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A PROPOSED SLIDING SCALE FOR THE ANNUAL CONTROL OF LAKE NASSER RESERVOIR

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ABSTRACT

A sliding scale for the annual control of the output from the Aswan High Dam Researvoir is proposedin the present paper. The scale depends upon the amount of water remaining in the reservoir from the previous year and also upon the maximum amount of water that could be saved from the water requirements of the main crops.

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1. INTRODUCTION

It is well known that Africa has been suffering since ten years from abnormal dryness. Food aids from U.N. and some countries have been sent to stop the catastrophic famines. It is believed that some meteorological changes have occurred, but no definite reasons for these changes have been given. In fact, the phenomenon called" desertation" is now common in some African countries; meaning the destroy of the agricultural lands.

Table 1: The Water Conditions in Lake Nasser in 11 Years

Water Year	Input to the Lake milds.m^3	Water Level in the Lake ms	Hydraulic Conditions of the Lake	Water Year	Input to the Lake milds. m^3	Water Level in the Lake m	Hydraulic Conditions of the lake
1974/75	69.0	165.60	Filling	1979/80	84.30	171.27	Emptying
1975/76	81.5	172.42	"	1980/81	50.00	171.13	"
1976/77	52.8	171.70	Emptying	1981/82	45.00	170.36	"
1977/78	65.6	172.52	Filling	1982/83	40.70	165.87	"
1978/79	62.1	173.04	Filling	1983/84	43.00	163.60	"
				1984/85	32.00	157.00	"

2. DROUGHT EFFECTS

The Aswan High Dam has saved Egypt from the dry years up to 1985. However, before the arrival of the flood on August 1985 Egypt was in a very critical situation. Six years had passed from 1980 with a continuous lowering of the water level of Lake Nasser.

Long-term forecasts showed that the flood of 1985 would be lower than any of all the preceeding floods. Only 19 milliards m^3 would arrive to the lake. Had this happened, Egypt would have met a disaster which would have been greater than all the disasters of the African countries combined. This is due to the intense population of 49 millions with no other resources. Engr. Zaki Kenawy, former minister of Irrigation and the Chief Director of the Aswan High Dam during its construction, expressed his feelings of the gloomy conditions in which Egypt was by giving the advice to everybody to save any piece of bread, for it might be useful during the next year. This was on May 1985 three months before the arrival of the flood on August. Unexpectedly, that flood came generous and again Aswan High Dam saved Egypt from the disaster. However, that event should not pass without a careful study in order to be sure that it would not happen again.

Let Us Recall the Measures which were proposed if the 1985 flood came as low as 19 milds. m^3 in Lake Nasser

a. The withdrawal of the "dead water" zone in Lake Nasser whose size is 30 milds. m^3. Obviously, this meant the stoping of the hydro-electric station of the Aswan High Dam which supplies 80 % of Egypt's demands of electricity.

b. The remaining 7 milds. would be cut from Sudan because Sudan had not fully utilized her share in Aswan High Dam Reservoir.

   Both items would give 56 milds. which are the annual water requirements for Egypt.

As for the first proposal, it should be remembered that the entrances of the tunnels were concreted from the bed-level of the river at R.L. (85.65) to R.L. (123.00) which is the bed-level, of the new entrances, Fig. (1). These new entrances were constructed in order to reduce the heights for the operation of the tunnels'gates. Thus, the volume between the the above-mentioned levels contains real dead water and is about 6.5 milds. m^3. Therefore, the volume which should be cut from the Sudan share would be 7+6.5 = 13.5 milds. m^3. This seemed to be impractical.

