A THESIS ON A WATER SUPPLY SCHEME

IN

ZGHORTA SUB-DISTRICT

TRIPOLI DISTRICT

BY

SALEH ZUHDI TUFFAHAH

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TRIPOLI DISTRICT

LEBANON

IN PARTIAL REQUIREMENT FOR THE DEGREE OF

BACHELOR OF SCIENCES

IN

CIVIL ENGINEERING

BY

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TABLE OF CONTENTS

PRELIMINARY PART

CHOICE OF PROBLEM.

DRINKING WATER:- Need and necessity.

HEALTH & PHYSIOLOGY:- Factors to be considered are:

1. Demand of water (Drinking etc.)
2. Health
3. Population and percentage increase.

Here health and population shall be considered, later the demand will be dealt with, more fully.

"No country may exist without water". This is a statement which is and must be taken for-granted. Towns from the very start of life originated in places where water was abundant, because it expresses itself in all fields of every day life. It is necessary for drinking, cooking, washing, irrigation and in all aspects of life. Even in "CORAN" the significance of water is emphasized.

Let us have a look on this region under consideration:

The people are poor, their health is not sound, and though their country is rich by nature, yet nothing is done to use or even start the use of these natural resources, which, no doubt, leads to large Scale Production.) Sentence Construction

We cannot expect any man to improve his own condition and use his mind in the correct way, if he is physically unable to do so.

Here we have a group of poor Fallaheen, who need our help. On the other hand, we can help them, and that will not cost us much effort. Then, why not go ahead, and do it ? Superfluous

Again these villagers are citizens of our country. Is it not our duty as citizens of the same country, to help flourishing it, by helping its individuals to live a prosperous and easy life ?

Now, I think, we are convinced that water is necessary and must be given to these six villages of:

Racheine, Harf-Arde, Ferdlios, Karabache, Kfar-Hata and Asnoune.

We must not forget that while we supply them with water, we must be sure that it is not contaminated; otherwise, the result will be negative and in the other direction. We want to increase the population and not decrease it. ~~Don't we~~ ?

The percentage increase of population is usually deducted from statistics. But in the absence of these statistics, as it is in the case in our problem, it is then left to the designer's judgement to estimate this percentage. This comes under demand and is discussed later.

Another point to be added, is the fact that this problem is practical and may be enforced if it is approved by the Lebanese Government.

OUTLINE OF THE PROBLEM

This project is to supply the following villages with drinking water:

NAME OF VILLAGE	POPULATION
Racheine	1495
Harfe-Arde	1127
Ferdelios	617
Karabache	236
Kfar-Hata	117
Asoune	204

There are three springs which may be utilized, out of which we are choosing the largest, cleanest, most economical and easiest to be utilized.

This spring gave 400 cubic meters per day, measured on 18.9.1946. Sept. 18, 1946.

It is to have two branches as shown in the plans. The first goes to Racheine and Harf-Arde, while the second goes to remaining villages. It is to be noted that the second branch crosses a river and that means a bridge has to be constructed. But since our knowledge about this locality is limited and as the river is small, such a structure is not included in our problem.

THE STRUCTURES: necessary for the carrying out of the problem are:

1. Collecting Chamber with galleries and intake from the spring.
2. (a) A reservoir at every village.
   (b) A reservoir at point No. 4 where the second branch of the system, gives a third branch to Ferdelios.

The largest of these reservoirs, and the collecting chamber shall be considered in our design.

Conveyance of Water: Water shall be transmitted through steel pipes with diameters and details as shown in the plans, and as calculated later.

ANALYSIS OF THE PROBLEM

The main point to be considered here is the demand of water:

The first problem that a designer is faced with, when he starts a water supply scheme is:

What is the demand of the people ? and what must be the right demand ?

There is a wide variation, while no limitation is given as to the numerical value of the demand: the least being 5 litres per Capita per Day. It may reach one thousand.

