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BAARDHEERE DAM PROJECT - SOMALIA

SUMMARY REVIEW

OF

PROJECT DESIGN

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Baardheere Dam Project - Somalia

SUMMARY REVIEW OF PROJECT DESIGN

1. Introduction

This report is prepared in response to a request from the Bureau for ~~Asia~~ Africa, Agency for International Development to review: (1) ElectroConsult's report of August 1985 on the status of consulting engineering design services, and (2) Electrowatt's draft report of September 1985 on detailed project design accomplished by ElectroConsult under its contract with the Baardheere Dam Project Authority, Government of Somalia.

2. Juba River

The Juba River is considered the primary resource in the overall future development of Somalia. It is the only stream in all of Somalia with a perennial flow.

The Juba is formed by the confluence of three rivers in the Ethiopian plateau that come together near the border at Dolo. It flows southward for 700 kilometers (km) and discharges in the Indian Ocean near Kismayo about 400 km southwest of Mogadishu. The average yearly discharge is substantial--somewhat more than 6,000 million cubic meters (MCM). The rate of flow varies widely from season to season: from a mean annual rate of about 200 cubic meters per second (cusecs) to as low as 15 cusecs in the dry season and flooding up to 1500-2000 cusecs in rainy seasons.

3. Development Scheme for Juba River

a. Present Situation

Rain is scarce and irregular in the Juba River Valley and the yields from rainfed agriculture are low and uncertain. Some seasonal crops are grown in flood recession areas. Except for small family farms that grow seasonal crops in small areas near the river, present irrigated agriculture in the Valley is confined to some 20,000 hectares (ha) in banana plantations, the Sugar Project, the Mogambo Project and the Jilib State Farm which rely on run-of-river supply and is insufficient during low flow months.

b. Irrigation

The key to agriculture development of the Valley is the provision of year-round irrigation water to some 175,000-200,000 ha of selected land. Essential to the scheme is construction of the multi-purpose Baardheere Dam somewhat less than halfway down the Juba River on its course from the border with Ethiopia to the sea. The dam would provide controlled releases of some 4,000 MCM of water annually for irrigation. Supplies may be drawn from the river by gravity to serve about 30% of the potential cultivated area and by low-lift pumping for the remainder.

c. Flood Control

The dam and its associated detention reservoir would eliminate annual flooding downstream, except for a most unusual hydrometeorological event, by regulating flood flows to a rate that would keep the river within its banks.

d. Electric Power

The Baardheere Dam and its associated hydroelectric plant would provide electric power for the bulk of Somalia's energy needs to the year 2000 and a high proportion for some years to come. Furthermore, its generation from water power would replace for fifty years, or more, equivalent generation from imported fossil fuel. The country currently depends entirely on diesel plants for its electricity needs.

4. Baardheere Dam Design Features

The topography and geology of the selected site is excellent for construction of a large dam. No stability or leakage problems are indicated.

A concrete gravity type dam is envisaged which will rise about 75 meters above lowest foundation and extend about 600 meters bank to bank. Its construction will require about 750,000 cubics meters of concrete. The long, narrow reservoir impounded by the dam will extend some 140 km upstream--almost to the town of Luuq.

A 105 MW (thousand kilowatts) power plant will be built at the toe of the dam with two 225 kilovolt (KV) transmission lines sending power to Mogadishu and down the Juba Valley to Kismayo, 370 km and 340 km away respectively. Firm capacity of the hydroplant is calculated by ElectroConsult at 97 MW with firm annual energy production of 423 GWh (million kilowatt hours).

Requirements for irrigation water in excess of that released through the hydroplant turbines will be discharged to the natural river channel through regulated bottom outlets in the

dam. A mid-level intake and outlet will be provided fór gravity feed to proposed irrigated areas in the Baardheere area immediately downstream. An ungated overflow spillway will be incorporated in the dam to pass flood flows.

5. Status of Engineering

The Government of Somalia contracted with ElectroConsult (ELC), Milan in July 1983 to make technical studies and prepare the detailed design and tender documents for construction of the dam, power plant, switchyard and transmission lines. Then in February 1985, a further contract was entered into with Electrowatt (EWI), Zurich for technical review of ELC's work.

ElectroConsult has virtually completed the design of all project components though certain confirming, or modifying, hydraulic model tests have yet to be carried out. However, Electrowatt's review of ELC's project design and associated studies has raised a number of questions that have merit and should be resolved before tender design drawings and specifications are issued. These points are presented in detail in EWI's draft report of September 1985.

