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Hydro-morphometric and Hydrochemical Criteria to Select the Optimal Location for Small Dam in Um Al-Shibabit Valley, Al-Shirqat, Northern Iraq

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ABSTRACT

In this study, a morphometric analysis of the Um Al-Shibabit Valley basin has been done. It reflects that Um Al-Shibabit Valley is of the 7th order valley consisting of two sub-basins (northern and southern). The Valleys of two parts of the basin are linked about 6 kilometers from the Tigris River. The areal, shape, discharge, and topographic properties of the basin are determined. The area, perimeter, length, and width of the basin are 295 km², 80 km, 24 km, and 14.5 km, respectively. The shape is intermediate between circular and a rectangular basin. The discharge characteristics reveal a quick access of the downstream floods during heavy rainstorms. The hydro-chemical properties of water in the valley are studied. The chemical analyses reflect a high salinity in the upstream, near Mehha Saltern. The abundant salt in this part of the valley is sodium chloride, while the salinity decreased in the midstream to reach the lowest concentration near Ain Al-Baidha Spring. The concentration returns to increase toward the downstream, where NaCl and CaSO4.2H2O are the main salts; while in Ain Al-Baidha Spring, the main salt is CaSO4.2H2O. The water of the valley is usable for animal drinking, construction, and irrigation of crops, palm, barley, and wheat. Mineralogical and chemical diagnoses reflect that quartz, calcite, feldspar, gypsum, palygorskite, kaolinite, dolomite, and halite are the abundant minerals in the transported sediments in the valley. The optimum location selected according to the hydro-morphometric, hydro-chemical, and mineralogical conclusions is considered a location for the suggested small dam. The location is near the confluence of the two main branches of the valley. The study suggests that the separated high-salinity water at the upstream can be used for salt production and other industrial uses.

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الخصائص المورفومترية والهيدروكيميائية لاختيار الموقع الأمثل لسد صغير على وادي ام الشبابيط في قضاء الشرقاط، شمالي العراق

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الملخص

تم في هذه الدراسة إجراء التحليل المورفومتري لحوض وادي ام الشبابيط. تشير نتائج التحليل الى أن الوادي من الرتبة السابعة ويتكون من حوضين ثانويين (شمالي وجنوبي)، تلتقي الوديان المكونة للجزأين على بعد 6 كيلومترات عن مصب في نهر دجلة. تم حساب الخصائص المساحية والشكلية والتصريفية والتضاريسية للحوض، اسفرت النتائج ان مساحة الحوض ٢٩٥ كم ومحيطه ٨٠ كم وطوله ٢٤ كم وعرضه ١٤.٥ كم، وأن شكله يمثل حالة وسطية ما بين الدائري والمستطيل. تشير خصائصه التصريفية إلى وصول سريع للموجات الفيضية إلى المصب عند زخات المطر الشديدة. درست الخواص الهيدروكيميائية لمياه الوادي وتبين ارتفاع ملوحة المياه في اعالي الوادي قرب مملحة محة وان الملح في الوادي هو ملح كلوريد الصوديوم وخصوصا في أعاليه، أما في وسط الحوض فان الملوحة تقل تدريجيا لتكون اقل ما يمكن عند عين البيضة، ثم تعود للزيادة باتجاه المصب، وأن الملح السائد في هذه المواقع هو أيضا كلوريد الصوديوم يليه الجبس، ماعدا في عين البيضة فان الجبس هو الملح السائد، وأن مياه الحوض في جميع المواقع عدا أعالي الوادي تصلح لشرب الحيوان وللبناء والإنشاءات ولري المحاصيل والنخيل والخضار الإستراتيجية في المنطقة تم تشخيص معادن الـ (dolomite, kaolinite, palygorskite, gypsum, feldspar, calcite, quartz and Halite) كمعادن سائدة في الرسوبيات المنقولة في الوادي، وهذا ما عززته التحليلات الجيوكيميائية لرسوبيات الوديان. بناءا على المعطيات الهيدرومورفومترية والهيدروكيميائية ومعدنية الرسوبيات تم انتخاب المقطع المثالي، الذي يقترح ان ينشأ عنده السد بعد التقاء الوديان الرئيسة القادمة من جزئي الحوض الجنوبي والشمالي بعد عزل مياه أعالي الوادي ذات المحتوى الملحي العالي، واقتراح استثمار مياهه في إنتاج الملح أو الاستخدامات الصناعية الأخرى.

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Introduction

Water has been an important factor in humanity and the emergence of civilizations because of its attraction, which has paved the way for human societies as a verified basis for their first step in residing near natural water resources (Hussein and Salih, 2024). Water crisis is a term that indicates the scarcity of suitable water for human use and water pollution. The water crisis is affected by geographical, political, economic, and cultural factors, which require the development of techniques of water use and management with scientific methods (Badawy et al., 2023). Studies indicate that the solution is to find a perfect integrated way to manage the available water sources, and one of the ways that leads to such management is to study the valley's hydrology. Developing water sources within the region is the biggest challenge facing decision-makers, given the diminishing water resources on the one hand and the increasing demands on the other. The study of valley water storage is one of the most important solutions for developing water resources and their sustainable management.

Location of Study Area

The study area is undulated, and it is located in the west and south-west of the city of Al-Shirqat, north of Iraq, between the geographic coordinates (longitudes 43° 0' 27.7" E -43° 14' 37.9" E and latitudes 35° 21' 59.1" N -35° 38' 25.9" N). The height of the basin reaches 250 m (a.s.l) in the west, and slopes to the east, reaching a height reaches 150 m (a.s.l). The valley meets with the Tigris River southeast of Al-Shirqat, which is the last drainage order in the watershed that represents the Um Al-Shibabit valley. This valley runs seasonally and reaches its peak in the winter, especially during heavy rainfall (Fig. 1). The valley dries up in the summer, which calls for thinking about storing water in the valley and recycling it during the dry period.

Geological Background

Geologically, the gypsum and clay beds are exposed within the Fatha Formation (Middle Miocene) in most of the basin, especially in its western part, and it consists of cycles of gypsum, anhydrite, and marl, in addition to friable rocks in the upper part of the formation. Moreover, there are layers of salt rock within the basin depth (Al-Juboury et al., 2001). These layers of salt rock could be the main source of table salt dissolved in water, as will come later.

The valley breaks through a sediment strip on the west bank of the Tigris River and flows into the river south of Al-Shirqat (Salih et al., 2012).

