Chapter 6

SITUATION OF EXISTING POWER STATIONS

6. SITUATION OF EXISTING POWER STATIONS

6.1 General

Deterioration of facilities at existing power stations was diagnosed during the First Field Survey (March 1996). In deterioration diagnosis of a facility, the common practice is to stop the main equipment and check the degree of deterioration at each part of the interior.

However, under the present circumstances where supply capability is inadequate, stopping main equipment cannot be readily done. Moreover, there can be cases where considerable numbers of years have gone by since commissioning, and if stopped for diagnoses, the equipment may not be operative when attempting to restart it.

Accordingly, it was judged impossible for deterioration diagnosis work to be carried out stopping main equipment, and judgments of deterioration were made under conditions of main equipment not stopped.

Deterioration diagnosis was made by the method below.

① Visual inspection of appearance regarding turbine-generator, auxiliary equipment, control equipment, circuit breakers, etc.
② Reference to past history of trouble.
③ Visual inspection of appearance regarding intake dam, headrace, head tank.
④ Visual inspection of appearance regarding penstock also.

In judgment of deterioration, the standards for deterioration judgment in Japan were referred to.

6.2 Contador Hydro Power Station

Fig. 6.1 provides a general plan of the Contador Hydro Power Station.

6.2.1 General Description

Effective head:	477 m
Power discharge:	540 l/s (270 l/s x 2 units)
Station output:	1,920 kW
Operation commencement:	September 23, 1967

Turbine type:	Horizontal shaft single jet Pelton
Transmission line:	30 kV (Contador - Santo Amaro)
Location:	Lemba Province
Intake channel:	Approx. 8 km

6.2.2 History and Situation

This station is connected to the electric power system of EMAE, has the second largest installed capacity (1,920 kW) next to Sao Tome Thermal Power Station (installed capacity 5,200 kW, as of January 1996), and is an important power station for EMAE.

This power station was constructed with technical cooperation funds from Portugal, with operation started in 1967. However, until the present time, there have been numerous occasions when mountainside collapses have occurred at stream intakes and intake waterways, and due to trouble with equipment and deterioration with time, the power station has been unable to fulfill its role adequately. As of March 1996, there had been a large-scale collapse at the upstream part of the intake waterway so that water from two main intake dams was not coming down, and because of the shortage of water, operation was being done using one unit from 6 to 12 in the morning and 5 to 12 in the evening for generation of approximately 700 to 1,000 kW of power.

There are two units of main equipment, but in November 1995, the stator coil of the No. 2 unit was burned due to short-circuiting and the unit is not running.

The headrace is presently under repair, and it was said this would be completed at the end of March for conduction of water to become possible. However, the generator of the No. 2 unit needs to be sent to Portugal for repair, but the funds required for this cannot be raised and the unit has been idle since occurrence of the trouble.

The present situation is that there is no outlook for repair.

6.2.3 Electro-mechanical Component

(1) Turbines

Type:	Pelton; 1,485 cV
Revolution:	1,000 rpm
Power discharge:	270 l/s

Head (normal): 477 m
Manufacture year: 1966
Manufacture No.: Unit-1, 2156, Unit-2; 2157
Manufacturer: Maierwerk, K. G. (R.F.A.)

(2) Generator
Type: AVA. 10.018
Continuous rated output: 1,200 KUA (Cos Æ: 8, 960 kW)
Max. output: Cos Æ: 1, 1,200 kW
Output voltage: 6,000 V, 3Æ
Frequency: 50 Hz
Revolution: 1,000 rpm
Manufacture year: 1966
Manufacturer: Efacec

(3) Control component (panel)

(4) Main transformer
Rated capacity: 1,200 kVA
Primary voltage: 6,000 V
Secondary voltage: 30,000 V
Type: 3-phase batch
Manufacture No.: Unit-1; 6423, Unit-2
Manufacturer: Efacec

(5) Station transformer
Rated capacity: 75 kVA
Primary voltage: 30,000 V
Secondary voltage: 400 V
Type: 3-phase batch
Manufacture No.: 6410
Manufacture year: 1964

(6) Breaker for 30 kW
Model: HKR-7/6

Manufacture No.:	207/71
Manufacture year:	1963
Manufacturer:	Delle

6.2.4 Degradation Assessment

(1) Civil Structures

A field reconnaissance by visual means was carried out on March 5 during the First Field Investigations regarding civil structures of this power station. The Italian consulting firm, Le Centro Ricerche Geologiche S.r.l. had dispatched two geologists and one hydroelectric power engineer to the field to carry out investigations and studies on water way structures and the stability of surrounding hill side. Their report, Etudes Geologiques Concernant la Centrole Hydro-electrique de Rio Contador, was submitted to the Sao Tome and Principe Government and Communaute Europeane in September, 1995, and conclusion and recommendations were made for renovation of the civil structure.

(a) Intake Dam

This power station has a total of six mountain stream intake facilities with water amounting to the maximum discharge of 0.54 m3/sec drawn at these facilities. The streams where intake facilities are provided are, from upstream, Zico, the mainstream Contador, Vilefa, Agriao, Lisboa, and Angolar. (See Fig. 6.1. excerpted from the abovementioned report.)

All of these intake facilities have large quantities of sediment with ensnared driftwood deposited completely up to overflow crests. In the case of the Angolar intake facility, it has been buried by sediment brought down by floodwater. Almost all intake gates (spindle gates) and scour gates are rusted tight or twisted, and they are in a condition that opening and closing cannot be done.

Numerous holes of around 60-mm diameter have been opened in strainer form in the protective curtain walls provided at intake forebays, with water to be flowed by means of these holes, but fine sand is contained in the deposited sand-gravel to cause clogging and the targeted amount of intake is not being sufficiently obtained.

In order for the intake facilities to be made to function normally from these conditions, the sand-gravel, driftwood, and trash deposited at the individual intake dams must be removed. To make possible intake from the tops of the clogged curtain walls, the walls are to be modified into side overflow weirs by cutting away their tops 15 to 20 cm in height and 2.0 to 2.5 m in width.

Furthermore, the holes in strainer form are not be plugged. Gates which have become inoperable will all need to be replaced.

(b) Headrace

The length of the headrace is approximately 7,000 m. Of this length, there is 4,950 m of open canal along mountainsides, 400 m of 18 aqueducts long and short, and 8 tunnels totaling 1,650 m from about 40 m on the short side to about 435 m on the long.

Of these sections, there are nine locations at parts of open canals along mountainsides where facilities to prevent rockfalls have been provided.

The waterway cross section, in case of an open canal along mountainsides, has an inside width of 75 cm, and depth of 75 cm with thickness of side walls and bottom slab 12 cm. On top of this, there are covers, each one 5 cm in thickness, 65 cm in longitudinal length, and 105 cm in width (approximately 80 kg).

Caual cross sections of aqueducts are roughly the same as for the open canals along mountainsides.

The inside cross section of a tunnel is of total height of 1.80 m, radius of arch portion 0.70, side wall height 1.10 m, and with concrete lining 0.20 m in thickness. The waterway at this part, facing downstream, has a width of 0.60

m and height of 0.70 m on the left side, with the partition wall between the foot path at the right side being reinforced concrete of 0.10 m and thickness of invert concrete 0.10 m.

Collapsed areas, large and small, can be seen here and there at slopes along the headrace route made up of waterways of such diverse types. Large-scale collapses occurred in the past in Aqueduct No. 13 area, upper part of Rebordelo District immediately upstream of Tunnel T2, and immediately upstream of Tunnel 8 area, (upper part of Manuel Morais), and especially at the P former, in January 1974, the headrace fell down over a length of 26 m due to collapse of the slope, while further, it is recorded that 40 people died at Rebordelo Village on the river side. The slope at this collapse site has a steep gradient of 70 to 80 deg, presenting a landslide topography opened in a U-shape approximately 500 m wide in the southeast-northwest direction and approximately 700 m in the direction from the mountain to the river.

The geology of the collapsed slope is comprised of tuff breccia containing large amounts of hard angular fragments of basaltic character having diameters 3 to 10 cm and 20 cm at maximum, with the matrix part filling out the rock consisting of a porous tuff. There is nothing to indicate a sedimentary structure such as bedding planes, and the rock is massive, but it is weathered as a whole and friable: so soft as to crumble under a light blow of a hammer.

The collapsed part of 26 m at the downstream side of the aqueduct No. 13 of total length of approximately 62 m was under repair with the target date of completion toward the end of March, 1996. However, although the slope has been cleared to an extent and prominent cracking, loosening, and soft spots are not recognizable, on the slope about 10 m higher than the waterway level, there are trees left standing after the collapse and rock blocks about several meters in size thought to have been loosened. Although these are considered to be stable for the moment, since the aqueduct presently being restored is extremely slender consisting of three girders of H-steel (15 cm x 20 cm) and a reinforced concrete girder-type waterway of thickness 10 and several centimeters with piers, it would readily be damaged if hit by falling rocks weighing about several hundred kilograms or more from 5 to 6 m above, and restoration work taking up to several months would be required.

The following methods are conceivable for coping with such a situation:

1) Case of Securing Safety with Waterway in Present Alignment

   a) Install rock bolts of about 4 m length at 2 to 4 m intervals in rock of the loosened zone at the slope above the waterway, stretch wire mesh across exposed rock, install weephole pipes of about 3 inches at spacing of 4 to 6 m2 per pipe, and place shotcrete of thickness about 10 cm to prevent collapses both large and small.

   b) Install anchor bars at the slope above and below and stretch out rock nets.

2) Case of Selecting Alternative Route

   a) Connect the existing tunnel waterway (T2) and the aqueduct upstream of the collapse site with a new tunnel waterway about 70 m in length. The tunnel dimensions would be excavation width 1.6 m and height 2.0 m, with the lining to be by application of shotcrete 10 cm thick. In the event of encountering a sheared zone, prevent collapsing through combined use of wire mesh and rock bolts. The construction period required in this case will be 2.5 to 3 months.

Of the two cases above, the proposal of (b) for a new tunnel will be somewhat more costly, but it is thought to be a semi-permanently safe method.