G. Daries gives: 35 - 40 litres per Capita per Day as an average value. It is a logical number.

Mr. Levy Salvador says, in his lessons on water supply schemes:

"The results of many experiments lead to the conclusion that the average requirement of one Capita per Day is 50 liters."

But he always talks about city supplies.

Mr. Yentch says: "For cities whose population is less than 50000, 40-50 litres per Capita per Day is good".

We can now safely assume, an average number of 40 for cities, and 30 for villages. But in the country, where villagers have gardens, lands to be irrigated, animals etc. other factors must be considered.

There is no definite and correct rule regarding their requirements.

Mr. Levy Salvador gives the following table:-

NAME OF ANIMAL	DEMAND in Litres per Capita per Day
Cow or Ox	50
Horse (May be the Ass)	40
Domestic Pig	10
Sheep	5
1 M^2 in a garden	1-3
Domestic bird	3/4-13/4 (This depends upon the kind of bird)

We cannot depend upon these numbers in our estimate. We must think of the future and the conditions that may be created or changed by the New Supply of Water to be given. Usually the amount given, in any locality, must satisfy the usual domestic daily requirements. In the future we may assume, that the average number of animals shall be equal to the population of the village and we have to supply each of these animals with the amount stated before.

We can now assume, even for poor conditions, that every man has three sheep and five square meters in a garden, and that every 7-10 men have one cow and one ox:

Therefore the total demand per Capita in litres per Day shall be:

3 sheep at 5	=	15
5 square Meters in a garden at 2	=	10
1/10 of a cow at 150	=	5
1/10 of a horse at 40	=	4
		34 Litres per Capita per Day.

Adding the 30 litres already estimated and assuming 10% losses, we get:-

$$34 + 30 = 64$$

$$64 \times 110/100 = 70.4$$ say 75 Litres per Capita per Day.

An average value of 100 litres, and even more, per Capita per Day may be assumed, but since the total requirement, would then be more than the spring can supply, and to raise the amount supplied by the spring to the new requirement, will require very expensive structures, such as six months' reservoir, new galleries etc., it is here neglected.

75 Litres per Capita per Day is therefore assumed.

We must not forget that this locality is full of springs, that of course helping to decrease the demand and be on our side. We also suppose it is possible to collect and utilize them. In our design we consider only the largest source.

It is safe and in accordance with the most practical rules to consider for our locality, the increase of the population based on a future percentage increase. This percent is assumed, as for other practical cases, to be 50% of the present population.

Following is a table for the calculation of the water requirement in a day based on this 50% increase:

NAME OF VILLAGE	PRESENT POPULATION	PLUS 50%	TOTAL ASSUMED POPULATION (after 25 years)
Racheine	1495	750	2245
Harf-Arde	1127	565	1692
Ferdelios	617	310	927
Karabache	236	120	356
Kfar-Hata	117	60	177
Asnoune	204	102	306
		GRAND TOTAL	5703

The demand will then be:-

$$\frac{5703 \times 75}{1000} : 427.7$$ say 430 cubic Meters per Day.

The spring can supply 400. This difference which is negligible is due to the fact that the assumed value of 75 was a little higher than estimated; it can be neglected. The capacity of the largest reservoir will then be $\frac{2245 \times 75}{1000} = 165$ cubic Meters. We will assume it, to have a capacity of 200 cubic Meters.

RESERVOIR CAPACITY: It has been, and is the usual practice, to design reservoirs on a 2-day capacity basis. It is true that in cases of mechanical troubles, the reservoir content will serve as a reserve for the village, but the fact that this project cannot stand this much of expenses, calls for the necessity of designing it, for almost, one day capacity. It must not be forgetten that wells will support the village for a short period in cases of accidents.

The following table gives the RESERVOIR CAPACITY as estimated.

TABLE OF RESERVOIR CAPACITY

Count him

NAME OF VILLAGE	DEMAND	RESERVOIR CAPACITY
Racheine	165 M^3	200 M^3
Harf-Arde	185 M^3	150 M^3
Ferdelios	72 M^3	90 M^3
Karabache	30 M^3	40 M^3
Kfar-Hata	15 M^3	25 M^3
Asnoune	25 M^3	35 M^3

At pt. No.4 volume of reservoir 72 + 30 + 15 + 25 = 142 M^3

EXPERIMENTAL OR DESIGN PART

Planning of the Work.

