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MINISTRY OF HYDRAULIC AND ELECTRICAL RESOURCES

WATER SUPPLY OF KESROUAN COASTAL ZONE FROM EL MADIQ SPRING

FEASIBILITY STUDY

VOLUME 1: REPORT

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JANUARY 1996

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CHAPTER 1
INTRODUCTION

1. INTRODUCTION

1.1 Objective of the report

This feasibility study has the objective of identifying the most suitable development scenario for water supply from El Madiq spring to localities in the Kesrouan Caza as well as to Jbeil Caza. The study will also provide preliminary design details and cost estimates for the selected alternatives taking into account initial investment cost, operation and maintenance costs as well as the ability and willingness of the consumers to pay for the service provided.

1.2 Scope of work

This project is to provide potable water supply mainly for Kesrouan coastal zone with a possible extension to Jbeil coastal zone to Aamchit and middle Kesrouan up to Ajaltoun.

The localities in Jbeil Caza are : Nahr Ibrahim, Halat, El Fidar, Beit El Boumi, Aamchit and Jbeil.

The localities in Kesrouan Caza are : El Aaqibe, Bqaq Ed Dine(part of Aaqibe), El Bouar, Es Safra, Tabarja, Kfar Yassine, Adma, Defne, El Maameltein, Kfarhabab (part of Ghazir), Sahel Aalma, Jounie, Haret Sakhr(part of Jounie), Ghadir(part of Jounie), Sarba, Bkerke(part of Jounie), Harissa, Daraaoun, Ghosta, Batha, Zouk Mkayel and Zouk Mosbeh.

The localities in middle Kesrouan are: Shaile, Mazraet Er Ras, Jiita, Balloune, Aintoura, Ain Er Rihane and Ajaltoun.

As part of the works, we also studied the irrigation needs of the perimeter stretching from Tabarja to Aamchit.

This study will present viable alternatives and discuss each, making economical, technical and practical evaluations.

CHAPTER 2

CHARACTERISTICS OF THE PROJECT AREA

2. CHARACTERISTICS OF THE PROJECT AREA

2.1 General

The project area is shown on Fig. 2.1. The localities range in size from small communities of 600 persons to larger ones such as Jbeil of over 15000 persons. The project area is characterized by a high population density since it is considered a major touristic attraction pole in the Lebanon due to the presence of a large number of seaside resorts, amusement centers, theaters, cinemas, restaurants, recreational centers, hotels,etc.

High industrial densities exist in the region and these are mainly located between Zouk Mosbeh and Zouk Mkayel.

2.2 Natural conditions

2.2.1 Topography

Localities under study are generally located between altitudes ranging from 0 m to 250 m except the region between Bkerke and Ghosta that lies between the elevations 350 m and 860 m

2.2.2 Climate and Hydrology

A Mediterranean climate prevails over the region under study, characterized by dry summers and damp winters. The temperature ranges from 13.5⁰ C in January to 27.7⁰ C in August. The relative humidity ranges from 60 to 70 % throughout the year. The temperature, relative humidity, wind speed, rainfall and daily hours of sunshine are given in Table 2.1 below.

Fig.2.1

LIMITS OF PROJECT AREA

- (A) KESROUAN COASTAL ZONE
- (B) MIDDLE KESROUAN AREA
- (C) JBEIL COASTAL ZONE



Table 2.1 Climatic and Hydrologic Conditions

Month	Jan	Feb	March	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Temperature : °c	13.5	13.8	15.4	18.2	21.8	24.9	26.9	27.7	26.2	23.5	19.3	15.6
Relative Humidity : %	66	66	66	70	70	71	72	71	67	64	64	65
Wind Speed : m/s	2.6	2.8	3.0	2.5	2.2	2.4	2.6	2.3	2.0	1.8	1.8	2.4
Daily hours of sunshine	4.6	6.3	6.4	8.2	10.0	11.7	11.9	11.3	9.0	7.8	6.6	6.6
Rainfall : mm	216	167	115	51	25	1	0	0	11	41	117	176

2.2.3 Geology

Lebanon is generally considered to have an abundance of water. Generally, this water surplus is found not in surface flows but in groundwater aquifers. In the following discussions, the geological system and its hydrogeological consequences are described in more detail.