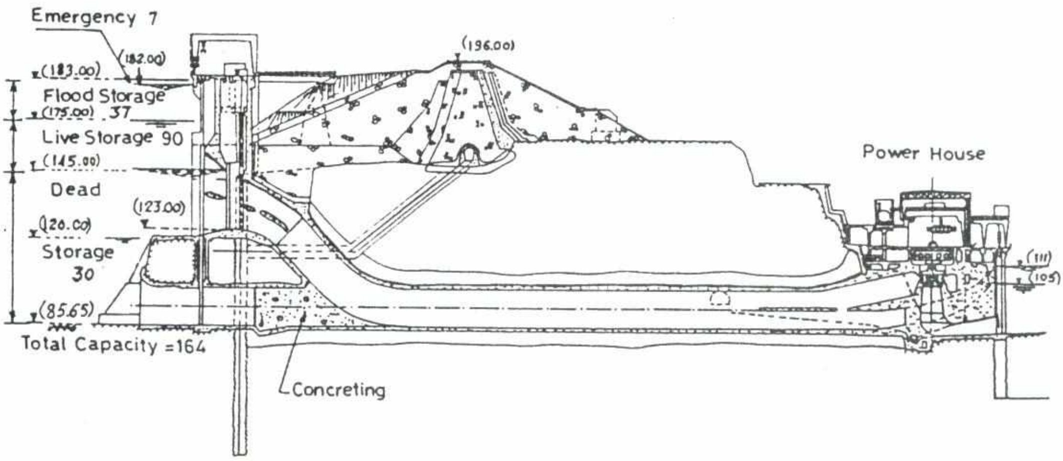

Fig.(1)Concreting The Entrances Of Tunnels And Reservoir Capacities In Milds.m^3

Later, two other proposals were given as follows:

(a) Re-use of drainage water

(d) Exploitation of underground water.

It should be noted that most of the drainage water in Egypt is used more than twice. This is because all the main drains of Upper and Middle Egypt and the Delta have their escapes into the river Nile. Only the main drains of north Delta escape their waters into the sea. As for the underground water in the valley, it is well known that its main source is the river Nile itself. Thus, it cannot be considered as an additional water resources.

The main problem in this respect is "whether it is probable that the cycle of years of extremely low input in Lake Nasser might be repeated".

Unfortunately, this is true. The reasons are as follows:

(a) Aswan High Dam was completed in 1970. During the four years 75,76,78 and 79 the reservoir was filling as seen in Table 1. The highest level which was reached, was 173.04; then the reservoir started to be emptied in the following six years. This is peculiar for "Over-year Storage" which is sometimes called the Century Storage" i.e. the reservoir can supply the demands for 100 years. One would ask "Has the reservoir capacity been correctly designed and has it been correctly regulated?"

(b) In 1954, when Aswan High Dam had been just a thought, the author made a study . Hurst new theory of Long-Term Storage[(1),(2)]. After discussing the validity of this theory, the author assumed that the then existing records of the Nile annual discharges at Aswan, from 1870 to 1950, would repeat in the future in sequent order[(3)]. The mean annual input to the proposed over-year storage reservoir was 92.38 milds. m^3. He assumed that the

