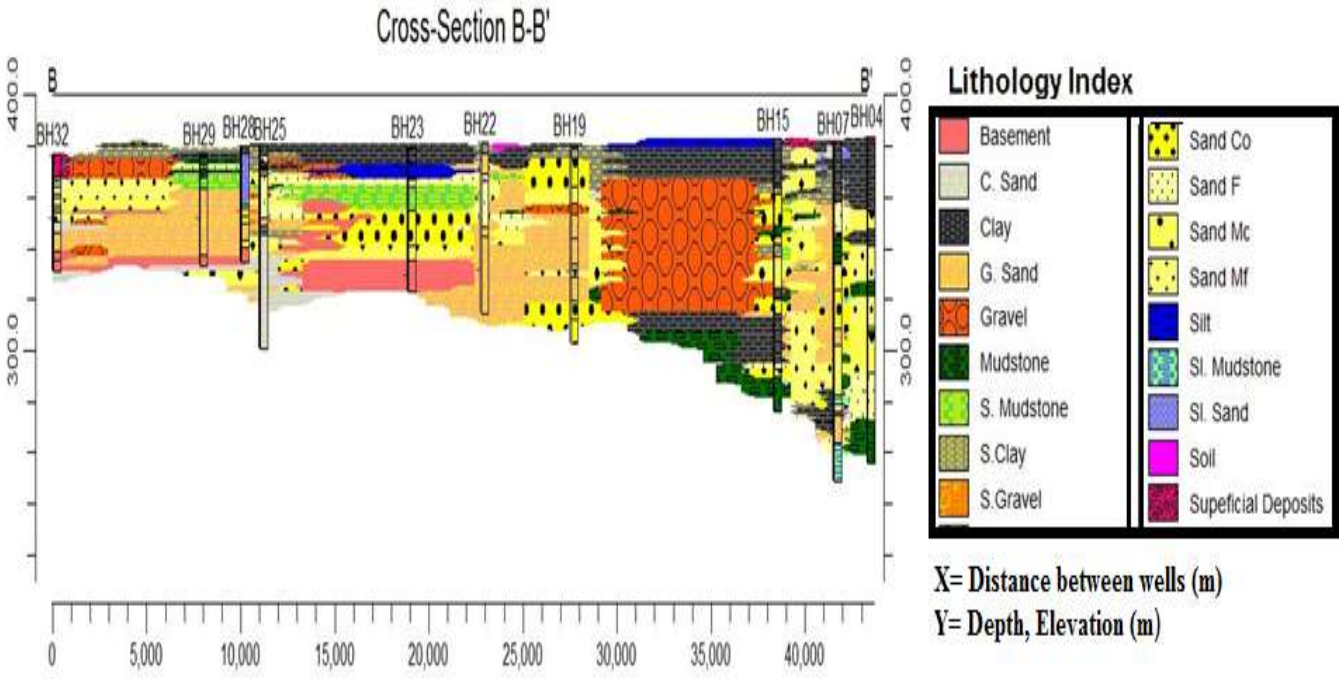

Figure 8. illustrated cross section B-B'

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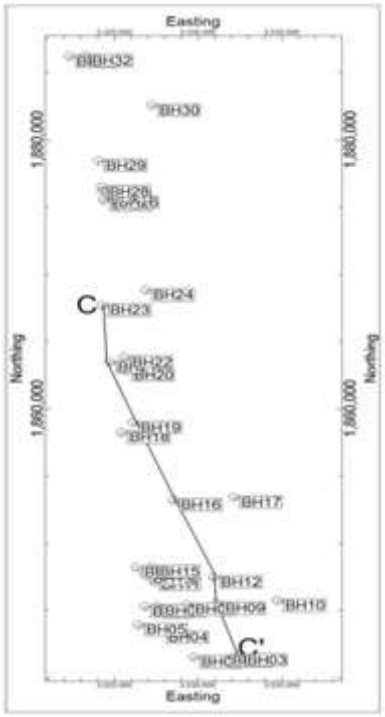