The water is to be collected from the spring in a collecting structure (chamber with a gallery, intake etc.) from which it is going to be taken into two branches:

1. To Racheine and then to Harf-Arde.
2. A branch that goes straight, then crosses a river, after which it gives a third branch to Ferdelios at point No.4., then it continues leading to the remaining villages successively.

At every village, there is going to be constructed a reservoir with intake to receive water from the mains, and from which water is going to be distributed to the villages, each from its reservoir.

All conveyance pipes are to be of steel.

All necessary details and drawings are herewith shown.

Other Minor details cannot be included in such a thesis.

STEPS IN DESIGN

A.

Diameters of Pipes: Following are various equations (Formulas) for the velocity of flow of water in cast iron pipes.

NAME OF ORIGINATOR	FORMULA	REMARKS
Darcy	$v = \sqrt{\frac{RS \times d}{ab}}$	$a = 7.726 \times 10^{-5}$ $b = 6.47 \times 10^{-6}$ for new pipes
Lampe	$v = 77.68 D_1^{0.694} S^{5.55}$	
Flamant	$V = 86.38 D_1^{5/7} S^{5/7}$ Or $I = \frac{4a U^2}{D\sqrt{UD}}$	$a = 0.00023$
Hazen & Williams	$v = 1.318 cR^{.63} S.^{54}$	$c = 130$
Fanning	$h = f \frac{1v^2}{2g D_1}$	$f = 0.0075-0.018$
Foss	$S = C_f Q^{11/6}$	$C_f = \frac{0.00065}{D_1^5}$
Wegmann and Aeryns	$v = 182.5 R^{723} S^{.539}$	for clean, new, cast iron pipes
Maurice Levy	$U = K\sqrt{\frac{ID}{2}(1+3\sqrt{D/2})}$	$K = 20.5$

Where:

V = Velocity of water in pipes in feet per second.

U = Velocity of water in pipes in meters per second.

I = Slope of pipes in Meters per Kilometer.

D_1 = Diameter of pipe in inches.

d = Diameter of pipe in feet.

D = Diameter of pipe in cms.

R = Hydraulic Radius in feet.

S = Slope of hydraulic grade line.

L = Length of pipe in feet.

One of the best and most accurate Formulas is Flamant's formula. It is practical, economical and widely spread in America and Europe.

Also since the formula of Flamant has another metric form, it is widely spread here, thus adding to its advantages. It applies to diameters less than 125 cms.

In spite of the fact that the formula of Mr. Maurice Levy is conservative and leads to smaller sections and larger velocities, it is widely spread in this country; the main reason being that it is a metric formula. In Europe it is used for diameters exceeding one meter; here it is used for smaller diameters. These two formulas were used and in both cases a nomogramme was used. The inclined distances for pipe lines were assumed to be 15% more than the horizantal distances. (Practically, this is a good assumption).

Following is a table of the computations for the diameters as found from the nomogrammes:

	DISTANCE			Demand		Slope	M.Levy		Flamant	
LINE	Hor.	INC.1	H.2-H1.	M3/DAY	Lit/Sec.	M/Km.	Vel.	Diam	Vel.	Dm
1-2	1480	1850	28	300	3.50	15.1	0.85	8	0.68	9
2-3	1170	1460	16	135	1.55	10.9	0.55	6	0.53	7
1-4	1670	2085	3	142	1.64	1.44	0.27	10	0.24	10.9
4-5	940	1175	31	72	0.82	26.3	0.67	4.25	0.6	4.75
4-6	1560	1950	9	70	0.81	4.62	0.33	6	0.3	6.5
6-7	375	470	9	40	0.51	19.1	0.54	4	0.5	4.4
7-8	675	845	5	25	0.3	5.92	0.27	3.9	0.26	4.1

Where:

The velocity is given in metres per second and the diameter is given in cms.

