Headrace receiving end ..... headrace tunnel and steel lining section

Penstock receiving end ..... upper penstock tunnel and steel penstock

Powerhouse receiving end ... lower penstock tunnel, powerhouse, and tailrace tunnel

Other ..... aggregate plant

11.1.2 Construction Program and Construction Schedule

Starts of operation in this Project, as stated in Chapter 5, "Load Forecast and Electric Power Development Scheme", are to be in 1996 for the Lower Kihansi Project and in 1999 for the Upper Kihansi Project.

The general schedule required for these starts of operation is shown in Fig. 11-3.

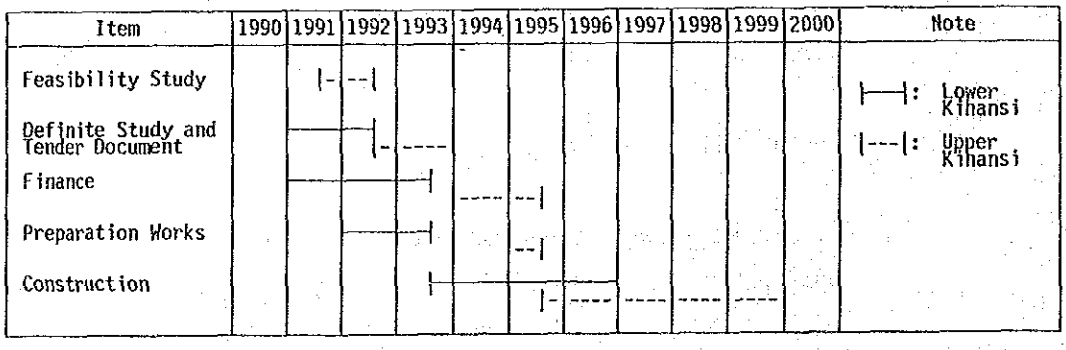


Fig. 11-3 Schedule of KIHANSI Project

The quantities of the major civil works in this Project are as given in Tables 11-1 and 11-2. The principal facilities expected to be required at the peak of construction are listed in Table 11-3.

The construction periods in this Project, as a result of studies taking into consideration construction scales and layouts of structures, is estimated 4.5 years for the Upper Kihansi Project, and 3.5 years for the Lower Kihansi Project, both for main construction work not including preparatory works. The layout plans for temporary facilities and construction schedules for construction are shown in Figs. 11-4 through 11-6.

(1) Upper Kihansi Project

i) Preparatory Works

It is possible for facilities such as living quarters, offices, aggregate plant, and concrete plant of the Lower Kihansi Project to be utilized for the Upper Kihansi Project works. Preparatory works for the Upper Kihansi Project are access roads and electric power facilities for construction. These works are planned to be started from January 1995, the first year of the Project, and to be completed in 6 months.

ii) Diversion Tunnel

Diversion tunnels are to consist of a sub-diversion tunnel for the tributary and a main diversion tunnel for the main river.

Table 11-1 Principal Civil Works

(Upper Kihansi)

Item	Description	Civil Works
Sub Diversion Tunnel	D = 2.0 m L = 300 m	Tunnel Ex. = 1,200 m^3 Con. = 100 m^3
Main Diversion Tunnel	D = 3.0 m L = 425 m	Tunnel Ex. = 5,200 m^3 Lining Con. = 2,100 m^3
Coffer Dam		Embankment = 57,000 m^3
Dam	H = 95.0 m L = 583.0 m	Excavation = 895,000 m^3 Embankment = 5,348,000 m^3
Spillway	B = 10.0 m	Excavation = 524,000 m^3 Concrete = 100,000 m^3
Intake	B = 6.0 m H = 50.0 m	Excavation = 109,000 m^3 Concrete = 15,000 m^3
Headrace Tunnel	D = 3.3 m L = 653 m	Tunnel Ex. = 10,000 m^3 Lining Con.= 4,200 m^3
Penstock	D = 3.3 m - 1.85 m L = 510.2 m	Excavation = 62,000 m^3 Concrete = 6,300 m^3
Powerhouse	B = 20.0 m L = 22.5 m H = 35.0 m	Excavation = 73,000 m^3 Concrete = 16,000 m^3
Tailrace Tunnel	D = 4.0 m L = 641 m	Tunnel Ex. = 14,300 m^3 Lining Con.= 5,800 m^3
Outlet	B = 10 m	Excavation = 49,000 m^3
Switchyard		Excavation = 300 m^3 Concrete = 100 m^3

Table 11-2 Principal Civil Works
(Lower Kihansi)

Item	Description	Civil Works
Coffer Dam		Embankment = 9,000 m^3
Dam	H = 35.0 m L = 177.0 m	Excavation = 121,000 m^3 Embankment = 54,500 m^3
Intake	B = 6.0 m H = 23.0 m	Excavation = 18,000 m^3 Concrete = 3,900 m^3
Headrace Tunnel	D = 3.0 m L = 1,258.7 m	Tunnel Ex. = 14,500 m^3 Lining Con.= 4,700 m^3
Penstock	D = 3.0 m - 0.9 m L = 2,936.3 m	Excavation = 34,100 m^3 Lining Con.= 19,700 m^3
Powerhouse	B = 25.5 m L = 59.0 m H = 34.6 m	Excavation = 162,000 m^3 Concrete = 20,900 m^3
Tailrace Tunnel	D = 3.5 m L = 580.0 m	Tunnel Ex. = 9,500 m^3 Lining Con.= 3,700 m^3
Outlet	B = 4.0 m - 10.0 m	Excavation = 6,300 m^3 Concrete = 1,100 m^3
Switchyard		Excavation = 400 m^3 Concrete = 500 m^3

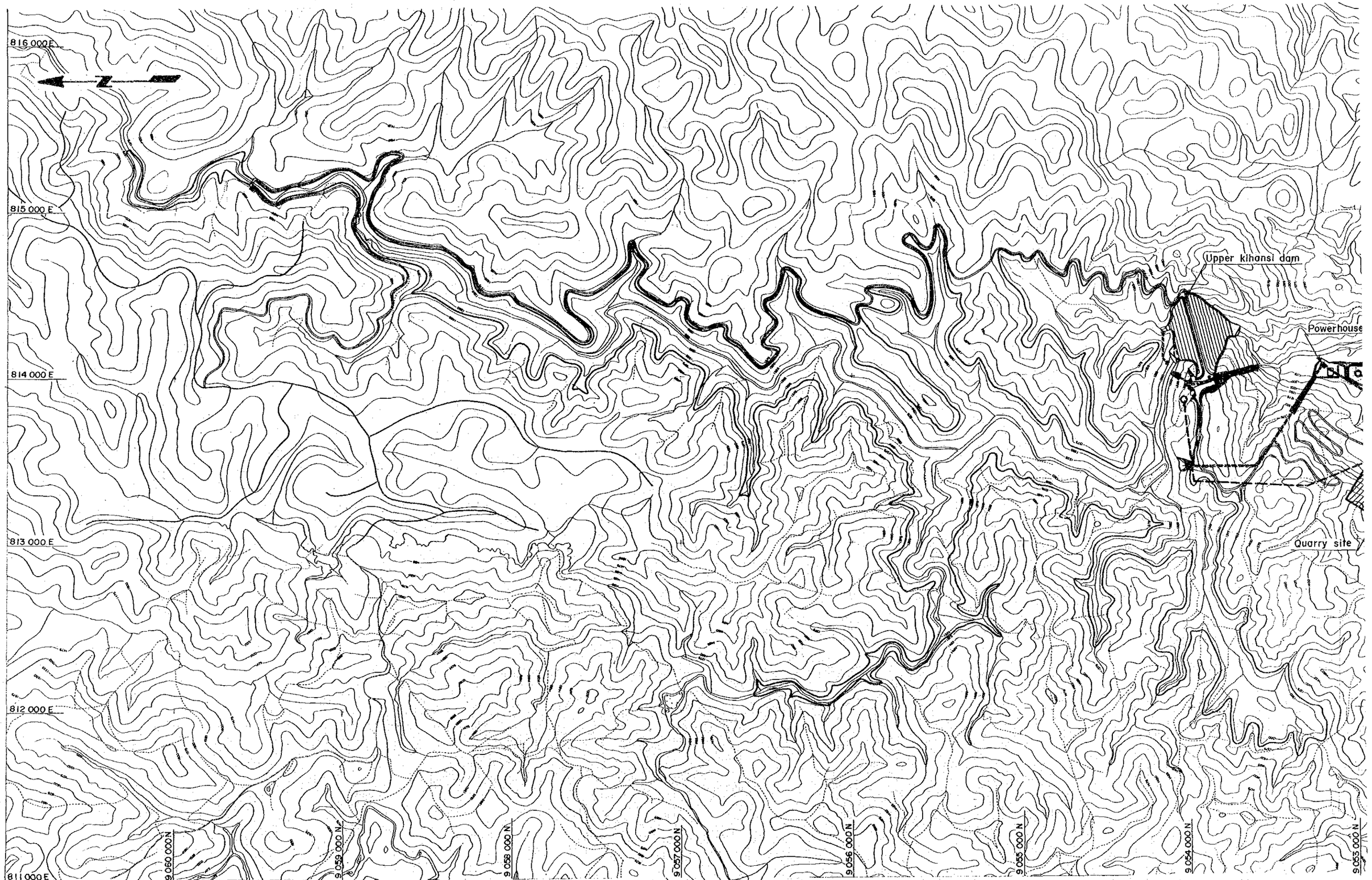
Table 11-3 Principal Machinery

(i) Upper Kihansi

Machinery	Specification	Unit
Concrete Plant (Spillway, Powerhouse)	Drum Mixer 0.75 m^3 x 2	1
Aggregate Plant	200 t/H	1

(ii) Lower Kihansi

Machinery	Specification	Unit
Tower Crane (Dam)	200 $^{t-m}$	1
Concrete Plant (Dam, Headrace Tunnel)	Drum Mixer 0.75 m^3 x 2	1
Concrete Plant (Penstock, Powerhouse)	Turbine Mixer 1.0 m^3 x 1	1
Aggregate Plant	200 t/H	1


816 000 E
815 000 E
814 000 E
813 000 E
812 000 E
811 000 E
N
Upper kihansi dam
Powerhouse
Quarry site
9 060 000 N
9 059 000 N
9 058 000 N
9 057 000 N
9 056 000 N
9 055 000 N
9 054 000 N
9 053 000 N

Upper kihansi dam

Powerhouse

Construction office and camp

Receiving sub station

NO. 1 Work adit

Access road

Distribution line
(for construction)

