1.2 Construction Schedule

1.2.1 Construction Period and Time Target

The 7 years implementation period including financial arrangement is recommended for the project after the completion of the feasibility study. First 3 years are required for the arrangement of construction finance, the selection of engineering consultant, the detailed engineering services and the tendering time, and latter 4years are required for the construction work of the project. In order to secure this target, the following basic schedule shall be kept in the process of the project.

a) Financial arrangement	:	For 9 months from January 1986 to September 1986.
b) Contracting of engineering services	:	For 3 months from October 1986 to December 1986.
c) Engineering services for detailed design	:	For 14 months from January 1987 to February 1988.
d) Tender and contract including prequalification	:	Completion in December 1988. Prequalification: for 3 months from December 1987 to February 1988. Tender and contract: for 10 months from March 1988 to December 1988.
e) Main construction works	:	Commencement in January 1989. Completion in December 1992. Within 48 months.
f) Commissioning of commercial operation of power station	:	At beginning of January 1993.

The construction schedule noted above is programmed on the condition that the contractor for construction and installation works will be selected by international competitive tender. The arrangement of construction finance shall be made by the Ministry of Energy and Regional Development / the Lake Basin Development Authority, just after the completion of the feasibility study.

1.2.2 Engineering Services for Detailed Design, Pre-construction Stage and Construction Supervision

The engineering services for detailed design consist of the works for the topographic survey, subsurface and material investigation, detailed design, preparation of drawings and bill of quantity, preparation of tender document and cost estimate, preparation of design report. The detailed design will be performed by the consultant for 14 months from January 1987 to February 1988. The consultant will also assist in prequalification of contractors. Upon the completion of the prequalification in February 1988, the tendering, evaluation and contracting are scheduled to be executed in 10 months. The contract awarding will be done by the end of December 1988. The engineering services for construction supervision are scheduled to be commenced from January 1989 for 4 years.

1.2.3 Construction Schedule

The construction works will be performed for 4 years from January 1989 to December 1992. The overall construction schedule is shown in Figure 1.1 by a bar chart. The land acquisition and compensation to be claimed for the construction of the project will be settled by the Lake Basin Development Authority in advance of the commencement of the construction. The major construction works involved in each year are described as follows:

1989

Immediately after concluding the contract, all preparatory works will be started in this year, inclusive of mobilization, procurement and transportation of construction materials, construction of access roads in the work site, temporary buildings and other facilities.

Main civil works will be commenced from two work adits of the headrace tunnel in April, just after the construction equipment and materials arriving at the site. Tunnel excavation of the headrace tunnel including penstock tunnel is scheduled to be started from June and to be continued to next year. Excavation and embankment works of the diversion channel for the intake weir are scheduled to be started in October and be completed by December. Road construction works of a new access road is scheduled to be completed in this year.

Upon the completion of contract awarding, the design and manufacturing for metal works relating to the weir, intake and penstock, electrical works for generating equipment, substation equipment and transmission line will be started by the contractor.

1990

Headrace tunnel excavation will be continued succeeding to the previous year, and is scheduled to be finished by the end of this year. A surge tank will be constructed in this year in parallel with the excavation works of the headrace tunnel.

Excavation works for the intake weir, intake and desilting basin will be completed by March. Grouting work for the intake weir portion and overflow section is scheduled in this year. Concrete work for the weir, pier and overflow section is scheduled to be commenced in May, whilst in October for the intake and desilting basin.

Excavation works along the penstock line are scheduled to be commenced in May and slab concrete work will be started from October. Excavation and concrete works for the tailrace and substructure and superstructure of powerhouse are scheduled to be completed by the end of this year.

Succeeding to the previous year, the design and manufacturing for metal works, generating equipment, substation equipment and transmission line will be continued. The shipping and transportation is scheduled to be made from April. Installation of an orifice gate steel conduit for the intake weir will be started in October. Intake metal work will be also started in December.

1991

Arch concrete-lining work for the headrace tunnel is scheduled to be commenced in January. Removal of cofferdams is scheduled to be performed in October after the completion of installation of the weir orifice gate. Intake weir concrete work for the remaining overflow section and non-overflow section will be performed from November. Remaining civil works for the intake and desilting basin will be performed in this year.

Building works for the power station are scheduled to be performed from January to December. After the completion of installing an overhead crane in January, the installation of draft-tubes and casing is scheduled to be commenced from February. The second concrete work will be performed from March to May and the installation of turbines and generators is scheduled to be commenced from June.

Succeeding to the previous year, the installation of gates, trashracks, rakes and stoplogs will be continued and completed in this year. Steel pipe installation for the penstock line is scheduled to be started in March, after the completion of its civil works. Construction of transmission line is scheduled to be started in February. The shipping and transportation for penstock metal works and generating equipment are to be continued by middle of this year and the end of this year respectively.

1992

Invert concrete-lining for the headrace tunnel is scheduled to be started in March, after the completion of arch concrete-lining work. Backfill grouting and consolidation grouting for the headrace tunnel will be performed from May to September. Remaining concrete work for the intake weir is scheduled to be completed by February.

Succeeding to the previous year, the installation of a penstock steel pipe, generating equipment and transmission line construction will be continued and completed by August. Installation of a switchgear and substation equipment is also scheduled to be performed in this year.

Dry test operation of turbines and generators is scheduled to be conducted in June. Wet test operation is scheduled to be conducted within three months by the end of this year so that the commercial operation will be commenced from the beginning of January 1993.

1.3 Construction Plan and Method

The construction plan of the project is worked out on the basis of the mode and target schedule of construction. Taking into consideration, in addition to the above, such conditions as availability of construction forces, weather condition, geological and topographic conditions of the site, the mechanized construction method is applied in principle.

With regard to the workable days, it is assumed to be 240 days per year for excavation and embankment works. While, the workable day for concrete work, grouting work, tunnel work and shaft work is to be 300 days per year. As for the daily working hours, one 8 hours shift per day is applied for earthwork and concrete work and two 10 hours shift per day is applied for tunnel work.

1.3.1 Preparatory Works and Construction Facilities

Substantial facilities for the construction use, such as temporary access roads from the permanent access road to each work site, water supply, power supply, air supply, telecommunication, temporary buildings and construction plant, shall be constructed by the contractor in principle. These facilities will be maintained by the contractor during the whole construction period. These preparatory works are scheduled to be performed within the first year.

(1) Access road

Since there is no available road to the intake weir site, tunnel portal and power station site, access roads will be connected from the existing earth roads. These access roads of 21.4 km in total will be used as the permanent access roads after the completion of the project.

The temporary access roads required for construction services will be branched off from the permanent access roads.

(2) Temporary buildings

Temporary buildings are required for the construction use; the employer's office, contractor's office, quarters, repair shop, steel work shop, warehouse and labour quarters which will be provided by contractor in and near the project site. The temporary buildings of about 5,000 m^2 in total floor area will be necessary based on the required staff and labour force of 500 persons. The land of 2.4 ha required for the temporary buildings and construction facilities will be acquired by the Lake Basin Development Authority in advance of the commencement of construction.

(3) Water supply

Water required for the construction and camp use is to be taken from the Sondu River and other suitable tributaries. The water supply facility of 4.3 m^3/min in total capacity is required.

(4) Power supply

Power for the construction and camp use is planned to be supplied by diesel generators with total installed capacity of 1,800 KW.

(5) Telecommunication system

An internal telecommunication system for the project will be installed so as to execute smooth operation of the construction.

1.3.2 River Diversion

River diversion during construction of the intake weir, intake and desilting basin structures is made by a diversion channel planned at the left abutment. The cofferdam of 250m in total length is constructed at the downstream and upstream, and along the diversion channel. The diversion channel and cofferdams are scheduled to be constructed for 3 months from October 1989 and the removal of cofferdams will be performed in October 1991 after the completion of weir metal work.

Channel excavation will be carried out by using 7 m^3/min crawler drills, 21-ton bulldozers with ripper, 2.3 m^3 tractor shovels and 11-ton dump trucks. The embankment material will be transported from the disposal area of excavated material, spreaded by 11-ton bulldozers and compacted by 5-ton vibrating rollers.

1.3.3 Waterway

(1) Intake weir, intake and desilting basin

The intake weir with two orifice gates is to be 23 m in height, 80 m in length and 24,450 m^3 in concrete volume. The intake and desilting basin is 29 m in width (max.), 103 m in length and 18,830 m^3 in concrete volume. The construction works for the above structure will be made from January 1990 soon after the river is diverted through the channel.

Foundation excavation of 17,480 m^3 for the intake weir and 51,150 m^3 for the intake and desilting basin will be carried out by using 7 m^3/min crawler drills, 21-ton bulldozers with ripper, 2.3 m^3 tractor shovels and

11-ton dump trucks. Fill and backfill for the intake weir and desilting basin are estimated at 6,210 m^3 and 26,690 m^3 respectively. The fill and backfill materials will be hauled from the disposal area, and will be spreaded by 11-ton bulldozers and compacted by 5-ton vibrating rollers.

Consolidation and curtain grouting works for the intake weir are 550 m in length and 1,800 m in length respectively. Grouting works will be carried out by drilling with 5.5 kw rotary drills and injecting with 7.5 kw grout pumps and 200 lit x 2 grout mixers.

One concrete plant with 1.0 m^3 mixers will be installed at the weir site for the construction work of intake structure and headrace tunnel. The concrete will be transported by 3.2 m^3 agitators and placed by 20-ton truck cranes with a 1 m^3 bucket and 45 m^3/h concrete pump car.

Intake weir metal work consists of two sets of weir orifice gate and one set of weir orifice stoplog. The intake and inlet metal works consist of four sets of intake gate, one set of service gate and monorail crane, one set of intake trashrack, one set of intake mechanical rake, one set of inlet stoplog and one set sand flush facility. The installation works for weir metal work and intake metal work will be performed in 11 months from October and in 12 months from December respectively.

The gate leaves, guide frames, hoists and necessary accessaries for the weir orifice gate and intake gate will be fabricated at the contractor's factory in sub-assembly units convenient for transportation from the Mombasa port to the field shop in the project site.

The sub-assemblies delivered to the project site will be carried to the installation site by using 20-ton trailers and handled by 20-ton truck cranes. Other metal works will be performed in a similar way.

(2) Headrace tunnel

The headrace is a concrete-lined tunnel of 4.2 m in diameter and 4,314 m in length. Two work adits of 4.0 m in width and 400 m in total length are planned to be driven at the distance of 150 m and 50 m from the downstream portal and upstream portal respectively, in order to excavate the tunnel in parallel with the construction works for the intake structure and surge tank. The construction period including work adits and grouting works is planned to be 3.5 years.

Excavation of both adits is scheduled to be started simultaneously and will be made by the full-face attack method. The headrace tunnel excavation of 87,570 m^3 is scheduled to be performed in 19 months. The full-face attack method is to be applied for the excavation and the hauling of tunnel spoil is to be made by the rail method. Two tunnel faces are set up to be attacked from both ends simultaneously. Drilling will be carried out by using a drill jumbo with a drifter and broken rocks will be hauled by using a 0.6 m^3 muck loader and 4.5 m^3 muck car with a 10 ton battery locomotive. The driving progress speed is planned to be 220 m per month (110 m/set x 2 faces).

An arch and then invert method is applied for concrete-lining work. The concrete lining work of 20,450 m^3 is scheduled to be performed in 18 months including invert concrete and 2 sets of construction equipment will be used simultaneously. Concrete will be transported by a 3.2 m^3 agitator from the 1.0 m^3 batcher plant to both tunnel portal, discharged into the 3 m^3 pneumatic placer with the 4 ton battery locomotive and placed behind the sliding form of 12 m in span by means of the pneumatic placer. The concrete-lining progress is planned to be 300 m per month (150 m/set x 2 sets). Upon the completion of arch concrete-lining, invert concrete will be placed by the invert finisher in combination with a 3 m^3 agitator car and 4 ton battery locomotive.