$H_2 - H_1$ = The difference in elevation in metres, between the two stations under consideration.

The Average of the two formulas is found to be :

Line	1-2	2-3	1-4	4-5	4-6	6-7	7-8
Diam.	8.5	6.5	10.5	4.5	6.25	4.2	4.0 cms

In chosing the Pipe Diameters we must take into consideration, the fact that the diameters down town are given in inches and not in cms. Again a very exact diameter can not be found, so chose the next diameter.

Dimensions of pipes Down Town, are as follows:

Inside Diameter 1/2, 3/4, 1, 1 1/4, 1 1/2, 3, 4, 5,.....(14) All being in inches.

In deciding about the final diameters of pipes, the following factors have to be considered:

1. Effect of Age: With increasing age of service, metal pipes commonly become corroded and tuberculated, which diminishes the discharge under the same head (both, from increased roughness, and diminished sectional area).

Mr.E.B. Weston, recommends, that friction head for a given discharge be taken as 16% greater than when the pipe is new and clean, that for each 5 years of age; i.e., for an age of 15 years, take as friction head the value obtained for the head and multiplied by 148.

Probably, no wise Engineer would attempt to predict the discharge of a 5 year old cast iron pipe line within 10% accuracy.

2. Refill Stresses: Forces to be considered are internal static pressure, water hammer and those caused by earth refill over and around a pipe.

Allowance for water hammer is essential in designing a pipe system; extra thickness is required for cast iron pipe. Many breaks in lines and pumps are in record. Water hammer is more severe, the quicker the closing, the higher the velocity of water, and the greater the length of the moving column of water.

3. Other losses like loss at bend, friction loss, sudden contraction and sudden enlargement etc. may be neglected.

For circular reservoirs the controlling steel bars are the horizantal bars. The walls are taken as the walls of a hollow cylinder with a uniform pressure from within. and the pres. of earth?

Design of Top Slab Covering.

It is assumed as a square of 8 x 8 meters, designed in this manner, then deductions are made. It is to be two way reinforced.

Assumed load = 500 Kgs. per square meter

Moment = $1/10\ Wl^2 = 1/10 \times 500 \times 8 \times 8 \times 100 = 320000$ Kg. Cms

$K = 1/2kj \times F_c = 1/2 \times 50 \times 7/8 \times 3/8 = 8$ Kgs. per sq. cms.

$d^2 = M/bK = 320000/8 \times 100 = 400\ cms^2$; therefore d = 20 cms.

Use 22 cms, Total depth.

$$\text{Area of steel} = \frac{M}{fs \times j \times d} = \frac{320000}{1200 \times 7/8 \times 20} = 15.2 \text{ sq. cms.}$$

Use 18 millimeter round bars at 15 cms. spacing.

Circular Beams

Use a beam 30 cms x 40 cms = 1200 cms^2

Use 3-20 round bars at the bottom,

and 3-16 round bars at the top,

$As = 9.42 + 6.03 = 15.45\ cms^2$,

use 8 mm round U stirrups at 10 cms spacing

Design of Walls.: Two way reinforced.

$p \times d = 2\ S_t \times t$ or $t = P \times d / 2\ St$. Where;

P = pressure = $4 \times 1000 / 100 = 0.4$ Kgs. / cms^2

d = diam. of reservoir = 800 cms.

S_t = allowable load on concrete = 5 kgs. / cms^2; therefore,

$t = 0.4 \times 800 / 2 \times 5 = 32$ cms.

A thickness of 35 cms at the bottom of the wall, is assumed. The wall is made tapering towards the top, being there, 15cms.

For area of steel:

Maximum moment at the bottom = $W \times h^3 / 6$

$= 1000 \times 64/6 \times 100 = 10.67 \times 10^5$ Kgs. cms.

$$A_s = \frac{M}{f_s j d} = \frac{10.67 \times 10^5}{1200 \times 7/8 \times 32} = 31.3 \text{ cms}^2.$$

use 25 mm. round bars at 15 cms spacing in the lowest two meters.

