6.5.4 Substation

Additional 225 kV switchgears for the transmission line from the Memvé Elé Power Station will be constructed at the reserve bays in the premises of the Yaoundé Substation.

Arrangement of 225 kV double bus will be adopted to meet with the existing one. Installation levels of switchgears will be 950 kV in terms of the rated lighting impulse voltage and 400 kV in terms of the rated power frequency withstand voltage in accordance with the IEC Standard.

The rated breaking current of circuit breakers, ratted short-time withstand current of disconnecting switches and their rated normal current will be selected from the standard values specified in the relevant IEC Standards. That rated current is recommended to be determined based on the analysis results of the power system at the time when the Project is implemented.

High speed single/multi pole reclosure will be provided for the Memvé Elé - Yaoundé line so that power flow of the sound transmission line will not exceed the rated capacity when faults occur.

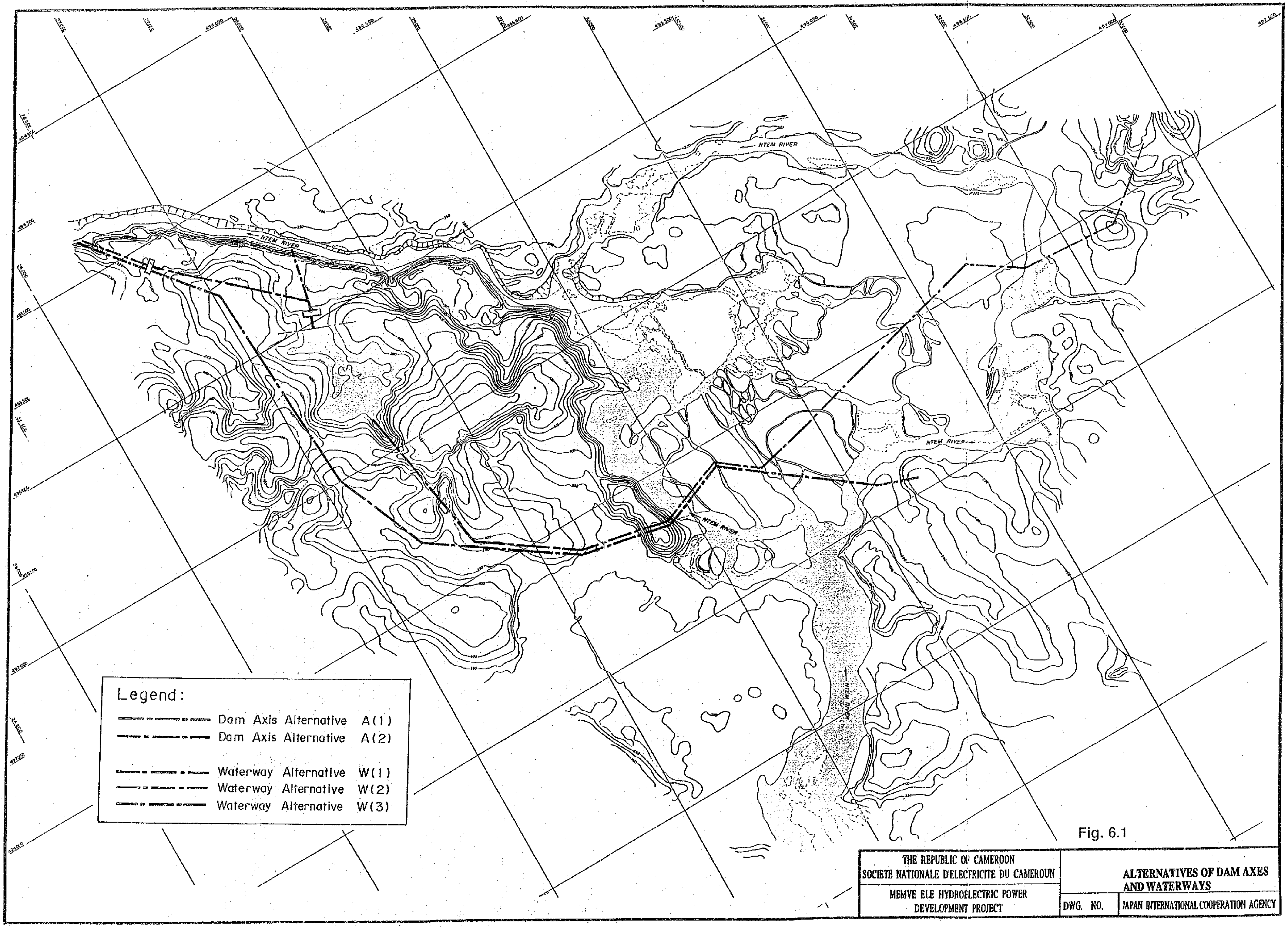
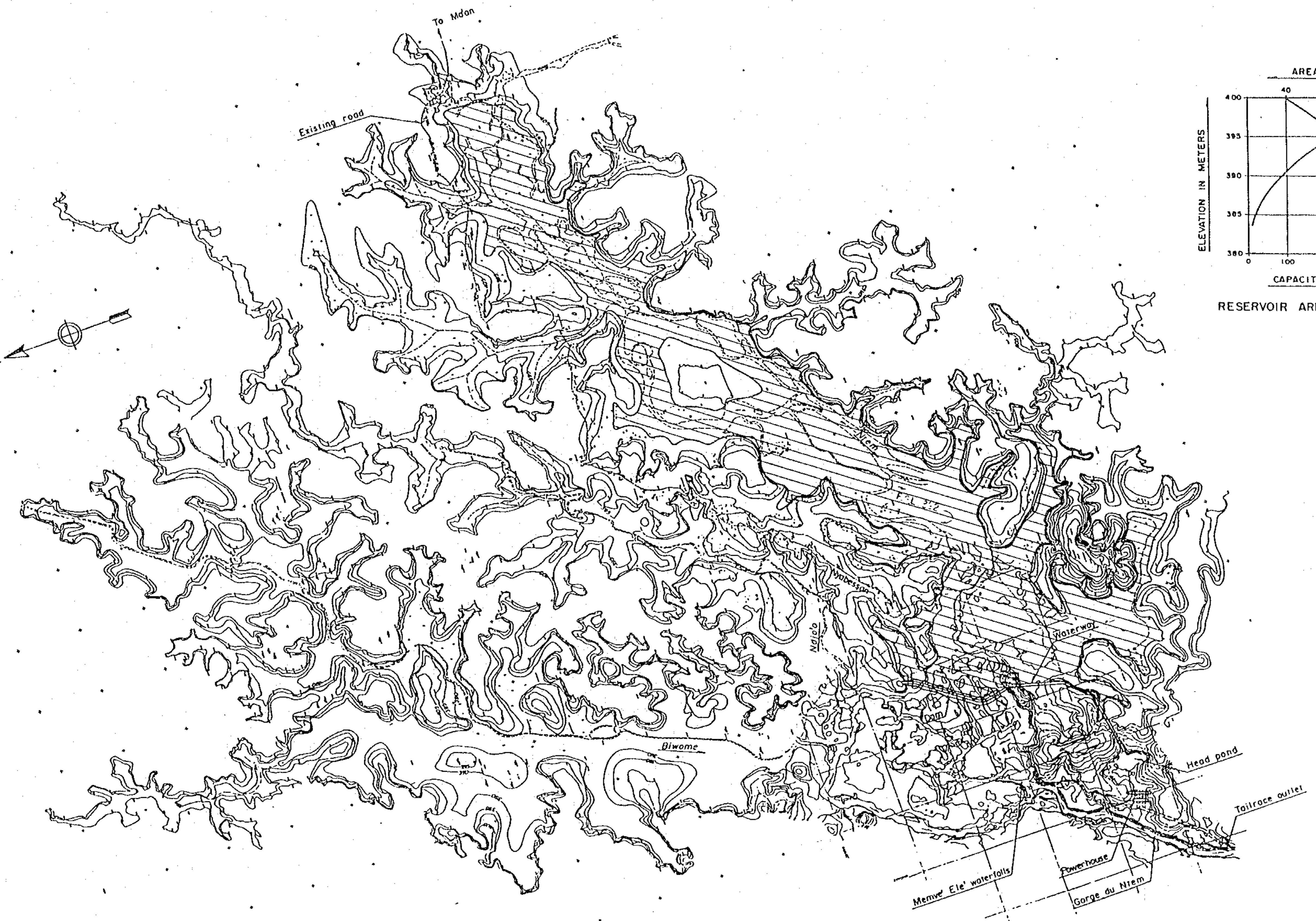
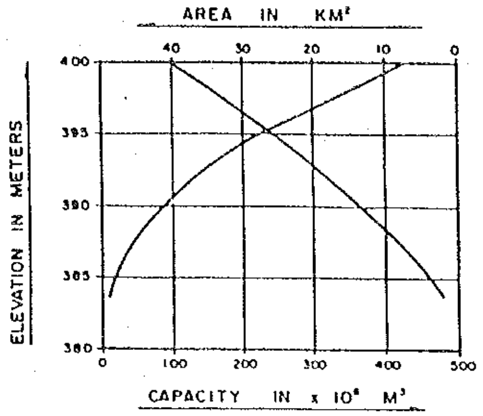

Legend:
Dam Axis Alternative A(1)
Dam Axis Alternative A(2)
Waterway Alternative W(1)
Waterway Alternative W(2)
Waterway Alternative W(3)
NTEM RIVER
NTEM RIVER
NTEM RIVER
NTEM RIVER
THE REPUBLIC OF CAMEROON
SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN
MEMVE ELE HYDROELECTRIC POWER
DEVELOPMENT PROJECT
ALTERNATIVES OF DAM AXES
AND WATERWAYS
DWG. NO.
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.1





RESERVOIR AREA / CAPACITY CURVE

SCALE 0 1 2 km

Fig. 6.2

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

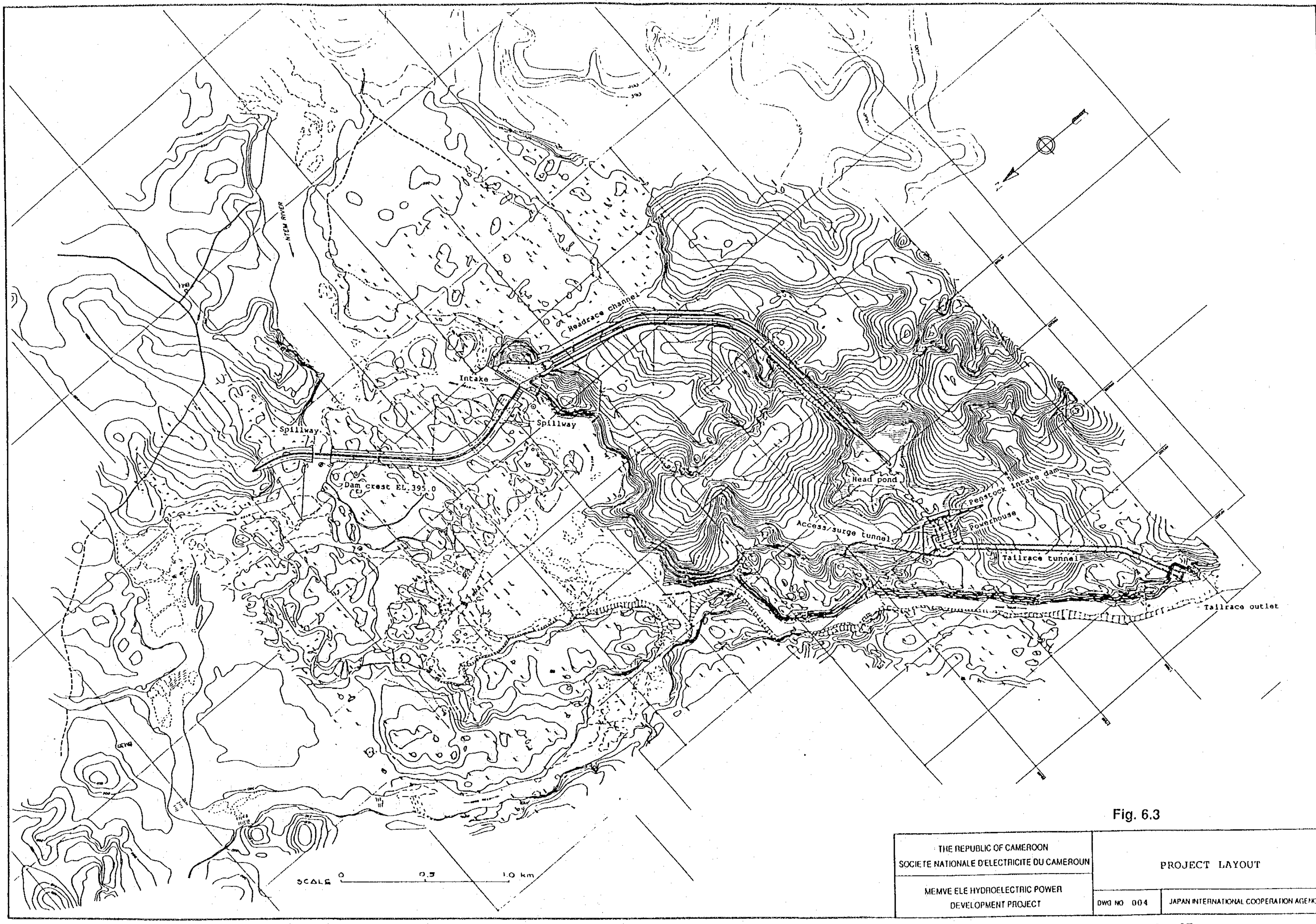
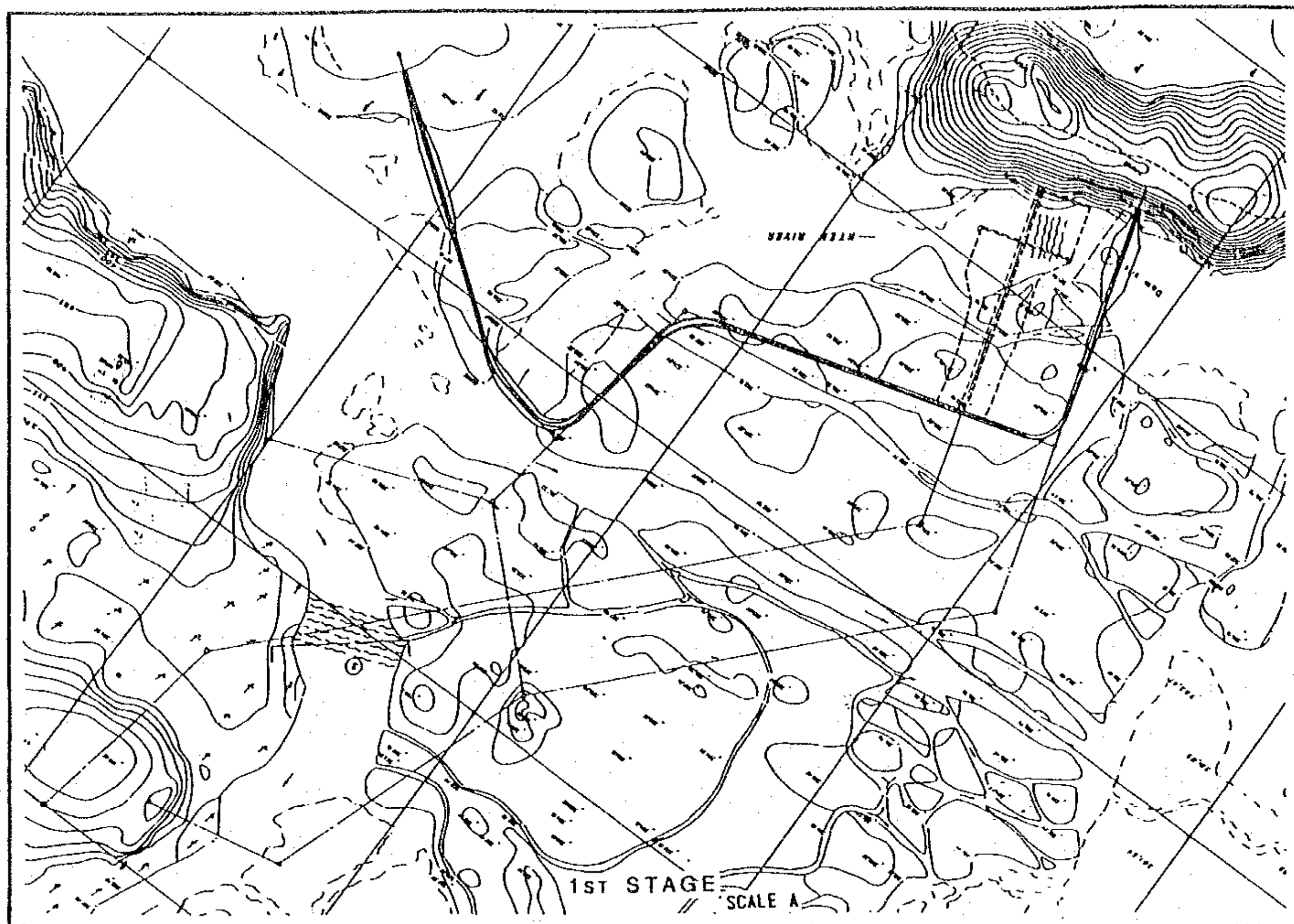
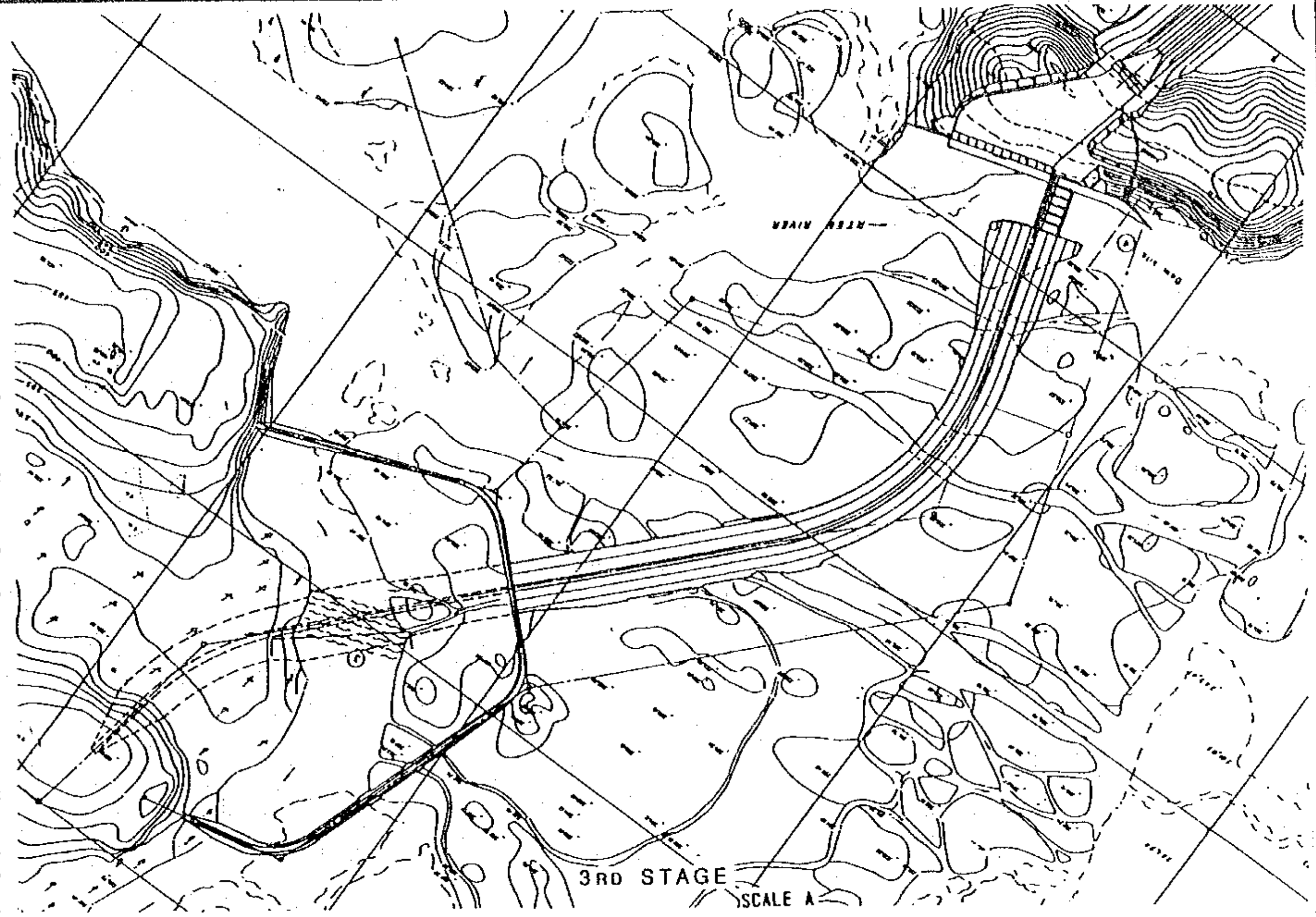
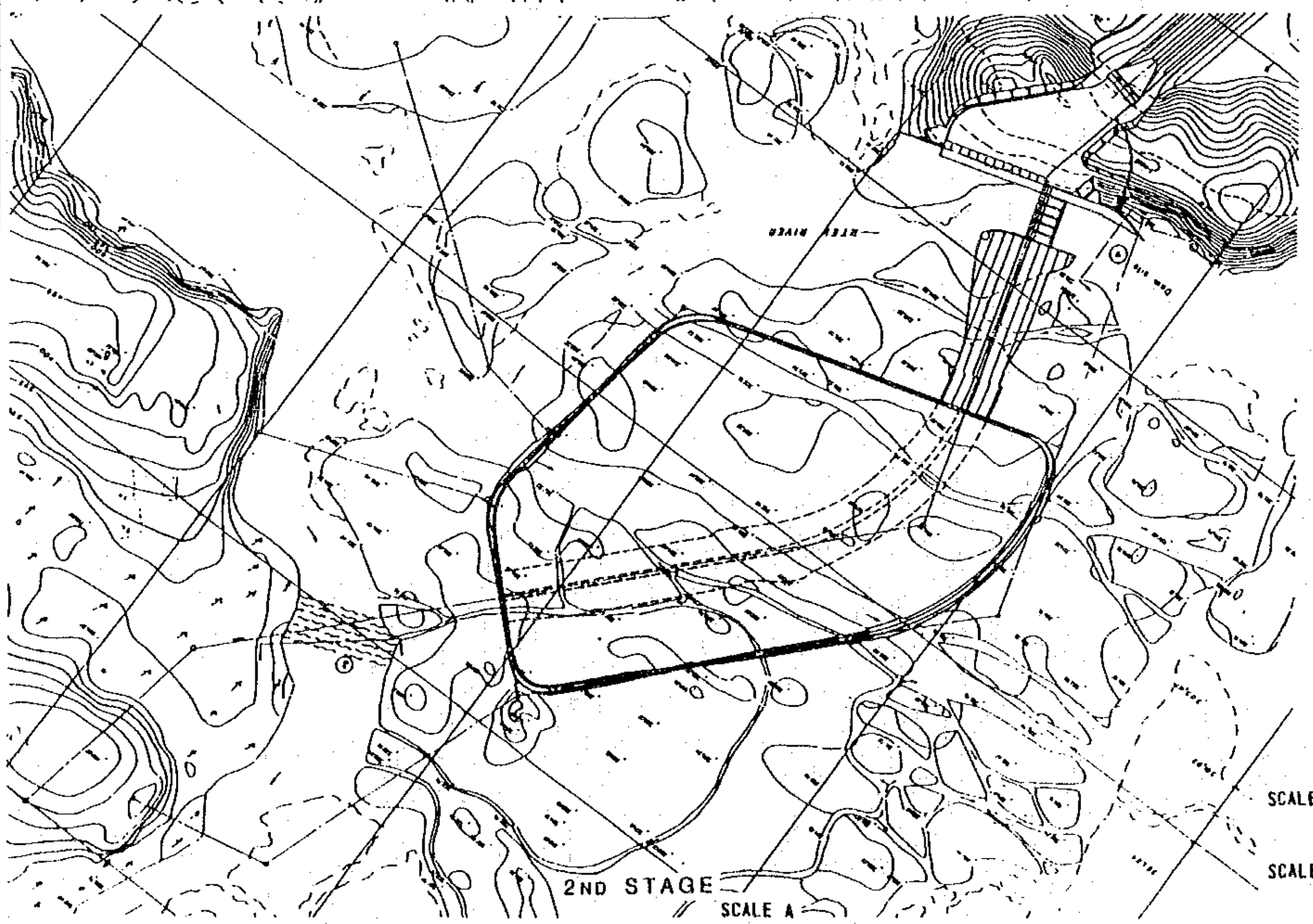


