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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE REPUBLIC OF CAMEROON
SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN

FEASIBILITY STUDY ON MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT
EXECUTIVE SUMMARY

OCTOBER 1993

NIPPON KOEI CO., LTD.

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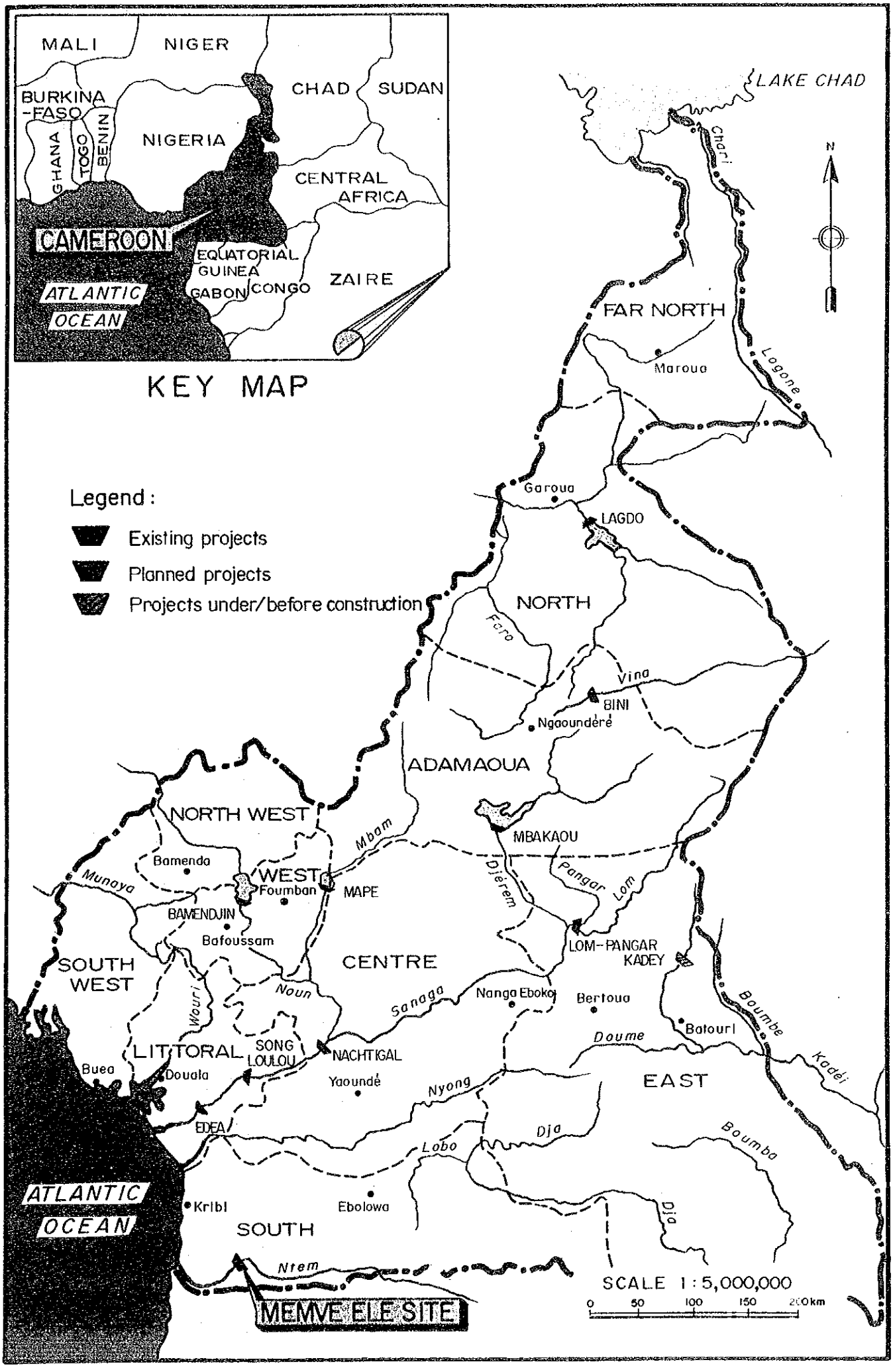
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EQUATORIAL GUINEA
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N
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Logone
Garoua
LAGDO
Legend :
Existing projects
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Projects under/before construction
NORTH
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Ngaoundéré
ADAMAOUA
NORTH WEST
Mbam
MBAKAOU
Bamenda
Munaya
WEST
Foumban
MAPE
Djerem
Pangar
Lom
BAMENDJIN
Bafoussam
LOM-PANGAR KADEY
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Nyong
EAST
Kadéi
EDEA
Lobo
Dja
Boumba
ATLANTIC OCEAN
Kribi
Ebolowa
SOUTH
Ntem
MEMVE ELE SITE
SCALE 1 : 5,000,000
0 50 100 150 200km

FEASIBILITY STUDY
ON
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT

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Background and Objective of the Study

1. According to a study by the National Electricity Corporation of Cameroon (SONEL), which is the sole government agency responsible for development of electric power and its supply to consumers, the economically exploitable hydropower potential in Cameroon is estimated to be about 20,000 MW in total. As a result, SONEL is developing these abundant hydropower resources as its main power source. The total installed capacity of power generating facilities of SONEL was 804 MW in 1991, 723 MW of hydro (90%) and 81 MW equivalent of thermal power (10%) by small diesel plants.

2. The total hydro-power energy production was 2,659 GWh in 1989/90 with average annual increasing ratio of 4.9% during the period from 1971 to 1990, the total thermal power production was 43.0 GWh in 1989/90 with 3.5% in average annual increasing ratio during the same period. Therefore, the total power production both of hydro and thermal powers was 2,702 GWh, and its average annual increasing ratio was 4.9%.

3. There are two interconnected power transmission networks in Cameroon, i.e., the South Interconnection Network (Sanaga system) and the North Interconnection Network (Lagdo system). And isolated demand centers which are far from such transmission or sub-transmission line networks are supplied by diesel power plants.

4. The present installed hydropower capacity of the South Interconnection Network is 650 MW. All of this capacity is present in the Sanaga river basin. It is estimated that the Network now supplies the peak power of 390 MW and the annual energy production of 2,570 GWh in 1990/91. According to the power demand forecast (by Micro Method with medium forecast), however, in 2010 the Network will have the peak power demand of about 630 MW. To meet the above demand, the Network should provide the installed capacity of about 850 MW, adding the decrease of peak power supply capacity in dry season (about 145 MW) and reserve capacity about 70 MW. Therefore, new electric power development is needed to cope with the power deficit in the future.

5. The proposed Memvé Elé project, which is located on the Ntem river flowing in the southern part of the country (Fig. 1), and will be connected to the South Interconnection Network, was first studied during the inventory survey as a chain development plan on the Ntem. It is also listed up in the Sixth 5-year Development Plan (1986-1991) as one of the prior projects to be studied and designed for the project implementation.

6. Such being the background, Government of Cameroon (GOC) requested the Government of Japan (GOJ) in March 1988 to conduct the Feasibility Study (the Study) on Memvé Elé Hydroelectric Power Development Project (the Project). In response to this request, Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation program of GOJ, implemented the preliminary study in October, 1989 for the purpose of the project selection and identification. The Study has been carried out by the JICA Study Team in close cooperation with SONEL since December 1990.

Work Progress

7. The Study consists of:

(1) Identification Stage (December 1990 to March 1991),

(2) Field Investigation Stage (May 1991 to September 1992), and

(3) Feasibility Grade Design Stage (September 1992 to October 1993).

The study results at the Identification Stage are described in Progress Report 1 submitted to SONEL in March 1991. The study of the Field Investigation Stage concluded *Progress Report 2* in September 1992. The feasibility-grade design works at the final stage yielded firstly the *Interim Report* turned to SONEL in February 1993 and secondarily the *Draft Final Report* in July 1993. In the *Interim Report*, preliminary discussions were made, and basic concepts of the project development are identified in terms of project scale. In the *Draft Final Report*, further discussions such as on project evaluation was added.

This report, Final Report, is hereby submitted to present the final conclusions of the Study.

Project Area and Location

(1) Location of the project

8. The Ntem River on which the proposed Memvé Elé site is located, is one of the largest rivers of Cameroon. It drains a catchment area of about 31,000 km2 at the southern edge of the country. In the upper reaches it flows along the border between Cameroon and Gabon

and in the lower reaches between Cameroon and Equatorial Guinea. Some of its tributaries originate in Gabon and Equatorial Guinea (See Fig. 1).

The proposed Memvé Elé site is situated in the lower reaches of the Ntem basin approximately 100 km upstream of the estuary. Its catchment area is 26,350 km2. At this site there is the Memvé Elé waterfalls with about 35 m head offering favorable site for hydroelectric power development.

(2) Meteorology and hydrology

9. The Ntem basin that is shown in Fig. 2 belongs to the equatorial climate zone and shows four different seasonal patterns as described below.

- rainy season from March to June ; relatively frequent rainfall with moderate intensity, high temperature and moderate humidity
- dry season from July to mid-September ; relatively low temperature and high humidity
- rainy season from mid-September to mid-December ; very frequent rainfall with high intensity, moderate temperature and high humidity
- dry season from mid-December to February ; high temperature and low humidity

10. The climate of the Ntem river basin upstream of the project site is mild with small variation of 23 °C to 25 °C on average monthly air temperature throughout the year at Amban (EL. 560 m) and Ebolowa (EL. 603 m). Mean annual rainfall of the Ntem river basin is around 1,738 mm as shown in Table 1. The recorded rainfall series are shown in Table 1. An isohyetal map is shown in Fig. 3. The seasonal pattern of rainfall can be explained by one type mentioned above for the entire basin. Mean annual discharge at the damsite is 398 m3/s. The annual mean runoff is shown in Table 2. The flow condition of the Ntem river is relatively stable as illustrated in Fig. 4.

11. The recorded maximum flood discharge is estimated at 2,110 m3/s at the damsite. Flood frequency analysis shows that 100-year and 10,000-year flood discharges are 2,300 m3/s and 3,450 m3/s respectively. The flood hydrograph is summarized in Fig. 5.

12. Sediment inflow into the proposed reservoir is estimated to be 25 ton/km2/year (19.2 m3/km2/year) at Nyabessan. This is almost equally compared with the rate estimated for Nachtigal site on the Sanaga river (28 ton/km2/year) and less compared with the rate for the entire Sanaga river basin (44 ton/km2/year).

(3) Geology

13. The project site located in south Cameroon is widely composed of pyroxene hornblend gneiss and granitic gneiss that sedimentary rocks of Precambrian period was underwent metamorphosed as shown in Fig. 6. The geological map of dam site is shown in Fig. 7. Immediately downstream of the site, the waterfalls called as Chute Du Memvé Elé with some 35 m in head is located. The downstream of the waterfalls form very steep cliff and the gorge "Gorge Du Ntem".

14. The geological feature in the site is characterized by the development and distribution of fault and scistocity in the same direction of the gorge. The result of seismicity analysis shows that the three events only had affected to the site during past some 300 years. The earthquake coefficient (k) for the site for return period of 100 years is calculated as $k = 0.01$ G. No geological evidence regarding the active faults was found through the investigation.

Socio-Economy

15. The estimated total population in Cameroon is 10.5 million in 1986 as shown in Table 3, which is based on the publication by the government. The population density is as 22.5 persons/km2 in the whole, and that in South Province where the project site belongs is as 7.9 persons/km2. The population is summarized in Table 3. The estimated population in Cameroon in 1991 is 12.24 million.

16. Gross Domestic Products (GDP) of Cameroon amounted to F. CFA 3,732 billion in current price as of 1988, showing an average growth rate of 14.0 % during last 10 years from 1979 as shown in Table 4. The growth rate in 1980 constant price was 5.2 % during last 8 years from 1980 to 1988. It is noted that growth rates since 1987 shows minus. Per capita income indicated approximately F. CFA 334,000 in 1988 with the annual average growth rate of 10.7 % as shown in Table 4.

17. In 1987, the Government finance of Cameroon amounted to F. CFA 879.5 billion (equivalent to 22.0 % of GDP) in expenditure and F. CFA 742.8 billion in receipts, at the average annual rise rate of 14.6 % and 13.7 % respectively during the period from 1982 to 1987. The Government finance is summarized in Table 5. On the viewpoint of budget scale, the receipts have been reduced year by year. Accordingly, the actual receipts were decreased, and the expenditures were also curtailed. Therefore, the Government financial statistics show that the expenditures exceeded receipts since 1987. These deficits were supplemented by foreign loans and domestic loans.

SONEL's revenue and expenditure are increasing steadily (See Table 5). The expenditure corresponds roughly to 9 % of the Government expenditures. The cash balance is fair.

18. The Government of Cameroon have made public the Industrial Development Plan 1989-2000 (the Plan). In this Plan, the Government of Cameroon projected several kind of economic and financial indicators divided into 4 scenarios, i.e. the **Scenario A** which was made on pessimistic viewpoint in economic growth rate, the **Scenario B** which was made on rather optimistic viewpoint, the **Scenario C** which was made from the standpoint between the Scenario A and B, and the **Scenario D** which was made on most optimistic viewpoint.

According to this Plan, the GDP was projected to become as follows as a macro-economic prospect.

Scenario	Total GDP in 2000 (F.CFA billion) (1985 constant price)	Growth ratio (%)
A	5,043	2.55
B	5,874	3.72
C	5,732	3.64
D	6,680	4.82

Note: Increasing ratio means average annual increasing ratio for the period from 1989 to 2000.

In view of decline of GDP growth in recent years, it is somewhat difficult to project the future growths of GDP which depends on the extent of betterment of social infrastructures henceforward. This study tentatively assumes that the GDP will increase with the rate assumed in Scenario A or less as the expectable maximum growth up to year 2000, by the rate assumed in Scenario C up to 2010, and the rate in Scenario B after 2010.

Environmental Impact

19. The Initial Environmental Examination (IEE) was carried out in 1990/92. The output was presented in the report entitled Preliminary Report on Analysis of Initial Environmental Condition, Recommendations and Specification for Further Impact of Study which is attached to this report as Appendix. That report showed the potential socio-environmental issues related to the proposed project and proposed two lots of the survey works as:

(a) study on public health and impacts on it due to the proposed project, and

(b) study on economic activities, habitation and infrastructures.

The major issues were foreseen to be *i)* resettlement of people and *ii)* health problem due to creation of water impounding of the water storage.

20. The results of the Environmental Impact Assessment (EIA) are summarized in Table 6 and described hereinafter.

(1) Deterioration of water quality (Appraisal: none)

Besides the obstacles remained in the reservoir such as trees and grasses, decay of submerged biomass will lead a sensitive change in the water quality. However, the water quality in the reservoir and the downstream can be diluted and kept clean by circulation of reservoir water in a short period (2 to 3 days) because of the run-of-river type development.

(2) Natural Environment

i) Effect on ecology by development of project (Appraisal: small)

The project site is located near the Campo fauna reserve. The impact to this zone is small because the reservoir created by the dam construction is far away from the said zone, as the small scale development damming up the Ntem river only is adopted.

The reservoir created by dam construction has an area of 19 km2. Water rise due to the dam is about 10 m. A part of equatorial forest will be submerged and animals living in this area will be ridded to the surrounding.

In the swamp zone sharing large part of the submerged area, there are many wild palm trees and few marketable trees. As to the marketable trees growing on high land, following measures are conceived.

1) Allocation of felling/cutting of marketable trees in the reservoir area to forest exploiters.
2) Opening and clearing hauling roads by ordering local employee.

To protect the animals in the reservoir area from downing and being isolated in small islands, it is recommended to carry out beating drums and gun shots in the air regularly for many days before impounding the reservoir.

ii) Effect on landscape (Appraisal: small)

Memvé Elé waterfalls having a height of 35 m exist just downstream the proposed dam site. It is considered that the discharge passing through the falls become small due to diversion of water for power generation. There are two tributaries, the Ndjo'o and Biwome, jointing with the Ntem river between the dam site and Memvé Elé falls.

The average discharge of both the Ndjo' o and Biwome, 35 m3/sec, can be used as a compensation flow. Furthermore, river outlet facilities will be provided for the dam body.

The dam site is located at the very remote area and the transportation means are poor. So, the tourism for this area is not popular now.

(3) Socio-Economic Environment

i) Effect on historical and cultural heritage and existing infrastructure (Appraisal: none)

The influence zone close to the project possesses little historical and cultural heritage. Furthermore, there is no specific infrastructure to be affected by the project development.

ii) Resettlement (Appraisal: small)

Numbers of houses affected are only 9. The cost of resettlement is estimated at F. CFA 7.5 million. The cultivated land to be submerged is about 100 *ha*. The compensation cost for the cultivated lands and agriculture is greater than that of resettlement and estimated at around F. CFA 80 million .

iii) Effect on traffic means (Appraisal: small)

The public road connecting Ma' an with Nyabessan will be cut off by submergence at two bridges, near Alen II and between Nemeyong and Alen I. The formation height of road near the bridges may be elevated by embankment and replacement of the bridges (span is less than 10 m) will be required.

The transportation mean to cross the Ntem river is carried out by a canoe. The dam crest road can be utilized for communication between Nyabessan village and villages at the opposite bank.

iv) Effect on downstream water utilization (Appraisal: none)

Water used for the power generation is put back to the Ntem river at the tailrace outlet about 4 km downstream of the dam. There is few private house along the river course between the dam site and the tailrace outlet. As the project is of run-of-river type, the flow condition downstream the tailrace outlet will not change remarkably. The downstream river side of the tailrace outlet is not at all populated.

v) Occurrence of diseases such as malaria caused by insects or water (Appraisal: small)

The entomological investigation assesses the existence of notable vectors, simulium of human onchocerca (creeping disease), anopheles of malaria and tse-tse flies of sleeping sickness (trypanosomiasis) from the view of point of medical and veterinary interest.

Considering the already high level of malaria present in the project zone in all seasons, the intensity of transmission of this disease will not be generally modified.

The absence of onchocerca presently in the project site and far distance to the nearest homes will minimize the risk of outbreak of this parasitic disease.

As to the sleeping sickness, owing to the fact that there will be intensive mobilization of population following construction of the dam, the proximity of breeding area at Campo being about 60 km from the site keeps permanent danger.

It is important to expand the medical facilities at the time of construction and to envisage an adequate anti-vector campaign program based on local strategies. While hygienic measures and health education are also important to the population. The monitoring for the health problem during/after the construction is very important.

(4) Effect on environment during construction period (Appraisal: small)

As there is few private house around the construction site, noise and vibration by construction will not affect on the residents. However, it is expected that vehicle for transportation of construction materials and equipment will cause noise and vibration and affect on the residents living along the existing road. The road will be improved by grading and widening, and speed limitation should be considered before the commencement of construction.

21. Overall, it has been assessed that impact on the environment is not serious in comparison with other hydropower projects because of the adoption of the run-of-river type development. However, the monitoring for the health problem due to creation of water impounding reservoir is very important for the project.

Power Survey

22. There are two major networks of the interconnected power transmission system in Cameroon, i.e., South Interconnection Network (Sanaga system) and North Interconnection Network (Lagdo system).

The installed capacity of the power plants in Cameroon is 804 MW as detailed in Table 7, and their composition is 90 % in hydro and 10 % in diesel plants, of which the South Interconnection Network shares 701 MW or 87.2% and the North Interconnection Network 103 MW or 12.8%.

Location of the existing power plants and transmission line is shown in Figs. 8 and 9, respectively.

23. The consumers are divided into three, low tension (LT), medium tension (MT) and high tension (HT) consumer. The historical energy consumption by consumers is shown in Table 8. The HT consumer holds 59% of the total energy consumption.

Average growth rate in the last 10 years was 3.8 % per year for HT consumer, 2.7 % for MT consumer and 7.3 % for LT consumer, and overall 4.3 % per year. The growth rate in the latest year (1989/90 - 90/91) is relatively low compared with the growth in the preceding period, presumably due to socioeconomic regression effected in the world.

Table 9 shows historical energy production records in comparison with consumption records. The growth of energy production shows a similar trend to that of consumption. Loss of energy in the public sector amounts to 20 to 26 % in recent years, while that for HT consumer is within a range between 0.6 and 2.9 %.

24. The typical daily load curves for public sector in the South Interconnection Network in 1988/89 shows a night peak pattern and the peaking time starts 18:00 and ends 23:00 as shown in Fig. 10. The daily load factors (for public sector only) are about 75.6% in working day, 71.5% in Saturday and 69.9 % in Sundays and holidays. While, annual load factor is about 60 % in the South Interconnection Network.

Load varies not only on a daily basis but also on seasonal basis with a range of 40 MW which corresponds roughly to 20 % of public sector power demand. The highest demand usually occurs in January to March and sometimes in May or June. However, the pattern of the daily load curve seems to be almost similar throughout the seasons.

25. There are two methods for the demand forecasts for the public sector which was made by SONEL in 1989/90; one is the macro method (trend method) for 10-year forecast (up to 1998/99) and the other is the micro method for 15-year forecast (up to 2014/15). The

demand forecast of energy production and peak power in the South Interconnection Network estimated in this Study are shown in Figs. 11 and 12, and summarized below in terms of trend method and the micro method :

(South Interconnection Network)

Trend Method

Year	High Scenario Energy (GWh)	High Scenario Peak (MW)	Medium Scenario Energy (GWh)	Medium Scenario Peak (MW)	Low Scenario Energy (GWh)	Low Scenario Peak (MW)
1990/91	2,568	390	2,568	390	2,568	390
1994/95	2,697	418	2,697	418	2,697	418
1999/00	2,879	452	2,879	452	2,879	452
2004/05	3,504	571	3,285	529	3,084	491
2009/10	4,388	739	3,801	628	3,318	536
2014/15	5,641	978	4,456	752	3,585	586
Average growth rate (%)	3.3	3.9	2.3	2.8	1.4	1.7
Public sector only (%)	5.7	5.8	4.2	4.3	2.6	2.8

(South Interconnection Network)

Micro Method

Year	High Forecast Energy (GWh)	High Forecast Peak (MW)	Medium Forecast Energy (GWh)	Medium Forecast Peak (MW)	Low Forecast Energy (GWh)	Low Forecast Peak (MW)
1990/91	2,568	390	2,568	390	2,568	390
1994/95	2,797	434	2,759	427	2,742	470
1999/00	3,154	502	3,055	483	3,019	531
2004/05	3,578	582	3,400	548	3,271	587
2009/10	4,153	690	3,829	629	3,541	647
2014/15	4,890	829	4,376	732	3,849	716
Average Growth Rate (%)	2.7	3.2	2.2	2.7	1.7	2.6
Public Sector Only (%)	4.8	4.8	3.9	3.9	3.2	3.9

As a summary of the above demand projection, the following can be recommended:

(1) North Interconnection Network will remain as a relatively small power market in a foreseeable future. There will be no acute merit nor need of interconnection to the South Interconnection Network.

(2) Accordingly, the proposed Memvé Elé Project would be planned in consideration of power/energy demand of the South Interconnection Network. Looking at the demand projections of various scenarios for the South Interconnection Network projections overall, this study presumes that the "Medium Growth Scenario" of the micro method (refer to Table 10) represents the most likely features of power demand growth in light of the projected GDP growths which is discussed in Paragraph 18 above.