At two metres above the bottom;

$A_s = 31.3 \times 8 / 64 \times 32 / 25 = 5.12$ sq. cms.

Use 16 millimeter round bars at 15 cms. spacing, till the top.

N.B. Enough steel must be put on both sides of the wall to take care of the inward pressure of the soil when the reservoir is empty and the outward pressure of the water.

Vertical bars : Use 16 mm. round bars at 20 cms. spacing.

Drainage : 2 1/2 % slope of base, is allowed for drainage, with a pipe 4" in diam. as shown.

Overflow : 4" diam. pipe is used.

Ventilation : 6" Vent is used.

Intake diam. depending upon the reservoir under consideration, here being, 5" .

All pipes are of steel, while other details are as shown in drawing.

A man-hole 75 cms. in diam. is used for cleaning. A flight of wood kept outside the reservoir shall be used for reaching the bottom.

For the present this reservoir is not totally covered. In the future, it may be better to cover it. Then the top slab must be made thicker, because it has to carry more earth; the vent has to be raised, and the entrance to the regulating chamber has to be shifted to the top and a man-hole, will then be necessary.

As long as the reservoir covering is exposed to sun, the water may get hot, and it may seem necessary to cover it with a layer of good whitewash that can stand heat.

It usually absorbs 90% of the heat and only 10% passes in.

....

DESIGN of Collecting Chamber and detail etc.

No specific formulas to be applied. Only experience and the use of old designs can help. The CHAMBER presented herewith, was chosen.

It includes the following:

1. A gallery with perforated walls surrounded by rubble masonry from the outside.

2. Intake.

3. Collecting chamber with:

   (a) Over flow pipe.

   (b) Drainage pipe.

   (c) Exit pipe with filter, 2 in number, one for each branch of our system (all pipes are of steel)

   These are the main points in the design as shown.

SUPPLEMENTARY REMARKS

Before ~~closing up~~ with this thesis, the following remarks and comments must be considered:

1. Conveyance of water and pipes:

Steel pipes and fittings:

Advantages: dimensions are standardized; jointing is cheap; thickness sufficient to provide ample safety against corrosion, bursting, handling, air pressure and trench loads, tapping and making service; connection more readily done than with other types, wood or reinforced concrete; long life; good Hydraulic flow conditions, if properly coated and maintained; dependability under fire demands.

Disadvantages: cost; weight; high freight rates; tuberculation by soft and coloured waters, which may reduce carrying capacity as much as 71%; liability to electrolysis; external corrosion from acid soils.

2. Special pipes: and types of connections:

1. Expansion joint pipe : is used when exposed to high expansion and contraction and for carrying water under high pressure. Moulded rubber gaskets are slipped over the spigot ends, which are faced, and the whole group drawn into position by the ring clamp as shown. It is very tight with steel pipes.

2. Threaded Pipe: Can be finished up to 16 in. diameter; Threads and fittings are special.

3. Flexible ball joints: tight joint with parts accurately machined. The outer bell is reinforced near the flange. A retaining ring is used to allow for 20" deflections. It is made

to bolt to flange, or to bolt to the outer bell: it supports the entire joint.

4. High pressure pipe: It stands 750 Lbs. (12" diam.)

A large safety factor must be provided.

5. Universal cast iron pipes: An iron to iron joint consisting of a shallow conical hub with a machined bearing surface, and a spigot the taper of which is 1/2 degree sharper than that of the hub. Each has a pair of bolt lugs (two for high pressure)

Making joints in bell and spigot pipes: molten lead; leadite a composition of iron, sulfur slag, and salt finely ground and thoroughly mixed.

Metalium: a composition of dark grayish luster, furnished in pellet form in 100 lbs. bag. It is poured like lead.

Cement: either neat or as mortar may be used better than lead in all respects except rigidity under settlement.

Lead Wood: must be calked pneumatically, because of high cost of a hand work.