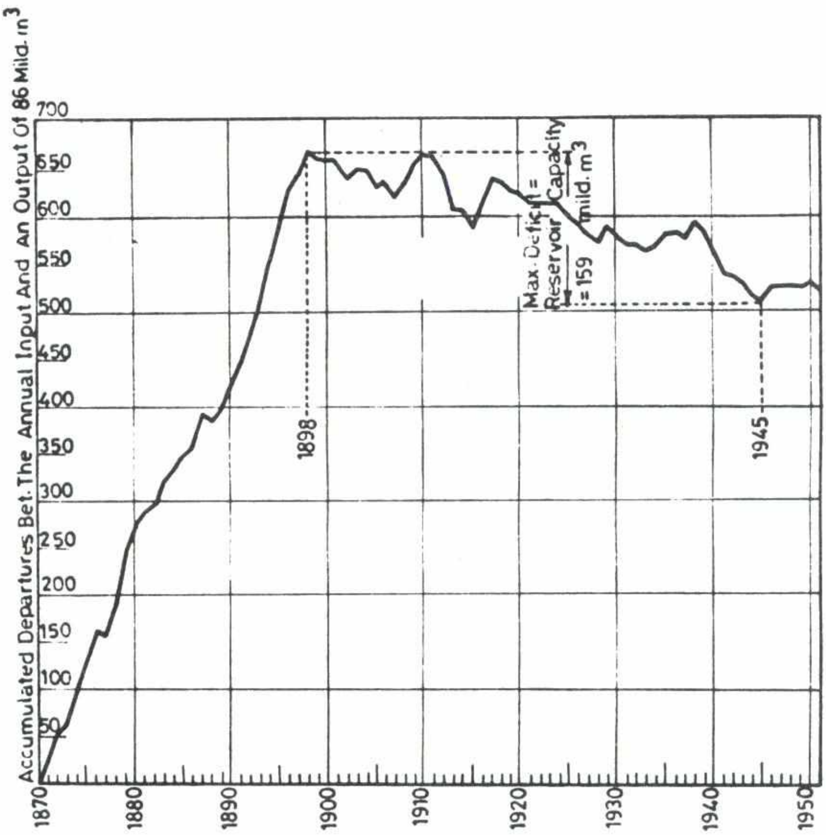

Fig.(2) Determination Of The Reservoir Capacity Whose Output is Less Than The Mean Input.

demands of Egypt should cover the present cultivated area of 6.0 millions feddans + the future cultivable area of 3.0 million feddans i.e. 9.0 millions feddans. For Sudan, the existing cultivated and the future cultivable areas in the arid and semi-arid zones were 2 millions feds. He assumed the average losses from the reservoir would be 6.0 milds. m^{3*}. The total annual requirements for Egypt and the Sudan would be 86 milds. m^3, i.e. 6.38 milds. m^3 less than the annual mean supply. The capacity of an over-year storage reservoir whose output is less than the mean supply would be the maximum deficit of the accumulated departures between the annual supply I (Input) and the annual demand O(output) of 86 milds m^3. This could be obtained by tabulating the results as shown in Table 2.

Table 2 Determination of the Max. Deficit

Year	Annual Supply milds. m^3	1 - 86 milds. m^3 +	1 - 86 milds. m^3 -	Accumulated departurees 1-86
–				
1870	112	26		26
1871	116	30		56
1872	96	10		66
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* Those assumptions are different from the items of the Nile-Water aggreement which was held bet. Egypt and the Sudan in 1959.