As for other sections of the headrace inspected by the Survey Team, besides portions such as at the tops of waterway side walls at tunnel outlets which had concrete of probably high water-cement ratio (W/C) broken off due to deterioration from cyclic temperature variations, the deterioration was of a degree where cover slabs placed on the waterway along the mountainside had been damaged or were missing at places where, it is thought, they had been removed to inspect the condition of sedimentation in the waterway, and there was no part where downflow of power generating water was being hindered, the impression being that the waterway had been maintained in comparatively stable condition. If anything, much grass had grown on the waterway bed, with grass about to extend into the waterway where covers had been opened. If left untended too long, grass could grow inside the waterway to make water spill over from the waterway to scour the waterway bed or to cause the waterway to collapse, and it is desirable for grass cutting to be done at such places at time intervals that trouble will not occur.

(c) Head Tank

This head tank is of masonry concrete located on a ridge extending from northwest to southeast at an elevation of approximately 560 m with a length of approximately 70 m from southwest to northeast, width about 18 m, maximum water depth 3.5 m, and tank capacity 3,000 m3. The design is such that inflow from the headrace is purposely conducted from the north side to the south side, the upstream side of the tank, so that sediment from the headrace will not directly enter the downstream part of the tank.

According to the beforementioned report of the Italian consulting firm, there are fine cracks in the sidewall parts of this head tank with a small amount of leakage seen, but in a brief visual observation, there were no defective parts recognized which would be problematic in particular, and leakage, cracking, etc. to be causes of anxiety were not seen. If something is to be cited, it might be that hardware such as sluice gates and sand flush valves have not been painted, and with rusting having progressed, it is desirable for painting to be done.

(d) Penstock

The penstock runs approximately 1,500 m from the head tank at EL. 560 m to the powerhouse with pipe diameter varied in four sizes from 590 mm (wall thickness t = 5 mm) to 520 mm (t = 8 mm) to 515 mm (t = 8 mm), to 492 mm (t = 14 mm).

Joining of pipes along this length has been done by welding. The pipeline is mostly raised about 2 m from the ground surface resting on concrete saddles, but there are places where steel pipe is directly in contact with the ground surface.

Although there is nothing in maintenance and management of the penstock line which would be problematic at the moment, if anything, a preservative such as tar epoxy should be painted on at any section where steel pipe contacts ground and the section should be buried in ground at a safe depth through banking of soil. Also, where there are loose rocks or unstable soil on both sides of the pipeline laid on the steep excavated slope, shaping of the slope is to be done for stabilization, while rock nets are to be installed at parts of the slope where rock falls are expected. Furthermore, soil has intruded at tops of saddles where concrete and steel pipe are in contact and grass has grown. This will promote oxidation of steel pipe at these parts to accelerate corrosion, and it will be necessary to bear in mind removal of this soil and grass.

In the First Field Investigation, it was not learned what the strength of the penstock pipe material was, but from the pipe diameter and pipe thickness at the bottom, the stress applied to the pipe would be around 930 kg/cm2, and it is surmised that this is a value in the neighborhood of the allowable stress of the pipe. Corrosion allowance of the pipe is not included in this calculation. Therefore, if rusting occurs on the steel pipe, not only will the safety factor be lowered, but if the rusting were to progress, this could very well lead to failure of the pipe. According to visual inspection in field investigations, since rust, although slight, can be seen in the silver gray paint, it will be important to keep in mind to paint the pipe.

(e) Powerhouse

In connection with the powerhouse building, deterioration is not particularly seen in concrete structures, but breakage of glass panes of windows around the building, breakage of window panes of the battery room, loss of door leaves at powerhouse entrances, and much breakage of lights in the station are conspicuous, and it is thought normal operation and management of the power station is being obstructed. In this regard, it will be necessary to as soon as possible replace window panes, install door shutters at entrances, and put in lights where necessary to facilitate smooth operation and maintenance.

The right-hand back side of the powerhouse comprises a steep cliff and part of the weathered rock has been braking off to fall and hit the powerhouse. It is necessary for loose rock to be removed and at the same time the slope reshaped so that the powerhouse will not be damaged by large-scale falls as weathering progresses in the future.

(f) Other

Besides the abovementioned electrical facilities there are roads being used for maintenance and repair such as one leading to Intake Dam No. 1 and the upstream part of the headrace and one leading to the head tank and the downstream part of the headrace. The maintenance and repair conditions of these roads are not very good and traffic is difficult for vehicles other than high-clearance 4-wheel-drive vehicles (jeeps). There are two places along these roads where large-scale collapses have occurred and the roads have been cut into pieces making it completely impossible for passage of vehicles. One of these locations is the old trolley track bed sandwiched by Manual Morais District and Angolar Gully, while the other is in the vicinity of EL. 500 m approximately 1.2 km short of the head tank, the lengths of the stretches cut being both about 30 m.

The impassability of vehicles due to these collapses not only causes loss of time in maintenance and inspection of this power generation facility with its long waterway, but is also especially a great hindrance to repair works. Consequently, it is desirable for restoration work to be done on these locations where the roads have been cut along with repairs of irregularities in the road surfaces.

(2) Power generation components

A visual check showed no rust on the turbine. (The surface coating is peeled and the surface is covered with oil.) Erosion was observed on the turbine bucket. According to the EMAE station manage, the jet and needle are both damaged. The bearing is, at this time, still operable despite the burnt metal.

Regarding the governor, only manual operation is available, although it is switchable to 'Auto' or 'Manual'. Load and speed are adjusted manually. Output in response to load fluctuation is adjusted at the other station (by DG at the San Tome Thermal Power Station). The Contador Hydro Power Station is operated at the almost constant load. Originally, depending on the water level of the head tank, automatic operation was possible. However, head tank measurement (water level, etc.) is not conducted automatically due to problems with the power supply/control cable to the head tank and the control equipment. it is, therefore, measured manually. A 24-hour monitoring personnel is stationed at the head tank to measure the water level, etc. This person telephones the operator every hour to advise the situation. As of March, 1996, only 10 to 12 hr/day operation was consulted, this depending on the water level.

Table 6.1 shows the analysis results of each component.

6.3 Gue Gue Hydro Power Station

A general plan of Gue Gue Hydro Power Station is shown in Fig. 6.2.

6.3.1 General Description

Item	Before Renovation	After Renovation
Effective head		47.72 m
Power discharge		0.90 m^3/sec
Installed capacity		320 kW
Start-up		February 1995
Turbine type		Cross-flow turbine
Transmission line		30 kV and 6 kV

Location		(Approx. 10 km southwest of Sao Tome City)
Headrace length		Approx. 1,100 m
Generating type	Run off river type	Run off river type

6.3.2 History and Situation

The power generated at this power station is connected to the electric power system of EMAE (30 kV and 6 kV). The location is close to Sao Tome City, and being one of the two hydroelectric power stations of EMAE, for the small scale of 320 kW, it is an important power station from the standpoint of the system.

This power station was commissioned in 1945, but after that it was left untended for approximately 10 years due to generator trouble and damage to waterway structures such as the headrace. Since then, recently, a loan of $1,800,000 was received from France and, at last in February 1995, civil facilities were repaired, electrical equipment completely exchanged, and operation was resumed.

However, the large quantity of debris which had been brought by flood water into the settling basin immediately below the intake dam has not been removed and even in the season when river runoff is comparatively small, water taken in is hindered by the deposited material from flowing down properly and spills over from the settling basin. Hence, operation is being done at 150 kW, less than half the rated capacity. If the sediment had been removed, the power output would have been several tens of kilowatts larger. If this condition were to be left unremedied, even when runoff of about the maximum available discharge is drawn in the high-water season, the greater part would spill over from the settling basin and power generation at the rated capacity of 350 kW will not be possible.

6.3.3 Electro-mechanical Component Specifications

(1) Turbine (Cross-flow Turbine)

Type	D-8832
Output	366 kW
Power discharge	0.90 m^3/sec
Speed	458 rpm
Head	47.72 m

Year of manufacture	1993
Manufacturing no.	No. 5748
Manufacturer	Ossberger

(2) Generator

Type	DKBN TOUK 1530-6
Rated capacity	400 kVA
Output Voltage	6,000 V
Frequency	50 Hz
Speed	1,000 rpm
Year of manufacture	1993
Manufacturing no.	400/2314
Manufacturer	AVK (Germany)

(3) Speed Increaser

Type	MISH 0713
Primary speed (turbine side)	458 rpm
Secondary speed (generator side)	1,000 rpm
Year of manufacture	1993
Manufacturing no.	K189 305 30H-1
Manufacturer	Fleneer

(4) Main Transformer

Rated capacity	
Primary voltage	
Secondary voltage	
Type	
Manufacturing no.	
Manufacturer	

(5) Station Service Transformer

Rated capacity	
Primary voltage	
Secondary voltage	
Type	

Manufacturing no.
Manufacturer

(6) 30 kV Circuit Breaker
Type
Manufacturing no.
Year of manufacture
Manufacturer

(7) 6 kV Circuit Breaker
Manufacturing no.
Year of manufacture
Manufacturer

6.3.4 Condition of Generating Facilities (as of March 1996)

Since only about one year had elapsed since total renovation in February 1995, there are problems of deterioration regarding civil structures such as the dam, waterway, penstock, etc. and electrical equipment at the time of investigation.

However, the settling basin immediately downstream of the intake is completely filled with sand-gravel of particle size up to a maximum of 6 to 7 cm, and a very large percentage of intake water is obstructed by the sand-gravel. Not being able to flow down normally, the water is spilling over from the top of the settling basin.

Various reasons for sand-gravel being carried into the settling basin via the intake are conceivable, one being the scour gate not being opened in the flood season. Another is that the scour gate provided is small in capacity (cross-sectional area) for the amount of sediment transported in, while the position of the gate seal is slightly high. It is thought that as a result intake screen bars have been partially damaged, or spacing between bars have been widened for these reasons.

However, it is necessary first of all to remove the sand-gravel in the settling basin. Otherwise, the intake will be clogged with sediment and intake capacity lowered extremely, so that the required amount of discharge cannot be secured. Further, scour gates should be frequently opened and closed during off-peak times to flush away the sediment around the fronts of intakes as much as possible. When it has become possible to check the screen, this is to be done such as by discharging the stream flow from spillway of the dam, and in the event of damage, repairs are to be made. In case bar spacing is too wide, replacing is to be considered and carried out.