Intake Pipes: Generally they are of steel with flexible joints, laid at a depth to escape damage. Their size must be large enough to reduce friction, but not so large as to cause deposit of sediment. Where strams are liable to great fluctuation in level, pumps must be placed in a subterranean pit. Intake capacities should be increased with consumption.

Laying steel pipes:

Bedding: Steel pipes must be very carefully bedded as to have a uniform support under bottom. They must never rest on a boulder etc... Thorough tamping is necessary to increase refill capacity, whenever we meet rock, It must, then, be covered by a layer of earth.

Care in laying: Pipes must be clean, inside, when put in trenches; the open ends should be plugged when the work is stopped to prevent any stones rolling inside. Back filling must be free from ashes, cinder or any corrosive material. Rocks must not be permitted in the backfill if close to the pipe.

Depth of laying: Never less than 1 meter.

Inspection: All pipes must be inspected, before and after laying.

Cleaning steel pipes: All growths,sediment etc... which reduce capacity must be removed. Cleaning may be by flushing, pulling through a cleaner or by water driven turbine cleaners. In flushing a number of blow-offs or hydrants, is opened; it is not safe.

Electrolysis of water pipes: Effect:

It injures steel mains and service connections.

Kinds:

1. Stray current electrolysis, due to return from electric railroads, telephone etc...
2. Earth currents may cause it.
3. Electrolysis of water which effects the pipes.

Conditions: It occurs only when a current leaves the pipe; this may be :

a) At insulating joints where current passes from one pipe to another through earth.

b) Where current leaves the pipe line permanently.

Remedies: Points, insulating papers and taxtiles are not good; cement is porous; they should not be used. The best way is to try to locate pipes as far from electric wiring as possible and use insulation joints. Leadite in joints is not recommended. Cement and Metalium are better. Drainage wherever possible is a good remedy.

Leakage from Mains: It can be detected, by many instruments (detectophone etc.) All require direct contact with pipe.

Leakage can not be less than 3000 gallons per mile per day, if not carefully tested and all defects remedied. In small systems, like ours, leakage is more liable because of poorer construction, It can be reduced by testing in an open trench under a pressure at least 50% more than the maximum static pressure, recalking all dripping joints and by replacing all defective pipes.

2. Reservoirs: Designs are usually controlled by ground level, water levels and nature of foundations.

In some places it may be economical and practical to increase the capacity by excavating and lowering the reservoir floor below ground level. In others, loss of head, cost of excavation, or natural ground water level, may force us to raise the reservoir floor as high as possible. In the case of sound and dry foundations the floor may be 12-15 cms. of reinforced concrete with a 5 cms. of leveling concrete. Usual steel content is 5-7 Kg. per $met.^2$. When we have a poor foundation or if there is a steep slope, the floor may be supported on piles or columns. If wet foundations are met, like a permeable bed of gravel, the thickness of the floor must be increased to stand the reversed upward pressure of the ground water.

Advantages of covered reservoirs:

1. Walls may span vertically.
2. Though it adds to the cost, yet it prevents the growth of algae.
3. It reduces evaporation.
4. Safe against pollution.
5. Safe against freezing.
6. Low temperature is maintained in summer.
7. No modification of structures necessary if water is filtered.
8. Mosquitos, flies, etc... can never touch the water.
9. It prevents the entrance of dust, leaves.
10. Frequent cleaning is, here, eliminated.

Reservoirs' controllers should include all necessary valves and gauges. If an electric gauge recorder is to be placed, tubes for floats must be provided. An overflow pipe must always be present. Drain and waste conduits must be included; all valves must be operated from one floor with extension stems, if needed. To shut off the flow, use altitude control valves. Valves can either be operated electrically or mechanically.

Lining: A good water tight lining of properly proportioned asphaltic concrete 5 cms. thick as minimum; similar to those used in highways.

It may or may not be reinforced. Reinforcement is 0.3% the area of the concrete section. The reservoir may be paved if wanted.

Lining may fail:

1. at intersection of slopes with bottom.
2. Cracks in lining caused by wt. of water.
3. Joints between slabs.