Waterway

Lower kihansi dam

Aggregate plant

Concrete plant

Quarry site

9 057 000 N

9 056 000 N

9 055 000 N

9 054 000 N

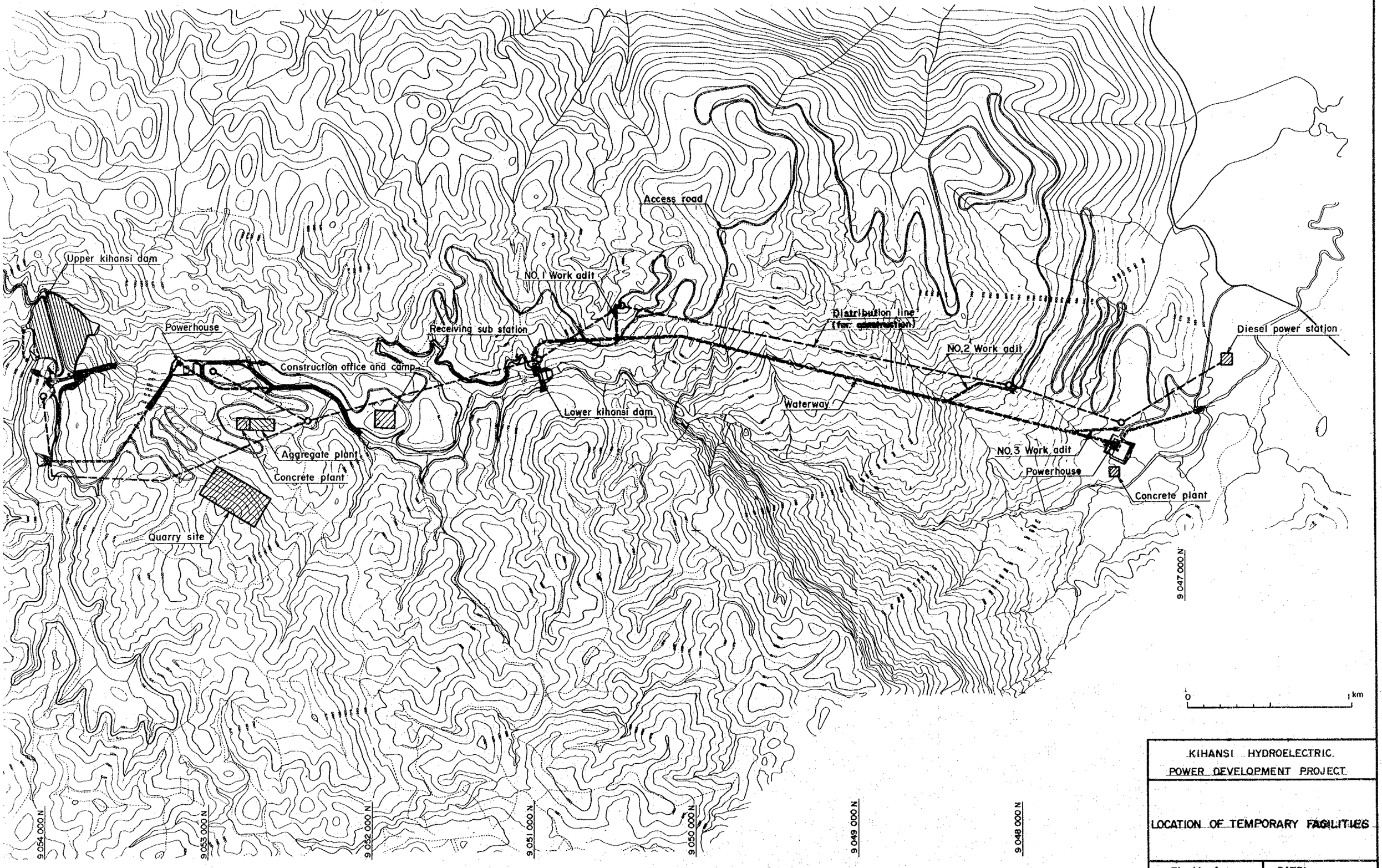
9 053 000 N

9 052 000 N

9 051 000 N

9 050 000 N

9 049 000 N



KIHANSI HYDROELECTRIC POWER DEVELOPMENT PROJECT

LOCATION OF TEMPORARY FACILITIES

Fig. 11-4 | DATE:

Fig. 11-5 Construction Schedule (Upper Kihansi)

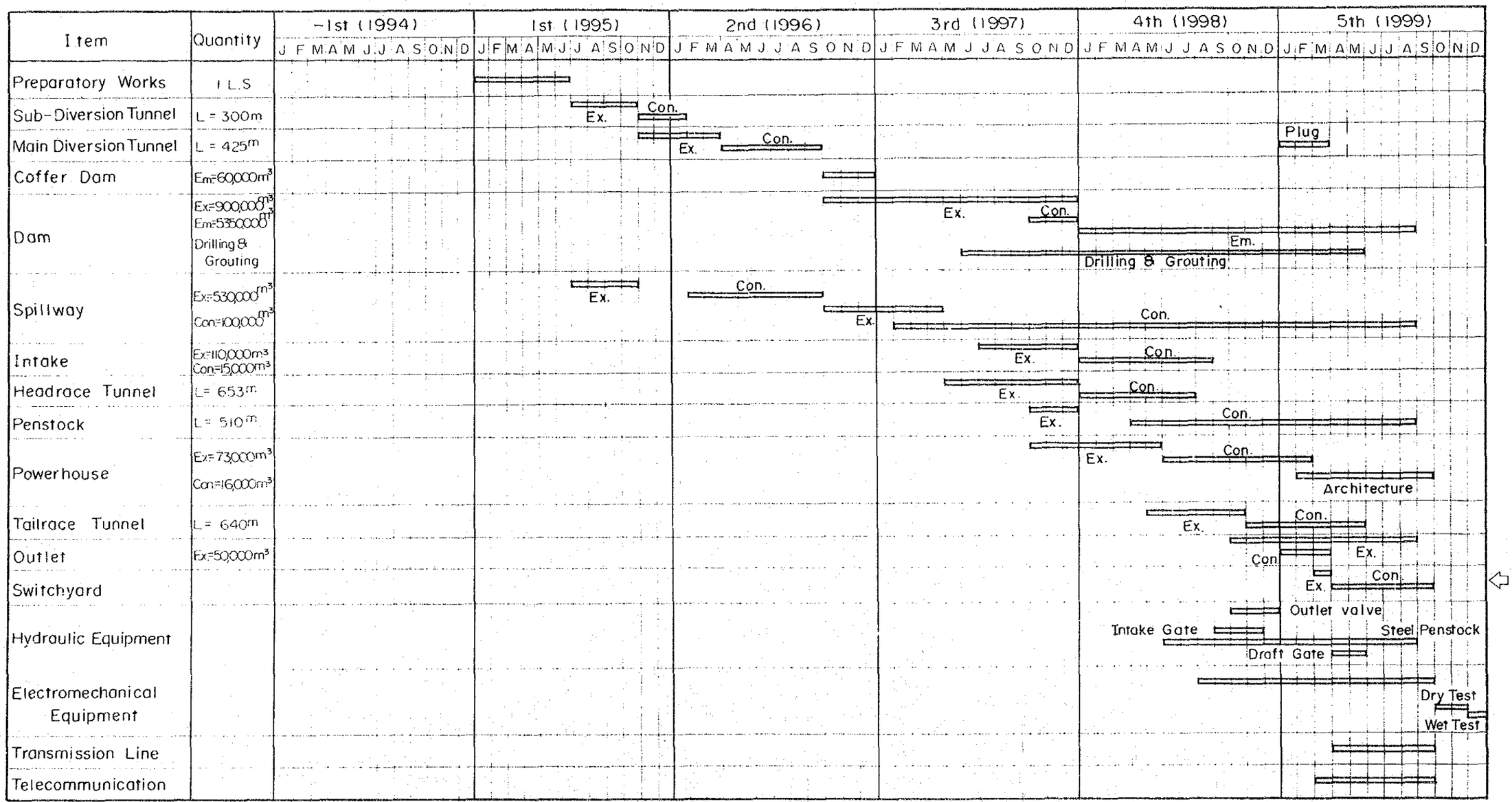


Fig. 11-6 Construction Schedule (Lower Kihansi)

Item	Quantity	~1st (1992)	1st (1993)	2nd (1994)	3rd (1995)	4th (1996)	5th (1997)
		J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
Preparatory Works & Camp Facility	1 L.S						
Access Road	L = 50 km						
Dam	Ex=122,000m³ Con=54,500m³ Drilling & Grouting		Ex. Care of River	Con. Ex. Drilling & Grouting Care of River	Con. Drilling & Grouting	Plug	
Intake	Ex=18,000m³ Con=3,900m³		Ex. Con.	Con.			
Headrace Tunnel	L = 1,259m		Adit Ex. Ex.	Con.	Con.	Plug	
Penstock Tunnel	L=2,936m		Adit Ex. Ex.	Ex.	Con.	Plug	
Powerhouse	Ex=162,000m³ Con=20,900m³			Ex. Con. Architecture			
Tailrace Tunnel	L = 580m			Ex. Con.			
Outlet	Ex=7,000m³ Con=1100m³			Ex. Con.		Operation No.1	Operation No.2,3
Switchyard	1 L S			Con. Ex.			
Hydraulic Equipment				(Flushing Gate) (Intake Gate) (Steel Penstock) (Outlet Gate)			
Electromechanical Equipment				No. 1 No. 2,3	Dry Test Wet Test Dry Test Wet Test		
Transmission Line					Test		
Telecommunication					Test		
Substation (IRINGA)					Test		

The sub-diversion tunnel is of excavation diameter of 2.2 m and total length of 300 m, with the work to be started from July of 1995, the first year, and there is no problem if it is completed by October of the second year.

The main diversion tunnel is of excavation diameter 3.6 m and total length of 425 m, with the downstream outlet planned to be diverted for use as the chute of the spillway. Therefore, excavation of the tunnel portion is to be started after completing open excavation of the spillway chute portion. The open excavation requires a period of 4 months from July to October of 1995, the first year, while the tunnel excavation is scheduled from November to March of the following year.

Concrete work is to be started on the chute portion from March of 1996, the second year, for completion in 8 months, and on the tunnel portion from April of the same year for completion in 6 months in September.

The intake orifice portion of the bottom outlet is to have excavation and concrete work completed during the same period as the main diversion tunnel, while only excavation is to be completed for the plug section.

iii) Cofferdamming

It is planned for the cofferdam works of the two locations of mainstream and tributary to be completed in a period of 3 months by October of 1996, the second year, when the sub and main diversion tunnels are completed.

iv) Dam

Dam excavation can be broadly divided into the right-bank side, the river-bed portion and the left-bank side. Work at the right-bank portion is to be started simultaneously with work on the spillway from October of 1996. The second year, when the diversion tunnel is almost completed, with excavation done toward the river bed. Since the diversion tunnel is completed at the end of the second year, the mainstream is to be diverted, and the left-bank side and the river bed are to be excavated in sequence from the third year, and dam excavation is to be completed at the end of the third year.

Foundation treatment work consists of curtain grouting and consolidation grouting. The foundation treatment work is to be done from the middle of 1997, the third year, when dam excavation of the vicinity of the river bed is partly completed, prior to embankment of the dam. The work is to be performed upward from the river bed on both banks at the same time and be completed in May of 1999, the fifth year.

The concrete work which corresponds to the connection between the dam and spillway is to be completed by the end of the third year which is before the start of embankment of the dam.

In embankment of the dam, the core, filter, and rock zones are to be started at the same time. Starting is to be at the beginning of the fourth year, with embankment done in order, it being planned for all of the dam work to be completed in August 1999, which is the twentieth month.

v) Spillway

Spillway work can be divided into chute work and horizontal section work including the inlet structure. The work on the chute section, as stated in the subsection on diversion tunnels, is to be started in July of the first year and to be completed in September of the second year, this chute being planned to be used as a part of the river diversion facility.

Excavation of the horizontal section is to be started from October of the second year along with dam excavation and to be completed 6 months later in April of the third year. Concrete work is planned to be started from March of the third year, when a part of the excavation has been completed, and to be completed in August of 1999, the fifth year, the same as completion of the dam embankment.

vi) Intake

For the intake work, it is planned for excavation of the intake to be completed by the time headrace tunnel excavation is completed. Starting of excavation is to be in July of 1997, the third year, and completion is to be 6 months later at the end of the same year. Concrete work is to be started immediately after completion of excavation and is to be completed in August 1998. Installation of a trashrack and gate is started partly overlapping concrete work, and this work is completed at the end of the fourth year when all of the intake work is completed.

vii) Headrace Tunnel

The headrace tunnel is of a length of 620 m and excavation diameter 4.1 m excluding 140 m of the penstock tunnel from the total tunnel length of 760 m. The work is to start with excavation from the downstream side including the penstock, and the inclined shaft portion in the vicinity of the intake is planned to be excavated from the downstream side after completing excavation of the tunnel. Excavation is to be done by full-face cutting, starting from May of 1997, the third year, with breakthrough by the end of the same year. Lining concrete at the inclined shaft part is to be placed from the intake and working upward from the bottom. The horizontal section is to be placed using steel forms of inside diameter 3.3 m starting from the intake side and going toward the penstock side. The concrete work is to be completed in July of 1998, the fourth year.

viii) Penstock

The penstock work can be divided into a tunnel portion, surface inclined portion, and powerhouse connection portion. Excavation of the tunnel portion is of a total length of 140 m and is to be performed simultaneously with the headrace tunnel. The steel penstock pipe is to be of inside diameter of 3.3 m and installation is to start from August of 1998, the fourth year when lining concrete of the headrace tunnel is to be completed and is scheduled to be completed in 6 months.