Figure9. illustrated cross section (C-C') location

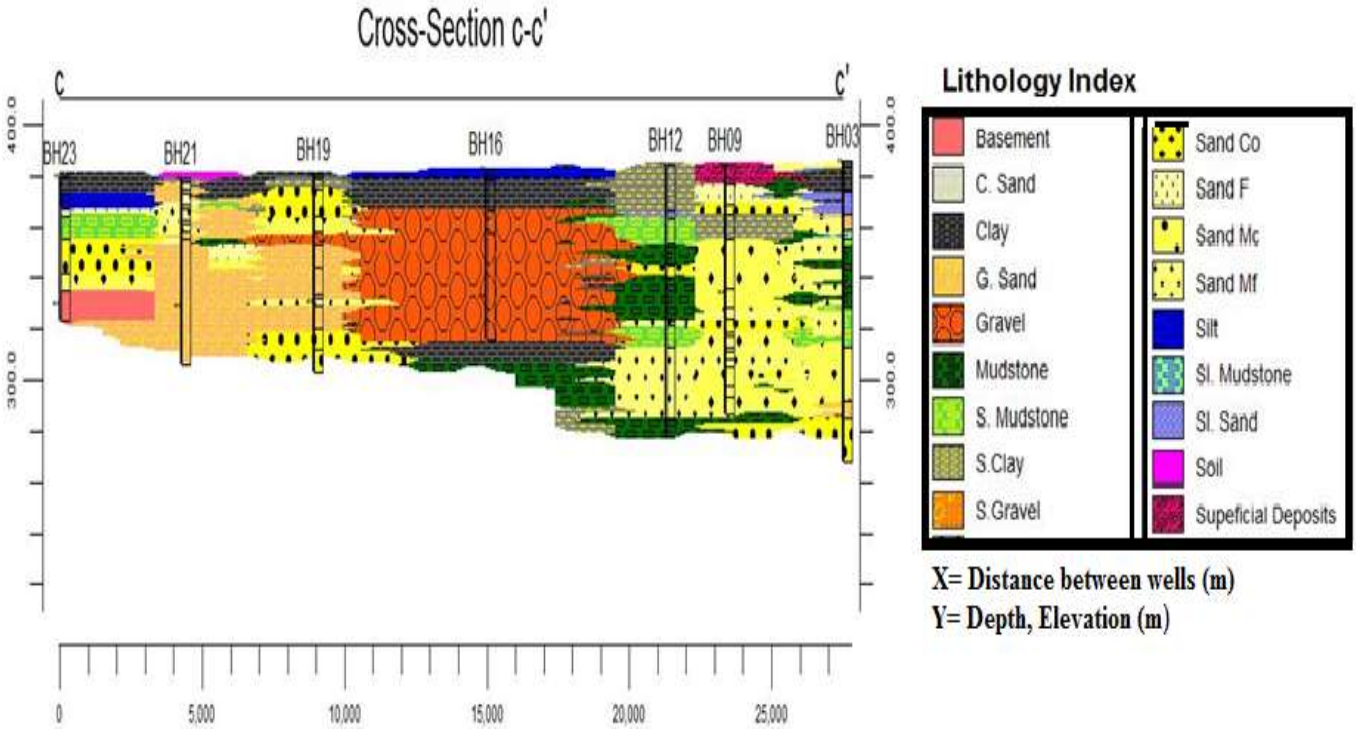

Figure 10. illustrated cross section C-C'

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From cross sections A-A‘, B-B‘ and C-C‘ Figure (6, 8, 10) consequently and from screened interval table (1) the all 32 well product from the main Nubian aquifer. To evaluate this aquifer the Arc Gis map program was used for construction contour maps to show the distribution of the SWL, TDS, EC and PH. The elevation contour show in figure (11)