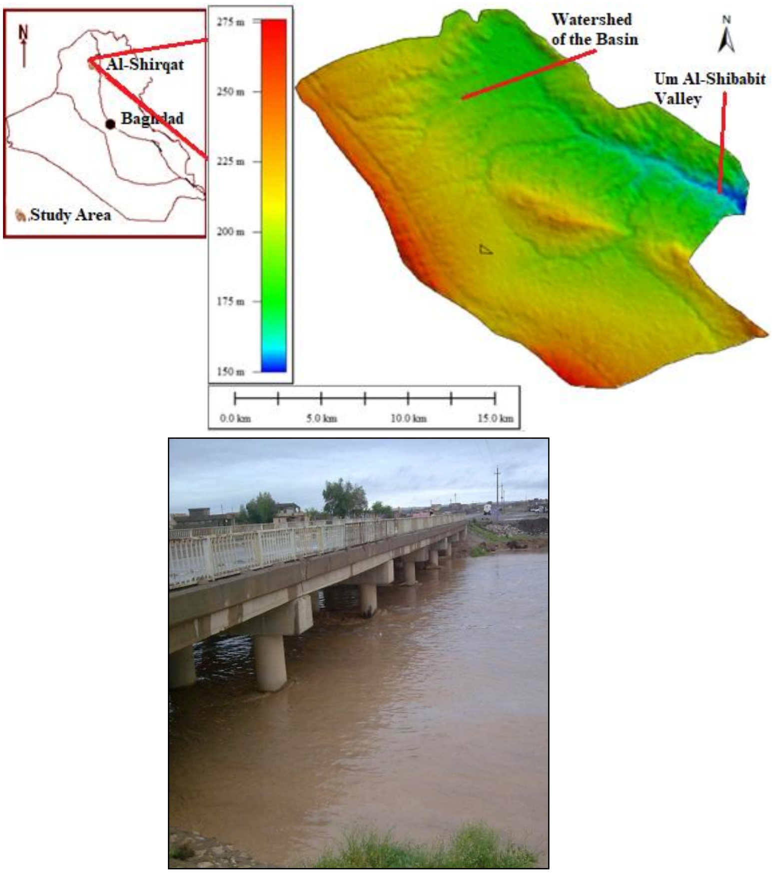

Fig. 1. Um Al-Shibabit basin location, with 2D DEM, and Um Al-Shibabit Valley bridge near Al-Khusum village during the flood.

This study is of great importance in investing in the valley's water resources to develop the region, especially in increasing the area of agricultural land and natural pastures.

The study aims to carry out morphometric analyses of the area and to diagnose the valley's orders; hence, determining the perfect locations for storing water at the convergence of the major valleys. The qualitative properties of the valleys' water have been discussed, classified, and evaluated for various purposes. The sediment and mineral load of the valley are discussed as important factors for the future problems that may occur in the suggested dam reservoir. The study also evaluates the possible uses of the clayey sediments.

Materials and Methods

The Digital Elevation Model (DEM) that covers the study location is used to extract the geomorphological and geometric features; the boundaries of the watershed were derived from the DEM produced by the United States Geological Survey (USGS) of 10X10m spatial resolution. By applying the global mapper V.13 software and the ArcGIS V. 10.8 software, these data are used to derive and distinguish the drainage orders and to determine the optimum location of the dam.

Watershed characteristics: The Arc GIS 10.8 and Global Mapper 13 systems are used to derive the outer boundaries of the river basin and its parameters, basin area, and highest and lowest points at numerous heights within the area. Then, the geographic information system ArcGIS 10.8 is used to extract layers, where each one of them represents the drainage orders of the river. These orders are extracted from the DEM and topographic maps of the area with a scale of (1:25000); then, they are checked using the American Satellite Imager Landsat-8 for the area in 2013. The number and lengths of the valleys in each order of the database of each layer, the real and ideal length, and the width of the basin are extracted.

Eight water samples from the valleys were collected during the 2^{nd} heavy rain in the wet season from upstream towards downstream. Chemical analytics were performed at the laboratories of the General Company for Geological Survey and Mining to classify and evaluate the water samples for different uses and show the variations of the properties with the direction of flow.

Accordingly, chemical analyses are performed to determine the concentrations of major cations Ca^{++}, Mg^{++}, Na^{+}, K^{+}, and major anions NO_3^-, Cl^-, HCO_3^-, and SO_4^- in ppm. Other physicochemical parameters, such as TDS, EC, and pH, are measured as well. The analyses are accomplished in the laboratories of the General Company of Geological Survey and Mining.

Five geological samples are selected to isolate the clay's suspended loads to perform chemical, mineral, and grain size analyses in the General Company for Geological and Mineral Survey to determine its source, to evaluate it for different uses, and to treat the engineering problems that resulted in the bottom of the reservoir.

Results and discussion

Hydro-morphometric analysis

It is considered one of the most appropriate methods for quantitatively describing and classifying river basins based on capacity, parameters, length, width, and variation of land surface heights and the length and number of valleys and their branches (Strahler, 1954).

The morphometric analysis is of great importance because it provides a method of assembling the drainage of the water and the arrival of the flood waves on the side of the water drainage (Badowi et al., 2024). The morphometric characteristics are measured based on the equations of Strahler (1954; in Mohammad et al., 2024).

These numerical, longitudinal, and areal data of the basin are used to calculate all its hydro-morphometric properties (Fig. 2).

The *stream orders* are the numerical grade of the tributaries that form the basin drainage network, so each tiny stream is connected with the other to form another stream that has a higher order, and this, in turn, connects to a symmetry system to be the highest order, etc. (Mohammad et al., 2024).

The *numbers and lengths* of the valleys were inserted within seven orders as given in Table 1, in which Um Al-Shibabit is considered to be of the seventh order. The bifurcation ratio is an important measure that controls the surface drainage rate, and it represents the ratio between the number of streams in the specified order to the number of streams in the next higher order (Al-Babawati, 1995).

The *bifurcations* remained similar (up to 2) for all the higher orders (the upstream of the basin) except the last order (which is close to the estuary) decreased to 0.36; this is because the basin consists of two sub-basins (separated by the light green line). They meet at the last order; the values of the drainage orders and the calculated drainage characteristics are listed in Table 1. The drainage density is a measure of the ability of the valleys to transport the rainwater toward the estuary. The drainage increases with the increase of the capacity, and it usually increases in areas with heavy rainfall, especially the areas that have surface clay beds with low permeability (Al-Juboury, 2009).