The surface inclined portion has a steel penstock diameter from 3.3 to 2.5 m and a length of approximately 270 m with excavation started from October of the third year, and down to the finished level of the powerhouse at EL. 1,163 m is to be

completed in 3 months. In succession to this, excavation of the powerhouse connection portion is to be performed at the same time as excavation for the powerhouse, and completion of all excavation for the penstock is to be in March of the fourth year.

Concrete placement is to be started from the powerhouse side at the same time as the penstock work, and it is planned for all work on the penstock to be completed in August of 1999, the final year.

ix) Powerhouse

The powerhouse work consists of the powerhouse proper, draft gate chamber, and embankment work for the outdoor switchyard.

Excavation is to be started simultaneously with the penstock excavation of October of the third year, and is to be completed in 8 months in May of the fourth year.

After completion of excavation, sidewall concrete and foundation concrete are to be placed immediately, and embankment is to be performed from places where concrete has reached the required strength, and embankment work is to be completed. Subsequently, installation of electromechanical equipment, placement of concrete around equipment, and architectural work are to be performed, and it is planned for all work to be completed by October of the fifth year when test operation is to be started.

x) Tailrace Tunnel and Outlet

The tailrace tunnel is to have an excavation diameter of 5.0 m and total length of 641 m, with excavation done toward the powerhouse from the tailrace outlet. Tunnel excavation is to be done by a full-face cutting method starting from May of the fourth year and to be completed in October of the same year. Lining concrete placement is to be started using steel forms immediately after completing excavation and is planned to be completed in May of the fifth year.

The tailrace outlet work is to be performed along with the tailrace tunnel work. From the outlet to approximately 500 m downstream, river-bed excavation is to be carried out to lower the water level, and this excavation is to be done simultaneously with excavation for the tailrace, and the work is planned to be completed in August of the fifth year.

xi) Turbine and Generator

Work for the turbine and generator is to be performed parallel to concrete placement in civil works, and it is planned for installation work to be completed in 14 months from August of the fourth year. Dry tests and wet tests are to be completed in 3 months from October of 1999, the fifth year, and the plan is for commercial operation to be started at the end of December in 1999.

xii) Transmission Line and Communication Lines

It is planned for all work on the transmission line and communications lines to be completed by the time of starting tests on the turbine and generator.

xiii) Plugging of Diversion Tunnels and Water Impoundment

It is necessary for impounding of water in the reservoir to be done while operating Lower Kihansi Power Station. The time required for water storage is estimated approximately 6 months to 10 months in an ordinary water discharge year.

Installation of bottom outlet facilities in the main diversion tunnel is to be started in October of the fourth year while discharging the whole quantity and is to be completed in 3 months. Subsequently, plugging work on the main diversion tunnel is to be carried out while adjusting the discharge quantity, and it is planned for all work to be completed in March of the fifth year, with water stored up to low water level by November in preparation for wet tests.

(2) Lower Kihansi Project

i) Preparatory Works

As preparatory works there are road works, electric power facilities for construction, living quarters, offices, etc. Of these, roads can be divided into permanent roads to be used for maintenance and administration after completion of the Project and access roads for use in work on the headrace tunnel, penstock, etc. The permanent roads, as shown in Fig. 11-4, are a new road going from Lower Kihansi Powerhouse to Uhafiwa via Lower Kihansi Dam, Upper Kihansi Powerhouse, and Upper Kihansi Dam of total length of 50 km and width of 5 m, and an improved road from Iringa to Uhafiwa of total length of 123 km and width of 5 m. The work on these roads is to be started in January 1992, 1.5 years prior to start of the main Project work, with the stretch from Lower Kihansi Power Station to Upper Kihansi

Power Station completed by June 1993 when the main Project work is to be started. Subsequently, road construction is to be performed in parallel with the main construction, and the stretch from Iringa to Upper Kihansi Power Station is planned to be completed in June 1994.

Preparatory works necessary for the main Project such as access roads, electric power facilities for construction, living quarters, etc. are to be started from January 1992 prior to start of main construction work and to be completed in June of the following year.

ii) Cofferdamming

Dam construction is to be done first at the left bank on the intake side. This is because the diversion waterway inside the dam is to be provided at the left-bank side, and because the finished elevation of excavation downstream of the dam is to be 1,110 m and diversion work will be easier.

Prior to work on the left bank, the river-bed release method is to be adopted by means of cofferdamming a part of the river bed to divert the river flow to the right-bank side. The structural type of the cofferdam is to be earthfill, and it is planned for work to be done from June of 1993, the first year.

Construction of the right-bank side cofferdam is to be started from October of the second year when dam concrete on the left-bank side is completed. This cofferdam work is planned so that a part of dam proper on the left-bank side is utilized with cofferdams built at the upstream and downstream ends. During construction on the right-bank side, diversion of the river is planned to be achieved

using the diversion waterway constructed inside the dam body at the left-bank side.

iii) Dam

For dam construction, as stated under cofferdamming, excavation is done first together with the intake portion on the left-bank side, with dam concrete planned to be placed by tower crane after completion of excavation. In the dam construction, excavation is to be completed in approximately 4 months from July of the first year, with placing of dam concrete started from November of 1993, the first year, and completed in September of the following year. For 6 months before completion of dam concrete, foundation treatment consisting of curtain grouting work is to be performed along with the concrete work.

In construction work on the right-bank portion, excavation is to be started immediately after completion of work on the left-bank side. The excavation is to be completed in January of 1995, the third year, and for dam concrete placement the tower crane used for the left-bank portion is to be transferred to the right-bank portion, and concrete placement and foundation treatment are to be completed within the same year. It is planned for flushing gate installation to be completed in 6 months from July of the third year.

iv) Intake

Since the intake is to be located adjacent to the left-bank part of the dam, excavation is to be performed simultaneously with excavation for the dam. Intake concrete can be divided into intake proper concrete and tunnel connection concrete. The intake proper concrete includes retaining wall

concrete and is placed during the same period as dam concrete. Tunnel connection concrete is planned to be completed in approximately 2 months from November of the second year when excavation and lining concrete of the headrace tunnel is completed.

Intake gate installation is to be completed in 6 months from July of the third year, the same as the flushing gate of the dam.

v) Headrace Tunnel

The headrace tunnel consists of a horizontal tunnel section at EL. 1,070 m and an inclined shaft in the vicinity of the intake. The tunnel length is to be 1,190 m for the horizontal portion and approximately 90 m for the inclined portion. The inside diameter is to be 3.0 m for both with the cross section to be circular. It is planned for steel lining to be provided at a section of approximately 200 m of the horizontal portion where the overburden is thin. This tunnel is planned to be constructed, divided into approximately 660 m on the upstream side and approximately 530 m on the downstream side by providing a work adit approximately 200 m in length at a point approximately 500 m downstream of the dam axis.

Excavation of the work adit is to be done by a full-face cutting method starting from July of the first year with completion in 3 months, and immediately after completion, excavation of the headrace tunnel is to be started. Excavation is to be started at the same time for both the upstream and downstream sides and to be completed in 9 months. For the inclined shaft, an Alimak raise climber is to be used. Steel forms are to be used for the lining concrete and the inclined shaft portion is to be completed in 4 months from July of the second year,

while the horizontal portion, the upstream side including the steel lining, requires a period of 9 months and is to be completed in March of 1995, the third year. For the downstream side, concrete work is to be started awaiting completion of the upper-stage excavation of the penstock and lining concrete so that it is started from December of the third year and completed in May of 1996, the fourth year.

The rock around the tunnel is loosened due to blasting, and therefore, grouting is to be performed. Grouting work is to be done sequentially from parts where lining concrete has attained the required strength.

Plugging of the work adit is to be done in 2 months from September of the fourth year when lining concrete and grouting work of the headrace tunnel is completed, upon which all headrace tunnel work is planned to have been completed.

vi) Penstock

Penstock construction is to be divided into four categories as shown in Table 11-4.

Table 11-4 Detail of Penstock Tunnel

Item	Length	Diameter
Upper Inclined Shaft	646 m	3.00 m ~ 2.70 m
Upper Horizontal Tunnel	1,082 m	2.70 m
Lower Inclined Shaft	423 m	2.70 m ~ 2.20 m
Lower Horizontal Tunnel	786 m	2.20 m

Work adits are arranged at two locations, the upper stage work adit (EL. 600 m) and the lower stage work adit (EL. 296 m). The upper stage work adit is to be provided in the vicinity of the intersection between the upper horizontal tunnel and the lower inclined shaft and is to be 500 m in length, 4 m in width, and 4.5 m in height. This work adit is to be made by full-face excavation from July of 1993, the first year of the work and completion is to be 5 months later in November. From December of the same year, work on the upper horizontal tunnel is to be started by full-face excavation and is to be completed in June of 1994, the second year, at an average monthly advance rate of 125 m. The upper inclined shaft is to be excavated by the full-face cutting method using an Alimak raise climber, and it is planned for completion in November of 1995, the third year.

Lining concrete of the upper inclined shaft is to be placed using steel forms, poured from the work adit of the headrace tunnel and placed from the bottom upward. The work is to be started from December of the third year and to be completed in 7 months. The lining concrete of the upper horizontal tunnel is to be placed using steel forms similarly to the inclined shaft and is to be done from the upper inclined shaft toward the work adit. It is planned for the work to be completed in 11 months from February of the third year.

The lower stage work adit is planned to be constructed entering by an inclined shaft from the vicinity of the powerhouse reaching the lower horizontal tunnel at a point approximately 300 m from the powerhouse. This work adit is to be completed in 3 months from July of 1993, the first year of the work. Excavation is to be done by full-face cutting method. The lower horizontal tunnel is

to be constructed by full-face excavation simultaneously for both the powerhouse side and the lower inclined shaft side from the intersection with the work adit. The period required is to be 3 months for the powerhouse side, while work toward the lower inclined shaft is to be completed in 5 months in August of the second year. From September, excavation of the lower inclined shaft is to be started from the bottom with completion of excavation in January of 1995, the third year.

Installation of steel penstock and placing of backfill concrete are to be done in succession to completion of excavation. For the lower inclined shaft, delivery, installation, and welding of steel penstock and placement of concrete are to be done from the upper stage work adit, with completion to be in June 1996 using a construction period of 18 months. Delivery, installation, and welding of steel penstock and placement of concrete for the lower horizontal tunnel are to be performed from the lower stage work adit and are to be completed in September 1996, 19 months later.

With regard to the bifurcation in the vicinity of the powerhouse, it is planned for excavation from the powerhouse to be done after completion of excavation for the powerhouse, upon which installation and welding of the steel penstock and placement of concrete are to be done.

Plugging work on the upper and lower stage work adits is to be completed in 2 months from October of 1996, the fourth year, when all work in the installation of steel penstock pipe is completed.

vii) Powerhouse and Outdoor Switchyard

The powerhouse work consists of the powerhouse proper and embankment work for the outdoor switchyard.

Excavation is to be started from January of 1994, the second year, and open excavation is to be completed in 8 months. After completion of open excavation, tunnel excavation for the bifurcation of the penstock and concrete work for foundation and sidewall are to be started. Tunnel excavation for the bifurcation is to be completed in 5 months, and installation and welding of steel penstock and concrete placement are to be completed in 7 months while concrete of the powerhouse is being placed. Regarding powerhouse concrete, the foundation and sidewall concrete are to be completed in approximately 10 months, and embankment work is to be completed after carrying out filling around the powerhouse, but inside the powerhouse, concrete work goes on until December of the third year paralleling turbine and generator installation.