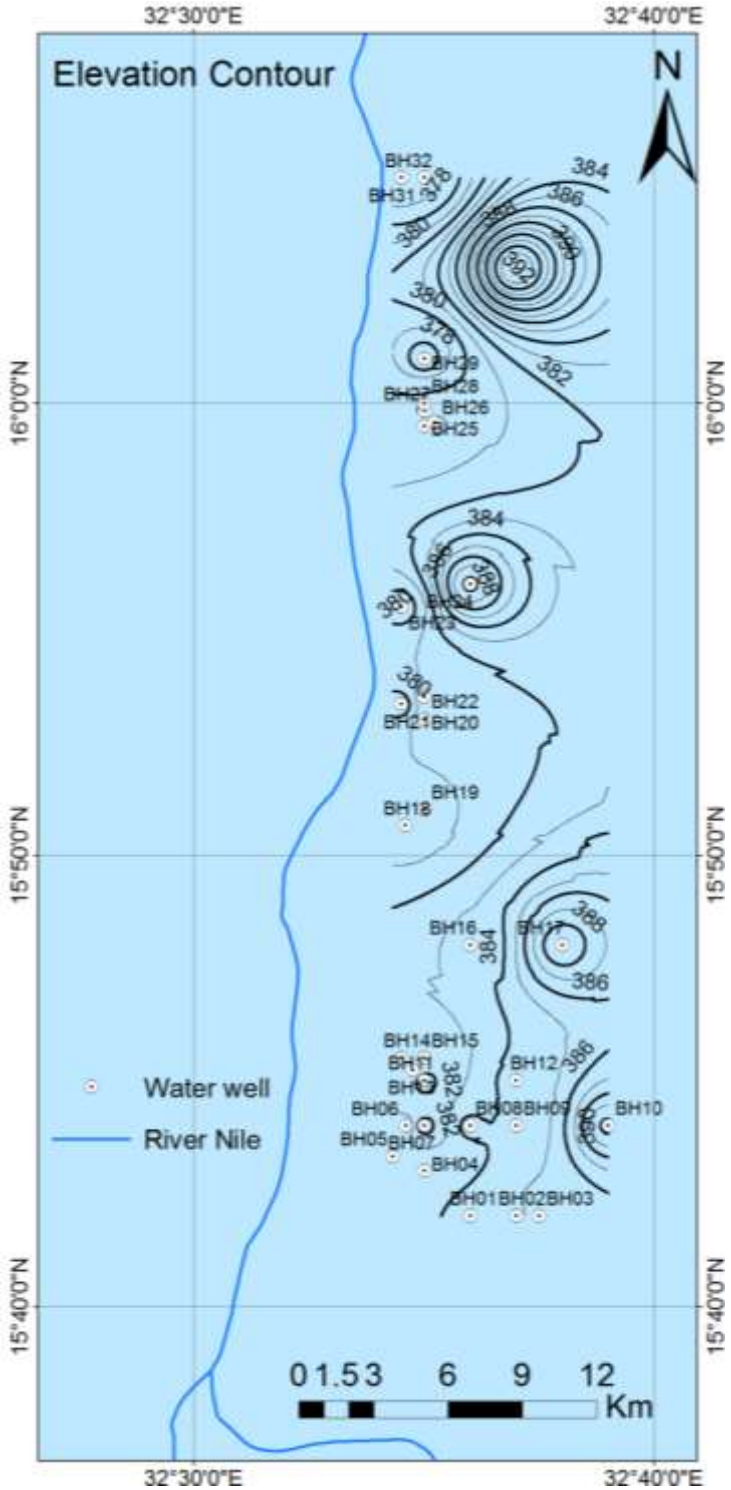

Figure 11. illustrated Bahri elevation contour (m)

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In lower aquifer The values of the static water levels in all area near the Nile and Blue Nile is near from the surface (10-20m) and increase when far from the River Nile and Blue Nile to reach (116.5 m) in Abo Sedir north area (BH17) figure (12). And this illustrates the importance of the Nile and Blue Nile in the recharge. Also, SWL contour map indicates the direction of groundwater flow. The SWL values In northern area is nearest to surface (10-20m) due to basement depths in range 40 to 60m.