Development Scale

26. The development scale was optimized by three-step screening:

The first screening was to select the optimum dam and waterway alignment among alternatives based on cost/kWh. The second screening was to select the optimum turbine discharge and the full supply level (FSL) resulting in the maximum net-benefit. The third screening was DST (Development Scale and Timing) optimization.

27. The results of first screening are shown in Fig. 13. The first screening selected the project feature such as:

- the small scale dam alignment using runoff only from Ntem river, and
- the waterway system equipped with a 2.5 km long headrace channel, headpond, and two lanes of 1.5 km long tailrace tunnels.
- FSL = EL. 392 m (tentatively)
- Maximum turbine discharge = 450 m3/s (tentatively)

28. The second screening brought on the following points.

(i) There is a tendency that the net-benefit drops following that the maximum turbine discharge falls over 500 m3/sec, but there is no remarkable difference in the net benefit in case the turbine discharge is less than 500 m3/sec.

(ii) There is not clear difference in the net benefit between the full supply level EL. 390 m and EL. 394 m.

(iii) The selected plan in the first screening (Q_{max} = 450 m3/s and FSL = 392 m) is one of the optimum plan resulting in the maximum net-benefit (See Fig. 14).

(iv) The third screening yield five plans such as:

FSL (m)	Max. Turbine Discharge (m3/s)		
	Q = 400	Q = 450	Q = 500
EL. 390	-	Plan 1	-
EL. 392	Plan 2	Plan 3	Plan 4
EL. 394	-	Plan 5	-

29. In the third screening (DST optimization), the Nachtigal upstream project (4 x 66 MW), which is a competitor with the Memvé Elé Project, is considered in the study. The Nachtigal project located on the Sanaga river is planned to be connected to the South Interconnection Network at Oyomabang substation in Yaoundé through 225 kV transmission line.

The study on development timing is selected a plan maximizing the synthetic net-benefit among many developing sequences. The DST optimization concluded that the most beneficial future development in terms of the system's net-benefit; First stage of Nachtigal - First stage of Memvé Elé - Second stage of Nachtigal - Second stage of Memvé Elé - Third stage of Nachtigal in sequence.

Furthermore, the DST optimization chooses the Plan 3 as the most beneficial scheme concerning whole the South Interconnection Network. The Plan 3 is expected to generate 201 MW of peak power and 1,140 GWh a year with the project cost of F. CFA 112.7 billion (US $416.5 million).

Development Timing

30. The optimum development timing in the South Interconnection Network is shown below. It is judged to be optimal that the Memvé Elé project follows to the first stage of Nachtigal project.

	Development Timing	Installed Capacity (MW)	Annual Energy Production (GWh)	Project Cost (Bill. F. CFA)
1st Nachtigal	2001	2 x 66.7	1,090	84.2
1st Memvé Elé	2010	2 x 50.3	750	86.8
2nd Nachtigal	2015	1 x 66.7	400	14.6
2nd Memvé Elé	2017	2 x 50.3	390	25.9
3rd Nachtigal	2021	1 x 66.7	110	8.4

The above development scale and timing is shown in Fig. 15 in comparison with the power demand forecast.

Project Features

31. The catchment area of the Ntem basin at the site is around 26,350 km2, and the average natural inflow is 398 m3/s, which compares to about 40% discharge of flow duration. The effective head of the project 52 m is mainly created by the Memvé Elé waterfalls with an about 35 m head and an about 15 m head in a rapid downstream of the falls.

The project is of run-of-river type with a regulating pondage and comprises a low dam and its related structures, a headrace channel, a power station and a high-tension-voltage transmission line. The dam is 1,850 m long and 20 m high at the highest section. The headrace channel is about 2.5 km long. The power station is equipped with 4 generating units with a 50.3 MW capacity each under a head of 52 m. Power produced is forwarded to Yaoundé by the transmission line of 225 kV with a length of 280 km connected to the Capital.

The project features are shown in Figs. 16 to 30 and concluded as follows:

(1) Location: Near Nyabessan village, Ma'an district, Ntem department, South province

(2) River System: Ntem river, Memvé Elé falls

(3) Type of Power Generation: Run-of-river type with regulation pondage

(4) Principal Features of Power Generation

Plant discharge:	450 m3/sec
Effective head:	52.3 m
Installed capacity:	201 MW in total
Number of generator units:	4 units
Annual average energy output:	1,140 GWh

(5) Hydrology

Catchment area:	26,350 km2
Annual precipitation:	1,738 mm
Annual mean discharge:	398 m3/sec
Flood peak discharge	
10,000-year probable flood:	3,450 m3/sec
1,000-year probable flood:	2,880 m3/sec
200-year probable flood:	2,480 m3/sec
100-year probable flood:	2,300 m3/sec
Recorded max. flood:	2,110 m3/sec

(6) Water Storage

Normal high water level: (Full supply level, FSL)	EL. 392.0 m
Low water level:	EL. 391.5 m
Gross storage:	130 mill. m3
Effective storage:	8 mill. m3
Water surface area at FSL:	19 km2

(7) River Diversion Work

Design discharge:	2,110 m3/sec
Diversion method:	Multi-stage diversion
Cofferdam:	Rockfill dam with inclined core; top of crest at EL. 385 m

(8) Dam

Type:	Earthfill dam
Top of dam:	EL. 395 m
Height of dam:	20 m (Max. height)
Dam crest length:	1,850 m
Embankment volume:	884,000 m3

(9) Spillway

Type:	Gated concrete weir
Spillway design discharge:	3,450 m3/sec
Spillway gates:	5 sets x 11.0 m (W) x 10.5 m (H), radial gates
Sand flush gate:	1 set x 11.0 m (W) x 13.5 m (H), radial gate

(10)	Intake	
	Type:	Lateral type with raised sill at EL. 386 m in front of entrance
	Max. plant discharge:	450 m3/sec
	Screen at intake entrance:	12 sets x 13.5 m (W) x 5.5 m (H)
	Forebay:	160 m (W) x 230 m (L)
	Gravel trap and sand flush gate:	1 set x 1.0 m (W) x 1.0 m (H)
	Intake gate:	4 sets x 11.0 m (W) x 6.5 m (H)
(11)	Headrace Channel	
	Type:	Concrete lined trapezoid section
	Length:	2,400 m
	Bottom width of channel:	15 m
	Slope of side wall:	V : H = 1:2.0
(12)	Head Pond	
	Full supply level (FSL):	EL. 392 m
	Minimum operating level (MOL):	EL. 390 m
	Effective storage:	600,000 m3
(13)	Penstock Intake	
	Type:	Lateral type
	Screen:	8 sets x 10 m (W) x 18 m (H)
	Intake gates:	4 sets x 6.0 m (W) x 6.0 m (H)
(14)	Penstock	
	Type:	Embedded steel conduit
	Length:	4 lanes x 95 m
	Diameter:	6.0 - 4.0 m
(15)	Powerhouse	
	Type:	Semi-underground
	Installed capacity:	4 units x 50.3 MW
	Dimensions:	32 m (W) x 120 m (L) x 62.5 m (H)
(16)	Draft Tunnel:	4 lanes x 6.9 m (Dia)
(17)	Tailrace Surge Tunnel and Chamber:	7 m wide x 6 m high x 770 m long, 9 m wide x 30 m high x 60 m long
(18)	Tailrace Tunnel:	2 lanes x 9.0 m (Dia) x 1,380 - 1,450 m (L)
(19)	Tailrace Outlet:	Portal with gates and elevated sill
(20)	Switchyard:	Outdoor type

(21) Generating Equipment:

Turbine	4 units of vertical shaft Francis, 52.3 m of rated net head, 450 m3/s of max. discharge, 206,400 kW of rated output, 200 rpm of rated speed
Generator	4 units of three-phase synchronous (201.2 MW in total), 55,900 kVA of rated capacity, 11 kV of rated voltage, 50 Hz of rated frequency, 0.9 of power factor, 50,300 kW of rated output
Main transformer	4 units, 55,900 kVA capacity, 11/145-132-119 kV voltage
(22) Transmission Line System:	225 kV, 285 km long, 2 circuits, connected to the South Interconnection Network
(23) Substation:	Expansion of Oyomabang substation in Yaoundé

Project Cost

32. The project cost is estimated as follows:

	Installed Capacity (MW)	Foreign Currency (Mill US$)	Local Currency (Bill. F. CFA)	Total (Bill F. CFA)
First Stage	2 x 50.3	261.1	11.80	82.47
Second Stage	2 x 50.3	95.9	4.33	30.28
Total	201.2	357.0	16.13	112.75

Notes; Price level: as of middle of June 1993
Exchange rate: US $ 1.0 = F. CFA 270.6
Breakdown of construction cost is shown in Table 11.

33. The unit energy cost is estimated at F. CFA 7.8/kWh (2.9 US¢/kWh) considering interest during construction and price escalation. It can be said that the Memvé Elé project is an inexpensive development plan.

Procurement and Construction Schedule

34. Implementation of the project involves various pre-construction activities. On an assumption that the Memvé Elé project is commissioned in year 2010, a general implementation schedule is presented in Fig. 31. The commencement of the construction works is scheduled in October 2004 after the contract award. The project is planned to

complete by the end of September 2010 using information and data available at this moment, giving a time period of 5.0 years or 60 months. The construction schedule is shown in Fig. 32.

Project Evaluation

(1) Economic Evaluation

35. The economic benefit of the Project can be defined as the cost of alternative thermal plant. For the kW-value and the kWh-value of the primary power, the alternative thermal plant is assumed to be gas-turbine plants, while for the kWh-value of the secondary power, it is oil-fired thermal plants on a premise that both the types of plant would be introduced to the system in the future. Economic Internal Rate of Return (EIRR) is estimated at 16.5% as shown in Table 12.

(2) Financial Evaluation

36. Growth of power demand for the HT consumers is not expected for the time being, as the existing HT consumer mainly composed of ALUCAM, which consumed 95.4% of the total energy for HT Consumers, will continue to receive power from the Edéa hydropower station in the future. Accordingly, the electricity consumers for the Memvé Elé power station will be turned to MT and LT consumers. As of 1991, the average electricity tariff is 49.5 F. CFA/kWh for MT/LT consumers. Based on this tariff, Financial Internal Rate of Return (FIRR) is 22.9% (See Table 13).

37. If the project fund is arranged as described in Paragraph 40 hereinafter, annual balance of the revenue and expenditures of the Project would become surplus from the very beginning year of commercial operation. (See Table 14)

(3) Socio-environmental Impact

38. As described in Paragraphs 19 to 21, the negative impact to the socio-environment is not serious.

Implementation Program

39. Notwithstanding the recommendation given in Paragraph 30 (first stage of Nachtigal precedent to first stage of Memvé Elé), SONEL can have an option of implementing the Memvé Elé first placing the following policies in mind:

(a) building a power source in different river (other than the Sanaga) aiming at diversification of hydrological risks (e.g., severe draught on the Sanaga)

(b) giving a priority onto electrification in the southern regions for improving social well-being and promoting economic activities in the area.

SONEL is now carrying out the feasibility study on the Lom-Pangar Reservoir Project, which aims at firming up the dry season output at Song Loulou / Edéa by 216 MW. An attractiveness of this scheme is that this power firm-up benefit can be realized supposedly at cost of one third to one half of the Memvé Elé cost, depending on the size of the Lom-Pangar project development. The feasibility study of the Lom-Pangar is foreseen to be completed towards January 1994.

It is recommended that, once the Lom-Pangar feasibility study comes out, SONEL would compare the relative merits of three schemes in advance of the detailed design work; (i) Memvé Elé, (ii) Nachtigal and (iii) Lom-Pangar, for making the decision on which project should precede first.

40. SONEL is managed on a self-paying basis without a subsidy from the government or other relevant organization. For the implementation of the Memvé Elé project, a grant-in-aid from the government is not considered to follow the normal management at present.

Following is assumed as the terms of financing sources to be recommended.

Financing Sources	Amount (bill. F. CFA)	Amount (equiv. mill. US$)	Interest (%)	Repayable period (year)
International Financial Agency	47.9	177.0	10.0	20
Bilateral aid	47.9	177.0	4.0	30
Domestic fund	16.9	62.5	12.0	15
Total	112.7	416.5	-	-

41. The total project cost F. CFA 112.7 billion (US$ 416.5 million) is equivalent to 19% of the government annual revenue (refer to Table 5) or 180 % of the SONEL's annual revenue. The Project is identified as a large scale project for both the government and SONEL. For the project implementation, it is necessary to discuss with the government organization concerned (the Ministry of Finance, the Ministry of Mines, Water and Energy Resources) and International Aid Agency mainly composed of World Bank, and to keep in touch with them carefully.

Table 1 Estimated Basin Rainfall

Year	Interpolated Annual Rainfall (mm)												Annual Basin Rainfall (mm)			
	Station															
	Akom II	Ambam	Djoum	Ebolowa	Mvangan	Nyabessan	Oveng	Sangmelima	Oyem	Bitam	Minvoul	Mefo	Ntem Nyabessan	Ntem Ngoazik	Ndjo'o Abem	Biwome Nyabessan
1951	1,398	1,704	1,855	1,629	1,874	1,570	1,789	1,931	1,934	2,534	1,715	1,985	1,881	1,791	1,849	1,714
1952	1,797	2,463	1,864	1,973	2,249	2,130	2,016	2,362	1,804	2,273	2,251	2,770	2,208	2,131	2,561	2,334
1953	1,261	1,886	1,327	1,620	1,712	1,611	1,441	1,470	1,433	1,342	1,528	2,173	1,583	1,545	1,989	1,775
1954	1,395	1,840	1,625	1,727	1,862	1,706	1,598	1,532	1,740	1,904	1,579	2,125	1,748	1,687	1,988	1,815
1955	1,221	1,566	1,599	1,627	1,719	1,762	1,480	1,276	1,730	1,689	1,371	1,842	1,585	1,568	1,816	1,656
1956	1,260	1,936	1,234	1,996	1,836	1,911	1,641	1,908	1,980	2,158	1,883	2,224	1,921	1,867	2,122	1,882
1957	1,362	1,698	1,824	1,805	1,921	1,679	1,680	1,501	1,472	1,724	1,553	1,978	1,689	1,657	1,880	1,732
1958	1,071	1,103	1,614	1,527	1,546	1,198	1,518	1,450	1,656	1,471	1,512	1,363	1,444	1,500	1,309	1,240
1959	1,272	1,307	2,077	1,848	1,918	1,270	1,852	1,711	1,902	1,755	1,839	1,574	1,729	1,790	1,475	1,409
1960	862	1,268	1,379	2,132	1,702	1,133	1,742	1,953	1,750	1,890	1,778	1,534	1,684	1,689	1,403	1,244
1961	665	1,141	835	1,788	1,339	1,174	1,280	1,408	2,014	1,174	1,346	1,402	1,356	1,421	1,327	1,144
1962	1,350	1,866	1,473	1,999	1,926	1,109	1,708	1,840	1,034	1,593	1,652	2,152	1,668	1,567	1,811	1,648
1963	987	1,600	1,364	1,788	1,662	1,485	1,592	1,766	2,165	1,902	1,874	1,877	1,775	1,783	1,749	1,532
1964	1,085	1,614	1,465	1,807	1,719	1,635	1,578	1,592	2,071	2,008	704	1,891	1,541	1,419	1,807	1,607
1965	1,075	1,636	1,609	2,238	1,934	1,969	1,813	1,831	2,255	1,694	567	1,914	1,584	1,528	1,932	1,708
1966	1,094	1,660	1,743	2,434	2,056	1,928	1,982	2,052	2,438	2,484	1,999	1,939	2,087	2,088	1,935	1,713
1967	1,254	1,829	1,551	2,037	1,921	1,916	1,675	1,623	1,905	2,340	1,653	2,114	1,890	1,805	2,049	1,832
1968	1,336	1,985	1,478	1,667	1,812	1,576	1,554	1,611	1,466	2,224	1,642	2,275	1,790	1,642	2,046	1,831
1969	1,322	1,710	1,688	1,947	1,923	1,609	1,761	1,798	1,858	2,229	1,794	1,991	1,870	1,815	1,866	1,707
1970	1,256	1,855	1,685	2,338	2,076	1,744	1,869	1,843	2,118	2,370	1,831	2,141	2,011	1,943	2,011	1,796
1971	881	1,453	1,180	1,924	2,010	1,444	1,570	1,539	1,837	1,938	1,585	1,725	1,700	1,702	1,633	1,424
1972	693	1,540	763	2,003	1,633	1,892	1,571	1,646	2,053	2,246	1,671	1,815	1,781	1,756	1,840	1,540
1973	927	1,460	898	1,827	1,606	1,758	1,589	1,746	1,955	2,191	1,752	1,732	1,751	1,744	1,741	1,527
1974	1,353	1,716	1,928	1,985	1,484	1,608	1,604	1,918	1,863	2,170	1,891	1,997	1,827	1,742	1,870	1,718
1975	1,331	1,325	2,049	2,081	1,500	1,641	2,352	1,599	1,947	1,704	1,633	1,593	1,721	1,771	1,609	1,537
1976	1,967	1,515	2,102	1,828	1,501	1,677	2,932	1,947	1,781	2,022	1,915	1,789	1,899	1,932	1,752	1,805
1977	1,865	1,729	2,221	1,826	1,422	1,441	3,113	1,419	1,222	1,525	1,487	2,010	1,712	1,672	1,824	1,812
1978	1,415	1,404	1,466	1,747	1,420	1,441	1,601	1,709	1,797	1,995	1,722	1,674	1,658	1,629	1,598	1,540
1979	1,658	1,753	1,430	2,155	1,763	1,553	1,599	1,438	1,820	2,034	1,502	2,035	1,749	1,650	1,877	1,801
1980	1,303	1,903	1,661	1,622	1,206	1,498	1,556	1,518	1,374	2,109	1,567	1,892	1,652	1,473	1,763	1,626
1981	1,090	1,471	1,538	1,588	1,758	1,524	1,408	1,499	1,590	1,945	1,552	1,950	1,624	1,583	1,811	1,604
1982	1,877	1,707	1,859	1,714	2,090	1,461	1,490	1,674	1,594	2,096	1,693	2,084	1,775	1,707	1,880	1,855
1983	1,361	1,468	1,409	1,331	1,532	1,324	1,436	1,576	1,212	1,683	1,614	1,735	1,506	1,471	1,601	1,521
1984	2,564	1,743	1,674	1,941	2,096	1,698	1,783	1,885	1,625	1,966	1,865	2,025	1,858	1,847	1,918	2,076
1985	1,189	1,684	1,730	2,043	1,980	1,792	1,870	2,015	1,837	2,084	1,970	1,964	1,917	1,922	1,908	1,711
1986	1,565	1,376	1,298	1,852	1,844	1,481	1,475	1,433	1,559	1,553	1,498	1,645	1,555	1,579	1,591	1,578
1987	1,810	1,678	1,395	1,944	2,157	1,520	1,534	1,436	1,371	1,555	1,500	1,958	1,644	1,628	1,815	1,796
1988	2,247	1,907	1,677	1,817	2,168	1,614	1,726	1,801	1,342	1,889	1,796	2,194	1,824	1,772	2,004	2,046
1989	1,909	1,325	1,389	1,609	1,812	1,455	1,509	1,618	1,558	1,722	1,648	1,593	1,589	1,623	1,548	1,638
Mean	1,367	1,637	1,563	1,866	1,787	1,588	1,725	1,689	1,745	1,928	1,639	1,915	1,738	1,703	1,808	1,679

Table 2 Annual Mean Runoff

Station : Nyabessan River : Ntem (26,350 km2)

Year		Mean Annual Runoff			Specific Discharge
		(m3/s)	(mm)	(10^6m3)	(m3/s/km2)
1957	*	409	489	12,898	0.0155
1958		218	261	6,883	0.0083
1959		379	454	11,952	0.0144
1960		452	542	14,290	0.0171
1961		353	423	11,139	0.0134
1962		441	528	13,905	0.0167
1963		396	474	12,486	0.0150
1964		447	537	14,141	0.0170
1965		470	562	14,819	0.0178
1966		588	704	18,541	0.0223
1967		468	560	14,767	0.0178
1968		437	524	13,814	0.0166
1969		461	551	14,532	0.0175
1970		460	551	14,509	0.0175
1971		318	380	10,025	0.0121
1972		337	404	10,642	0.0128
1973		341	408	10,750	0.0129
1974		403	483	12,725	0.0153
1975		363	435	11,460	0.0138
1976		420	504	13,274	0.0159
1977		373	446	11,755	0.0141
1978		365	437	11,505	0.0138
1979		363	435	11,451	0.0138
1980		358	430	11,325	0.0136
1981		376	450	11,852	0.0143
1982		416	498	13,134	0.0158
1983		249	298	7,857	0.0095
1984		440	528	13,913	0.0167
1985		490	586	15,440	0.0186
1986		328	393	10,358	0.0125
1987		357	427	11,246	0.0135
1988		465	558	14,703	0.0176
Mean		398	476	12,565	0.0151

* Including interpolated data

Table 3 Population in Cameroon

Province (capital city)	(1) Area (sq.km)	Population (2) 1975/76	Population (2) 1986/87	Population density per sq.km 1975/76	Population density per sq.km 1986/87	Population growth rate/annum 1976-1987
East (Bertoua)	108,900	366,562	517,198	3.4	4.7	3.18%
Littoral (Douala)	20,220	935,457	1,352,833	46.3	66.9	3.41%
North (Garoua)	67,798	479,306	832,165	7.1	12.3	5.14%
North-West (Bamenda)	17,300	978,030	1,237,348	56.5	71.5	2.16%
West (Bafoussam)	13,890	1,035,920	1,339,791	74.6	96.5	2.37%
South-West (Buea)	24,910	620,709	838,042	24.9	33.6	2.77%
Adamawa (Ngaoundere)	61,992	359,445	485,185	5.8	7.8	2.76%
Central (Yaounde)	68,942	1,177,125	1,651,600	17.1	24.0	3.13%
Extreme-North (Maroua)	34,260	1,395,194	1,855,695	40.7	54.2	2.63%
South (Ebolowa)	47,190	315,297	373,798	6.7	7.9	1.56%
Total	465,402	7,663,045	10,483,655	16.5	22.5	2.89%
Special department (capital city)*						
Wouri(Douala)	886	-	-	-	-	-
Mfoundi(Yaounde)	256	-	-	-	-	-

Sources:
(1) Camerpun Les Enterprises de Production et de Vente, 1985/86-1990/91.
(2) Situation et Perspectives Demographiques du Cameroun(Resume), September 1990.
(*) Population et Supercifie Estimees par Unite Administratif en 1976 et an 1984 Selon le Decoupage Administratif en Vigueur en 1984 et Villes de 5000 Habitants ou Plus par Unite Administratif en 1984.

Note: Total population in both years 1975/76 and 1986/87 is slightly different from that in Table 2.6, which is due to different data sources.