2.3 Demography

2.3.1 Land use

In addition to the residential centers, the study area encompasses commercial, industrial and agricultural areas. Commercial centers are located in Es Safra, Tabarja, El Maamettein, Jounie, Haret Sakhr, Zouk Mkeyel and Zouk Mosbeh. Industrial establishments are spread between Zouk Mkeyel and Zouk Mosbeh. Agricultural areas cover the perimeter between Tabarja and Aamchit.

2.3.2 Future land use

It is foreseen that the near future will witness the merging of Kfar Hbab and Adma into the larger growing Metropolitan city composed of Jounie, Sahel Aalma, Sarba, Zouk Mkeyel and Zouk Mosbeh. This is particularly due to the existence of highways and road networks that encourage growth along the mentioned pattern.

Furthermore, the upgrading of the highway between Jounie and Beirut and the removal of bottle necks along this main artery, could encourage a large sector of the population working in Beirut to take advantage of the less costly habitats in the Jounie area that lies within commuting distance from Beirut.

2.4 Area economy

Kesrouan is one of the more developed districts within Lebanon. Its location near the Capital Beirut, has hastened the development of its infrastructure, particularly in the communication sector. Kesrouan enjoys relatively acceptable roads and highways that link it with Beirut through the Metn district. It is blessed with beautiful scenarios, lavish sandy beaches, beautiful mountains and a fine weather. It is not unexpected, therefore, that the region is considered as a touristic attraction pole. In addition, Kesrouan has one of the few classified industrial zones in Lebanon located between Zouk Mosbeh and Zouk Mkayel, which has almost reached saturation limits in certain parts. During the recent years, the town of Jounie, which is rapidly growing into a sophisticated small city, has acquired certain recognition as an entertainment and commercial center. It houses some of the best movie theaters in Lebanon, in addition to a large number of restaurants and shopping centers.

It is clear that the economy of Kesrouan depends largely on four main sources, the tourism industry, the entertainment facilities, the commercial sector and the manufacturing industries. Of these four, tourism seems to be the most promising, and will constitute the major source of income for the general population, who can benefit from it either directly or indirectly, such as through rental of apartments or indirectly as a result of the growth of commercial business and services rendered to the expected vacationers.

2.5 Population Growth

A number of demographic studies have been carried out by the United Nations for the Lebanon as a whole before the war . These studies have shown that the annual population increases are as follows :

Table 2.2 U.N Estimates Of Population Growth In Lebanon

Years	Population Growth
1958 - 1963	2.4 %
1963 - 1970	2.9 %
1970 - 1977	3.1 %

The increasing growth rate observed may be due to an improvement in medical facilities reducing the death rate significantly without a corresponding drop in birth rates.

In the years 1961 and 1964, the Directorate General of Census published population figures. At the end of 1961, the number of officially registered Lebanese was 2,151,884 and at the end of 1964 it rose to 2,367,141 affecting an average compound rate of increase of 3.23 %. For Kesrouan, according to the same source, the population at the end of 1961 was 76,536 distributed over 95 villages and towns and rose to 82,770 in 1964, with a compound rate of increase equal to 2.65 %

Recent studies (1994) conducted by the consultant "Khatib & Alami" for the Ministry Of Environment revealed that the yearly population growth rates for Kesrouan are between 2 and 2.2 %

In order to establish an exact growth rate, the population figures for at least 20 years are needed. These data are not available but we managed to get some statistics and information from Kesrouan Water Board about the number of water subscribers between the year 1982 and 1994.

From the obtained information, we could establish a model to estimate the number of subscribers during the project period of 25 years between 1995 and 2020.

Furthermore, we drew the logarithmic graphs of the population evolution between 1982 and 1994 based on the number of subscribers as supplied by Kesrouan Water Board, the drawn graphs were extended up to the year 2020 as shown on Figures 2-3

The results obtained were not significant, because we noticed that the number of subscribers has decreased in some towns after the end of the hostilities like in Ghosta, Tabarja, Maameltine etc.. because some displaced people had moved back to their initial homes.