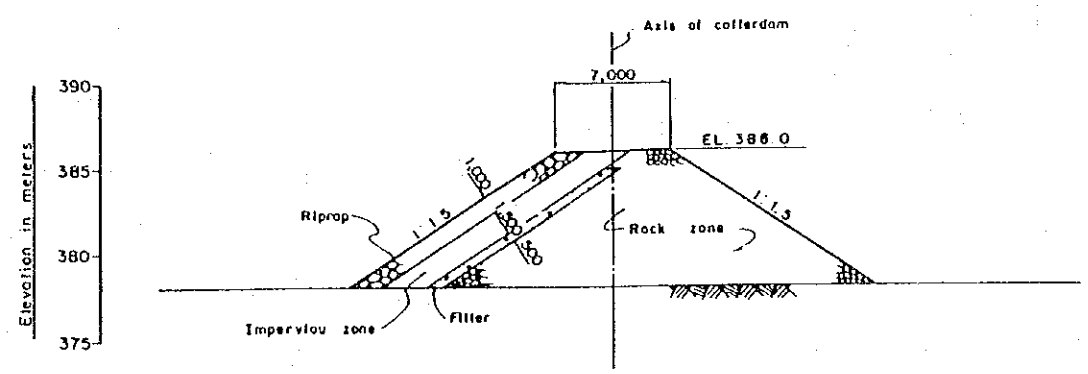
Fig. 6.3

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







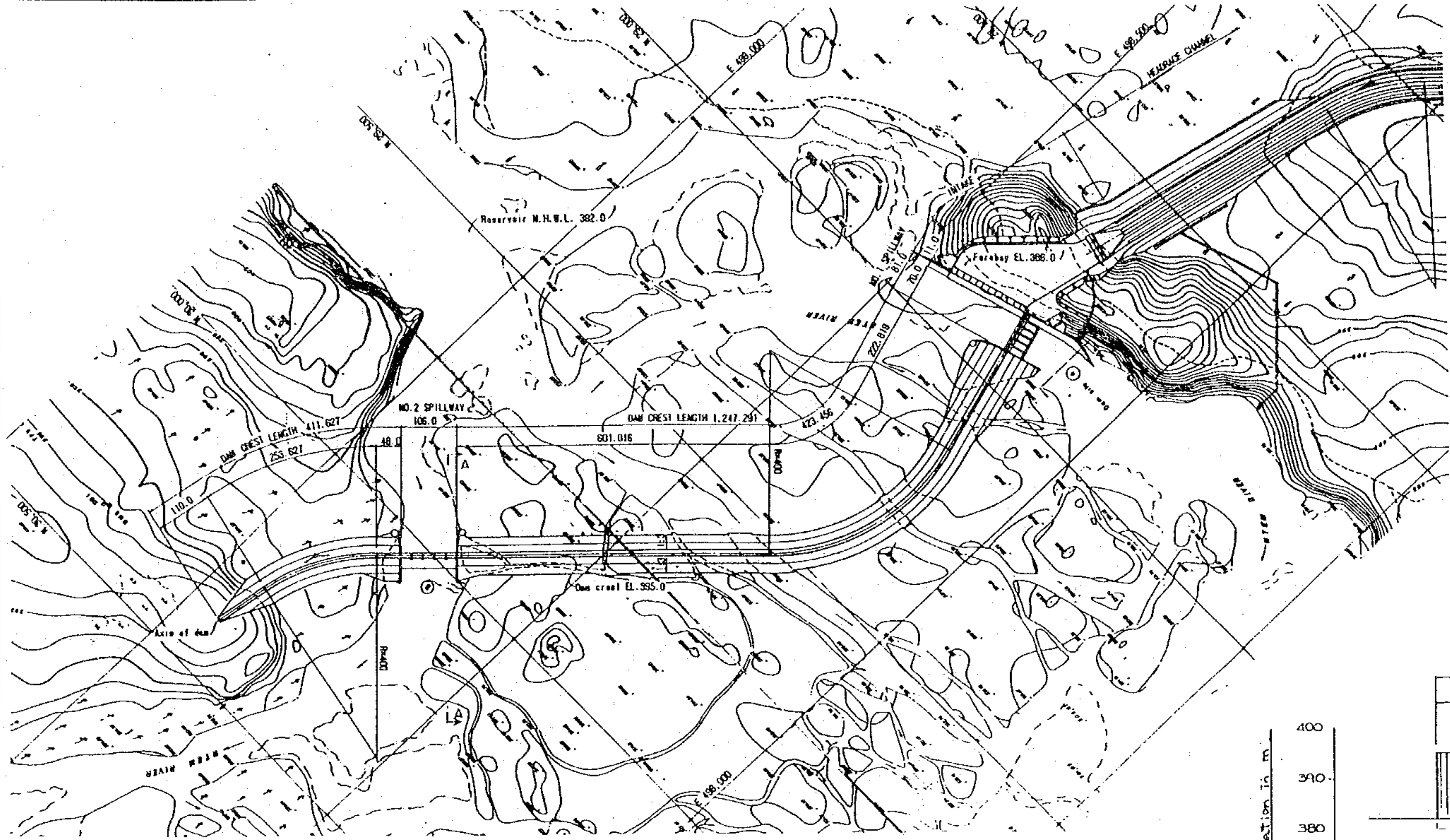


TYPICAL CROSS SECTION OF COFFERDAM
SCALE B

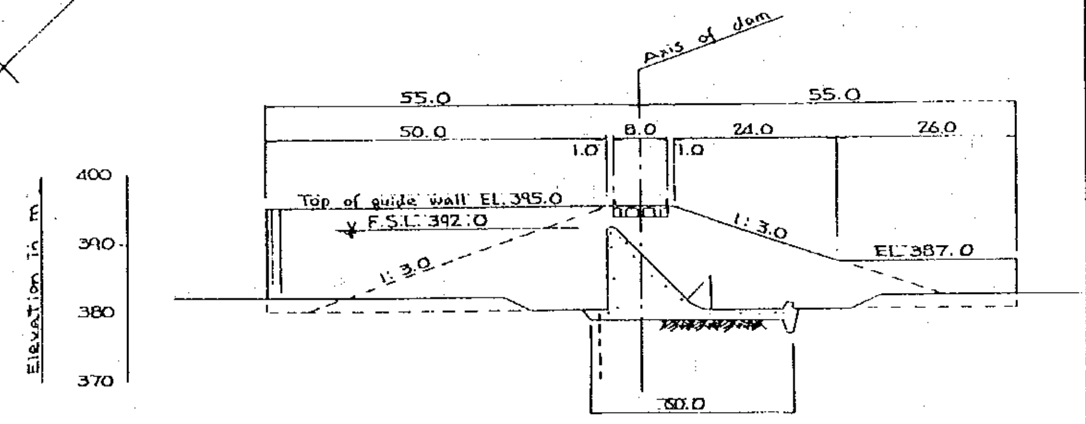
SCALE A 0 ——— 500m

SCALE B 0 ——— 20m

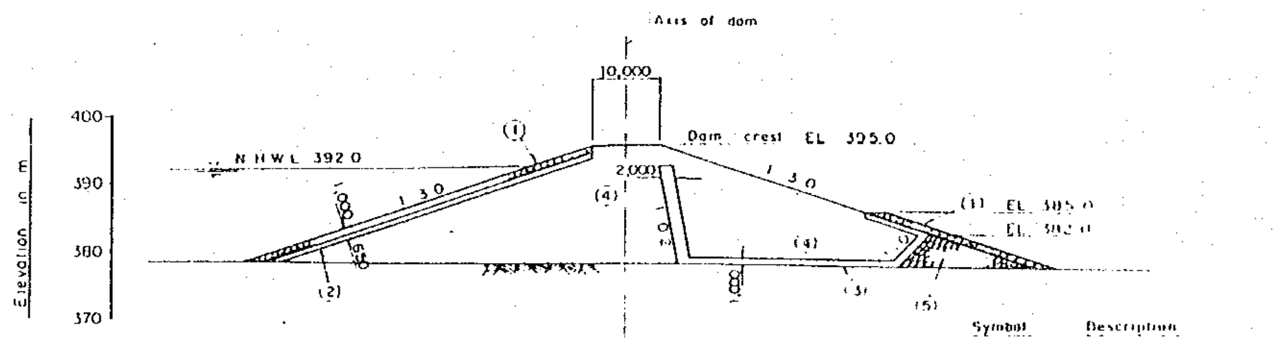
THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	**Fig. 6.4** DAM, RIVER DIVERSION PLAN
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 009 — JAPAN INTERNATIONAL COOPERATION AGENCY



P L A N SCALE A



SECTION A - A SCALE B



TYPICAL CROSS SECTION

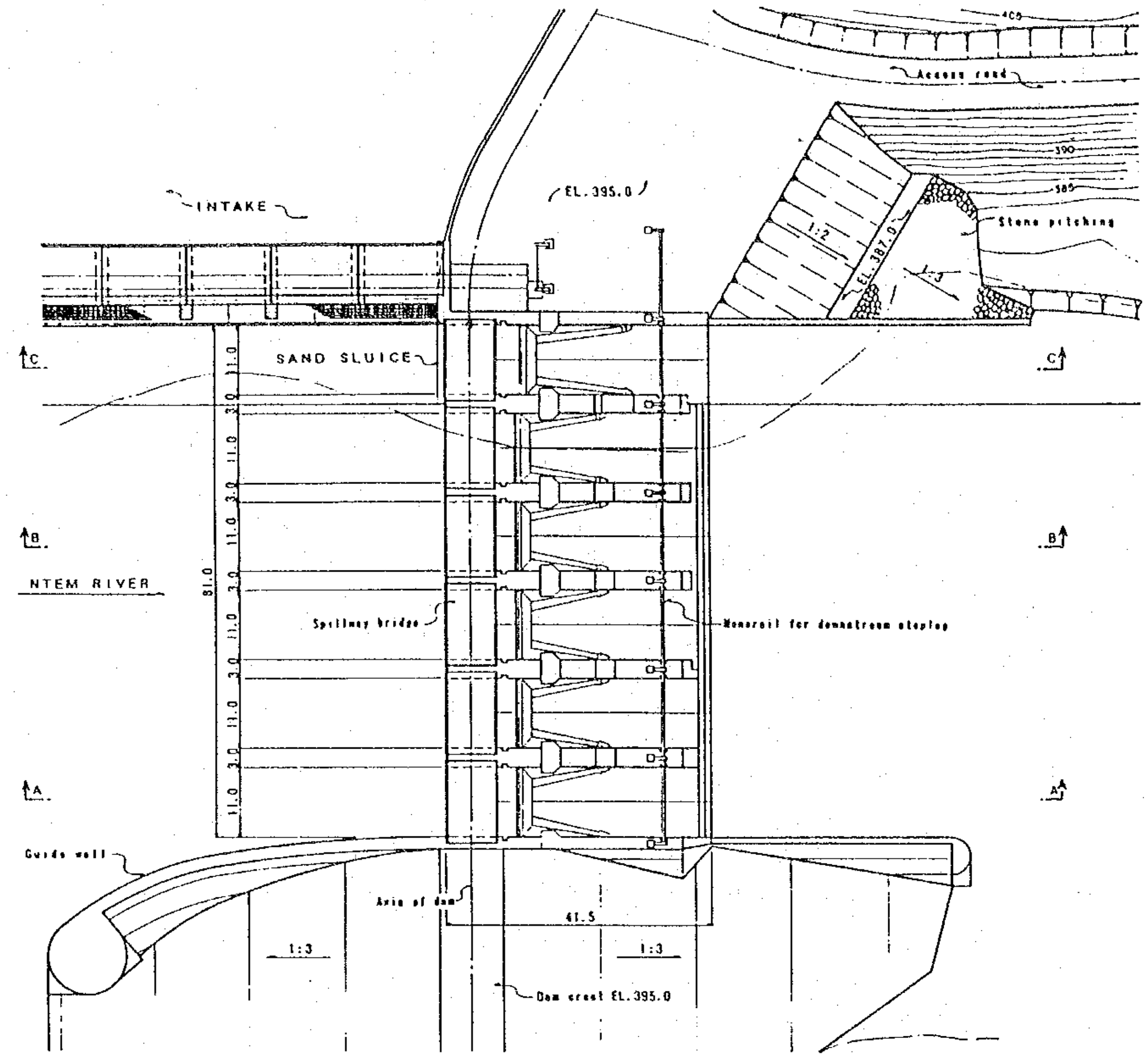
Symbol	Description
(1)	Riprap
(2)	Transition
(3)	Filter
(4)	Impervious material
(5)	Rockfill

SCALE A 0 500m

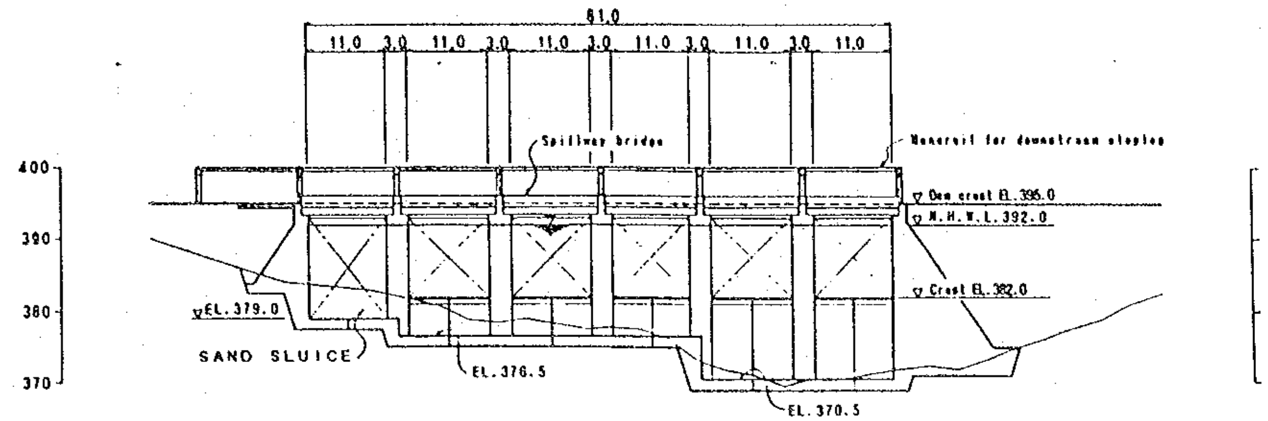
SCALE B 0 50m

SCALE B

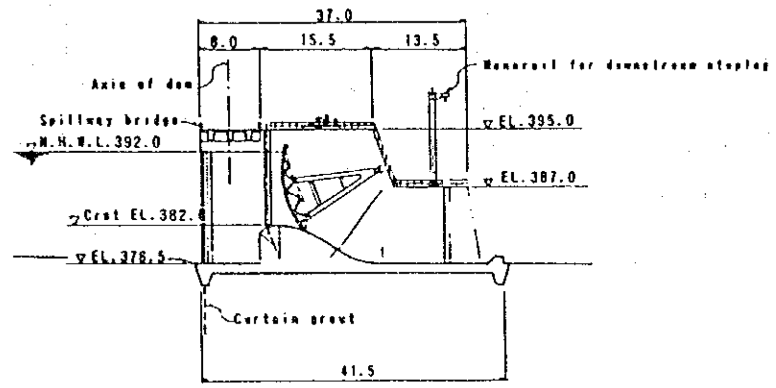
THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	**Fig. 6.5** DAM, PLAN AND TYPICAL SECTION
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 010 — JAPAN INTERNATIONAL COOPERATION AGENCY