Table 4 Gross Domestic Products and Income per Capita

(Current price)

(F.CFA billion)

Industry of origin	(1) 1979	(1) 1980	(1) 1981	(1) 1982	(1) 1983	(1) 1984	(1) 1985	(2) 1986	(2) 1987	(2) 1988	Average annual growth R. (%)
PRIMARY SECTOR											
Agriculture/ forestry/ fishery	359	404	488	587	607	702	790	908	976	954	11.5%
Growth (%)	-	12.6%	20.7%	20.2%	3.5%	15.6%	12.6%	14.9%	7.5%	-2.3%	
SECONDARY SECTOR											
Extractive industry	33	106	202	263	401	521	630	505	359	353	30.0%
Growth (%)	-	218.7%	90.5%	30.6%	52.2%	30.0%	21.0%	-19.9%	-28.8%	-1.8%	
Manufacturing	102	124	174	247	291	359	422	515	546	519	19.8%
Growth (%)	-	21.8%	40.0%	42.2%	17.8%	23.2%	17.8%	21.9%	6.0%	-4.9%	
Electricity/ gas and water	14	17	18	22	30	35	38	45	48	53	15.5%
Growth (%)	-	17.5%	4.2%	26.9%	35.6%	16.9%	7.1%	19.6%	6.2%	9.6%	
Construction and public works	68	84	103	125	146	193	228	279	265	175	11.1%
Growth (%)	-	24.1%	22.4%	21.0%	16.6%	32.1%	18.2%	22.4%	-4.7%	-34.1%	
TERTIARY SECTOR											
Trade/restau-rants/ hotels	184	202	232	249	311	415	565	658	571	583	13.7%
Growth (%)	-	10.2%	14.8%	7.3%	24.6%	33.5%	36.1%	16.6%	-13.3%	2.2%	
Transportation/ warehouse/ communication	78	90	104	119	129	147	231	249	232	215	12.0%
Growth (%)	-	16.0%	15.1%	15.2%	8.0%	14.4%	56.6%	7.8%	-7.0%	-7.0%	
Bank/insurance/ real estate/ services rendered to undertakings	168	190	248	285	355	397	455	470	491	383	9.6%
Growth(%)	-	13.5%	30.3%	14.9%	24.6%	11.7%	14.7%	3.3%	4.3%	-21.9%	
Furnishing services to community and personal services	11	18	23	28	35	39	46	54	56	59	20.1%
Growth (%)	-	54.9%	30.9%	22.3%	23.2%	13.9%	17.8%	16.6%	4.3%	4.3%	
PUBLIC ADMINI-STRATION	129	175	206	247	314	388	434	453	461	438	14.5%
Growth (%)	-	35.0%	17.7%	20.3%	27.1%	23.4%	11.9%	4.2%	1.9%	-5.0%	
Total	1,146	1,410	1,797	2,173	2,618	3,195	3,839	4,135	4,005	3,732	14.0%
Growth (%)	-	23.1%	27.4%	20.9%	20.5%	22.0%	20.2%	7.7%	-3.2%	-6.8%	
Income/Capita (1,000 F.CFA)	134	168	209	246	289	337	386	395	381	334	10.7%
Growth (%)		25.4%	24.4%	17.7%	17.5%	16.6%	14.5%	2.3%	-3.5%	-12.3%	

Sources: (1) Comtes Nationaux du Cameroun (Version SCN), Resultats 1985/86, Projection 1986/87 et 1987/88, January 1989.

(2) Note Annuelle de Statsitique, 1987/88.

Note: Note:Income/Cp means income per capita.

Table 5 Government Finance

Government Receipts /Expenditure : (F.CFA billion)

Item	1982	1983	1984	1985	1986	1987	1988	1989(*	1990(*
Budget scale in receipts	310.0	410.0	520.0	620.0	740.0	800.0	650.0	600.0	600.0
1. Expenditures	445.7	638.0	742.5	855.2	897.8	879.5	-	629.4	606.7
Regular and development	445.6	546.7	700.7	813.8	882.1	908.4	-	625.9	605.1
Lending minus repayment	0.1	91.3	41.8	41.4	15.7	(28.9)	-	3.5	1.6
2. Receipts	390.4	671.9	795.4	885.7	923.9	742.8	-	524.7	454.1
Revenue	390.4	612.3	790.5	885.6	919.1	742.8	-	524.7	454.1
Grants	0.0	59.6	4.9	0.1	4.8	0.0	-	0.0	0.0
3. Surplus (+) or Deficit (-)	(55.3)	33.9	52.9	30.5	26.1	(136.7)	-	(104.7)	(152.6)
4. Source of Financing	-	(33.9)	(53.0)	(30.5)	(26.1)	136.7	-	104.7	152.6
Domestic loan	-	(56.5)	(88.7)	(63.4)	(70.0)	73.1	-	6.5	15.6
Foreign loan	-	22.6	35.7	32.9	43.9	63.6	-	98.2	137.0
5. Cash Balance	-	0.0	(0.1)	0.0	0.0	0.0	-	0.0	0.0

Source: International Financial Statistics, September 1989.
(*): Tableau de Bord des Finances Publique, 1988/89, 1989/90.

Note : - Lack of data.
(*) means temporary estimates.

SONEL Revenue /Expenditure (For reference) :

Item	1982	1983	1984	1985	1986	1987	1988	1989	1990
Revenue	28.9	-	38.6	43.1	48.6	54.6	55.6	53.9	61.7
Expenditure	29.1	-	40.0	42.7	47.8	54.4	54.5	56.0	55.8
(% to 1. above)	6.5	(-)	5.4	5.0	5.3	6.2	(-)	8.9	9.2
Cash Balance	(0.2)	-	(1.4)	0.4	0.8	0.2	1.1	(-2.1)	5.9

Source : Compte Rendu de Gestion 1975/76 - 1989/90

Table 6 Environmental Checklist (1/2)

	Check Items	Major	Small	None	Not Clear	Problems	Action & Countermeasures Planned	Remarks
Pollution	1. Deterioration of water quality (including detrimental changes in water temperature) in the dam reservoir and downstream			X				The water quality in the reservoir and the downstream can be diluted and kept clean by circulation of reservoir water in a short period (2 to 3 days) because of the run-of-river type development.
Natural Environment	1. Effect on ecology		X			The reservoir created by dam construction has an area of 19 km2. Water rise due to the dam is about 10m. A part of equatorial forest will be submerged and animals living in this area will be ridded to the surrounding.	In the swamp zone sharing large part of the submerged area, there are many wild palm trees and few marketable trees. As to the marketable trees growing on the higher land, following measures are conceived. 1) allocation of felling/cutting of marketable trees in the reservoir area to forest exploiters. 2) Having contracts with peasant woodcutters for opening and clearing hauling roads. To protect the animals in the reservoir area from drowning and being isolated in small islands, it is recommended to carry out beating drums and gun shots in the air regularly for many days before impounding the reservoir.	
	2. Effect on landscape					Memve Ele waterfalls having a height of 35m exist just downstream the proposed dam site. It is considered that the discharge passing through the falls become small due to diversion of water for power generation.	There are two tributaries, the Ndjo'o and Biwome, jointing with the Ntem river between the dam site and Memve Ele falls. The average discharge of both the Ndjo'o and Biwome 28m3/sec can be used as a compensation flow. Furthermore, river outlet facilities will be provided for the dam body.	The dam site is located at the very remote area and the transportation means are poor. So, the tourism for this area is not popular now.
Socio-economic Environment	1. Effect of construction of the facility on the historical and cultural heritage			X				The influence zone close to the project possesses little historical and cultural heritage.
	2. Effect on existing Infrastructure			X				There is no specific infrastructure to be affected by the project devcelopment.
	3. Resettlement		X			Numbers of houses affected are only 9.	The cost of resettlement is estimated at 7.5 million F.CFA. The compensation cost for the cultivated lands and agriculture is greater than that of resettlement and estimated at around 80 million F. CFA.	

Table 6 Environmental Checklist (2/2)

Socio-economic Environment	4. Effect on traffic mean		X			The public road connecting Ma'an with Nyabessan will be cut of by submergence at two bridges, near Alen II and between Nemeyong and Alen I.	The formation height of road near the bridges may be elevated by embankment and replacement of the bridges (span is less than 10m) will be required. The transportation mean to cross the Ntem river is carried out by a canoe. The dam crest road can be utilized for communication between Nyabessan village and villages at the opposite bank.	
	5. Effect on other downstream water utilization			X				Water used for the power generation is put back to the Ntem river at the tailrace outlet about 4km downstream of the dam. There is no private house along the river course between the dam site and the tailrace outlet. As the project is of run-of-river type, the flow condition downstream the tailrace outlet will not change remarkably but be a little regulated.
	6. Occurrence of diseases such as malaria, caused by insects or water		X			The entomological investigation assesses the existence of notable vectors, simulium of human onchocera (creeping disease), anopheles of malaria and tse-tse flies of sleeping sickness (trypanosomiasis)from the view point of medical and veterinary interest.	It is important to envisage an adequate anti-vector campaign program based on local strategies. While hygienic measures and health education are also important to the population.	
Others	1. Effect on the environment during construction period		X			As there is few private house around the construction site, noise and vibration by construction will not affect on the residents. However, it is expected that vehicle for transportation of construction materials and equipment will cause noise and vibration and affect on the residents living along the existing road.	The road will be improved by grading and widening, and speed limitation should be considered before the commencement of construction.	
	2. Environmental Monitoring		X				The monitoring for the health problem due to creation of water impounding reservoir is very important for the project.	In general it has been assessed that impact on the environment is not serious in comparison with other hydropower projects because of the run-of-river type development.

Table 7 (1) Existing Power Plants (1/4)

(As of end of 1991)

(I) South Interconnected Network

Name	Installed Capacity (MW)	Year of Commissioning
(A) Hydro Power Plants		
1. Edea		
a) No.I:	34.160	
- 2 x 11.360 MW		1953
- 1 x 11.440 MW		1958
b) No. II:	124.950	
- 6 x 20.825 MW		1973
c) No. III:	104.125	
- 2 x 20.825 MW		1973
- 2 x 20.825 MW		1975
- 1 x 20.825 MW		1976
Sub-total	263.235	
2. Song Loulou	387.600	
- 4 x 48.450 MW		1981
- 2 x 48.450 MW		1987
- 1 x 48.450 MW		1988
- 1 x 48.450 MW		1989
Total of hydro	650.835	

(B) Thermal Power Plants (Diesel only)	(Standby) (MW)	(Autonomous) (MW)
1. Littoral and South regions		
a) Bafoussam	10.000	-
b) Douala (Bassa I & II)	15.160	-
c) Kribi	0.400	-
d) Nkongsamba	1.162	-
e) Campo	-	0.136
f) Mape	-	0.716
g) Messondo	-	0.112
h) Mouanko	-	0.096
i) Nkondjock	-	0.240
Sub-total	26.722 (12.410)	1.300 (0.594)

Table 7 (2) Existing Power Plants (2/4)

(As of end of 1991)

	(Standby) (MW)	(Autonomous) (MW)
2. Central, South and East regions		
a) Ebolowa	1.200	-
b) Mvomeka'a	0.495	-
c) Sangmelima	1.021	-
d) Yaounde (Mefou)	10.280	-
e) Abong-Mbang	-	0.875
f) Ambam	-	0.372
g) Batouri	-	0.729
h) Bertoua	-	2.270
i) Betare-Oya	-	0.126
j) Djoum	-	0.152
k) Edom	-	0.200
l) Yokadouma	-	0.326
Sub-total	12.996 (7.982)	5.050 (3.764)

	(Standby) (MW)	(Autonomous) (MW)
3. North-west and South-west regions		
a) Bakebe	0.025	-
b) Bamenda	0.340	-
c) Bota	2.478	-
d) Kumba	0.180	-
e) Kumbo	0.400	-
f) Nkambe	0.256	-
g) Mundemba	-	0.197
h) Wum	-	0.192
Sub-total	3.679 (2.294)	0.389 (0.368)
Total of thermal	43.397 (22.686)	6.739 (4.726)

Note:

1) Standby units in thermal (diesel) power plants mean the ones connected to the interconnected network but the autonomous units are yet to be connected to it like isolated system.
2) Figures shown in parentheses mean the present guarantee of their output.
3) In the East region, Kadey HEPP is expected to be commissioned in 1995/96.

Table 7 (3) Existing Power Plants (3/4)

(II) North Interconnected Network

Name	Installed Capacity (MW)	Year of Commissioning
(A) Hydro Power Plants		
1. Lagdo	72.000	
- 4 x 18.000 MW		1983
Total of hydro	72.000	

(B) Thermal Power Plants (Diesel only)	(Standby) (MW)	(Autonomous) (MW)
1. Garoua region		
a) Garoua	19.942	-
b) Guider	0.200	-
c) Yagoua	1.200	-
d) Maroua	1.900	-
e) Kousseri	-	1.424
f) Poli	-	0.236
Sub-total	23.242 (16.842)	1.670 (1.152)

	(Standby) (MW)	(Autonomous) (MW)
2. Ngaoundere region		
a) Ngaoundere	-	4.400
b) Meiganga	-	0.600
c) Touboro	-	0.184
d) Tignere	-	0.152
e) Banyo	-	0.512
f) Tibati	-	0.392
Sub-total	- (-)	6.240 (4.664)
Total of thermal	23.242 (16.842)	7.910 (5.816)

Note:

1) North network is expected to be interconnected with the South interconnected network in future, but its timing is yet unkown.
2) Stand-by units in thermal (diesel) power plants mean the ones connected to the interconnected network and the autonomous units are yet to be connected to it.
3) Figures shown in parentheses mean guarantees of their output.

Table 7 (4) Existing Power Plants (4/4)

(III) Summary

Particulars	Installed Capacity (MW)
(A) Hydro Power Plants	
1) South network	650.835
2) North network	72.000
Total	722.835
(B) Thermal Power Plants	
1) South network	
a) Standby in the network	42.934 (22.686)
b) Autonomous	6.727 (4.726)
Sub-total	49.661 (27.412)
	26.722 (12.410)
2) North network	
a) Standby in the network	23.242 (16.842)
b) Autonomous	7.910 (5.816)
Sub-total	31.152 (21.994)
Total	80.813 (49.406)
Grand-total	803.648

Note:

1) Figures shown in parentheses mean guarantees of their output.

Table 8 Historical Energy Consumption by Consumers

(I) By Consumer Category

(Unit:GWh)

Year	HT Consumers	MT Consumers	LT Consumers	Totals	Increase Rate (%)
1975/76	985.4	164.4	148.7	1,298.5	-
76/77	909.5	188.6	166.9	1,265.0	-2.6
77/78	807.4	212.4	189.7	1,209.5	-4.4
78/79	835.8	261.2	220.8	1,317.8	9.0
79/80	759.8	279.9	255.5	1,295.2	-1.7
80/81	952.4	302.7	282.2	1,537.3	18.7
81/82	1,352.8	314.3	350.6	2,017.7	31.2
82/83	1,265.1	368.3	393.8	2,027.2	0.5
83/84	1,186.2	380.3	395.1	1,961.6	-3.2
84/85	1,285.6	435.9	439.6	2,161.1	10.2
85/86	1,296.5	472.1	478.6	2,247.2	4.0
86/87	1,174.7	488.5	533.7	2,196.9	-2.2
87/88	1,240.1	482.0	550.8	2,272.9	3.5
88/89	1,368.9	482.3	545.0	2,396.2	5.4
89/90	1,385.1	475.4	547.9	2,408.4	0.5
90/91	1,381.6	396.5	573.5	2,351.6	-2.4
(Share 90/91)	(58.8%)	(16.8%)	(24.4%)	(100%)	
Average growth: rate (last 10 years)	3.8%	2.7%	7.3%	4.3%	(80/81-90/91)

(II) By HT Consumers

Year	Alucam	Socatral	Cellu-cam	Cimen-cam	*Sonara **Cicam	Total
1979/80	736.2	14.8	8.9	-	-	759.9
80/81	861.6	14.7	72.9	-	*3.2	952.4
81/82	1,264.6	12.0	67.7	-	*8.6	1,352.8
82/83	1,174.9	12.5	53.9	17.8	*6.0	1,265.1
83/84	1,125.2	13.6	11.8	29.1	*6.4	1,186.2
84/85	1,221.9	13.2	9.9	32.5	*8.1	1,285.6
85/86	1,228.9	14.5	8.9	36.4	*7.7	1,296.5
86/87	1,113.4	14.0	4.6	35.1	*7.5	1,174.7
87/88	1,188.0	10.5	3.8	30.7	*7.1	1,240.1
88/89	1,315.5	11.4	3.4	28.1	*10.6	1,368.9
89/90	1,316.3	11.8	2.9	27.8	**26.2	1,385.1
90/91	1,317.8	12.5	2.7	26.1	**22.4	1,381.6
Share(90/91)	95.4%	0.9%	0.2%	1.9%	1.6%	100%
Average growth rate: (82/83 - 90/91)	1.4%	0.0%	-31.2%	4.9%	** -14.5%	1.1%

* South interconnected system
** North interconnected system

(Source : SONEL)

Table 9 Historical Energy Production and Consumption

1. All Consumers (LT + MT + HT Consumers)

Year	Total Production (GWh)	Total Consumption (GWh)	Loss of Energy (GWh)	(%)
1975/76	1,341.1	1,298.4	42.7	3.3
76/77	1,310.6	1,265.0	45.6	3.6
77/78	1,276.1	1,209.5	66.6	5.5
78/79	1,384.8	1,317.8	67.0	5.1
79/80	1,387.9	1,295.2	91.7	7.1
80/81	1,655.1	1,537.3	117.8	7.7
81/82	2,147.6	2,017.7	129.9	6.4
82/83	2,160.5	2,027.2	133.3	6.6
83/84	2,156.6	1,961.6	195.0	9.9
84/85	2,383.3	2,161.1	222.2	10.3
85/86	2,496.9	2,247.2	249.7	11.1
86/87	2,461.0	2,196.9	264.1	12.0
87/88	2,553.9	2,272.9	281.0	12.4
88/89	2,690.2	2,396.2	294.0	12.3
89/90	2,702.3	2,408.5	293.8	12.2
90/91	2,707.7	2,351.6	356.1	13.2

(Source : SONEL)

2. Breakdown by Public Sectors / HT Consumers

Year	Public Sector (LT + MT Consumers)			HT Consumers		
	Energy Production (GWh)	Energy Consumption (GWh)	Loss of Energy (%)	Energy Production (GWh)	Energy Consumption (GWh)	Loss of Energy (%)
1979/80	594.9	535.4	10.0	793.0	759.9	4.2
80/81	666.2	585.0	12.2	988.9	952.4	3.7
81/82	749.8	664.9	11.3	1,397.8	1,352.8	3.2
82/83	852.8	762.1	10.6	1,307.7	1,265.1	3.3
83/84	949.9	775.4	18.4	1,206.7	1,186.2	1.7
84/85	1,076.2	875.4	18.6	1,307.1	1,285.6	1.6
85/86	1,176.6	946.1	19.6	1,320.3	1,296.5	1.8
86/87	1,251.8	1,022.2	18.3	1,209.1	1,174.7	2.9
87/88	1,292.5	1,032.8	20.1	1,261.4	1,240.1	1.7
88/89	1,299.1	1,027.3	20.9	1,391.1	1,368.9	1.6
89/90	1,309.4	1,023.3	21.8	1,392.9	1,385.1	0.6
90/91	1,310.2	970.0	26.0	1,397.5	1,381.6	0.9

Note: Estimated by subtracting the public sector production from total production

Table 10 Electricity Demand Forecast

(Medium Forecast Scenario by Micro Method)

South Interconnection Network

Year	Public Sector				Industrial Sector		Total		
	Energy Production (GWh)	Average Power (MW)	Load Factor (%)	Peak Power (MW)	Energy Production (GWh)	Peak Power (MW)	Energy Production (GWh)	Peak Power (MW)	Load Factor (%)
1988/89	1174.0	134.0	59.9	223.8 *	1391.1	166.0	2565.1	389.8	75.1
1989/90	1190.4	135.9	60.9	223.2 *	1366.7	168.0	2557.1	391.2	74.6
1990/91	1193.3	136.2	60.8	224.0 *	1375.1	166.0	2568.4	390.0	75.2
1991/92	1237.2	141.2	60.5	233.4	1375.1	166.0	2612.3	399.4	74.7
1992/93	1283.9	146.6	60.5	242.3	1375.1	166.0	2659.0	408.3	74.4
1993/94	1332.8	152.2	60.5	251.5	1375.1	166.0	2707.9	417.5	74.0
1994/95	1384.1	158.0	60.5	251.2	1375.1	166.0	2759.2	427.2	73.7
1995/96	1437.8	164.1	60.5	271.3	1375.1	166.0	2812.9	437.3	73.4
1996/97	1494.1	170.6	60.5	281.9	1375.1	166.0	2869.2	447.9	73.1
1997/98	1553.0	177.3	60.5	293.0	1375.1	166.0	2928.1	459.0	72.8
1998/99	1614.9	184.3	60.5	304.7	1375.1	166.0	2990.0	470.7	72.5
1999/00	1679.7	191.7	60.5	316.9	1375.1	166.0	3054.8	482.9	72.2
2000/01	1745.9	199.3	60.5	329.4	1375.1	166.0	3121.0	495.4	71.9
2001/02	1810.9	206.7	60.5	341.7	1375.1	166.0	3186.0	507.7	71.6
2002/03	1878.9	214.5	60.5	354.5	1375.1	166.0	3254.0	520.5	71.4
2003/04	1950.1	222.6	60.5	368.0	1375.1	166.0	3325.2	534.0	71.1
2004/05	2024.6	231.1	60.5	382.0	1375.1	166.0	3399.7	548.0	70.8
2005/06	2102.6	240.0	60.5	396.7	1375.1	166.0	3477.7	562.7	70.5
2006/07	2184.4	249.4	60.5	412.2	1375.1	166.0	3559.5	578.2	70.3
2007/08	2270.1	259.1	60.5	428.3	1375.1	166.0	3645.2	594.3	70.0
2008/09	2359.9	269.4	60.5	445.3	1375.1	166.0	3735.0	611.3	69.8
2009/10	2454.2	280.2	60.5	463.1	1375.1	166.0	3829.3	629.1	69.5
2010/11	2553.0	291.4	60.5	481.7	1375.1	166.0	3926.1	647.7	69.2
2011/12	2656.8	303.3	60.5	501.3	1375.1	166.0	4031.9	667.3	69.0
2012/13	2765.8	315.7	60.5	521.9	1375.1	166.0	4140.9	687.9	68.7
2013/14	2880.2	328.8	60.5	543.4	1375.1	166.0	4255.3	709.4	68.5
2014/15	3000.4	342.5	60.5	566.1	1375.1	166.0	4375.5	732.1	68.2

Note: 1) In this table , a revised load factor (60%) is used for Public Sector as constant in consideration of past tendency.
2) Guaranteed power supply for Industrial Sector: see table 4.5.3.