Architectural construction works such as offices, and a control room are planned to be completed in 8 months from December of the third year, thus finishing all work at the powerhouse.

viii) Tailrace Tunnel and Outlet

The tailrace tunnel is to have an inside diameter of 3.5 m and length of 580 m. Excavation of this tunnel is to be performed by full-face cutting starting from the outlet and going toward the powerhouse. The excavation is to be started from November of the second year and to be completed in June of 1995. Work on lining concrete is to be started immediately, and along with concrete of the

outlet, all of the tailrace tunnel and outlet work is planned to be completed in June of 1996, the fourth year.

ix) Turbines and Generators

Installation of turbines and generators is to be started from June of 1995, the third year, when civil works around the powerhouse such as sidewall concrete are completed, and installation of the No. 1 unit is to be completed in approximately 16 months. Subsequently, various tests are to be conducted and commercial operation is to be started at the end of December in 1996. The No. 2 and No. 3 units are to start commercial operation 7 months behind the No. 1 unit.

x) Transmission Line and Communication Lines

With regard to the transmission line and communication lines, work on the former is to be started from April of the third year in order to be completed by the start of turbine and generator tests. As for communication lines, it is planned for work to start from March of the fourth year and to be completed in September of 1996, the fourth year, to be in time for the various tests to be started from October of the same year.

11.2 Construction Cost

The construction cost of this Project is estimated based on the assumption that design, construction methods, materials and products possessing the technological level that can be expected at the present stage is applied, and taking into consideration geological conditions of the project sites, regional conditions, project scale, etc. The price level is taken to be June 1989, with the exchange rate between local and foreign currencies being 1 US$ = 140 Tsh.

11.2.1 Basic Items

(1) Items of Cost Estimation

The items of cost estimation are the following:

i) Preparatory Works

Access road ..... Construction cost for new road of approximately 50 km from Uhafiwa near Upper Kihansi Power Station to the Lower Kihansi Power Station site, and improvement cost of the existing road from Iringa to Uhafiwa

Camp facilities and power supply for construction ..... Offices, living quarters,power distribution lines for construction, diesel generators and fuel therefor

ii) Compensation cost ..... Compensation for the inhabitants within water impoundment areas and environmental mitigation

iii) Civil Works

Care of river ..... Diversion tunnel and cofferdam

Dam ..... Dam proper, foundation treatment, etc.

Waterway structures ..... Intake, headrace tunnel, penstock, tailrace tunnel, tailrace outlet, etc.

Powerhouse and switchyard ..... Civil and architectural works

iv) Hydraulic equipment ..... Gate, trashrack, steel penstock, pipe, etc.

v) Electromechanical equipment ..... Turbine, generator, main transformer, auxiliary equipment, switchyard equipment, etc.

vi) Transmission line ..... All costs related to transmission line construction

vii) Engineering fee and administration cost ..... Planning, coordinating, administration, operation costs related to construction

viii) Contingency cost ..... Contingency expenses to deal with unforeseen changes in work quantities

ix) Interest during construction ..... Interest during the construction period

(2) Estimating Criteria

i) Civil Works Costs

The unit costs of civil works are calculated, first making comparisons and studies of unit construction costs in Tanzania in 1989, unit costs in existing

and similar construction projects in Tanzania, and unit construction costs at similar sites in Japan, then analyzing in accordance with the work execution procedures of various construction works, and last taking into consideration labor costs, materials costs, machinery costs, various expenses, etc. in Tanzania.

- Unit Labor and Materials Costs

  The unit labor and materials costs in Tanzania are given in Tables 11-5 and 11-6, respectively.

- Construction Machinery

All principal items of construction equipment such as dump trucks, bulldozers, large-sized cranes for concrete placement, and boring and grouting equipment are to be imported, and machinery costs are to be calculated based on CIF costs at Dar Es Salaam.

Table 11-5 Labour Wages

Labour Type	Rate per Month (Tsh)
Senior foreman	4,000 - 6,000
Labourer	2,000 - 3,000
Carpenter	2,500 - 4,000
Electrician	2,500 - 4,000
Mechanic	2,500 - 4,000
Operator (Heavy equip.)	4,000 - 6,000
Operator (Light equip.)	4,000 - 6,000
Bar bender	2,500 - 4,000
Welder	2,500 - 4,000
Plumber	2,500 - 4,000
Blacksmith	2,500 - 4,000
Driller	2,000 - 3,000
Groutman	2,500 - 4,000
Mason	2,500 - 4,000

Table 11-6 Material Cost

Material	Unit	Cost (Tsh)
Cement (Vulk)	t	9,100
Dynamite	kg	380
Electric detonator	pcs	95
Gasoline	l	67
Diesel	l	21
Heavy oil	l	18
Machine oil	l	21
Reinforcement bar	t	50,000
Timber	m^3	11,000

ii) Hydraulic Equipment

All hydraulic equipment such as gates and steel penstock pipe are to be imported from abroad. This cost is to include transportation costs to the installation sites and installation costs.

iii) Electromechanical Equipment

Electromechanical equipment such as turbines, generators, and transformers are all to be imported from abroad. The transportation costs to the powerhouse sites and installation costs are to be included in the costs of such equipment.

iv) Transmission Line Construction Cost

The unit price for transmission line construction is to be based on the unit price furnished by TANESCO.

v) Engineering Fee and Administration Cost

The engineering fee and administration costs are to comprise 7.5 percent of total construction cost of preparatory works, civil works, hydraulic equipment, electromechanical equipment, transmission lines, and compensation costs.

vi) Compensation Cost

The compensation amounts such as compensation for inhabitants furnished by TANESCO are to be used.

vii) Interest during Construction

Interest during construction is to be 8.5 percent for foreign currency and 12 percent for local one.

viii) Import Duty

The import duties on materials needed to be imported, construction equipment, and electromechanical equipment such as turbines and generators are to be made a uniform 20 percent.

ix) Contingency Cost

Contingency costs are to be 15 percent of civil works costs, and 10 percent of hydraulic equipment and electromechanical equipment costs.

(3) Classification of Local and Foreign Currency Requirements

i) Civil Works Costs

Cement, steel materials such as reinforcement bars and structural steel, and explosives are to be imported, and require foreign currency.

Machinery for civil works such as heavy dump trucks, bulldozers, and temporary facilities such as concrete plant, aggregate plant, cranes for concrete placement, etc. are all to be imported, and the construction costs are to be calculated with foreign currency. Special equipment such as boring machines, grout pumps, and compressors are to be procured through importation, and are to come under foreign currency.

ii) Hydraulic Equipment

Hydraulic equipment is to be included under foreign currency, but transportation costs in Tanzania and installation costs are to be under local currency requirements.

iii) Electromechanical Equipment and Transmission Line

Principal electromechanical equipment and transmission line equipment and materials are to come under foreign currency, and transportation costs in Tanzania and installation costs under local currency.

iv) Engineering Fee and Administration Cost

Local currency is to cover 20 percent, and foreign currency 80 percent.

v) Compensation Cost

Although compensation costs are to be paid with local currency, environmental mitigation cost is assumed to be foreign currency.

vi) Interest during Construction

Interest of 8.5 percent is to be calculated for foreign currencies and that of 12 percent for local ones.

11.2.2 Construction Cost

Construction cost is listed in Table 11-7, Table 11-8 (1) and Table 11-8 (2).

Table 11-7 Construction Cost

Unit: 1,000 US$

	Upper Kihansi			Lower Kihansi			Total		
	F.C	L.C	Total	F.C	L.C	Total	F.C	L.C	Total
1. Preparatory Works									
1-1 Access Road			0	15,280	3,820	19,100	15,280	3,820	19,100
1-2 Camp Facility & Others	3,600	1,000	4,600	10,100	3,200	13,300	13,700	4,200	17,900
Sub-total	3,600	1,000	4,600	25,380	7,020	32,400	28,980	8,020	37,000
2. Compensation & Others	1,695	5	1,700	1,698	2	1,700	3,393	7	3,400
3. Civil Works									
3-1 Diversion & Coffer Dam	2,059	641	2,700	160	40	200	2,219	681	2,900
3-2 Dam & Spillway	107,801	33,599	141,400	7,631	2,169	9,800	115,432	35,768	151,200
3-3 Intake	3,621	1,079	4,700	1,087	313	1,400	4,708	1,392	6,100
3-4 Headrace Tunnel	1,733	567	2,300	2,253	747	3,000	3,986	1,314	5,300
3-5 Penstock	1,698	502	2,200	7,364	2,836	10,200	9,062	3,338	12,400
3-6 Powerhouse & Switchyard	4,436	1,264	5,700	9,880	2,720	12,600	14,316	3,984	18,300
3-7 Tailrace Tunnel	1,878	622	2,500	1,203	397	1,600	3,081	1,019	4,100
3-8 Tailrace Outlet	610	190	800	390	110	500	1,000	300	1,300
Sub-total	123,836	38,464	162,300	29,968	9,332	39,300	153,804	47,796	201,600
4. Hydraulic Equipment	2,000	500	2,500	5,760	1,440	7,200	7,760	1,940	9,700
5. Electro-mechanical Equipment	10,700	3,400	14,100	27,700	8,700	36,400	38,400	12,100	50,500
6. Transmission Line	80	40	120	12,700	6,200	18,900	12,780	6,240	19,020
7. Total Cost (1+2+3+4+5+6)	141,911	43,409	185,320	103,206	32,694	135,900	245,117	76,103	321,220
8. Engineering & Administration	11,134	2,783	13,917	8,114	2,029	10,143	19,248	4,812	24,060
9. Physical Contingency	20,648	6,314	26,962	13,173	4,087	17,260	33,821	10,401	44,222
10. Interest during Construction	24,476	10,325	34,801	29,858	12,839	42,697	54,334	23,164	77,498
11. Grand Total (7+8+9+10)	198,169	62,831	261,000	154,351	51,649	206,000	352,520	114,480	467,000

Table 11-8 (1) Disbursement Schedule of Upper Kihansi

Unit: 1,000 US$

	Total			1st Year (1995)		2nd Year (1996)		3rd Year (1997)		4th Year (1998)		5th Year (1999)	
	F.C	L.C	Total	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C
1. Preparatory Works													
1-1 Access Road			0										
1-2 Camp Facility & Others	3,600	1,000	4,600	1,680	600	480	100	480	100	480	100	480	100
Sub-total	3,600	1,000	4,600	1,680	600	480	100	480	100	480	100	480	100
2. Compensation & Others	1,695	5	1,700	791	5	226	0	226	0	226	0	226	0
3. Civil Works													
3-1 Diversion & Coffer Dam	2,059	641	2,700	824	256	1,235	385						
3-2 Dam & Spillway	107,801	33,599	141,400			10,780	3,360	21,560	6,720	43,120	13,440	32,340	10,080
3-3 Intake	3,621	1,079	4,700					1,086	324	2,535	755		
3-4 Headrace Tunnel	1,733	567	2,300					1,213	397	520	170		
3-5 Penstock	1,698	502	2,200					340	100	849	251	509	151
3-6 Powerhouse & Switchyard	4,436	1,264	5,700					444	126	2,662	758	1,331	379
3-7 Tailrace Tunnel	1,878	622	2,500							1,502	498	376	124
3-8 Tailrace Outlet	610	190	800							61	19	549	171
Sub-total	123,836	38,464	162,300	824	256	12,015	3,745	24,643	7,667	51,249	15,891	35,105	10,905
4. Hydraulic Equipment	2,000	500	2,500							1,200	300	800	200
5. Electro-mechanical Equipment	10,700	3,400	14,100							3,210	1,020	7,490	2,380
6. Transmission Line	80	40	120			80	40						
7. Total Cost (1+2+3+4+5+6)	141,911	43,409	185,320	3,295	861	12,801	3,885	25,349	7,767	56,365	17,311	44,101	13,585
8. Engineering & Administration	11,134	2,783	13,917	1,113	278	2,227	557	2,227	557	3,339	835	2,227	557
9. Physical Contingency	20,648	6,314	26,962	494	129	1,916	581	3,802	1,165	8,234	2,531	6,201	1,909
10. Interest during Construction	24,476	10,325	34,801	208	76	1,136	453	3,190	1,324	7,411	3,134	12,531	5,338
11. Grand Total (7+8+9+10)	198,169	62,831	261,000	5,110	1,344	18,080	5,476	34,568	10,813	75,349	23,811	65,060	21,389