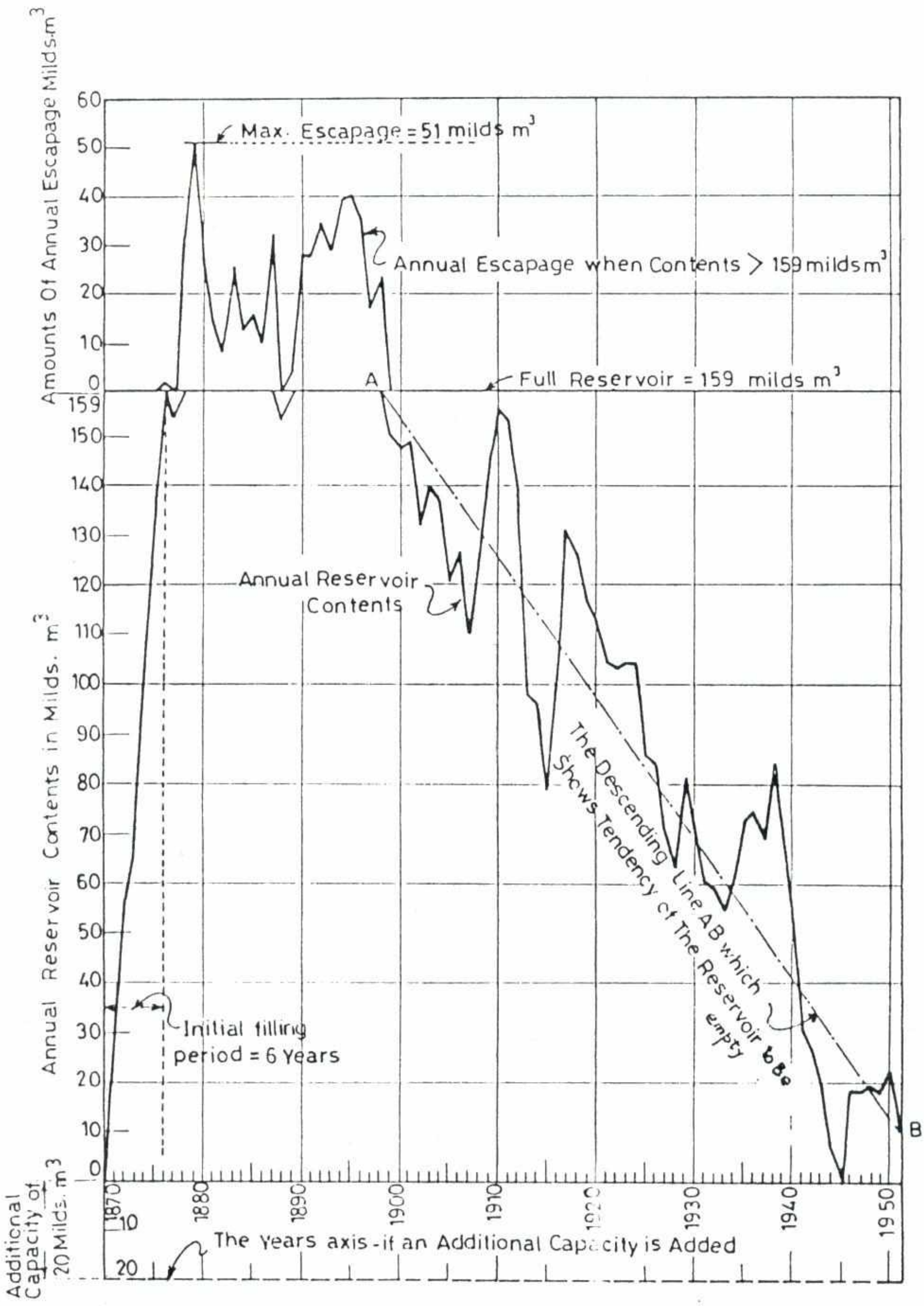


Fig.(3) A Regulation with a Constant Output: Annual Requirements Of 86 milds m^3 At Aswan

By plotting 1-86 as shown in Fig. (2) the maximum deficit i.e. the reservoir capacity was 159 milds. m^3. If after the construction of the dam with a live storage capacity of 159 milds. m^3, the cycle was repeated, 2 other columns should be added to Table 2 headed, " reservoir contents" and " escapage". The latter column showed the volumes which should be escaped when 1-86 was bigger than 159. The net result is shown in Fig. (3). The reservoir would be filled in six years. Escapage would occur up to point A which corresponded to year 1898. Then the reservoir contents would start to decline. This is shown by the average line AB in Fig. (3). Since the reservoir capacity was designed for the period of Maximum deficit, which occurred bet. years 1898 and 1945 as seen in Fig. (2), we should expect the reservoir to be empty in year 1945, in spite of the local rises of the reservoir contents above line AB in some high years. Referring to Fig. (3), there are 14 years between 1898 and 1945 in which the annual input I is higher than the demand; in 6 years of which the input is over 100 milds. m^3. Some authors suggested that an additional capacity should be added to the live storage capacity, say 20 milds. m^3 in order to avoid the year of empty reservoir. This additional capacity can again be studied in Fig. (3). The descending line AB still exists and all the effect of the additional capacity is to retard the year in which the reservoir would be absolutely empty for some other years.

This may explain the reason why Lake Nasser was about to be empty, had the flood of 1985 not come as an average flood. Between years 1980 and 1985, the annual demands of Egypt which are 56 milds. m^3 continued to be withdrawn from Lake Nasser despite the continuous lowering of the lake level.