In any event, for the rated capacity of 350 kW to be exhibited, removal of the sediment in the settling basin should be done periodically and frequently, even if manually, during power generating operations.

6.4 Sao Tome Thermal Power Station

The output of this power station is 5,200 kW (April 1996), approximately 70% of the total generating capacity of EMAE. It is close to the load center and is the most important of the three power stations of EMAE.

Figure 6.3 is a location map of Sao Tome Thermal Power Station. This power station is located at roughly the center of Sao Tome City, is close to the police station, and only about 200 to 300 m from the official residence of the President. Noise is a problem because of this.

6.4.1 General Description

No. of main units: 6
Power generation type: diesel power
Generator output: total of 5,200 kW
  ABC-1; 960 kW, operation start 1991
  ABC-2; 960 kW, operation start 1993
  ABC-3; 1,280 kW, operation start 1996
  Cummings-2; 800 kW, operation start 1987
  Cummings-3; 800 kW, operation start 1987
  Dorman; 400 kW, operation start 1995

6.4.2 History and Situation

Sao Tome Thermal Power Station (diesel) was commissioned in 1991, but the No. 1 and No. 2 units of ABC are of 1979 manufacture, and it is thought second-hand equipment from somewhere had been delivered. Maintenance had not been adequate while load variations are large so that operation under severe conditions is forced to be done, and trouble occurs frequently as a result. Equipment additionally installed later is experiencing frequent trouble for the same reason.

In March 1996 also, the turbines of ABC-1 (960 kW) and Cummins-3 (800 kW) were out of order and inoperative. Regarding ABC-1, the method of repairing the trouble spot had been decided, the funds for repair obtained, and it is scheduled for return to normal to be achieved shortly. Regarding Cummins-3, repair funds have not been raised, and the situation is that when restoration can be done is unknown.

If all of these generators can resume operation at rated capacity, the supply capability for the already-electrified area can be secured and it will be possible to avoid planned outage.

In this way, early return to operation of damaged equipment is strongly demanded. In order to meet demand, the addition of ABC-3 (1,280 kW) was completed and operation had been started in April 1996.

6.4.3 Electro-mechanical Component Specifications

(1) ABC-No. 1 (operation commencement; 1991)

Diesel engine
Model; 6DZC-750-166A
Output; 996 kW
Revolution; 750 rpm
Manufacture No.; 11893
Manufacture year; 1979
Manufacturer; A.B.C.
Generator
Model; LSA54VS4/8P
Output (kA); 1,250 kVA
Output (kW); 1,000 kW

Revolution;	750 rpm
Manufacture No.;	158076/1
AVR type;	8503
Current;	1804
Manufacturer;	Leroy Somer, France

(2) ABC-No. 2 (operation commencement; 1993)

Diesel engine

Model;	6EDZC-750-171A
Output;	1,066 kW
Revolution;	750 rpm
Manufacture No.;	12020
Manufacture year;	
Manufacturer;	A.B.C.

Generator

Model;	LSA54VS4/8P
Output (kA);	1,250 kVA
Output (kW);	1,000 kW
Revolution;	750 rpm
Manufacture No.;	160727-1

AVR type;	8503
Current;	1804
Manufacturer;	Leroy Somer, France

(3) ABC-No. 3 (operation commencement; 1996)

Diesel engine

Model;	8EDZC-750-181A
Output;	1,459 kW
Revolution;	750 rpm
Manufacture No.;	12127
Manufacture year;	1995
Manufacturer;	A.B.C.

Generator

Model; LSA54S7-8P

Output (kA); 1,600 kVA

Output (kW); 1,280 kW

Revolution; 750 rpm

Manufacture No.;

AVR model;

Current;

Manufacturer; Leroy Somer, France

(4) Cummings-2 (operation commencement; 1988)

Diesel engine

Model; KTA50/G1

Output;

Revolution;

Manufacture No.; 88231/1

Manufacture year; 1988 (Mar. 21)

Manufacturer; Cummings, England

Generator

Model; AC734A

Output (kA); 1,000 kVA

Output (kW);

Revolution; 1,500 rpm

Manufacture No.; C9465/2

AVR type; IP-ZI

Current;

Manufacturer; Cummings, England

(5) Cummings-3 (operation commencement; 1988)

Diesel engine

Model; KTA50/G1

Output;

Revolution; 1,500 rpm

Manufacture No.;

Manufacture year; 1988
Manufacturer; Cummings, England

Generator
Model; AC734A
Output (kA); 950 kVA
Output (kW); kW
Revolution; 1,500 rpm
Manufacture No.;
AVR type; F8811/2
Current; 1,420
Manufacturer; Cummings, England

(6) Dorman

Diesel engine
Model; 68E445A/12
Output;
Revolution; 1,500 rpm
Manufacture No.;
Manufacture year; 1994
Manufacturer; Dorman

Generator
Model; HC544D1
Output (kA); 500 kVA
Output (kW); kW
Revolution; 1,500 rpm
Manufacture No.;
AVR type; S x 440
Current; 760A
Manufacturer; Dorman

The facility specifications are described in Table 6-2.

6.4.4 Equipment Deterioration Diagnosis

As of March 1996, Cummins-3 (800 kW) and ABC-1 (960 kW) were stopped due to mechanical trouble (not operative). Of the two, the Cummins-3 stoppage was due to trouble with the part to prevent leakage of oil from the main shaft on the diesel side, the repair method has been decided, and with the outlook sure that funds required for repair will be obtained, it is considered that restoration can be achieved in a period of about one month.

However, trouble with this unit has occurred frequently in the past and it is thought antiquation has progressed considerably. Consequently, it is thought the unit cannot be expected to be usable over a long term in the future.

With regard to ABC-1, it has not been possible to request the aid of an engineer to check for the trouble spot, the condition of trouble, and method of repair due to lack of funds, and the outlook for restoration is nil. Troubles have frequently occurred with this unit also. It is thought antiquation has progressed in the same manner as with the Cummins-3 unit.

Because of the weak constitution of the electric power system of EMAE, the equipment is in the state of more or less continuous operation, and if trouble were to occur with one part of the system, the effect would be enormous with sudden stoppage or large load variation to result in severe operating conditions, causing fatigue of the machinery. It is thought antiquation will result sooner compared with thermal power station in general.

6.5 Restoration

6.5.1 Contador Hydro Power Station

This power station is almost 30 years old and it is considered that if civil structures were to be partially repaired or improved and electrical equipment replaced, the life of the power station can be secured for another 30 years. For this purpose, the repair and improvement works below will be required for civil facilities,

(1) Regarding access roads, perform restoration work without delay on the two locations where the roads have been cut by collapses, and also repair irregular road surfaces at the same time.

(2) Regarding the multiple intake facility sites, remove sand-gravel, driftwood, etc. accumulated upstream of the dams. Modify curtain walls at intake forebays into side

overflow-type intake weirs. Replace all inoperable gates. Other than these, a requirement would be to reexamine and redesign the restoration project for the No. 6 Angolar intake facilities presently buried by debris as a result of flooding.

(3) Regarding the headrace, the restoration work on the aqueduct of Pc13 was completed at the end of March 1996, but since in the long range it would still be insecure, it will be necessary to examine the methods described in 6.2.1(3) (a) and (b), and aim for implementation of permanent measures at an early date.
It will be necessary for replacements to be made where cover slabs of the headrace have been damaged and to carry out cutting of grass along the waterway as frequently as possible.

(4) Regarding the head tank, carry out inspections for leakage and cracking periodically and continuously, and in the event of conspicuous change, swiftly plan and implement remedial measures.

(5) Diligently remove loose rock on the steep slope of the penstock route which appear about to fall. On the other hand, where the steel pipe contacts the ground surface, study remedial measures and consider burial of the pipe.

(6) Budget and carry out at an early date installation of entrance doors, window panes, and necessary lights of the powerhouse along with shaping of the excavated slope adjacent to the powerhouse.

(7) Complete replacement of electrical equipment including turbine and generator is necessary.

6.5.2 Gue Gue Hydro Power Station

Deteriorated parts are not recognizable for the moment, but what is necessary first of all is to give priority to removal of sand-gravel deposited in the settling basin immediately downstream of the intake dam. What will be necessary next is to inspect and repair or improve the intake screen along with removing sediment accumulated at the intake dam.

6.5.3 Sao Tome Thermal Power Station

Excepting ABC-3 and DORMAN additionally installed this year, deterioration with time has progressed for units ABC-1, ABC-2, Cummins-2 and Cummins-3, and it is considered necessary for these to be renewed at an early date for improving the reliability of the entire power system.

Also, considered from the aspect of pollution such as due to noise it is thought removal to outside the city will be necessary.