Table 11-8 (2) Disbursement Schedule of Lower Kihansi

Unit: 1,000 US$

	Total			1st Year (1992)		2nd Year (1993)		3rd Year (1994)		4th Year (1995)		5th Year (1996)		6th Year (1997)	
	F.C.	L.C.	Total	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
1. Preparatory Works															
1-1 Access Road	15,280	3,820	19,100	3,820	955	7,640	1,910	3,820	955						
1-2 Camp Facility & Others	10,100	3,200	13,300	6,059	2,240	1,010	640	1,010	107	1,010	107	1,010	107		
Sub-total	25,380	7,020	32,400	9,879	3,195	8,650	2,550	4,830	1,062	1,010	107	1,010	107	0	0
2. Compensation & Others	1,698	2	1,700	1,018	2	170	0	170	0	170	0	170	0		
3. Civil Works															
3-1 Diversion & Coffer Dam	160	40	200			96	24	64	16						
3-2 Dam & Spillway	7,631	2,169	9,800			763	217	3,052	868	3,815	1,085				
3-3 Intake	1,087	313	1,400			326	94			761	219				
3-4 Headrace Tunnel	2,253	747	3,000			676	224	1,126	374	225	75	225	75		
3-5 Penstock	7,364	2,836	10,200			736	284	2,209	851	3,682	1,418	736	284		
3-6 Powerhouse & Switchyard	9,880	2,720	12,600					2,964	816	5,928	1,632	988	272		
3-7 Tailrace Tunnel	1,203	397	1,600					120	40	842	278	241	79		
3-8 Tailrace Outlet	390	110	500					78	22			312	88		
Sub-total	29,968	9,332	39,300	0	0	2,597	843	9,613	2,987	15,253	4,707	2,502	798	0	0
4. Hydraulic Equipment	5,760	1,440	7,200							2,880	720	2,880	720		
5. Electro-mechanical Equipment	27,700	8,700	36,400							5,540	1,740	19,390	6,090	2,770	870
6. Transmission Line	12,700	6,200	18,900							6,350	3,100	6,350	3,100		
7. Total Cost (1+2+3+4+5+6)	103,206	32,694	135,900	10,897	3,197	11,417	3,393	14,613	4,049	31,203	10,374	32,302	10,815	2,770	870
8. Engineering & Administration	8,114	2,029	10,143	406	101	811	203	1,623	406	2,434	609	2,434	609	406	101
9. Physical Contingency	13,173	4,087	17,260	1,635	480	1,713	509	2,192	607	3,941	1,278	3,414	1,127	277	87
10. Interest during Construction	29,858	12,839	42,697	550	227	1,692	700	3,068	1,250	5,448	2,289	8,666	3,778	10,434	4,595
11. Grand Total (7+8+9+10)	154,351	51,649	206,000	13,488	4,005	15,633	4,805	21,496	6,312	43,026	14,550	46,816	16,329	13,887	5,653

Chapter 12 EFFECTS ON ENVIRONMENT AND COMPENSATION

Chapter 12

EFFECTS ON ENVIRONMENT AND COMPENSATION

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Chapter 12 EFFECTS ON ENVIRONMENT AND COMPENSATION

12.1 Outline of Project

The outline of the project is mentioned here for identifying activities which might affect the environment through the establishment of the power station.

12.1.1 Location of Power Station

The planned power station site is located in the southwest part of Kilombero District of Morogoro Region near the borderline of Iringa Region. The upper dam and upper powerhouse are about 80 km south of Iringa City in the central and south part of the united Republic of Tanzania, the lower dam is about 3 km south of their location, and the lower powerhouse is another 4 km south of this place. The lower power station is located about 20 km away from Chita Station, the nearest station on the Tazara Railway (Fig. 12-1).

12.1.2 Outline of Power Station

The establishment of the power stations consist of the upper power station and the lower power station in a tributary of Kilombero River named Kihansi River in the Rufiji River System, and an area of 3.9 km^2 is to be submerged by the impoundment of the upper reservoir over a part of Kihansi River and its tributary named Ruaha River. The outline of main facilities related to power stations are as follows in Table 12-1.

12.1.3 Transmission Line

A single-conductor, two-circuit-transmission-line system (220 kV), 113 km in length, is planned to be constructed from the lower powerhouse to the existing Iringa Substation (Fig. 12-2).

Fig. 12-1 Location of Planned Power Station Site

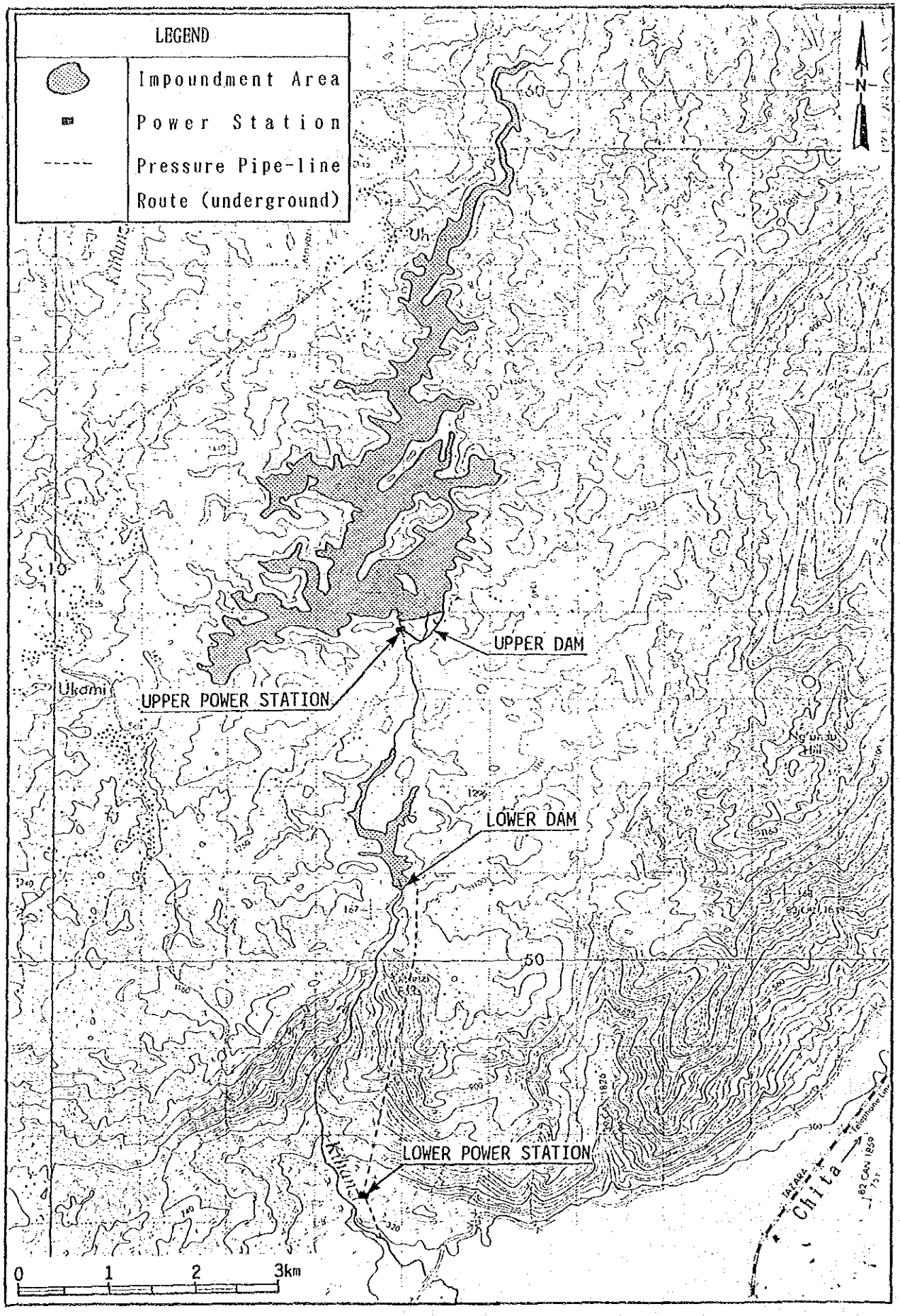
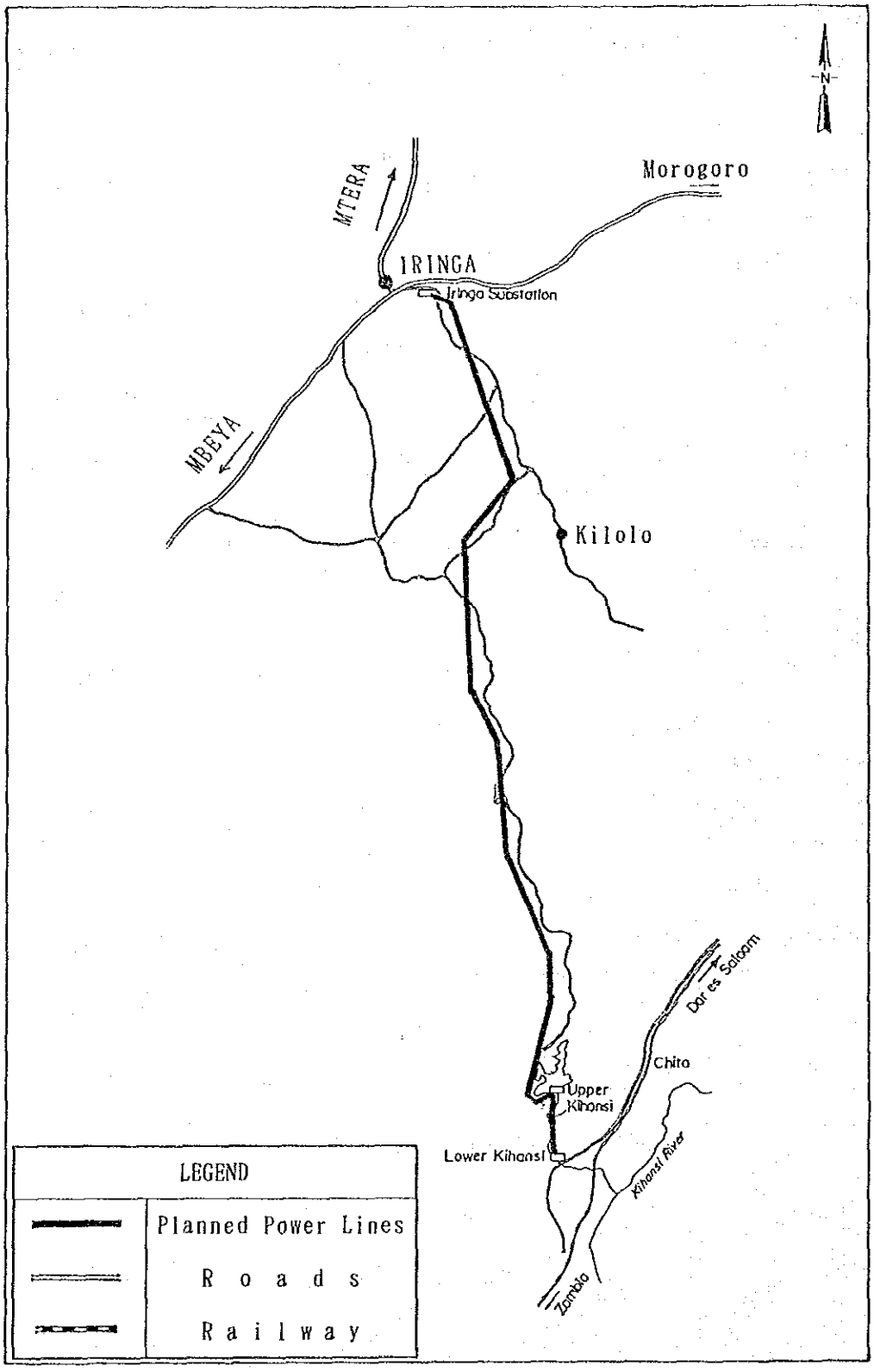


Table 12-1 Main Facilities of Power Station

Name of Power Station / Items	Upper Kihansi Power Station	Lower Kihansi Power Station
Power Generation Method	Dam and conduit type	Dam and conduit type
Maximum Output	47 MW	153 MW
Maximum Discharge	25.7 m^3/s	22.2 m^3/s
Firm Discharge	11.8 m^3/s	11.8 m^3/s
Effective Head	214.5 m	813.0 m
Catchment Area	583 km^2	590 km^2
Type of Dam	Rock-fill dam	Concrete dam (Gravitational type)
Dam Height x Length	95 m x 583 m	35 m x 177 m
Dam Volume	5,350 x 10^3 m^3	54 x 10^3 m^3
Available Drawdown	30 m	3 m
High Water Level	1,360 m	1,140 m
Low Water Level	1,330 m	1,137 m
Length of Impoundment	about 8.7 km	about 2.1 km
Average Daily Inflow	15.7 m^3/day	15.9 m^3/day
Total Storage Capacity	94.90 x 10^6 m^3	1.39 x 10^6 m^3
Effective Storage Capacity	75.10 x 10^6 m^3	0.48 x 10^6 m^3
Surface Area	3.9 km^2	0.3 km^2
Power Station	Semi-underground	Semi-underground
Switch Yard	Outdoor	Outdoor

Fig. 12-2 Transmission Line Route



12.2 Present State of Environment

The present state of the natural and social environment was surveyed for estimating and evaluating the effects on the environment through the establishment of the power stations.