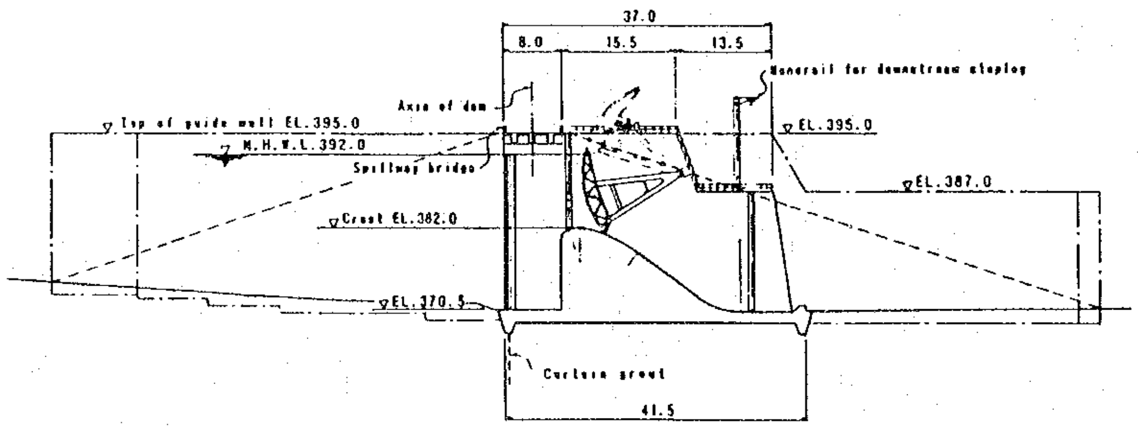
PLAN SCALE A



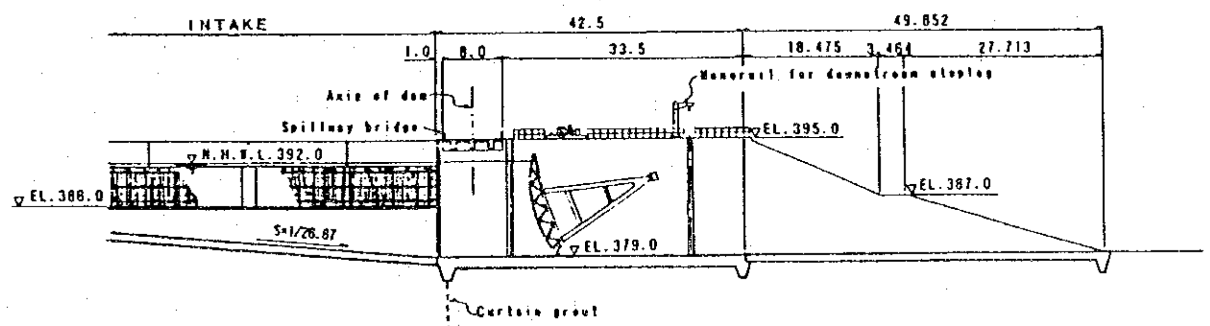
ELEVATION SCALE A



SECTION B—B SCALE A



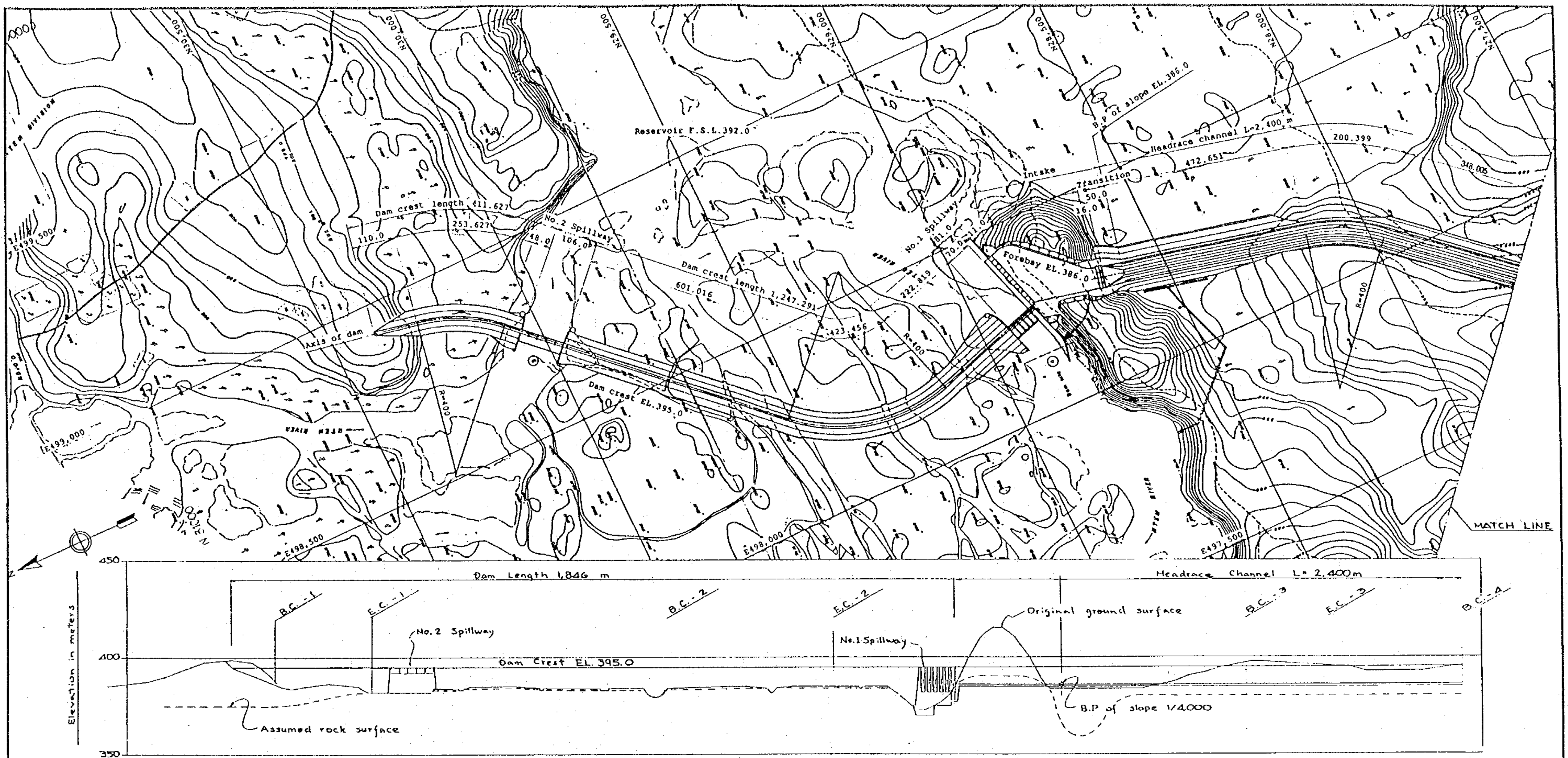
SECTION A—A SCALE A



SECTION C—C SCALE A
(SAND SLUICE)

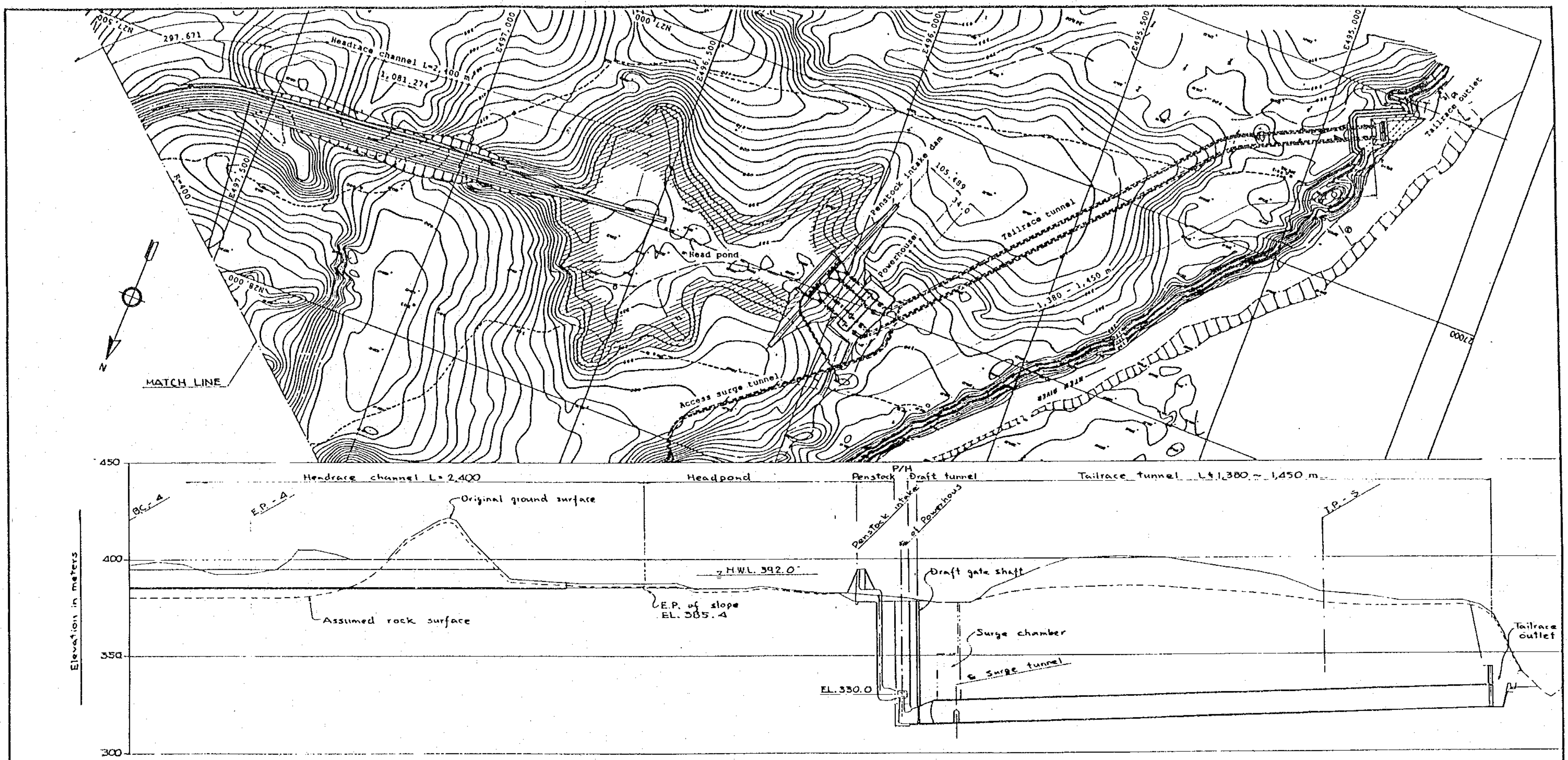
Fig. 6.6

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



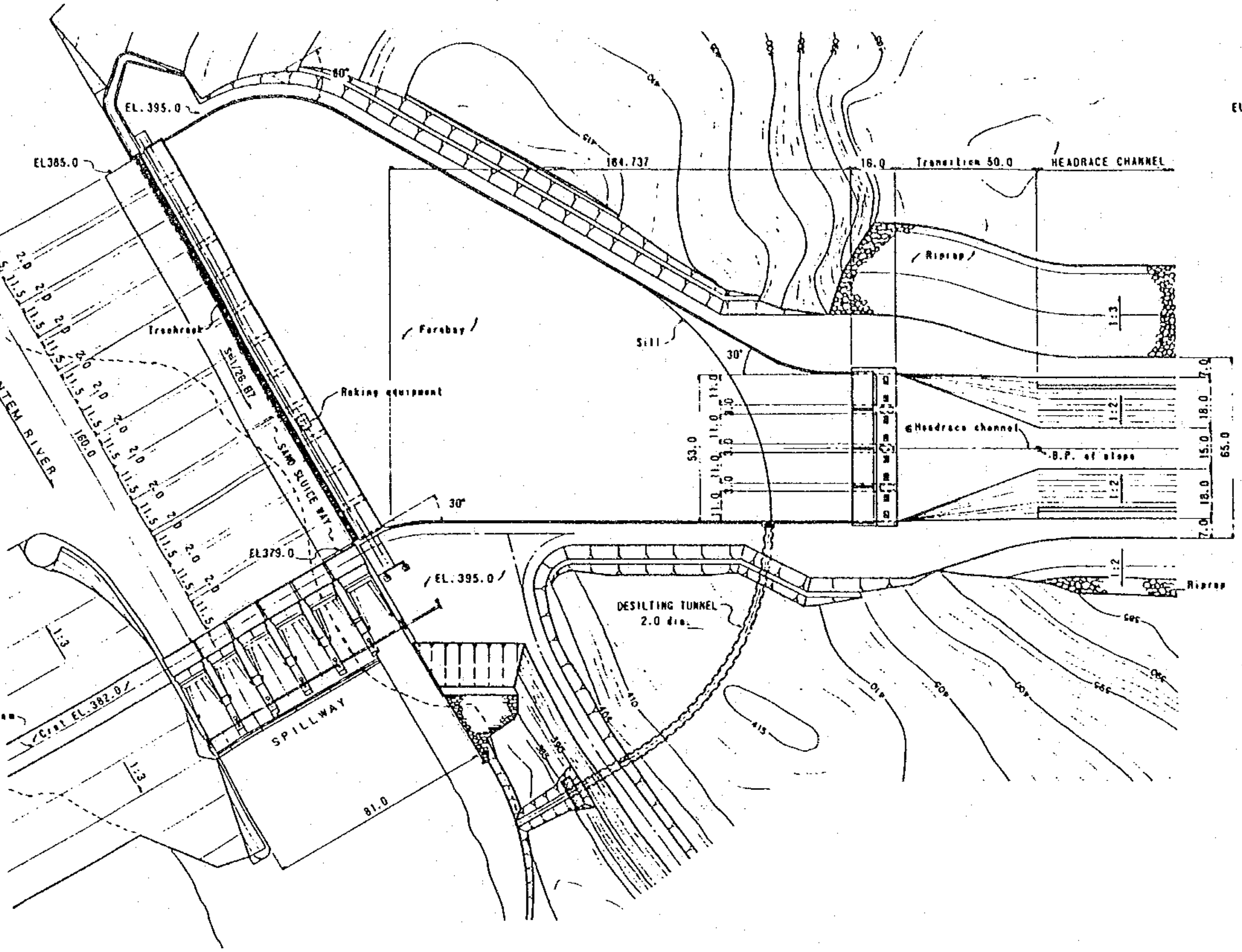
ORIGINAL GROUND HEIGHT (M)	399	398	386	382	385	384	384	385	385	385	385	396	384	395	397	395	393
FORMATION HEIGHT. (M)	395.0	395.0	395.0	395.0	395.0	395.0	395.0	395.0	395.0	395.0	395.0	386.0	386.0	386.0	385.9	385.8	385.8
ACCUMULATED DISTANCE (M)	-1,850	-1,800	-1,600	-1,400	-1,200	-1,000	-800	-600	-400	-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

THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	Fig. 6.7 WATERWAY, PLAN AND PROFILE (1)
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 012	JAPAN INTERNATIONAL COOPERATION AGENCY

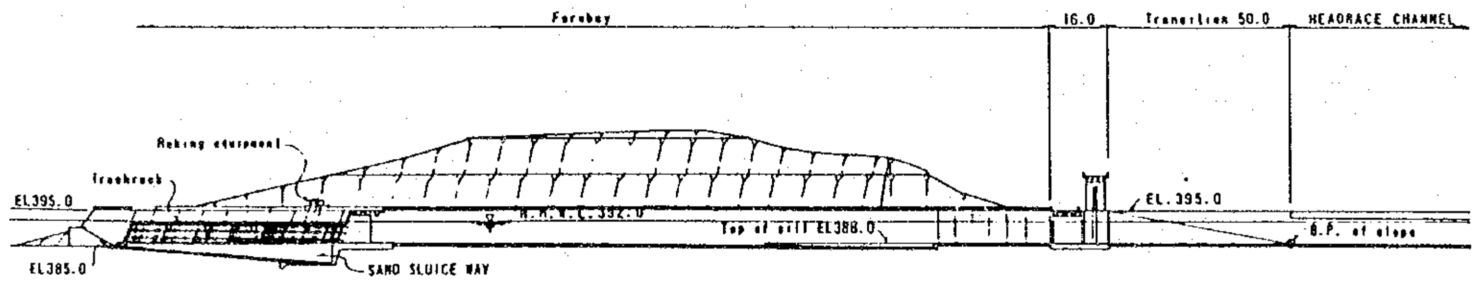


ORIGINAL GROUND HEIGHT (M)	398	397	403	412	400	388	387	385	383	381	377	395	401	398	391	381	378	351
FORMATION HEIGHT (M)	385.7	385.7	385.6	385.6	385.5	385.5	385.4											
ACCUMULATED DISTANCE (M)	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800	3,000	3,200	3,400	3,600	3,800	4,000	4,200	4,400	4,600	4,800
DISTANCE (M)	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
STATION NO. (M)	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48

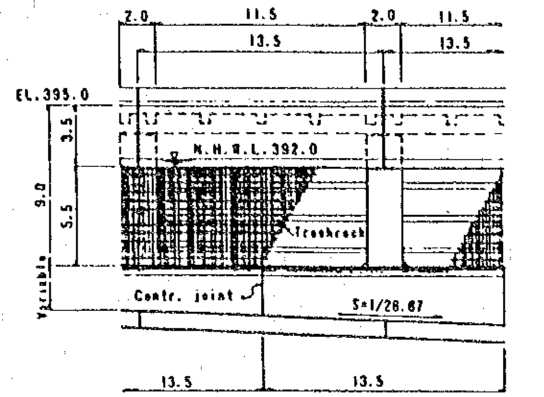
THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	**Fig. 6.8** WATERWAY, PLAN AND PROFILE (2)	
MEMVE'ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 013	JAPAN INTERNATIONAL COOPERATION AGENCY



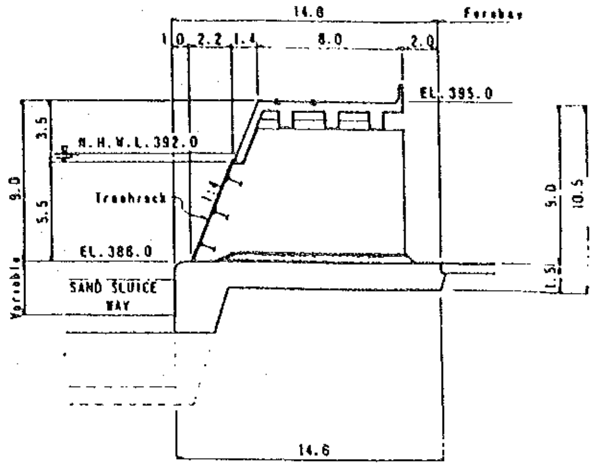
PLAN SCALE A



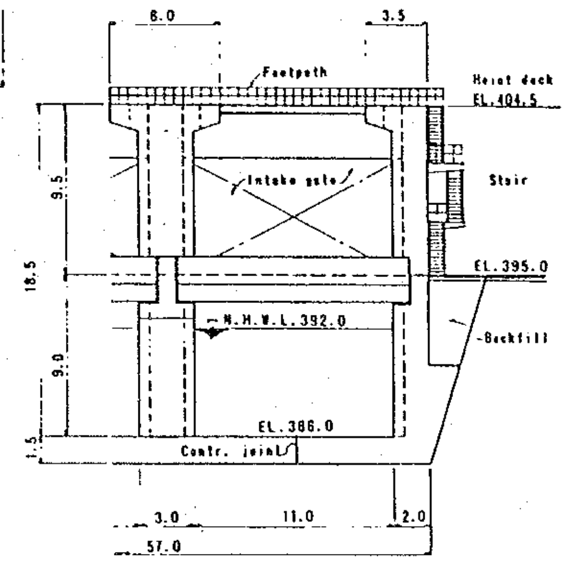
PROFILE SCALE A



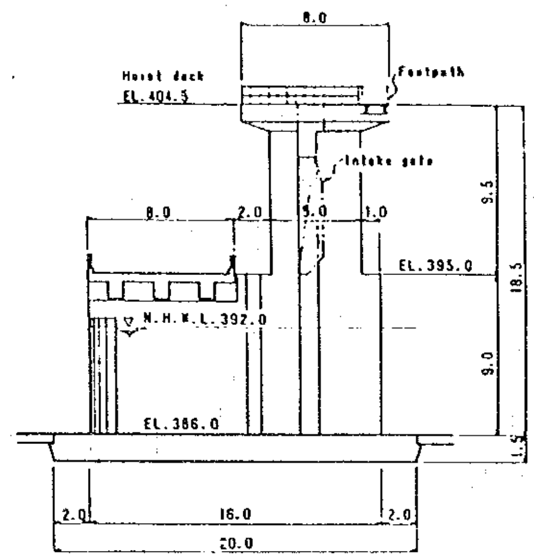
ELEVATION SCALE B



SECTION A—A SCALE B



ELEVATION SCALE B



SECTION B—B SCALE B

SCALE A 0 — 100m
SCALE B 0 — 20m

Fig. 6.9

THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	WATERWAY, INTAKE PLAN, PROFILE AND SECTIONS
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO. 014 JAPAN INTERNATIONAL COOPERATION AGENCY

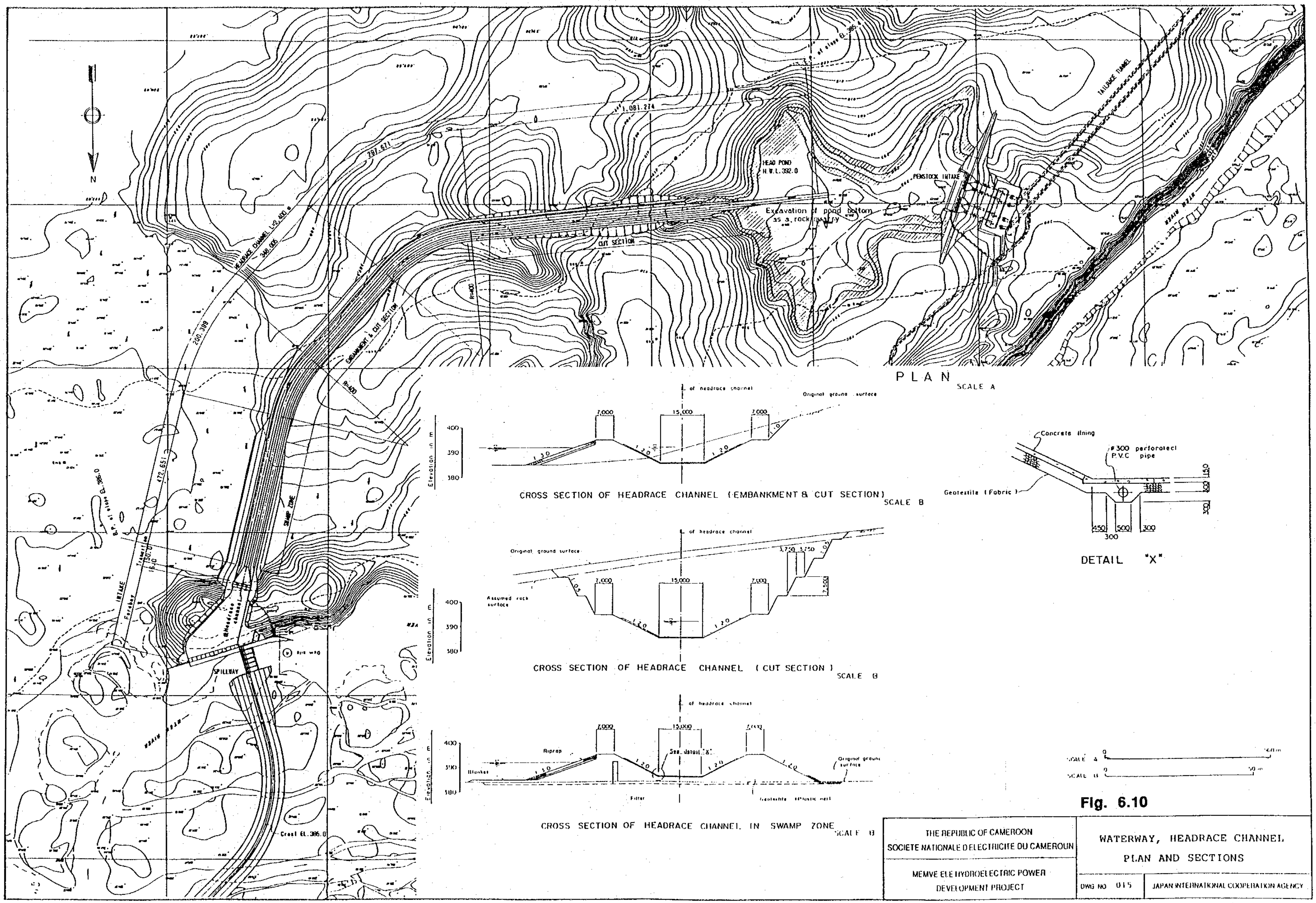

PLAN
SCALE A
HEAD POND
H.W.L.392.0
PENSTOCK INTAKE
TAILRACE TUNNEL
Excavation of pond bottom as a rock quarry
CUT SECTION
HEADRACE CHANNEL L=2,400 m
EMBANKMENT & CUT SECTION
SWAMP ZONE
INTAKE
SPILLWAY
Crest EL.385.0
R=400
N
CROSS SECTION OF HEADRACE CHANNEL (EMBANKMENT & CUT SECTION)
SCALE B
CROSS SECTION OF HEADRACE CHANNEL (CUT SECTION)
SCALE B
CROSS SECTION OF HEADRACE CHANNEL IN SWAMP ZONE
SCALE B
Original ground surface
Assumed rock surface
Riprap
Blanket
Filter
Elevation in m
Concrete lining
Φ300 perforated P.V.C pipe
Geotextile (Fabric)
DETAIL "X"
SCALE A
SCALE B
THE REPUBLIC OF CAMEROON
SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT
WATERWAY, HEADRACE CHANNEL
PLAN AND SECTIONS
DWG NO 015
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.10