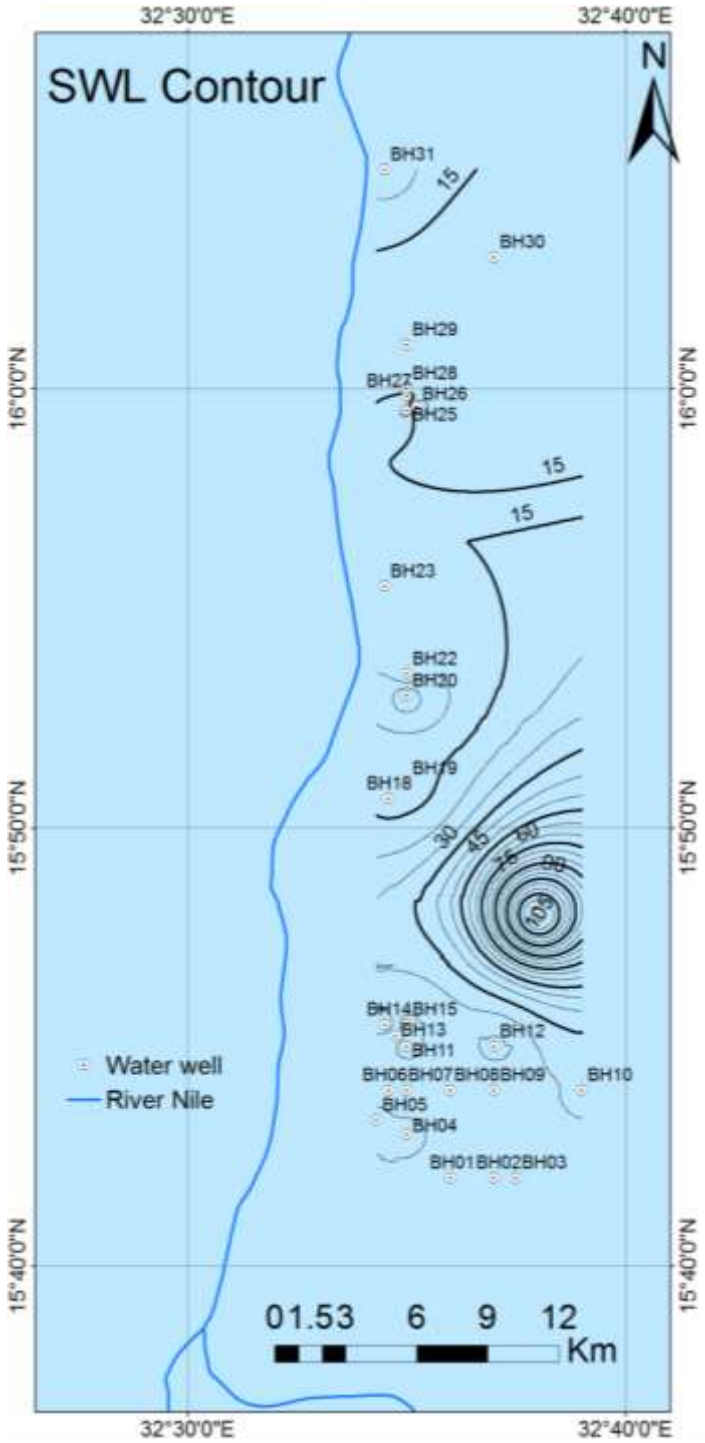

Figure 12. illustrated Bahri Contour SWL (from surface)

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The total dissolved solids (TDS) in lower aquifer has a mean value of 360 mg/L in almost of the area except the northern part the mean value of 280 mg/L.TDS small value 135 in Elkunger well (BH30) but high value 522 mg/L in south Eastern of study area (Elaolyab2) well (BH10) Figure (13). according to (ground water and wells, Johnson) the total dissolved solid standard for drinking water is (500mg/L) [16] the lower aquifer water is fit for drinking except Elaolyab area records high values.