4. Through porous places in the lining.

It is prevented by:

Cutting a V shaped groove 4 cms. deep and of 2.5 cms maximum width, then filling carefully with ironite and cement; a coating of gunite may be used.

Reservoir walls: They are justified where excavations are to be saved, where rock is present, where thickness is requested, and where the excavated materials are not good for tight embankment, or where the reservoir is to be covered with a road; all conditions of loading must be considered; inward, outward etc... The type of wall used here is the vertical wall.

Circular Tanks: They are easily calculated; economical; require a less perimeter for the same capacity and eliminate the inherent weakness of rectangular reservoirs at corners.

Shrinkage and leakage are reduced: No masonary drying out etc.

Disadvantages: Form work especially with beam and slab roof; also constant variation in the length of reinforcing steel, a lower value is assigned to the reinforcing steel. Difficulties of architectural treatment add to all of these.

Floor and wall joints: Since the diameter of a reservoir has a tendency to increase after filling due to the elasticity of steel in tension and as the base is rigid due to contact with ground, some reinforcing steel must be added to take care of the bending moment and shear at the base. No exact formulas can be used. It is left to the judgement of the designer.

Unless very low stresses are used in the roof, leakage will result. Some vertical steel bars are, therefore, added. A dense concrete water proofing materials may be used (better use more cement and good cement proportioning). Membranes and waterproof coatings can also be used. An interior coat of 7 1/2 % solution of calcium flurosilicate followed by two coats of glutin (after 24 hrs.) is excellent. In case a joint leakage takes place, make grooves between different day pours; to plumb all sections in line, copper stripes can be used. Filling of reservoirs with silt is very serious. This may limit the period of use of the reservoir. In chosing the location of the reservoir avoid places where silting is possible. Silting decreases capacity and decreases depth of water. To remove the silt use a scouring sluice (gallery). It is not very effective. Hydraulic sluicing or suction dredging is a better suggestion.

Spalling and discoloring must be avoided as much as possible. Efflorescence and freezing are the main causes. Try to diminish them.

Reservoir Intakes: They have equipment similar to large intakes on rivers and lakes. Blow-offs are provided. Gates must gear against high heads. Ports at different levels are needed to take off the best water during any semi annual overturns. Stop plank grooves, with disks, can be added. Divers require a manhole 3 ft. in diameter. dont cont. the syst.

Intakes and outlet works serve to pass the reservoir water into the supply conduit and to restore compensation water. Outlets and intakes have the same controlling conditions involving screens and gates.

Water must be taken at high velocity leading to the use of cylindrical gates or needle valves.

Stop disks and plants are to be introduced to simplify the replacement of any valve, Valves not replaceable must be of bronze.

Intakes must be protected against pollutions, infiltration and freezing.

A collecting gallery is used in our chamber.

Advantages are :

1. It intercepts water more completely than wells.
2. Suction pipe usually eliminated, with trouble from pumping air minimized.
3. A gallery costs less than a system of wells.

Care must be taken against pollution, otherwise, the water will be harmful.

E S T I M A T E S

Following, is a rough estimate of the scheme as a whole. It can not be considered as final or accurate, because our knowledge about the geology of the place is limited.

1) COLLECTING CHAMBER ESTIMATE:

a - Earth Work:	200 M^3 at 4 L.L. per M^3	=	800 L.L.
b - Masonry	110 " "35 " " "	=	3850 "
c - Conc. filling	100 M^2 " 4 " " M^2	=	400 "
d - Plaster	350 " "1.5 " " "	=	525 "
	Total	=	5575 L.L.
	say		5600 L.L.