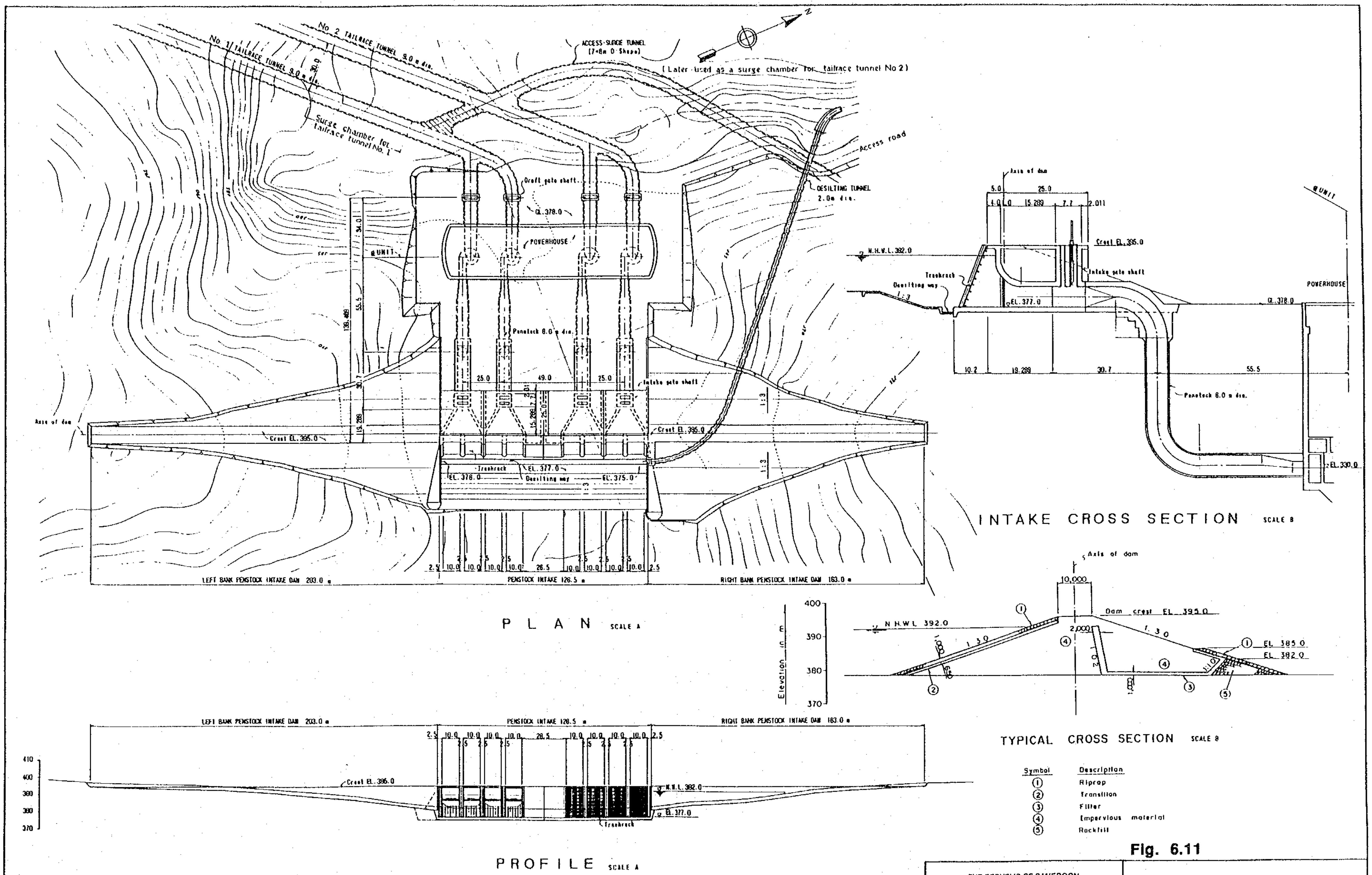
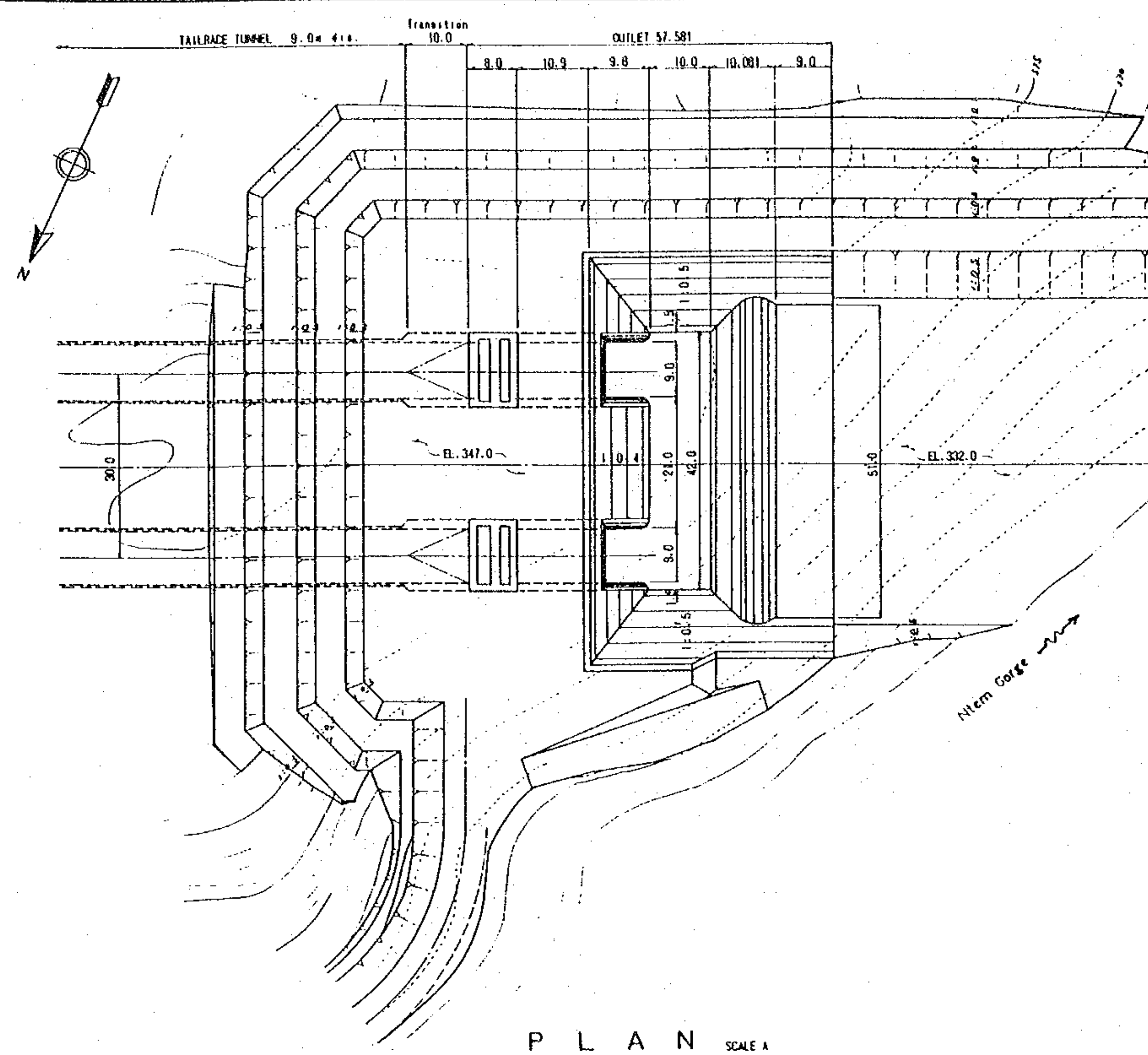
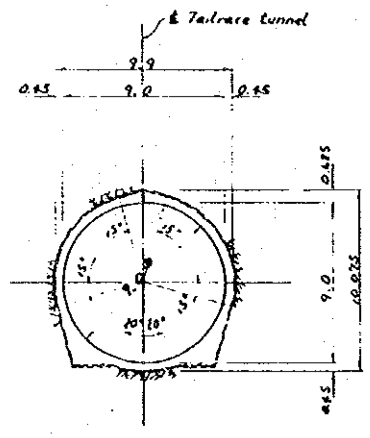


Fig. 6.11

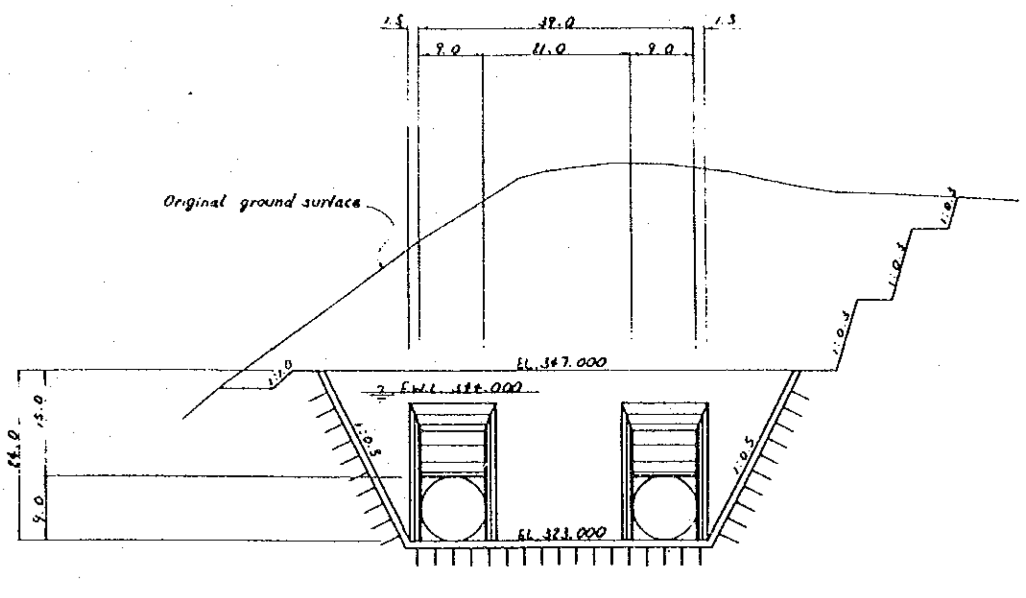
THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	WATERWAY, PENSTOCK INTAKE DAM PLAN AND SECTIONS
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 016 — JAPAN INTERNATIONAL COOPERATION AGENCY



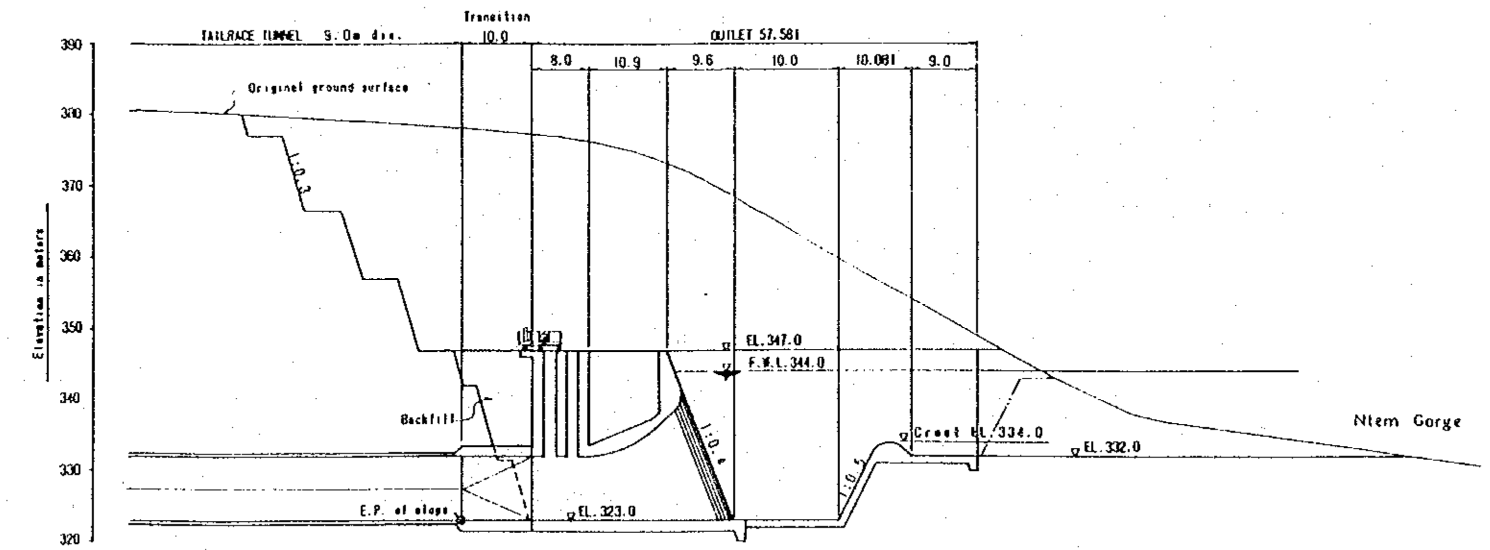
P L A N SCALE A



TAILRACE TUNNEL
TYPICAL SECTION SCALE B



ELEVATION SCALE A

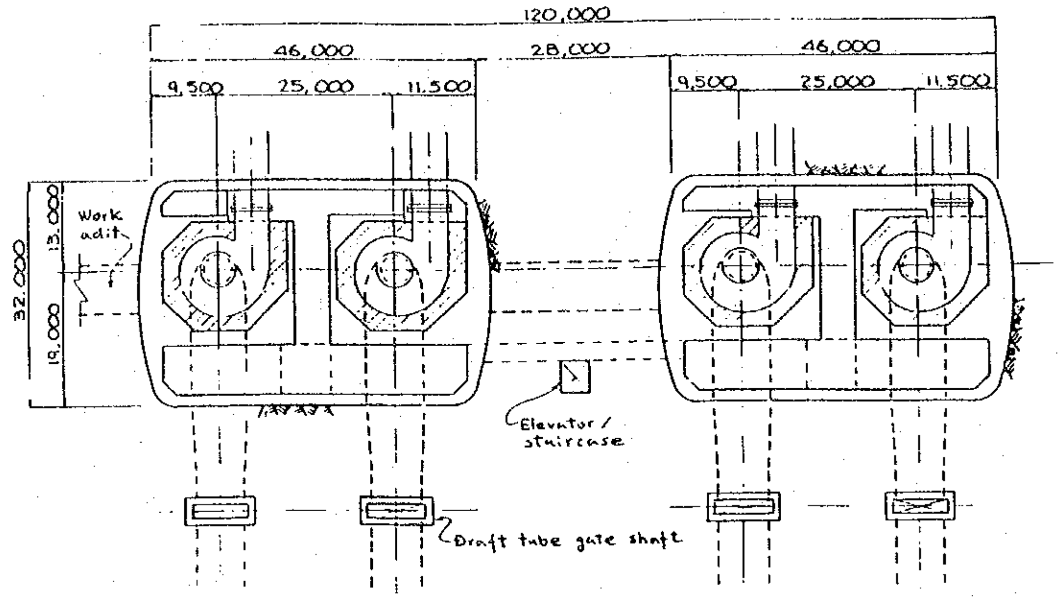


SCALE A 0 10m
SCALE B 0 10m

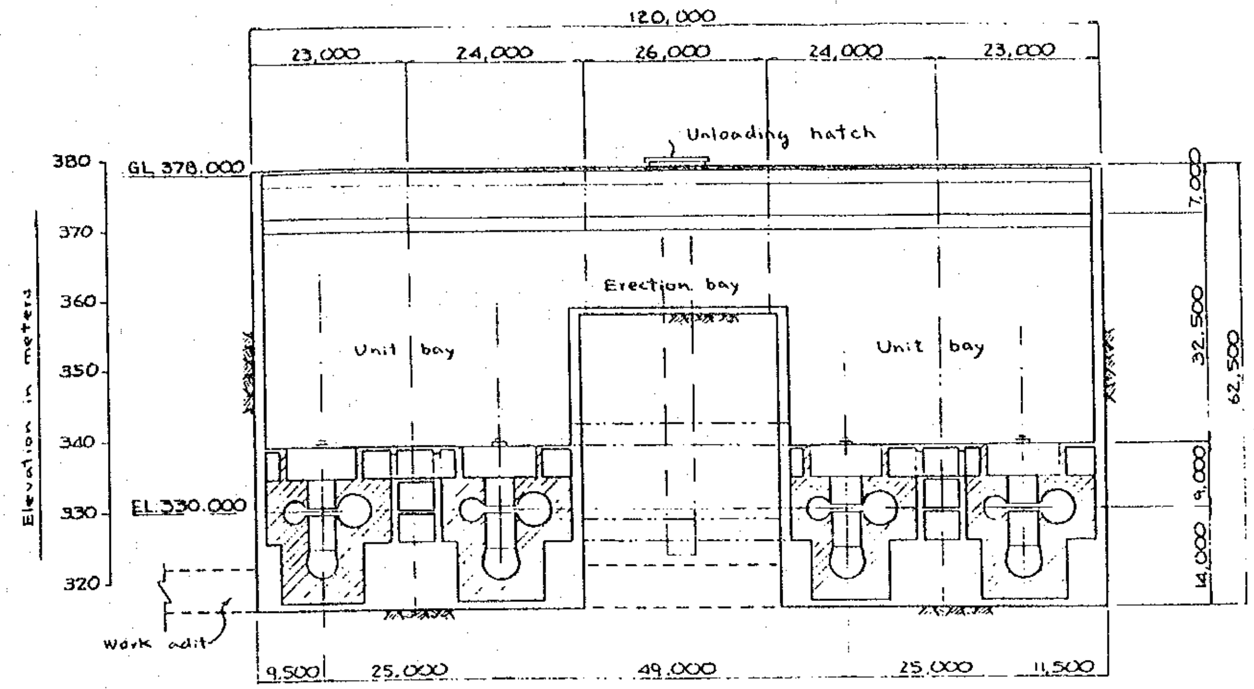
PROFILE SCALE A

Fig. 6.12

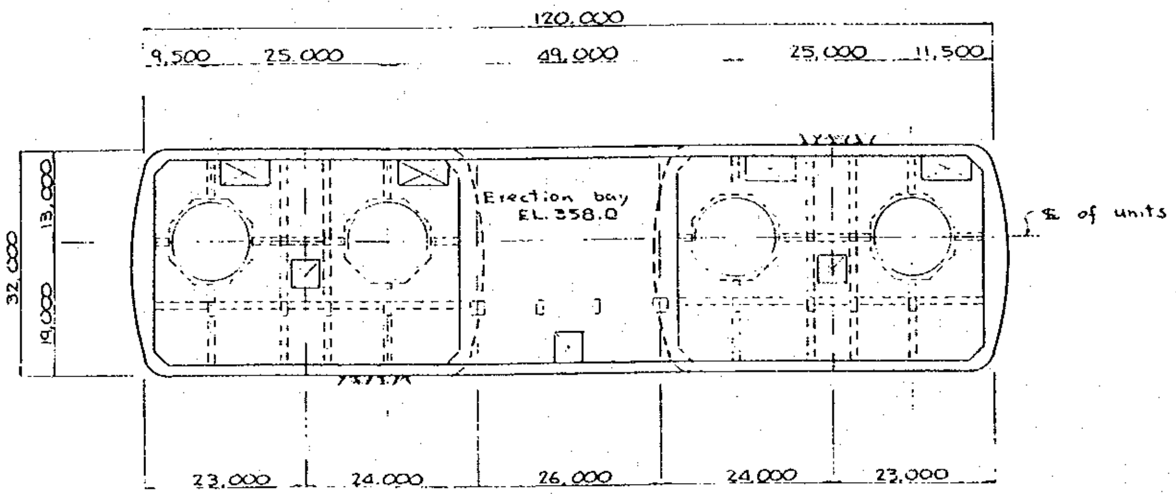
THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	WATERWAY, TAILRACE OUTLET PLAN AND SECTIONS
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 017 — JAPAN INTERNATIONAL COOPERATION AGENCY