The study area falls into the category of cities and big agglomerations, and since it was very difficult to obtain from the drawn graphs some correct and sound conclusions, the growth rate for future population projections will be taken as 2.5 %.

The rate of change of the population is assumed to be proportional to the actual population. The formula used for future population projections is :

$$P_t = P_0 \cdot e^{kt}$$

where :

- P_t : population at some future time t
- P_0 : present population
- t : projection period
- k : specific growth rate (here taken as 2.5%)

The assumption in this method is that the specific growth rate k is constant up to design period.

CHAPTER 9

ENVIRONMENTAL IMPACT CONSIDERATIONS

9. ENVIRONMENTAL IMPACT CONSIDERATIONS

9.1 Impact on water resources

The water resources exploited by Kesrouan Water Authority in Nahr Ibrahim river are limited to El Madiq spring (400 l/s).

The proposed works consists of improving the existing catchment works to exploit all the waters of the spring which are currently flowing in the river (about 400 l/s).

An additional two boreholes are also proposed to be drilled (one is already drilled) to pump the water from acquifer.

The improvement of the catchment works to exploit all the waters of El Madiq spring will decrease the flow in the river downstream the spring and consequently the remaining surface water in the river will not be sufficient to operate the KHDAIRA hydroelectric plant during summer period.

KHDAIRA hydroelectrique plant has to stop production for 3 or 4 months per year which means a loss of electric power of 1 Mw during the summer time.

The remaining surface water in the river downstream KHDAIRA plant will be enough to keep feeding Jbeil coastal zone with water for domestic use (after treatment) as well as for irrigation purpose.

The river will not dry during summer time, there will be at least about 750 l/s at year 2000 running during summer time in the river and about 215 l/s at year 2020.

The Ecological life in Nahr Ibrahim river will not be disturbe because enough resources will be available to keep it alive. The implementation of the works will not affect the ecological life of Nahr Ibrahim river nor the resources for irrigation and water supply of Jbeil coastal zone. The river will not dry during summer period.

9.2 Impact of project works

9.2.1 Catchment works

There are 3 alternatives for the catchment works, the first one consists of constructing reinforced concrete structure below the river bed (see chapter 6) to collect the uncaught water of the spring and to course the river.

This structure will not have any serious environmental impact other than coursing the river for about 50 m.

9.2.2 Transmission lines

The construction of the transmission lines is a difficult task and will need a lot of efforts to be implemented. Many complecated excavation and concrete works shall be executed and will create a lot of nuisance and disturbance to the public during the construction period.

In addition the laying of the pipelines in the valley of Nahr Ibrahim and the surrounding forest will need some destructive works in the river and the forest which will disturb the charm and the quietness of Nahr Ibrahim valley.

Regarding the conveyor line to Jounieh and the coastal zone, the proposed pipeline will be installed in the embarkement of the highway from Nahr Ibrahim to Nahr El Kalb. The existing main conveyor of 500 mm diameter will remain in service and the water supply will not be interrupted for long periods, only some interruptions will occur for few hours to make the connections with the new system.

9.2.3 Hydraulic tunnel

The construction of the tunnel (if the alternative 4 is considered) will have some positive effects because it will preserve the valley and the forest from being distured.

The construction works of the tunnel will not have any serious environmental impact other than finding a dump place to dump the excavated material from the tunnel (about 70.000m³).

The construction works of the tunnel shall be as safe as possible to eleminate any risk or danger that can threaten the workers.

The choice of the construction method if the tunnel by the contractor is a very important fact that can have positive or negative effects to the safety of the works. The chosen method shall take into consideration the safety of the workers as well as the equipment and the works.

Using a tunneling machine to dig the tunnel is advisable because it helps in creating safe conditions to the workers to perform the work.

9.2.4 Distribution system

The distribution network consist of installing about 150 Km of pipes to serve about 25 villages/towns, most of these pipes will be laid in trenches underneath asphalted roads. The construction works will disturb the public as well as the traffic for the whole construction period.

The contractor has to schedule his work and to prepare a time table for his interventions in order to minimize the disturbancy to the public.

