REPUBLIC OF LEBANON

MINISTRY OF ENERGY AND WATER

GEOLOGICAL AND HYDROGEOLOGICAL STUDY WITHIN HELTA REGION

Final Report

January 2014

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1 GEOLOGY OF HELTA-HELTA AREA

The geological investigation of the study area is originally based on the previous work done on north region. The bulk of information has been analyzed from stratigraphical work done by L. Dubertret. In addition, several techniques were utilized to modify the geological map and, hence, better understand the geology. These are particularly the remote sensing methods of MAPS photo satellite, aerial stereographic photographs with a scale 1/25000 (1963). Fieldwork also took an important share of the investigation. The final result is an up to date geological map with a 1/10000 scale (**Figure 1**) covering the study area and the proper understanding of the different geological aspects of this area such as: geomorphology, lithostratigraphy and structural geology.

1.1 GEOMORFOLOGY

The study area is characterized by a relatively moderate topography, and consists of the Turonian Formation and the Cenomanian Formation with an altitude between 550 and 800m above the sea level.

1.2 LITHO-STRATIGRAPHY

The outcropping rock formations in the study area extend from the Cenomanian Formation (C4) to the Turonian rock formation (C5).Furthermore, recent Quaternary alluviums and slope deposits especially in the plains, valleys, and along toes of the slopes.

1.2.1 Cenomanian Formation (C4)

This formation can be subdivided into 3 lithological units from bottom to top these are:

1) The lower Cenomanian rocks (C4a) which includes bioclastic limestones, yellowish marls and cherty limestones, thick bedded limestones, dolomites, and dolomitic limestones.
2) The middle Cenomanian rocks(C4b) that consists of a considerable limestone and dolomitic limestone block forming a cliff..
3) The upper Cenomanian rocks(C4c) which constituted of narrow beds of limestones with siliceous beds, thick beds of limestones and dolomitic limestones, and locally stratified light creamy limestones characterized by thin interbeds of cherty bands and nodules. The Upper Cenomanian formation covers almost all the study area. The average thickness of this formation is about 550m.

1.2.2 Turonian Formation (C5)

The Turonian rock formation has been divided into two different units since the beginning of the 20th century (1910 Douville and 1955 Dubertret). The stratigraphical investigations by SAINT-MARC, led to the refining of these two subdivisions: Basal Turonian Member and Terminal Turonian Member.
The former consists of dolomitic marls, dolomitic rocks, and dolomitic limestone rocks. It is characterized by the presence of Ammonites mega fossils. The latter, on the other hand, is characterized by the presence of Hippurites. In terms of lithology, the Terminal Member is

made up of dolomites limestones and dolomitic limestone rocks. Limestone outcrops exhibit different facies: oolitic, detrital, crystalline, lensoid, and silicified. The dolostones are coarse grained, light-brown color, they have a sugary texture and are fairly compacted. Upon weathering they become friable and form dolomitic sand in several places. Turonian formation outcrops on relatively wide surface area in the west and north-eastern part of the study area. The average thickness of this formation is about 200m.

1.2.3 Quaternary Deposits (Q)

These deposits are recent in age and consists of loose sandy clay in the plains, and gravel sin the valleys and along the toes of the slope. These deposits originated from older formations by gravity and running water.

1.3 STRUCTURAL GEOLOGY

The general structure configuration describing the study area is related to the western flexure of Mount-Lebanon and the presence of Kfar Chlaiman – Helta anticline.

The axis of Kfar Chlaiman – Helta anticline is oriented SW-NE and it is located to the middle of Helta village.

The beds of the eastern flank of this anticline which consist of Cenomanian (C4) formation are dipping by 20° toward the east, while the western flank of this anticline are dipping by 14° toward the west.

The Kfar Chlaiman – Helta anticline structure seem to be the dominant structural mechanism in the study area. Moreover the study area is crossed by a series of E-W and SE-NW trending faults.

1.4 HYDROGEOLOGY

The study area consists of different hydrogeological units. These are Cenomanian-Turonian aquifer, and Senonian aquiclude.