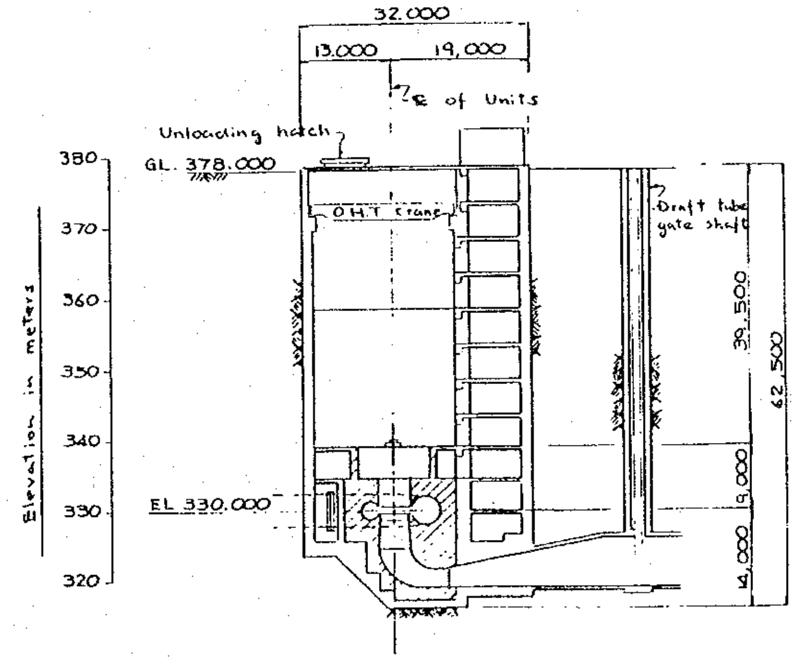
PLAN AT EL. 330.0



LONGITUDINAL SECTION



FLOOR PLAN AT EL. 358.0

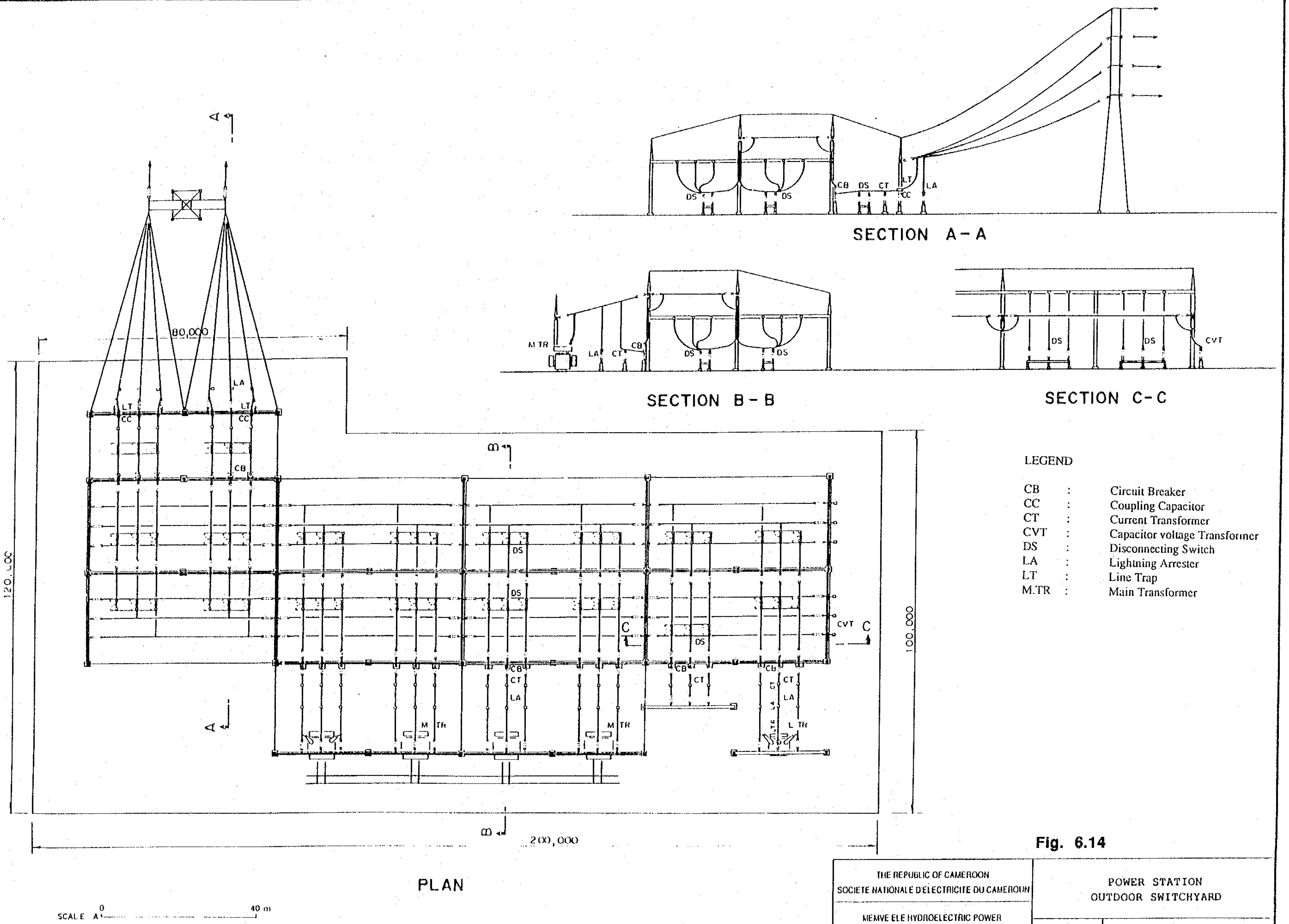


TRANSVERSE SECTION

SCALE 0 50 m

Fig. 6.13

THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	POWER STATION, POWERHOUSE PLAN, PROFILE AND SECTIONS
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 018 — JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

CB	:	Circuit Breaker
CC	:	Coupling Capacitor
CT	:	Current Transformer
CVT	:	Capacitor voltage Transformer
DS	:	Disconnecting Switch
LA	:	Lightning Arrester
LT	:	Line Trap
M.TR	:	Main Transformer

Fig. 6.14

THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	POWER STATION OUTDOOR SWITCHYARD
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 019 — JAPAN INTERNATIONAL COOPERATION AGENCY

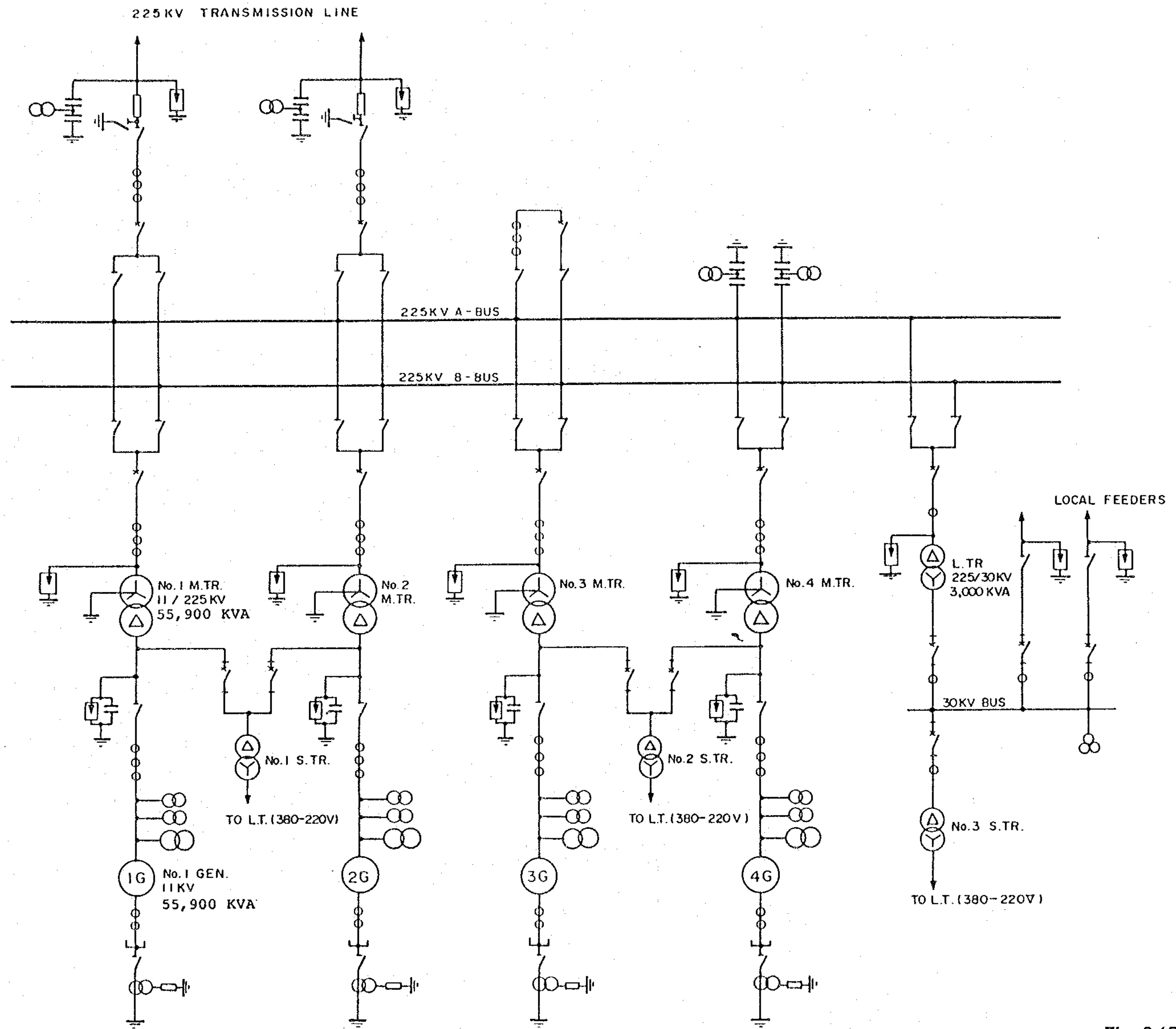
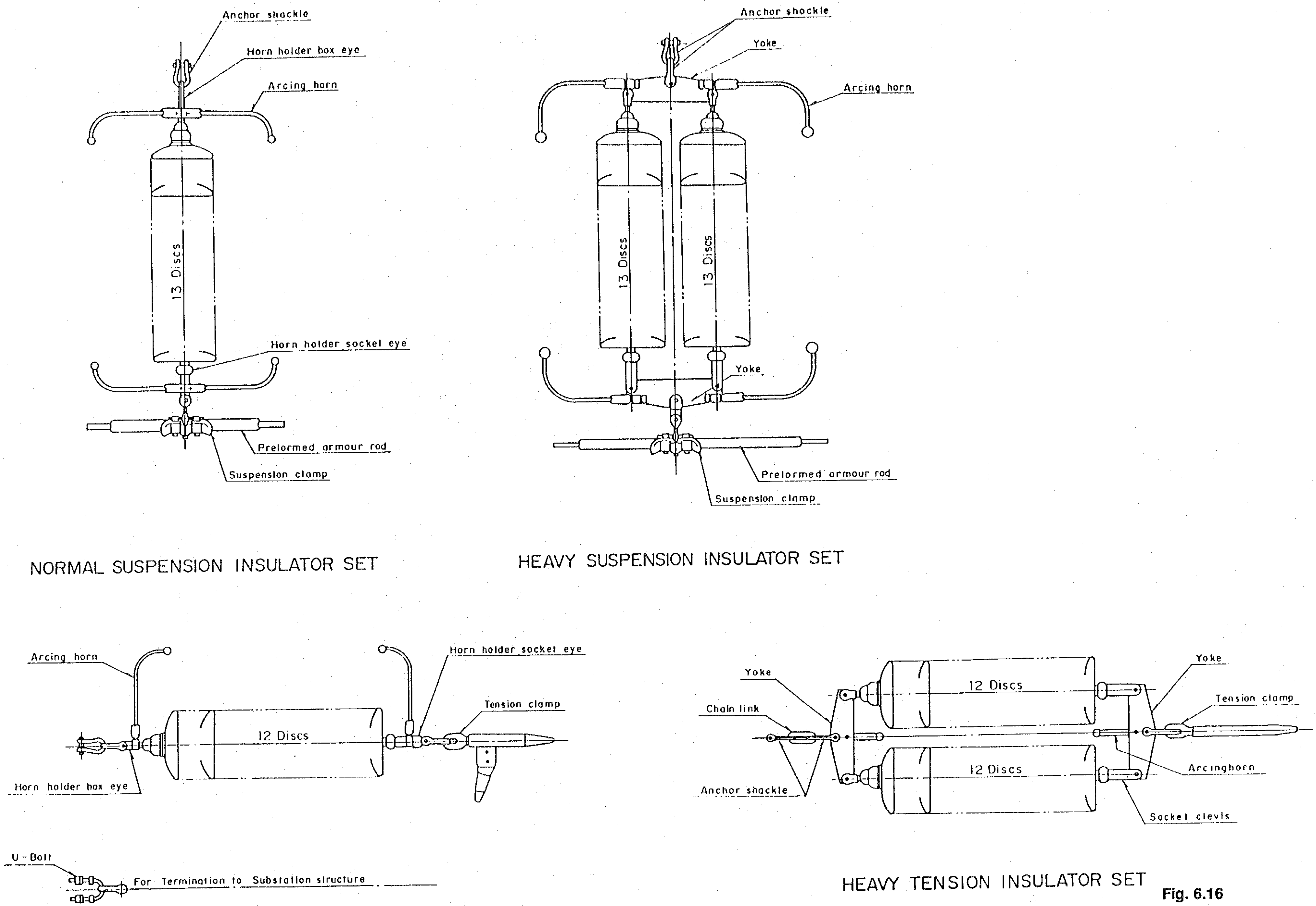


Fig. 6.15

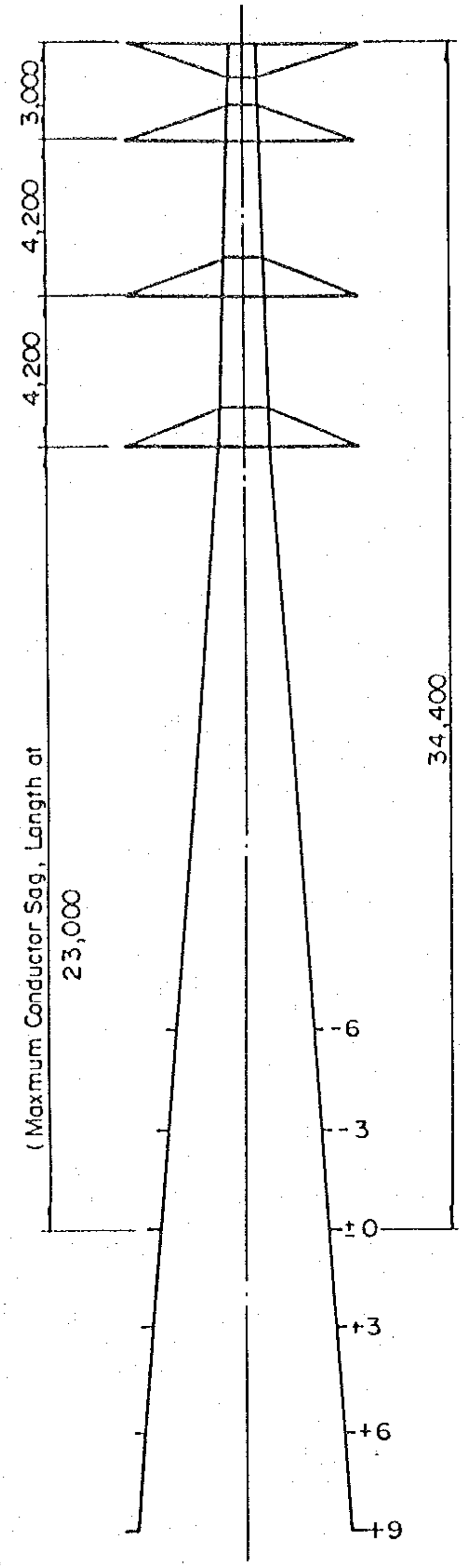
THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	SINGLE LINE DIAGRAM	
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO. 020	JAPAN INTERNATIONAL COOPERATION AGENCY



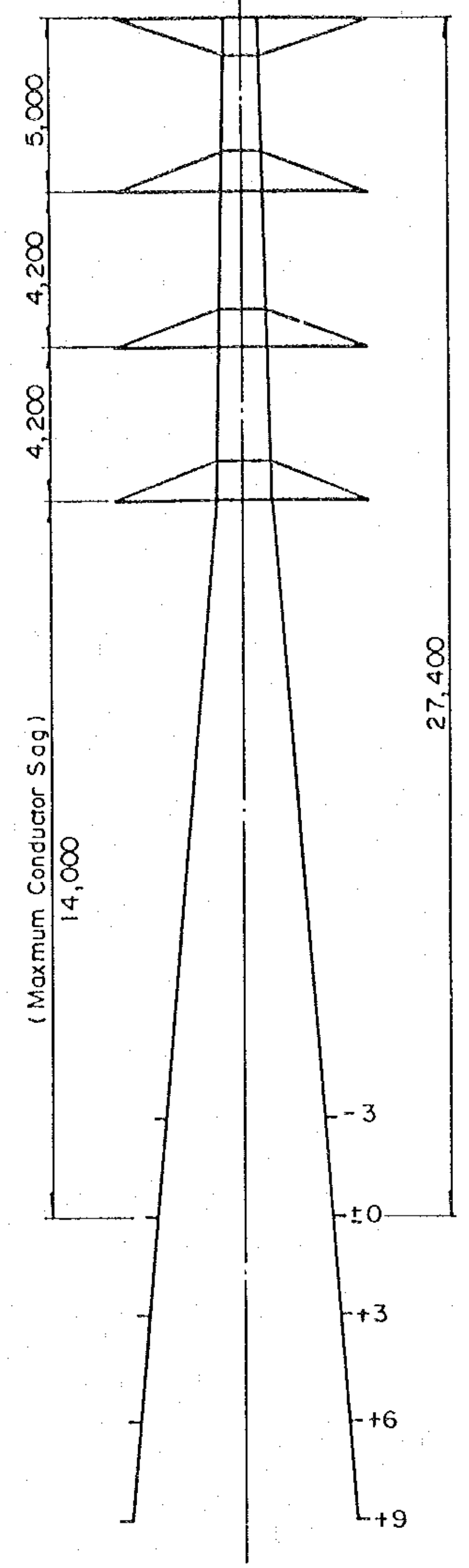
NORMAL TENSION INSULATOR SET

Fig. 6.16

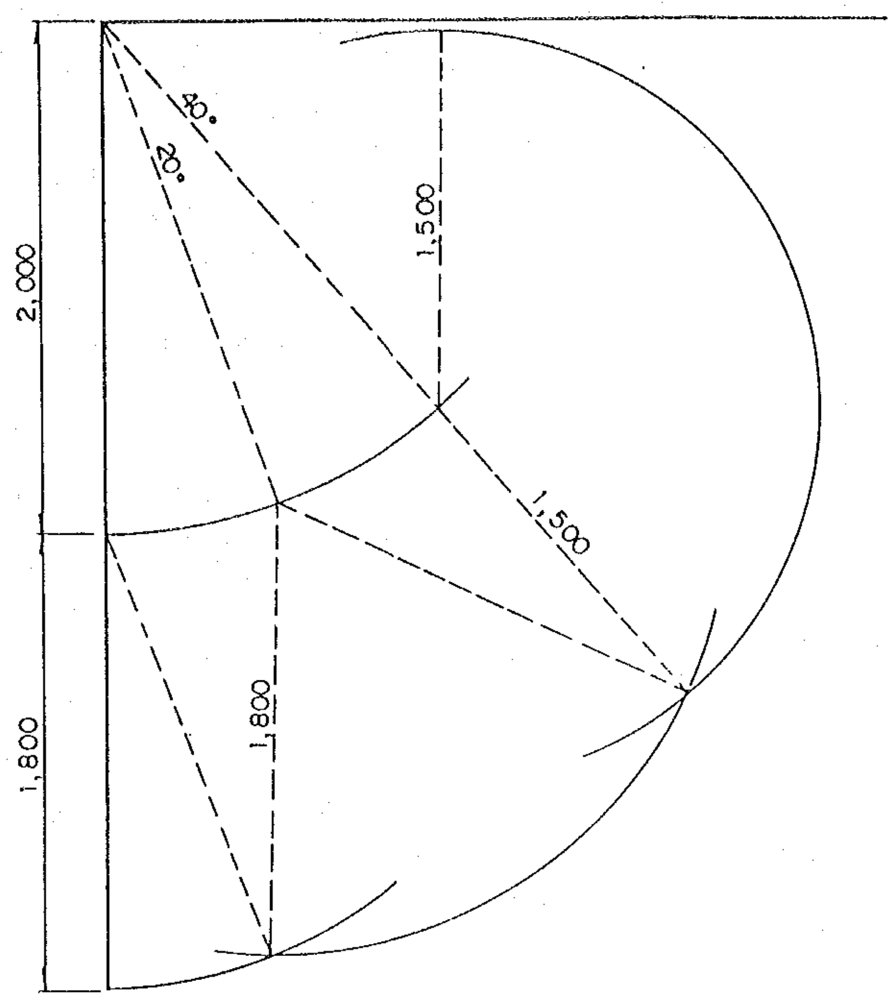
THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	TRANSMISSION LINE OUTLINE OF INSULATOR SETS
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 022	JAPAN INTERNATIONAL COOPERATION AGENCY



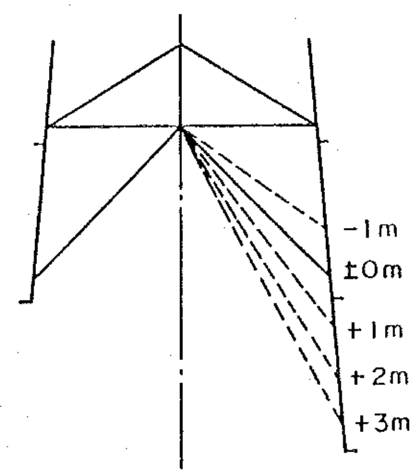
TYPE S TOWER



TYPE L,M,H & T TOWERS



CLEARANCE DIAGRAM



LOWEST PANEL OF TOWER AND
HILL SIDE EXTENSION

Fig. 6.17

THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	TRANSMISSION LINE SPATIAL DIAGRAM OF TOWER
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 021 — JAPAN INTERNATIONAL COOPERATION AGENCY

VII. Construction Plan and Cost Estimate

7.1 Construction Plan and Schedule

7.1.1 Introduction

A construction plan of the Project is prepared on the basis of the preliminary design discussed in the preceding Chapter 6, giving an outline of possible procedures, construction sequences, methods and types of plant and equipment to implement the construction works. The construction works will be divided into four packages shown below and will be executed by the contractor selected by international competitive biddings (ICB) for respective packages including prequalification. There is a possibility that the civil works can be further divided into two in the contract. As for the engineering services, a consultant will be required for the execution of the Project on the detailed design stage and the construction supervision stage, respectively.