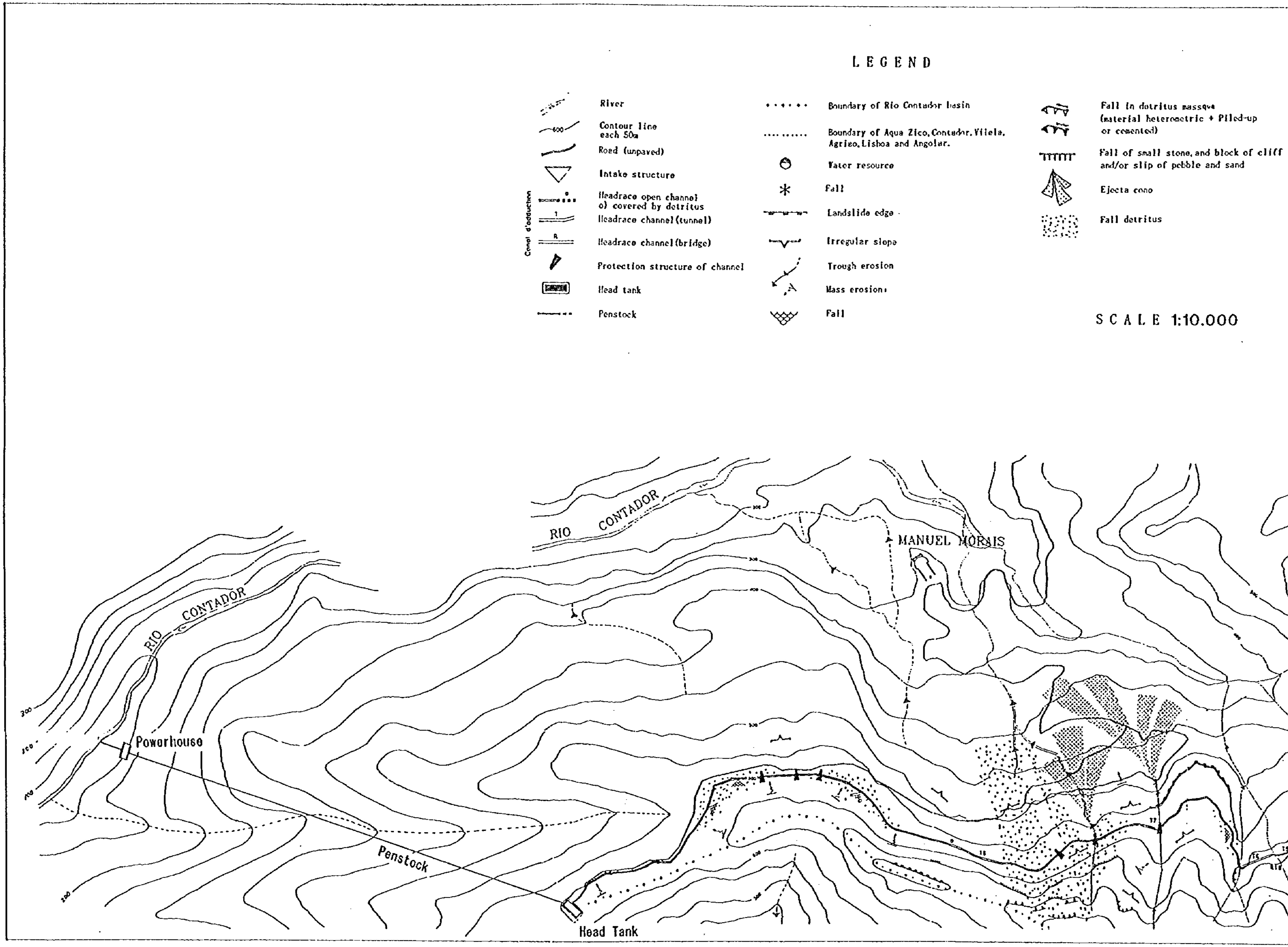
Table 6-1 Check-List

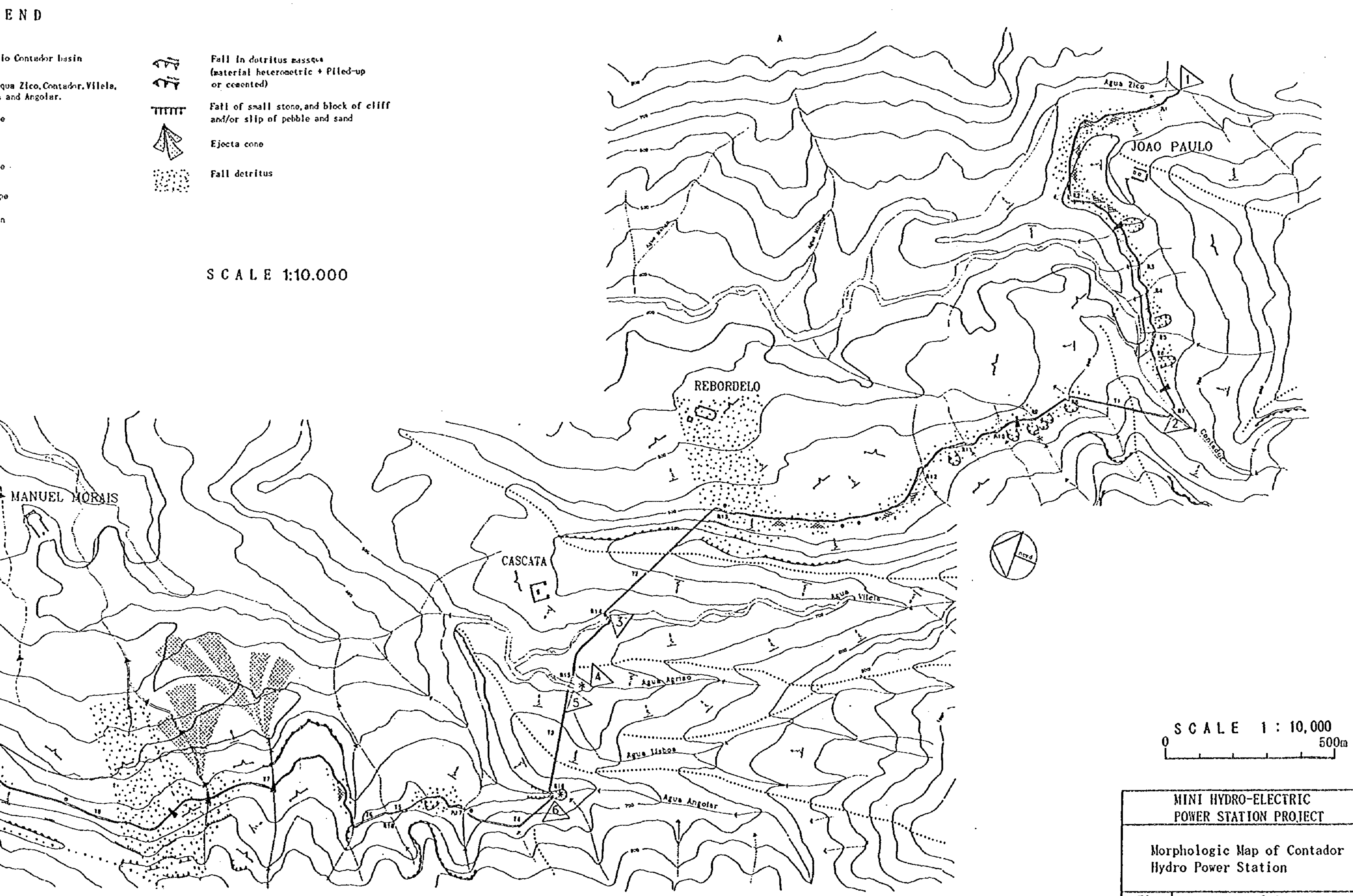
Contador Hydro Power Station; Turbines, Generator, etc.
Rated output x number of unit: 960 kW x 2
Present output x number of units: 960 kW x 1
Annual generated power:

	Specifications	Data	Replacement or utilization	Life expectancy	Note
Turbine	Horizontal shaft Pelton	1485 cV	Full replacement	25 years	Due to aging
Inlet valve	Rotary valve		Full replacement	25 years	Due to aging
Governor	Mechanical governor		Full replacement	25 years	Due to aging
Step-up gear					None
Generator	Synchronous generator	1,200 kVA	Full replacement		Due to aging
Transformer	3-phase batch transformer	6 kV/30 kV, 1,200 kVA	Full replacement		Due to aging
Control panel			Full replacement		Due to aging
Piping			Full replacement	25 years	Due to aging
Cables			Full replacement		Due to aging
Penstock	Overhead transmission line	30 kV	Usable	25 years	Due to aging
Transmission/ distribution line			Usable		Due to aging
Battery			Full replacement		Due to aging

Table 6-2 Facility Specifications (Sao Tome Power Plant)

	Item	ABC-1	ABC-2	ABC-3	CUM-2	CUM-3	DORMAN
Diesel Motor	Type	6DZC-750-166A	6EDZC-750-171A	8EDZC-750-181A	KTA 50/G1	KTA 50/G1	68E 445 A/12
	Out put (kW)	996	1,066	1,459	——	1,000	500
	Manufacture No.	11893	12020	12127	88231/1	8823/1	06239/9503/003
	Manufacture Year	1979	1979	1995	1988	1988	1994
	Manufacturer	ABC	ABC	ABC	CUMINS	CUMINS	DORMAN
Generator	Type	LSA54V54/8P	LSA54V54/8P	LSA54S7-8P	AC 734A	AC734A	HC544D1
	Out put (kVA)	1,250	1,250	1,600	1,000	950	500
	Out put (kW)	1,000	1,000	1,280	1,000	950	500
	Revolutio (rpm)	750	750	750	1,500	1,500	1,500
	AVR Type	8503	8503	R221	IP-ZI	F8811/2	S×440
	Current (A)	1,804	1,804	2,431	1,420	1,420	760
	Manufacture No.	158076/1	160727-1	163144-1	C9465/2	C9465/1	0049512/01
	Manufacture Year	1979	1979	1995	1988	1988	1994
	Manufacturer	Leroy Sommer	Leroy Sommer	Leroy Sommer	England	England	DORMAN
	Operation commencement	1991	1993	1996	1988	1995	1995