2) RESERVOIR AT POINT No.2 INCLUDING REGULATING CHAMBER:

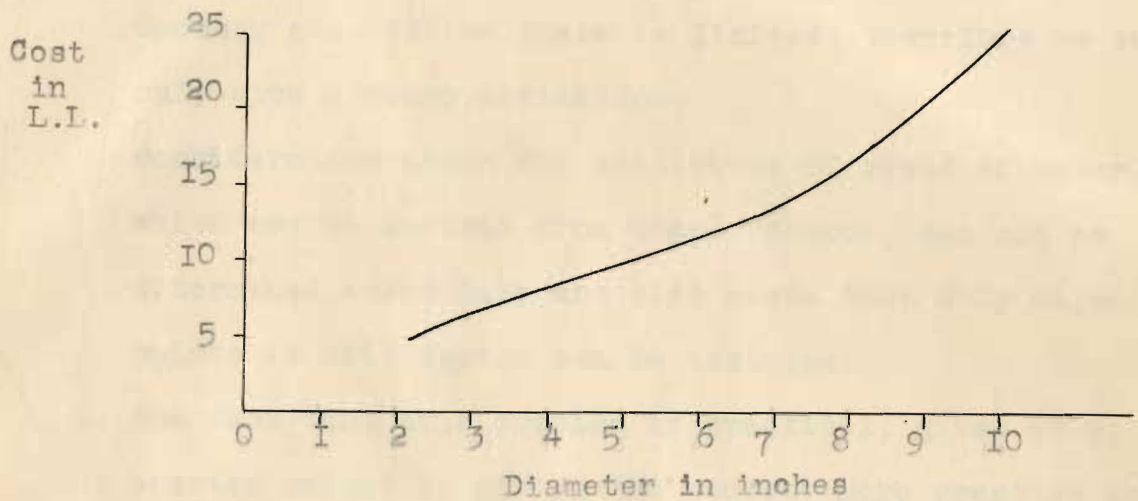
a - Earth Work	280 M^3 at 3 L.L. per M^3	=	840 L.L.
b - Rein.Concrete including woodwork	60 M^3 at 120 " " "	=	7200 "
c - Soling	15 M^3 at 2 " " "	=	30 "
d - Conc.filling	80 M^2 at 4 " " M^2	=	320 "
e - Plaster	300 " at 1.5 " " "	=	450 "
f - Manhole		=	50 "
g - Door and details		=	100 "
h - Whitewash		=	30 "
	Total	=	9020 L.L.
	say		9000 L.L.

Similarly the cost of the other reservoirs is calculated.

TOTAL COST OF ALL RESERVOIRS IS 30,000 L.L.

PIPES AND DETAILS - ESTIMATE:

A curve of the price of pipes per linear meter against the diameter is shown:



Cost of:

5" pipes	3800 Metre	at	9.8	L.L. per Met.	=	37240	L.L.
3" "	3000 "	"	6.5	" " "	=	19500	"
2 1/2" "	3200 "	"	5.6	" " "	=	17920	"
				Total	=	74660	L.L.
Fittings, taps, valves and other details = 25%					=	18700	"
				Total	=	93360	L.L.
				say		93500	"

THEREFORE THE TOTAL COST WILL BE:

1. COLLECTING CHAMBER	=	5,600	L.L.
2. RESERVOIRS AND DETAILS	=	30,000	L.L.
3. PIPES AND CONNECTIONS	=	93,500	L.L.
Total	=	129,100	L.L.
4. UNFORSEEN EXPENSES = 15%	=	20,900	L.L.
GRAND TOTAL	=	150,000	L.L.

THEREFORE THE TOTAL COST WILL BE ONE HUNDRED AND FIFTY THOUSAND LEBANESE POUNDS.

CONCLUSIONS

On ~~ending this thesis~~ some important points must be added:

1. Our knowledge as regards the Topography, Hydraulogy, Geology etc. of the place is limited; therefore we can only give a rough estimation.

   Consideration about the conditions of yield of water which may be derived from these factors, can not be determined accurately and that means that only major points in this design can be included.

2. The fact that this problem is practical, gives it a heavier weight in giving the student more practice and giving him the chance to deal with practical problems. The result will be good, especially if it is approved by the Lebanese Government.

3. The water of this spring is clean. The usual filtration, distillation etc.. methods are therefore, not needed and thus were not included in our design.

4. This being a design problem, can not include any theories. Only calculations and fundamental principles were here presented.

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