(a) Civil works including preparatory works

Civil works include the construction of cofferdams, main dam, spillway, waterway, power station, architectural buildings, and access road as well as preparatory works.

(b) Metal works

Metal works are composed of the installation of spillway gates, sand flush gate, intake trashracks, intake gates, scour valve, penstock intake trashracks, penstock intake gates, steel penstock, draft tube gate and tailrace outlet gate.

(c) Generating equipment

The works for generating equipment are for the installation of turbines, generators, transformers, switchgear and control equipment, ancillary equipment, transmission line protective relays and PLC communication.

(d) Transmission lines and substation equipment

The work includes that the construction of a 225 kV transmission line aligned for the route to Yaoundé via Ebolowa, and substation equipment to be extended at Oyomaban substation in Yaoundé.

7.1.2 Construction Plan

(1) Basic conditions

The construction method and sequence are planned on the basis of the mode of construction and the target schedule of construction. Availability of construction materials, labors, weather condition, geological and topographic conditions at the site and the mechanized construction method are as well taken into consideration besides the matters mentioned above.

The commencement of the construction works is scheduled in October, 2004 after the contract award. The project is planned to be completed by the end of September, 2009 using information and data available at this moment, giving a time period of 5.0 years (60 months).

With regard to the workable days, 280 days are assumed in a year for concrete and rock excavation works, 230 days for earthworks and 185 days for embankment works. While, workable days for minor concrete, grouting and tunnel works are planned to be 290 days per year.

(2) Preparatory works and construction facilities

(a) Access road

Improvement of the existing road connecting Nyabessan with Ebolowa will be required before commencement of the construction. The improvement works will consist of grading and widening of the road and replacement of bridges. Since there are no available roads to the main dam site and the power station site from Nyabessan village, the permanent access roads are planned to be connected from the existing road at Nyabessan. A total length of the access roads to be constructed is about 4.0 km. Construction/hauling roads required for the construction services will be branched off the permanent access road.

(b) Ferry facility

There is no available bridges crossing the Ntem river. The traffic mean to communicate between Nyabessan village and villages at the opposite bank is made by only a canoe. Ferry facilities for transportation of construction equipment and materials, and labors are required to be provided before the commencement of construction.

The main ferry facility (to be provided at Nyabessan) will be of a 30-ton class pontoon having a shallow draught depth. Although some underwater excavation of riverbed is to be made to secure the draught depth, the pontoon may possibly not able to be in service in the driest seasons. The main ferry facility will be supplemented by the following two facilities in the dry seasons:

a) A small flat-bottom ferry mainly for transportation of personnel and small cargoes

b) A temporal causeway facility crossing at a shallow river section upstream of Nyabessan

In principle, heavy cargoes shall be arranged to transport to the left bank in high water stage periods.

(c) Temporary buildings

The temporary buildings required for the construction works are planned to be provided mainly at the left bank of the Ntem river. The temporary buildings consist of a contractor's office, quarters, a repair shop, a workshop, a warehouse, labor quarters and so forth, requiring about 15,000 m2 in a total floor area.

(d) Water supply

Water required for the construction and the base camp is planned to be taken from the Ntem river and other nearby tributaries. Water supply facilities will be required separately at the main dam site and the power station site, requirements of which are to be 5.0 m3/min and 4.5 m3/min, respectively.

(e) Power supply

Electric power for the construction is at this moment planned to be supplied with a diesel generator of 1,600 kW for the main dam site and 3,300 kW for the powerhouse site to carry out civil works, metal works and generating equipment installation works, taking into account high power demands without break for construction. Also, electric power to the base camp is planned to be supplied from the diesel generator.

(f) Telecommunication

Wired telephone facilities will be provided for the construction use, and an automatic telephone exchange of 50 circuits will be installed at the contractor's office. A wireless radio communication system will also be installed for communication with SONEL Douala and Ebolowa.

(3) River diversion and cofferdam

River diversion for the construction of main dam, spillway and intake is planned to be carried out by multi-stage river diversion by cofferdams consisting of three stages. Construction works the cofferdams are on the critical path of the construction schedule. The first stage cofferdam will be provided near the left abutment for construction of the main dam, spillway and intake. The second stage be on the islands for the middle part of main dam, and the third stage be near the right abutment.

The river diversion work is one of paramount events through the construction. The construction equipment and embankment materials, especially quarry rocks, should be provided sufficiently prior to the commencement of the work; 38,000 m3 for first stage cofferdam, 21,000 m3 for second stage cofferdam, and 13,000 m3 for third stage cofferdam, giving a total volume of 72,000 m3.

The cofferring work will be carried out in dry seasons. The quarried rock excavation is planned to be done by the 7.5 m to 10 m high bench-cut method. Rocks will be drilled by 15 m3/min crawler drills and loaded by 5.0 m3 wheel loaders into 32 ton dump trucks. At the site, materials will be transported from the quarry or the stock-yard, and spread by 21 ton bulldozers. Impervious materials for the upstream slope will be transported from the borrow area and spread by 11 ton bulldozers.

(4) Main dam

All works of the main dam, which is the homogeneous earthfill dam type, are scheduled to be performed for a period of about 4 years correspondingly to the three stages. The following are the main works for the dam construction:

(a) Foundation excavation

Excavation works are scheduled to be performed prior to the foundation treatment and embankment. The excavation of common and weathered rock will be carried out using 32 ton bulldozers with the ripper, 5.0 m3 wheel loaders and 32 ton dump trucks. The foundation will be cleaned using hand tools and skips as the final treatment.

(b) Foundation treatment

Curtain grouting of 5,400 m will be carried out along the dam axis. Curtain grout hole will be drilled by 5.5 kW and 11 kW rotary drilling machines. Cement grout will be mixed at the central plant, delivered to 200 liter x 2 grout mixer installed at work site and injected by 7.5 kW and 11 kW grout pump. At the right abutment where a thick overburden is observed, a blanket by impervious materials will be provided at the upstream toe of main dam instead of the curtain grouting.

(c) Embankment

The embankment of earthfill is scheduled to be carried out in dry seasons of 46 months from June 2005 to March 2008. The embankment volume of impervious zone 673,000 m3 will be obtained from borrow areas near the dam site. Materials of the filter and transition zone 134,000 m3 will be produced by crushing plants and, if required, by mixing river sand. Riprap and rock materials 76,000 m3 is planned to be obtained from quarried and stockpiled rocks. The quarried rock excavation is planned to be done by the 7.5 m to 10 m high bench-cut method. Rock will be drilled by 15 m3/min crawler drills and loaded by 5.0 m3 wheel loaders into 32 ton dump trucks. At the embankment site, materials will be spread by 21 ton bulldozers and compacted by 15 ton vibrating rollers.

The filter and transition embankment zone is planned to be placed between the riprap zone and the impervious zone. Filter and transition zones materials with a size smaller than 150 mm in diameter, will be transported from the quarry site and be produced by 100 ton crushing plants. The materials will be spread by 11 ton bulldozers and compacted by 10 ton vibrating rollers.

Riprap materials, supplied from the quarry site, will be placed by 21 ton bulldozers and handled for surfacing by 0.6 m3 backhoes on the up-and-downstream slopes of the dam and all voids will be filled with smaller rock fragments.

Impervious materials will be transported from the borrow areas, spread by 11 ton bulldozers and compacted by 13.5 ton tamping rollers with 15 ton tractor. Following the last stage of embankment, the road pavement works will be performed.

(5) Spillway

Excavation works of the spillway will be performed in parallel with the foundation excavation of the main dam. Excavated rock materials will be hauled to the stockpile and will be used for rock embankment materials. The excavation works will be carried out using 10 m3/min crawler drills, 32 ton bulldozers with a ripper, 5.0 m3 wheel loaders and 32 ton dump trucks.

Concrete works of 58,000 m3 are scheduled to be carried out for after the foundation treatment. The concrete will be produced by the other 0.75 m3 x 2 concrete plant built at the left bank, which will also be used for the concrete works of the waterway structures, and powerhouse and so on. Concrete placement will be carried out using 3.2 m3 agitator trucks, 60 m3/hr concrete pump cars and 1.0 m3 concrete buckets with a 30 ton truck crane.

The spillway has five sets of spillway gates and one set of sand flush gate. This flush gate can be utilized as a river outlet facility for compensation flow for the downstream waterfalls.

The installation of gate leaves and guide frames for the spillway structure is scheduled to be carried out for 7 months from June, 2006 to December, 2006 taking into consideration the progress of civil works.

(6) Intake

The intake consisting of screen and raking facilities at the entrance, forebay and gate structure is designed at upstream of the headrace channel, of which open excavation and concrete lining works will be carried out. Open excavation works of 360,000 m3 are scheduled to be performed for 10 months.

Excavation and concrete works will be performed in a similar manner to those of the spillway.

(7) Headrace channel

An open type channel with concrete lining has the dimensions of 15 m in bottom width, side slope of 1:2.0 and 2.5 km long. A part of excavated materials is scheduled to use for the embankment materials. The excavation works will be carried out using 10 m3/min crawler drills, 32 ton bulldozers with a ripper, 5.0 m3 wheel loaders and 32 ton dump. The excavation works are scheduled to be 18 months from June 2006 to December 2007.

As for the embankment, special cares such as use of swampdozers and geotextile (plastic net) are needed for swamp area because of low bearing capacity. Impervious materials will be transported from the borrow area or the stockyard using 21 ton bulldozers, 2.3 m3 tractor shovels and 11 ton dump trucks. The materials will be spread by 11 ton bulldozers and compacted by 13.5 ton tamping rollers with a 15 ton tractor.

Concrete lining works are scheduled to be performed for 20 months from June 2006 to August 2008. Two sets of sliding steel forms will be applied for the side slope concrete placement. Concrete lining is planned to progress at a rate of 126 m per month with a 10.5 m long sliding form. Concrete will be transported from 0.75 m3 x 2 concrete plant built at the left bank. The concrete will be transported by 3.2 m3 agitator trucks from the concrete plants to the site, discharged into 6 m3 pneumatic placers, and placed behind the sliding form by the pneumatic placers.

(8) Head pond

The head pond is to be created by constructing a small dam (penstock intake/dam) at a swamp near by the Ntem gorge. This artificial pond has functions to supply turbine discharge for more than 10 min without inflow from intake and to catch suspended silt for prevention of turbine abrasion. It is recommended that the circumference and bottom of pond be used as a rock quarry to keep enough sedimentation capacity. An inspection road will be provided around the pond. The excavation works will be carried out using 10 m3/min crawler drills, 32 ton bulldozers with a ripper, 5.0 m3 wheel loaders and 32 ton dump truck.

(9) Penstock intake/dam

The penstock intake/dam is of a combined type of dam consisting earthfill dams at the both abutments and concrete intake structure at the center of dam. The foundation excavation, foundation treatment, embankment and concrete works will be made by the same manner of those for the main dam and spillway as stated above.

The gate leaves, the guide frames, the trashracks, the hoist and the necessary accessories for the intake gates will be fabricated to sub-assembly units at the contractor's factory. The subassemblies delivered to the project site will further be carried to installation site by a 20 ton trailer and handled by a 30 ton truck crane.

(10) Penstock lines

The penstock shafts (4 lanes) are planned to be 6.0 m in diameter and 52 m high, and located just downstream of the penstock intake/dam. Shaft excavation will be carried out for 11 months from April 2006 to February 2007 after the completion of access/surge tunnel and a work adit branching off from the said tunnel and leading to the bottom of shafts.

A pilot shaft of 2 m x 2 m will be driven by a raise climber machine upward from the bottom and then the shaft will be enlarged downward. Drilling of rock will be carried out using 2.7 m3/min stope drills for the pilot shaft, and 7 m3/min crawler drills and 2.4 m3/min jackhammers for enlargement. Broken rocks will be gathered into the pilot shaft using 0.4 m3 tractor shovels. Mucking will be made using 0.4 m3 muck loaders and 8-ton dump trucks through the access/surge tunnel.

Penstock metal works are scheduled to be performed in a period of 6 months. Before starting installation works, preparation works of 2 months will be required for all the metal works.

Backfill concrete works after installation of penstock are scheduled to be performed for three months from September 2007 to November 2007. Backfill concrete around the steel penstock will be placed upward from the shaft bottom in parallel with the steel penstock installation. Concrete will be transported from the intake site by 3 m3 agitators and discharged into 1 m3 buckets. As to the lower horizontal tunnels, concrete will be transported by 3.2 m3 agitator trucks from the work adit and placed by 45 m3/hr concrete pumps.

(11) Power station

The powerhouse of semi-underground-type (pit-type) reinforced concrete structure with the dimensions of 120 m long, 32 m wide and 60 m high is constructed to accommodate four 50 MW Francis type turbines and four 56 MVA generators. The power station works consist of an access/surge tunnel, a pit-type powerhouse, a draft tube gate chamber and shafts, and an outdoor switchyard. The following are the main works for the power station construction:

(a) Access/surge tunnel

The access/surge tunnel of 7 m wide and 6 m high is branched off near the powerhouse. One is planned to be drilled for reaching the bottom of powerhouse pit, and the other is for the downstream of draft tunnels. The access reaching to the powerhouse is used as a work adit during construction and will be plugged after completion. and the access reaching to the downstream of draft tunnel is used as a work adit during construction and a surge tank after completion. The access tunnel to the powerhouse will be further branched reading to the bottom of penstock shaft as a work adit during construction.

The access/surge tunnel will be constructed in 2005 and 2006, considering the construction schedule of the powerhouse, draft tunnels, tailrace tunnels, penstock shafts. All of excavation for the access/surge tunnels will be made by means of the dump-truck method and the full-face attack method. A driving rate is planned to be 80 m per month for each access tunnel. Drilling works will be carried out using 7-boom truck-mounted drill jumbos. Broken rocks will be loaded by 0.6 m3 side-muck loaders into 8 ton dump trucks for hauling to the spoil bank.

(b) Semi-underground (pit-type) powerhouse

The powerhouse structure is scheduled to be completed by June 2009 before the commencement of impounding. The first stage of construction consists of pit excavation. The second stage consists of placement of substructure concrete, installation of the draft tubes, placement of the second-stage concrete for them, construction of the superstructure, installation of the overhead traveling crane and spiral casings, placement of the second-stage concrete and installation of the turbines and generators.

Excavation of the powerhouse pit will be performed for 17 months from April 2006 and completed by August 2007 before the concrete works of substructure. The pit will be excavated conventionally downward.

Top pit excavation near to the ground surface some 10 m deep will be carried out as a normal excavation method. Immediately after exposing the surface of the side walls, shotcreting and rock bolting or PC anchoring are planned for protection them. On the other hand, glory hole of 2 m x 2 m for mucking will be driven by the raise climber from the bottom of pit through the access tunnel to the powerhouse.

After the completion of top pit excavation, the side walls will be then presplitted, and then the remaining pit portion will be benched down. The bench-cut excavation will be carried out with 1.5 m bench height using 10 m3/min crawler drills, 21 ton bulldozers with rippers, 0.6 m3 backhoes, 1.4 m3 side-dump tractor shovels and 8 ton dump trucks. Mucking will be carried out through the glory holes and the access/surge tunnel. Shotcreting and rock bolting, or PC anchoring will be carried out for each benching-down.

Concrete works of the substructure will be carried out using 3.2 m3 agitator trucks, 60 m3 concrete pump cars and 1 m3 buckets with a 30 ton truck crane. Concrete will be transported to the powerhouse through the access tunnel and from the top of pit.

Following the concrete placement to the substructures, draft tube installation, concrete placement to other structures and the second-stage concrete placement to the draft tubes, an overhead traveling crane is scheduled to be provided in June 2008 to install the casings, turbines and generators subsequently. The powerhouse building works will be performed in parallel with the installation of turbines and generators.

(c) Draft tube gate shaft

The concrete lined gate shaft (4 nos.) of 60 m high with inside dimensions 7.0 m x 1.5 m is planned to be located at the downstream of powerhouse. Excavation works will be performed for 2 months from mid-August 2007. While, the concrete lining works are scheduled to be carried out for 3 months from December 2007. Shaft excavation is planned to carry out in the same manner of those for the penstock shafts as stated above. A pilot shaft of 2 m x 2 m will be driven by a raise climber upward from the bottom (the draft tunnels) and then the shafts will be enlarged downward. Mucking will be made using 0.4 m3 muck loaders and 8 m3 dump trucks through the draft tunnels and the surge tunnel. Concrete will be transported by 3.2 m3 agitator trucks to the top of the shafts and placed by 45 m3/hr concrete pumps.

(12) Tailrace tunnel

Two lanes circular type tunnel with reinforced concrete lining has the dimensions of 9.0 m in diameter and 1,450 m long. Tunnel excavation works are scheduled to be carried out in about 1.5 years from July 2006 to December 2007. A full-face attack method is recommended to apply for driving the tunnel, while hauling of broken rocks is by the tire method. The driving will be carried out by one heading from the access/surge tunnel.

Drilling works will be carried out using 7-boom drill jumbos. The broken rocks will be loaded by 1.2 m3 tractor shovels into 8 ton dump trucks.

Concrete lining works are scheduled to be performed for 11 months from May 2007 to March 2008. A full circular method is recommended to apply for concrete lining, and one set of sliding steel form with the traveling needle beam will be provided for each lane of the tunnel. Concrete lining is planned to progress at a rate of 126 m per month with a 10.5 m long sliding form. Concrete will be transported from the concrete plant at the left bank by 3.2 m3 agitator trucks and discharge into 6 m3 pneumatic placer and placed behind the sliding form.

Following the completion of concrete lining, backfill grouting will be commenced. Mortar backfill grout will be injected into voids and space using 11 kW low pressure grout pumps.

(13) Tailrace outlet

At the end of the tailrace tunnels, a portal/gate structure is provided with an elevated sill EL. 334 m to maintain the minimum draft head and to prevent flowing debris from entering into the tunnel during flood.

Care of river (Ntem gorge) during construction is very important in this work. A cofferring dike with a crest level of EL. 343 m will be created by excavating the river bank. Excavation and concrete works will be performed in a similar way to those of the spillway.

7.1.3 Construction Schedule

(1) Implementation schedule

The target date for the commissioning of generating equipment is planned to be October 2009. Main construction works of the Project are planned to be 5.0 years from October 2004 to September 2009, while 15 years will be required for the Project after the completion of the feasibility study. The financial arrangement required for the detailed design stage and the construction work stage shall be made by SONEL. Fig. 7.2 shows an overall implementation schedule of the Project.

The following basic schedule shall be kept in order to secure the commissioning target of the Project:

(a)	Financial arrangement for the detailed design	:	4 years from January 1994 to December 1998

(b)	Selection of a consultant for the detailed design	:	6 months from January 1999 to June 1999
(c)	Detailed design and preparation of tender documents	:	24 months (2 years) from July 1999 to June 2001
(d)	Financial arrangement for construction works	:	24 months (2 years) from July 2001 to June 2003
(e)	Selection of a consultant for construction works	:	9 months from July 2003 to March 2004
(f)	Tender and contract including prequalification	:	6 months from April 2004 to September 2004
(g)	Main construction works	:	60 months (5 years) from the commencement of October 2004 to the completion of September 2009
(h)	Commissioning of the commercial operation	:	Beginning of October 2009

The engineering services are divided into two; i) design work for tender and detailed design and ii) construction supervision. The magnitude of the design work's cost is influenced by many factors, including project cost, type, and geographical conditions of the site. The cost of the design work are usually treated as some proportion of the construction cost in feasibility studies. Its proportion range is from 6% for large projects to 10% for small projects. The cost of the construction supervision is also estimated by some proportion of the construction cost. Its appropriate range is from 4% for large projects to 6% for small projects.