Table 11 Project Cost (1/2)

Work Descriptions	Qty Unit	Unit Price (FCFA)	Quantity	Foreign Currency		Local Currency		Total Amount (Mill. FCFA)	Total Amount (Mill. US$)
				Unit Price (FCFA)	Amount (Mill. FCFA)	Unit Price (FCFA)	Amount (Mill. FCFA)		
I Preparatory Works (20% of II)					5,057.6		2,167.5	7,225.1	26.700
II Civil Works					30,546.1		5,579.2	36,125.2	133.500
1. River Diversion					182.0		40.0	222.0	0.820
Coffering & coffer removal	m3	3,100	71,600	2,542	182.0	558	40.0	222.0	0.820
2. Main Dam					2,161.2		442.8	2,604.0	9.623
Common excavation	m3	1,100	262,400	935	245.3	165	43.3	288.6	1.067
Riprap	m3	2,500	75,900	2,050	155.6	450	34.2	189.8	0.701
Transition	m3	4,200	49,300	3,444	169.8	756	37.3	207.1	0.765
Filter	m3	4,200	84,800	3,444	292.1	756	64.1	356.2	1.316
Impervious	m3	2,000	673,200	1,640	1,104.0	360	242.4	1,346.4	4.976
Foundation treatment	m	40,000	5,400	36,000	194.4	4,000	21.6	216.0	0.798
3. Spillway					5,449.3		1,036.4	6,485.7	23.968
Common Excavation	m3	1,100	5,800	935	5.4	165	1.0	6.4	0.024
Rock Excavation	m3	3,500	17,400	3,010	52.4	490	8.5	60.9	0.225
Concrete	m3	71,000	90,400	59,640	5,391.5	11,360	1,026.9	6,418.4	23.719
4. Intake					3,183.8		589.0	3,772.8	13.942
Common Excavation	m3	1,100	515,000	935	481.5	165	85.0	566.5	2.093
Rock Excavation	m3	3,500	129,000	3,010	388.3	490	63.2	451.5	1.669
Concrete	m3	71,000	38,800	59,640	2,314.0	11,360	440.8	2,754.8	10.180
5. Headrace Channel					4,224.1		779.0	5,003.1	18.489
Common excavation	m3	1,100	767,000	935	717.1	165	126.6	843.7	3.118
Rock excavation	m3	3,500	426,000	3,010	1,282.3	490	208.7	1,491.0	5.510
Riprap	m3	2,500	28,000	2,050	57.4	450	12.6	70.0	0.259
Transition	m3	4,200	53,000	3,444	182.5	756	40.1	222.6	0.823
Soil embankment	m3	2,000	272,000	1,640	446.1	360	97.9	544.0	2.010
Concrete	m3	71,000	25,800	59,640	1,538.7	11,360	293.1	1,831.8	6.769
6. Headpond Dam					470.9		93.2	564.1	2.085
Common excavation	m3	1,100	97,000	935	90.7	165	16.0	106.7	0.394
Riprap	m3	2,500	15,810	2,050	32.4	450	7.1	39.5	0.146
Transition	m3	4,200	6,200	3,444	21.4	756	4.7	26.0	0.096
Filter	m3	4,200	21,400	3,444	73.7	756	16.2	89.9	0.332
Impervious	m3	2,000	119,000	1,640	195.2	360	42.8	238.0	0.880
Foundation treatment	m	40,000	1,600	36,000	57.6	4,000	6.4	64.0	0.237
7. Penstock Intake					2,589.7		489.8	3,079.5	11.380
Common excavation	m3	1,100	45,000	935	42.1	165	7.4	49.5	0.183
Rock excavation	m3	3,500	34,000	3,010	102.3	490	16.7	119.0	0.440
Concrete	m3	71,000	41,000	59,640	2,445.2	11,360	465.8	2,911.0	10.758
8. Penstocks					319.1		52.7	371.9	1.374
Common excavation	m3	1,100	6,500	935	6.1	165	1.1	7.2	0.026
Tunnel excavation	m3	7,000	14,600	6,160	89.9	840	12.3	102.2	0.378
Tunnel concrete	m3	75,000	3,500	63,750	223.1	11,250	39.4	262.5	0.970
9. Power Station					4,280.2		759.8	5,040.1	18.625
Common excavation	m3	1,100	36,000	935	33.7	165	5.9	39.6	0.146
Rock excavation	m3	3,500	6,700	3,010	20.2	490	3.3	23.5	0.087
Shaft excavation	m3	6,000	190,500	5,280	1,005.8	720	137.2	1,143.0	4.224
Concrete	m3	71,000	54,000	59,640	3,220.6	11,360	613.4	3,834.0	14.169
10. Surge Tunnel / Chamber					987.1		173.4	1,160.5	4.289
Common excavation	m3	1,100	3,000	935	2.8	165	0.5	3.3	0.012
Shaft excavation	m3	7,000	43,600	6,160	268.6	840	36.6	305.2	1.128
Concrete	m3	71,000	12,000	59,640	715.7	11,360	136.3	852.0	3.149
11. Tailrace Tunnels					5,073.8		830.2	5,904.0	21.818
Tunnel excavation	m3	7,000	264,000	6,160	1,626.2	840	221.8	1,848.0	6.829
Tunnel concrete	m3	78,000	52,000	66,300	3,447.6	11,700	608.4	4,056.0	14.989
12. Tailrace Outlet					1,624.7		292.7	1,917.4	7.086
Common excavation	m3	1,100	80,400	935	75.2	165	13.3	88.4	0.327
Rock excavation	m3	3,500	187,600	3,010	564.7	490	91.9	656.6	2.426
Soil embankment	m3	2,000	4,000	1,700	6.8	300	1.2	8.0	0.030
Concrete	m3	71,000	16,400	59,640	978.1	11,360	186.3	1,164.4	4.303

Table 11 Project Cost (2/2)

Work Descriptions	Q'ty Unit	Unit Price (FCFA)	Quantity	Foreign Currency		Local Currency		Total Amount (Mill. FCFA)	Total Amount (Mill. US$)
				Unit Price (FCFA)	Amount (Mill. FCFA)	Unit Price (FCFA)	Amount (Mill. FCFA)		
III Hydro-mechanical Equipment					**7,132.0**		**536.8**	**7,668.8**	**28.340**
1. Spillway					1,724.2		129.8	1,854.0	6.851
Spillway Gates	ton	2,400,000	471	2,232,000	1,051.3	168,000	79.1	1,130.4	4.177
Sand Sluice Gate	ton	2,400,000	146	2,232,000	325.9	168,000	24.5	350.4	1.295
Stoplogs	ton	2,400,000	154	2,232,000	343.7	168,000	25.9	369.6	1.366
Monorail Crane	kg	2,510	1,355	2,335	3.2	175	0.2	3.4	0.013
2. Intake					1,558.4		117.3	1,675.8	6.193
Trash Racks	ton	1,800,000	116	1,674,000	194.2	126,000	14.6	208.8	0.772
Intake Gates	ton	3,000,000	334	2,790,000	931.9	210,000	70.1	1,002.0	3.703
Rakes	-	L.S.			116.2		8.8	125.0	0.462
Stoplogs	ton	2,400,000	0	2,232,000	0.0	168,000	0.0	0.0	0.000
Desilting System	ton	5,000,000	68	4,650,000	316.2	350,000	23.8	340.0	1.256
3. Penstok Intake					1,558.4		117.3	1,675.8	6.193
Trash Racks	ton	1,800,000	116	1,674,000	194.2	126,000	14.6	208.8	0.772
Intake Gates	ton	3,000,000	334	2,790,000	931.9	210,000	70.1	1,002.0	3.703
Rakes	-	L.S.			116.2		8.8	125.0	0.462
Stoplogs	ton	2,400,000	0	2,232,000	0.0	168,000	0.0	0.0	0.000
Desilting System	ton	5,000,000	68	4,650,000	316.2	350,000	23.8	340.0	1.256
4. Penstock					1,424.4		107.2	1,531.6	5.660
Penstock	ton	1,400,000	1,094	1,302,000	1,424.4	98,000	107.2	1,531.6	5.660
5. Powerhouse					273.4		20.6	294.0	1.086
Draft Gates	ton	3,000,000	98	2,790,000	273.4	210,000	20.6	294.0	1.086
6. Tailrace					593.2		44.6	637.8	2.357
Outlet Gates	ton	3,000,000	139	2,790,000	387.8	210,000	29.2	417.0	1.541
Stoplogs	ton	2,400,000	92	2,232,000	205.3	168,000	15.5	220.8	0.816
IV Electro-mechanical Equipment					**26,615.0**		**7,010.0**	**33,625.0**	**124.261**
1. Generating equipment	unit	L.S.			19,150.0		1,350.0	20,500.0	75.758
2. Transmission line system	m	42,460	285,000		7,465.0		5,660.0	13,125.0	48.503
V Engineering Services (10% of I + II + III + IV)					**8,464.4**		**0.0**	**8,464.4**	**31.280**
VI General Expenses (1% of I + II + III + IV)					**0.0**		**846.4**	**846.4**	**3.128**
VII Contingencies (20 % of I + II + III + IV + V + VI)					**15,563.0**		**3,228.0**	**18,791.0**	**69.442**
Grand Total					**93,378.0**		**19,368.0**	**112,746.0**	**416.652**
Installed Capacity (MW)								**4 x 50.3**	
Annual Energy Production (GWh/yr)								**1,140.0**	
Annual Plant Factor								**0.65**	
Cost per kWh (FCFA/kWh)								**97.7**	
Cost per kW (1,000 FCFA/kW)								**563.7**	

Exchange Rate: US$1 = FCFA270.6

Table 12 Stream of Economic Cost and Benefit

Unit: Mill. US$

Year in order	Const-ruction Cost	Replace, O&M Cost	Total Cost	Benefit	Net Benefit (B - C)	Present Value Cost	Present Value Benefit	Notes
1	9.137	0.000	9.137	0.000	-9.137	8.307	0.000	MVL-1 construction begins.
2	45.686	0.000	45.686	0.000	-45.686	37.757	0.000	
3	91.372	0.000	91.372	0.000	-91.372	68.649	0.000	
4	121.829	0.000	121.829	45.511	-76.318	83.211	31.085	
5	36.549	0.000	36.549	68.267	31.718	22.694	42.389	MVL-1 complete (Thermal-1 put)
6	0.000	3.273	3.273	39.934	36.661	1.847	22.541	
7	0.000	3.273	3.273	39.934	36.661	1.680	20.492	
8	0.000	3.273	3.273	39.934	36.661	1.527	18.629	
9	0.000	3.273	3.273	39.934	36.661	1.388	16.936	
10	56.040	3.273	59.313	85.445	26.133	22.868	32.943	MVL-2 construction begins.
11	56.040	3.273	59.313	108.201	48.888	20.789	37.924	MVL-2 complete (Thermal-2 put)
12	0.000	4.372	4.372	53.581	49.208	1.393	17.072	
13	0.000	4.372	4.372	53.581	49.208	1.266	15.520	
14	0.000	4.372	4.372	53.581	49.208	1.151	14.109	
15	0.000	4.372	4.372	53.581	49.208	1.047	12.827	
16	0.000	4.372	4.372	53.581	49.208	0.952	11.661	
17	0.000	4.372	4.372	53.581	49.208	0.865	10.601	
18	0.000	4.372	4.372	53.581	49.208	0.786	9.637	
19	0.000	4.372	4.372	99.092	94.720	0.715	16.202	
20	0.000	4.372	4.372	121.848	117.475	0.650	18.112	(Thermal-1 replaced)
21	0.000	4.372	4.372	53.581	49.208	0.591	7.240	
22	0.000	4.372	4.372	53.581	49.208	0.537	6.582	
23	0.000	4.372	4.372	53.581	49.208	0.488	5.984	
24	0.000	4.372	4.372	53.581	49.208	0.444	5.440	
25	0.000	4.372	4.372	99.092	94.720	0.404	9.146	
26	0.000	4.372	4.372	121.848	117.475	0.367	10.224	(Thermal-2 replaced)
27	0.000	4.372	4.372	53.581	49.208	0.334	4.087	
28	0.000	4.372	4.372	53.581	49.208	0.303	3.715	
29	0.000	4.372	4.372	53.581	49.208	0.276	3.378	
30	0.000	4.372	4.372	53.581	49.208	0.251	3.071	
31	0.000	4.372	4.372	53.581	49.208	0.228	2.791	
32	0.000	4.372	4.372	53.581	49.208	0.207	2.538	
33	0.000	4.372	4.372	53.581	49.208	0.188	2.307	
34	0.000	4.372	4.372	99.092	94.720	0.171	3.879	
35	0.000	4.372	4.372	121.848	117.475	0.156	4.336	(Thermal-1 replaced)
36	0.000	4.372	4.372	53.581	49.208	0.141	1.733	
37	0.000	4.372	4.372	53.581	49.208	0.129	1.576	
38	0.000	4.372	4.372	53.581	49.208	0.117	1.432	
39	0.000	4.372	4.372	53.581	49.208	0.106	1.302	
40	0.000	121.002	121.002	99.092	-21.910	2.674	2.189	G/E & Metal [MVL-1] replaced
41	0.000	4.372	4.372	121.848	117.475	0.088	2.447	(Thermal-2 replaced)
42	0.000	4.372	4.372	53.581	49.208	0.080	0.978	
43	0.000	4.372	4.372	53.581	49.208	0.073	0.889	
44	0.000	4.372	4.372	53.581	49.208	0.066	0.809	
45	0.000	4.372	4.372	53.581	49.208	0.060	0.735	
46	0.000	40.343	40.343	53.581	13.237	0.503	0.668	G/E & Metal [MVL-2] replaced
47	0.000	4.372	4.372	53.581	49.208	0.050	0.608	
48	0.000	4.372	4.372	53.581	49.208	0.045	0.552	
49	0.000	4.372	4.372	99.092	94.720	0.041	0.929	
50	0.000	4.372	4.372	121.848	117.475	0.037	1.038	(Thermal-1 replaced)
51	0.000	4.372	4.372	53.581	49.208	0.034	0.415	
52	0.000	4.372	4.372	53.581	49.208	0.031	0.377	
53	0.000	4.372	4.372	53.581	49.208	0.028	0.343	
54	0.000	4.372	4.372	53.581	49.208	0.025	0.312	
55	0.000	97.823	97.823	53.581	-44.242	0.517	0.283	Civil [MVL-1] replaced
					Total	289.328	443.014	EIRR = 16.52%

Note: Total economic cost = Mill. US $416.652
Installed capacity = 201.2 MW in total
Capital recovery factor = 0.1005
Annual cost = Mill. US $29.087
B / C = 1.53 (Benefit-cost ratio)
B - C = Mill. US $153.686
Unit energy cost = 2.9 US¢/kWh
Exchange rate: US $1 = F.CFA270.6
Discount rate: 10.0%
MVL-1: Memvé Elé 1, MVL-2: Memvé Elé 2

Hydro's 95% dependable power = 201.2 MW (4.3 hours/day basis)
Alternative thermal capacity = 201.2 MW for MVL-1 and MVL-2
Alternative thermal cost = Mill. US $113.779
Alternative thermal O&M cost = US $22.60 /kW/year
Primary energy value = US $0.0769/kWh for Gas-turbine
Secondary energy value = US $0.0340/kWh for Oil-fired

Table 13 Financial Cash Flow

Unit: Mill. US$

Year in order	Const-ruction Cost	Replace-ment Cost	O&M Cost	Total Cost	Benefit	B - C	Present Value	
							Cost	Benefit
1	9.137	0.000	0.000	9.137	0.000	-9.137	8.307	0.000
2	45.686	0.000	0.000	45.686	0.000	-45.686	37.757	0.000
3	91.372	0.000	0.000	91.372	0.000	-91.372	68.649	0.000
4	121.829	0.000	0.000	121.829	0.000	-121.829	83.211	0.000
5	36.549	0.000	0.000	36.549	0.000	-36.549	22.694	0.000
6	0.000	0.000	42.035	42.035	129.206	87.171	23.727	72.933
7	0.000	0.000	42.035	42.035	129.206	87.171	21.570	66.303
8	0.000	0.000	42.035	42.035	129.206	87.171	19.609	60.275
9	0.000	0.000	42.035	42.035	129.206	87.171	17.827	54.796
10	56.040	0.000	42.035	98.074	129.206	31.131	37.812	49.814
11	56.040	0.000	42.035	98.074	129.206	31.131	34.374	45.286
12	0.000	0.000	43.134	43.134	198.388	155.254	13.744	63.212
13	0.000	0.000	43.134	43.134	198.388	155.254	12.494	57.466
14	0.000	0.000	43.134	43.134	198.388	155.254	11.359	52.242
15	0.000	0.000	43.134	43.134	198.388	155.254	10.326	47.492
16	0.000	0.000	43.134	43.134	198.388	155.254	9.387	43.175
17	0.000	0.000	43.134	43.134	198.388	155.254	8.534	39.250
18	0.000	0.000	43.134	43.134	198.388	155.254	7.758	35.682
19	0.000	0.000	43.134	43.134	198.388	155.254	7.053	32.438
20	0.000	0.000	43.134	43.134	198.388	155.254	6.412	29.489
21	0.000	0.000	43.134	43.134	198.388	155.254	5.829	26.808
22	0.000	0.000	43.134	43.134	198.388	155.254	5.299	24.371
23	0.000	0.000	43.134	43.134	198.388	155.254	4.817	22.156
24	0.000	0.000	43.134	43.134	198.388	155.254	4.379	20.141
25	0.000	0.000	43.134	43.134	198.388	155.254	3.981	18.310
26	0.000	0.000	43.134	43.134	198.388	155.254	3.619	16.646
27	0.000	0.000	43.134	43.134	198.388	155.254	3.290	15.133
28	0.000	0.000	43.134	43.134	198.388	155.254	2.991	13.757
29	0.000	0.000	43.134	43.134	198.388	155.254	2.719	12.506
30	0.000	0.000	43.134	43.134	198.388	155.254	2.472	11.369
31	0.000	0.000	43.134	43.134	198.388	155.254	2.247	10.336
32	0.000	0.000	43.134	43.134	198.388	155.254	2.043	9.396
33	0.000	0.000	43.134	43.134	198.388	155.254	1.857	8.542
34	0.000	0.000	43.134	43.134	198.388	155.254	1.688	7.765
35	0.000	0.000	43.134	43.134	198.388	155.254	1.535	7.059
36	0.000	0.000	43.134	43.134	198.388	155.254	1.395	6.418
37	0.000	0.000	43.134	43.134	198.388	155.254	1.269	5.834
38	0.000	0.000	43.134	43.134	198.388	155.254	1.153	5.304
39	0.000	0.000	43.134	43.134	198.388	155.254	1.048	4.822
40	0.000	116.630	43.134	159.764	198.388	38.624	3.530	4.383
41	0.000	0.000	43.134	43.134	198.388	155.254	0.866	3.985
42	0.000	0.000	43.134	43.134	198.388	155.254	0.788	3.623
43	0.000	0.000	43.134	43.134	198.388	155.254	0.716	3.293
44	0.000	0.000	43.134	43.134	198.388	155.254	0.651	2.994
45	0.000	0.000	43.134	43.134	198.388	155.254	0.592	2.722
46	0.000	0.000	43.134	43.134	198.388	155.254	0.538	2.474
47	0.000	35.971	43.134	79.105	198.388	119.283	0.897	2.249
48	0.000	0.000	43.134	43.134	198.388	155.254	0.445	2.045
49	0.000	0.000	43.134	43.134	198.388	155.254	0.404	1.859
50	0.000	0.000	43.134	43.134	198.388	155.254	0.367	1.690
51	0.000	0.000	43.134	43.134	198.388	155.254	0.334	1.536
52	0.000	0.000	43.134	43.134	198.388	155.254	0.304	1.397
53	0.000	0.000	43.134	43.134	198.388	155.254	0.276	1.270
54	0.000	0.000	43.134	43.134	198.388	155.254	0.251	1.154
55	0.000	93.450	43.134	136.584	198.388	61.803	0.722	1.049
						Total	527.917	1,034.252
							FIRR =	22.92%

Note: Total financial cost = Mill. US $416.652
Electricity tariff = 49.5 F.CFA/kWh
US 1$ = F. CFA270.6
Discount rate = 10.0%
O&M Cost consists of operation, maintenance and sub-transmission cost.
Sub-transmission cost is assumed 30% of annual revenue.

Table 14 Loan Repayability

Unit: Mill. US$

Year in order	Repay-ment Cost	OMR Cost	Sub-trans-mission Cost	Total Expendit-ure	Annual Revenue	Balance	Cummulative Surplus
1							
2							
3							
4							
5							
6	51.20	3.27	37.04	91.51	123.48	31.96	31.96
7	49.53	3.27	37.04	89.85	123.48	33.63	65.59
8	47.87	3.27	37.04	88.18	123.48	35.29	100.88
9	46.21	3.27	37.04	86.52	123.48	36.95	137.84
10	44.54	3.27	37.04	84.86	123.48	38.62	176.45
11	42.88	3.27	37.04	83.19	123.48	40.28	216.74
12	41.22	4.37	56.30	101.89	187.68	85.79	302.53
13	39.55	4.37	56.30	100.23	187.68	87.45	389.98
14	37.89	4.37	56.30	98.57	187.68	89.12	479.10
15	58.50	4.37	56.30	119.18	187.68	68.50	547.60
16	56.11	4.37	56.30	116.79	187.68	70.90	618.50
17	53.71	4.37	56.30	114.39	187.68	73.29	691.79
18	51.32	4.37	56.30	111.99	187.68	75.69	767.48
19	48.92	4.37	56.30	109.60	187.68	78.09	845.56
20	46.52	4.37	56.30	107.20	187.68	80.48	926.05
21	39.53	4.37	56.30	100.21	187.68	87.47	1,013.52
22	37.69	4.37	56.30	98.37	187.68	89.32	1,102.84
23	35.84	4.37	56.30	96.52	187.68	91.16	1,194.00
24	34.00	4.37	56.30	94.68	187.68	93.01	1,287.00
25	32.15	4.37	56.30	92.83	187.68	94.85	1,381.86
26	21.17	4.37	56.30	81.85	187.68	105.83	1,487.69
27	20.24	4.37	56.30	80.92	187.68	106.76	1,594.45
28	19.31	4.37	56.30	79.99	187.68	107.70	1,702.15
29	18.38	4.37	56.30	79.06	187.68	108.63	1,810.78
30	15.35	4.37	56.30	76.03	187.68	111.65	1,922.43
31	14.67	4.37	56.30	75.35	187.68	112.33	2,034.76
32	13.99	4.37	56.30	74.67	187.68	113.01	2,147.78
33	13.31	4.37	56.30	73.99	187.68	113.69	2,261.47
34	12.63	4.37	56.30	73.31	187.68	114.37	2,375.84
35	7.92	4.37	56.30	68.60	187.68	119.08	2,494.93
36	2.68	4.37	56.30	63.36	187.68	124.33	2,619.25
37	2.60	4.37	56.30	63.28	187.68	124.40	2,743.66
38	2.52	4.37	56.30	63.20	187.68	124.48	2,868.14
39	2.44	4.37	56.30	63.12	187.68	124.56	2,992.70
40	2.36	121.00	56.30	179.67	187.68	8.01	3,000.71
41	2.29	4.37	56.30	62.96	187.68	124.72	3,125.43
42	2.21	4.37	56.30	62.88	187.68	124.80	3,250.23
43	2.13	4.37	56.30	62.81	187.68	124.88	3,375.11
44	2.05	4.37	56.30	62.73	187.68	124.96	3,500.07
45		4.37	56.30	60.68	187.68	127.01	3,627.07
46		4.37	56.30	60.68	187.68	127.01	3,754.08
47		40.34	56.30	96.65	187.68	91.03	3,845.11
48		4.37	56.30	60.68	187.68	127.01	3,972.12
49		4.37	56.30	60.68	187.68	127.01	4,099.13
50		4.37	56.30	60.68	187.68	127.01	4,226.13
51		4.37	56.30	60.68	187.68	127.01	4,353.14
52		4.37	56.30	60.68	187.68	127.01	4,480.14
53		4.37	56.30	60.68	187.68	127.01	4,607.15
54		4.37	56.30	60.68	187.68	127.01	4,734.15
55		97.82	56.30	154.13	187.68	33.56	4,767.71
56		4.37	56.30	60.67	187.68	127.01	4,894.72
57		4.37	56.30	60.67	187.68	127.01	5,021.73
58		4.37	56.30	60.67	187.68	127.01	5,148.73
59		4.37	56.30	60.67	187.68	127.01	5,275.74
60		4.37	56.30	60.67	187.68	127.01	5,402.75

Note: Exchange Rate: US $1.00 = F. CFA270.6
OMR: Operation, maintenance and replacement
Sub-transmission cost is assumed 30% of annual revenue.