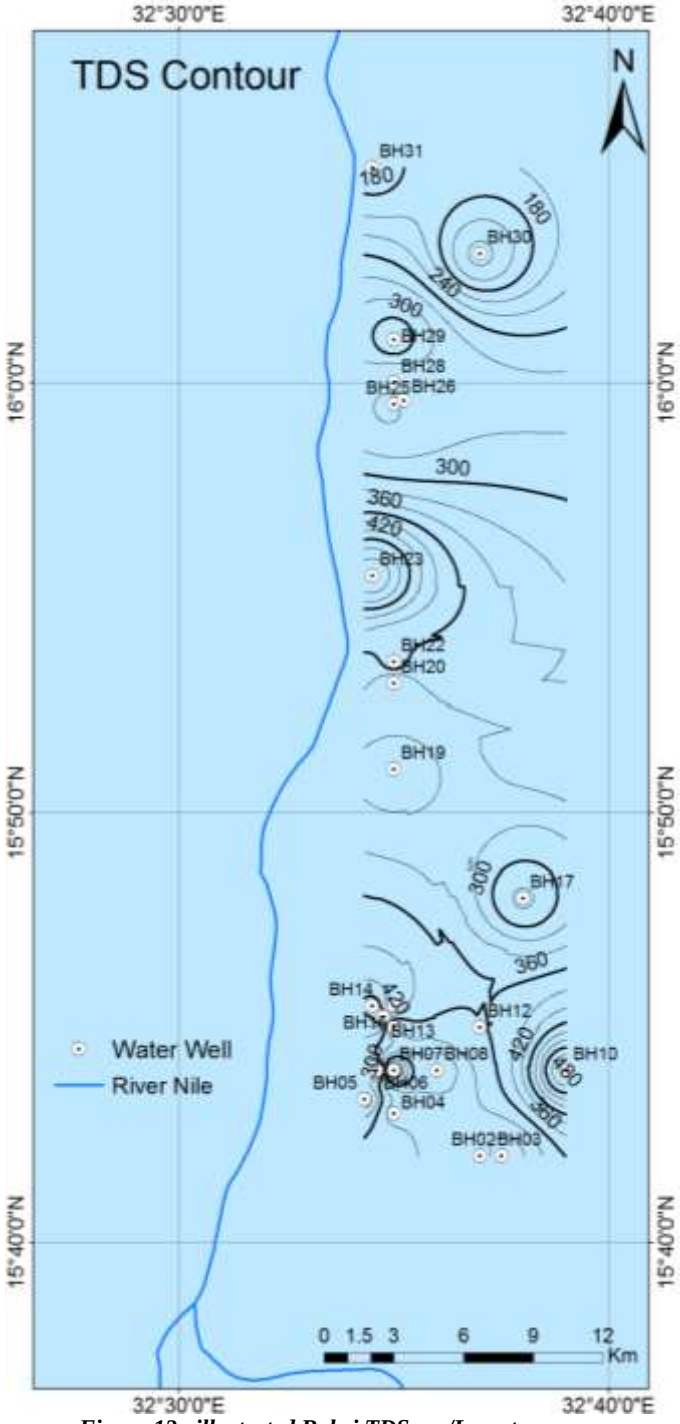

Figure 13. illustrated Bahri TDS mg/L contour

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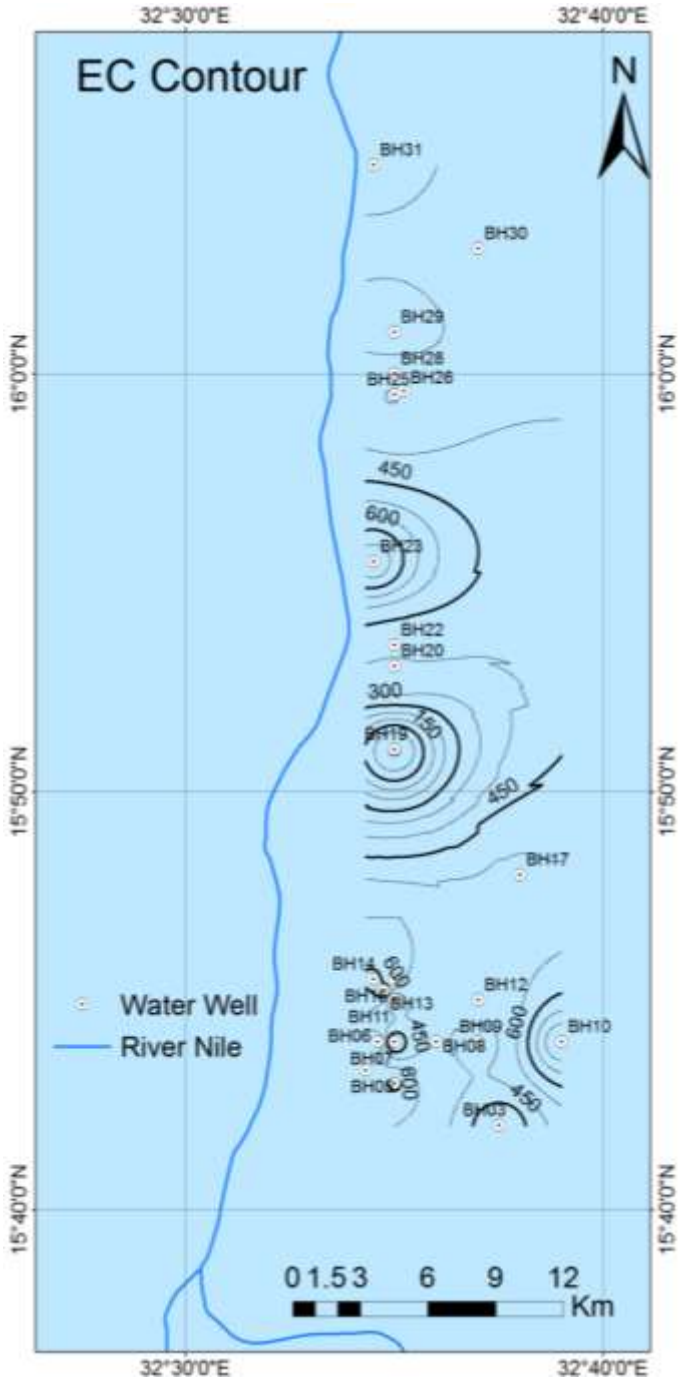
In lower aquifer the electrical conductivity has a mean value of 520 µS/cm in almost of the study area except the northern part the mean value of 370 µS/cm, small value 44 µS/cm in Elkhilala well (BH19) and a maximum value 745 µS/cm in (Elaolyab2) well (BH10) figure (14).The electrical conductivity (EC) values of the lower aquifer water show distribution almost similar to that of the total dissolved solids.



Figur***e 14. illustrated Bahri EC (µS/cm) contour***

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The PH distribution in lower aquifer show in figure (15).