In Memvé Elé's case, the cost of the engineering services can fairly be estimated as 6% of the direct construction cost for the design work and 4% of it for the construction supervision work.

(2) Construction schedule

Fig. 7.3 shows the construction schedule of the Project. The land acquisition and compensation for the Project will be settled by SONEL prior to the commencement of the construction. The work schedule for the major items are summarized by year as follows:

First year

(a) Award of contracts for civil works including preparatory works

(b) Mobilization and construction of site facilities

(c) Construction of base camp and access roads

Second year

(a) Award of contracts for hydro-mechanical works and transmission lines and substation equipment

(b) Construction of base camp and access road

(c) First stage river diversion works

(d) Foundation excavation, treatment and embankment of the main dam

(e) Foundation excavation, treatment and concrete works of the spillway

(f) Excavation and concrete works of the intake

(g) Excavation of the head pond

(h) Excavation of the access/surge tunnel

(i) Excavation of the tailrace outlet

Third year

(a) Foundation excavation, treatment and embankment of the main dam

(b) Excavation and concrete works of the spillway and intake

(c) Excavation of the headrace channel

(d) Excavation of the head pond and penstock intake/dam

(e) Excavation of the penstock shafts

(f) Excavation of the powerhouse

(g) Excavation of the access/surge tunnel

(h) Excavation of the draft tunnels

(i) Excavation of the tailrace outlet and tunnels

(j) Installation of spillway gates, sand flush gate, intake trashracks, intake gates and scour valve

Fourth year

(a) Award of contract for the generating equipment

(b) Second stage river diversion

(c) Excavation, foundation treatment and embankment of the main dam

(d) Excavation, embankment and concrete works of the headrace channel

(e) Excavation works of the head pond

(f) Excavation, foundation treatment, embankment and concrete works of the penstock intake/dam

(g) Installation of the penstock intake trashracks and penstock intake gates

(h) Installation of the penstock liners and backfill concrete

(i) Excavation and concrete works of the powerhouse

(j) Concrete works of the draft tunnels and access/surge tunnels

(k) Excavation and concrete works of the tailrace tunnel

Fifth year

(a) Third stage river diversion

(b) Excavation, foundation treatment and embankment works of the main dam

(c) Excavation, foundation treatment and concrete works of the spillway

(d) Concrete works of the headrace channel

(e) Excavation works of the head pond

(f) Concrete works of powerhouse

(g) Building works

(h) Concrete works of the tailrace tunnel

(i) Concrete works of the tailrace outlet

(j) Excavation and concrete works of the switchyard

(k) Installation of the draft tube and turbines

(l) Construction for the transmission lines

Sixth year

(a) Removal of cofferdams and impounding

(b) Installation of the generating equipment

(c) Construction of transmission line and installation substation equipment

(d) Concrete works of the powerhouse

(e) Building works

(f) Plug concrete of the work adits

(g) Commissioning tests

(h) Demobilization.

7.2 Cost Estimates

7.2.1 Introduction

Construction costs for the Project are estimated on the basis of the preliminary design. Unit prices for each work item are established considering local conditions, available construction equipment and materials and suitability of the construction method and referring to similar international projects.

The foreign and local currency portions of the project costs are estimated on basis of US Dollar and Cameroon franc (F. CFA) respectively, and the foreign currency portion expressed in US Dollar is converted to Cameroon franc for assessing the total cost.

Assumptions and conditions applied for the cost estimate are as follows:

(a) Price level : Price as of mid June, 1993

(b) Exchange rate : US Dollar 1.00 = F. CFA 270.6 = Japanese Yen 106.7 (or F. CFA. 1.00 = Yen 0.394)

(c) Work quantity : Quantities estimated from the preliminary design for the work items given in Table 7.6.

Construction works will be carried out by the contractors selected through international competitive biddings.

Construction costs are divided into direct construction cost and indirect construction cost. The direct construction costs (contract cost) are the cost for preparatory works, civil works, metal works, generating equipment, transmission lines and substation equipment. While, the indirect construction costs are the ones required for land acquisition and compensation, administration expenses, engineering services and contingencies.

7.2.2 Preparatory Works

Costs for the preparatory works comprise of the costs for insurance of works, temporary buildings, water supply system, electric power supply system, telecommunication system, provision of medical facilities, operation of medical services, inland transportation, testing laboratory and temporary access roads.

The cost for preparation works is estimated at 20 percent of the sum of the civil works, including the cost for the land acquisition and compensation detailed in Clause 7.2.8.

7.2.3 Civil Works

The cost of the civil works is estimated referring to basic price levels obtained from civil contractors and manufacturers of construction equipment and materials in Cameroon. The data consist of labor cost, material cost, equipment cost and contractor's indirect cost. Unit prices of the existing and the planned hydropower projects are also referred to the cost estimate.

(1) Labor cost

Wages obtained in Yaoundé and Ebolowa are based on the direct daily wages in an 8-hour shift of labor. The labor cost is shown in Table 7.1.

(2) Material cost

Most of construction materials are supplied from local markets, and therefore the local material prices were canvassed in Douala and Yaoundé. These local material prices include local net price, inland transportation, duties and value added tax, i.e. the purchase price at the project site. The imported materials which are not available in local markets are estimated on the examination of import duties and taxes. The prices of major construction materials are shown in Table 7.2.

(3) Equipment cost

Equipment and plant for the construction will be provided by the contractor. Referring to prevailing prices in Japan as of November 1992, the prices of equipment itself are estimated based on the CIF price in Douala. The duties and taxes charged for the import of equipment are excluded in this cost estimate.

The equipment cost is divided into foreign and local portions. The foreign currency portion mainly includes the costs of depreciation, spare parts and consumable, while the local currency portion includes the cost of mechanic labor, the cost for the repair and maintenance and administration expenses.

(4) Contractor's indirect cost

Overhead expenses and profits are contributed to the unit rates of each work item. These expenses are estimated at 25 percent of the direct cost including labor cost, material cost and equipment cost.

(5) Unit price

The unit prices for each work item are estimated in consideration of the above conditions and also referring to the prices in other similar projects as shown in Table 7.6.

(6) Bill of quantities

Cost estimates of civil works are based on the work quantity obtained from the preliminary design of the following structural components:

- Cofferdam
- Main dam
- Spillway
- Waterway (Intake, Headrace channel, Head pond, Penstock intake, Penstock lines, Draft tunnels, Access/surge tunnel, Tailrace tunnels and Tailrace outlet)
- Power station (Access tunnel, Pit-type powerhouse, Gate chamber, and Outdoor switchyard)
- Architectural building
- Access road
- Base camp.

7.2.4 Metal Works

The prices for metal works are based on the recent international contract prices of similar works. The cost of imported equipment and materials is estimated at the CIF price in Douala excluding import duties and taxes. Costs for supply and delivery of imported items, ocean freight and insurance are included in the foreign currency portion. Costs for unloading and other charges at the port and for inland transportation are estimated in the local currency portion. Installation costs are proportionally shared by the foreign and local portions. Structural components to estimate the cost of metal works are as follows:

- Spillway gates,
- Sand flush gate,
- Intake trashracks,
- Intake gates,
- Scour valve,
- Penstock intake trashracks,
- Penstock intake gates,
- Steel penstock,
- Draft tube gate, and
- Tailrace gates.

7.2.5 Generating Equipment

Price estimate of generating equipment is based on CIF price in Douala excluding import duties and taxes. Cost components of generating equipment including supply and erection cost are as follows:

Description	Quantity	Foreign Currency (Mill. US$)	Local Currency (Mill. F.CFA)
Turbines	4 sets	24.53	692.43
Generators	4 sets	20.40	289.18
Transformers	L.S.	6.75	95.51
Switchgear and control equipment	L.S.	11.31	159.18
Ancillary equipment	L.S.	1.60	23.88
Miscellaneous equipment	L.S.	4.01	55.71
Transmission line protective relays*	2 sets	2.24	31.84
Total	-	70.83	1,347.73

* Includes PLC telephone lines

7.2.6 Transmission Line and Substation Equipment

The prices for tower materials, conductors and substation equipment are estimated at the CIF price in Douala excluding import duties and taxes. Civil works such as site clearance, earthwork and foundation treatment are included in the transmission line cost.

The estimated costs are:

Description	Quantity	Foreign Currency (Mill. US$)	Local Currency (Mill. F.CFA)
Transmission Lines	L.S.	24.14	5,553.3
Substation	L.S.	3.39	106.1
Total	-	27.53	5,659.4

Following are the transmission line route and substation location assumed to estimate the construction cost:

- Transmission line: Yaoundé - Ebolowa - Nyabessan
- Substation equipment: Oyomabang

7.2.7 Land Acquisition and Compensation

All required land acquisition and compensation shall be carried out by SONEL along with the project implementation schedule. Those costs include the costs required for the acquisition of the reservoir and construction areas, transmission line routes, and road alignment.

Compensation and resettlement cost is estimated on the basis of the following assumptions and criteria:

(a) No monetary payment is required for acquisition of land in case of public project.

(b) Compensation for destruction of growing crops is based on the prices gazetted by the Ministry of Agriculture in 1985 (See Table 7.4). In the estimate of this study, the price is adjusted to 1993 price assuming a price escalation at 5 % per year (for crops).

(c) If the land under plantation is lost due to impoundment of the Project's pond or occupancy by the construction works, the Project will make the following compensations:

- supply of new land in adjacent area, and
- compensation for loss of net income from perennial crop production for a period of 5 years until the substitute crops are matured on newly cultivated land.

(d) In case of resettlement of housing, the following compensation will be provided:

- re-construction of new house in resettled area,
- compensation of inconveniences caused by resettlement, and
- provision of infrastructures such as roads, water well, tomb, church and other public facilities.

Table 7.3 shows the unit prices used for the estimate of compensation and resettlement cost. Based on these unit prices and quantities separately estimated, the total compensation/ resettlement cost is calculated to be roughly F. CFA 1,009 million as summarized in Table 7.5.

7.2.8 Administration Expenses

An allowance of 1.0 percent of the direct construction cost is provided for the executing agency of SONEL, which is a part of the local currency portion.

7.2.9 Engineering Services

The cost of engineering services for the detailed design including the preparation of tender documents and for the construction supervision is estimated at 10 percent of the sum of the direct construction cost.

7.2.10 Contingencies

Contingencies consist of unforeseen physical conditions (physical contingency) and inflation (price escalation). The rate of physical contingency is assumed at 20 percent of the sum of direct construction cost, cost of the engineering services and general expenses. The physical contingency is estimated assuming the escalation rates to be 2 % for foreign currency and 7 % for local currency.

7.2.11 Construction Cost

The construction cost of the project excluding price escalation is estimated at F. CFA. 112.7 billion (US$ 416 million equivalent). The proportion of foreign and local currency to the total construction cost is 85.7% and 14.3%, respectively.

The following show the summary of the total construction cost, and further details are referred to in Tables 7.1.

Work Description	Foreign currency (Mill. F. CFA)	Local currency (Mill. F. CFA)	Total (Mill F. CFA)
1. Preparatory works, land acquisition and compensation	5,057.6	2,167.5	7,225.1
2. Civil works	30,546.1	5,579.2	36,125.3
3. Hydro-mechanical works	7,132.0	536.8	7,668.8
4. Electro-mechanical equipment	26,615.0	7,010.0	33,625.0
5. Engineering services	8,464.4	0	8,464.0
6. General expenses	0	846.4	846.4
7. Contingencies	15,563.0	3,228.0	18,791.0
Total construction cost (base cost at 1993 price)	93,378.1 (82.8%)	19,637.9 (17.2%)	112,746.0 (100%)
8. Price contingency	28,405.2	20,180.8	48,586.0
Total cost	121,783.3	39,548.7	161,332.0

Note: Price contingency comes out at a relatively large amount due to assumption of completion of the project towards year 2009 (16 years after).

Table 7.1 Labour Cost

(UNIT: FCFA)

LABOUR TRADE	GRADE	SALARY/WAGE		REMARKS
		Monthly	Daily	
Unskilled Labour	1A	45,000	2,100	
	2A	56,000	2,600	
Concrete Worker	4D	105,000	4,800	
	5A	114,000	5,200	
Form Worker/Carpenter	4D	105,000	4,800	
	4F	120,000	5,500	
Steel Worker	4E	110,000	5,000	Re-bars
Mechanic	6E	150,000	6,800	Equipment repair
Equipment Operator		180,000	8,200	Heavy equipment
Truck Driver		160,000	7,300	Dump truck
Tunnel Worker		210,000	9,500	Tunnel excavation
Civil Works Foreman		250,000	11,400	
Engineers		500,000	-	
Surveyors		260,000	11,600	
Technicians		250,000	11,400	

Source : Construction Companies in Yaounde, September 1993

Notes : (1) Basic work hour: 10 hrs/day or 220 hrs/month

(2) Outstation allowance:

- Short term (2-3 months) : 3,000F/day (Grade 1-6)
  6,500F/day (Grade 6 over)
- Long term : 25% of salary rate
- No allowance in case of provision of accommodation

(3) Social insurance (CMPS), training tax and other charges: 40% of salaries

Table 7.2 Price of Major Construction Materials

Item	Manufacture	Unit	Price (FCFA)	Remarks
Cement, Ordinary	CIMENCAM	ton	48,000	Yaounde
			34,000	Douala at factory
Reinforcement Bar	SOLADO	ton	170,000	Yaounde
Structural Steel:				
- Channe 200x100x6	SOLADO	6m	50,000	
- Angle 40x40x4	"	6m	8,000	
- Sheet 20x400x0.4	"	m^2	200,000	
Wood Planks				
- Hard	Domestic	m^3	67,000	Coren at Yaounde
- Soft	"	m^3	67,000	"
Explosives				
- Soft (Sigmaguel)	BROCETTE	kg	2,890	
- Hard (Gomune)	"	kg	2,590	
- Nitrate	"	kg	300	
- Cord (Cordeur)	"	kg	430	
- Detonator	"	kg	650	
Concrete Admixture	-	-	-	No use
Fuel, Gasoline	Domestic	Litre	190	
Fuel, Diesel Fuel	"	Litre	163	
Lubricants, Melange	"	Litre	220	

Source : Dragage Construction Company in Yaounde, September 1992.

Note : Commission for 5% will be charged in case of import of cement and steels (pay to CIMENCAM/SOLADO)

Table 7.3 Unit Prices for Estimate of Compensation Cost

Item	Unit	Price(FCFA)	Remarks
Damsite/Reservoir Area:			
(a) Compensation for destruction of plantation	ha	1,800,000*1	Compensation for crops currently growing
(b) Clearing of substitute land	ha	700,000	Supply of new land for resettled family (1.0 ha)
(c) Compensation/re-construction of houses	family	1,000,000*2	Supply of new house for resettled family
(d) Compensation for resettlement	family	500,000*3	Compensation for inconvenience due to resettlement
(e) Compensation for crop maturing period	family	2,300,000*4	For perennial crops, 5 years until maturity
(f) Cost for infrastructures for resettled area	LS	100% of (b)+(c)	Road and other public facilities
<u>Access Road</u>			
(a) Compensation for plantation	ha	720,000*5	For land lost due to road enlargement
(b) Compensation for infrastructures	LS	20% of (a)	Relocation of public facilities (eg. electricity)

Table 7.4 Unit Prices of Compensation for Farm Lands (1985 PRICE)

Item	Unit Price		Remarks
	Young	Matured	
1. Annual Crops			
Oily: groundnuts, voandzou, soja, beans, etc.	30F/m2	50F/m2	
Cereals: maize, millet, so-gho, rice, etc.	30F/m2	50F/m2	
Fruits: Plantain	350F/stem	600F/stem	
Banana	200F/stem	350F/stem	
Pineapple	100F/head	180F/Read	6.5 - 11.7 Mill. F/ha
Tubers: yam, cocoyam,	50F/stem	80F/stem	600,000-960,000F/ha
colocasia, potatoes	1,500F/m2	1,500F/m2	
Garden crops	30F/m2	50F/m2	
Cotton tree	30F/m2	50F/m2	
Tobacco	25F/stick	40F/stick	
Sugar cane			
2. Long-life Crops			
(1) Fruit trees:	1,250F/stem	3,500F/stem	320,000-880,000F/ha
Citrus: lime, orange, grape, mandarine	1,250F/stem	3,500F/stem	320,000-880,000F/ha
Mango, Pear	150F/stem	560F/stem	
Pawrow	1,250F/stem	3,500F/stem	
Kolanut and Plum	575F/stem	1,720F/stem	
Other fruit trees			
Cocoa and coffee:	600F/stem	-	960,000F/ha
5 year's under	-	1,800F/stem	2,880,000F/ha
5-15 years	-	1,500F/stem	2,400,000F/ha
15-25 years	-	1,200F/stem	1,920,000F/ha
25 years over			
Palm oil and coconuts:	-	575F/stem	81,000F/ha
8 years under	-	1,150F/stem	180,000F/ha
8-15 years	-	2,000F/stem	300,000F/ha
15-25 years	-	1,725F/stem	260,000F/ha
25 years over	-	500F/stem	
Raffia palm tree	300F/stem	850F/stem	180,000-510,000ha
Rubber tree	120F/stem	160F/stem	
Tea			
(3) Medicinal Plants	75F	200F	800,000-
Quinguina	600F	1,200F	2,200,000F/ha
Voa canga	500F	1,000F	
Pigeum and yohimbe	500F	1,000F	
(4) Shed trees			
(5) Other cultivated trees	1,000F/stem	-	
5 years under	-	2,000F/stem	
5 years over			

Note: Number of trees per ha (for selected crops):

Tubers	12,000	Citrus	250
Mango	250	Pear	150
Palm oil	150	Coconut	150
Cacao/Coffee	1,600	Rubber	600
Quinquina	10,600	Pineapple	65,000

Source: Arrete No. 58/MINAGRI, Ministry of Agriculture, March 1985

Table 7.5 Land Acquisition and Compensation

Item	Unit	Q'ty	Unit Price (mill. F.CFA)	Amount (mill. F.CFA)	Remark
1 . Socio-sanitary prevention measure	L.S			18.5	Refer to Appendix V
2 . Compensation for land and houses	L.S			90.1	-do-
3 . Re-establishment of public infrastructure	L.S			18.2	-do-
4 . Resettlement	L.S			3.0	-do-
5 . Transmission Line					
5.1 Right-of-way for T/L	ha	1,136	0.70	795.2	
5.2 Land for tower position	ha	29.2	1.80	52.6	
6 . Access road					
6.1 New road (4.0km)	ha	6.0	0.72	4.3	
6.2 Enlargement (30km)	ha	30.0	0.72	21.6	
6.3 Compensation for infrastructure	L.S			5.2	20% of 6.1+6.2
				1,008.7	

Table 7.6 Project Cost Break Down (1/2)

Work Descriptions	Q'ty Unit	Unit Price (FCFA)	Quantity	Foreign Currency Unit Price (FCFA)	Foreign Currency Amount (Mill. FCFA)	Local Currency Unit Price (FCFA)	Local Currency Amount (Mill. FCFA)	Total Amount (Mill. FCFA)	Total Amount (Mill. US$)
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 7.6 Project Cost Break Down (2/2)

Work Descriptions	Q'ty Unit	Unit Price (FCFA)	Quantity	Foreign Currency Unit Price (FCFA)	Foreign Currency Amount (Mill. FCFA)	Local Currency Unit Price (FCFA)	Local Currency Amount (Mill. FCFA)	Total Amount (Mill. FCFA)	Total Amount (Mill. US$)
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	42,400	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