The *stream frequency* is calculated depending on the total ratio of valley numbers in all the orders to the basin area; it has reached 8.22 km in the basin, which is medium density according to the Strahler classification (1962), while the longitudinal drainage density (ratio of the total lengths of the valleys basin to its area) is low according to the same classification which amounted (3.36 km/km^2). As for the proportional density of the valleys, which represents the ratio of numerical density to the square of longitudinal density which reaching (0.73 valley/km). As for the low-density drainage under drought conditions and lack of rain reduces the chance of developing the upper levels of the basin river beds and increases their area. The intensity of the drainage is of great importance because it reflects the speed of the drainage waves traveling from parts of the basin towards the main channel to reach the drainage peak (Mustafa et al., 2024; Hussein and Salih, 2023). And it represents the numerical ratio between the longitudinal density and to numerical density, and the little value (0.41) means that the basin is still young and has a high drainage capacity.

River turns are evaluated by the deflection factor, which represents the ratio of the true length of the main valley to its ideal length (the shortest distance between the source and estuary of the river), as this factor reflects the problems caused by river deflections (Schumn, 1956; in Al-Juboury, 2009). The increase in the deflection means an increase in the river twists. Consequently, it increases in evaporation and leaching in the riverbed and complications in the geomorphologic situation on the deflection sides, as sedimentation occurs on one side and erosion on the other, the value of the deflection factor of the basin is very low (1.04), which shows the lack of curves.

Table 1: The river orders and calculated drainage characteristics for the Um Al-Shibabit catchment area

Order	No of Valleys	Length of Valleys (km)	Bifurcation ratio	Property	Value
1st	1819	483.312		Stream Frequency valley/km^2	8.22
2nd	456	234.707	1/2→3.99	Numerical Drainage Density km/km^2	3.36
3rd	114	125.229	2/3→4	Valleys' relative density valley/km	0.73
4th	29	72.785	3/4→3.93	Drainage intensity	0.41
5th	8	41.797	4/5→3.63	Sinuosity factor	1.04
6th	2	26.848	5/6→4		
7th	1	8.493	6/7→2		
Total	2429	993.171			

Geospatial characteristics: It specializes in the basin's geometric dimensions and the difference between them; a group of climate factors, rock types, and tectonic movements (Al-Khuzamy, 2004) affect these characteristics. They increase with the increase of water erosion and the weakness of the rocks' resistance and erosion activity, which may lead to lowering the base level or the occurrence of river capture (Al-Muhsin and Al-Azzawi, 2002). The basin area is important because it controls the water flow and obtains quantitative relationships by evaluating the hydrology of the basin. The difference between the basin's length and width is not significant, which may cause rapid water splashes during heavy rain showers, which may be taken into consideration when designing the dam and choosing the nominated low topography for storage (Table 2).

Table 2: Area characteristics of the Um Al-Shibabit drainage basin.

The actual length km	Ideal length km	Basin width km	Parameter km	Area km^2
24.2	23.16	14.5	79.46	295.32

Shape characteristics: It is used to evaluate basin hydrology. The elongation value indicates that the basin is closer to a circular shape than a rectangular with a value close to (1), which is due to the sharp differences in the hardness of the detector of the rock layers. The sharp contrast in climatic conditions was indicated by the evaluation of the circulation (basin consistency ratio), which exceeded 0.5, showing that the basin has an irregular flow temporally and high drainage during heavy rainstorms, in addition to the high sedimentary load.

As for the formal factor, which describes how wide the basin is along the stream, is (0.5). That also shows how wide the basin is towards the splitting area. The factor decreases towards the estuary, but the existence of two central valley's divides the basin into two sub-basins. As for the fusion factor of the basin, which is judged by the relationship between the perimeter and area of the basin, its value may suggest the large meanders of the valley's perimeter.

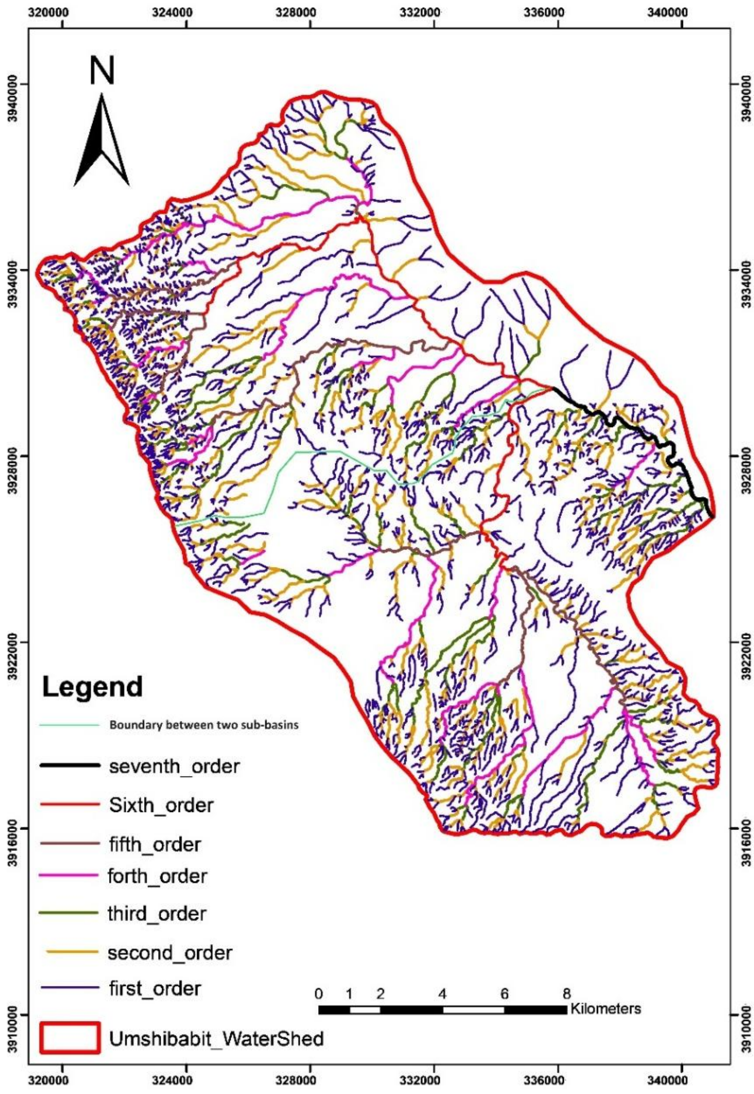

Fig. 2. Boundaries and stream orders of Um Al-Shibabit Valley and locations of the samples.

The proportion of the grip of the perimeter exceeded 1, which indicates the purpose of its staying away from the circular shape, but not to the stage that changes its rectangular shape. It means that its roundness is medium, so all these factors will control the design of the dam, and the selection of the suggested site (Table 3).