6. Significant Design Features Considered Not Final

Without going into repetitive detail of the merits here, I will mention the primary questions raised in EWI's review of ELC's design and their ramifications.

a. Hydrology and Reservoir Operation

EWI concurred in the results of the hydrology

investigation based essentially on a 32-year historical record of stage readings on the Juba upstream of the dam. In EWI's view projected evaporation losses from the reservoir and silting in the reservoir near the dam are overstated. Further, EWI suggested that the constraint on reservoir operation that the 100-year frequency flood should be reduced to maximum downstream flow of 700 cusecs might be raised to 1000 cusecs; at least, the effect of such an increase on necessary flood storage volume in the reservoir and related energy generation should be assessed.

b. Hydrogeology

Infrequent samples have shown that the salt content in the Juba river is sometimes high. Water quality should be assessed monthly and investigations made as to the source of the salinity--flow through gypsum formations, drainage from saline soils, or springs. Water quality of course has a direct bearing on the suitability for irrigation and in extreme cases could affect the kind of cement to be used in concrete surfaces in contact with the water.

c. Generator Unit Size

For a number of technical, and perhaps economic, reasons EWI suggests that a 4 X 26 MW units power plant might be preferable to the ELC recommended 3 X 35 MW units scheme. Such a change at this stage would require major modification of power plant and dam tender drawings.

d. Turbine Type

EWI makes a strong case that the Francis-type turbine (fixed blades) is more suitable to the conditions at Baardheere

than the Kaplan-type turbine (adjustable blades) selected by ELC. Again a change at this point would require major modifications to the tender drawings and specifications.

e. Bottom Outlet Control Works

ELC has selected Howell-Bunger valves in conjunction with ring-follower gates to regulate the flow of water through the bottom outlets. For reasons of economy and simplicity of operation and maintenance, EWI strongly recommends conventional radial gates for regulation backed up by simple slide gates.

f. River Diversion

EWI suggests an alternative to ELC's river diversion scheme (to dewater the dam construction site) which would lessen the deep cut in the right river bank and simplify final closure of the dam structure.

g. Hydraulic Model Tests

EWI suggests additional hydraulic model tesing to that planned by ELC, in particular:

- Influence of maximum tailwater levels on operation capability of the bottom outlets.
- Influence of bottom outlet operation on tailwater fluctuations near the powerhouse.
- Scouring downstream of the end sill of the plunge pool.
- Separate model for the mid-level irrigation outlet.
- The time scheduled by ELC for hydraulic model building and testing--six months--is considered much too short by

EWI who properly recommends about one year.

h. Transmission Line Conductor Size

EWI analysis demonstrates that the conductor size selected by ELC is too small, in terms of energy losses that may be expected, for a portion of transmission line routing. A re-sizing of conductor is suggested to suit disparities along the routing in natural physical conditions--altitude and temperature--that affect energy losses from the line.

7. Project Costs

ELC did not break cost estimates down by foreign and local currency. According to EWI's analysis the split is of the order of LC 20%:FX 80%. However, ELC should make the LC/FX differentiation in its detailed line-item project estimate.

EWI's estimate of construction costs were generally lower than ELC's for civil works and higher for equipment costs. However, there was a very close match for total cost: ELC $306 million to EWI $294 million. Therefore it appears that financial donors will be looking at a $300 million project of which about $240 million will be foreign exchange (to be paid out over say a five-year construction period).

A summary table of Project Costs follows based on 1984 prices and an exchange rate of 17.2 So. Sh. = $1.00.

ITEM	TOTAL COST $U.S.(000,000)	
	ELC	EWI
Dam & Appurtenant Works	166	129
Power Intake	3	4
Powerhouse	44	43
Switchyard	4	7
Transmission Lines	53	.76
Access Road	8	8
Housing	9	9
TOTAL DIRECT COSTS	287	276
Engineering and Administration Costs	19	18
TOTAL CONSTRUCTION COST	306	294

The overall costs include 15% for Civil Works contingencies and 10% for Equipment Cost contingencies.

8. Power Development Prospects

a. The Power Market

When one speaks of the "power market" in Somalia it refers primarily to the greater Mogadishu area and the Juba Valley down to Kismayo which together account for 85% of the country's total demand at present.

The basic data for current project development are presented in a Power Market Study of August 1984 (not available for this report) prepared by ELC. It is said to represent an updating of previous forecasts from 1977. EWI finds the power market study "generally satisfactory" but suggests aspects for additional investigation.

The population growth in the Mogadishu area was found to reflect an urban migration as well as natural growth. In the Juba Valley the situation is quite different. There is a scarcity of human resources and attracting the necessary population to develop the area is a matter pf primary concern.