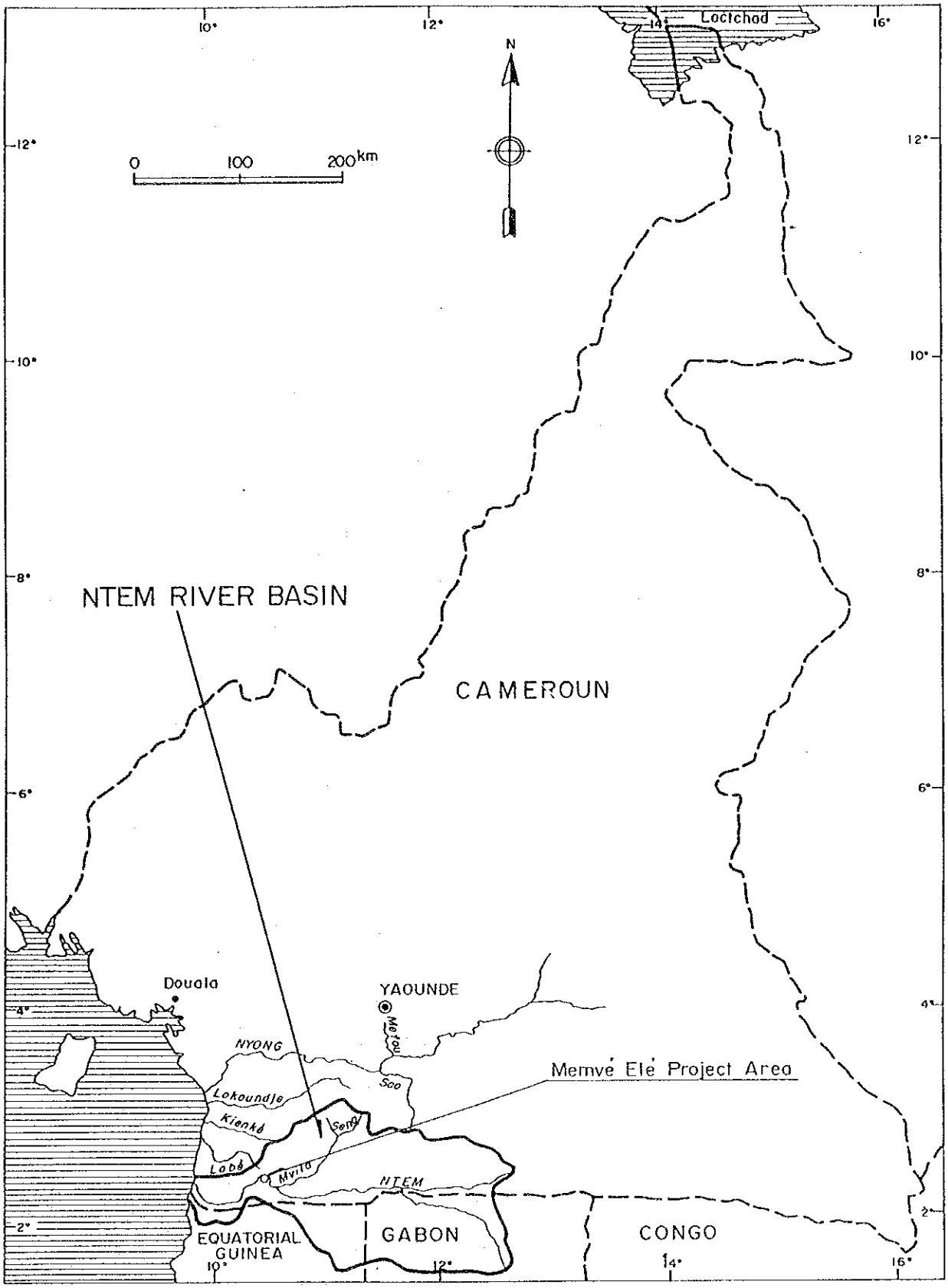


Fig. 1 Location Map

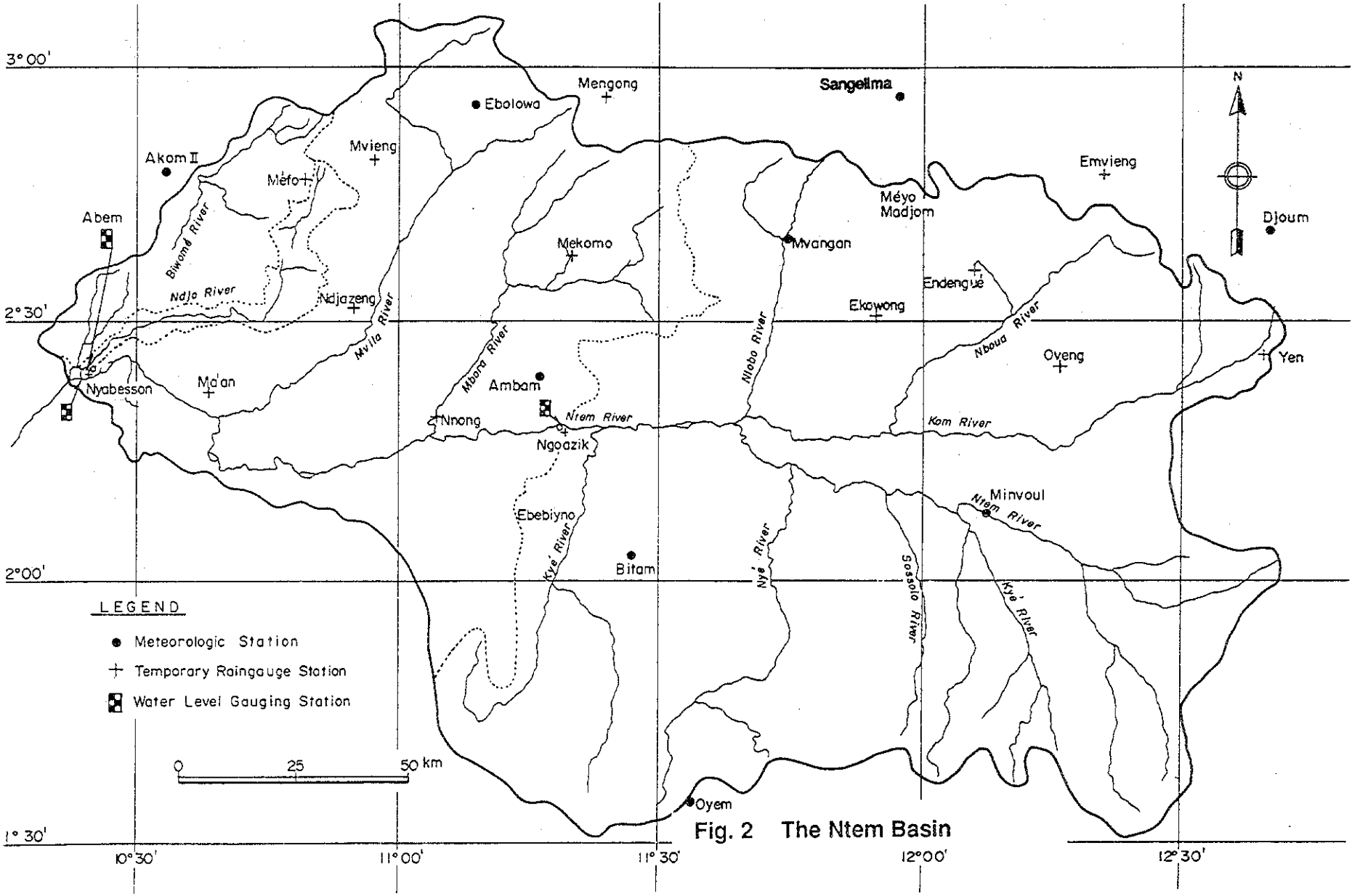


Fig. 2 The Ntem Basin

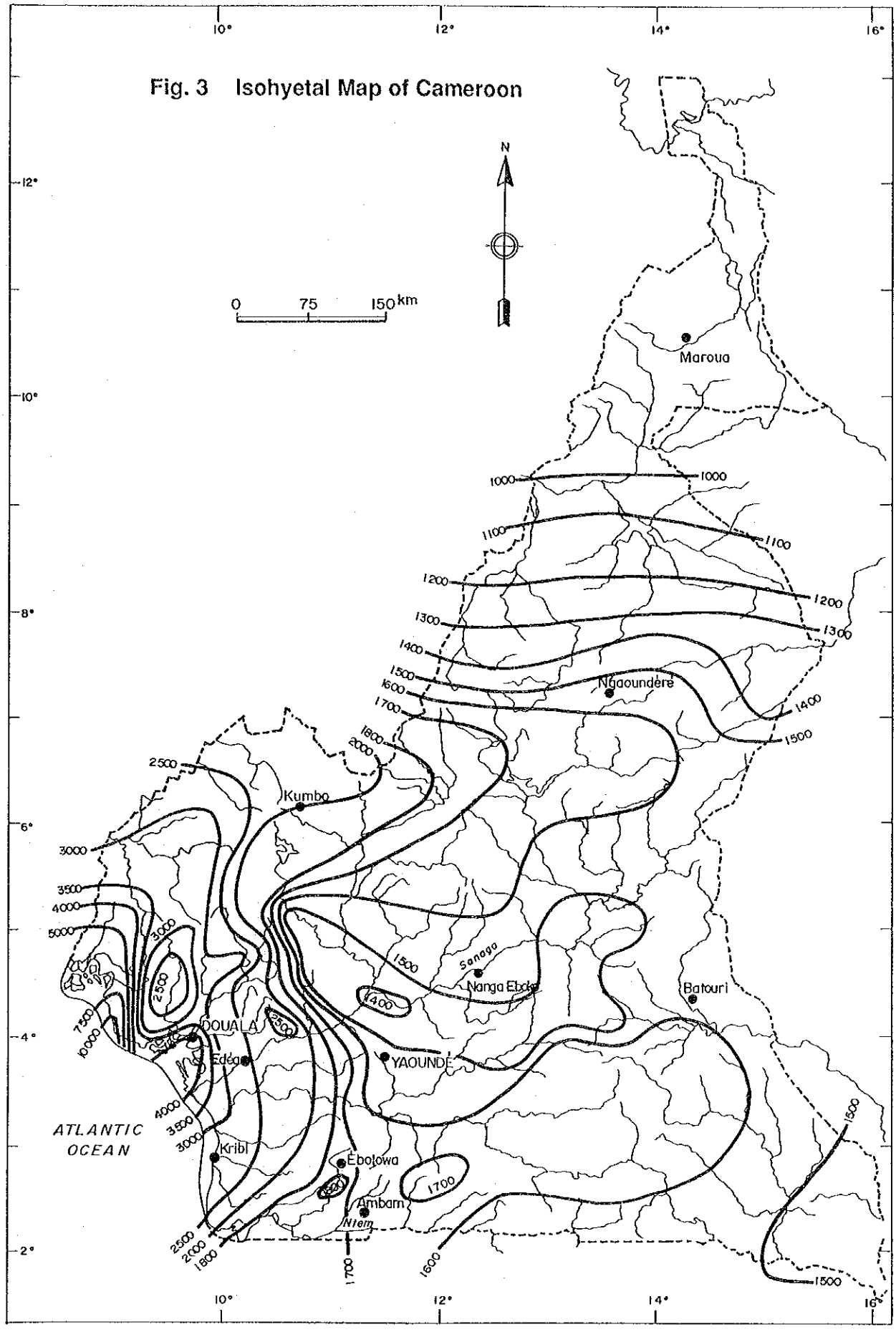


Fig. 3 Isohyetal Map of Cameroon
N
0 75 150 km
Maroua
Ngaoundéré
Kumbo
Batouri
Nanga Eboko
Sanaga
DOUALA
Edéa
YAOUNDE
Kribi
Ebolowa
Ambam
Ntem
ATLANTIC OCEAN
10°
12°
14°
16°
2°
4°
6°
8°
10°
12°
1000
1100
1200
1300
1400
1500
1600
1700
1800
2000
2500
3000
3500
4000
5000
7500
10000

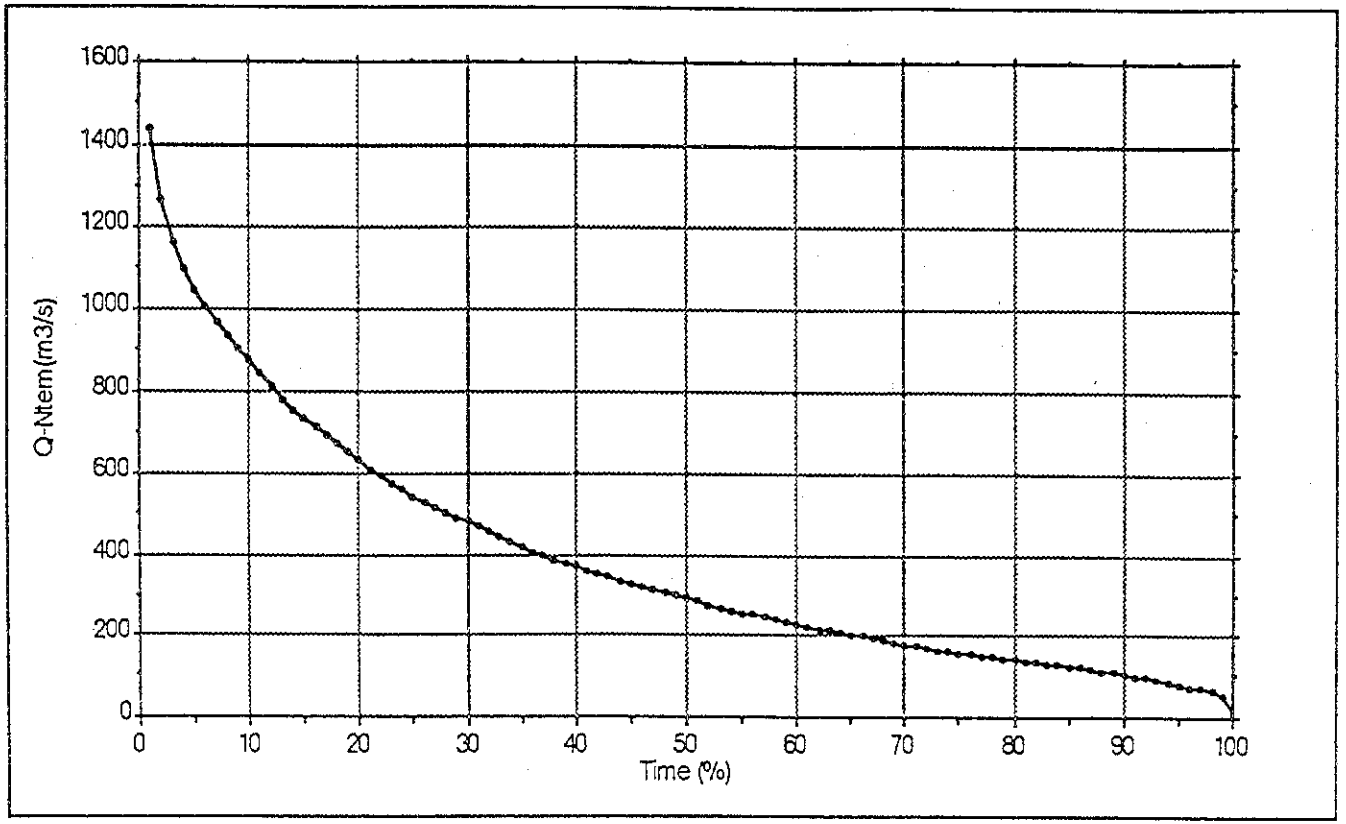


Fig. 4 Runoff Duration of Ntem River

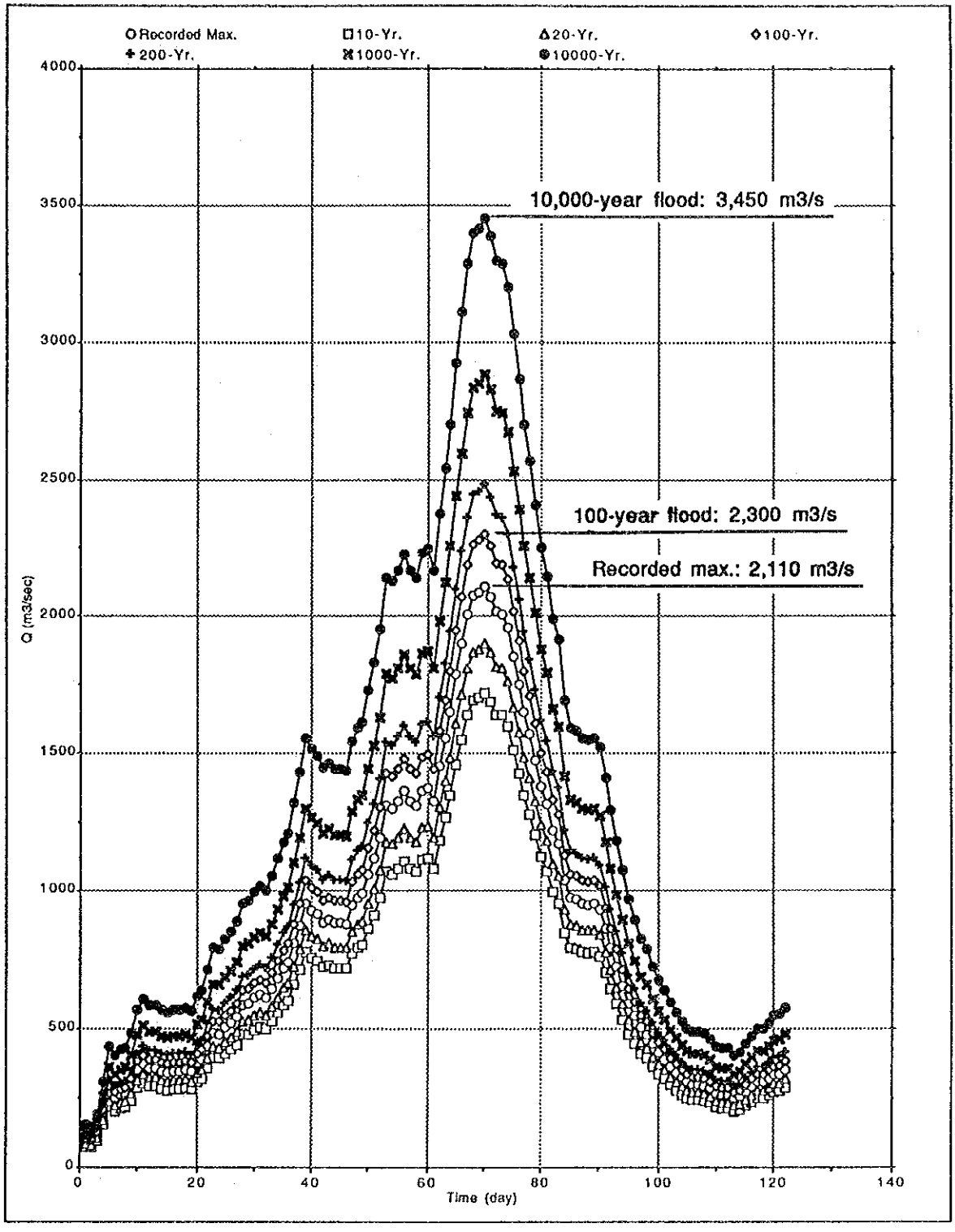
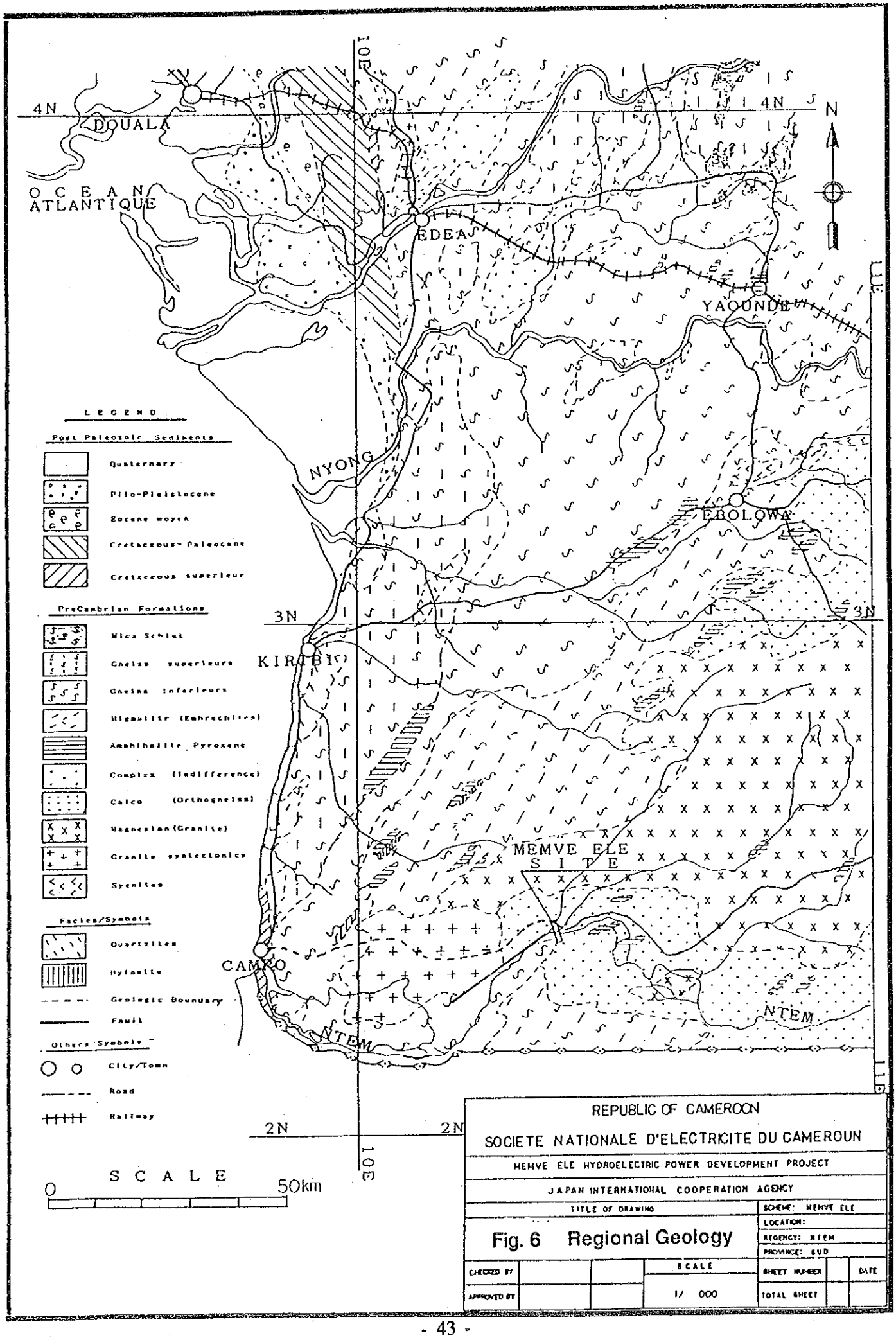