Table 3: The formal characteristics of Um Al-Shibabit Valley

elongation	rotation	shape factor	Pear shape	Integration factor	Perimeter cohesion
0.8	0.59	0.5	0.02	268.5	1.3

Terrain characteristics: Their importance lies in the evaluation of erosion activity, which depends on the nature of the basin rocks, and the high values indicate the terrain range and demolition activities (Mahsoub, 1980). The terrain ratios indicate the relationship between the basin terrain and its perimeter length, and they express its regression; the ratio rises whenever the difference between the highest and lowest points is more significant (Verstaphen, 1983). We infer from the high terrain values of the basin (107 km/km^2) that it has high terrain quality, which is an important indicator of high regression. The value of roughness increases with the increase of drainage density of the basin and the increase of terrain quality, which means the arrival of flood waves during heavy rainstorms (Mustafa, 1998). The highest and lowest points in the basin and its actual length, with an average value in the Um Al-Shibabit basin (0.005), show the high activity of sculpturing. Hypsometric integration is a criterion of the stages of the erosive cycle. Its lower value is (2.17 km/km^2) in the Um Al-Shibabit basin (Table 4). The basins have small areas, and it is still at the beginning of their erosive cycle (Abu Al-Enein, 1990; Al-Juboury, 2009).

Table 4: Terrain characteristics of the Um Al-Shibabit basin.

Terrain ratio (m/km)	Roughness value (km/km^2)	terrain average	Hypsometric integration (km^2/m)
1.7	5.75	0.005	2.17

Hydrochemistry of the water of Um Al-Shibabit

The types and concentrations of dissolved salts depend on their interaction with the rocks or soil preparation of the rocks and the speed of the water. Human activities may affect the concentrations of these materials in water, like irrigation and fertilization, and urban uses. The water quality is a primary factor of its usability for various uses, including the uses for which the dams are created. The water quality changes in different locations along the valley streams are also crucial for choosing the appropriate sites for water storage; the results of hydrochemical analyses to determine the concentrations of ions are included in Table 5.

Table 5: Concentrations of the major cations and anions in ppm units.

No.	Name	Ca^{++} ppm	Mg^{++} ppm	Na^{+} ppm	K^{+} ppm	$NO_3^{=}$ ppm	HCO_3^{-} ppm	$SO_4^{=}$ ppm	Cl^{-} ppm
1	Upstream of Um Al-Shibabit	441	221	1884	10.1	54	79	1640	3053
2	Gedhaib Valley	301	105	540	6.7	0	122	1406	710
3	Al Shouk Valley	232	8.82	574	10.1	0	79	781	710
4	Khudaira Valley	232	108	539	5.8	49	116	1028	710
5	Before Ain Al-Baidha	449	67	341	6.1	16	111	1480	355
6	Ain Al-Baidha	369	21	87	5.8	7	117	956	71
7	Jumalia Jadida	441	96	732	7.4	27	104	1661	888
8	Um Al-Shibabit Bridge	440	89	696	7.2	69	68	1640	817

pH is also measured. The Total Dissolved Solids (TDS) and the salts were measured from the total dissolved ions to demonstrate the accuracy of the analysis by their compatibility with TDS. The total hardship of TDS is calculated due to its importance in determining the usability of water for different uses (Najeeb et al., 2021). As the sum of the concentrations of the positive and negative ions concentrations are calculated in (ppm) to calculate the average of errors of the analysis by the ion balance (Mazor, 1990). Its value was lower than 1% in all samples, and the results are included in Table 6. The average error values show the accuracy of the analysis, which is acceptable according to the Mazor formula that assumes the ratio should be less than

5%; this is confirmed by the linear relationship between the CTDS and TDS concentration values with a correlation R^2=0.98 (Fig. 3).

The pH value is almost equivalent in all water samples, as the salinity was high in the upstream of the valley (near Mahha) compared to the other sites. This is due to the presence of rising salty water in the form of seepage from deep water sources in the Fatha Aquifer, which is rich with dissolved salts, as the formation is characterized by the presence of gypsum and halite salt layers or domes among its components (Jassim and Goff, 2006). The salinity starts to decrease towards the stream as a result of contributions of Kudhaib valley, Al-Shouk valley, and Khudhaira valley to Ain Al-Baidha, where the salinity decreased to the lowest limit at this spring and the other close freshwater springs. The salinity starts to increase towards the stream where the main valley meets the valleys of the southern sub-basins. Table 6 exhibits pH, dissolved salts, and intractability of Um Al-Shibabit water, and the chemical analysis error ratio.

Table 6: pH, dissolved salts, and intractability of Um Al-Shibabit water, and chemical analytics error ratio.

No.	Name	pH	TDS	TH	Cation epm	Anion epm	Error
1	Upstream of Um Al-Shibabit	6.69	7399	2006	122.37	122.44	%0.03-
2	Gedhaib Valley	7.27	3264	1183	51.70	51.30	%0.39
3	Al Shouk Valley	7.00	2440	617	37.59	37.60	%0.02-
4	Khudaira Valley	6.72	2864	1025	44.11	44.12	%0.01-
5	Before Ain Al-Baidha	7.02	2984	1398	42.93	42.91	%0.03
6	Ain Al-Baidha	7.20	1616	1009	24.11	23.94	%0.36
7	Jumalia Jadida	7.20	4080	1497	61.95	61.75	%0.16
8	Um Al-Shibabit Bridge	7.30	3940	1469	59.82	59.42	%0.34

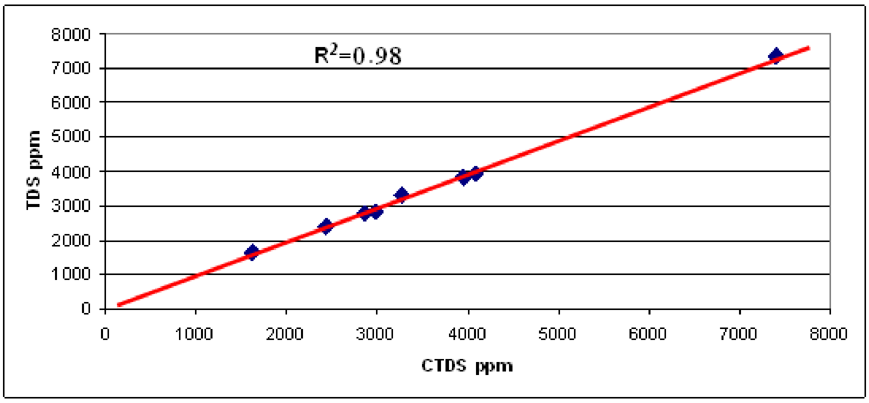

Fig.3. Linear relationship between the concentration values CTDS and TDS in different locations along the valley of Um Al-Shibabit.