Backfill grout and consolidation grout will follow the invert concrete lining work. The backfill mortar grout of 8,730 m^3 will be carried out by using 11 kw low pressure grout pumps. The consolidation grouting work of 4,750 m will be carried out by drilling with leg hammers and injected by 7.5 kw grout pumps and 200 lit x 2 grout mixers.

(3) Surge tank

A vertical shaft of 10 m in diameter and 51.9 m in height is planned to be constructed at the downstream end of headrace tunnel. Shaft excavation and concrete is estimated at 4,870 m^3 and 1,320 m^3 respectively. The underground portion is about 40 m and a pilot shaft enlargement method is to be applied for the shaft excavation.

The surge tank construction is scheduled to be made for 9 months. Open cut excavation of 11,260 m^3 will be carried out by using 7 m^3/min crawler drills, 21-ton bulldozers with ripper, 2.3 m^3 tractor shovels and 11-ton dump trucks.

The pilot shaft of 2 m x 2 m is excavated at the centre of shaft upward from the bottom. A raise climber will be used for the pilot shaft excavation and muck disposal will be done from the penstock tunnel. After the pilot shaft is rised up, enlarging to full shaft diameter will be made by drilling and shooting with the 7 m^3/min crawler drills and jackhammers. The progress per day is planned to be 1.2 m. Broken rocks will be dropped into the pilot shaft using 0.3 m^3 backhoes and loaded out by using 1.2 m^3 tractor shovels and 6-ton dump trucks at the bottom.

Concrete-lining work is divided into two stages, i.e., initial concrete-lining of 40 cm in thickness and second concrete-lining of 40 cm in thickness. The initial concrete-lining work will be done at every stage following drilling and shooting works of 1.2 m progress. The second concrete-lining work will be made upward from the shaft bottom, after the completion of shaft enlargement and initial concrete-lining works. The concrete will be discharged into a 1 m^3 bucket from a 3.2 m^3 agitator, handled to the concrete hopper by a 20-ton truck crane and distributed into the placing spot through a chute.

(4) Penstock tunnel and penstock line

A steel penstock of 3.3 to 2.1 m in diameter and 1,110.7 m in length consists of the upper penstock tunnel portion of 76 m and inclined open portion of 1,034.7 m. All the installation work including tests is scheduled to be completed by the end of August 1992 one month before the final wet test of generating equipment.

The penstock tunnel excavation of 2,880 m^3 and concrete of 1,650 m^3 will be executed in a similar way to the headrace tunnel and is scheduled to be completed prior to headrace tunnel excavation work.

Open cut excavation of 66,140 m^3 will be carried out using 7 m^3/min crawler drills, 21-ton bulldozers with ripper, 2.3 m^3 tractor shovels and 11-ton dump trucks. Concrete placing in the open portion of 5,340 m^3 will be performed by a 20-ton truck crane with a 1 m^3 bucket and 45 m^3/h concrete pump car.

Penstock metal work consists of one lane of penstock and one set of penstock valve. Installation work will be performed in 1.5 years from March 1991.

The penstock steel plate will be fabricated at the contractor's factory in piece and transported from the Mombasa port to the stock yard in the project site. The steel plate segment will be welded by an automatic welding machine into 6 m long segment at the site work shop. Each pipe segment will be transported to the installation site by 20-ton trailers. As for the penstock installation in the tunnel, the penstock-unit will be transported using rails mounted carriers. The installation works for inclined open portion will be made using an incline machine with a carrier and 30-ton truck crane.

1.3.4 Power Station

The powerhouse of reinforced concrete structure (21.0 m in length, 35.0 m in width and 24.0 m in height) is constructed to accommodate two units of 25 MW Francis type turbines and 27 MVA generators. The construction of power station including the tailrace, powerhouse, building work, switchyard and the installation of turbines and generators is planned to be performed in 3 years.

The powerhouse structure will be constructed in two stages. The first stage construction consists of substructure and overhead crane. The second stage construction consists of the installation of draft-tube, casing, turbine, generator and the second stage concrete.

Foundation excavation of 53,720 m^3 for powerhouse and 35,360 m^3 for tailrace will be carried out in 7 months, using 7 m^3/min crawler drills and 21-ton bulldozers with ripper. Excavated materials will be loaded by 2.3 m^3 tractor shovels into 11-ton dump trucks for hauling to the disposal area.

Immediately after the foundation excavation, concrete work of 4,650 m^3 will be performed from the substructure, which will be completed before the installation of overhead crane. Tailrace concrete work of 4,250 m^3 will be made in parallel with the substructure concrete work. The draft-tube and casing will be installed using the overhead crane. Subsequently, the second stage concrete around the draft-tube and casing and the remaining concrete will be placed according to the progress of installation of turbines and generators. Concrete will be supplied from the concrete plant which will be installed for common use for the headrace tunnel, surge tank, penstock tunnel and penstock line.

Substructure concrete will be transported by 3.2 m^3 agitators and placed by 45 m^3/h concrete pump cars and a 20-ton crane with 1 m^3 bucket. The second concrete and the remaining concrete will be placed by 45 m^3/h concrete pump cars.

Following the substructure construction, the superstructure construction and building finish work will be started in parallel with the installation of turbines and generators.

With regard to the generating equipment, substation equipment and transmission line, it will take approximately 3.5 years from the contract until completion of the installation works. Installation work of each unit of generating equipment will be performed for 1 year, except for the works for the draft-tube and casing. Test runs of generating equipment will be performed for 5 months in total of 2 months in dry condition and 3 months in wet condition.

Construction of the transmission line of 132 KV and substation is scheduled to be carried out for 1.5 years from February 1991. Installation works will be completed by August 1992 one month before wet tests of generating equipment.

1.4 Major Construction Equipment

As the result of the study of construction method, the major plant and equipment to be used for the construction of the project are shown in Table 1.1.

Chapter 2. COST ESTIMATE

2.1 Construction Cost

2.1.1 General

The construction cost for the implementation of the project is estimated on the basis of work quantities measured through the preliminary design and the unit prices are estimated for each item of work. For the cost estimate, local conditions, available equipment and materials, suitability of construction method, etc. are taken into account. The foreign and local currency portions of the construction cost are estimated at US Dollar and Kenya Shilling respectively and then converted to Kenya Shilling.

Cost estimates are prepared on the following basic assumptions and conditions:

Price Level : The prices are based on the current prices for labour, materials and equipment as of December 1984.

Exchange Rate : The ruling exchange rate used in this estimate is 1.00 US Dollar = 15.0 Kenya Shilling = 240 Japanese Yen.

All the construction work will be carried out by a contractor through international competitive tendering. The construction cost of the project is divided into the direct cost (contract cost) for preparatory works, main civil works, metal works, generating equipment & substation equipment and transmission line, and the indirect cost for land acquisition, administration expenses, engineering services and contingencies.

2.1.2 Construction Cost Estimation

(1) Preparatory works

The preparatory works include temporary access road, water supply, power supply, air supply, telecommunication, temporary buildings and other temporary works, etc. The cost for preparatory works is estimated at 10 percent of the sum of main civil works, metal works, generating equipment & substation equipment and transmission line.

(2) Main civil works

The direct cost of main civil works is estimated by adopting unit prices and lump sum prices. The cost estimate is based on the expense of labour, materials and construction equipment and plant. In addition to the direct cost, the contractor's indirect costs (overhead expenses and profit) are included in each unit price. Unit prices for each work item adopted for the cost estimate are shown in Table 2.1. The main components of the cost are described as follows:

Labour cost

Direct daily wages in 8 hour shift of local labour are based on the data and information obtained in Nairobi and the project area. The labour cost is presented in Table 2.2 and this cost does not include any overtime for Sunday and Public Holiday.

Material cost

Most of construction materials are supplied from local market. The local prices on materials used for the cost estimate are canvassed from Mombasa, Nairobi, Nakuru and Kisumu and are proportioned into foreign and local component. The imported material cost is estimated on the basis of C.I.F. price and added sales tax and duties. The local supplies are to be the purchased price at the site. The material cost used in the cost estimate is shown in Table 2.3.

Equipment cost

The cost estimate is based on the concept that construction equipment and plant will be purchased and owned by a contractor. The equipment cost is divided into foreign and local components. The foreign currency portion includes depreciation cost, spare parts and consumable cost, while the local component includes the cost of mechanic labour cost for the repair and administration expenses, import fees, taxes and duties. The equipment cost is estimated based on the purchase prices including C.I.F. prices, taxes and duties. The major equipment cost is shown in Table 2.4.

Contractor's indirect cost (overhead expenses and profit)

The overhead expenses comprise general administrative expenses and field expenses. The general administrative expenses are salaries and allowance for the contractor's personnel, legal welfare expense, travelling and communication expense, depreciation, insurance, profit and so on. The field expenses are allowance for the contractor's personnel, labour control expense, local taxes, stationery and communication expenses and so on.

The overhead expenses and profit contributed to the unit price or lump sum price of each work item are estimated at 25 percent of the direct cost including labour cost, material cost and equipment cost.

(3) Metal works

The metal works include the supply and installation of gates, stoplogs, trashracks, steel penstocks and valves. These equipment and facilities are planned to be imported. The cost estimate for these metal works is made on the basis of unit price per ton of the current international contract prices for similar works, and the tax and duties are excluded. The cost is estimated on the basis of F.O.B. price in Japan.

The costs for supply and delivery on imported item, ocean freight and insurance are considered to be foreign currency portion. The costs for unloading and other charges at Mombasa port and inland transportation are estimated by local currency. The cost of installation is estimated to be at about 36 percent of F.O.B. price for weir and intake metal works. As for the penstock installation, 76 percent of F.O.B. price is applied. About 80 percent of installation cost is assumed to be foreign currency portion and the remaining is for local portion.

(4) Generating equipment and transmission line

The cost for the generating equipment, substation equipment and transmission line is estimated on the basis of the current international contract prices, and the tax and duties are excluded. The cost is estimated on the basis of F.O.B. price in Japan. The costs for supply and delivery on imported item, ocean freight and insurance are considered to be foreign currency portion. The costs for unloading and other charges at Mombasa port and inland transportation are estimated by local currency. The installation cost is estimated at 25 to 45 percent of the F.O.B. price for generating equipment and substation equipment. As for the transmission line, it is estimated at 60 percent. About 75 percent of installation cost is assumed to be foreign currency portion and the remaining is for local portion.

(5) Land aquisition and compensation cost

All required lands and right of way shall be acquired by the Lake Basin Development Authority in accordance with the project implementation schedule. The costs for land acquisition and compensation are shown in Table 2.5.

(6) Administration expenses

An allowance of 2 percent of the direct cost (contract cost) is provided for the government administration expenses of the project.

(7) Engineering services

The cost of the engineering services for construction supervision is estimated on man-month base. In addition, the cost for detailed design and preparation of tender document in the pre-construction stage is estimated at US$ 3 million.

(8) Contingency

The contingency is provided to cope with unforeseen physical conditions and price escalation due to inflation. The physical contingency is estimated at 10 percent of the amount of preparatory works, main civil works, land acquisition and compensation, administration expenses and engineering services. As for the metal works, generating equipment & substation equipment and transmission line, the cost for the physical contingency is estimated at 5 percent of the amount for the direct cost. The price contingency is estimated by applying the inflation rate of 3 percent per annum for foreign currency portion and 9 percent of local currency portion. The price escalation is estimated on the disbursement schedule.