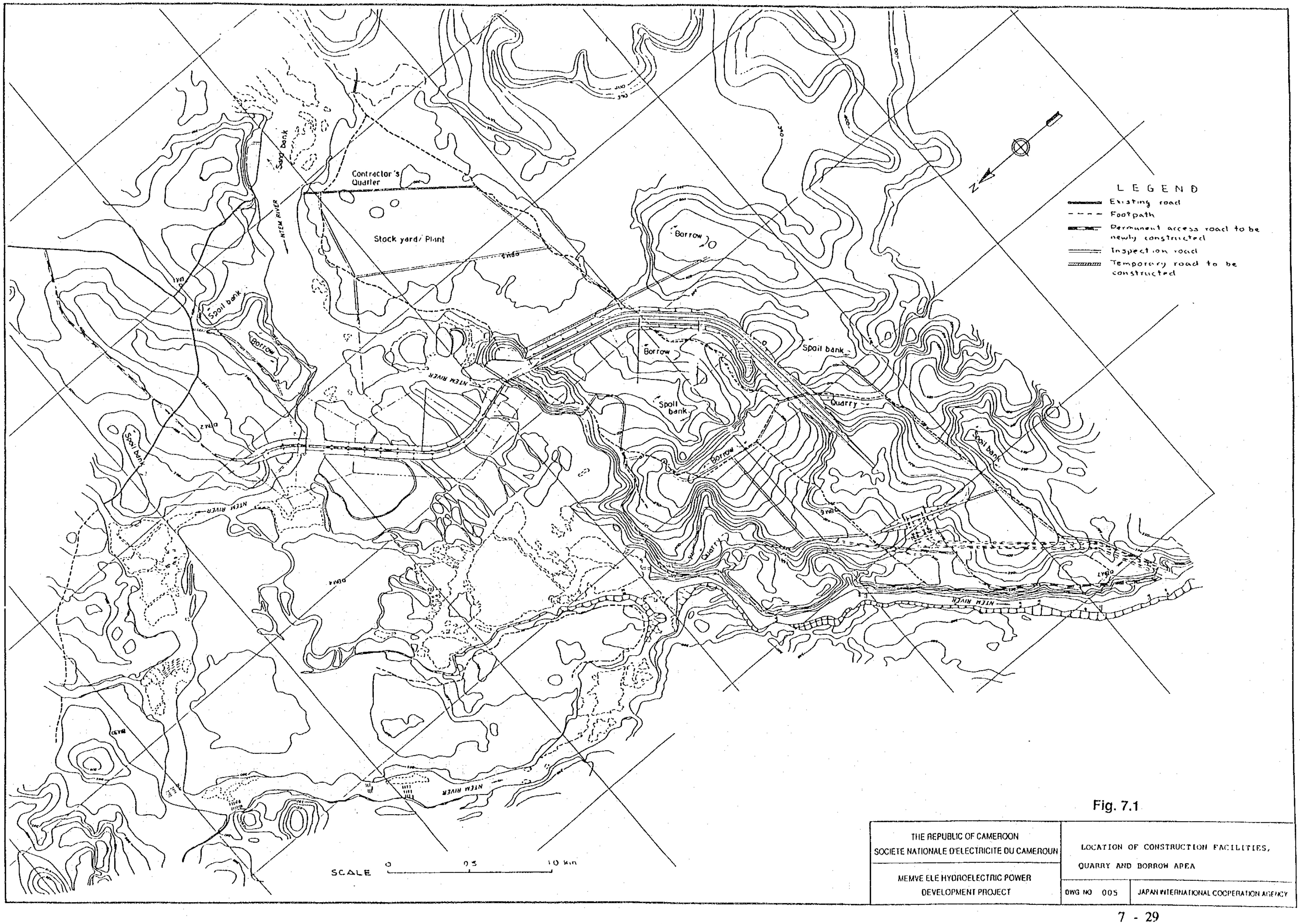
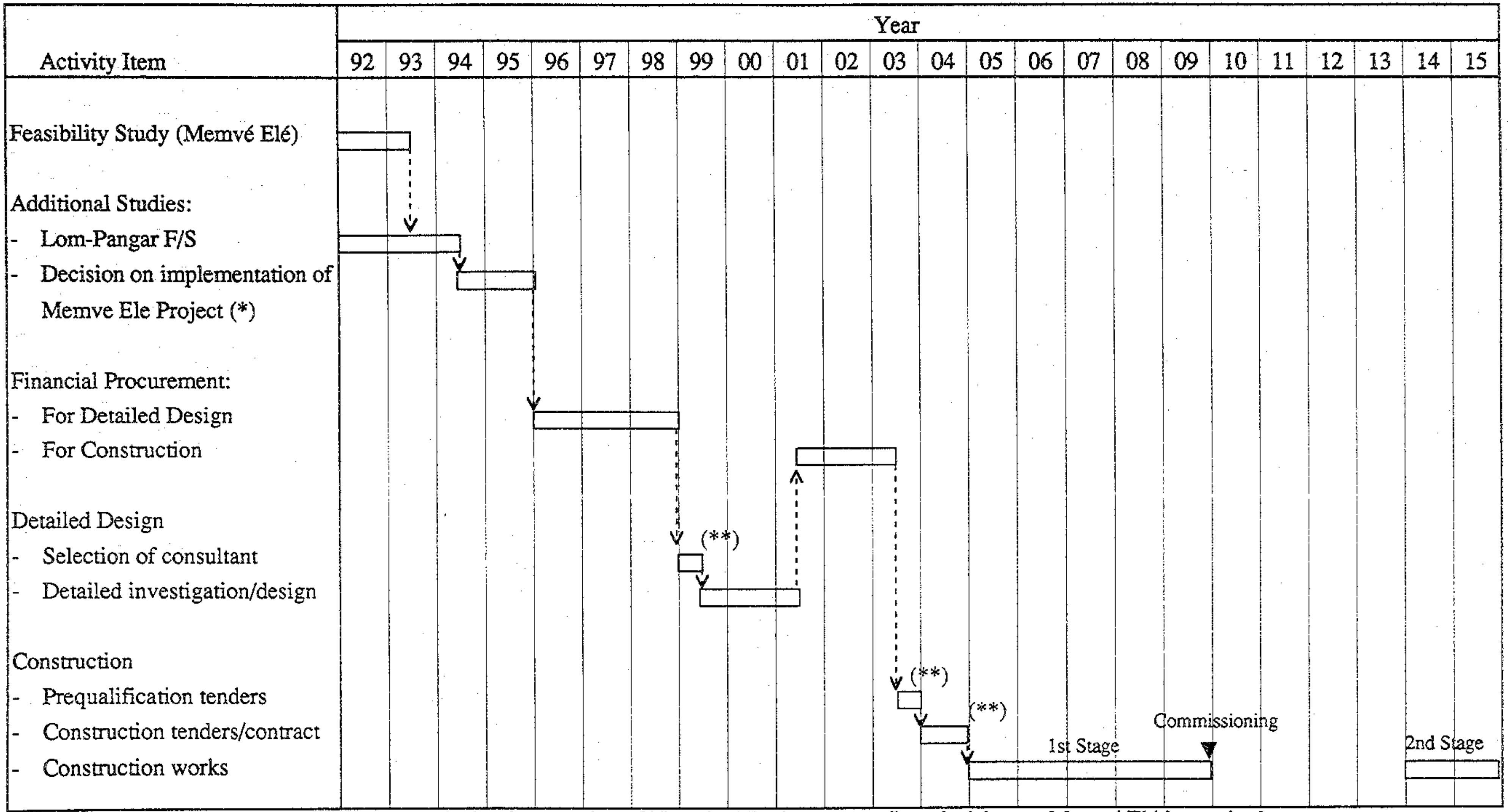


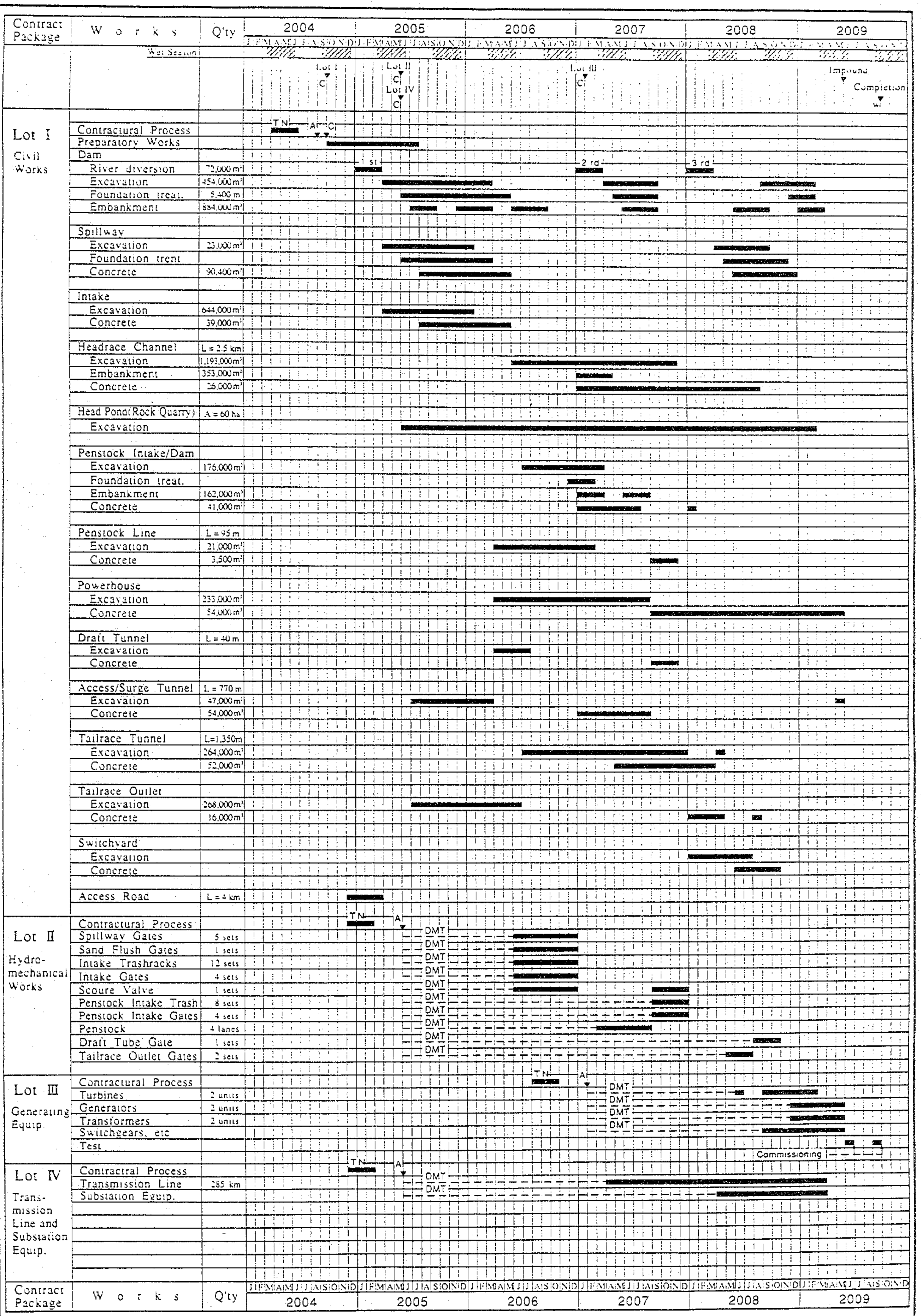
Fig. 7.1

THE REPUBLIC OF CAMEROON SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN	LOCATION OF CONSTRUCTION FACILITIES, QUARRY AND BORROW AREA
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT	DWG NO 005 — JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 7.2 Overall Implementation Schedule



(*) whatever the implementation of Nachtigal Project comes first, decision on Memvé Elé is required
(**) including tender, evaluation and contract



SYMBOL

T N	Tendering
A ▼	Award of Contract
C ▼	Commencement of work
W ▼	Completion of work
DMT	Design, manufacturing & transportaion

THE REPUBLIC OF CAMEROON
SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN

MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT

Fig. 7.3
CONSTRUCTION TIME SCHEDULE

DWG NO. 008

JAPAN INTERNATIONAL COOPERATION AGENCY

VIII. PROJECT EVALUATION

8.1 Project Evaluation Method

(1) General

Economic analysis of a power project represents a special case in project evaluation because of its characteristics of a public utility enterprise. Benefits of power are realized, for instance, in the form of increased production value as it is used as one of input to economic activities. It is difficult to measure such increased production value because there exists no definite barometer to measure the utility value of domestic power consumption.

Prices of a commodity in a competitive market are regarded as reflecting consumers willingness-to-pay, a legitimate measure of benefits associated with this commodity. In case of power, however, such a market hardly exists, particularly in developing countries where power is developed and supplied by governmental or public enterprise like SONEL. Prices for electricity are often kept at low level for political or socio-economic reasons such as to contribute to public welfare or to industry growth.

As a result, there usually exist potential customers waiting to be connected to the power supply system, i.e., unsatisfied demand at the tariff prices. This is exactly the condition observed in Cameroon. In Cameroon' s case, the electricity prices especially for the high tension consumers represent only the lower bounds of the benefits to accrue from the power.

(2) Alternative Facility Cost Method

In view of the difficulty especially in measuring benefits of power projects as mentioned above, what is called the alternative facility cost method is often used in the evaluation of hydropower projects. By this method, the benefits of a hydropower project is defined as the cost of thermal alternative having the comparable supply performance to the hydro that would be saved, should the hydropower project be implemented. This method is applied to the case in question here, and the power and the energy value of the hydropower will be calculated.

8.2 Criterion of Project Evaluation

The project is evaluated in terms of economic internal rate of return (EIRR) as well as financial internal rate of return (FIRR). Assumptions used for the evaluation are:

Exchange rate:	US \$1.00 = F.CFA 270.6
Economic conversion factor:	0.85
Project life:	50 years for civil works, and 35 years for metal and generating equipment
Operation and maintenance (O&M) cost:	0.5% of capital cost in civil works plus 2% of capital cost in electrical/ mechanical works
Alternative power plants:	gas turbine thermal for Memvé Elé's primary energy, and oil-fired thermal for Memvé Elé's secondary energy
Fuel price:	primarily based on international fuel prices corresponding to crude oil price US \$20 (at border price)

Since the Cameroon fuel price is very expensive compared to the international price, the additional economic evaluation is made referring to domestic fuel price as one of the sensitivity tests (See Sub-section 8.3.2 for details).

8.3 Economic Evaluation

8.3.1 Economic Internal Rate of Return (EIRR)

(1) Economic Cost and Benefit

(a) Economic cost

The capital cost of the Project are shown in Table 7.6 in terms of financial cost. The economic cost is converted from the financial cost under the following assumptions:

$$C_e = C_f + f_c C_l$$

where C_e: economic cost

C_f: foreign currency cost

C_l: local currency cost

f_c: economic conversion factor (0.85)

The stage-wise development is assumed as described in Chapter 6; First Development (Memvé Elé 1) and Second Development (Memvé Elé 2). It is also assumed that Memvé Elé 2 becomes in operation seven years later than that of Memvé Elé 1 referring to the medium growth forecast by the microscopic method[1]. The allocation of the project cost is obtained to be 73% for Memvé Elé 1 and 27% for Memvé Elé 2 from discussions on the construction plan and cost estimate.

For both of Memvé Elé 1 and Memvé Elé 2 the economic project life is assumed 50 years long for civil works and 35 years long for metal works, generating equipment and transmission line system. The replacement cost is considered to be 100% presence at the end of each economic life.

For Memvé Elé 1, the disbursement period of the construction cost is hypothesized to be five years having the allocation of 3%, 15%, 30%, 40%, and 12% for each construction year. For Memvé Elé 2, it is two years with the disbursement allocation of 50% and 50%. The annual operation and maintenance (O&M) costs are assumed to be 0.5% of the capital cost in civil works and 2% of the capital cost in hydromechanical and electrical works.

(b) Economic Benefit

The economic benefit of the Project can be defined as the cost of alternative thermal plants. Alternative thermal power plant is assumed to be gas-turbine plant (saving in thermal construction cost and primary energy production cost) and oil-fired plant (saving in secondary energy production cost), which are regarded to have similar supply performance to the proposed Memvé Elé hydro plant. Both types of plant do not exist at present in Cameroon, but an assumption placed here is that they will be introduced someday in the future when the system expands to a fairly large size. Here, the primary energy is defined by the hydroelectric power generated with discharge having the 95% dependability.

The dependable peak power of the Memvé Elé Plant is 201 MW as large as the installed capacity. This is because the Memvé Elé Plant can generate full power for at least 4.3 hours a day even in the driest period by regulating the inflow of 95%-dependable runoff at 80.2 m3/s. Accordingly, the alternative plant, diesel generators, must generate 201 MW at least.

The economic benefit is estimated under the following conditions:

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1 See Fig. 5.12 for the development timing.

i) In cash-flow of benefit, it is regarded that the investment cost is disbursed in the end of each year of the construction stages, and that the O&M costs are disbursed afterwards,

ii) Fixed cost of the alternative power plant is estimated as;

Construction Cost (Investment)

- Financial cost	US $1,000/kW
- Economic cost	US $985/kW = US $1,000/kW x (0.9 + 0.1 x 0.85) Note that 10% of the cost is assumed local.
- Adjustment factor	1.148 (See Table 8.1)
- Economic construction cost	US $1,131/kW = US $985/kW x 1.148
- Service life	15 years

- Table 8.1 shows the calculation of kW value of alternative thermal plants (for reference).

O&M cost

- US $22.6/kW/year = US $1,131/kW x 0.02/year

(2% of the construction cost is assumed fixed every year for O&M)

iii) The variable cost of the alternative power plant (energy value) is estimated at US $0.0769/kWh (gas turbine) for the hydro primary energy and at US $0.0340/kWh (oil-fired) for the hydro secondary energy, respectively (see Table 8.1).

iv) It is assumed that annual energy supply is 95% of the annual possible energy production owing to an assumption of 5% transmission line loss.

(2) Economic Internal Rate of Return (EIRR)

The economic internal rate of return (EIRR) is calculated to be 16.5 %. The cost and benefit stream is shown in Table 8.2.

When 10% of discount rate is assumed, the project cost and benefit are obtained to be US $289.3 million and US $443.0 million, respectively. The benefit-cost ratio (B/C) is found to be 1.53. The net benefit (B−C) is as large as US $153.7 million.

8.3.2 Sensitivity Analysis

Sensitivity tests were carried out for the following cases taking into consideration uncertainties involved in the future costs and fuel prices:

(1) 10% and 20% increase for the capital costs of the Project,

(2) 10% and 20% decrease for the benefits of the Project,

(3) combinations of 10% cost increase and 10% benefit decrease, and 20% cost increase and 20% benefit decrease, and

(4) adoption of domestic fuel price of F.CFA 178/*l* for gas oil and F.CFA 105.7/*l* for MFO (see Table 8.1) instead of international fuel price.

The results of the sensitivity tests are summarized as follows:

	Cases	Net Present Value (Mill. US$)	Economic Internal Rate of Return (%)
(1)	10% Cost Increase	124.8	14.8
(2)	20% Cost Increase	95.8	13.4
(3)	10% Cost Decrease	182.6	18.6
(4)	20% Cost Decrease	211.6	21.2
(5)	10% Cost Increase and 10% Benefit Decrease	80.5	13.1
(6)	20% Cost Increase and 20% Benefit Decrease	7.2	10.3
(7)	Domestic Fuel Price	794.2	34.7

Even under the most unfavorable condition of 20% construction cost increase plus 20% benefit decrease, the project still keeps EIRR of 10.3% based on the international fuel price. In addition, the Project has 34.7% of EIRR if a fuel price is evaluated with a domestic fuel price which is as high as triple of the international price. The sensitivity tests verify the project variable in terms of economic evaluation.

8.3.3 Unit Energy Cost

The unit energy cost is obtained to be 2.9 US ¢/kWh for the Project. Where the capital recovery factor is 0.1005 (discount rate = 10%, evaluation years = 50 years); the annual cost is US $29.1 million; the annual energy output is 1,140 GWh for the complete scheme of Memvé Elé Project (Memvé Elé 1 plus Memvé Elé 2). The value can be regarded attractive for the

Project implementation. (The value is favorably compared with those of other projects; e.g., 5.5 US ¢/kWh for the Sondu-Miriu Hydropower Project – Feasibility Study, 1985, Kenya; 6.5 US ¢/kWh for the Ermanek Hydropower Project, – Feasibility Study, 1990, Turkey)

8.4 Financial Evaluation

Financial evaluation puts its primal purpose on financial viability of the Memvé Elé Project itself and manageability of the implementing agency (SONEL) to repay foreign and local portions of investment costs. As far as the aspect of financial viability is concerned, analytical viewpoint focuses on financial rate of return to all resources engaged when the project is implemented. Its analysis usually puts an emphasis on FIRR which is the discount rate to equalize the present worth of investment costs and projected revenue amounts. Concerning to financial manageability of the implementing agency, analyses are placed on financial impact of the project to the implementing agency.

8.4.1 Financial Internal Rate of Return (FIRR)

Financial costs of the Memvé Elé project are estimated at the price level 1993 as dealt with in the preceding Chapter 7. Operation and maintenance costs of the project are simply assumed at 0.5% of civil works cost plus 2% of hydromechanical/electrical works cost..

Power revenue is earned by selling electric energy. Electricity tariff, which is a crucial element for the assessment of financial viability as well as the amount of energy generation, is estimated at US $0.183/kWh (49.5 F.CFA/kWh) on an MT and LT average at the level of 1991.

FIRR, as seen in Table 8.3, was estimated at 22.9% on the condition of excluding price escalation from both of costs and benefits. Thus, the project is judged able in terms of FIRR.

8.4.2 Sensitivity Analysis

Sensitivity tests for FIRR were carried out taking into account future costs and electricity tariff as follows:

Case 1: Price escalation by 5 % per annum is counted for costs, but not for revenue.

Case 2: Price escalation by 5 % per annum is counted for revenue, but not for costs; that is, electricity tariff is increased by 5% per annum (a half rate to general inflation rate), although past performance is 12% per annum, by the commissioning year of the project.

Case 3: The electricity tariff of US $0.165/kWh (F.CFA 44.5/kWh) is applied, which is 10% decrease from 1991 level[2].

Case 4: The electricity tariff of US $0.084/kWh (22.7 F.CFA/kWh) is applied. The tariff is based on entire average of electricity selling price (including HT energy sale).

The results of the sensitivity tests are summarized as follows:

	FIRR (%)
Case 1	19.2
Case 2	28.0
Case 3	20.9
Case 4	11.9

Even under the most unfavorable condition for the project, i.e., Case 4, the project will expect the return of 11.9% in FIRR. The project can be assessed viable in terms of financial analysis.

8.4.3 Loan Repayability

(1) Terms of loan

Following are assumed as the terms of loan so as to examine the loan repayability of the Project:

1) Loan

SONEL is financially independent of the Cameroon Government. No grant aid from the government is, therefore, assumed for the project implementation. One of the most applicable scenarios SONEL might go is multi-financing as listed below:

2 This is a case that is very close to the revised tariff system in 1993.