12.2.1 Protection of Nature

The protection of nature is regarded as an important cultural and economic issue in the United Republic of Tanzania, and the construction of the power stations should be carefully planned in consideration of the protection of nature.

There are thirteen national parks in the United Republic of Tanzania, covering an area of 102,658 km^2 or 11% of the national land. Sixteen places and fifty to sixty places have been designated as game/wildlife reserves with an area of 39,750 km^2 (4%), and game controlled areas with an area of 121,655 km^2 (12%), respectively in addition to forest reserves with an area of 134,075 km^2 (Data-1).

(1) National Park

All activities are prohibited in a national park except animal and plant watching and photographing. Nobody is allowed to enter the park without permission and stay there exceeding the time limit.

At present, there is no national park at the planned power station site or in its vicinity. Part of the Uzungwa Mountains, which includes the planned power station site on its western edge, is planned to be designated as a national park in the future, but the proposed park area is more than

100 km away from the planned power station site (Fig. 12-3).

(2) Conservation Area

The conservation area was established for the proper use of natural resources and for the protection of the Masai's vested rights. Agriculture is prohibited, but Masai activities such as livestock grazing and residence are allowed.

At present, the area near the borderline of Kenya is designated as the Gorongoro Conservation Area.

(3) Game/Wildlife Reserve

The game/wildlife reserve is designated for controlling the use of natural resources for future, apart from protecting the animals and plants. In principle, nobody is allowed to live inside the reserve. Licensed professional hunting is allowed only between July and December. Even forest resources in the game/wildlife reserve cannot be used without permission. However, there is no game/wildlife reserve at the planned power station site or in its vicinity.

(4) Game Controlled Area

Hunting for all animals except specified animals inside the game controlled area is allowed if permitted, but there are various restrictions on hunting methods. Hunting is allowed for land application such as farming, living, etc., and protection of farm products.

Kibasira Swamp downstream from the outlet of the lower power station in the vicinity of the planned

power station site is designated as the Kilombero Game Controlled Area (Fig. 12-3).

(5) Forest Reserve

The protection of a forest reserve aims at the proper use of natural resources by avoiding the unruly development of forests through the collection of firewood and construction materials and the slash-and-burn method of agriculture, and at developing it properly as required.

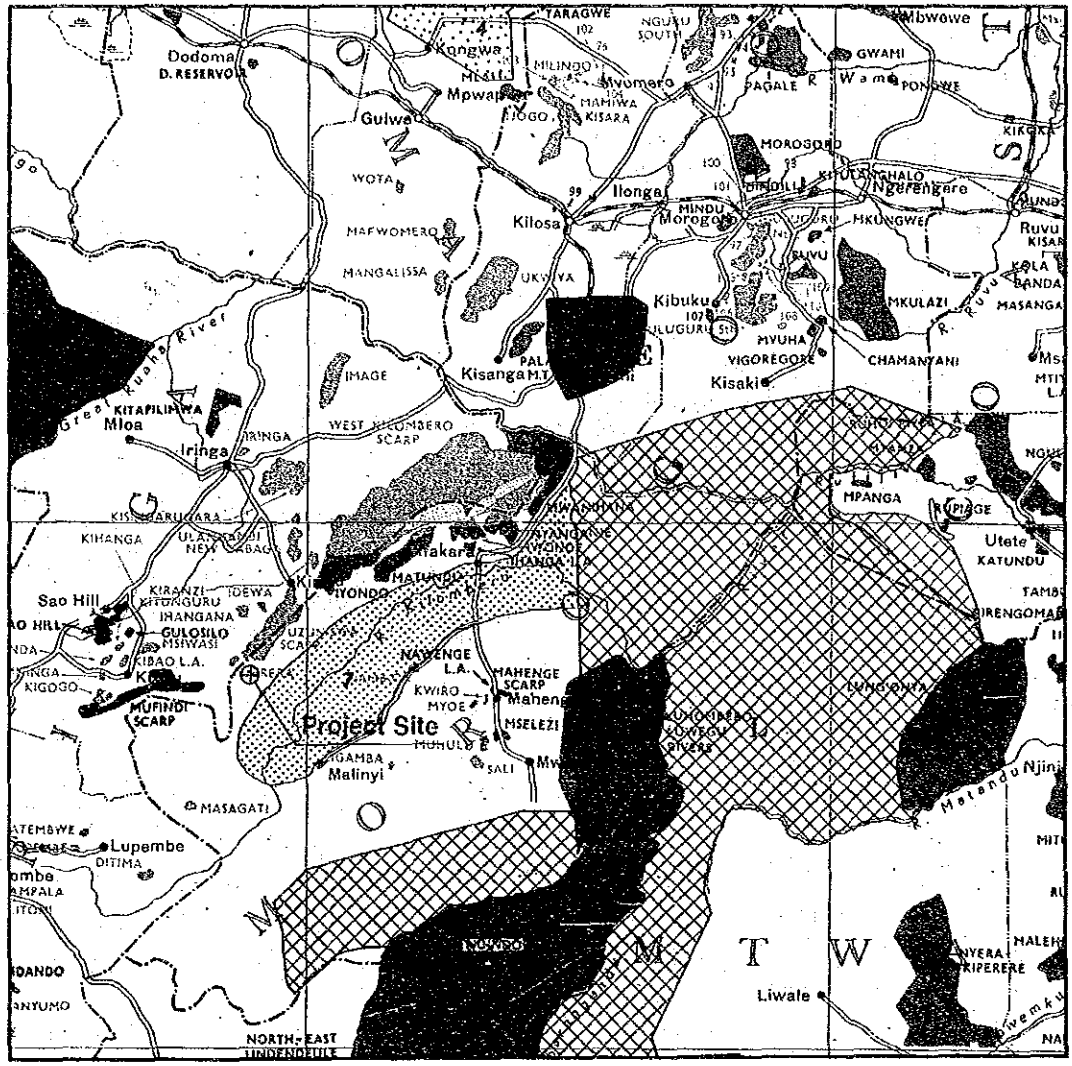
The forest reserve is expected to secure various effects such as water source development, soil erosion prevention, climatic stability, animal species protection, etc. The forest reserve consists of two kinds of forests, namely, productive forests and protective forests.

In the forest reserve, the private use of forests, such as land possession, living, deforestation, farming, natural product acquisition, pasturage, etc., is not allowed but the development of forests for public interests like the construction of power stations is allowed.

The Uzungwa Scarp Forest Reserve is located at the planned power station site on the left side of Ruaha River (Fig. 12-4).

Of the gross area of the forest reserve with an area of about 300 km^2, an area of 2.3 km^2 or about 1% of the gross area will be submerged by the impoundment of the upper dam.

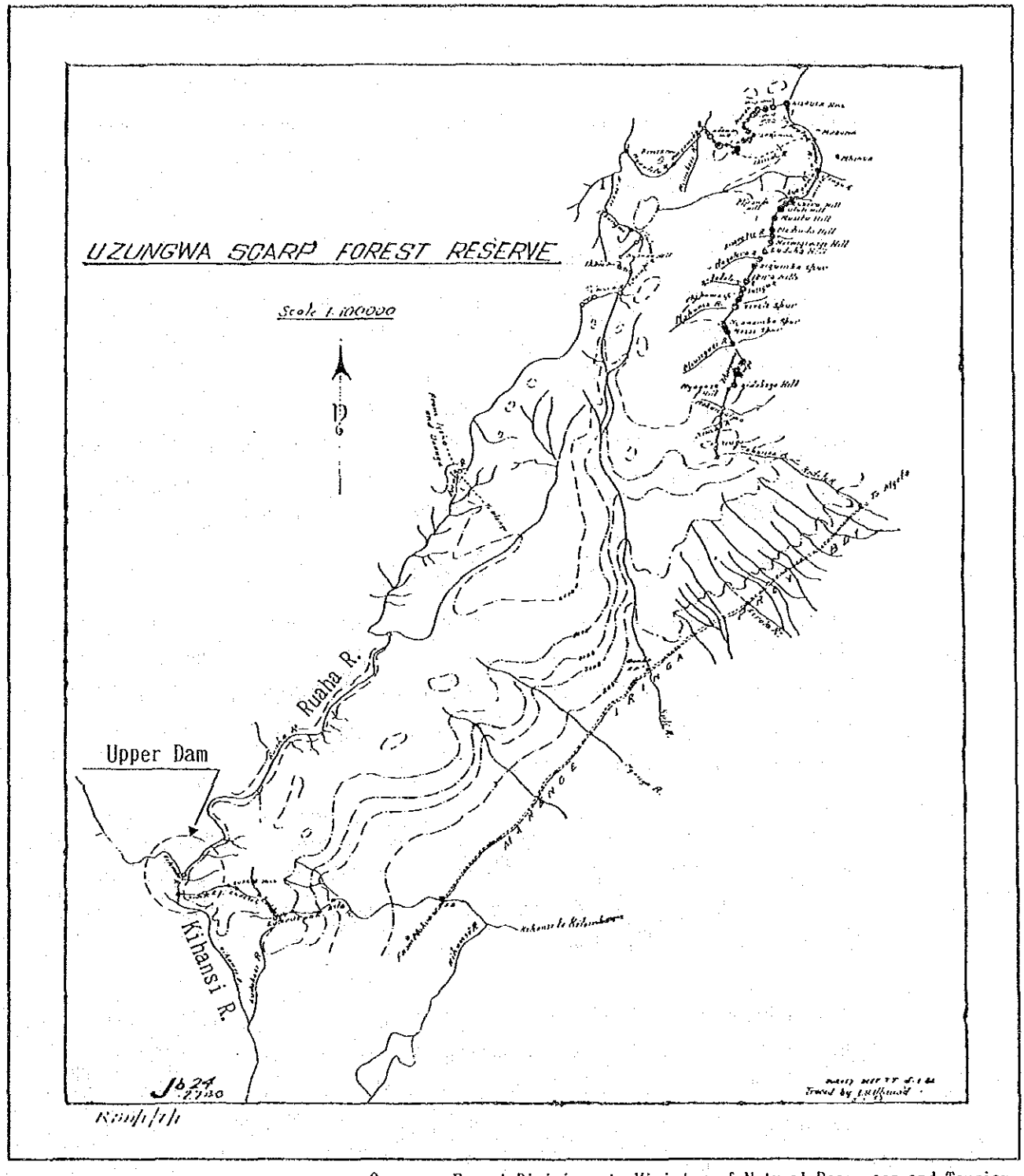
Fig. 12-3 Present State of Designated Areas for Protection of Nature



REFERENCE

- National Park
- Game Reserves
- Controlled Areas
- Proposed National Park Area
- Closed Forest
- Woodland
- Grassland
- International Boundaries
- Regional Boundaries
- District Boundaries

Fig. 12-4 Location of Uzungwa Scarp Forest Reserve



Sources : Forest Division at Ministry of Natural Resources and Tourism

12.2.2 Natural Scenery

The planned power station site is located about 80 km south of Iringa City. The upper dam is to be constructed just under the confluence of Kihansi River and its tributary named Ruaha River as a reservoir with an area of 3.9 km^2 over both Kihansi River and Ruaha River.