1.4.1 Cenomanian-Turonian Aquifer (C4)

The Cenomanian-Turonian aquifer represents one of the main aquifers in Lebanon and is the most productive aquifer in the Cretaceous sequence. It is characterized by its high secondary porosity causing ground water to flow mainly through fractures, joints, and channels which is a typical occurrence in karstic aquifers.

1.4.2 Senonian (C_6) aquiclude

The clay and marl horizons within the Senonian formation act as relatively impermeable zones that minimize the flow between the different underlying and overlying aquifers.

As it has been said previously, the anticline axis of Kfar Chlaiman – Helta crosses the middle of Helta village with the Cenomanian (C4) Formation outcropping at its top and on its flanks. The beds on the eastern flank of this syncline are dipping by 20° toward the east, and the western flanks are dipping by 14° toward the west.

We have to remind here, that the project area lies on the Cenomanian dolomitic limestone formation. These rocks are highly fissured and the density of fissures increases in the vicinity of the major faults.

In addition, the trend of the syncline flanks give an idea of the ground water flow direction since the ground water has a tendency to flow to the areas of least resistance.

As a result, the water precipitation that falls on the limestones of the Cenomanian formation infiltrates underground follows the fractured and faulted zones and moves westward and forms what we call an aquifer.

Therefore, the best productive site for the water well to be drilled is on the syncline axis or to its eastern flank, but not on the anticline axis.

1.5 DESIGN OF THE WATER WELL

1.5.1 Helta well

1.5.1.1 Borehole location

The well is located on Plot No. 754 to the left side of the road leading form Helta to Assia at the following coordinates (Fig. 2):

X = -309978 km
Y = +8640 km
Z = 605 m
(Douma map, 1/20.000)

1.5.1.2 Access to Borehole

Access to the site is easy on a main road. Some excavation and clearing for the well site is necessary in order to park the drilling machines.

1.5.1.3 Depth

700 m

1.5.1.4 Expected discharge

432-605 m^3/day (or 5-7 l/s).

1.5.1.5 Static water level

250 m below ground level.

1.5.1.6 Geology

The anticline axis of Kfar Chlaiman - Helta, crosses the middle of Helta village with a Cenomanian (C4) formation outcropping at its top and on its flanks. The beds on the eastern flank of this anticline are dipping by 20° toward the east. The well has been located on the western flank of the anticline. It will cross at the beginning the dolomitic limestones of the Upper Cenomanian (C4c). These limestones are highly karstified and might contain many karstic voids.

The beds that will be penetrated by the drilling rig are:

a) The limestones and dolomitic limestones of the Upper Cenomanian (C4c) Formation (200 m).
b) The marls and marly limestones of the Middle Cenomanian (C4b) Formation (300 m).
c) The dolomites and limestones of the Lower Cenomanian (C4a) Formation (200 m).

1.5.1.7 Schedule of drilling, casing and grouting

The Contractor shall present the schedule for drilling in order to have a final casing and screen diameter of 12″. The well is to be drilled with a rotary rig and provide for all additional equipment such as water and fuel, as well as treating collapsing rocks at his own expense.

Nevertheless, the schedule of the proposed works could be as follows (Fig. 3):

- Drilling by rotary methods with a 22" bit from 0 to 20m, with samples collection as described in the general specifications from this depth and onwards.

- Installing 18" I.D. casing (black steel, thickness 5mm)

- Grouting the annular space as described in the general specifications, from the bottom to the surface, then waiting between 36 to 48 hours for the cement to set, and then continue the drilling works.

- Drilling with a 17.5" bit from 20 to the depth of 200 m.

- Installing 15.5" ID casing (black steel, thickness 5mm).

- Drilling with 14.75" bit from 200 to the total depth of 700 m.

- Installing 12" casing and screens as shown below:
  a) Casing:
     Diameter: 12" ID
     Type: Carbon steel
     Thickness: 6 mm
     Total length: 650 m

  b) Screens:
     Diameter: 12" OD
     Type: Carbon steel, bridge slotted 12.2% void, 1.5-2mm slots.
     Thickness: 6 mm
     Total length: 50 m.

The installation of the casing and screens will be in accordance with the general specifications, and in particular, the welding and closure of all openings such that the water only enters the well through the screen openings, in order to minimize the pollution from zones above the SWL.