3. IDEAL METHOD OF REGULATION

Obviously, whatever the reservoir capacity might be, we cannot take from it a constant output even if this output is less than the mean supply, i.e. we cannot use the following equation for the regulation of the reservoir:

$$O = M - L = 92.38 - 6.38 = 86 \text{ milds. } m^3 \qquad (1)$$

in which, O is the yearly constant output

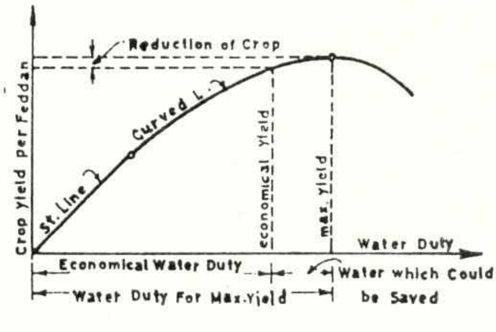
M is the mean supply (input)

L is the constant reduction of the mean

The reduction of the mean by a quantity L is necessary to reduce the reservoir capacity. In the study made by the writer(3) it was found that the Reservoir capacity "R" based on the mean supply which is the range between the maximum and minimum accumulated departures with respect to the mean, was 487 milds. m^3. When the output was reduced by 6.38 milds. m^3 per year the capacity became 159 milds. "R" Thus,the reduction L has nothing to do with the regulation of the reservoir, but it depends upon the available capacity of the reservoir site R.

If the output O in Eq.(1) is varied every year according to the reservoir contents, then Eq. (1) can be modified as Eq.(2)

$$O = (M - L) - F.W \qquad (2)$$



(4)Relationship Bet. Water Duty & Crop Yield.

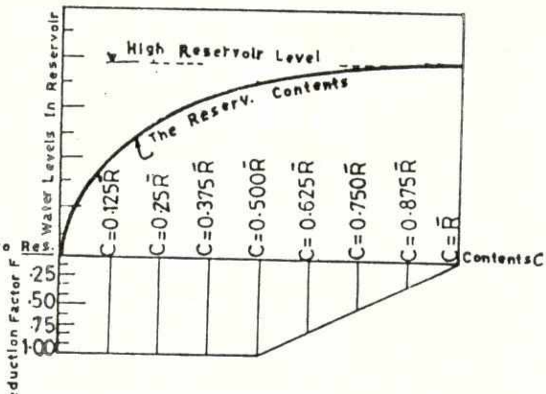


Fig.(5) The Proposed Reduction Factor F

Table III Example of using the sliding scale for the years 1912–1917 at Aswan

year*	Input I milds. m^3	I-O ± milds. m^3		Reduction Factor $F = \frac{2(\bar{R}-C)}{\bar{R}}$	Reduction F×W milds.	I - O milds. m^3		Reservoir contents at the end of the year C	Escapage milds.
		+	-			+	-		
1912								142	-
1913	46		40	2(159-142) ÷ 159 = 0.21	0.21 x 15 = 3		37	105	-
1914	84		2	2(159-105) ÷ 159 = 0.68	0.68 x 15 = 10	8		113	-
1915	69		17	2(159-113) ÷ 159 = 0.58	0.58 x 15 = 9		8	105	-
1916	113	27		2(159-105) ÷ 159 = 0.68	0.68 x 15 = 10	37		142	-
1917	111	25		2(159-142) ÷ 159 = 0.21	0.21 x 15 = 3	28		159	11

*the years are solar years and the inputs are taken from ref. (1).

± the output O = 86 milds. m^3 per year; for Egypt + the Sudan + Losses.

in which, W is the maximum reduction of the water requirements of the main crops. These should be determined from the results of the agricultural experimental stations. We should think of using the "economical water-duties" for the different crops[4]. By these water duties, big amounts of water could be saved with little reduction of yield, as is seen in Fig. (4). Generally, W varies between 0.15 and 0.20 of the water requirements for the main crops, with an average value of 0.175. Hence, the max. reduction = 0.175 x 86 = 15 milds. m^3 per year. It should be mentioned that the reduction should not be the same every year. For this reason, we have introduced the reduction factor F in Eqn. (2). F varies between the value o when the reservoir is full and the value 1.00 when the contents of the reservoir reach 50 % the reservoir capacity. If we assume that F varies linearly between these two limits, then Fig. (5) shows this proposed "Reduction Factor F".