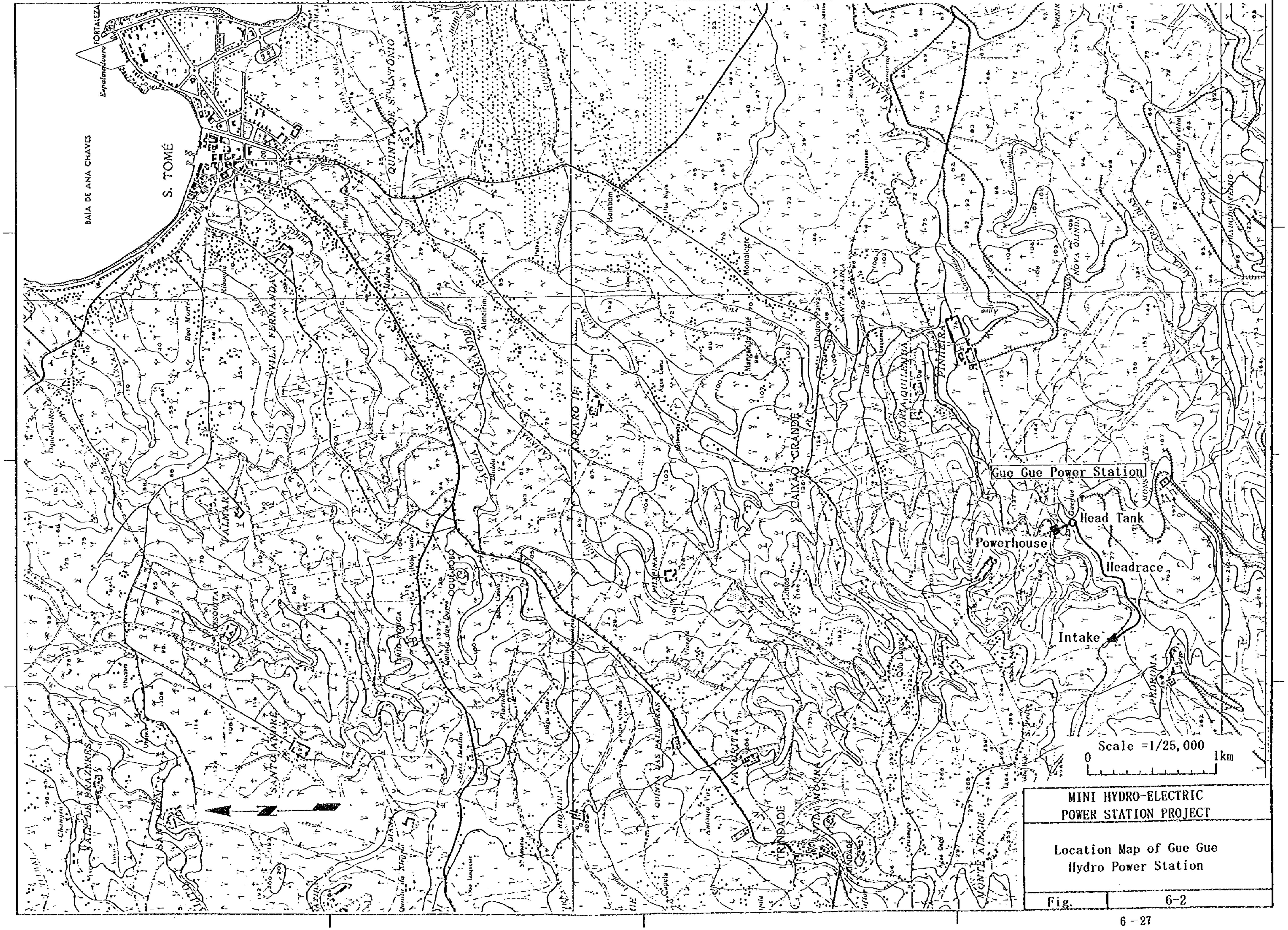

LEGEND
River
Contour line each 50m
600
Roed (unpaved)
Intake structure
Canal d'adduction
Headrace open channel
o) covered by detritus
Headrace channel (tunnel)
Headrace channel (bridge)
Protection structure of channel
Head tank
Penstock
Boundary of Rio Contador basin
Boundary of Aqua Zico, Contador, Vilela, Agrieo, Lisboa and Angolar.
Water resource
Fall
Landslide edge
Irregular slope
Trough erosion
Mass erosion
Fall
Fall in detritus massque (material heterometric + Piled-up or cemented)
Fall of small stone, and block of cliff and/or slip of pebble and sand
Ejecta cono
Fall detritus
SCALE 1:10.000
RIO CONTADOR
RIO CONTADOR
MANUEL MORAIS
Powerhouse
Penstock
Head Tank
300
250
200
200



MINI HYDRO-ELECTRIC
POWER STATION PROJECT

Morphologic Map of Contador
Hydro Power Station

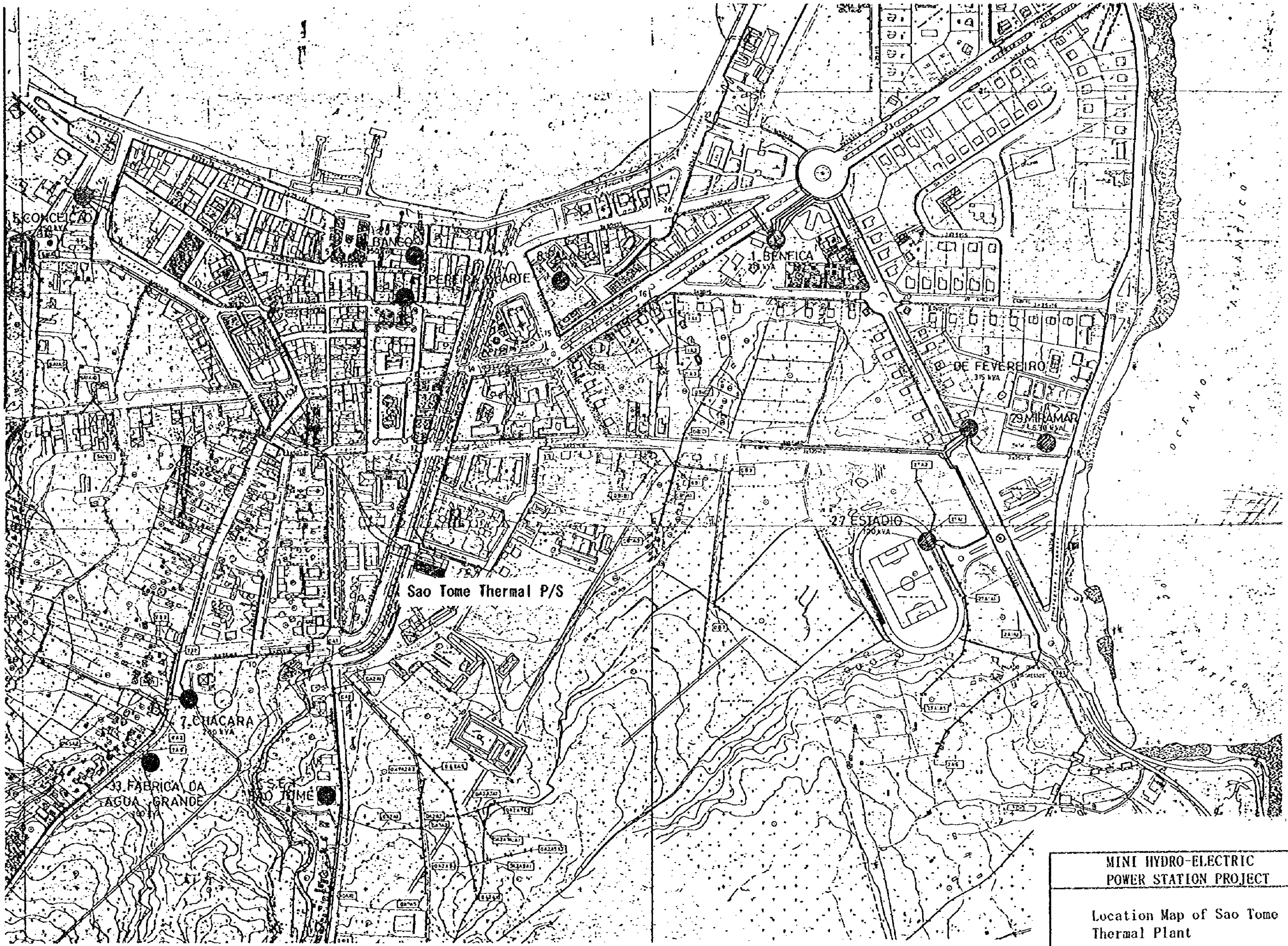
Fig. 6-1



MINI HYDRO-ELECTRIC
POWER STATION PROJECT

Location Map of Gue Gue
Hydro Power Station

Fig. 6-2



MINI HYDRO-ELECTRIC
POWER STATION PROJECT

Location Map of Sao Tome
Thermal Plant

Fig. 6-3

Chapter 7

METEOROLOGY
AND
HYDROLOGY

7. METEOROLOGY AND HYDROLOGY

7.1 Air Temperature and Rainfall

The characteristics of typical meteorological stations in Sao Tome Island is shown in Table 7-1. The long-term (14-30 years) monthly mean air temperatures, rainfalls, relative humidities, sunshine hours, and evaporations of the principal meteorological observation stations (19 stations) of Sao Tome Island from 1961 to 1990 are given in Ap. Table 7-1. The locations of these principal meteorological observation stations are shown in Fig. 7-1. Further, from the rainfall observation records of the more than 40 stations in the entire country during the 20 year period from 1951 to 1970, an isohyetal map was prepared in December 1972 for hydropower development of the Guia and Io Grande rivers in the southwestern part of Sao Tome Island *1 (see Fig. 7-2). This isohyetal map is somewhat old, but it is convenient to use for comparisons and studies with flow-durations and project sites of other rivers.

*1: Servico Meteorologico, Cartas das Isoietras Mensais e Anuais das Ilhas de S. Tome e Principe,Dezembro 1972

7.2 Hydrology

The principal rivers of Sao Tome Island are shown in Fig. 7-3, clockwise from the north at the top, the Do Ouro, the Manuel Jorge, the Abade, the Io Grande, the Lemba, the Cantador, and the Contador, and other than these, there are a number of small streams. On these rivers and streams, water level-discharge gauging stations were provided by the former U.S.S.R. in 1981, and by Portugal in 1988, but most of them have later become damaged or because of lack of funds, being hindered from carrying out normal data collecting activities.

The locations of water level-discharge gauging stations on the principal rivers of Sao Tome are shown in Fig. 7-3, but at present, there is not one of these water level-discharge gauging stations with facilities which are operating normally. In the past, short-term discharge observations were carried out on principal rivers by the former U.S.S.R. and Portugal, with observations made installing various measurement instruments, but with damage or washouts of gauging stations due to floods, and lack of maintenance and administration funds, observations were gradually discontinued to result in the present situation. Consequently, hydrological data derived over a long term do not exist. The present state of existing material and data concerning hydrology is described below.