Fig. 5 Hydrograph of Probable Flood



REPUBLIC OF CAMEROON

SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN

MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE OF DRAWING

Fig. 6 Regional Geology

SCHEME: MEMVE ELE

LOCATION:

REGENCY: NTEM

PROVINCE: SUD

CHECKED BY			SCALE	SHEET NUMBER		DATE
APPROVED BY			1/ 000	TOTAL SHEET		

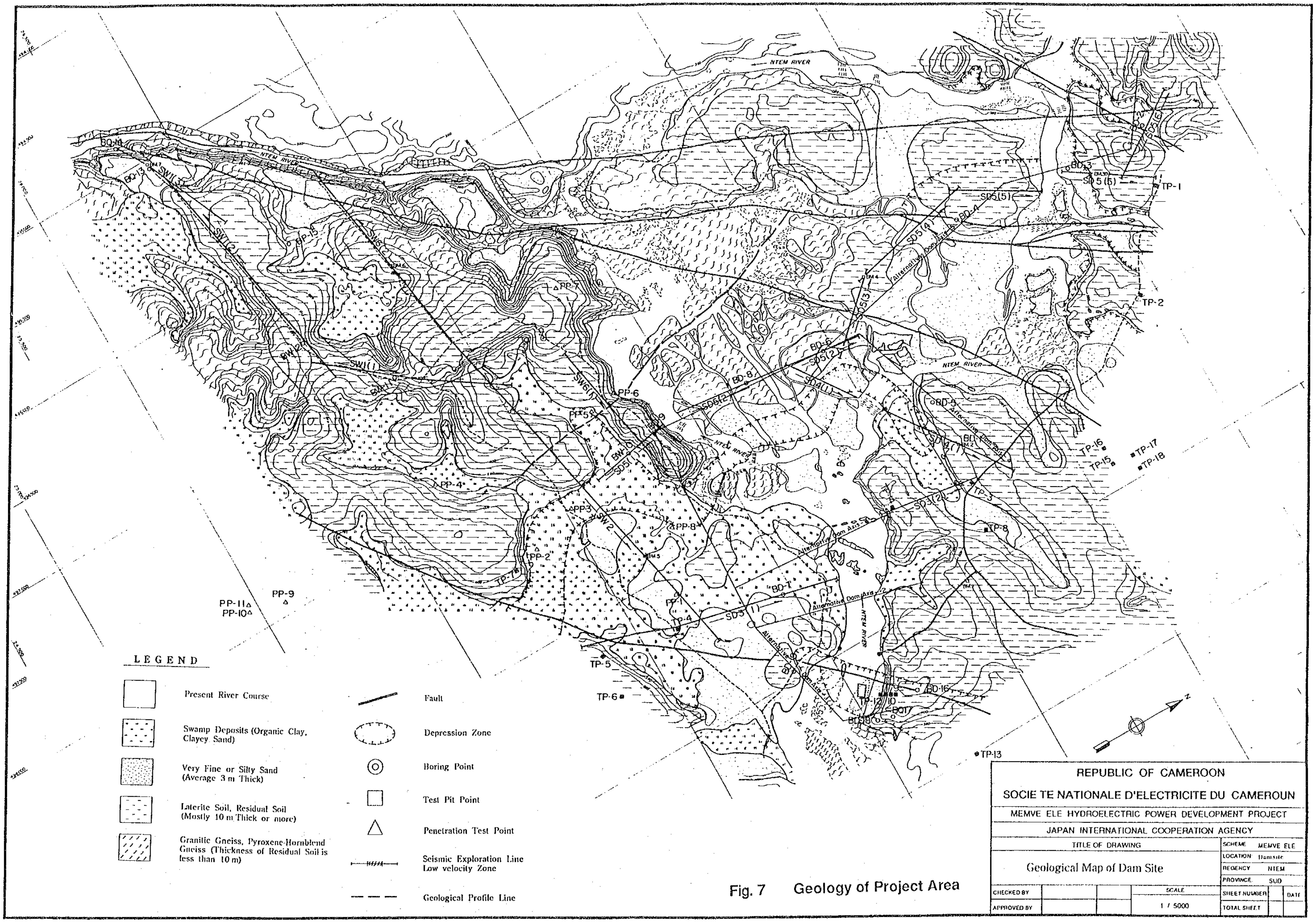


Fig. 7 Geology of Project Area

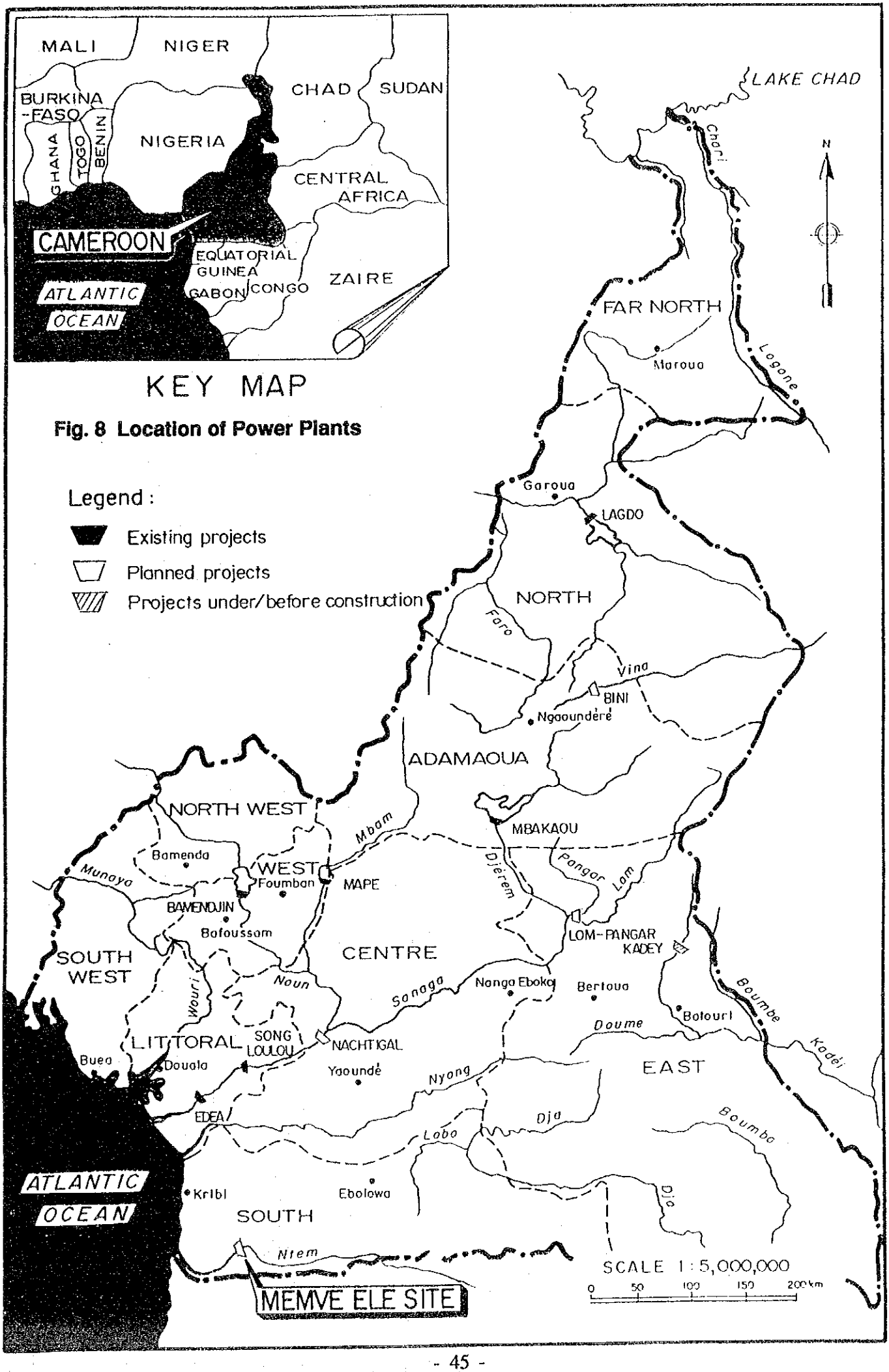


Fig. 8 Location of Power Plants

Legend :

- Existing projects
- Planned projects
- Projects under/before construction

Fig. 9 Transmission Line Networks

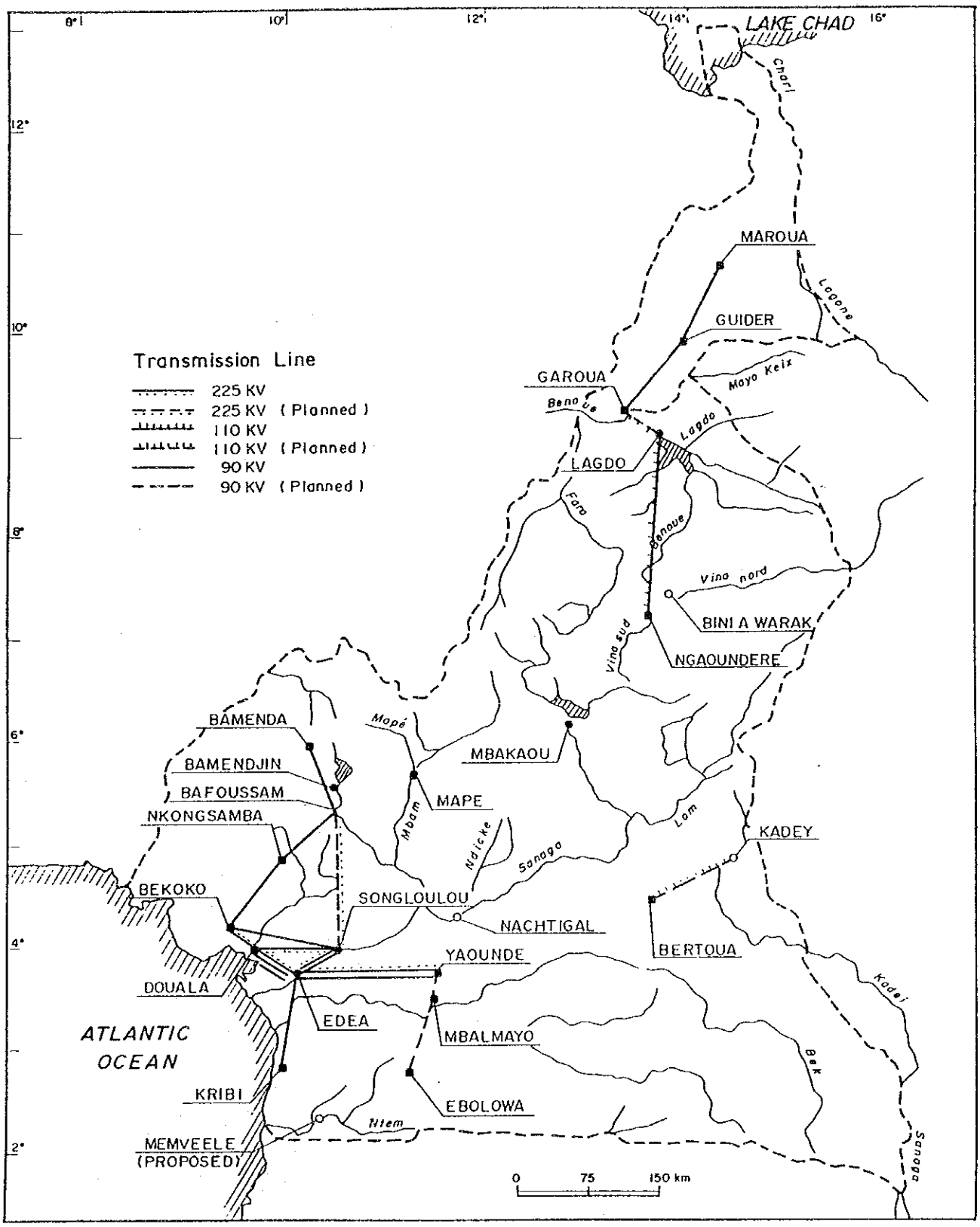
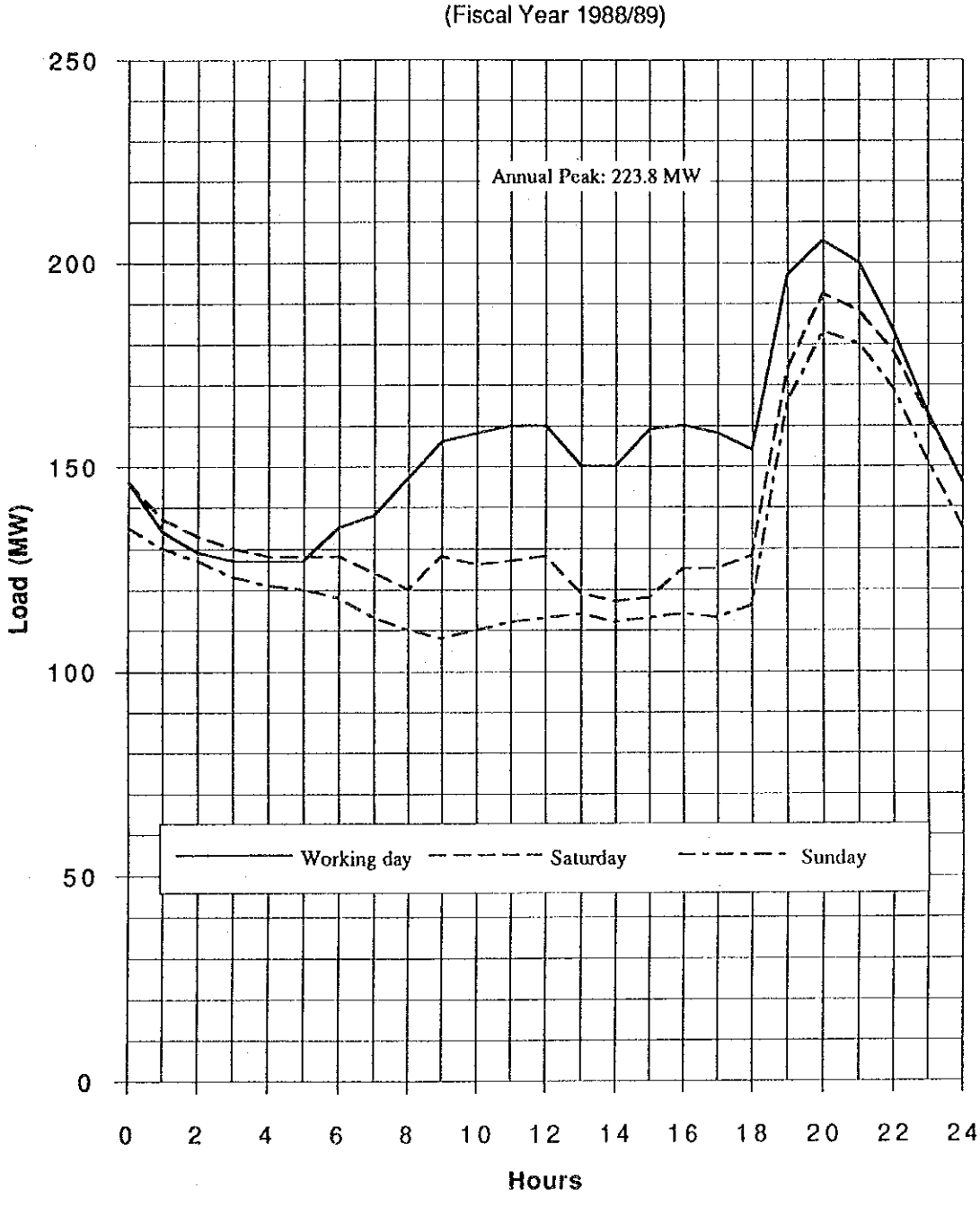


Fig. 10 Load Patterns



Note: 1. Working day (Load factor: 75.5%, Peak time: 4.43 hrs, 205.3 MW max., 155.7 MW average)
2. Saturday (Load factor: 71.5%, Peak time: 4.89 hrs, 192.3 MW max., 137.6 MW average)
3. Sunday & Holiday (Load factor: 69.9%, Peak time: 5.05 hrs, 183.0 MW max., 128.0 MW average)

Fig. 11 Forecast of Peak Power Demand

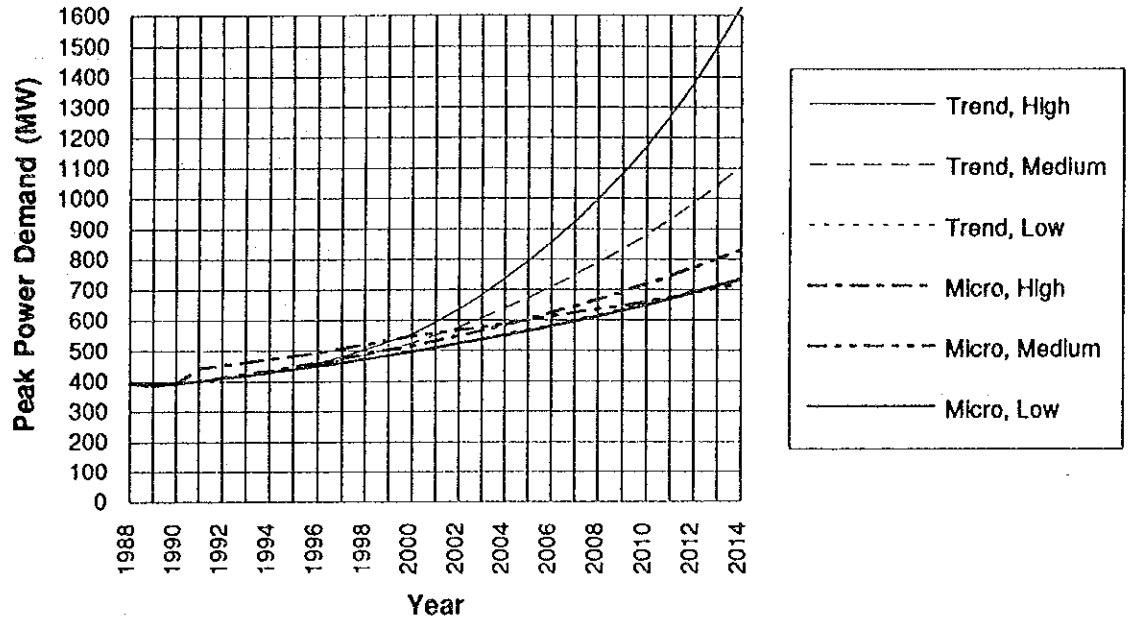
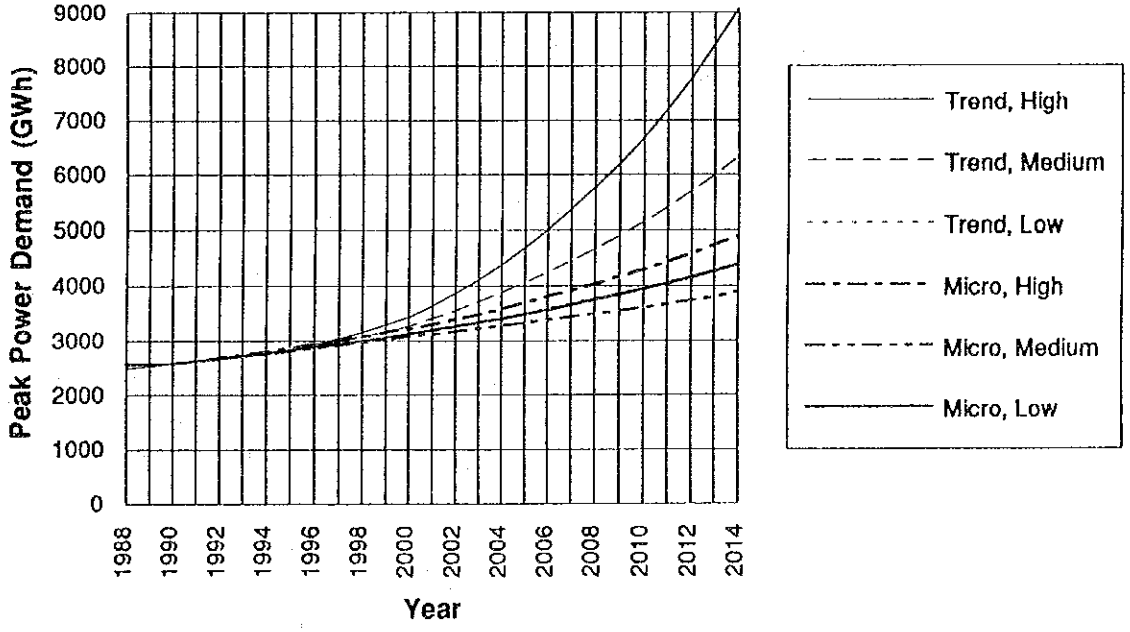