In sum, the present power market statistics in the service area of the Baardheere Project appear to provide an adequate basis for forecasts of annual power demand and energy requirements.

b. Power Forecasts

The ELC forecasts are reported by EWI to follow established procedures for "the analysis of a small partially developed power supply system in a developing country". Two approaches were used--analytical and macroeconomic, the latter as a check on the former. The results were deemed "reasonable and appropriate" with some reservations.

In particular, doubts exist that the take up in demand in the short term projected for the Juba Valley will be realized. With respect to Mogadishu, future demand will likely be constrained by tariffs. Thermal plants costs in Somalia were found to be well above normal international installation costs.

EWI's projection for demand and energy requirements follow:

POWER DEMAND (MW)

Year	Mogadishu	Juba Valley	Total
1985	28	9	(not interconnected)
1990	45.5	15	60.5
1995	63	21	84
2000	88	28.5	116.5
2005	113	36	149

ENERGY REQUIREMENTS -Interconnected System

Year	Energy(GWh)
1990	265
1995	368
2000	510
2005	653

These forecasts differ from those of ELC inasmuch as they are somewhat below the minimum forecast for the period. On the page following is a graphic representation showing historical values for energy demand and forecast values to the year 2015. The segment for years 1985-2005 includes both the ELC and EWI forecasts for comparison.

In sum there seems little doubt that while the Baardheere plant capacity will exceed the entire system demand until year 2000, by the year 2010 the peak system demand will approach twice the Baardheere capacity.

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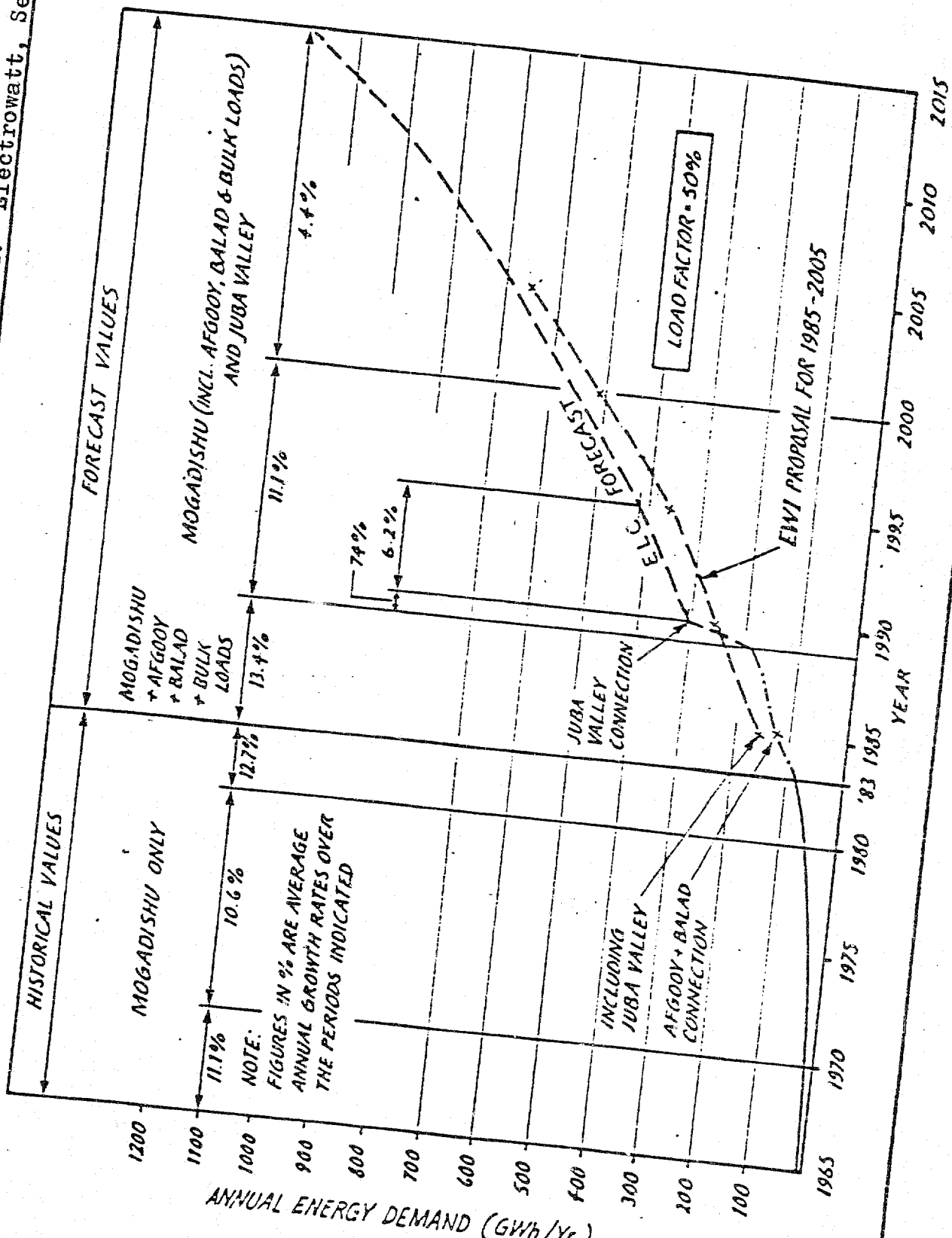
SOURCE: Electrowatt, September 1985