The location of the recorded main spots of natural scenery near the planned power station site are as shown in Fig. 12-5. The representative sceneries near the planned upper power station site and the reservoir are as shown in Fig. 12-6 (1). The forest reserve is on the left side of Ruaha River, and burned/cultivated fields and their unused fields in turn are on the right side of Ruaha River and both sides of Kihansi River.

The lower dam is planned 3 km downstream from the upper dam, and almost all the places are burned/cultivated fields and their unused fields in turn in this section on both sides of Kihansi River as shown Fig. 12-6 (2). This scenery continues to the Kihansi Falls about 4 km downstream from the lower dam.

The representative scenery along Kihansi River is the Kihansi Falls with a 200 m head of water (Fig. 12-6 (2)). Nobody visits there since there is no road to the Kihansi Falls surrounded with forests.

The lower power station is planned to be constructed on the edge of an upstream swamp at 300 m above sea level. And in its vicinity is a savanna with luxuriant true grasses.

The area downstream from the outlet of the lower power station is a swamp studded with acacias (Fig. 12-6 (3)).

Fig. 12-5 Photographic Spots of Natural Scenery

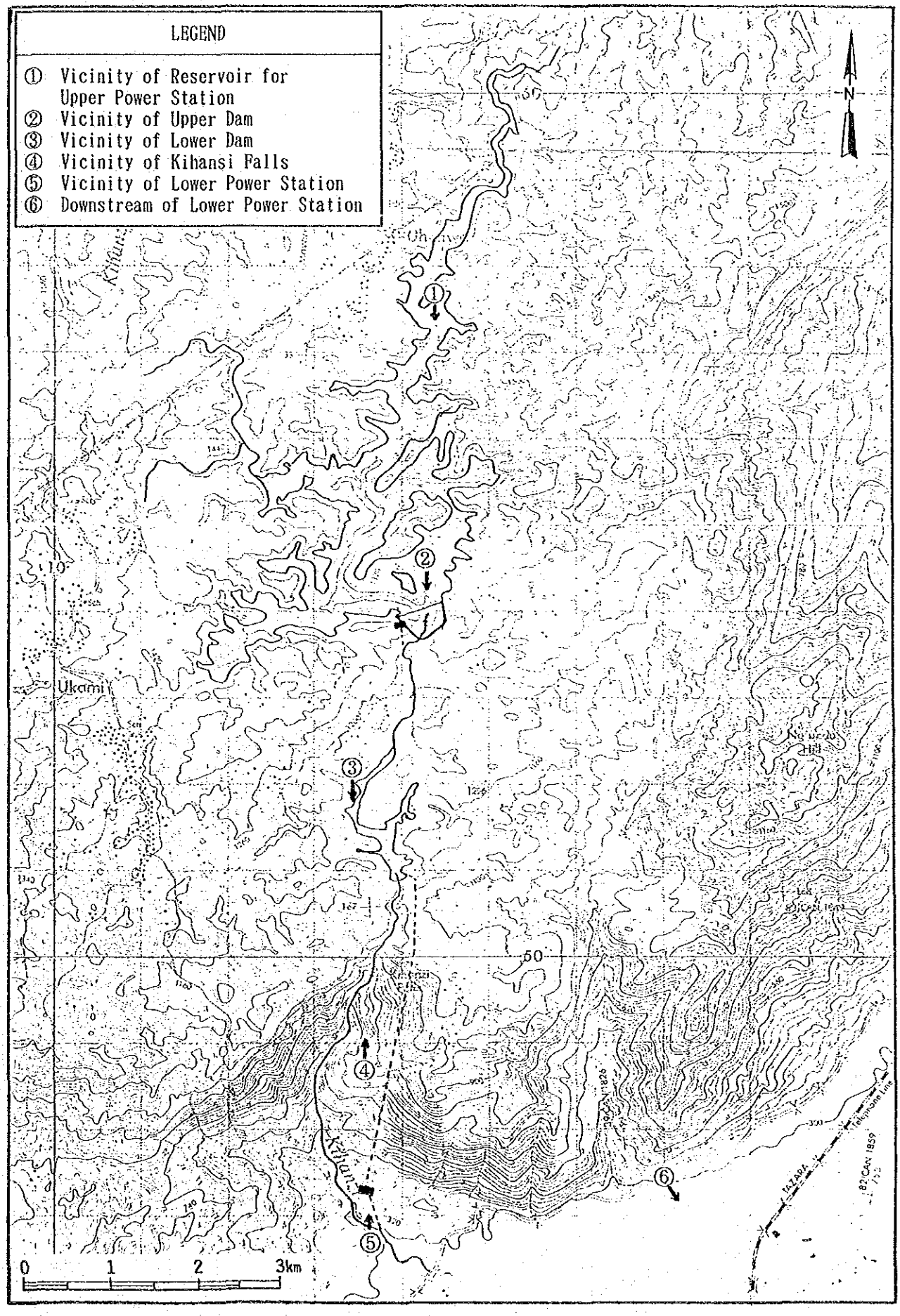
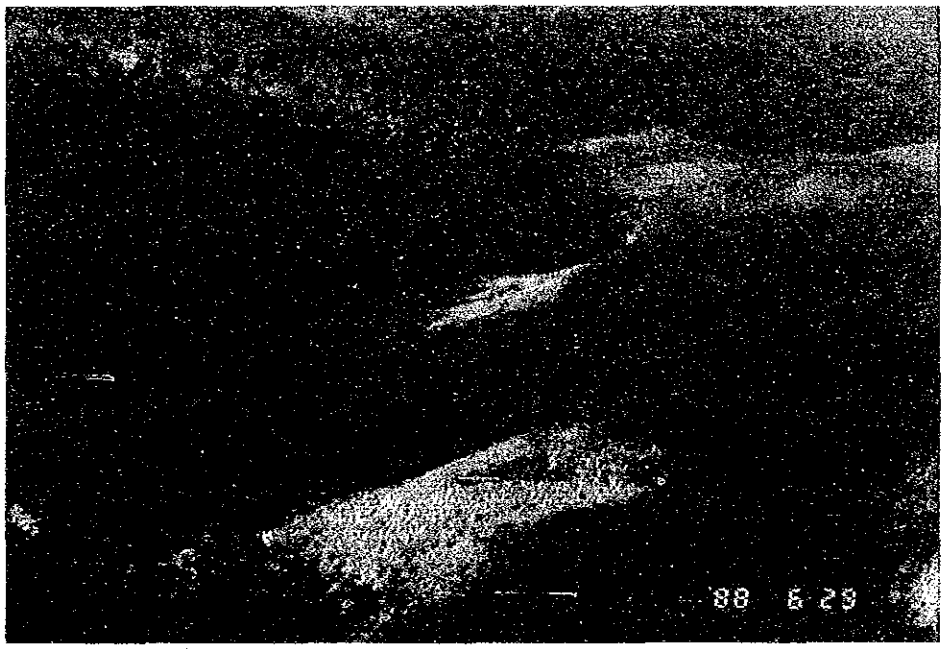


Fig. 12-6 (1) Photographs of Natural Scenery

1 Vicinity of Reservoir for Upper Kihansi Project



2 Vicinity of Upper Dam

Fig. 12-6 (2) Photographs of Natural Scenery

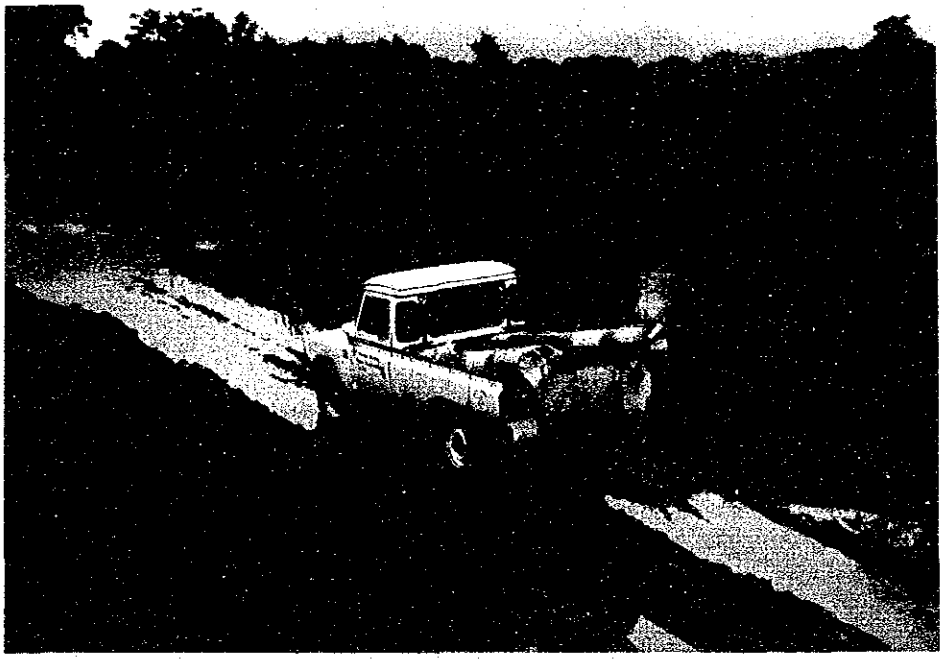
3 Vicinity of Lower Dam

4 Vicinity of Kihansi Falls

Fig. 12-6 (3) Photographs of Natural Scenery

5 Vicinity of Lower Powerhouse

6 Downstream of Lower Kihansi Project

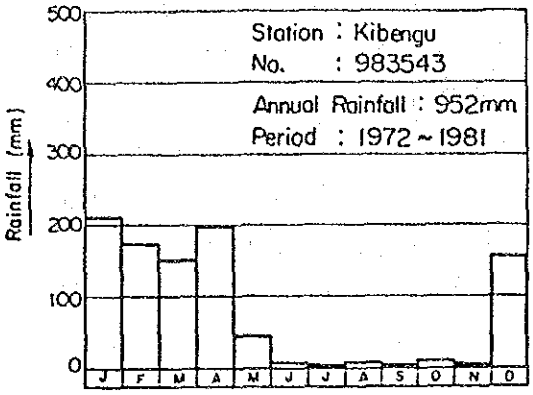


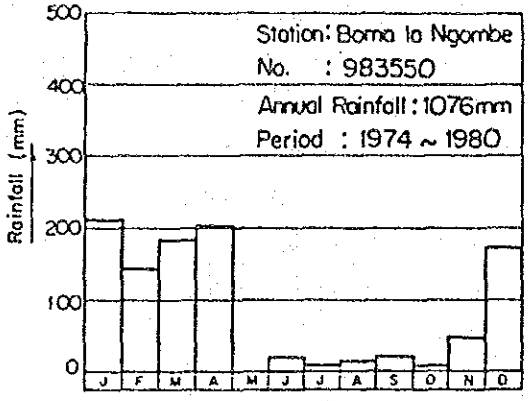
12.2.3 Meteorology

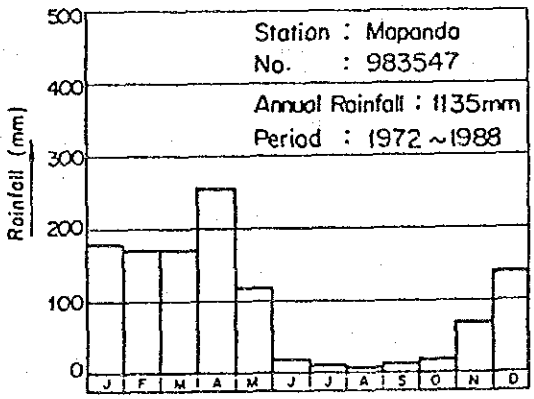
The planned power station site is located in the southwestern part of the United Republic of Tanzania belonging to the tropical savanna meteorological section. This meteorological section is characteristic of being clearly divided into the rainy season and the dry season. The rainy season at the planned power station site lasts from November to May, but it rains a little bit even during the dry season. Therefore, it is a relatively humid climate (Fig. 12-7).