Fig. 12 Forecast of Energy Demand



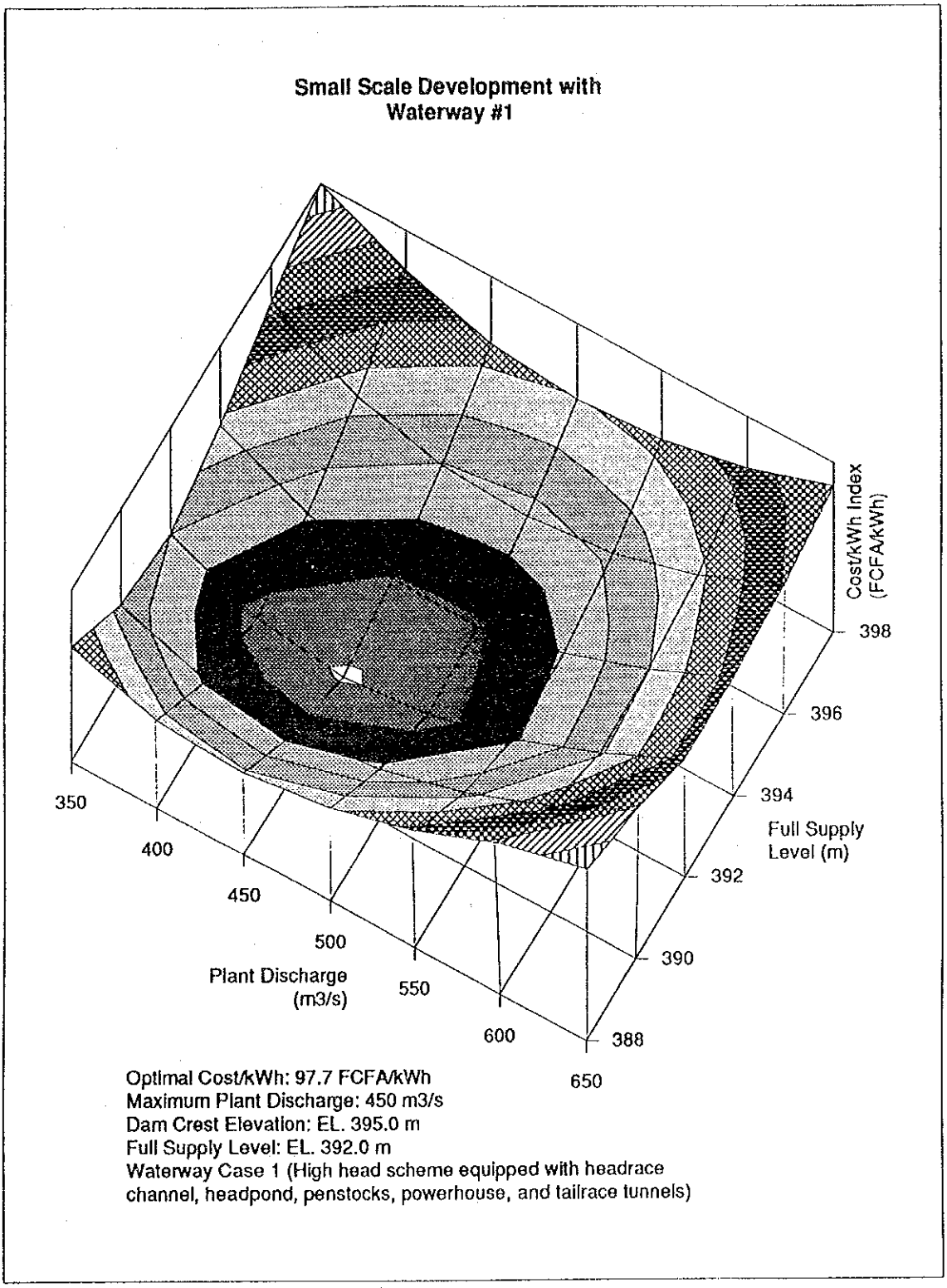
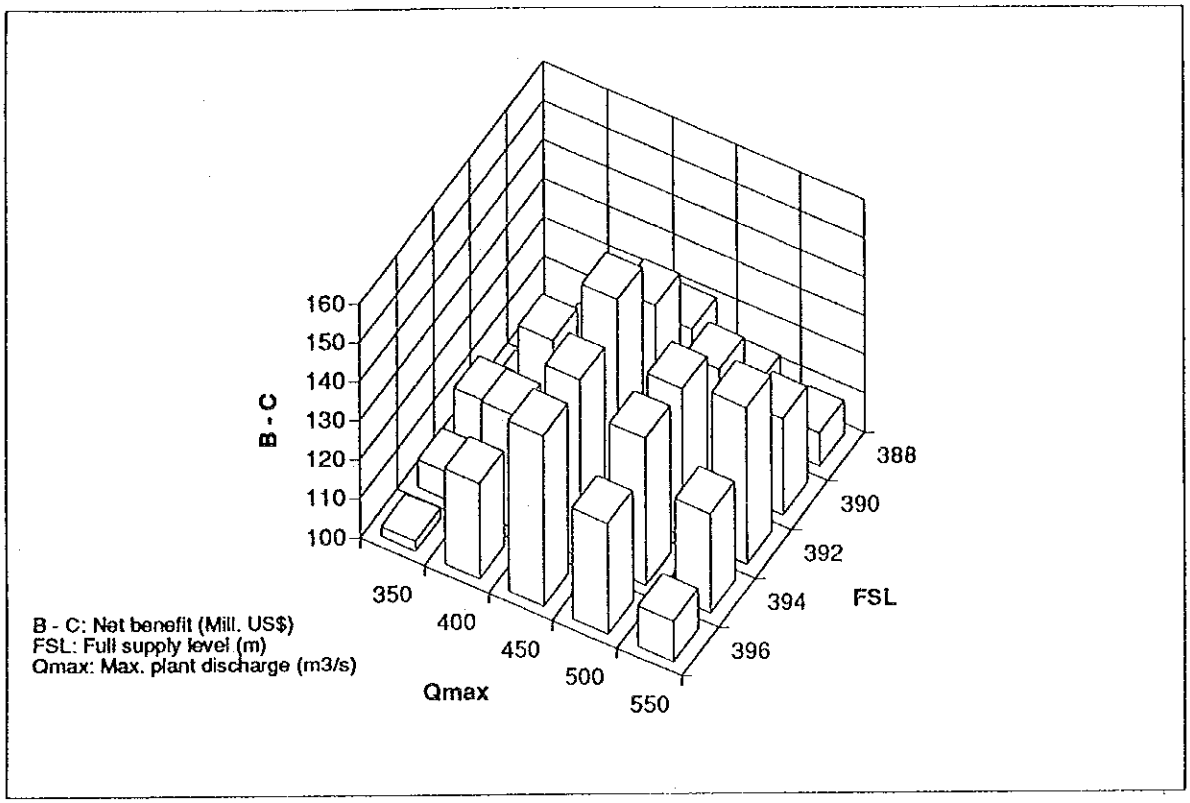


Fig. 13 Cost/kWh Optima



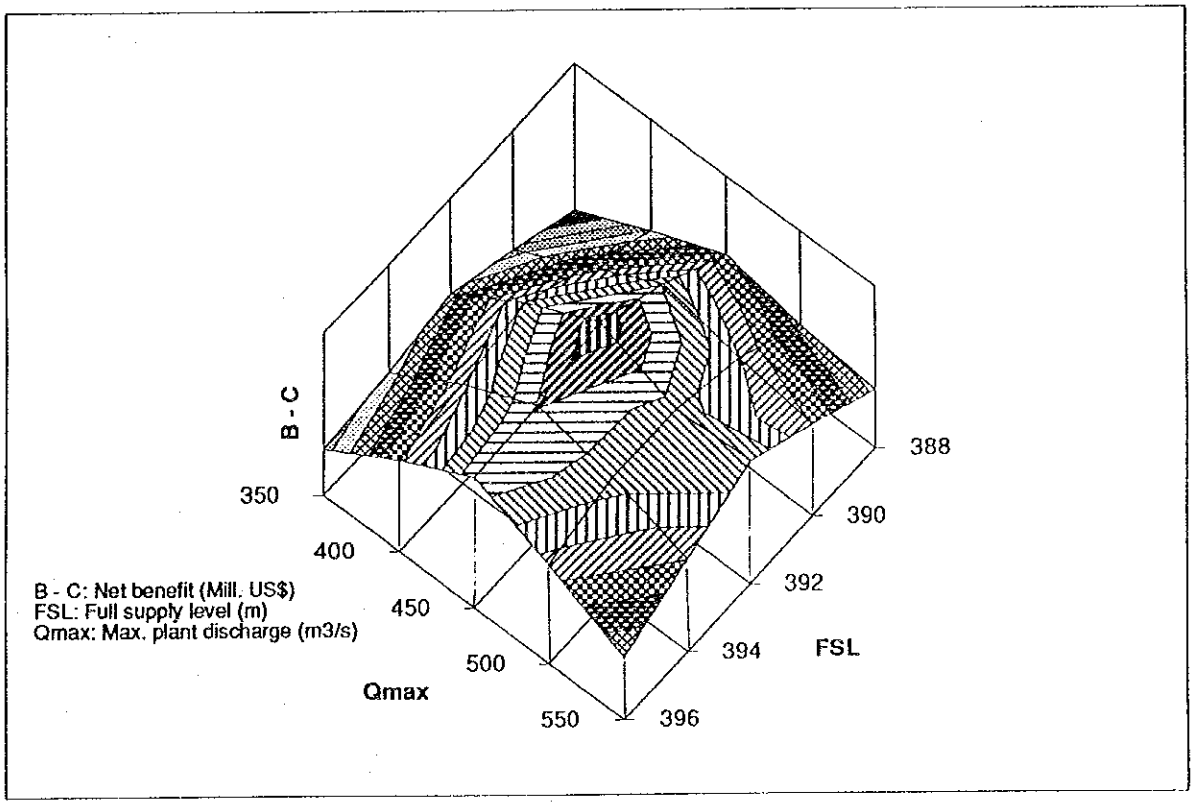


Fig. 14 Net Benefit Optima

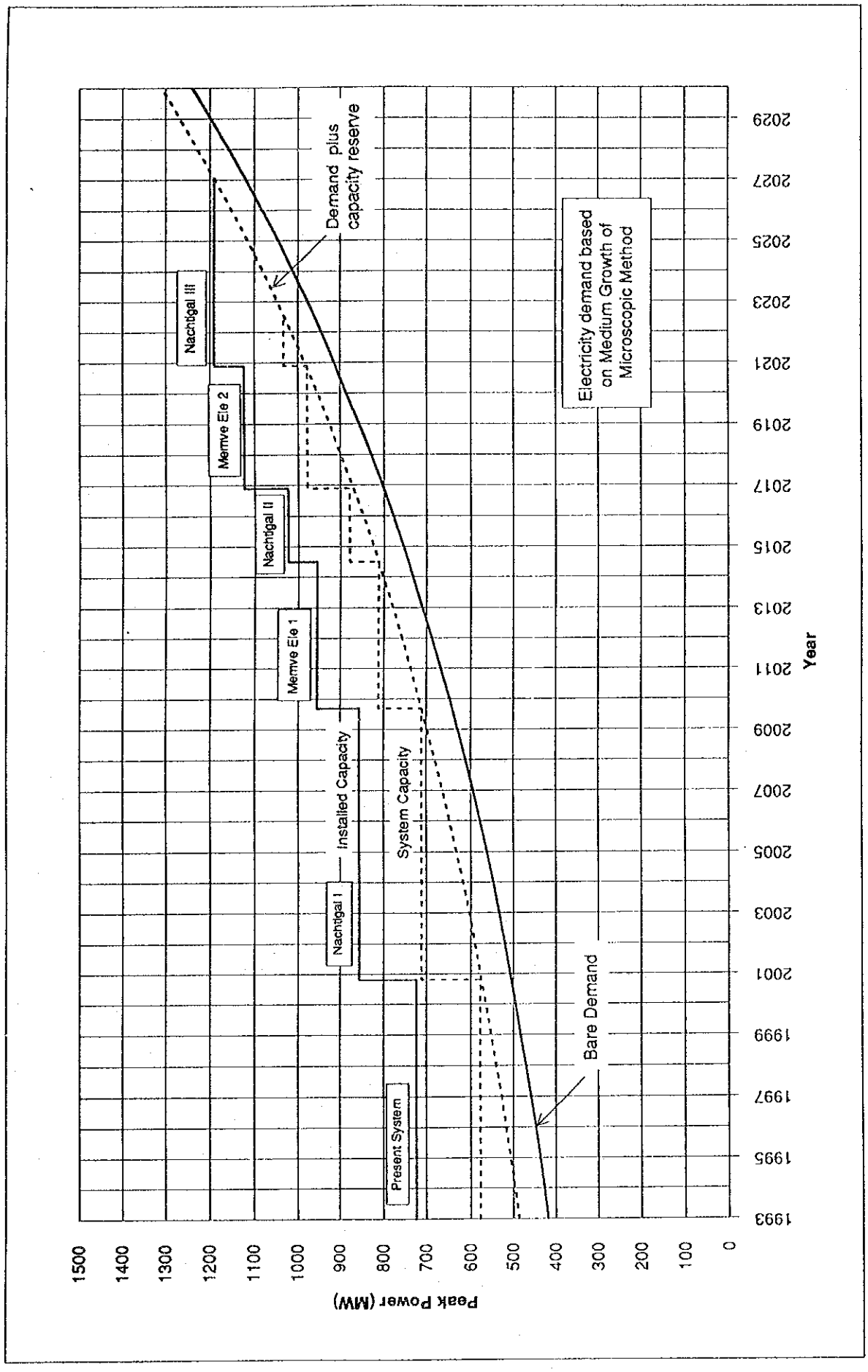
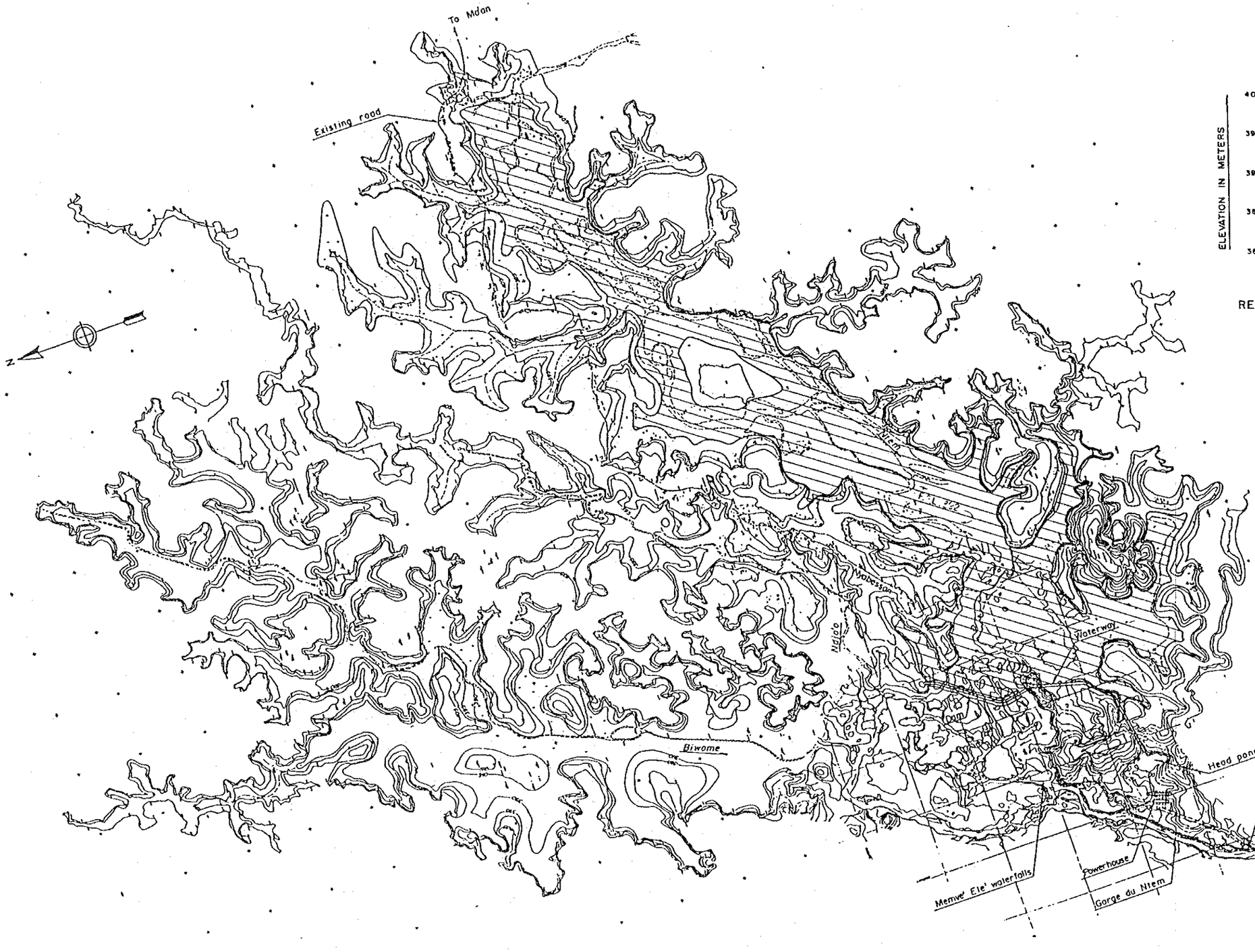
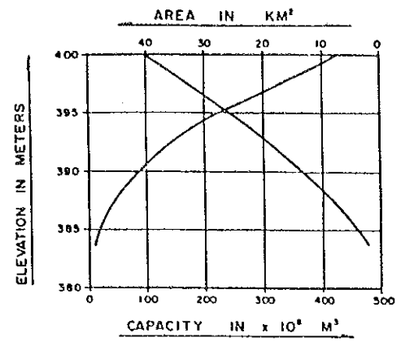