BAARDHEERE DAM PROJECT REVIEW
ELECTRIC ENERGY DEMAND IN MOGADISHU AND JUBA VALLEY
SUMMARY OF HISTORICAL & FORECAST VALUES



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9. Irrigation Development Prospects

Though Baardheere Dam and the assured supply of water for downstream irrigation is the key to significant increase in agricultural production in Somalia, the realization of such production is a long way down a difficult road.

A potentially productive area of some 175,000-200,000 hectares is estimated to come under command of the project. Bringing it to beneficial production will be a tedious and slow process: delineating the areas with suitable soils; finding, training and motivating skilled farmers; constructing suitable irrigation and drainage works and farm layouts; operating and maintaining the systems; year to year supply of vital unputs for successful cultivation--seed, fertilizer, pesticides. equipment, farmer credit, extension and marketing services.

The point at this juncture of Baardheere project development is that though agriculture in the Juba Valley is essential to future economic development, it would be specious to assign a benefit stream from it to the Baardheere Dam Project in the near or medium term.

10. Project Economics

The scope of project economic studies made by ELC covered hydropower aspects only--compared to equivalent fossil-fueled facilities. The reservoir operation studies carried out did take into account the effect of flood attenuation and water supply for irrigation but put no value on either of these functions.

The benefit-cost evaluations by ELC for the hydropower component were based on a rather arbitrary cost allocation to power of 45% to 55% of common facility costs--dam, spillway, etc. With such allocations hydropower showed a most attractive Internal Rate of Return (IRR) of 16.4% to 18.8%. In the present circumstance, returns calculated in such a way do not fairly reflect the situation and are hardly indicative of a viable project.

A more realistic indicator is attained by assigning all, or nearly all, of total costs of Baardheere Dam to hydropower while taking benefits for the value of energy produced. EWI adopted this approach and recalculated the IRR using EWI developed construction costs, EWI revised energy forecasts, EWI revised energy valuation, and allocation of 80% to 100% of Baardheere Dam costs to hydropower. The results were:

Cost Allocation	IRR
80%	10.9%
100%	8.7%

It is believed that 9% is a realistic assessment of the IRR for the project with benefits accruing only from the sale of electric energy.

11. Findings and Conclusions

a. The Baardheere Dam Project is a technically sound undertaking. Certain design details as pointed out in the Electtowatt Report (some of which are mentioned in 6. above) need a further careful look by ElectroConsult and probable modification. If not already undertaken, meetings between ELC and EWI sould be held forthwith to resolve the matters in question. It is unfortunate that EWI's review of key studies and feature design were not undertaken before designs reached the detailed tender drawing stage.

b. It is esential that hydraulic model tests be completed so that design modifications, when indicated, can be carried over to the tender drawings before contract bidding.

c. It appears that ELC considers the tender design drawings virtually complete. In fact this stage may be some months away if proper attention is given to the EWI design critique and results of hydraulic model studies.

d. A program for sampling of water quality monthly at the dam site should be initiated and investigations begun to discover the origins of salinity in the Juba River.

e. An IRR of 9% as computed above is believed to be realistic and to represent a reasonable return under present national economic conditions. Comprehensive cost-benefit studies incorporating suitable cost allocations and appropriate benefit valuations, with sensitivity analyses, should be prepared for

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presentation to potential donors so that economic and financial rates of return may be soundly assessed.

12. The Bottom Line

The overall future development of Somalia depends to a major degree on the Juba River. The Baardheere Dam Project is the sine qua non for agricultural development of the Juba Valley. Further, it will utilize a "free" renewable source for producing electrical energy in a significant amount for 50 years or more, and generate income from the sale of power to pay out the project while irrigated agriculture perforce slowly develops.

It is unthinkable that a resource such as the Juba River will remain essentially untapped in a a poor country such as Somalia. The crux of the matter is whether financial sources can be found for such a large capital investment now and whether the country will be able to service the debt.