FIG.2 : LOCATION MAP OF HELTA BOREHOLE

SCALE:1:20000

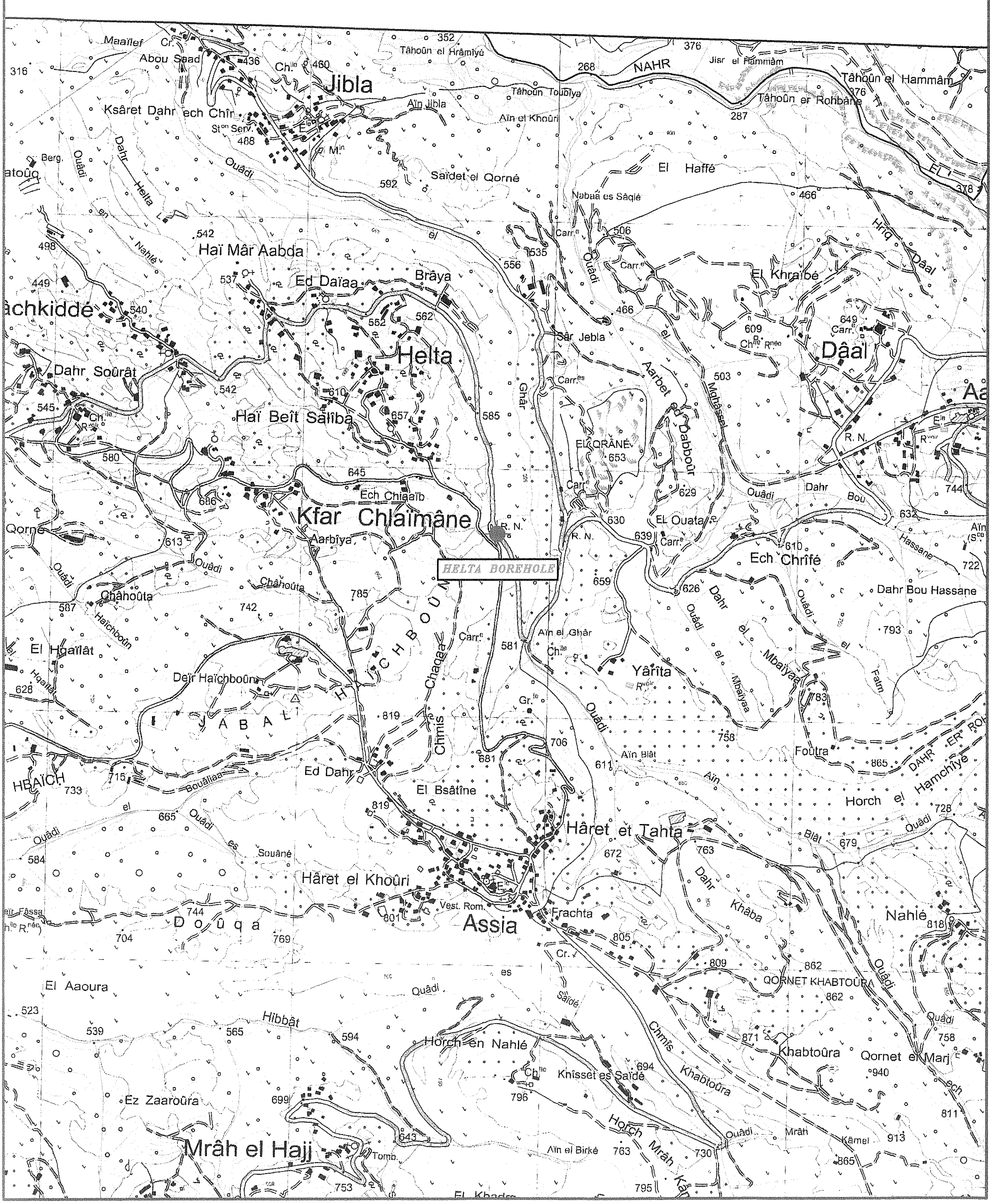

FIG. 3 : VERTICAL CROSS SECTION OF HELTA BOREHOLE