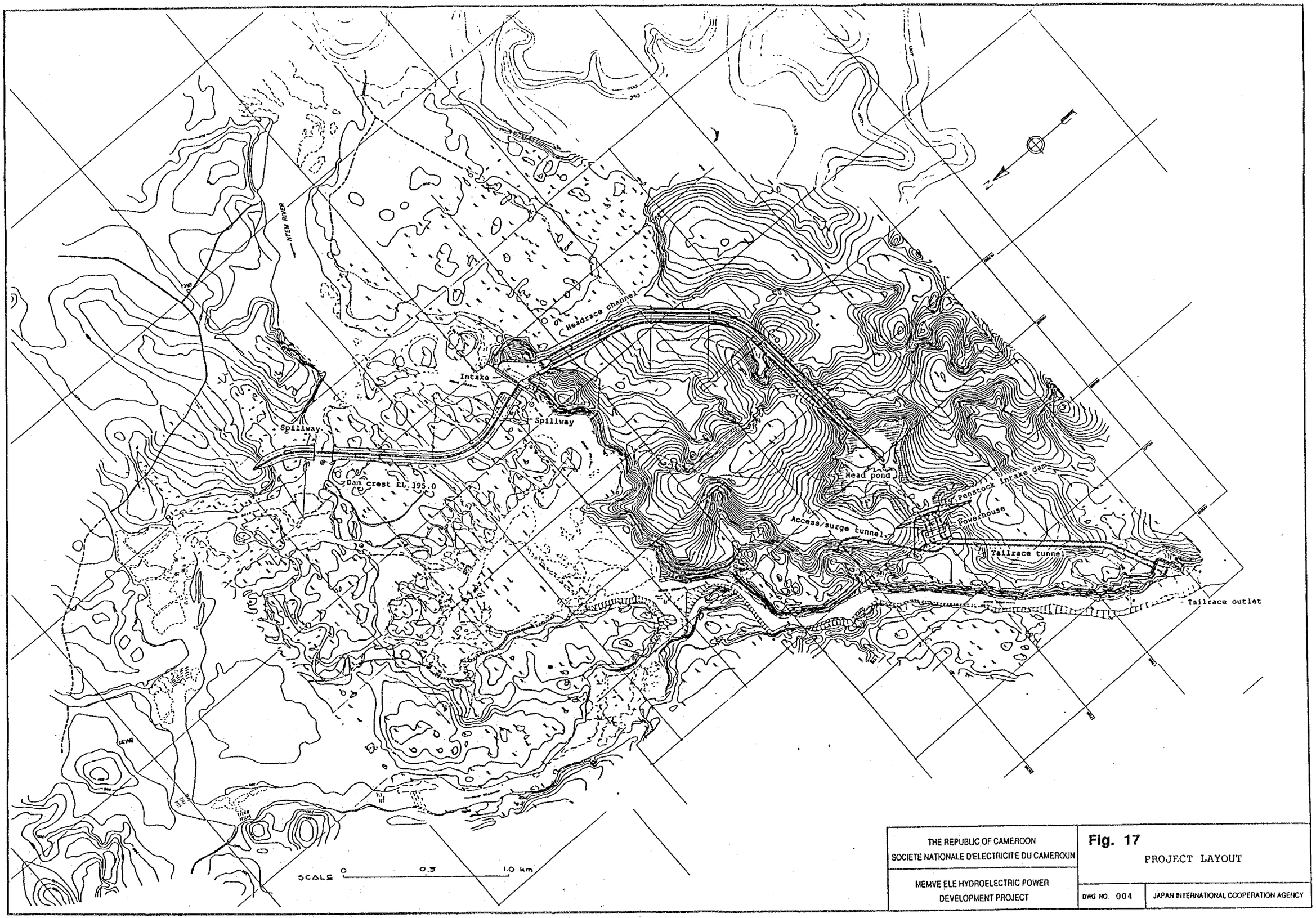
Fig. 15 Optimal Development Timing



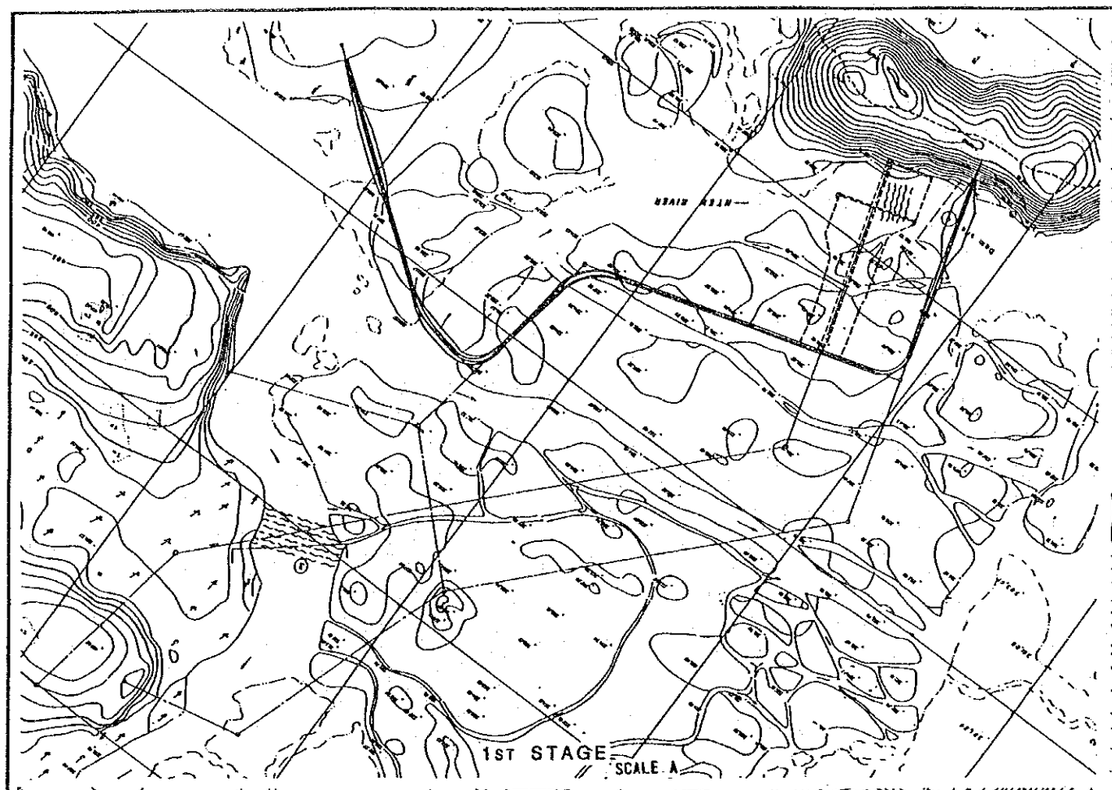


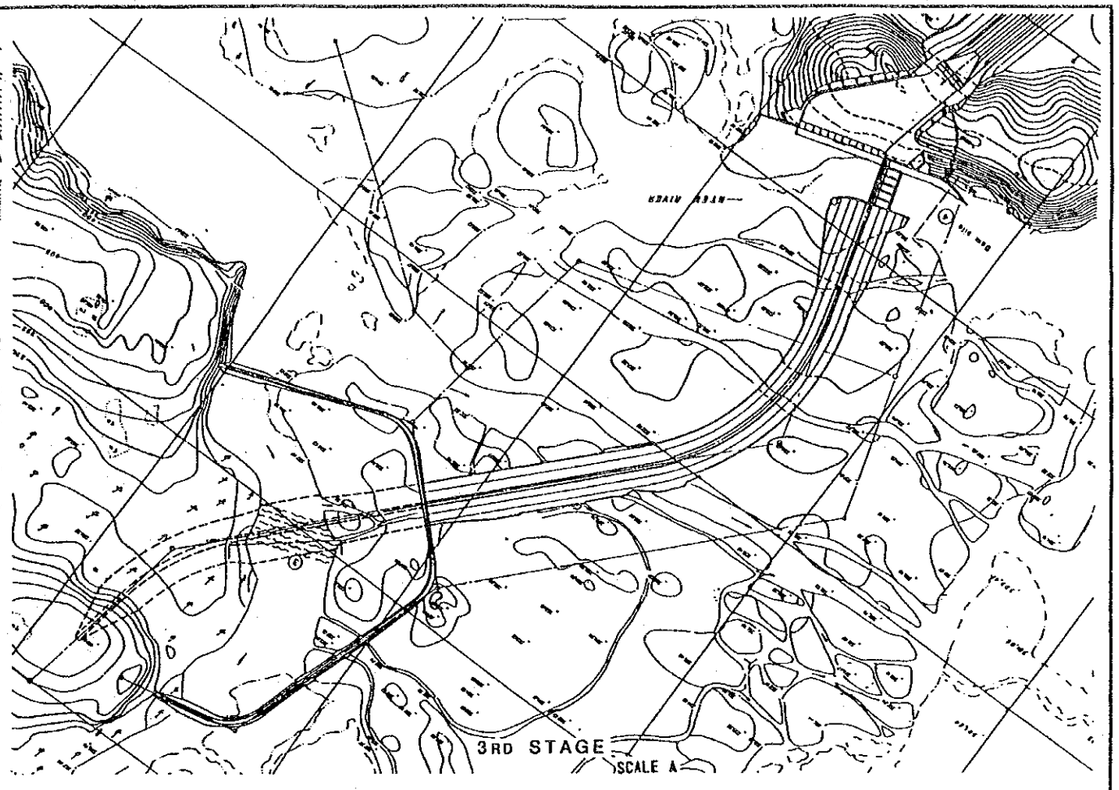
RESERVOIR AREA / CAPACITY CURVE

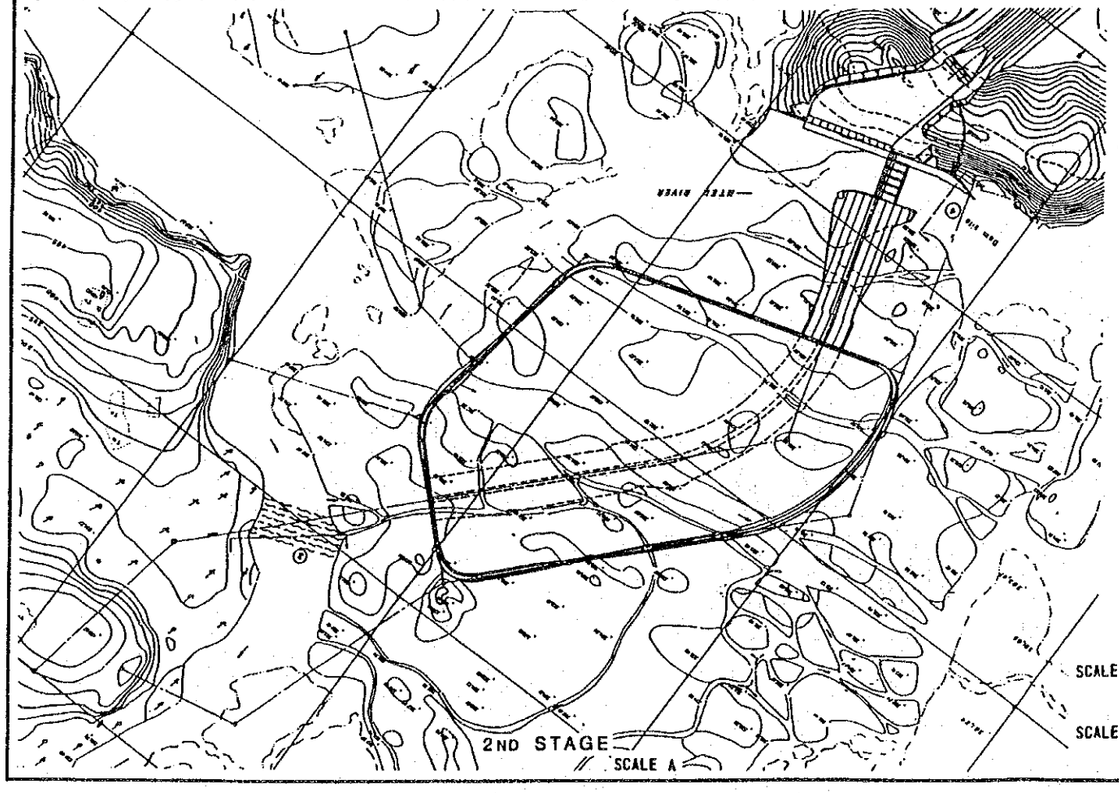
THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	Fig. 16 RESERVOIR
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 003 / JAPAN INTERNATIONAL COOPERATION AGENCY

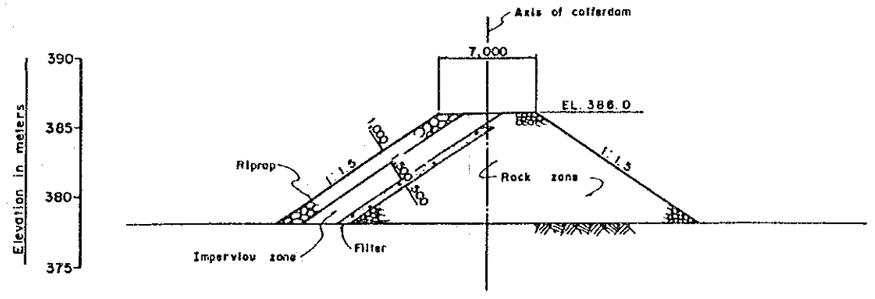


THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	**Fig. 17** PROJECT LAYOUT
MEMVE'ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO. 004 / JAPAN INTERNATIONAL COOPERATION AGENCY







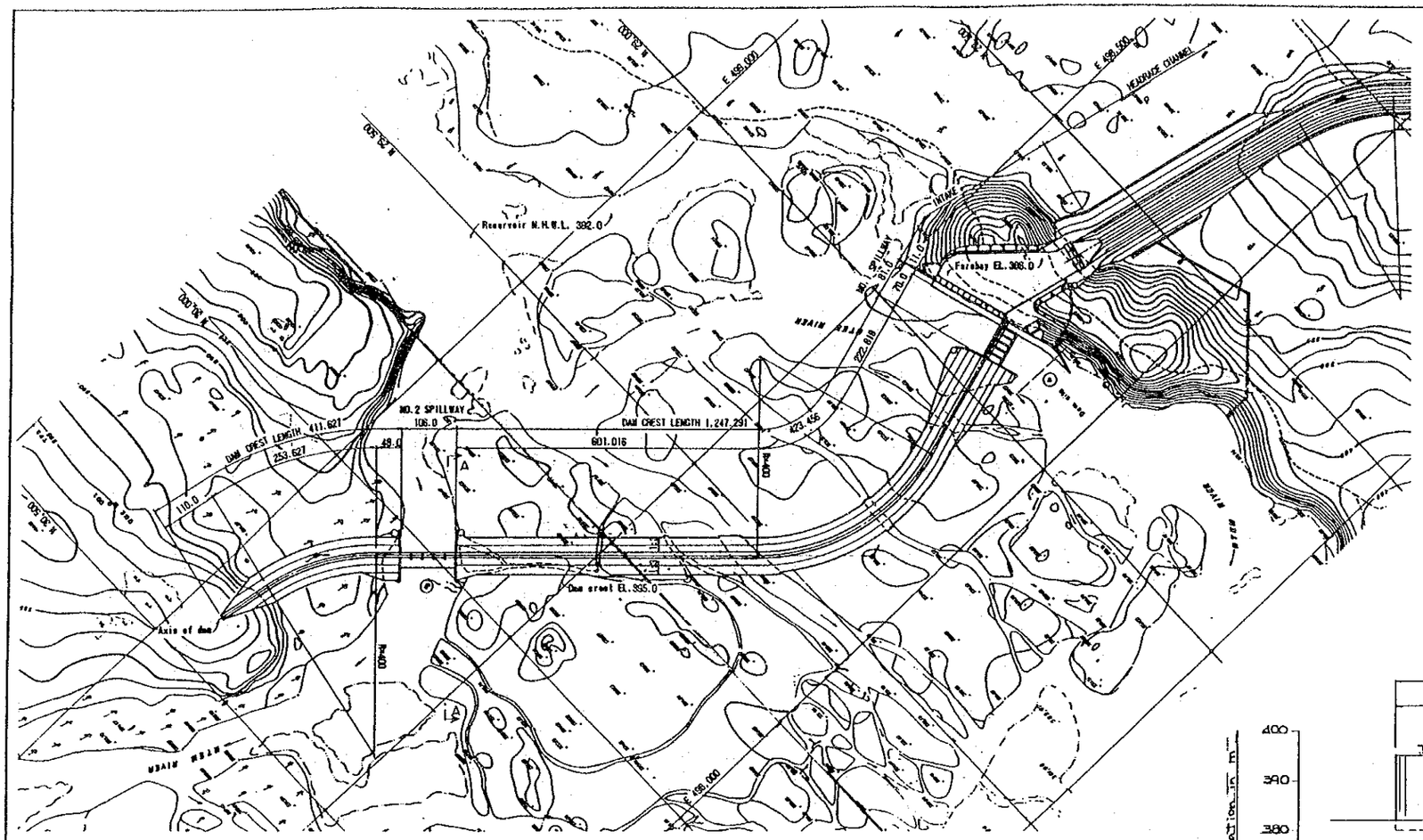


TYPICAL CROSS SECTION OF COFFERDAM
SCALE B

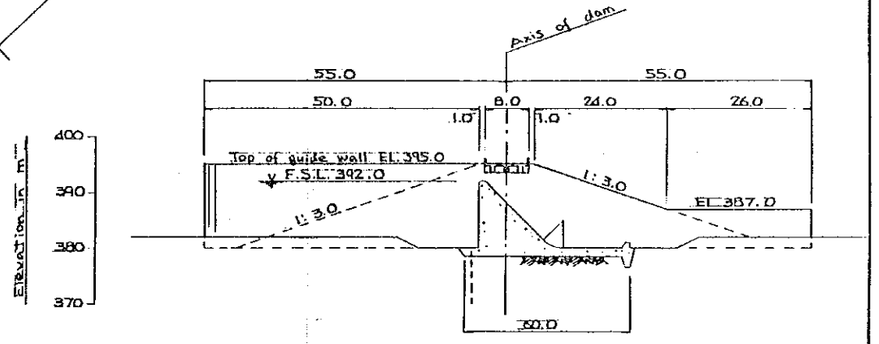
SCALE A 0 500m

SCALE B 0 20m

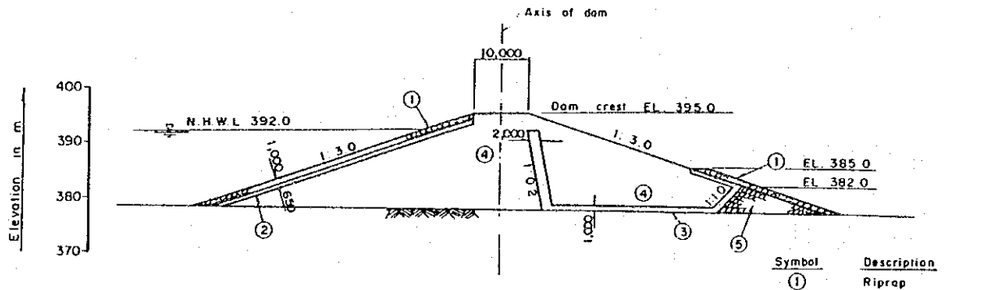
THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	**Fig. 18** DAM, RIVER DIVERSION PLAN
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG. NO. 009 — JAPAN INTERNATIONAL COOPERATION AGENCY



P L A N SCALE A



SECTION A - A SCALE B



TYPICAL CROSS SECTION

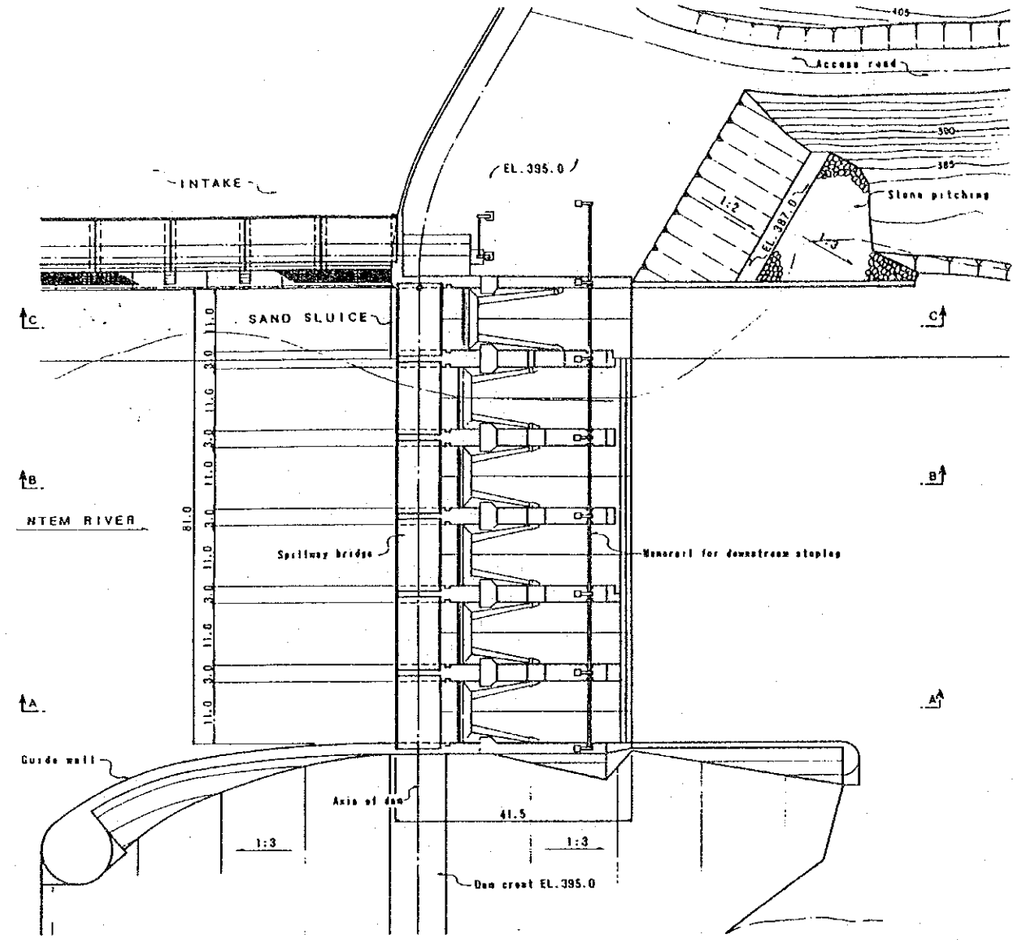
Symbol	Description
①	Riprap
②	Transition
③	Filter
④	Impervious material
⑤	Rockfill

SCALE A 0 500m

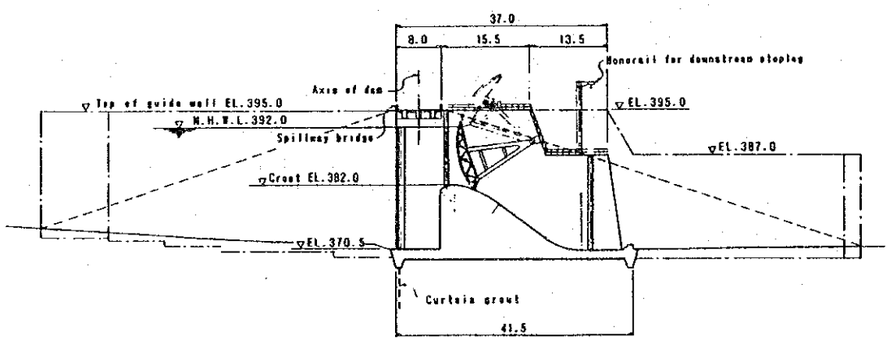
SCALE B 0 50m

SCALE B

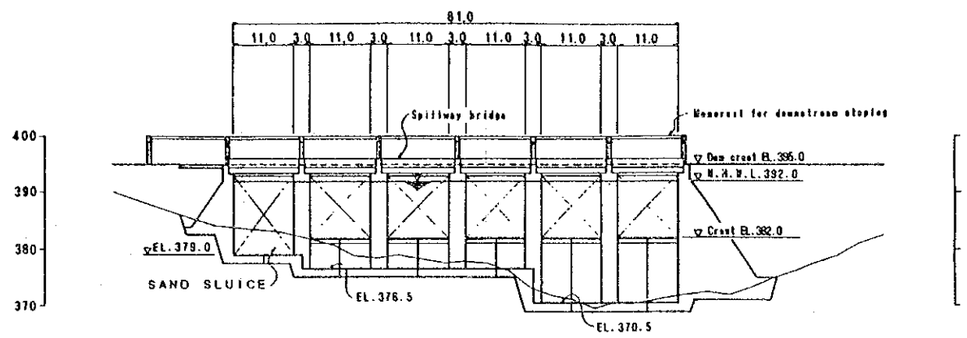
THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	**Fig. 19** DAM, PLAN AND TYPICAL SECTION
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 010 | JAPAN INTERNATIONAL COOPERATION AGENCY



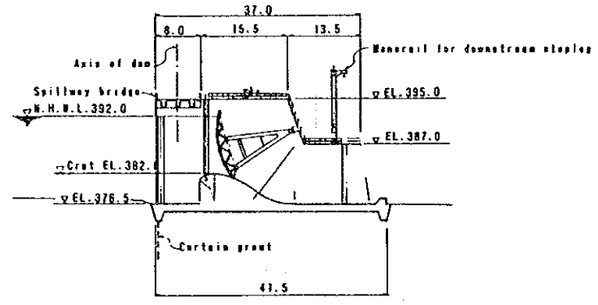
PLAN SCALE A



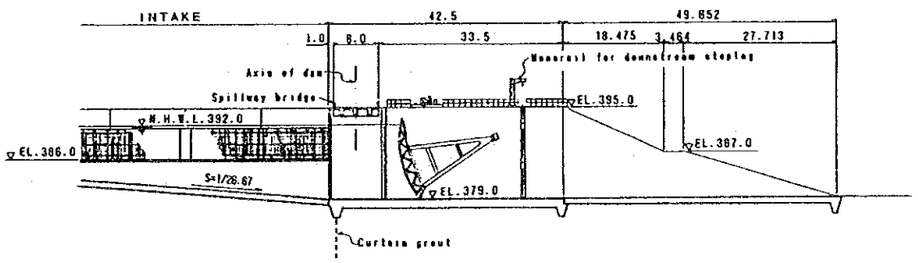
SECTION A—A SCALE A



DOWNSTREAM ELEVATION SCALE A



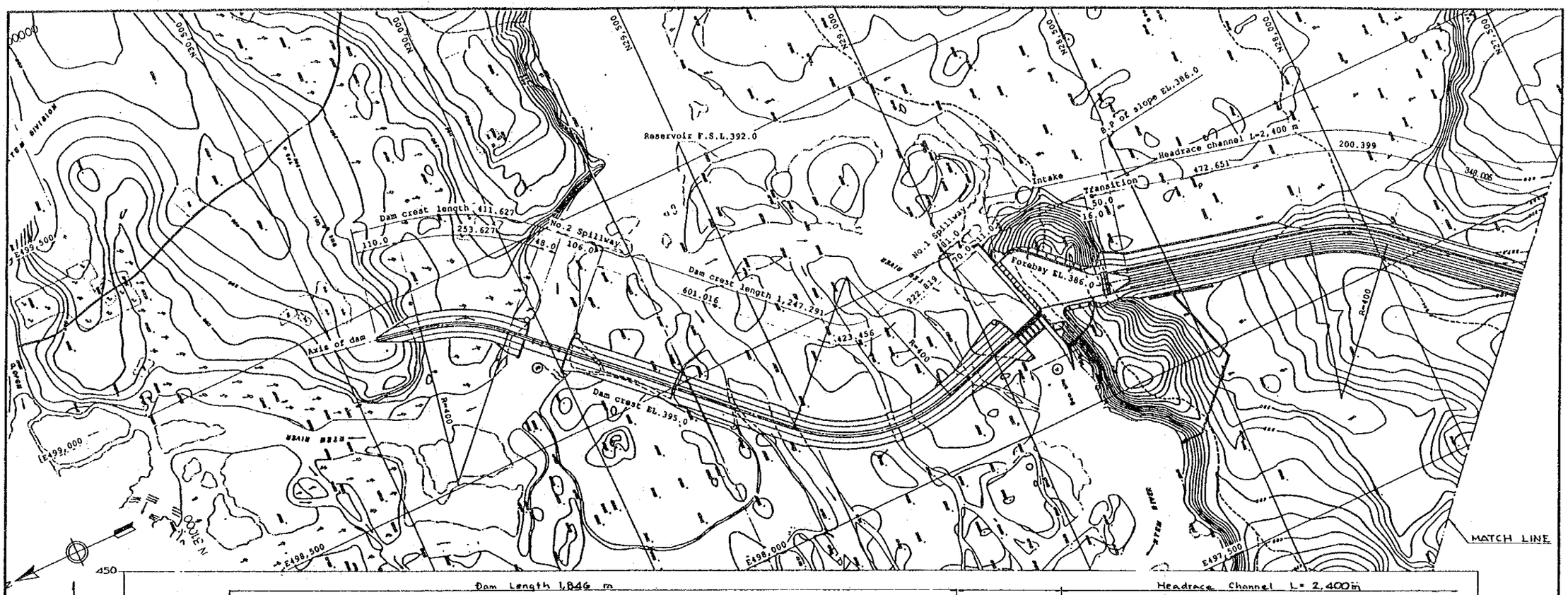
SECTION B—B SCALE A



SECTION C—C (SAND SLUICE) SCALE A

SCALE A 0 50m

THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	**Fig. 20** SPILLWAY PLAN, PROFILE AND SECTIONS
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG. NO. 011 / JAPAN INTERNATIONAL COOPERATION AGENCY



ORIGINAL GROUND HEIGHT (M)	399	398	396	392	395	394	394	395	395	395	395	396	394	395	397	395	395
FORMATION HEIGHT (M)	395.0	395.0	395.0	395.0	395.0	395.0	395.0	395.0	395.0	395.0	395.0	396.0	396.0	396.0	395.9	395.8	395.8
ACCUMULATED DISTANCE (M)	-1,850	-1,800	-1,600	-1,400	-1,200	-1,000	-800	-600	-400	-200	0	200	400	600	800	1,000	1,200
DISTANCE (M)		50	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
STATION NO.	-18-50	-18	-16	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	11

SCALE A 0 500 m

THE REPUBLIC OF CAMEROON
SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN

MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT

Fig. 21
WATERWAY, PLAN AND PROFILE (1)

DWG NO. 012

JAPAN INTERNATIONAL COOPERATION AGENCY