2.1.3 Construction Cost

The construction cost for the project is estimated at KShs. 1,320.9 million equivalent in total, consisting of KShs. 1,004.0 million equivalent in foreign currency portion (US$ 66.9 million 76%) and KShs. 316.9 million in local currency portion (24%). The construction cost and detailed cost estimate are shown in Table 2.6 and Table 2.7 respectively. The breakdown of construction cost is shown in Table 2.9.

2.2 Annual Disbursement Schedule

The annual disbursement of construction cost for foreign and local currencies is estimated on the basis of the construction schedule. The disbursement schedule is shown in Table 2.8 and summarized as follows.

	Foreign Currency		Local Currency	Total
Year	Mill. US$	Mill. KShs.	Mill KShs.	Mill. KShs
1987	(3.00)	45.00		45.00
1989	(16.66)	249.94	82.04	331.98
1990	(15.93)	238.98	110.98	349.96
1991	(23.30)	349.54	82.58	432.12
1992	(8.04)	120.58	41.27	161.85
Total	(66.93)	1,004.04	316.87	1,320.91

TABLES

Table 1.1 Major Construction Plant and Equipment

Item No.	Description	Spec.	Total Required Number
1	Bulldozer w/ripper	21 ton	7
2	Bulldozer	11 ton	5
3	Tractor shovel	2.3 m^3	6
4	Tractor shovel	1.6 m^3	3
5	Backhoe	0.6 m^3	2
6	Backhoe	0.3 m^3	1
7	Dump truck	11 ton	30
8	Dump truck	6 ton	10
9	Vibrating roller	5 ton	3
10	Crawler drill	7 m^3/min	12
11	Air compressor	10 m^3/min	12
12	Concrete plant	1.0 m^3	2
13	Crushing plant	100 ton/h	1
14	Agitator truck	3.2 m^3	8
15	Concrete bucket	1.0 m^3	2
16	Concrete pump car	45 m^3/h	2
17	Boring machine	5.5 kw	3
18	Grout pump	7.5 kw	6
19	Grout mixer	200 lit x 2	6
20	Truck crane	32 ton	2
21	Truck crane	20 ton	2
22	Trailer	20 ton	2
23	Motor grader	3.7 m	1
24	Sprinkler truck	6 klit	1
25	Leg hammer	30 kg	5
26	Sinker	24 kg	5
27	Raise climber		1
28	Muck loader	0.6 m^3	2
29	Train loader	200 t/h	2
30	Muck car	4.5 m^3	26
31	Battery locomotive	10 ton	4
32	Ventilation fan	300 m^3	24
33	Ventilation fan	100 m^3	4
34	Air compressor	27 m^3/min	4
35	Drill jumbo	7-boom	2
36	Battery locomotive	4 ton	6
37	Concrete placer	3.0 m^3	6
38	Agitator car	3 m^3	4
39	Sliding form	12 m	2
40	Grout pump	11 kw	2
41	Grout mixer	300 lit x 2	2
42	Winch	100 kw	1

Table 2.1 Unit Price for Major Civil Works

Work Item	Unit	Foreign Currency (US$)	Local Currency (KShs.)
Excavation, common (L=1,000m)	m^3	3.30	11.00
- do - (L=2,000m)	m^3	3.80	12.20
- do - (L=3,000m)	m^3	4.10	13.60
Excavation, weathered rock (L=1,000m)	m^3	4.80	16.50
- do - (L=2,000m)	m^3	5.30	18.00
- do - (L=3,000m)	m^3	5.80	19.50
Excavation, rock (L=1,000m)	m^3	10.10	55.60
- do - (L=2,000m)	m^3	10.60	57.60
- do - (L=3,000m)	m^3	11.20	59.90
Embankment (L=500m)	m^3	3.80	13.80
Fill & backfill (L=1,000m)	m^3	4.40	15.80
- do - (L=2,000m)	m^3	4.80	17.00
- do - (L=3,000m)	m^3	5.20	18.20
Excavation, tunnel	m^3	44.10	369.00
- do - , shaft	m^3	33.20	201.00
Concrete, weir, slab	m^3	42.50	342.00
- do - , structure (L=6,000m)	m^3	50.40	402.00
- do - , structure (L= 500m)	m^3	44.20	376.00
- do - , superstructure	m^3	45.40	409.00
- do - , tunnel	m^3	54.60	478.00
- do - , shaft	m^3	60.50	482.00
Formwork, weir	m^2	2.00	49.80
- do - , structure	m^2	2.50	55.50
- do - , tunnel	m^2	7.40	36.40
- do - , shaft	m^2	16.00	81.30
Reinforcing bar	ton	504.00	4,190.00
Steel support	ton	700.00	4,500.00
Steel structure	ton	1,050.00	5,250.00
Consolidation grout, open	m	46.30	246.00
- do - , tunnel	m	32.90	238.00
Curtain grout	m	81.00	536.00
Backfill grout	m^3	38.00	385.00
Gravel surface	m^3	10.90	46.60
Slope protection, concrete	m^2	8.80	75.20
- do - , gunite	m^2	13.00	138.00
Asphalt pavement	m^2	10.30	6.30
Fence	m	10.00	96.00
U-drain ditch	m	4.40	100.00

Table 2.2 Labour Cost (Wage Rate)

Description	Unit	Foreign Currency (US$)	Local Currency (KShs.)
Foreman	M.D	145	-
Foreman A	M.D	-	85
Foreman B	M.D	-	70
Operator A	M.D	-	75
Operator B	M.D	-	65
Assistant operator	M.D	-	60
Driver	M.D	-	60
Mechanic A	M.D	-	80
Mechanic B	M.D	-	60
Electrician A	M.D	-	80
Rigger A	M.D	-	70
Carpenter B	M.D	-	60
Boring worker A	M.D	-	75
Concrete worker A	M.D	-	70
Driller A	M.D	-	70
Driller B	M.D	-	60
Tunnel worker A	M.D	-	70
Pipe fitter	M.D	-	60
Powder operator	M.D	-	70
Reinforcement worker	M.D	-	70
Grout worker A	M.D	-	75
Grout worker B	M.D	-	65
Pavement worker	M.D	-	60
Skilled labor	M.D	-	40
Common labor	M.D	-	30

Table 2.3 Material Cost (1/2)

Description	Unit	Foreign Currency (US$)	Local Currency (KShs.)
Gasoline	lit	0.4	2.0
Light oil	lit	0.4	-
Electric	kwh	-	1.0
Lubricant	lit	1.7	-
Grease	kg	2.7	-
Portland cement, ordinary	ton	46.7	700.0
Air-entraining agent	kg	1.0	7.8
Water-reducing agent	kg	1.4	10.8
Air-bubble agent	kg	2.4	18.0
Reinforcing bar	ton	370.0	2,400.0
H-shape steel	ton	700.0	4,500.0
Channel steel	ton	560.0	3,600.0
Dynamite	kg	4.8	36.3
ANFO powder	kg	1.5	11.3
Detonator, ordinary	no.	0.8	5.6
Detonator, delay	no.	0.9	6.6
Timber, plank	m^3	-	2,500.0
Timber, square	m^3	-	2,000.0
Timber, log	m^3	-	1,800.0
Metal form, 300 x 1500	no.	12.4	93.1
Metal form, 200 x 1500	no.	12.5	94.1
Metal form, 150 x 1500	no.	9.7	72.8
Metal form, 100 x 1500	no.	8.4	63.1
Separator, 8-10mm dia.	m	0.3	2.4
Cone	no.	0.2	1.1
Form oil	lit	1.3	9.7
Cast iron pipe, 75mm dia.	m	11.3	84.4
Gas pipe, 65mm	m	4.8	35.9
Galvanized pipe, 100mm	m	7.8	58.8
Galvanized pipe, 150mm	m	13.0	97.8
Galvanized pipe, 200mm	m	19.8	149.0
P.V.C. pipe, 40mm	m	1.0	7.5
Vinyl vent pipe, 400mm	m	5.1	38.4
Vinyl vent pipe, 500mm	m	6.4	48.1
Spiral bent pipe, 600mm	m	14.6	109.0
Annealed iron wire	kg	-	15.0
Lozenge-shaped net, 14 mesh	m^2	2.0	15.0
Cross bit, 36mm	no.	28.8	216.0
Cross bit, 38mm	no.	29.7	223.0
Cross bit, 44mm	no	33.1	248.0
Cross bit, 50mm	no.	45.0	338.0
Cross bit, 55mm	no.	48.3	363.0
Insert bit, 22mm	no.	61.3	459.0
Taper rod, 22mm	no.	31.4	235.0
Taper rod, 22mm	no.	39.5	297.0
Taper rod, 25mm	no.	63.8	478.0

Table 2.3 Material Cost (2/2)

Description	Unit	Foreign Currency (US$)	Local Currency (KShs.)
Rod, crawler drill, 35D, 3m	no.	143.8	1,080.0
Rod, crawler drill, 35D, sleeve	no.	43.8	328.0
Rod, crawler drill, 35D, shank	no.	98.0	734.0
Rod, crawler drill, M110, 3m	no.	143.8	1,080.0
Rod, crawler drill, M110, sleeve	no.	43.8	328.0
Rod, crawler drill, M110, shank	no.	97.9	734.0
Injection branch	no.	167.9	126.0
Injection hose	m	16.3	122.0
Return hose	m	0.1	0.9
Boring rod, 40.5mm	m	55.4	416.0
Metal bit, 46mm	no.	16.5	124.0
Tube core barrel, 46mm	no.	71.2	534.0
Diamond bit	carat	41.7	312.0
Diamond reamer	carat	41.7	312.0
Sand at quarry	ton	-	15.0
Asphalt emulsion	lit	1.3	-
Asphalt mixture	ton	26.7	400.0

Table 2.4 <u>Major Equipment Cost (1/2)</u>

Description	Unit	Foreign Currency (US$)	Local Currency (KShs.)
Bulldozer, 21 ton	Hr	33.49	150.80
Bulldozer, 11 ton	Hr	18.69	84.10
Bulldozer w/ripper, 21 ton	Hr	39.35	178.70
Backhoe, 0.3 m^3	Hr	14.74	65.60
Tractor shovel, 1.6 m^3	Hr	19.75	89.60
Tractor shovel, 2.3 m^3	Hr	27.53	125.00
Muck loader, 0.6 m^3	Hr	33.17	152.70
Dump truck, 11 ton	Hr	10.21	45.70
Battery locomotive, 4 ton	Hr	14.70	73.20
Battery locomotive, 10 ton	Hr	37.44	186.60
Muck car, 4.5 m^3	Day	12.42	57.40
Truck crane, 20 ton	Hr	26.63	112.70
Grout pump, 7.5 kw	Day	17.25	76.30
Grout pump, 11 kw	Day	22.33	98.90
Grout mixer, 200lit x 2	Day	7.70	34.10
Grout mixer, 300lit x 2	Day	9.70	42.90
Crawler drill, 7 m^3/min	Hr	13.03	56.10
Leg hammer, 30 kg	Day	5.13	21.20
Pick hammer, 7.5 kg	Day	0.64	2.60
Drifter 30 kg	Day	7.48	30.90
Drill jumbo, 7-boom	Day	17.82	78.10
Guide shell, 2.0m, 30kg	Day	10.38	44.20
Boring machine, 5.5 kw	Day	20.93	91.80
Jack hammer, 15 kg	Day	5.56	23.00
Train loader, 200 t/h	Day	83.05	352.70
Motor grader, 3.7 m	Hr	18.90	82.90
Vibrating roller, 5 ton	Hr	7.50	32.50
Agitator truck, 3.2 m^3	Hr	11.36	49.60
Concrete pump car, 45 m^3/h	Hr	29.72	136.90
Concrete placer, 3.0 m^3	Hr	13.06	58.50
Concrete bucket, 1.0 m^3	Day	17.47	77.10
Concrete plant, 1.0 m^3	Hr	61.78	274.20
Agitator car, 3 m^3	Hr	10.98	49.20
Air compressor, 10 m^3/min	Day	52.71	233.80
Air compressor, 27 m^3/min	Hr	5.88	25.50
Ventilation fun, 300 m^3/min	Day	19.12	81.20
Ventilation fun, 100 m^3/min	Day	0.97	4.10
Sprinkler truck, 6.3 klit	Hr	9.13	40.20
Jaw crusher, single, 600x900	Hr	13.38	61.80
Cone crusher, 900 mm	Hr	16.73	72.00
Spiral classifier, 900x6500	Hr	6.17	27.80
Vibrating feeder, 50 t/h	Day	4.80	19.90
Vibrating feeder, 100 t/h	Day	7.00	29.00
Apron feeder, 1000x3500	Hr	13.02	58.30
Vib. screen, 1200x3000	Hr	2.94	13.80
Vib. screen, 1800x4200	Hr	4.90	23.20

