REPUBLIC OF LEBANON

MINISTRY OF ENERGY AND WATER

GEOLOGICAL AND HYDROGEOLOGICAL STUDY OF EL AARBANIYE REGION (CAZA OF BAABDA – MOUNT LEBANON)

Final Report

December 2014

Bureau Technique pour le Développement (BTD)

Phone: 04-712157 / 712158
Fax: 04-712159
Email: btdbtd@dm.net.lb

TABLE OF CONTENTS

GEOLOGICAL AND HYDROGEOLOGICAL STUDY OF EL AARBANIYE REGION (CAZA OF BAABDA – MOUNT LEBANON)

1 INTRODUCTION

El Aarbaniye town is located in Baabda Caza at an average elevation of 550 m a.s.l. It is surrounded by Sfayla village to the north, Arsoun village to the west, Dlaibe and Rouaissat Salima to the south in Baabda Caza.

The yearly average rain precipitation on El Aarbaniye area is 1500 mm/year and it is characterized by cold weather in winter and nice warm weather in summer.

2 GEOLOGY OF EL AARBANIYE AREA

After having undertaken detailed field studies and investigations, the attached geological map at a scale 1/10000 has been prepared.

This geological map (Fig. 1) and the geological section made give a clear picture of the stratigraphic succession prevailing in the area, as well as the geological structure.

2.1 LITHO-STRATIGRAPHY

The outcropping rock formations in the study area extend from the middle Jurassic Kesrouane Formation (J4) to the Chouf Sandstone Formation (C1), through the entire Bhannes Formation (J5), Bikfaya Formation (J6), and Salima Formation (J7). Furthermore, recent Quaternary alluviums and slope deposits especially in the plains, valleys, and along toes of the slopes.

2.1.1 The Jurassic System

The Kesrouane Formation (J_4)

The Kesrouane Formation encompasses rocks having Oxfordian to Kimmeridgian geologic age (Middle Jurassic). The stratigraphic thickness of this unit exceeds 1000m. The Kesrouane rocks are broadly exposed in the middle and western part of the study area. This formation consists of a monotonous succession of grey dolostones and micritic white-grey limestones (Wetzel and Dubertret, 1951). The dolostones are coarse grained, they have a sugary texture and are fairly compacted. Upon weathering they become friable and form dolomitic sand in several places. The micritic limestone rocks have a very high strength, they are massively bedded and contain few fossils. When weathered, they display huge hummocks and slacks extensively pitted and grooved by precipitation dissolution effect. The Kesrouane Formation is easily recognized by its bluish grey weathered color, its massiveness, and its steep outcrops (cliffs easily exceeding 100m in elevation).
This Formation owes its hydrogeological importance mainly to its significant secondary karstic porosity and permeability. Hence, karstic features such as surface karstic Lapiaz and subsurface cave networks are frequent.

The Bhannes Formation (J_5)

This formation makes a belt surrounding the (J4) formation. It is outcropping in the North, West and the middle of the study area. These deposits (J5) consist of alternation of yellowish to grayish shales, marls and tuffs, which are semi pervious. They are overlain by highly fissured pervious columnar basalts and then by poorly fossiliferous chocolate shales. In the area of study, this formation is however essentially shaley, with an average stratigraphic thickness in the order of 50m.

The Bikfaya Formation (J_6)

The Bikfaya Formation (J6) outcrops on the middle of the study area. It consists of massive limestone (light gray to beige) rocks containing quartzitic veins and siliceous concretious. They are highly porous, permeable, and deeply Karstified. The thickness of the Bikfaya Formation in the study area is about 60m.

The Salima Formation (J_7)

This Formation consists of yellow to light brown detretic limestones, and makes a very wide belt surrounding the (J_6) Formation. The average thickness of the Salima Formation in the study area is around 30m.

2.1.2 The Cretaceous System

The Chouf Sandstone Formation (C_1)

Directly superimposing the Salima Formation the Chouf sandstone averages a stratigraphic thickness of 100 m in the study area. It has a Neocomian – Barremian geologic age, and marks the beginning of the Cretaceous system. The Chouf sandstones outcrop in large patches at the middle, and northern part of the study area. This formation is dominated by poorly sorted sandstone often cross-bedded, weakly siliceously cemented making it highly friable. It is generally seen as having a brown to orange color due to a long atmospheric exposure, which enhances further oxidation in an iron oxide rich sand. Dark purple iron oxide 0.5 cm thick bands sub-parallel to bedding could be seen within the sand probably indicating higher iron concentrations. Recently exposed sandstone sections in quarries for example reveal lighter colors such as yellow or light brown due to lower oxidation levels. The quartz grains vary greatly in size some reaching 0.5 mm and they are mostly sub-rounded. Green and light blue clay inter-layers are found within the Chouf Sandstone Formation with one layer reaching 0.5 m in thickness. The sandstone is highly porous and moderately permeable allowing a good filtration of groundwater.