The results of the chemical analyses reflect a large variation in the concentration of major ions from one site to another along the valley due to the contribution of the other tributaries to bringing water with different hydrochemical properties that reflect the watershed conditions of each tributary separately (Fig. 4).

For example, a large increase in the concentrations of sodium (positive) and chloride (negative) is observed in the upstream of the valley compared to the rest of the ions in the same site. And as for their concentrations in the rest of the sites, due to the presence of sources of rising salty water in the form of leaching from deep water in the Fatha forming reservoir, as mentioned before (Fig. 5).

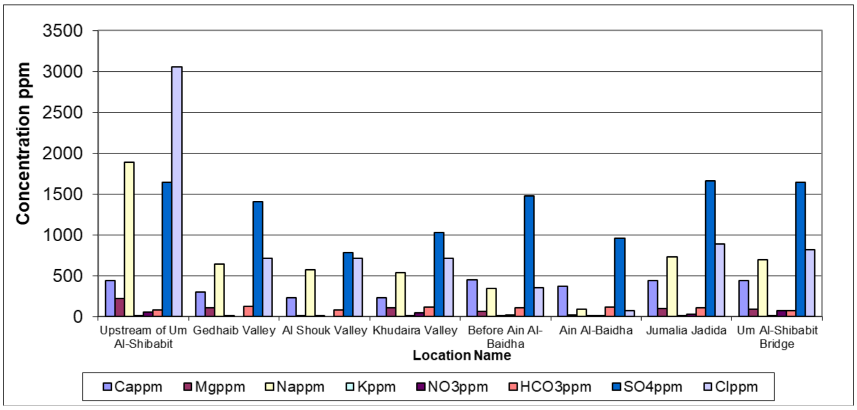

Fig.4. Variation of dissolved ion concentrations along Um Al-Shibabit valley stream.

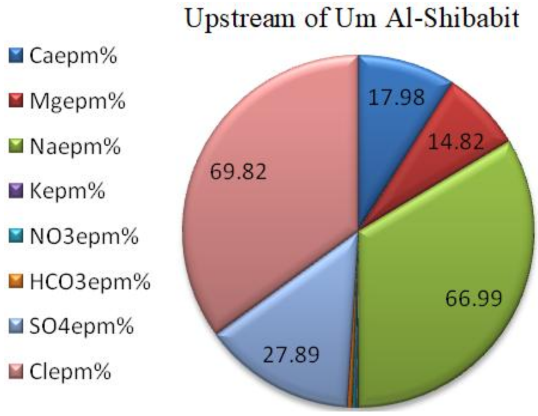

Fig.5. Prevalence of the concentration ratios of magnesium and sodium in the upstream of Um Al-Shibabit, where NaCl is the most available salt.

The prevalence of these two ions continues in the rest of the sites except in Ain Al-Baidha. As for the concentrations of calcium (positive) and sulfates (negative), they come in the second order as a result of the dissolving the gypsum rocks and they are the most common in Ain Al-Baidha where their source of nutrition is far from layers rich in salt (halite) (Fig. 6). Bicarbonate and magnesium concentrations are a little lower in the valley water as a reflect of lack of carbonate rocks within the basin outcrops. Potassium concentration is very low, which is typical for this ion that always coexists subordinately with sodium ions in salty rocks.

The chemical analyses' results are projected onto the triple Piper projection chart to classify the water at different locations and to indicate its hydrochemical potential. This chart shows that Ain Al-Baidha water is within the normal alkaline groundwater, in which sulfur mien is prevalent. In contrast, the rest samples are within alkaline water, in which chloride or chloride-sulfate is prevalent (Fig. 7).

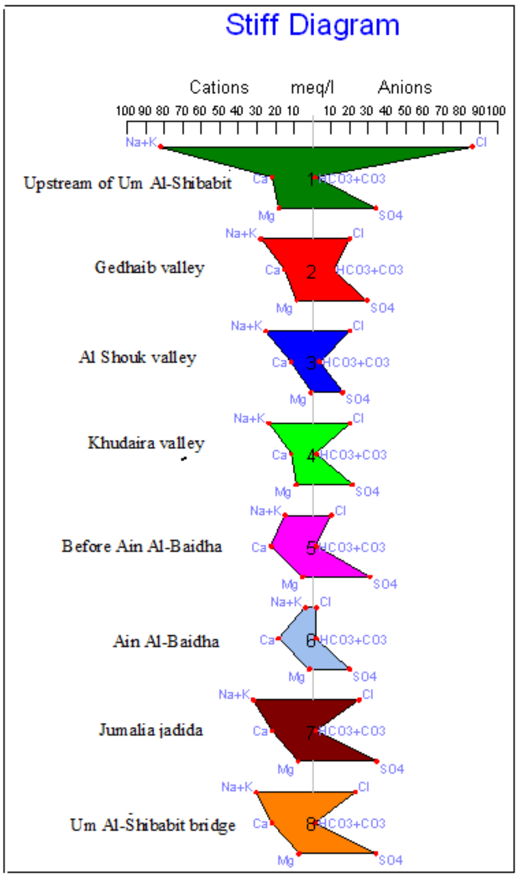

Fig. 6. Distribution of the concentration of the positive and negative ions on the Stiff Chart with meq/1 units, and the prevalence of positive (sodium) and negative (chloride) is illustrated.