The construction works shall not interrupt the water supply through the existing system for a long period, the allowed interruption shall be limited to make the connection works.

9.2.5 Reservoirs and pumping stations

The reservoirs and pumping stations will be constructed normally on closed land and therefore the construction works shall not disturb the public nor the traffic.

The pumping stations shall be constructed away from the residential buildings to minimize the nuisance to the public.

9.3 Expected positive impacts

The actual level of services in Kesrouan coastal zone is low (about 45 l/d/cap), therefore the region is in urgent need for additional resources and an adequate distribution system to increase the level of services to an acceptable level.

The coastal band of the area is full with hotels, restaurants, summer resorts and leisure centers. It is considered as a potential economical center for Kesrouan and the country.

The aim of the project is to provide additional resources to meet the needs of the inhabitants as well as the needs of the fast growing touristic area along the coast.

CHAPTER 11

COMPARISON OF PROPOSED ALTERNATIVES

11. COMPARISON OF PROPOSED ALTERNATIVES

The alternatives proposed in this study concern the first part of the transmission line between El Madiq spring and the highway, while for the other parts (distribution and transmission system) there is only one alternative.

11.1 Technical and economical analyses

11.1.1 Catchment works

We elaborated in chapter 6 three alternatives for the catchment works as follows:

- 1- Catchment works - Surface galleries
- 2- Radial wells
- 3- Boreholes

- The first alternative needs excessive construction works and involves coursing of the river for about 200 m.

The proposed works take time to be constructed and our cost estimate is 6.000.000 USD. It is the most expensive alternative but the advantage it doesn't need any operation cost (water pumping is not required, no cost of energy) and the maintenance cost is minimal.

- The second alternative consists of constructing 3 wells to collect the water. The construction cost is estimated at 5.000.000 USD like the first alternative, the operation and maintenance costs are minimal (water pumping is not required).

- The third alternative: consists of drilling 7 boreholes and equip them with water pumps.

The cost of construction works is estimated at 1.500.000 USD which makes it the cheapest solution but it needs permanent pumping which involve a high cost for energy consumption 500.000 USD per year.

Encountered problems are difficult to be solved and require considerable delays in the implementation of works. Furthermore, it is quite difficult to keep works undamaged, preserve them in time and consequently convey water to its destination under the most favorable conditions.

In fact, rocks displacements or landslides are frequent during times of flood; stone quarries expand towards the upstream and cause masses of earth to fall into the river, which leads consequently to more eventual disorders in the channel .

It is not advisable to stop the water supply of the region even for short periods of time.

Alternative 4

This alternative requires a highly qualified enterprise fitted with equipment that comply with the technical constraints of the site.

At the starting point of the spring, the ground is clayey and stretches over several hundreds of meters. Then, it becomes rocky, consisting mainly of limestone. The existence of faults is not ruled out.

Elementary research shows that the rocky massif is identical all along the remaining section of the tunnel (\cong 4500 m).

Digging problems that are encountered are those of a common tunnel. A tunneling machine adequate for the required section and the distance to be covered would satisfy all technical requirements.

A ventilation system shall be performed in order to ensure the most favorable security conditions for workers. The transport of fills and materials shall depend on chosen equipment.

A coating layer shall be necessary according to encountered formations. A soil investigation is to be carried out. The ground serving as a roof for the tunnel shall exceed 100 meters in many places, while at the exit and at the crossing of the unique watercourse the said roof shall not exceed 30 meters.

Risks resulting from this solution as for the perennially of this work are almost inexistant; protection and security are ensured and water supply to water consumers is uninterrupted. The river bed shall not undergo any modifications and no work shall change the existing environment.

Furthermore, this unique work shall serve for conveying drinking water to Kesrouan coastline and the region of Jbeil, and allow as well the transport of the required volumes of water *necessary for the irrigation of Jbeil-Kesrouan coast.*

This shall spare the government incurring expenses given the fact that there shall be no need for rehabilitating irrigation channels. Nevertheless, hereafter are problems to be resolved subsequently:

- Optimum diameter of the tunnel
- Catching and conveying additional surface river waters inside the tunnel with the *possibility of building a treatment plant treating it at the downstream, or through a transmission line*
- Optimum method of water distribution taking into account the available head
- Study of hydraulic works required at the inlet and outlet of the tunnel.