2.1.3 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. The Quaternary deposits outcrop at the south western part of the study area.

2.2 STRUCTURAL GEOLOGY

The general structural configuration describing the study area is related to the western flexure of Mount-Lebanon and the whole Jurassic -Cretaceous strata plunge to the West in the direction of the flexure. However, these strata in the study area are clearly disturbed by two major faults trending NE-SW and west- east making the whole geological formations between these two faults dropping relatively by the surrounding ones and forming a graben structure.

The general bedding attitude in the area is dipping 10 - 20° toward the West and South-West when it is not disturbed by faulting. As we mentioned previously the study area is bounded by 2 major faults, which made the whole Jurassic block dropping down and forming what we call a graben.

3 HYDROGEOLOGY

The study area consists of different hydrogeological units. The limestone formations are the major aquifers and form very important ground water reservoirs. The thickness is suitable (n x 100 meters), fracturing is intensive and enhanced by karstification process. The main aquifer in the study is the Kesrouane unit (J4). It is a karstic aquifer and characterized by very high secondary porosity and permeability as well as a large stratigraphic thickness. The Bhannes deposit (J5) unit is impervious.

3.1 THE AQUIFERS

The Kesrouane Aquifer

It is the most important water-bearing unit in the area as evidenced by the highest yielding springs, which emerge from this unit and drain the water mostly originating from the direct recharge of the aquifer itself as implied by the exposure of the unit and bedding attitude. This Formation owes its hydrogeological importance mainly to its significant secondary karstic porosity and permeability. Hence, karstic features such as surface karstic Lapiaz and subsurface cave networks are frequent. The (J4) aquifer is tapped by high productive wells in the area of Bmariam, Btebyat, and others.

Hydrogeologically speaking, the Jurassic limestones, being thick and karstified constitute a very important aquifer.

3.2 AQUICLUDES

The Bhannes Aquiclude

This unit consisting of highly impermeable shales and basalts and act as an impermeable zone that minimize the water flow between the different underlying and overlying aquifers.

4 DESIGN OF THE WATER WELL (BH1)

4.1 BOREHOLE LOCATION

The well is located beside a secondary road leading to Salima village to the east of El Aarbaniye at the following coordinates:

X = -318813 m
Y = -30019 m
Z = 545 m
(Dhour ech Choueir map, K-5, 1/20.000)

4.2 ACCESS TO BOREHOLE

The access of the site is easy because of the presence of a secondary road. Some cleaning and excavation for the well site is necessary in order to park the drilling machine.

4.3 DEPTH

600 m.

4.4 EXPECTED DISCHARGE

6-8 l/s (or 518-691 m^3/day).

4.5 STATIC WATER LEVEL

250 m below ground level.

4.6 LAYERS THAT WILL BE PENETRATED

The layers that will be penetrated by the drilling are:

a) The sands and sandstone of Lower Cretaceous (C1) – 100 m.
b) Salima Formation Detritic limestones (J7) – 30 m.
c) Bikfaya formation, Cherty limestones (J6) – 60 m.
d) Bhannes formation, chocolate marls (J5) – 50 m.
e) Kesrouane formation limestones and dolomitic limestones (J4) - ~350 m.

4.7 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. 2):

- Drilling by rotary methods with a 22" bit from 0 to 20m, with samples collection from this depth and onwards.

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

- Grouting the annular space 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 20m to the depth of 200 m.

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

- Drilling with a 14.75" bit from 200 to the total depth of 600 m.

- Installing 12" casing and screens as shown below:
  a) Casing:
     Diameter: 12" OD
     Type: Carbon steel
     Thickness: 6 mm
     Total length: 500 m

  b) Screens:
     Diameter: 12" OD
     Type: Carbon steel, tourch-cut 4% void, 15x4mm slots.
     Thickness: 6 mm
     Total length: 100 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.