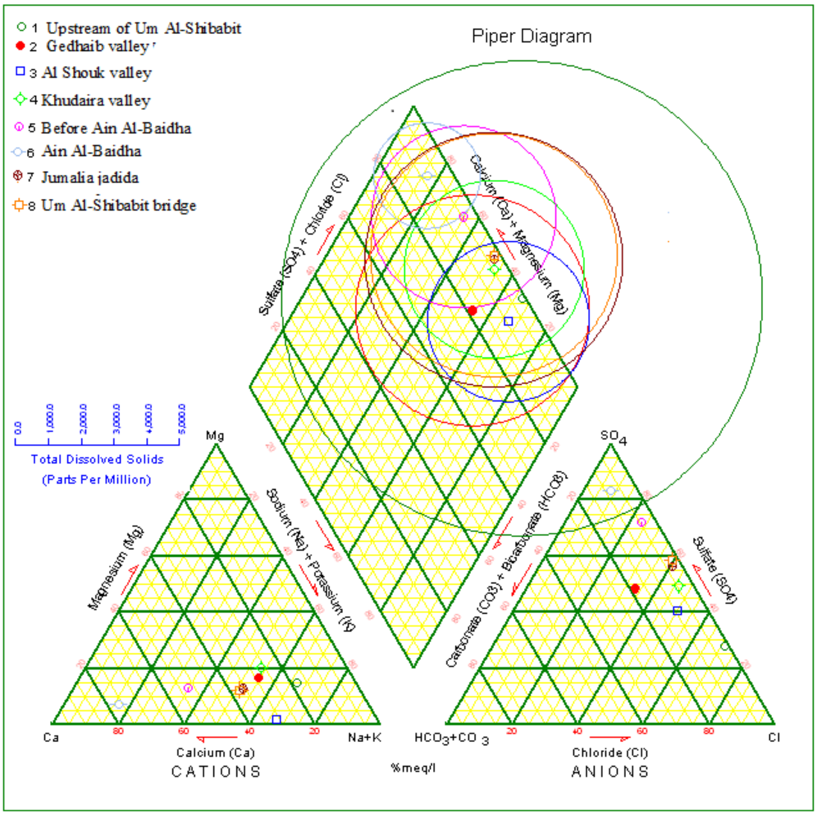

Fig. 7. Chemical ions projection on the triple Piper chart.

The ion concentrations are converted into ppm units as given in Table (6), then to epm units, then at last to epm% as listed in Table (7) to calculate the hypothetical salt combination for each mentioned used method mentioned (Collins, 1976) listed in Table (8). It is shown in this table that the prevalent default salt is NaCl, especially in the heights that reach 66.99% and may reach more than 95% after the water goes through the drying and sedimentation cycle. This makes it a promising area for investment in the salt industry or other industries, such as caustic soda, that require isolation in the case of thinking about storing water in the valley, and this site is unique in the lack of Na_2SO_4 and a low concentration of $MgSO_4$ (3.49%).

Table 7: Major ion concentrations (in epm%) dissolved in the water of Um Al-Shibabit.

No.	Name	Ca^{++} epm%	Mg^{++} epm%	Na^{+} epm%	K^{+} epm%	$NO_3^{=}$ epm%	HCO_3^{-} epm%	$SO_4^{=}$ epm%	Cl^{-} epm%
1	Upstream of Um Al-Shibabit	17.98	14.82	66.99	0.21	0.71	1.06	27.89	69.81
2	Gedhaib Valley	29.01	16.76	53.9	0.33	0	3.9	57.06	39.04
3	Al Shouk Valley	30.86	1.93	66.52	0.68	0	3.46	43.27	53.27
4	Khudaira Valley	26.3	20.22	53.15	0.34	1.79	4.31	48.5	45.4
5	Before Ain Al-Baidha	52.18	12.92	34.55	0.36	0.6	4.24	71.82	23.34
6	Ain Al-Baidha	76.32	7.31	15.75	0.62	0.47	8.02	83.14	8.37
7	Jumalia jadida	35.51	12.8	51.38	0.31	0.7	2.75	56	40.55
8	Um Al-Shibabit bridge	36.78	12.3	50.61	0.31	1.87	1.88	57.48	38.76

Table 8: Default salt combination (in epm%) from UmAl-Shibabit water.

No.	Name	$CaCO_3$	$CaSO_4$	$MgSO_4$	$MgCl_2$	Na_2SO_4	NaCl	KCl	Total
1	Upstream of Um Al-Shibabit	1.07	16.91	11.33	3.49	0	66.99	0.21	100
2	Gedhaib valley	3.90	25.11	16.76	0	15.19	38.71	0.33	100
3	Al Shouk valley	3.46	27.40	1.93	0	13.94	52.58	0.69	100
4	Khudaira valley	4.39	21.91	20.22	0	7.25	45.90	0.33	100
5	Before Ain Al-Baidha	4.27	47.91	12.92	0	11.42	23.13	0.35	100
6	Ain Al-Baidha	8.06	68.26	7.31	0	7.96	7.79	0.62	100
7	Jumalia jadida	2.77	32.74	12.8	0	10.85	40.53	0.31	100
8	Um Al-Shibabit bridge	1.92	34.86	12.3	0	11.42	39.19	0.31	100

Gypsum ($CaSO_4.2H_2O$) is the prevalent salt near Ain Al-Baidha with a ratio of 49.91% before it and 68, 26% beyond it; this indicates that the source of its sustenance is from karst cavities, cracks, and fractures of the gypsum layers in the orifice formation. Its continuous flowing and the short-term stay of its water in its middle host made the concentrations of its total salts low. As for the points confined between the upper valley and Ain Al-Baidha, the ratio of gypsum order is the second after halite, and this is expected in an area with outcrops that are rich in gypsum. As for the points after Ain Al-Baidha towards the downstream, the waters of the valleys of the sub-basin that meet the central valley raise the gypsum ratios to be close to the halite ratios, which is no more than 40% for both salts. As for Na_2SO_4 and $MgSO_4$, their ratios are low and not more than 20% at Ain Al-Baidha, where carbonates are present in a small proportion and interfere with gypsum rocks. As for sulphate salt, it is the least among all salts as its ratio does not reach 1%. This has technical benefits in the case of investing in the upper valley for the salt industry, as it is easy to separate it from halite.

To evaluate the study area waters for drinking purposes, the concentrations of dissolved and salinity ions, the pH, and total hardness listed in Tables 5 and 6 are compared with the Iraqi standards of drinking water (IQS, 2009) and with the international standard specifications of WHO (2024). It is found that this water is not suitable for human consumption, but can be used for animal drinking by comparison with the Altoviski (1962) specifications, whose classification is adopted to decide the suitability of the basin's water for construction purposes. And it is found that it is suitable in all sites for this purpose except at the top of the basin near the Mahha area.

From the comparison of different ions, solidity, and hardness with the standard specifications of the irrigation waters (Ayres and Westcot, 1989) and with the extent to which crops tolerate the concentration of salts (Todd, 1980), it can be said that this water (except at the upper valley) is suitable for irrigation of different field crops such as barley, cotton, sunflower, corn and wheat, also vegetables such as tomato, cucumber, onion, and palm. It is preferable to use the modern irrigation methods that reduce the effect of salinity.

Analysis of clay and non-clay minerals in the recent sediments of Um Al-Shibabit valley and its branches is carried out for the untreated clay samples using X-ray diffraction (XRD). It is found that the results of the current mineral analysis show the presence of the following minerals: palygorskite, kaolinite, and non-clay minerals (quartz, feldspar, calcite, and dolomite) (Table 9). The clay minerals are distinguished depending on the base reflections and other unique reflections for each mineral, following Mustafa et al. (2022).

Palygorskite is a clay mineral that is formed in certain environments where calcite and dolomite, especially the fibrous type, are formed together (Sudo et al., 1981), as shown in Figure 8.