Table 2.4 Major Equipment Cost (2/2)

Description	Unit	Foreign Currency (US$)	Local Currency (KShs.)
Belt conveyor, 15x300mm	Hr	1.44	5.50
Belt conveyor, 30x450mm	Hr	3.72	14.20
Belt conveyor, 30x600mm	Hr	4.78	18.30
Belt conveyor, 15x750mm	Hr	3.47	13.20
Grizzly	Day	118.13	506.10

Table 2.5 Land Acquisition

(Unit: KShs.)

	Description	Quantity (ha)	Unit Rate	Total
1.	Reservoir and Intake	3.6 14.4	11,000/ha 7,500/ha	39,600 108,000
2.	Surge Tank	0.3	7,500/ha	2,250
3.	Penstock Line	1.0	7,500/ha	7,500
4.	Tailrace, Powerhouse and Switchyard	2.4	7,500/ha	18,000
5.	Substation	0.1	7,500/ha	750
6.	Temporary Facilities	2.4	7,500/ha	18,000
	Total	24.2		194,100

Table 2.6 Construction Cost

Description	Foreign Currency (1,000 US$)	Local Currency (1,000 KShs.)	Total (1,000 KShs.)
1. Preparatory works	4,005.0	14,631.6	74,706.6
2. Civil works	14,009.8	106,884.5	317,031.5
3. Metal works	8,338.0	11,815.4	136,885.4
4. Generating equipment & substation equipment	15,928.0	22,152.0	261,072.0
5. Transmission line	1,774.0	5,464.0	32,074.0
Total (1 - 5)	44,054.8	160,947.5	821,769.5
6. Land acquisition & compensation	-	194.1	194.1
7. Administration expenses	-	16,435.4	16,435.4
8. Engineering services	6,030.0	-	90,450.0
Total (1 - 8)	50,084.8	177,577.0	928,849.0
9. Physical contingency	3,706.5	15,786.2	71,383.7
10. Price escalation	10,144.4	123,510.7	275,676.7
Grand total	63,935.7	316,873.9	1,275,909.4

Note: A cost of US$ 3 million is necessary for detailed design and preparation of tender document on the pre-construction stage besides the above costs.

Table 2.7 Detailed Construction Cost (1/2)

Description	Foreign Currency (1,000 US$)	Local Currency (1,000 KShs.)	Total (1,000 KShs.)
1. Preparatory works	4,005.0	14,631.6	74,706.6
2. Civil works			
2.1 River diversion	401.8	2,254.4	8,281.4
2.2 Waterway	1,579.9	12,331.4	36,029.9
2.2.1 Intake weir			
2.2.2 Intake and desilting basin	1,887.7	14,266.2	42,581.7
2.2.3 Headrace tunnel	6,209.1	51,223.6	144,360.1
2.2.4 Surge tank	438.5	2,883.4	9,460.9
2.2.5 Penstock	879.9	5,886.1	19,084.6
Sub-total (2.2)	10,995.1	86,590.7	251,517.2
2.3 Power station			
2.3.1 Tailrace	501.3	3,545.0	11,064.5
2.3.2 Powerhouse	814.9	5,385.1	17,608.6
2.3.3 Switchyard	136.4	732.1	2,778.1
2.3.4 Building works	474.5	4,107.5	11,225.0
Sub-total (2.3)	1,927.1	13,769.7	42,676.2
2.4 Outlet channel	101.6	514.0	2,038.0
2.5 Road construction	584.2	3,755.7	12,518.7
Total (2)	14,009.8	106,884.5	317,031.5
3. Metal works			
3.1 Weir metal work	758.5	1,211.4	12,588.9
3.2 Intake metal work	1,600.3	2,553.8	26,558.3
3.3 Penstock metal work	5,979.2	8,050.2	97,738.2
Total (3)	8,338.0	11,815.4	136,885.4
4. Generating equipment & substation equiupment			
4.1 Generating equipment	11,908.0	16,001.0	194,621.0
4.2 Substation equipment	4,020.0	6,151.0	66,451.0
Total (4)	15,928.0	22,152.0	261.072.0
5. Transmission line	1,774.0	5,464.0	32,074.0
Total (1 - 5)	44,054.8	160,947.5	821,769.5

Table 2.7 Detailed Construction Cost (2/2)

Description	Foreign Currency (1,000 US$)	Local Currency (1,000 KShs.)	Total (1,000 KShs.)
6. Land acquisition & compensation	-	194.1	194.1
7. Administration expenses	-	16,435.4	16,435.4
8. Engineering services	6,030.0	-	90,450.0
Total (1 - 8)	50,084.8	177,577.0	928,849.0
9. Physical contingency	3,706.5	15,786.2	71,383.7
10. Price escalation	10,144.4	123,510.7	275,676.7
Grand total	63,935.7	316,873.9	1,275,909.4

Note: A cost of US$ 3 million is necessary for detailed design and preparation of tender document on the pre-construction stage besides the above costs.

Table 2.8 Disbursement Schedule

(Unit: F.C. 1000 US$, L.C. 1000 KShs)

Description	Total		1989		1990		1991		1992	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
1. Preparatory Works	4,005.0	14,631.6	4,005.0	14,631.6	-	-	-	-	-	-
2. Civil Works										
2.1 River Diversion	401.8	2,254.4	395.4	2,233.7	-	-	6.4	20.7	-	-
2.2 Waterway	10,995.1	86,590.7	2,946.0	23,861.9	6,068.8	46,507.8	1,282.8	10,102.0	697.5	6,119.0
2.3 Power Station	1,927.1	13,769.7	192.7	1,377.0	1,013.0	6,933.0	699.6	5,236.7	21.8	223.0
2.4 Outlet Channel	101.6	514.0	10.1	51.4	-	-	67.7	227.4	23.8	235.2
2.5 Road Construction	584.2	3,755.7	584.2	3,755.7	-	-	-	-	-	-
Sub-total (2)	14,009.8	106,884.5	4,128.4	31,279.7	7,081.8	53,440.8	2,056.5	15,586.8	743.1	6,577.2
3. Metal Works										
3.1 Weir Metal Work	758.5	1,211.4	118.4	-	209.6	476.5	430.5	734.9	-	-
3.2 Intake Metal Work	1,600.3	2,553.8	249.7	-	394.7	699.1	955.9	1,854.7	-	-
3.3 Penstock Metal Work	5,979.2	8,050.2	703.0	-	1,205.2	1,712.9	2,511.6	3,692.1	1,559.4	2,645.2
Sub-total (3)	8,338.0	11,815.4	1,071.1	-	1,809.5	2,888.5	3,898.0	6,281.7	1,559.4	2,645.2
4. Generating Equipment and Substation Equipment										
4.1 Generating Equipment	11,908.0	16,001.0	1,765.0	-	1,474.0	1,668.1	6,924.4	10,611.6	1,744.6	3,721.3
4.2 Substation Equipment	4,002.0	6,151.0	586.6	-	-	-	2,449.1	2,772.9	984.3	3,379.0
Sub-total (4)	15,928.0	22,152.0	2,351.6	-	1,474.0	1,668.1	9,373.5	13,383.6	2,728.9	7,100.3
5. Transmission Line	1,774.0	5,464.0	235.0	-	490.5	555.3	737.9	3,029.9	310.6	1,878.8
Total (1 - 5)	44,054.8	160,947.5	11,791.1	45,911.3	10,855.8	58,552.7	16,065.9	38,282.0	5,342.0	18,201.5
6. Land Acquistion and Compensation	-	194.1	-	194.1	-	-	-	-	-	-
7. Administration Expenses	-	16,435.4	-	4,455.6	-	4,427.8	-	5,585.4	-	1,966.6
8. Engineering Services	6,030.0	-	1,634.7	-	1,624.5	-	2,049.3	-	721.5	-
Total (1 - 8)	50,084.8	177,577.0	13,425.8	50,561.0	12,480.3	62,980.5	18,115.2	43,867.4	6,063.5	20,168.1
9. Physical Contingency	3,706.5	15,786.2	1,159.7	5,056.1	1,059.3	6,042.5	1,111.1	3,252.0	376.4	1,435.6
10. Price Escalation	10,144.4	123,510.7	2,077.0	26,423.7	2,392.4	41,959.1	4,076.0	35,462.1	1,599.0	19,665.8
Grand Total	63,935.7	316,873.9	16,662.5	82,040.8	15,932.0	110,982.1	23,302.3	82,581.5	8,038.9	41,269.5

Note: A cost of US$ 3 million is necessary for detaied design and preparation of tender document on the pre-construction stage besides the above costs.

Table 2.9 Breakdown of Construction Cost (1/9)

(Unit: F.C. US$, L.C. KShs.)

Item No.	Description	Unit	Quantity	Foreign Currency		Local Currency	
				Unit Price	Amount	Unit Price	Amount
1.	Preparatory Works	L.S.			4,004,980		14,631,600
2.	Civil Works						
2.1	River Diversion						
(1)	Excavation, Common	m^3	18,000	3.80	68,400	12.20	219,600
(2)	Excavation, Rock	m^3	21,000	10.60	222,600	57.60	1,209,600
(3)	Embankment	m^3	1,880	3.80	7,140	13.80	25,940
(4)	Concrete	m^3	2,270	42.50	96,480	342.00	776,340
(5)	Removal of Cofferdam	m^3	1,880	3.80	7,140	12.20	22,940
	Sub-total (2.1)				401,760		2,254,420
2.2	Waterway						
2.2.1	Intake Weir						
(1)	Excavation, Common	m^3	8,630	3.80	32,790	12.20	105,290
(2)	Excavation, Rock	m^3	8,850	10.60	93,810	57.60	509,760
(3)	Fill and Backfill	m^3	6,210	4.80	29,810	17.00	105,570
(4)	Concrete, Weir	m^3	17,100	42.50	726,750	342.00	5,848,200
(5)	Concrete, Structure	m^3	5,250	44.20	232,050	376.00	1,974,000
(6)	Concrete, Slab & Base	m^3	2,100	42.50	89,250	342.00	718,200
(7)	Formwork, Weir	m^2	5,000	2.00	10,000	49.80	249,000
(8)	Formwork, Structure	m^2	3,080	2.50	7,700	55.50	170,940
(9)	Reinforcing Bar	ton	370	504.00	186,480	4,190.00	1,550,300
(10)	Consolidation Grouting	m	550	46.30	25,470	246.00	135,300
(11)	Curtain Grouting	m	1,800	81.00	145,800	536.00	964,800
	Sub-total (2.2.1)				1,579,910		12,331,360

Table 2.9 Breakdown of Construction Cost (2/9)

(Unit: F.C. US$, L.C. KShs.)