Thus, at full reservair $F = 0$

Between full researvoir and resrvoir content $C=0.5\ R$

$$F = \frac{2(R-C)}{R} \qquad (3)$$

Below reservoir contents $C = 0.5\ R$, $F = 1.00$

Table 3 shows an example of using the proposed sliding scale for the years 1912-1917 at Aswan. To work the sliding scale, we should have the reservoir contents of the preceding year 1912 which is 142 milds m^3. Escapage is not to the sea, but to Toshka Depression. This would help re-charging the Owases

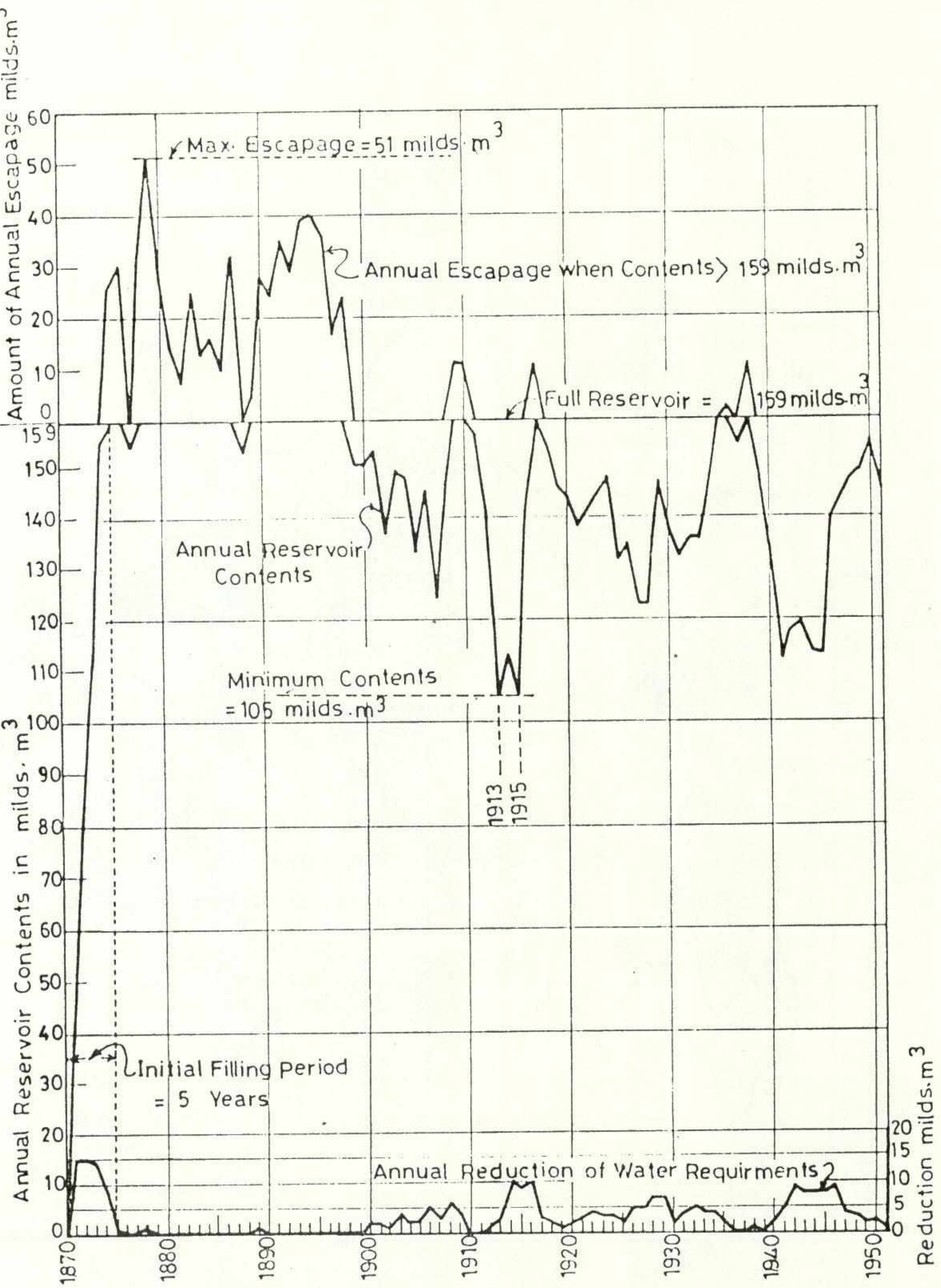


Fig.(6) A Regulation with A Reduced Output According to The Proposed Sliding Scale Shown In Eq^{s}(2) & Table III