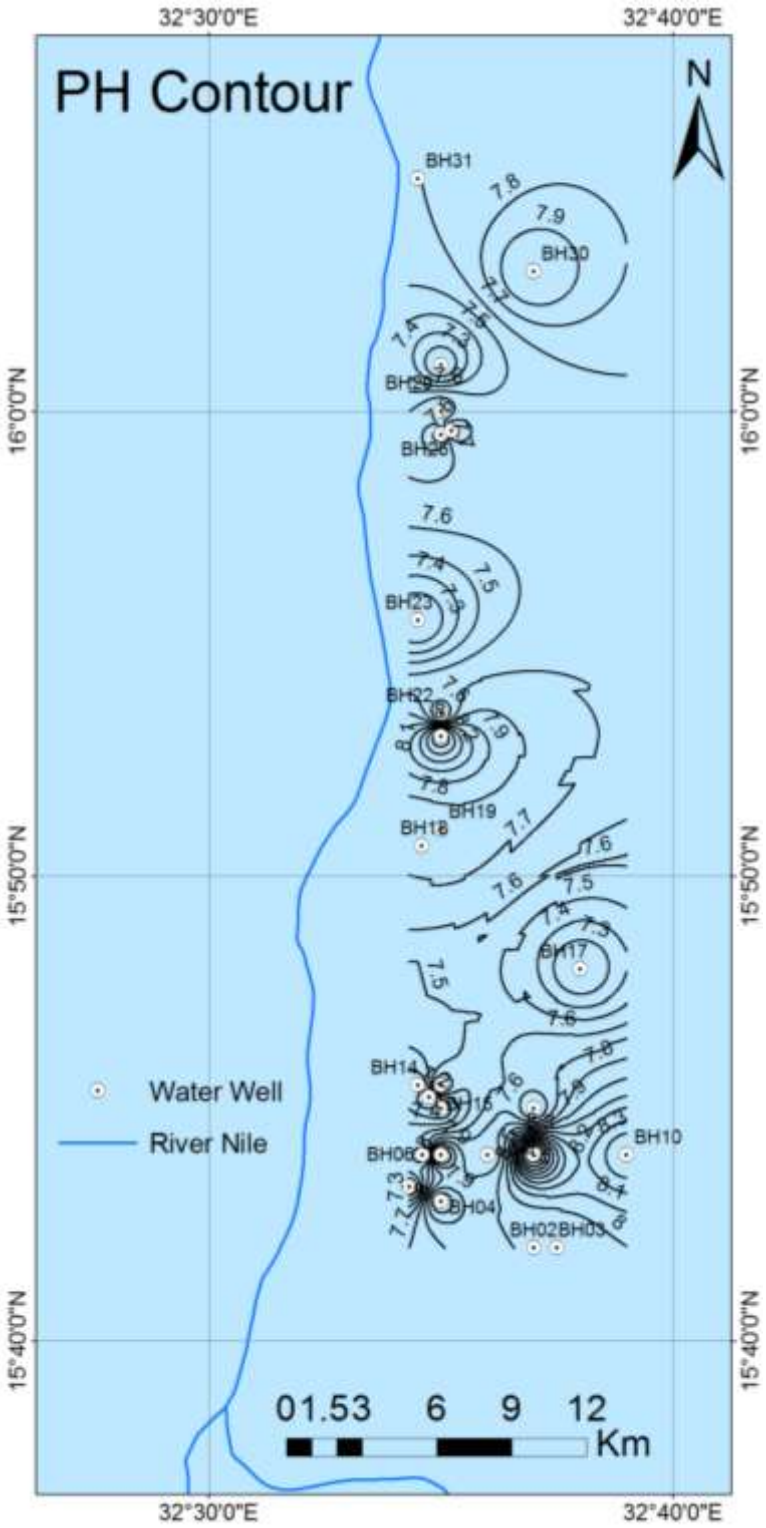

Figure 15. illustrated Bahri PH contour

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4. CONCLUSION

The aquifer system of the Khartoum Bahri area consists of two aquifers. The upper aquifer has small thickness and not continuous it includes Umm Ruwaba Formation or Superficial deposits, Lower aquifer is the principal one and it includes mainly Nubian sand stone formations which main sedimentary formations utilized for the groundwater extraction in the area. The lower aquifer in some area is partial confined and in others is unconfined (one aquifer) or confined. In northern part of the study area, the thickness of the Nubian aquifer is small due to presence of the basement in depths range from 40 to 60 m.

The distribution of the static water levels in lower aquifer in all area near the Nile and Blue Nile is near from the surface. And this illustrates the importance of the Nile and Blue Nile in the recharge.

Groundwater in the Lower aquifer in the study area is fit for drinking due to the total dissolved solid distribution except Elaolyab2 area (BH10) records high value (522 mg/L). The electrical conductivity (EC) values of the lower aquifer water show distribution almost similar to that of the total dissolved solids.

5. ACKNOWLEDGEMENTS

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