Item No.	Description	Unit	Quantity	Foreign Currency		Local Currency	
				Unit Price	Amount	Unit Price	Amount
2.2.2	Intake & Desilting Basin						
(1)	Excavation, Common	m^3	17,600	3.80	66,880	12.20	214,720
(2)	Excavation, Rock	m^3	33,550	10.60	355,630	57.60	1,932,480
(3)	Fill and Backfill	m^3	26,690	4.80	128,110	17.00	453,730
(4)	Concrete, Structure	m^3	13,070	44.20	577,690	376.00	4,914,320
(5)	Concrete, Slab & Base	m^3	5,760	42.50	244,800	342.00	1,969,920
(6)	Formwork	m^2	14,110	2.50	35,280	55.50	783,110
(7)	Reinforcing Bar	ton	940	504.00	473,760	4,190.00	3,938,600
(8)	Slope Protection, Gunite	m^2	430	13.00	5,590	138.00	59,340
	Sub-total (2.2.2)				1,887,740		14,266,220
2.2.3	Headrace Tunnel						
(1)	Excavation, All Class in Tunnel	m^3	87,570	44.10	3,861,840	369.00	32,313,330
(2)	Excavation, All Class in Work Adit	m^3	6,000	44.10	264,600	369.00	2,214,000
(3)	Steel Support	ton	74	700.00	51,800	4,500.00	333,000
(4)	Concrete, Tunnel	m^3	20,450	54.60	1,116,570	478.00	9,775,100
(5)	Formwork, Tunnel	m^2	57,600	7.40	426,240	36.40	2,096,640
(6)	Backfill Grouting	m^3	8,730	38.00	331,740	385.00	3,361,050
(7)	Consolidation Grouting	m	4,750	32.90	156,280	238.00	1,130,500
	Sub-total (2.2.3)				6,209,070		51,223,620
2.2.4	Surge Tank						
(1)	Excavation, Common	m^3	4,300	4.10	17,630	13.60	58,480
(2)	Excavation, Weathered Rock	m^3	3,560	5.80	20,650	19.50	69,420
(3)	Excavation, Rock	m^3	3,400	11.20	38,080	59.90	203,660
(4)	Excavation, All Class in Shaft	m^3	4,870	33.20	161,680	201.00	978,870
(5)	Steel Support	ton	46	700.00	32,200	4,500.00	207,000
(6)	Concrete, Structure	m^3	330	50.40	16,630	402.00	132,660
(7)	Concrete, Shaft	m^3	1,320	60.50	79,860	482.00	636,240

Table 2.9 Breakdown of Construction Cost (3/9)

(Unit: F.C. US$, L.C. KShs.)

Item No.	Description	Unit	Quantity	Foreign Currency		Local Currency	
				Unit Price	Amount	Unit Price	Amount
(8)	Formwork, Structure	m^2	810	2.50	2,030	55.50	44,960
(9)	Formwork, Shaft	m^2	1,240	16.00	19,840	81.30	100,810
(10)	Reinforcing Bar	ton	45	504.00	22,680	4,190.00	188,550
(11)	Consolidation Grouting	m	240	32.90	7,900	238.00	57,120
(12)	Slope Protection , Gunite	m^2	1,490	13.00	19,370	138.00	205,620
	Sub-total (2.2.4)				438,550		2,883,390
2.2.5	Penstock						
(1)	Excavation, Common	m^3	48,470	4.10	198,730	13.60	659,190
(2)	Excavation, Weathered Rock	m^3	16,860	5.80	97,790	19.50	328,770
(3)	Excavation, Rock	m^3	810	11.20	9,070	59.90	48,520
(4)	Excavation, All Class in Tunnel	m^3	2,880	44.10	127,010	369.00	1,062,720
(5)	Steel Support	ton	18	470.00	8,460	3,000.00	54,000
(6)	Fill and Backfill	m^3	1,230	5.20	6,400	18.20	22,390
(7)	Concrete, Portal, Anchor Block & Saddle	m^3	5,340	50.40	269,140	402.00	2,146,680
(8)	Concrete, Tunnel	m^3	1,650	54.60	90,090	478.00	788,700
(9)	Formwork, Structure	m^2	5,980	2.50	14,950	55.50	331,890
(10)	Formwork, Tunnel	m^2	1,160	7.40	8,580	36.40	42,220
(11)	Reinforcing Bar	ton	21	504.00	10,580	4,190.00	87,990
(12)	Backfill Grouting	m^3	200	38.00	7,600	385.00	77,000
(13)	Consolidation Grouting	m	600	32.90	19,740	238.00	142,800
(14)	Slope Protection, Concrete	m^2	1,160	10.00	11,720	80.40	93,260
	Sub-total (2.2.5)				879,860		5,886,130
	Sub-total (2.2)				10,995,130		86,590,720

Table 2.9 Breakdown of Construction Cost (4/9)

(Unit: F.C. US$, L.C. KShs.)

Item No.	Description	Unit	Quantity	Foreign Currency		Local Currency	
				Unit Price	Amount	Unit Price	Amount
2.3	Power Station						
2.3.1	Tailrace						
(1)	Excavation, Common	m^3	5,990	3.30	19,770	11.00	65,890
(2)	Excavation, Weathered Rock	m^3	26,670	4.80	128,020	16.50	440,060
(3)	Excavation, Rock	m^3	2,700	10.10	27,270	55.60	150,120
(4)	Fill and Backfill	m^3	2,690	4.40	11,840	15.80	42,500
(5)	Concrete, Slab & Base	m^3	2,090	42.50	88,830	342.00	714,780
(6)	Concrete, Structure	m^3	2,160	44.20	95,470	376.00	812,160
(7)	Formwork	m^2	6,390	2.50	15,980	55.50	354,650
(8)	Reinforcing Bar	ton	212	504.00	106,850	4,190.00	888,280
(9)	Slope Protection, Gunite	m^2	520	13.00	6,760	138.00	71,760
(10)	Fence	m	50	10.00	500	96.00	4,800
	Sub-total (2.3.1)				501,290		3,545,000
2.3.2	Power House						
(1)	Excavation, Common	m^3	4,680	3.30	15,440	11.00	51,480
(2)	Excavation, Weather Rock	m^3	33,810	4.80	162,290	16.50	557,870
(3)	Excavation, Rock	m^3	15,230	10.10	153,820	55.60	846,790
(4)	Fill and Backfill	m^3	16,260	4.40	71,540	15.80	256,910
(5)	Concrete, Wall in Substructure	m^3	2,740	44.20	121,110	376.00	1,030,240
(6)	Concrete, Slab in Substructure	m^3	1,910	44.20	84,420	376.00	718,160
(7)	Concrete, 2nd Stage	m^3	1,220	45.40	55,390	409.00	498,980
(8)	Formwork, Structure	m^2	5,440	2.50	13,600	55.50	301,920
(9)	Reinforcing Bar	ton	230	504.00	115,920	4,190.00	963,700
(10)	Slope Protection, Gunite	m^2	1,040	13.00	13,520	138.00	143,520
(11)	Asphalt Pavement	m^2	720	10.30	7,420	6.30	4,540
(12)	U-drain Ditch	m	110	4.40	480	100.00	11,000
	Sub-total (2.3.2)				814,950		5,385,110

Table 2.9 Breakdown of Construction Cost (5/9)

(Unit: F.C. US$, L.C. KShs.)

Item No.	Description	Unit	Quantity	Foreign Currency		Local Currency	
				Unit Price	Amount	Unit Price	Amount
2.3.3	Switchyard						
(1)	Excavation, Common	m^3	5,430	3.30	17,920	11.00	59,730
(2)	Excavation, Weathered Rock	m^3	14,370	4.80	68,980	16.50	237,110
(3)	Fill and Backfill	m^3	370	4.40	1,630	15.80	5,850
(4)	Concrete, Structure & Base	m^3	390	44.20	17,240	376.00	146,640
(5)	Formwork	m^2	840	2.50	2,100	55.50	46,620
(6)	Reinforcing Bar	ton	16	504.00	8,060	4,190.00	67,040
(7)	Slope Protection, Gunite	m^2	560	13.00	7,280	138.00	77,280
(8)	Gravel Surfacing	m^3	950	10.90	10,360	46.60	44,270
(9)	Fence and Gate	m	120	10.00	1,200	96.00	11,520
(10)	U-drain Ditch	m	360	4.40	1,580	100.00	36,000
	Sub-total (2.3.3)				136,350		732,060
2.3.4	Building (Architectural) Work						
	Power House Superstructure						
(1)	Concrete, Superstructure	m^3	1,010	45.40	45,850	409.00	413,090
(2)	Formwork	m^2	6,160	2.50	15,400	55.50	341,880
(3)	Reinforcing Bar	ton	54	504.00	27,220	4,190.00	226,260
(4)	Steel Structure, Roof	ton	90	1,050.00	94,500	5,250.00	472,500
(5)	Crain Girder	ton	18	700.00	12,600	4,500.00	81,000
(6)	Finishing Work		L.S.		58,670		460,420
(7)	Building Facilities & Electric Works		L.S.		58,670		460,420
	Sub-total				312,910		2,455,570
	Substation						
(1)	Substation Building and Foundation		L.S.	160.00	52,800	1,600.00	528,000
	Sub-total				52,800		528,000

Table 2.9 Breakdown of Construction Cost (6/9)

(Unit: F.C. US$, L.C. KShs.)

Item No.	Description	Unit	Quantity	Foreign Currency		Local Currency	
				Unit Price	Amount	Unit Price	Amount
	Appurtenant Buildings						
(1)	Intake Weir Observation House	m^2	30	-	-	1,200.00	36,000
(2)	Repair Shop/Diesel Generator House	m^2	680	160.00	108,800	1,600.00	1,088,000
	Sub-total				108,800		1,124,000
	Sub-total (2.3.4)				474,510		4,107,570
	Sub-total (2.3)				1,927,100		13,769,740
2.4	Outlet Channel						
(1)	Excavation, Common	m^3	17,180	3.30	56,690	11.00	188,980
(2)	Excavation, Weathered Rock	m^3	3,860	4.80	18,530	16.50	63,690
(3)	Concrete	m^3	190	44.20	8,400	376.00	71,440
(4)	Formwork	m^2	790	2.50	1,980	55.50	43,850
(5)	Bridge (W=7m, L=10m, 1 No.)	m	10	1,600.00	16,000	14,600.00	146,000
	Sub-total (2.4)				101,600		513,960
2.5	Road Construction						
(1)	Kusa - Power Station	km	3.2	27,300.00	87,360	175,500.00	561,600
(2)	Okanowac - Surge Tank	km	4.1	27,300.00	111,930	175,500.00	719,550
(3)	Nyamarimba - Andingo Bware	km	4.5	27,300.00	122,850	175,000.00	789,750
(4)	Andingo Bware - Intake Weir	km	6.1	27,300.00	166,530	175,500.00	1,070,550
(5)	Ramba - Intake Weir	km	3.5	27,300.00	95,550	175,500.00	614,250
	Sub-total (2.5)				584,220		3,755,700
	Total (2)				14,009,810		106,884,540

Table 2.9 Breakdown of Construction Cost (7/9)

(Unit: F.C. US$, L.C. KShs.)