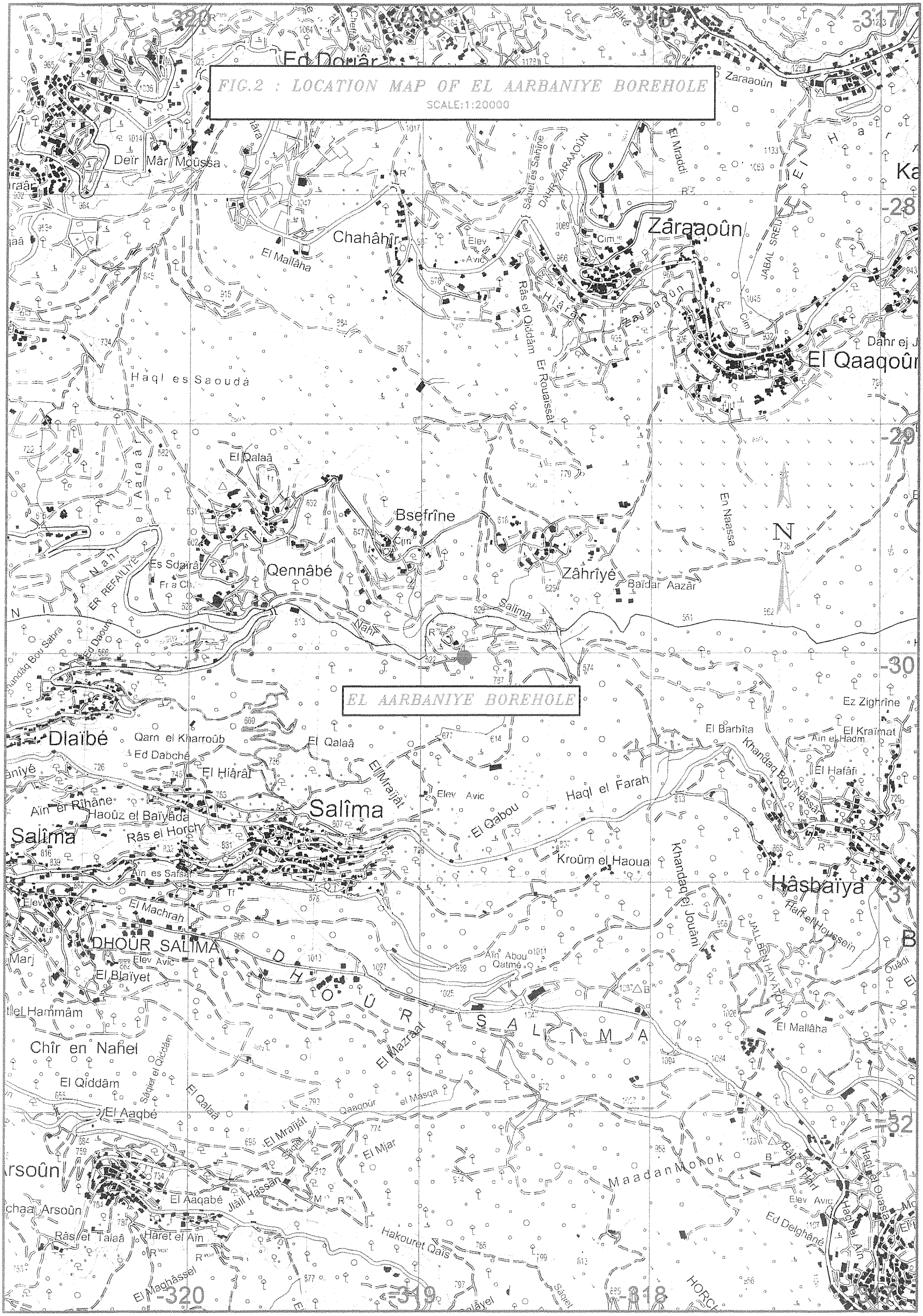
FIG.2 : LOCATION MAP OF EL AARBANIYE BOREHOLE
SCALE:1:20000
EL AARBANIYE BOREHOLE
Deïr Mâr Moûssa
Chahâhîr
El Mallâha
Zâraaoûn
El Qaaqoûr
Haql es Saouda
El Qalaâ
Bsefrîne
Qennâbé
Es Sdaïra
Zâhrîyé
Baïdar Aazâr
En Naassa
N
Ez Zighrîne
El Barbîta
Khandaq Bou Nassar
Dlaïbé
Qarn el Kharroûb
Ed Dabché
El Hiâraf
Salîma
Haql el Farah
El Qabou
Kroûm el Haoua
Hâsbaïya
Khandaq el Jouâni
DHOÛR SALÎMA
D H O Û R S A L Î M A
El Blaïyet
El Machrah
Chîr en Nahel
El Qiddâm
El Aaqbé
El Mazraat
El Mraïjât
El Mjar
Maadan Mohok
Arsoûn
Hakouret Qaïs
El Maghâssel
Ed Delghâné

FIG. 3 : VERTICAL CROSS SECTION OF EL AARBANIYE BOREHOLE