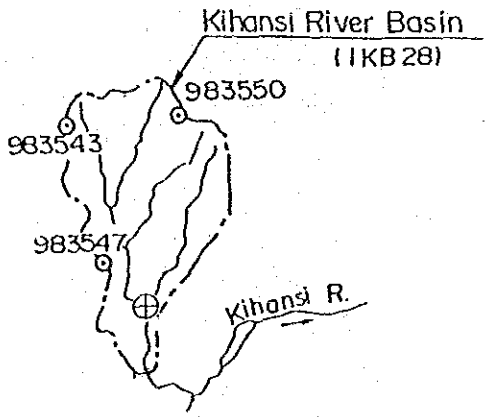
The planned power station site is located in the rainiest part of the United Republic of Tanzania, and the annual rainfall amounts even about 1,500 mm as shown in Fig. 12-8 the Rainfall Distribution with 10% Probability. Therefore, this area belongs to the humid climate or sub-humid climate zone.

Fig. 12-7 Seasonal Changes in Rainfall



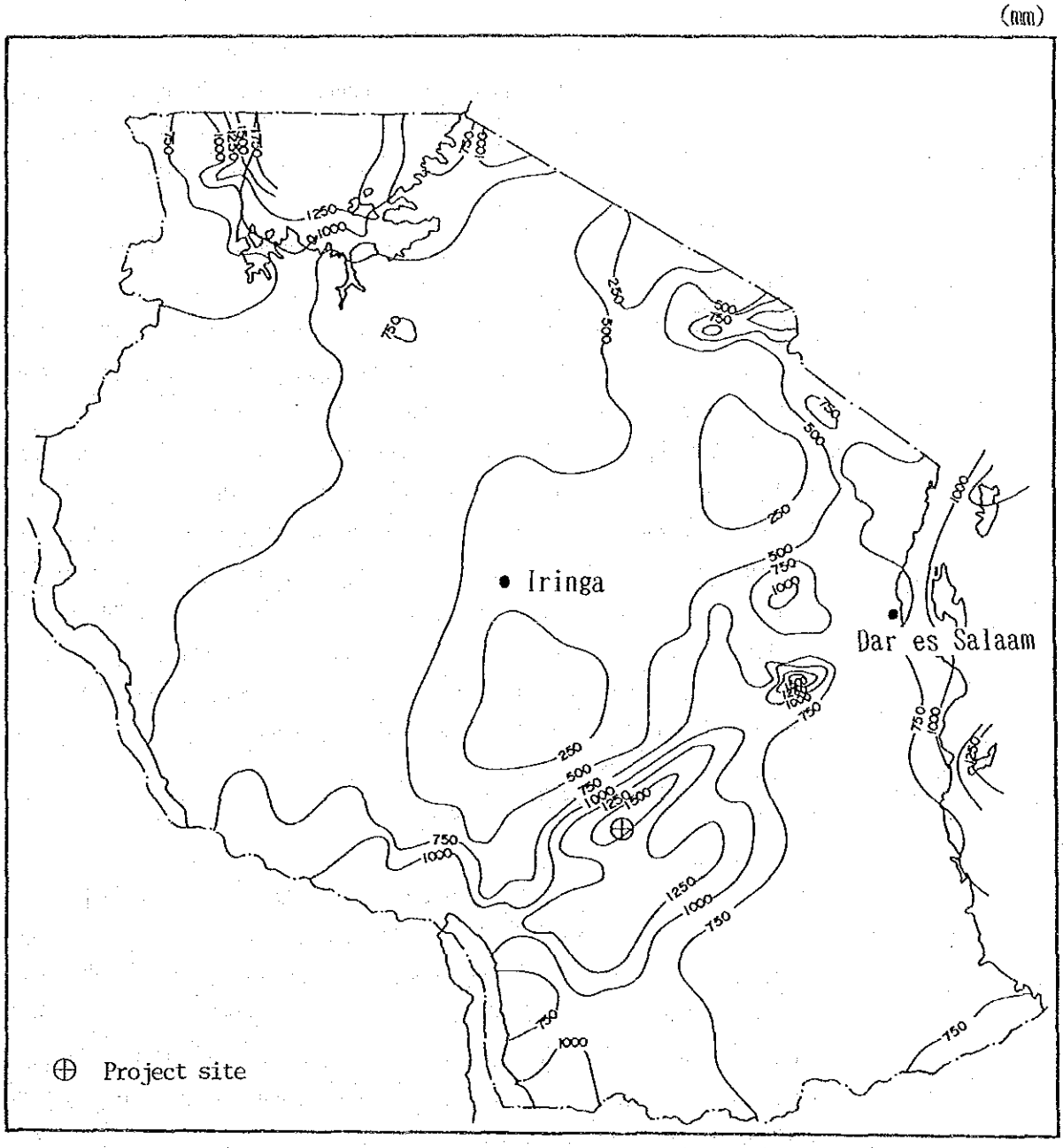






LEGEND	
⊙	Rainfall Observatory
—·—	Kihansi River Basin
⊕	Project site

Fig. 12-8 Rainfall Distribution with 10% Probability



Sources : Government of the United Republic of Tanzania

12.2.4 Topography and Geology

(1) Topography

The planned power station site is located between a plateau more than 1,000 m above sea level and low land less than 500 m above sea level which continues from the coast of the Indian Ocean.

The source of Kihansi River originates in gently-sloping hilly land 2,000 m to 1,500 m above sea level reticulated with rivers. The area 1,500 m to 1,100 m above sea level downstream from the source of Kihansi River is gently-sloping near the summits of mountains, and often very steep along rivers by water erosion. The area 1,100 m to 300 m above sea level downstream from there has a precipice 800 m in height. This precipice continues northeast along Kilombero Valley and is called Uzungwa Scarp. There is low land less than 300 m above sea level under the precipice, and it is a swamp which is partly overflowed in the rainy season.

(2) Geology

The Kihansi River Basin is located in the Usagaran Orogenic Belt which bounds the southeast part of the Tanzanian Shield spread widely to the west from the central part of Tanzania. The geological structure of the basin is characteristic of precipices, especially Uzungwa Scarp reaching even 800 m in height.

The basement rocks making up the basin are Precambrian gneisses and granites. The most predominant of these gneisses, the quartzo-feldspathic gneiss, can be seen in a wide range from the vicinity of Kihansi River head down to the Uzungwa Scarp. On the other hand, the granites

which consist mostly of biotite granite are scantily seen around the source of Kihansi River in the entire basin. Surface deposits are widely distributed in a swamp less than 300 m above sea level, but river deposits are sporadically distributed along rivers higher than Uzungwa Scarp. The surface soil in the vicinity of the planned power station site consists of humus and lateritic soil in the forest, and lateritic soil covering the basement rocks in other areas (Fig. 12-9).

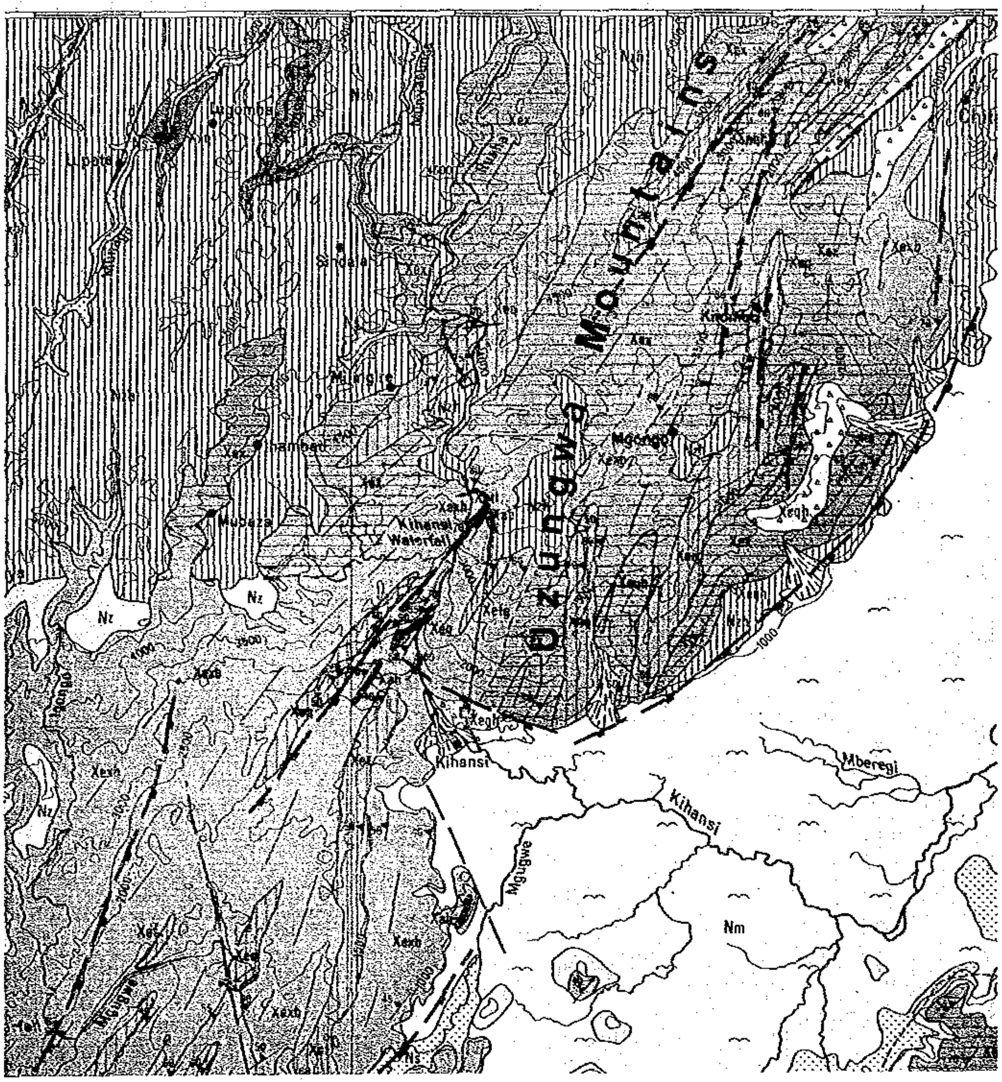
(3) Mineral Resources

Around the planned power station site, no collection of mineral resources is enforced except materials for brick. No mineral veins have not been recognized there, either.

(4) Soil Erosion

Around the planned power station site, there is no large scale devastated land nor prominently eroded topographic land that may cause the outflow of soil, but the outflow of soil in burned/cultivated fields and their unused fields continues to occur constantly in the rainy season.

Fig. 12-9 Geological Map



Nm	Mbuga.mbuga soil (clay, black cotton etc.)
Ns	River deposits (silt, sand, gravel)
	Talus fan
	Debris on main scarps
Nh	Humus-rich soils of rain forest
Nz	Lateritic earths (loamy sands, brown, pink, red to yellow)
	Garnet amphibolite
Xexb	Quartzo-feldspathic gneiss with biotite, fine- to medium-grained
Xez	Quartzo-feldspathic gneiss with high amounts of microcline, medium- to coarse-grained
Xezg	Quartzo-feldspathic gneiss with high amounts of microcline and with garnet, medium- to coarse-grained
	Quartzo-feldspathic gneiss with thick layers of quartzitic gneisses, occasionally with microcline phenocrysts and garnet, fine-grained
	Quartzo-feldspathic gneiss with biotite, occasionally with garnet, streaky, sometimes homogeneous, fine- to medium-grained
	Quartzo-feldspathic gneiss with hornblende and layers and lenses of amphibolitic gneisses, partly migmatized, fine- to medium-grained

0 5km