Item No.	Description	Unit	Quantity	Foreign Currency		Local Currency	
				Unit Price	Amount	Unit Price	Amount
3.	Metal Works						
3.1	Weir Metal Work						
(1)	Weir Orifice Gate	ton	110	5,505.00	605,550	8,420.00	926,200
(2)	Weir Orifice Stoplog	ton	35	4,370.00	152,950	8,150.00	285,250
	Sub-total (3.1)				758,500		1,211,450
3.2	Intake Metal Work						
(1)	Intake Gate	ton	88	5,505.00	484,440	8,420.00	740,960
(2)	Intake Service Gate	ton	44	4,370.00	192,280	8,150.00	358,600
(3)	Intake Trushrack	ton	45	3,360.00	151,200	6,110.00	274,950
(4)	Intake Mechanical Rake	ton	25	8,525.00	213,130	9,140.00	228,500
(5)	Inlet Stoplog	ton	65	4,370.00	284,050	8,150.00	529,750
(6)	Sand Flush Facility	ton	50	5,505.00	275,250	8,420.00	421,100
	Sub-total (3.2)				1,600,350		2,553,760
3.3	Penstock Metal Work						
(1)	Penstock	ton	1,800	2,937.00	5,286,600	4,025.00	7,245,000
(2)	Penstock Valve (Butterfly Valve)	ton	40	8,630.00	345,200	9,170.00	366,800
(3)	Irrigation Outlet (Hollowjet Valve)	ton	20	9,110.00	182,200	9,290.00	185,800
(4)	Draft Tube Gate	ton	20	5,505.00	110,100	8,420.00	168,400
(5)	Intake Irrigation Facility	ton	10	5,505.00	55,050	8,420.00	84,200
	Sub-total (3.3)				5,979,150		8,050,200
	Total (3)				8,338,000		11,815,410

Table 2.9 Breakdown of Construction Cost (8/9)

(Unit: F.C. US$, L.C. KShs.)

Item No.	Description	Unit	Quantity	Foreign Currency		Local Currency	
				Unit Price	Amount	Unit Price	Amount
4.	Generating Equipment & Substation Equipment						
4.1	Generating Equipment						
(1)	Turbines		L.S.		3,848,000		5,131,000
(2)	Generators		L.S.		3,859,000		5,145,000
(3)	Transformers		L.S.		481,000		569,000
(4)	Ancillary Equipment		L.S.		791,000		1,012,000
(5)	Switchgear & Control Equipment		L.S.		1,708,000		2,396,000
(6)	Miscellaneous Materials		L.S.		320,000		584,000
(7)	Transmission Line Protective Relay		L.S.		563,000		751,000
(8)	Power Line Carrier Telephone		L.S.		338,000		413,000
	Sub-total (4.1)				11,908,000		16,001,000
4.2	Substation Equipment						
(1)	Transformers		L.S.		81,000		113,000
(2)	Switchgear & Control Equipment		L.S.		3,105,000		4,140,000
(3)	Miscellaneous Material		L.S.		834,000		1,898,000
	Sub-total (4.2)				4,020,000		6,151,000
	Total (4)				15,928,000		22,152,000
5.	Transmission Line		L.S.		1,774,000		5,464,000
	Total (1-5)				44,054,790		160,947,550
6.	Land Acquisition		L.S.		-		194,100
7.	Administration Expenses		L.S.		-		16,435,390

Table 2.9 Breakdown of Construction Cost (9/9)

(Unit: F.C. US$, L.C. KShs.)

Item No.	Description	Unit	Quantity	Foreign Currency		Local Currency	
				Unit Price	Amount	Unit Price	Amount
8.	Engineering Services		L.S.		6,030,000		-
	Total (1 to 8)				50,084,790		177,577,040
9.	Physical Contingency		L.S.		3,706,500		15,786,200
10.	Price Escalation		L.S.		10,144,400		123,510,700
	Grand Total				63,935,690		316,873,940

Note: A cost of US$ 3 million is necessary for detailed design ans preparation of tender document on the pre-construction stage besides the above costs.

FIGURES

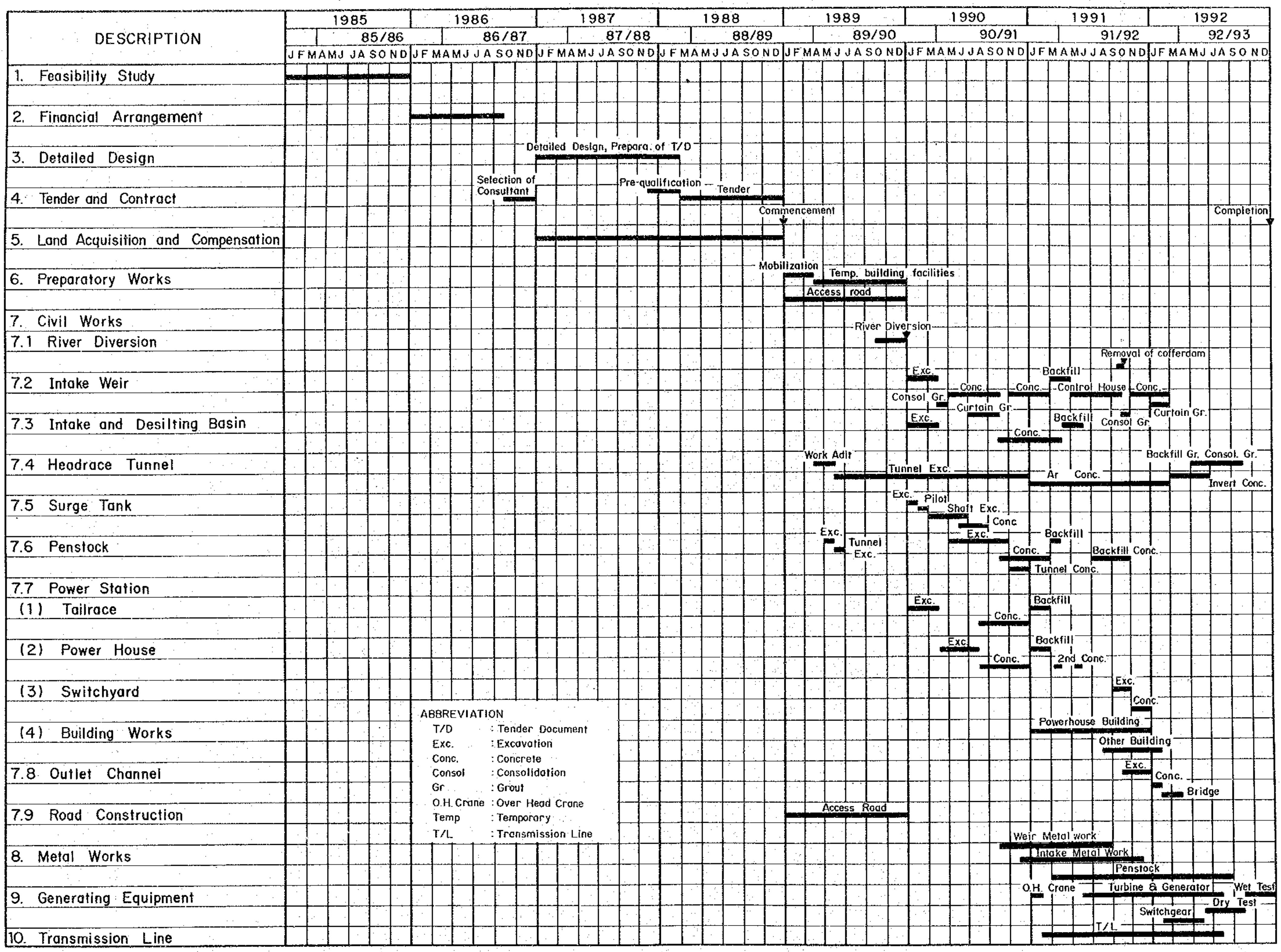

Figure 1.1
Construction Schedule

REPUBLIC OF KENYA
SONDU RIVER
MULTIPURPOSE DEVELOPMENT PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

APPENDIX VII EXTENSIBLE IRRIGATION AREA IN KANO PLAIN

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REFERENCES

1. Lake Basin Development Authority
   "Five Year Development Plan", February 1983

2. UNDP, "Lake Basin River Catchment Development River Profile Studies", 1985

Chapter 1. EXTENSIBLE DEVELOPMENT PLAN

1.1 General

The Sondu River has 41.6 m^3/sec of annual discharge at the Sondu/Miriu intake site, while the irrigation area (8,540 ha net) of the preset study, Pre-feasibility Report on Kano Plain Irrigation Project of Volume III, consumes only about 7.4 m^3/sec. Most of the diverted water runs into the Lake after generating the power and branch off the irrigation water.

On the other hand, the whole Kano plain has 60,000 ha1/ of potential irrigation area.

In this circumstance, following discussion about irrigation development possibility in the Kano Plain is necessary for future development of water resources in Kano Plain.

1.2 Irrigable Area

For the convenience of plan formulation, the Kano plain is divided into the following three zones by the major rivers as shown in Figure 1.1.

Zone	Location	Net irrigable area (ha)
A	Kendu Bay - Awach Kano River (project area in the pre-feasibility study)	8,540
B	Awach Kano River - Nyando River	7,070
C	Right bank of the Nyando River	10,000
	Total	25,610

The discussion of irrigable area in Zone A is given way to Volume III, Pre-feasibility Report on Kano Plain Irrigation Project.

The irrigable area for Zone B was selected in the land suitability classification study described in the separate volume of Appendix III of Volume V, "Soil and Land Evaluation".

For Zone C, irrigable area is estimated referring to the result of the UNDP river profile studies.[2/]

1.3 Hydrological Data

The Sondu and the Nyando rivers are main water sources for the Kano plain irrigation development. The monthly river discharge record at 1JG1 (Table 1.1) for the Sondu River and 1GD4 (Table 1.2) for the Nyando River are applied for estimating total available irrigation water.

1.4 Water Requirement

The irrigation water required for each zone is calculated as follows. It is noted that the requirements of Zone C are based on the estimates by the UNDP and that the highest requirement for whole Kano Plain is 19.1 m^3/sec on October with an average value of 12.5 m^3/sec.

	Zone A	Zone B	Zone C[2/]	Total (m^3/sec)
Jan.	4.83	2.58	4.02	11.43
Feb.	2.03	1.17	2.46	5.66
Mar.	2.96	1.93	3.40	13.95
Apr.	3.61	2.47	4.02	10.10
May	4.57	2.60	6.38	13.55
June	6.24	3.48	8.20	17.92
July	3.26	1.81	3.23	8.30

Aug.	0.90	0.56	3.16	4.62
Sep.	3.63	2.31	6.98	12.92
Oct.	7.35	4.33	7.37	19.05
Nov.	6.81	3.82	6.37	17.00
Dec.	6.07	3.40	5.54	15.01
			Average	12.46

1.5 Development Alternatives

To search the optimal development scale of the Kano Plain irrigation development, following two cases are conceived.

Case - 1: Irrigation in the area of Zone A and Zone B by using water released from the tailrace of the Sondu/Miriu power plant.

Case - 2: Irrigation in the whole Kano Plain; i.e. Zone A, Zone B & Zone C, by the Sondu/Miriu diversion and Awasi diversion on the Nyando River.

1.6 Reservoir Storage Requirement

Water balance calculation between irrigation water requirement and river discharge gives the required reservoir storage volume. The calculation for above two cases were carried out in monthly base and result is shown in Figure 1.2 and 1.3.

Case - 1: This case required eitht times of supplemental water in 37 years (refer to Figure 1.2). It is meant that the Sondu River will cover about 15,610 ha irrigation area without any storage dam with 78% dependability.