(1) U.S.S.R. Investigations

"GUIDROPROEKT", the project and investigation institute of Leningrad, in May 1981, prepared a recommendation report *2 for obtaining basic data for utilization of hydropower resources of Sao Tome and Principe islands. The items on which investigations were made at the same time by their survey team during this period are as follows:

- Collection, preparation of the statistics, analyses of hydrological and meteorological data of the principal river basins of Sao Tome
- Field reconnaissances from April to October 1980 for potential investigations of hydroelectric power development plans
- Installation of observation stations for collecting hydrological data and observations
- Transfer of knowledge on hydrological investigations to counterparts

In this report, discharge gauging records from April to October, the longest for the year of 1980, are given for the Manuel Jorge River (Guada Ague and Pian-Pian Canal gauging stations), the Abade River (Bombaim and Agua Ize), the Io Grande River (Manuel Caroca), the Lemba River (Santa Jose and Lemba), the Contador River, and the Do Ouro River (Agua de Justante and Central A.Neto).

(2) Master Plan forIo Grande

GUIDROPROEKT carried out discharge observations of the principal rivers on Sao Tome Island in 1986, and at the same time, formulated a master plan *3 of a hydroelectric development plan for the Io Grande River, the largest river of Sao Tome Island, which is located in the southern part of the island. Daily discharge data for a roughly 5 year period from 1980 to 1985 on the Manuel Caroca site on the Io Grande River which was utilized for planning are included in this master plan report.

The actual measurement data in connection with hydrology of (1) and (2) described above, and the hydrological observation data and reports of other observation sites were almost all scattered and lost during the period of transition from the old order to the present democratic order, and what are available at present are limited to data in the possession of individuals, and practically nothing can be utilized by public organs.

*2: V/O Technopromexport-USSR: Clima e Hidrologia Topografia, Recomendacoes, Para o Aproveitamento dos Recursos Hidroenergeticos de Republica Democratica de Sao Tome e Principe, Elaborados pela Filial de Leninegrado do Instituto de Projeccao e Pesquisas "GUIDROPROEKT", Maio, 1981

*3: Central Hidroelectrica Io Grande-1, 1ª Fase do Anteprojecto Tecnico, Elaborado pelo Instituto "GUIDROPROEKT",Leninegrado, 1986

(3) Bilateral Agreement with Portugal

In 1989, a bilateral agreement between the two countries of Sao Tome and Principe and Portugal concerning utilization, processing, and treatment of data from the discharge gauging observation networks of the two islands of Sao Tome and Principe was signed, and based on that agreement, the General Bureau of Natural Resources of Portugal dispatched a survey mission to carry out field investigations on the two islands for a period of approximately one month. The main work of the survey mission consisted of installing a discharge gauging network on the principal rivers of Sao Tome Island and instructing and training local hydrology specialists *4. Fourteen local hydrologists were trained in Sao Tome and Portugal based on this agreement, and with 13 discharge gauging stations provided on the entire island, actual measurements of discharge for preparation of rating curves, long-term recording and reading of water levels, maintenance and administration of gauging stations came to be carried out by local specialists, and in October 1989, the first annual yearbook on discharge in Sao Tome and Principe *5 was prepared. However, the system was for the observation data obtained in the field to be first sent to the Institute of Resources (Direciao General dos Recursos e Aprovestamentos Hidraulicos, Portugal) in Lisbon, where the data were organized and analyzed, and the final results sent back to Sao Tome in the form of the previously-mentioned discharge yearbook. It is said that at present the daily discharge of 13 sites for the two years of 1988/89 (the one year from October 1988 to September 1989) and 1989/90 can be used, but the yearbook does not contain data from all sites.

*4: Exploracao, Processamento e Tratamento dos Dados da Rede Hidrometrica de S. Tome e Principe,Divisao de Hidrometria,Lisboa, Marco de 1989

*5: "CAUDAIS", Ano Hidaologicao, 1988-89 and 1989/90, Secretaria de Estado do Ambiente e Recursos Naturais-Portugal, Ministerio do Equipamento Social eAmbiente

(4) Monthly Average Discharge Data

The monthly average discharges of the principal rivers over long periods of time are given in Ap. Table 7-2, but there are numerous questionable points regarding observation methods, the discharge calculation method, etc. For example, the values in these tables are not monthly average values of daily discharges, but the averages of measurements made several times during a month, while data to indicate the calculation basis used at that time do not exist at all, and careful attention must be paid in using the data.

Since this project is a mini-hydropower project of run-of-river type, it was decided to use the daily discharge yearbook data from 1988 of higher reliability described in (3) above and the water level observation values and actual measurement discharge data owned by MESA to determine daily discharges and employ these in formulating plans.

7.3 Meteorological and Hydrological Outlines of Principal Rivers

The principal rivers of Sao Tome Island, as shown in Fig. 7-3, extend radially outward over the entire island with the center point being Mt. Sao Tome located slightly to the west of the island center. The present conditions of the principal rivers are as described below. The outlines of water level-discharge gauging stations provided on the principal rivers are listed in Table 7-2.

7.3.1 Do Ouro River Basin

This river has its fountainhead at EL. 1,340 m on the northern slope of Lagoa Amelia Crater, EL. 1,412 m, located in the northern part of Sao Tome Island. The river basin is roughly symmetric on right and left sandwiching the river, the length of the river channel being approximately 19.3 km. The catchment area at the river mouth is 36.5 km^2, with the area spreading out in the northeast direction from fountainhead to river mouth. At the midstream and downstream areas, part of the river water is being drawn as irrigation water and drinking and miscellaneous-use water, and it is reported that there is hardly any water flow at the downstream stretch in the dry season of June-August.

On this river, there had been water level-discharge gauging stations equipped with recording water gauges provided with aid from Portugal (the two stations of Boa Esperanca having a catchment area of 13.8 km^2 and Central A. Neto having 48.0 km^2), and water levels had been observed from 1988. However, at present, equipment is operative at the former, but recording paper cannot be purchased so that observations are not being made, while equipment at the latter has been damaged and is not being used.

The water levels and estimated discharges from 1988 to 1992 are given in Tables 7-3 and 7-4. For the method of estimating runoff, 7.4.1 should be referred to.

The river gradient is 1:6.4 at the upstream part, 1:12.2 at the midstream part and about 1:14.4 when averaged. According to the data of a 25-year period from 1966 to 1990 of Agostinho Neto Meteorological Observatory located at the downstream part of the midstream stretch, the annual mean rainfall is 975.3 mm, the air temperature 25°C, and the evaporimeter evaporation an annual average of 830 mm, the calculation being that 85% of rainfall is evaporated. The large amount of evaporation is the feature of this river.

The discharge according to measurements by eye at the time of general observations in the field in March 1996 was approximately 1.2 m^3/sec where the national highway crosses the river (river width 50-60 m, flow channel about 4 m), but several days later, when measurements (visual) were made at the same point, there was less discharge, the amount being approximately 05-0.6 m^3/sec. It is thought the influence of rainfall upstream had been evident in the previous discharge. There are boulders over the entire width of the river, the river gradient is steep, and this is a stream of which the gut is easily changed.

Approximately 10 km upstream from the river mouth there is a privately-owned hydroelectric power station (Central Electric Do Ouro Power Station: Total capacity: 344 kW) which was constructed in 1941 and having a catchment area of 30.5 km² presently in operation.

Two hydroelectric power stations at the upstream and midstream parts of this river are planned.

7.3.2 Manual Jorge River Basin

Similarly to the Do Ouro River, this river has its fountainhead at the slope of Lagoa Amelia Crater (EL. 1,420 m) and flows down to the east. There are many tributaries from the right-bank side at the upstream and midstream parts, but at the downstream part, there is only one tributary, the Carambola. The length of the river channel is 22.9 km, the catchment area at the river mouth is 36.4 km^2, the river gradient is 1:7.9 at the upstream section and 1:14.1 at the midstream section, an average of about 1:25.6. There are a number of waterfalls of 10 to 20 m class on this river in the vicinity of Sao Nicolau Village 19 km upstream from the river mouth, and at the downstreammost fall (height: 20 m), the water held in the basin of the fall is utilized and intake accomplished by a rectangular waterway of concrete roughly 0.3 m in height and 0.4 m in width, with this supplied as drinking and miscellaneous-use water and irrigation water to a number of neighboring villages (Quinta dos Flores e Milaro). The intake quantity at the times of investigation in March and July 1996 were about 36 and 25 liter/sec in average. Both banks of the river are covered by tropical forests and tall grasses, and nothing but the water channel can be seen. At the left bank, there are cacao plantations down to the edge of the water. The river width is about 15 m in the vicinity of EL. 450 m with the flow comparatively swift. The discharge was 1.3 to 1.4 m^3/sec measured by eye, while pH according to handy water quality testing paper was 6 to 6.5.

Representative meteorological observatories in this river basin are Lagos Amelia in the upstream area and Uba Budo in the downstream area. The annual mean temperature at Lagos Amelia in the 24-year period from 1967 to 1990 was 17.8°C because of the high elevation (EL. 1,488 m), the annual average rainfall 2,615.1 mm with much of it (350-460 mm/month) in October-November, about 30% being concentrated in that period. The average rainfall in the dry season of June-August is 30 to 60 mm. Annual evaporation is around 276 mm and low.

The mean temperature during a 23-year period at downstream Uba Budo (EL. 243 m) was 24.4°C, while rainfall was a plentiful 1,266 mm with much of it in October-November (180-200 mm/month), it becoming extremely little at 10-20 mm/month in the dry season of June-August. The annual average evaporation was about 660 mm.

On this river there had been two water level-discharge gauging stations under the control of MESA at a point 10 km upstream from the river mouth: Pian-Pian (Canal: for low water level gauging) and Pian-Pian (Ponte: for high water level gauging) but due to lack of maintenance and administration funds, observations could not be continued and measurement equipment was removed, and neither station is being used at present. The spacing between the two gauging stations is approximately 20 m with Ponte for large discharges at the foot of a bridge upstream of Canal. The Ponte site has a width of approximately 7-8 m and, being on the downstream side of the bridge, it is well-suited for observations. At the Canal site it is a rectangular waterway of concrete approximately 1.5 m wide, and is of a setup for measuring water level on conducting the water flow to the center, but it is buried under sediment at present.