Kaolinite is distinguished based on the base reflection (7.13) Angstrom to the levels (0.01) and (3.58) (Carroll, 1970; Brindly and Brown, 1980) as shown in figure (8).

Clay minerals represent one of the most important essential mineral components in rocks and clay deposits, and these minerals may be either from clastic rocks origin, locally formed, or from a transformative origin and thus have great importance in knowing the prevailing climatic and environmental conditions at the time of their sedimentary deposits. To know the original rocks from which they were derived, or to know the impact of the transformation process affecting their formation.

The main clay minerals shown in the current studies are kaolinite and palygorskite, while the non-clay minerals include quartz, feldspar, calcite, and dolomite (Table 9, Fig. 8). The presence of palygorskite in the claystone sample is under study, and this indicates the local origin of this mineral. The palygorskite belongs to the group of clay minerals with fibrous textures (inosilicate double chain) and is the hydrated magnesium-aluminum silicate. Many studies have shown that this mineral is more locally formed or (informed) more than any other origin. Thus, it is considered one of the minerals that are useful in confirming the origin of the ancient climate (paleoclimatic indicators) as it is formed in dry and semi-dry soils (Singer, 1980). Special chemical conditions form it, and its presence is associated with carbonate rocks, especially dolomite, due to its prevalence of evaporation origin. Magnesium, with a high concentration and high pH, is also necessary to form this mineral (Banat, 1980).

Table 9: Results of XRD analysis representing clay and non-clay minerals in selected deposits of Um Al-Shibabit Valley.

No.	Name	XRD
1	Upstream of Um Al-Shibabit	Quartz, Calcite, Feldspar, Gypsum, Palygorskite, Kaolinite, Dolomite
2	Gedhaib Valley	Quartz, Calcite, Feldspar, Gypsum, Palygorskite, Kaolinite, Dolomite
3	Khudaira Valley	Quartz, Calcite, Feldspar, Gypsum, Palygorskite, Kaolinite, Dolomite
4	Ain Al-Baidha	Quartz, Calcite, Feldspar, Gypsum, Palygorskite, Kaolinite, Dolomite
5	Um Al-Shibabit Bridge	Quartz, Calcite, Feldspar, Gypsum, Palygorskite, Kaolinite, Dolomite, Halite

The most suitable environment for this mineral to form is underground (subaerial) (Chamley and Muller, 1991), where the appropriate environmental conditions for the presence of palygorskite are available.

As for the rest minerals, they are detrital, and this also matches with the percentage of the potassium-feldspar, which is commonly found in sandy sediments of the rocks of the upper crater unit to form the orifice, which is considered one of the most important structures exposed in the region, providing clastic deposits in the valleys (Al-Juboury, et al., 2001). As for kaolinite, it is formed from the crushing of igneous rock fragments rich in potassium feldspar. Grim (1968) showed that the kaolinite could be formed in flood environments (fluviatile) or near shore, and is formed due to the excavation of other minerals, as shown by Parham (1966), that the presence of kaolinite indicates its presence in evaporation environments. From what aforementioned previously mentioned, we note that there is a significant relationship between the identified clay minerals and the other carbonate minerals associated with them, such as calcite and dolomite. As for quartz and feldspar minerals, they are usually formed from the excavation of sandstone in sediments of the formations exposed in the area.

The presence of the evaporite minerals such as gypsum and halite is also associated with either the crushed rocks that contain these minerals in situ and from a nearby source, or it represents one of the minerals that was formed from evaporation due to high temperature and scarcity of rain, especially since the valley flows from a low evaporative.

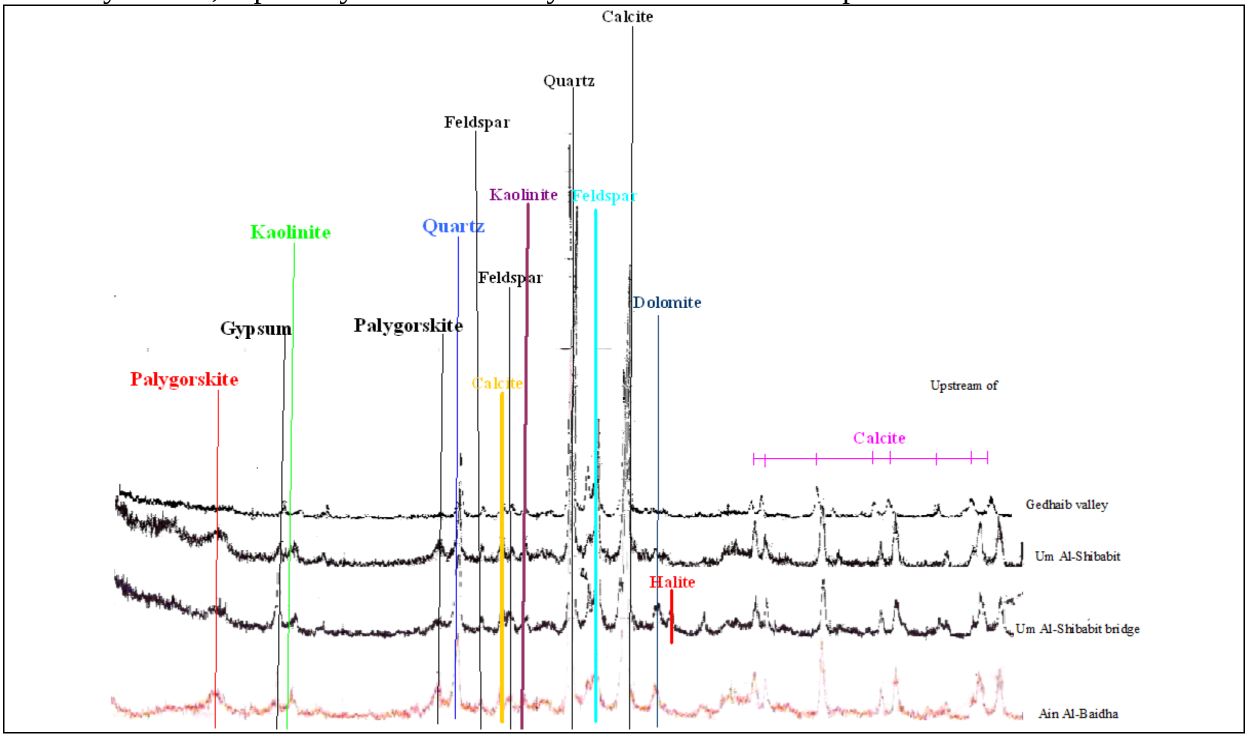

Fig. 8. Diffractograms of clay-separated components in a recent sediment sample of secondary valleys supplying Um Al-Shibabit.