Case - 2: Maximum required reservoir capacity is about $110 \times 10^6 m^3$ and water deficit occurs 17 times in 37 years (refer to Figure 1.3). According to the water balance calculation, about $18 \times 10^6 m^3$ of reservoir will need for 80% dependability irrigation. The Magwagwa reservoir has more volume than maximum required volume of $110 \times 10^6 m^3$, and consequently the whole Kano Plain (25,610 ha) will receive enough irrigation water from the reservoir with 100% dependability after completion of Magwagwa dam.

Chapter 2. COST AND BENEFIT

2.1 Cost Estimate

The project costs of both alternative cases are estimated based on the present study and LBDA's study.

The cost of case - 1 is calculated by using estimated construction quantity and unit prices.

For case - 2, the construction cost of alternative B-2 of UNDP's study is applied. Following table presents the cost estimation for both cases.

Case - 1	Case - 2
KShs 1,163 million	KShs 1,745 million

2.2 Irrigation Benefit

The benefit to be derived from the project is estimated also by using the results of present study and UNDP's study. Following table shows the project benefit at the full development stage for both cases.

Case - 1	Case - 2
KShs 323 million	KShs 419 million

2.3 Cost-Benefit Flow

The annual flows of cost and benefit are shown in Table 2.1 for both cases. The following table shows the present value of benefit and cost discounted at the discount rate of 10%.

(KShs million)

	Case - 1	Case - 2
Present value of cost	782	1,180
Present value of benefit	1,413	1,829

TABLES

Table 1.1 Monthly Mean Discharge at 1JG1 (1/2)

Unit : m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1946			2.36	3.69	14.12	48.26	37.46	83.08	82.50	33.22	16.95	10.04	39.71
1947	13.16	11.83	15.58	99.60	264.97	79.78	52.07	56.27	59.93	53.99	13.44	8.50	61.13
1948	5.30	3.46	2.79	5.17	9.61	25.33	26.59	57.29	64.40	19.03	10.30	2.78	19.35
1949	3.49	2.78	1.74	4.15	5.53	13.46	15.77	36.09	57.62	23.48	10.85	9.31	15.39
1950	6.58	3.89	5.72	14.07	20.89	22.62	35.44	44.78	57.90	24.23	10.47	6.96	21.21
1951	4.50	4.67	4.23	110.48	92.02	87.55	35.21	45.12	28.54	31.42	45.78	123.48	51.28
1952	60.32	14.73	8.72	44.83	201.45	65.52	29.04	52.92	46.56	25.71	15.73	10.62	48.33
1953	5.49	3.17	2.31	6.16	9.86	10.75	9.85	11.96	9.73	7.05	6.65	6.45	7.48
1954	3.32	1.72	1.58	5.89	45.75	75.33	39.00	34.10	56.07	26.91	13.32	11.00	26.16
1955	5.92	5.55	3.10	6.81	16.26	10.25	16.51	45.16	86.04	63.39	25.04	19.21	25.36
1956	41.62	31.56	14.51	36.77	104.10	75.25	48.16	54.04	86.63	40.64	27.72	16.73	48.14
1957	8.58	6.95	6.57	47.67	113.96	149.81	63.26	53.37	45.54	15.27	10.62	9.40	44.35
1958	6.47	9.71	9.70	9.76	66.99	33.78	34.66	32.82	45.29	27.77	13.87	11.52	25.32
1959	8.64	6.64	11.68	37.04	69.75	35.22	16.09	18.29	28.56	22.84	23.27	14.49	24.44
1960	9.74	6.20	17.90	70.06	62.60	55.34	36.56	40.10	78.78	43.50	23.21	13.08	38.06
1961	6.76	4.54	4.32	9.72	24.06	15.55	12.92	33.03	46.28	56.62	258.81	227.19	58.49
1962	85.56	26.66	12.65	32.71	182.56	111.75	88.55	45.75	86.22	73.18	31.11	18.04	66.56
1963	31.95	24.98	21.17	74.05	264.96	118.43	34.96	51.32	37.63	10.98	12.69	88.08	64.63
1964	33.83	13.38	25.37	183.64	108.52	49.04	69.10	71.89	60.73	75.29	22.12	11.40	60.41
1965	10.03	6.37	4.01	32.45	72.74	23.59	15.38	16.38	17.01	11.81	31.57	22.14	22.04
1966	11.02	11.29	32.36	89.45	80.88	33.29	26.36	24.60	71.05	24.10	22.88	11.86	36.61
1967	6.55	4.35	3.64	19.93	99.09	64.22	75.48	40.09	30.81	17.02	21.22	57.12	36.92
1968	15.32	17.18	51.35	122.92	160.99	92.59	57.35	93.56	46.83	17.75	29.27	93.28	66.73
1969	22.83	48.94	39.46	29.85	37.70	23.70	14.16	16.94	34.87	14.15	9.58	6.89	24.71
1970	14.33	22.60	66.73	126.23	115.65	82.58	42.54	79.93	79.54	59.12	27.14	11.90	60.80

Table 1.1 Monthly Mean Discharge at 1JG1 (2/2)

Unit : m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	10.54	6.86	4.61	11.21	41.77	66.50	64.14	100.38	93.93	46.17	16.84	10.38	39.63
1972	10.25	9.19	7.44	7.66	32.37	41.38	45.88	44.40	26.74	19.83	74.83	47.23	30.62
1973	43.61	32.63	20.06	12.45	33.23	80.71	31.40	48.67	62.91	36.59	30.01	13.36	37.07
1974	7.11	4.50	5.71	71.24	51.20	56.58	130.91	67.00	55.03	42.84	24.24	11.02	44.27
1975	6.21	4.42	5.50	28.79	33.33	50.50	42.40	94.43	136.64	81.90	36.79	14.41	44.74
1976	8.89	6.17	5.39	8.42	22.84	41.59	58.00	50.89	73.24	21.65	11.29	9.07	26.49
1977	11.65	24.01	13.92	89.55	163.96	81.02	109.92	78.33	53.35	26.12	109.91	78.31	70.40
1978	31.26	28.15	168.06	198.19	153.49	46.46	58.52	55.92	70.46	73.79	40.71	28.57	79.78
1979	21.22	69.63	48.07	69.45	92.72	75.23	56.32	63.41	35.35	15.33	10.08	7.65	46.85
1980	5.87	5.22	7.70	14.76	39.42	55.90	64.56	33.42	32.28	14.00	13.23	10.36	24.79
1981	5.69	6.26	12.53	142.07	93.51	33.41	40.33	79.29	62.33	56.68	22.00	13.11	47.41
1982	7.57	4.48	2.66	4.82	44.02	72.24	36.89	65.10	50.18	35.82	122.30	163.90	51.09
1983	26.80	11.74	7.50	16.96	48.94	50.50	42.83	55.15	107.71	80.22	51.82	24.52	43.84
Mean	16.70	13.69	17.86	49.99	81.46	56.74	45.12	51.98	58.09	36.01	34.14	32.98	41.59

Table 1.2 Monthly Mean Discharge of the Nyando (1/2)

Station : 1GD4 Unit : m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1955	3.56	3.77	5.80	11.87	42.27	19.77	31.04	73.19	83.15	54.35	27.79	30.27	41.76
1956	17.97	10.25	12.18	20.60	36.05	46.44	57.39	82.70	62.44	42.91	26.52	24.87	37.03
1957	5.47	4.43	5.63	19.30	36.86	79.70	45.30	52.75	36.93	20.89	17.61	16.71	29.30
1958	4.35	7.74	7.86	5.38	31.81	34.63	57.12	57.34	22.54	6.72	3.53		24.92
1959	3.18	2.57	3.59	5.89	12.31	6.76	2.50		6.94	5.61	27.93		5.50
1960	4.78	3.50	15.30	25.59	34.01	34.61	28.95	38.07	49.62	29.93	28.35	13.20	25.42
1961	2.46	2.28	4.39	6.38	15.04	17.28	16.95	62.02	59.58	43.60	147.45	98.50	36.37
1962			11.67	29.71	71.03	64.29	53.92	62.86	63.58	42.03	30.49	21.79	45.19
1963	9.44		13.12	23.65	85.88		31.23	49.89	33.71	13.58	18.63	53.33	32.15
1964	6.77	5.05	6.03	56.98	31.84	29.47	46.89	62.19	55.76	45.69	17.00	11.60	31.61
1965	6.41	4.49	4.03	6.62	8.58	5.99	6.24	6.76	5.66	5.84	9.52	6.96	6.48
1966	2.20	5.00	9.56	23.50	11.10	10.27	11.29	13.67	27.01	6.18	6.86	7.41	11.14
1967	2.09	1.86	2.03	9.74	30.89	17.84	52.45	35.04	19.96	7.91	23.85	30.48	20.23
1968	6.98	23.92	23.10	66.54	44.56	36.18	29.69	50.64	15.80	8.71	7.41	13.44	26.65
1969	8.22	11.36	8.90	4.24	11.38	5.34	5.13	7.92	8.28	4.45	3.78	2.63	6.89
1970	15.74	6.89	9.99	22.29	19.75	13.75	12.79	25.68	20.25	11.06	6.15	4.45	14.04
1971	3.57	2.28	2.44	10.64	17.46	14.64	20.12	25.30	22.13	13.15	6.90	5.76	12.23
1972	4.68	6.37	3.36	3.24	12.33	12.14	12.79	12.22	7.71	10.23	21.64	10.09	9.58
1973	8.69	8.76	4.72	4.62	10.47	11.15	7.18	16.47	17.55	9.31	7.09	3.90	9.11
1974	3.21	2.36	3.23	22.70	9.68	10.30	24.39	12.15	12.34	8.26	5.08	3.51	9.96
1975	2.41	2.87	4.55	9.40	7.61	12.41	15.20	28.77	36.13	20.55	7.85	6.75	13.40
1976	3.56	3.06	2.42	3.74	1.89	7.50	10.80	10.98	11.13	4.11	3.67	3.07	5.56
1977	3.21	4.99	3.14	11.47	32.47	21.66	20.43	21.00	15.06	9.22	35.18	15.91	16.14
1978	10.84	1.89	18.11	24.26	23.73	10.41	15.93	17.72	18.27	14.38	8.41	9.06	14.46
1979	6.65	40.78	12.28	14.61	12.84	17.12	13.71	21.37	1.89	6.59	6.03	4.29	13.16
1980	8.93	3.54	2.91	7.07	15.32	10.43	10.59	7.42	6.41	3.81		2.73	7.18

Table 1.2 Monthly Mean Discharge of the Nyando (2/2)

Station : 1GD4 Unit : m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1981	2.30	2.43	4.66	23.10	17.01	5.92	10.85	19.56	16.45	11.34	5.64	45.48	14.60
1982	2.50	3.08	2.22	6.55	14.73	10.46	6.29	14.77	7.85	6.74	16.46	26.10	9.66
1983	6.28	4.45	3.01	5.75	6.51	8.70	7.48	17.79	20.52	17.84	9.04		9.48
Mean	5.94	6.67	7.25	16.74	24.33	20.54	22.92	32.37	26.37	16.72	19.14	18.17	18.59

Table 2.1 Cash Flow Diagram (1/2)