In 1974, the water gauging station for small discharges (Canal site) was restored by Portugal, but this was buried by sediment in short time. The observation data obtained up to that time all went to the Portuguese side and nothing remains on the Sao Tome side.

In 1988, with aid from Portugal, the low water level gauging station was restored and a water level gauging station for observation of large discharges was newly provided (Ponte) with the aid of Portugal. Data were collected by recording water gauges of one-month windings. At present, what can be used are, besides the previously-mentioned data contained in discharge yearbooks, water level gauging data from 1990 and the 7 or 8 actually measured discharge data of each year. The 1990 and 1991 water level and discharge data of Pian-Pian (Ponte) Gauging Station calculated using these water level and discharge data are shown in Table 7-5 and Fig. 7-4.

At the downstream part of this river, there is Gue Gue Hydroelectric Power Station (320 kW) operated and maintained by EMAE. Chapter 6, 2.2, should be referred to for details of this station.

At the upstream part of this river, there are plans for two new hydroelectric power stations, Manuel Jorge No. 3 and No. 4.

7.3.3 Abade River Basin

The Abade River, similarly to the two rivers mentioned above, rises from the vicinity of Lagos Amelia Crater, and flows down eastward roughly parallel to the Manuel Jorge River. Its main tributaries are the Bomba River (catchment area: 7.7 km^2) on the left-bank side. The length of the river flow is 20.9 km and the catchment area at the river mouth is 51.3 km^2. The river gradient at the upstream part to an elevation of about 800 m is 1:5.9, and at the midstream part it is 1:11.4. The river gradient approximately 11 km upstream from the mouth is gentle compared with the abovementioned two rivers and is about 1:59.

There are two meteorological observatories which are representative of the Abade River and its vicinity, they being Bombaim (EL. 445 m) located upstream and Agua Ize, downstream at EL. 15 m. It is reported that intake of water for drinking and miscellaneous-use is done for a number of hamlets at the midstream and downstream stretches of this river.

Comparisons of Observation Results at Two Meteorological Observatories

Observatory	EL .(m)	Mean Temp. (°C)	Annual Rainfall (mm)	Evaporation (mm)
Bombaim	445	22.4	2,594.2	450
Agua Ize	15	25.3	1,549.9	747

Water level-discharge gauging stations on the Abade River are the two of Agua Ize (catchment area: 36.5 km^2, observations started 1988) 1.2 km upstream from the river mouth and Bombaim (catchment area: 12 km^2, observations started 1989) located upstream. The water level-discharge records based on the results of measurements at the two observatories are shown in Ap. Tables 7-3 and Table 7-6, and Figs. 7-1 and 7-5 and Ap. Fig. 7-1. The Abade River, at the time of field reconnaissances in March 1996 at the Agua Ize site had a river width of approximately 10 m with discharge measured by eye of 0.3 to 0.4 m^3/sec. It was heard that the peak of flood would arrive 2 to 3 hours after rainfall. The pH of river water was about 6.5.

Development of one new hydropower site each is planned for the upstream and midstream parts of this river.

7.3.4 Io Grande River Basin

The Io Grande River, among the principal rivers of Sao Tome Island, is located at the southernmost end, and is the largest river. Its fountainhead is on the southern slope of Mt. Calvario (EL. 1,595 m) approximately 2.5 km southwest from Lagoa Amelia Crater, and the river basin extends down in the southwest direction. The main tributaries from the left-bank side are the Ana Chaves (27.6 km^2), the Joao (8.1 km^2), and the Unbugo (25.1 km^2), while there is none from the right-bank side. The catchment area at the river mouth is 105.5 km^2 and the length of the river channel is 24.3 km. The average gradient of the river bed is 1:17.1, but it is 1:4 at the upstream part and about 1:13 at the midstream part. The river gradient from the mouth to roughly 7 km upstream is gentle at 1:184 to present a flat lowland and in the rainy season flooding occurs in this flat land to form a marshy area. The river and its surroundings being as much as 50 km distant from densely populated Sao Tome City, and other than existence of large-scale palm plantations at parts, development has not progressed and the entire river basin is covered by dense forests and other vegetation.

According to long-term data of a 24-year period of Angolares Meteorological observatory (EL. 30 m) in the vicinity of this river, the annual mean temperature is 25.2°C, annual rainfall 3,254.5 mm, and annual average evaporation 566 mm.

A water level-discharge gauging station is at Manuel Caroca close by the river mouth, the catchment area being 103.2 km^2. Although observations had been carried out from 1988, at present the observatory is damaged and cannot be used. The water level and discharge records are given in Ap. Table 7-4.

The water quantity at the time of the field reconnaissance in March 1996 was large compared with other rivers, the water was clear and river width wide. Two dam-type power stations are planned in this river basin.

7.3.5 Lemba River

This river is located at the western side of Sao Tome Island, the side to its east bounding the Io Grande tributary of Ana Chaves. Its north side is adjacent to the basin of the Cantador River, and the stream flows down in the northwest direction. The fountainhead of the Lemba is on the west slope

(EL. 900 m) of Mt. Charuto (EL. 1,240 m). The relief of the river basin is mountainous with the entire mountains covered with tropical trees and other vegetation. The midstream and downstream parts are areas where cacao is being cultivated. The valley is V-shaped in the upstream part, while in the midstream and downstream parts the widths are from 50 to 100 m with development of marshy land, and the gut of the river is unstable. The catchment area at the river mouth is 45.2 km^2, the total length of the river channel approximately 14.8 km, and the river gradient on average is about 1:16.4. The inclination at the upstream part is especially steep (1:5).

The nearest meteorological observatory is at Santa Catarina in the downstream areas, and according to long-term data of 25 years from 1966 to 1990, the mean annual temperature, rainfall, and evaporation are 25.4°C, 2,894.7 mm, and 658.7 mm, respectively. Since the location is south of Mt. Sao Tome, rain clouds heavily laden with moisture from the Atlantic Ocean strike against Mt. Sao Tome to bring heavy rain in the area in general, and out of 12 months of the year monthly rainfalls exceeding 200 mm are recorded in 9 months, with 510 mm reached in October. There is rainfall of about 20 to 60 mm even in the dry season of July-September, and the discharge duration is favorable throughout the year.

There was one water level-discharge gauging station on this river which was installed with Portuguese aid in 1989, but it was washed out by flood and cannot be used at present. Discharge data presently available are given in Ap. Table 7-5. The water flow at the point of intersection with the national highway was clean at the time of the field reconnaissance in March 1996, the discharge was about 4 - 5 m^3/sec and abundant and stable compared with other rivers. Sand and boulders are seen in large quantity at the river bed. The river width is approximately 100 m.

Hydroelectric power stations are planned at Santa Jose (midstream part) and Santa Jose (midstream part) and SantaCatarina at the downstream part to utilize this abundant water.

7.3.6 Cantador River Basin

The mouth of the Cantador River is located 2.4 km to the north of the Lemba River's on the south and the Io Grande tributary Ana Chaves on the east. On the north side, it is adjacent to the small stream of Mata Mina. Its fountainhead is on the south slope of Mt. Sao Tome, and abundant rainfall is gathered there and flows down to the west. This river has an elevation difference of 1,600 m. The total river channel length is 11.9 km, the average river gradient is 1:7.4 and steep, and especially at the upstreammost part it is as much as 1:3.3. The catchment area at the river mouth is 12.2 km^2. The meteorological observatory nearest to the Cantador River is Santa Cantarina on the Lemba River described in 7.3.5.

The water level-discharge gauging station on the Cantador River was provided in 1989 at Santa Catalina (Ponte Rodoviaria: catchment area: 9.0 km^2), but this was washed away by flood. Water level-discharge records presently available are given in Ap. Table 7-6.

There is a plan for one hydroelectric power station in this river basin.

7.3.7 Contador River Basin

The Contador River is located on the north side of Mt. Sao Tome, and is adjacent to the Do Ouro, the Manuel Jorge, the Abade, the Io Grande, and the Cantador rivers at its upstream part. The fountainhead is at the north slope (EL. 1,840 m) of Mt. Sao Tome, and with a flow channel of approximately 12 km (average river gradient 1:7.7) the river emties into the Atlantic Ocean south of Ponta Figo. The catchment area at the river mouth is 23.5 km^2, and the river gradient at the upstreammost part is steep at 1:3.8. The river, similarly to the Cantador, has a V-shaped valley which is deep with steep slopes on both sides. The river bed is a rock mass on which there are boulders lying, while at the downstream stretch there are places where marshes are formed, and the river bed is easily changed by flood.

Meteorological observatories in the vicinity are Ponta Figo near the river mouth and Neves, approximately 2.5 km north ofPonta Figo, whose data can be used.

Observatory	Mean Temp. (°C)	Annual Mean Rainfall (mm)	Annual Average Evaporation (mm)
Ponta Figo	25.5	1,122	1,003
Neves	25.6	1,985	928

The river width at the point where the Contador intersects the national highway downstream is roughly 100 m, the flow being swift to the upstream side of the bridge and gentle from the bridge to the river mouth. The discharge according to measurement by eye as of March 1996 was about 2 m^3/sec. A water level-discharge gauging station was opened on the Contador River in 1988, but was damaged soon after by flood, and there are no data at all which can be used.

On the Contador River there is the existing Contador Hydroelectric Power Station (unit capacity: 960 kW x 2 units = 1,920 kW) under EMAE management, but this is presently operating at about one third of capacity because of partial damage to the headrace and other factors. For details of this power station 2.1 in Chapter 6 should be referred to.

7.4 Discharge at Project Site

As described in Chapter 8.3, in the upstream part of the Manuel Jorge River was selected the optimum development site for this project. The discharge data of the Manuel Jorge River which can be used for planning is limited as described in 7.3.2, and the daily discharges during approximately 4-year period from Oct. 1988 to Sep. 1992 and specific discharge per 10 km^2 of the Manuel Jorge River were estimated from comparison studies of daily discharge data of similar rivers in the vicinity. The technique of this is described below.