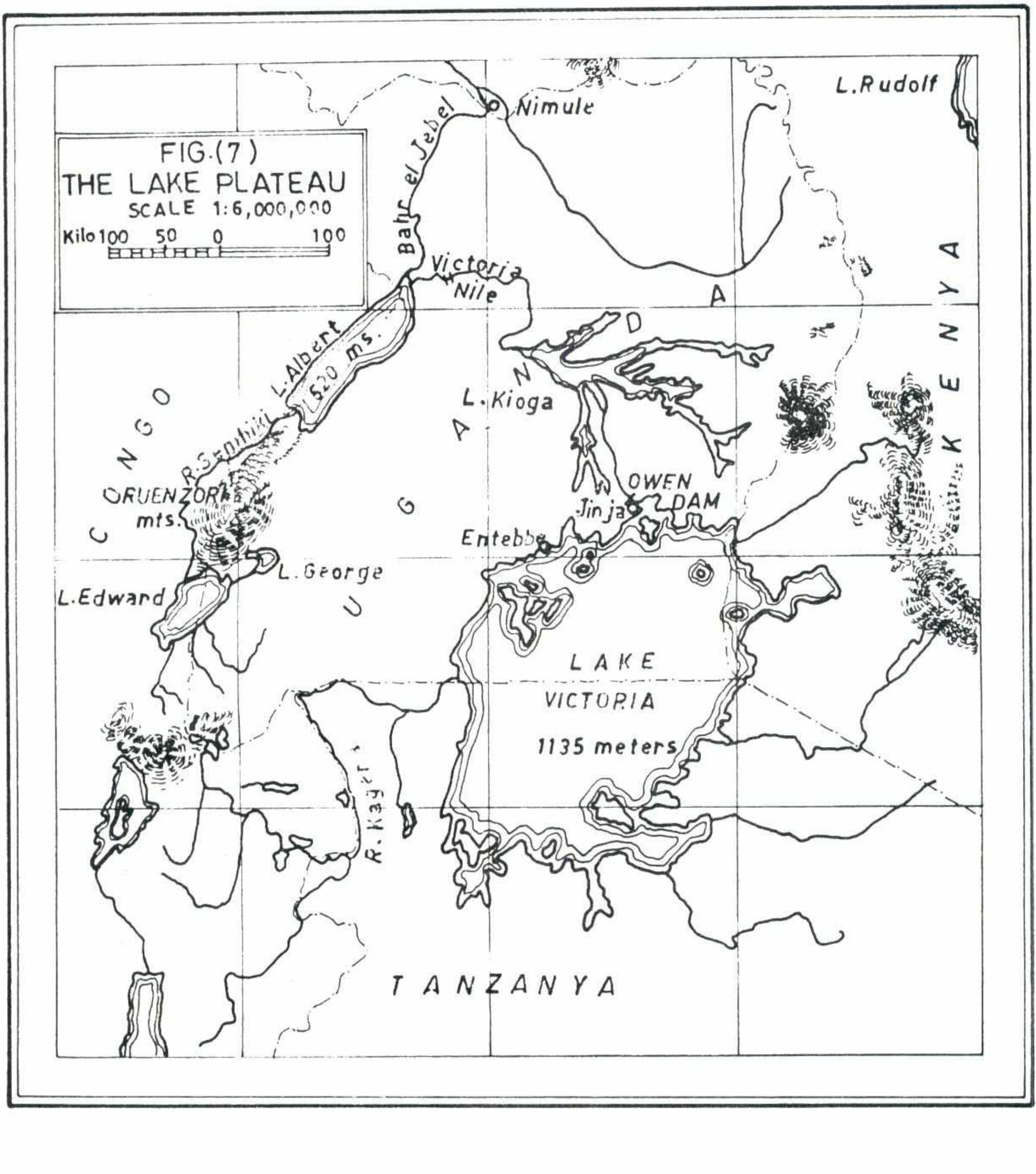


FIG.(7)
THE LAKE PLATEAU
SCALE 1:6,000,000
Kilo 100 50 0 100
L.Rudolf
Nimule
Bahr el Jebel
Victoria Nile
L.Albert
520 ms.
L.Kioga
OWEN DAM
Jinja
Entebbe
RUENZORI mts.
L.George
L.Edward
LAKE VICTORIA
1135 meters
R.Kagera
CONGO
UGANDA
KENYA
TANZANYA

wells.