Case - I (15,610 ha)				Case - II (25,610 ha)			
Year	Cost	O&M	Benefit	Year	Cost	O&M	Benefit
-5	4795			-5	5140		
-4	16873			-4	18021		
-3	62064			-3	65817		
-2	292302			-2	438382		
-1	277841			-1	430830		
0	179952			0	252045		
1	109519	13406	37914	1	189374	22143	47669
2	109519	14827	93755	2	195804	25248	118047
3	109519	16249	157850	3	148826	27413	198831
4		16249	227634	4		27413	290755
5		16249	267632	5		27413	345695
6		16249	293523	6		27413	381643
7		16249	311160	7		27413	403186
8		16249	320544	8		27413	416323
9		16249	322101	9		27413	418932
10		16249	322101	10		27413	418932
11		16249	322101	11		27413	418932
12		16249	322101	12		27413	418932
13		16249	322101	13		27413	418932
14		16249	322101	14		27413	418932
15		16249	322101	15		27413	418932
16		16249	322101	16		27413	418932
17		16249	322101	17		27413	418932
18		16249	322101	18		27413	418932
19		16249	322101	19		27413	418932
20		16249	322101	20		27413	418932
21		16249	322101	21		27413	418932
22		16249	322101	22		27413	418932
23		16249	322101	23		37513	418932
24		16249	322101	24		27413	418932
25		16249	322101	25		27413	418932
26		16249	322101	26		27413	418932
27		16249	322101	27		27413	418932
28		16249	322101	28		27413	418932
29		16249	322101	29		27413	418932
30		16249	322101	30		27413	418932
31		16249	322101	31		27413	418932
32		16249	322101	32		27415	418932
33		16249	322101	33		27413	418932
34		16249	322101	34		27413	418932
35		16249	322101	35		27413	418932
36		16249	322101	36		27413	418932
37		16249	322101	37		27413	418932
38		16249	322101	38		27413	418932
39		16249	322101	39		27413	418932
40		16249	322101	40		27413	418932
41		16249	322101	41		27413	418932
42		16249	322101	42		27413	418932

Table 2.1 Cash Flow Diagram (2/2)

Case - I (15,610 ha)				Case - II (25,610 ha)			
Year	Cost	O&M	Benefit	Year	Cost	O&M	Benefit
43		16249	322101	43		27413	418932
44		16249	322101	44		27413	418932
45		16249	322101	45		27413	418932
46		16249	322101	46		27413	418932
47		16249	322101	47		27413	418932
48		16249	322101	48		27413	418932
49		16249	322101	49		27413	418932
50		16249	322101	50		27413	418932

FIGURES

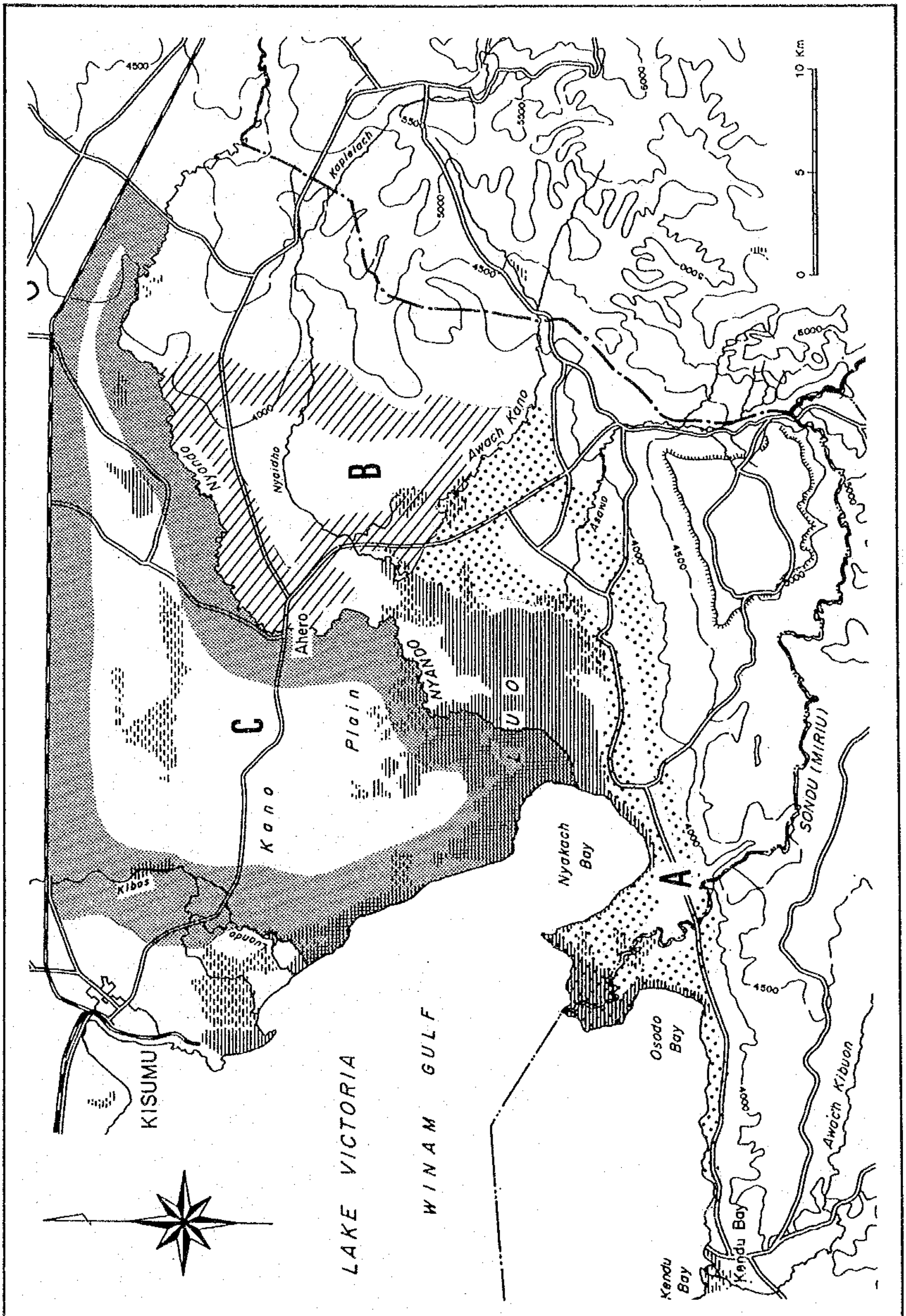

Figure 1.1
Location Map of Extensible Development Area

REPUBLIC OF KENYA
SONDU RIVER
MULTIPURPOSE DEVELOPMENT PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Command area : 15,610 ha

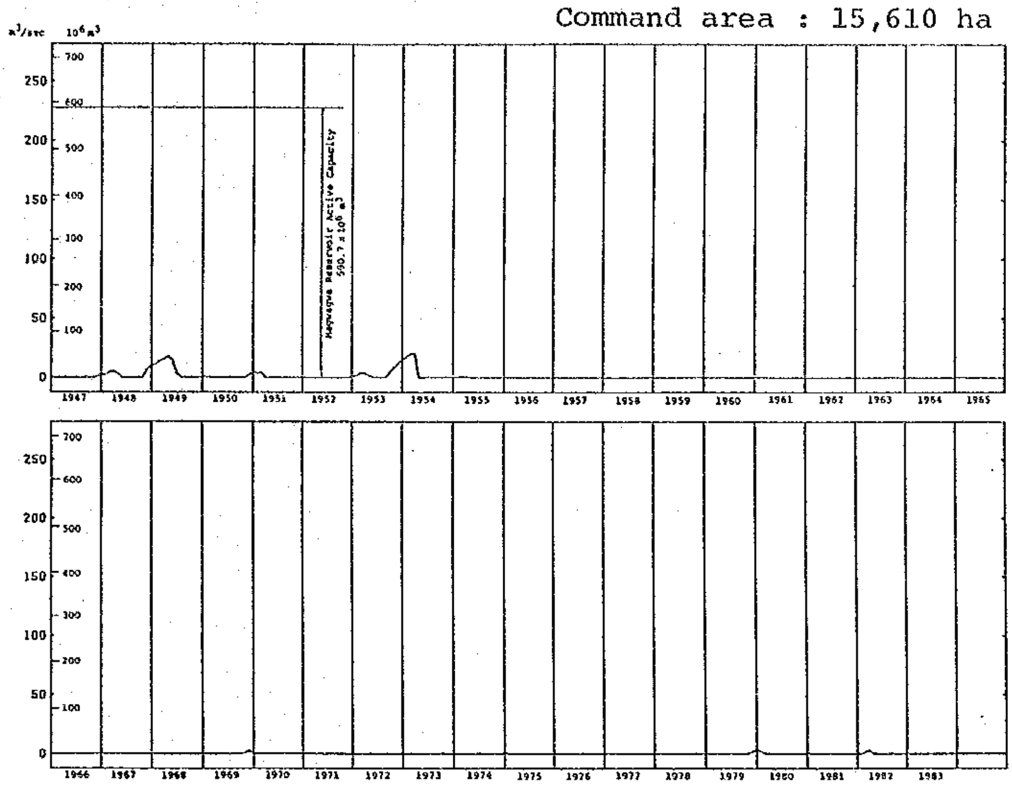

Figure 1.2 Required Reservoir Capacity for Case - 1

Command area : 25,610 ha

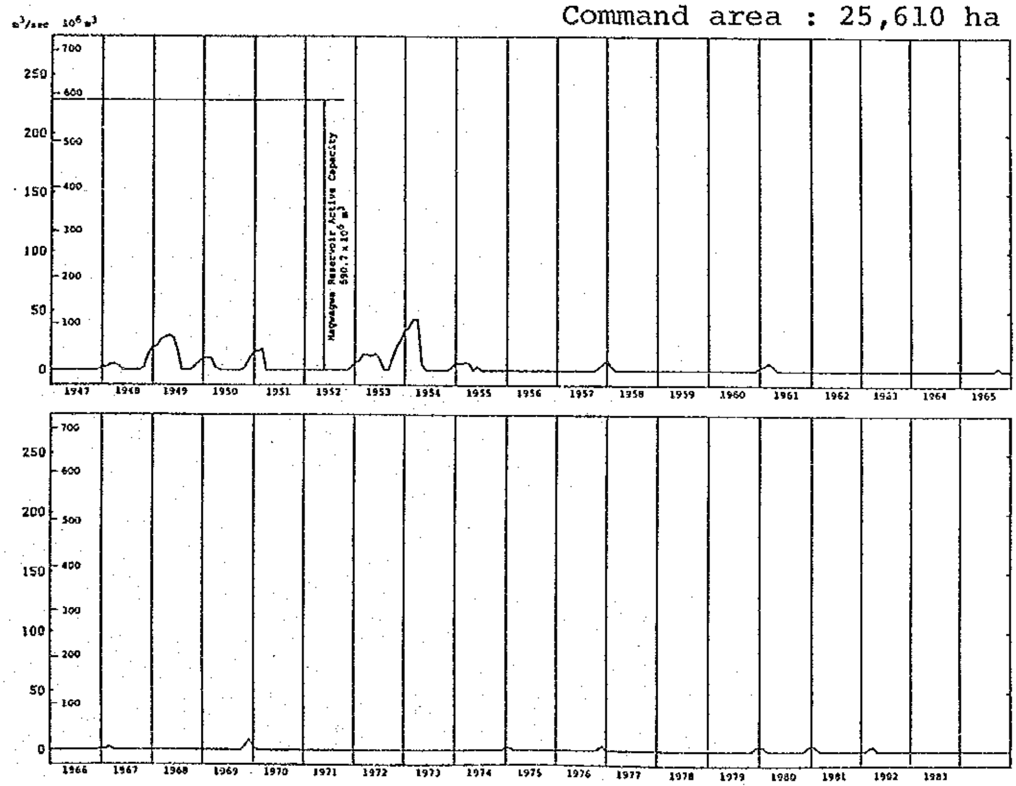

Figure 1.3 Required Reservoir Capacity for Case - 2