The results of the geochemical analysis of the valley sediments were in agreement with the results of the mineral analysis. As the insoluble components formed the main component of the sediments, including quartz, clay minerals, and feldspar, it is noted that there is a significant ratio of silicon dioxide, a lack of salts washed into the valley's water, and a lack of organic materials (Fig. 9).

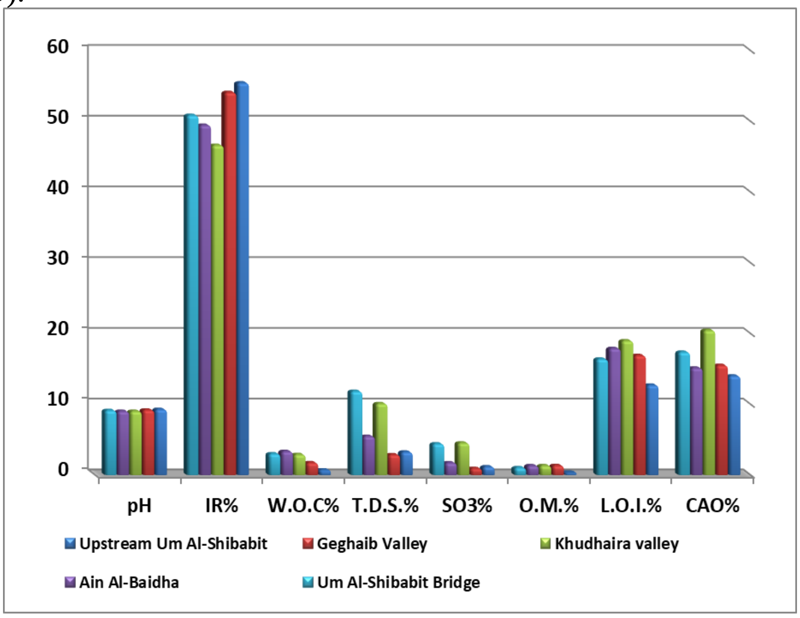

Fig. 9. Contrast of the geochemical characteristics of the sediments of Um Al-Shibabit valley.

Selection of the suggested dam site

The selection of a site for constructing a dam is not easy. It must be taken into consideration all the geomorphological, morphometric, and hydrological variables, the land ownership, land uses, groundwater conditions, and engineering conditions properties of the rocks, and the availability of dam construction materials in the presence of a topographic depression suitable for storage. These conditions may be less in the case of establishing small dams on seasonal valleys under study.

The morphometric analysis produces several data points, including the large number of orders in the basin compared to its area, as it was classified as seventh, and there were two northern and southern sub-basins, and the valley that formed them met 6 km away from the Tigris estuary.

Its shape represents a mid-shape between rectangular and circular. Its drainage characteristics show a rapid arrival of flood waves downstream in severe rainstorms. This encourages the idea of constructing the dam immediately after the meeting point to ensure the benefits of both of the sub-watersheds and also not getting closer to the Tigris River to guarantee the optimal benefit of the water storage.

The hydrochemical properties of the valley waters are studied. And the increase of the salt in the water is shown in the upper valley near Mahha. As for the middle of the basin, the salinity decreased gradually to reach the least amount in Ain Al Baidha. Then it starts to increase again until reaching the river estuary, so it is preferable to separate or isolate the salty part of the basin in the upper valley for the salt industry purposes or other industrial investments, and to avoid harming the stored waters.

The digital elevation model is used to derive the topographic section of the valley at the convergence point of the two sub-basins, which represents a topographic gorge that secures the water storage in the lower part of the basin at a depth of 5 m. The cross-sectional width reaches less than 600 m, where the cross-section is an important factor in the design and cost of dams, as for the financial and constructional material needed for this purpose (Fig. 10).

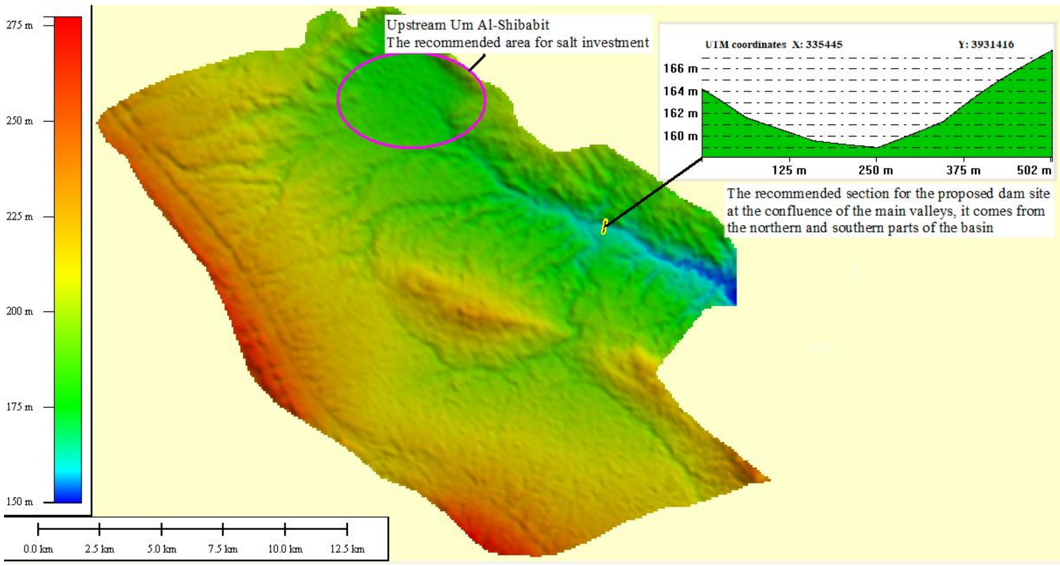

Fig. 10. Topographic section and suggested site for water storage and the nominated area for isolation in the upper area of Um Al-Shibabit

Conclusions

The areal, shape, topographic, and drainage characteristics indicated that the rapid arrival of flood peaks to the suggested dam site should be taken into consideration for the dam design. The analysis shows that the existence of two sub-basins, north and south, within the central basin is determinant in selecting the location of the proposed dam. The hydrochemical and default salt studies show an increasing concentration of salts, especially table salt, in the upper basin, which should be separated to secure the type of water in the basin. The hydrochemical properties reflect the validity of the valley waters for agricultural and constructional purposes, as well as for human consumption, except for the upper basin. Based on the above-mentioned, the study recommends stopping the random construction and housing towards the sides of valleys and establishing factories for the production of table salt and caustic soda in sites that are rich in sodium chloride.

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