The cost of alternative 3 is 13.700.000 \$ and if we add the cost of the road to be constructed to install the pipeline which is estimated at 4.000.000 \$ the total cost of alternative 3 will be 17.700.000 \$.

The cost of alternative 4 (tunnel) is 16.500.000 \$ which is less than the cost of alternative 3. Therefore from a technical and economical point of view, alternative 4 seems to be more convenient and adequate than the other alternatives.

11.1.3 Distribution networks

The pipes to be used for the distribution networks and the transmission lines from the tunnel towards the reservoirs can consist of:

- Ductile iron pipes
- Coated steel pipes
- Asbestos cement pipes
- GRP pipes
- HDPE pipes

The unit costs of these five types of pipes have been given in tables 8.3 and 8.4 as well as the total costs of the networks for the five proposed types.

The calculations show that the Ductile Iron pipes are the most expensive pipes and the steel coated pipes are the cheapest ones.

Table 11.2 pipes cost comparison

Type	Percentage (Base = 100 for coated steel)
Ductile Iron	122
Coated Steel	100
Asbestos cement	102
GRP	117
HDPE	108

The cost of the Asbestos cement pipes is slightly higher than the coated steel pipes (2%), HDPE pipes are more expensive by 8%, GRP by 17% and the Ductile Iron pipes by 22%.

11.3 Recommendations

11.3.1 Water resources

As discussed earlier in section 4.5, the available resources of El Madiq spring (without the addition of two wells) will be sufficient to feed Kesrouan coastal zone until the year 2015 even at summer time. After that year additional resources from El Madiq two wells shall be provided to cover the deficit that will occur.

The available resources (El Madiq spring plus two wells) will be sufficient to feed Kesrouan coastal zone plus Jbeil coastal zone or Middle Kesrouan area until the year 2020.

Jbeil coastal zone soon will be provided with a treatment plant which will treat the water diverted from Nahr Ibrahim river. If we divert the water of El Madiq spring to Jbeil area, there will be no need to operate the treatment plant of Jbeil while Middle Kesrouan will be in need of this water.

Therefore we recommend to use the surplus of El Madiq spring to feed Middle Kesrouan area rather than Jbeil coastal zone, because Kesrouan caza is not provided with any treatment plant.

During the winter season, the resources from El Madiq spring will provide all the needs of Kesrouan coastal and Middle zone as well as Jbeil coastal zone if needed even after the year 2020.

Middle Kesrouan zone is actually in need of 74 l/s. until the end of El Madiq project after 3 or 4 years, Middle Kesrouan shall be supplied with water from other source which is Jeita wells that can be executed in one year time.

After the completion of El Madiq project, The resources of Jeita wells can be diverted to an other area.

The 600 l/s for irrigation purposes will be ensured all the time, the surface water in Nahr Ibrahim Valley downstream the El Madiq catchment works will be ensured to feed Jbeil with water at Nahr Ibrahim intake point but the Khdaïra hydroelectric plant will be forced to stop the operation during the summer period.

11.3.2 El Madiq catchment works

The first and second alternatives are costly but their operation cost is free. Alternative 3 the cheapest one has a high operation cost after 10 years it will be as costly as alternative 1 and 2. We recommend to elaborate additional study to see the disadvantage and advantages of each alternative as well as the cost including the running cost for a period of 7 or 10 years.

11.3.3 Transmission lines

We recommend to adopt the tunnel alternative because it is faster (construction time speaking) at a comparable price with the pipelines alternative, but the big advantage of the Tunnel is the least environment impact to the forest and Nahr Ibrahim Valley. We strongly recommend this solution to preserve the nature in this area.

11.3.4 Distribution networks

Dispite the Ductile Iron pipes are most expensive than other pipes, we recommend to use this type of pipes because its life span is higher than the cheapest pipe and the difference in cost is small (4 or 5%) compared to the total cost of the project.