The results of using the sliding scale for the years 1870-1950 are shown in Fig. (6), which should be compared with Fig. (3). As a result of using the sliding scale the reservoir is tending always to be full. The lowest content of the resrvoir is 105 milds. m^3 i.e. 2/3 the resrvoir capacity. This occurs in 1913 and 1915 instead of 1945. There will be no need to have an additional capacity as a reserve. There will be also no need to have an additional capacity for the sub-annual fluctuations of inputs and outputs during the various months. The lower diagram in Fig. (6) shows the magnitudes that should be cut from the outputs O in the different years. It never reached the assumed permissible reduction W and the average it was only 5 % of the water requirements.

5. An Auxiliary Reservoir

If for some unforseen events we find that Lake Nasser is depleating despite the use of the sliding scale, then we should not wait until the reservoir becomes completely empty. It was shown that no other water resources can compensate the present water requirements of Egypt from the river Nile. Furthermore, it would be unreasonable that Egypt might suffer from low inputs in the reservoir, while it is located at the tail of the river Nile whose main source is Lake Victoria, one of the biggest fresh-water lakes in the world. In fact, when over-year storage was found to be the only solution to satisfy Egypt's water demands in all years, Lake Victoria was looked upon as the main reservoir. This was in 1946 before the Aswan High Dam was proposed. The advantages of this lake is its very big area which is about 67000 Km^2, Fig. (7). A lowering of 1.0 m. of the lake's level would give about 67 milds. m^3. Furthermore, there are no losses by evaporation since the rainfall over its surface is 98 milds. while evaporation is only 93 milds. m^3. Even when Egypt was thinking of constructing the Aswan High Dam for over-year storage she did not give up the idea of using Lake Victoria as an auxiliary reservoir. For this reason Egypt shared the expenses of Owen Dam which was constructed in 1954 at Rippon Falls. The objects of this dam are:

a. Hydro-electric Development of power to Uganda from a fall of about 20 ms. This object has been fulfilled.

b. Over-year storage to Egypt. This object has not yet been fulfilled.

The dam was designed to satisfy the 2 objects. It has 6 vents 3.00 ms. wide x 5.10 ms. high. Some of them pass the normal discharge which is 21 milds. m^3 per year. The Egyptian inspectorate in Ginga collaborate with the authorities of Uganda to guarantee the passage of this normal discharge to Victoria Nile. The vents of the dam are designed to pass 40 milds. m^3. Thus, Egypt and the Sudan can withdraw from Lake Victoria 19 milds. m^3. more than the natural supply of Victoria Nile.This addition to Lake Nasser would help to avoid any droughts in Egypt. The Jongli canal should, by all means, be completed in one or two years so that the gains from the auxiliary reservoir of Victoria Lake may not be wasted by evaporation in the Sudd Region.

5. CONCLUSIONS

1. The Aswan High Dam Reservoir should not be regulated by passing a constant annual output even if this output is less than the mean supply. The output should be varied every year according to a sliding scale which depends upon the water contents remaining in the resrvoir from the last year and upon the maximum amount of water which could be saved from the water requirements of the main crops.

2. The absence of a sliding scale in regulating the output from Lake Nasser might be the main reason that the lake was depleting before the arrival of the 1985 flood.

3. A sliding scale is proposed in this paper. It is tried on the annual dischrages at Aswan for the years 1870-1950.

4. Victoria Lake should be used as an auxiliary reservoir for Aswan High Dam. Jongli Canal should, by all means, be completed in one or 2 years for the benefit of Egypt and the Sudan.

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