7.4.1 Discharge Calculation Method

Daily discharge data of Pian-Pian Gauging Station on the Manuel Jorge River are given in the 1989/90 discharge yearbook (but not in the 1988/89 yearbook) in the form of water level and discharge records prepared based on analyses by the Resources Research Institute of Portugal. On the other hand, there are actual measurement data *6 (data on a number of water levels and daily discharge) of MESA for checking rating curves for the years since 1989. It was decided to estimate the long-term discharge of the ManuelJorge River employing these two kinds of data.

*6: Discharges at the gauging station site, when large floods occur, often vary due to changes in the transverse cross section and river-bed gradient at the discharge gauging site because of the floods. Accordingly, what is generally done is to modify the rating curve which had been applied up to that time based on actually measured discharge if the river channel cross section was found to be difference from before on checking the transverse cross section and the discharge after the flood had subsided.

(1) Checking of Discharge Determined by Estimating Formula and Discharge Yearbook

In contrast to the water levels and estimated discharges in the discharge yearbook based on the discharge calculation formula (discharge calculated from water level) estimated in 1988 by the Portuguese Resources Research Institute, a calculation formula (binomial curve equation) for estimating discharge by the method of least squares using water level and discharge data actually measured by MESA (16 data from January to August) was first obtained. These results are given in Tables 7-7 and 7-8, and Figs. 7-6 and 7-7. Using water levels given in the discharge yearbook in this estimating calculation formula the daily discharge of that year were obtained by month, and the monthly averages of the two compared. As a result, the differences between the two were around ±10% and comparatively favorable. Hence, for estimating daily discharges thereafter, it was decided to apply this method using water level and discharge data (for rating curve checking) measured at the various gauging stations. Further, in case of a site which could be compared with the discharge yearbook, it was decided for calculations to be made while confirming accuracies checking differences as much as possible.

(2) Calculation Method for Daily Discharges of Years not Reported in Discharge Yearbook

In this case, the discharge calculation formula was obtained by the abovementioned method of least squares from the measured water level and discharge data for checking rating curves of principal rivers possessed by MESA. The water levels used in calculations were principally those at 9:00 a.m. out of the hourly water levels measured every day at the individual gauging stations.

7.4.2 Discharge Data of Pian-Pian Gauging Station

The discharge data of Pian-Pian (Ponte) Gauging Station on the Manuel Jorge River are given in Table 7-5 and Fig. 7-4, but the observation data are for a short period of about 1.5 years, while there are periods of no measurements during that time. Since it is desirable from the standpoint of formulating plans for the missing records to be supplemented and daily discharge data for even longer terms to be obtained, data for the blank periods were supplemented and the period was lengthened as much as possible.

(1) Utilizable Data of Nearby Similar Rivers

In the vicinity of the Manuel Jorge River there is the Abade River located to the south and the Do Ouro River to the north, and the water level data of Bombaim Gauging Station (catchment area: 12.0 km^2) at the upstream part of the Abade River, although with blank portions along the way, are available for a 3.6-year period from January 1989 to the middle of September 1992, while on the Do Ouro River, there are two gauging stations, Boa Esperanca (13.8 km^2) and Central A. Neto (48.0 km^2) upstream, and although data are missing for both from October 1988 to April 1991, their water level data can be used. The latter further has considerable blanks up to June 1992, but there are water level data which can be used. Water levels of the Manuel Jorge River which can be used are for approximately 1.5 years from January (with blanks) 1990 to April 1991.

(2) Examination of Similarities of Streams

The daily discharges of the abovementioned rivers were obtained by the technique described in 7.4.1 in order to examine the similarities of the above three rivers. The 5-day average discharges per 10 km^2 of catchment area were obtained from these daily discharge and graphed (see Fig. 7-8), and centering on the Manuel Jorge River, the degrees of correlation with the other rivers and discharge duration trends were examined. Firstly, to judge the degree of correlation for the long term of February to August 1990 for which data of the Manuel Jorge River exist, studies were made on the Abade River and the Do Ouro River individually and, as a result, it was found that the degree of correlation of the Manuel Jorge River with the Do Ouro (Boa Esperanca) was 0.53 and not on the very good side, but was of better correlation than the 0.3 for the Abade (Bombaim). Next, since for a run-of-river type mini-hydropower project the discharge of the dry season (July-September) is especially important, the correlations with the two rivers in the dry season were examined and, as a result, it was found that the degree of correlation with the Do Ouro (Boa Esperanca) was higher (correlation coefficient: $\gamma = 0.84$). Therefore, it was decided that basically the long-term daily discharge of the Manuel Jorge River would be determined based on the long-term data of Do Ouro (Boa Esperanca).

7.4.3 Supplementation of Blank Periods of Discharge Data

In supplementing missing data on daily discharges of the Manuel Jorge, Abade, and Do Ouro rivers, since discharge data do not exist for all of the observation period (October 1988 to September 1992), there are blank periods at parts and it is necessary for supplementation to be done using the data of the three rivers. Fortunately, the blank periods of the three rivers were divergent and did not occur at the same times so that supplementing could be done with one or the other, and it was succeeded in estimating the discharge of the Manuel Jorge (Ponte) location for the 4-year period of October 1988 to September 15, 1992.

(a) Firstly, in order to supplement the daily discharge of the Do Ouro (Boa Esperanca) from January to February of 1989, the correlation coefficient and regression line of the Do Ouro (Central A. Neto: also expressed as C.H.) with Do Ouro (Boa Esperanca) were determined and supplementing was done using this regression line.

Then, for the blank period from February to March of the same year, the correlation coefficient and regression line of the Abade River (Bombaim: x) and the Do Ouro River (Boa Esperanca: y) from January to April 1991 were determined, and since a good degree of correlation ($\gamma = 0.88$) was found, this regression line ($y = -0.059 + 0.936x$) was applied to the said blank period and the daily discharge of the Do Ouro (Boa Esperanca) was obtained.

(b) For supplementation of the blank period of the Do Ouro (Boa Esperanca) from July to August 1989, the correlation and regression line of the Abade (Bombaim: x) and the Do Ouro (Boa Esperanaca: y) from May to September 1991 were obtained, and after ascertaining the correlation degree ($\gamma = 0.91$), the daily discharge of the said blank period was calculated by this regression line ($y = 0.063 + 0.737x$).

(c) For supplementation of December 1989 to January 1990, the daily discharge of this blank period was determined applying the correlation degree and regression line of the Abade (Bombaim) and the Do Ouro (Boa Esperanca) from January to April 1991 mentioned in (a) above.

(d) For supplementation of August to September 1990, the daily discharge of this blank period was calculated based on data of the Do Ouro (Boa Esperanca: x) from June to August 1990 and data of the Manuel Jorge (Pian-Pian Ponte: y) during the same period. (see (b) above.)

(e) For supplementation of the blank period of the Do Ouro (Boa Esperanca) in April 1991, the daily discharge of this blank period was supplemented using the correlation degree and regression line based on long-term data of daily discharge of the Abade River (Bombaim) from May to Septemer 1991 and the data of the Do Ouro (Boa Esperanca) during the same period. (See (b) above.)

(f) For supplementation of the blank period of July to September 1992 of the Do Ouro (Boa Esperanca), calculations were made based on the correlation and regression line of the Abade (Bombaim) from May to September 1991 and the discharge of the Do Ouro (Boa Esperanca) during the same period. (See (b) above.)

(g) Based on the supplementations made in spots according to (a) to (f), the discharges of blank periods for the Do Ouro River (Bon Esperanca) were supplemented, and data for obtaining long-term discharge of the Manuel Jorge River (Pian-Pian: Ponte) were made complete. The daily discharges of the Manuel Jorge River at the Pian-Pian: Ponte site from October 1, 1988 to September 15, 1992 were obtained using the correlation degree ($\gamma = 0.530$) and regression line ($y = 0.660 + 0.098x$) of the Manuel Jorge (Pian-Pian: Ponte: y) and the Do Ouro (Boa Esperanca: x) from February to August 1990.

7.4.4 Discharge Calculation Results

Upon having supplemented the blank periods for the various rivers as described in the previous clause, the continuous daily discharges and specific discharges per 10 km^2 during the roughly 4-year period from October 1, 1988 to September 15, 1992 at the Pian-Pian Ponte site on the Manuel Jorge River were respectively obtained. These results are given in Fig. 7-9 and Tables 7-9 and 7-10.

In case of a small-scale power station of run-of-river type such as in this project, at times of large discharges such as during the flood season, only a portion of the water is used for power generation, and rather, the capacity is decided by the discharge during the low-water dry season. This estimation formula is based on long-term (7 months from February to August) discharges taking into consideration discharges during the dry season, and although the correlation between the two rivers cannot be said to be especially good, it is thought these are discharge data which can adequately serve for the purpose of studying the project.

The duration curves for the 3-year period from January 1989 to December 1991 were obtained based on these specific discharges as shown in Fig. 7-10.

7.4.5 Long-term Periodicity Studies of Discharge-Duration Curve

The discharge-duration curve for the 3-year period from 1989 through 1991 obtained under the preceding clause was calculated based on the discharge data (Pian Pian Gauging Station) of a short period of less than 4 years. It is necessary for the discharge to be used for formulation of a final plan based on the results grasping the correlation between short-term discharge at Pian Pian Gauging Station and discharge over a long term to be determined.

For this purpose, as mentioned previously, since discharge data from actual measurements were limited, it was decided to study the periodicity from precipitation data of the project site neighborhood where observation data of a comparatively long term are available.

As shown in Ap. Table 7-1(B) in the Appendix, there are 5 locations in the vicinity of the Manual Jorge River for which there are precipitation observation records, and the closest correlations between them were for annual precipitations (mean). Based on the data of Morro da Trindade (EL. 348 m), the 5-year moving average of monthly precipitation data for the 24-year period from 1971 through 1994 was examined for the two cases of annual precipitation and the precipitation of the dry season from June to September using the moving average method.

As a result, the discharge duration of the Manual Jorge from 1989 through 1991 with regard to annual precipitation as observed from rainfall was estimated to be approximately that of an average year, while when comparisons were made of dry seasons, the discharges of these 3 years were found to be about 10% less than in an average year. These results are given in Figs. 7-2 and 7-3.

7.5 Flood Discharge at Project Site

7.5.1 Flood Discharge Calculation Technique

In calculations of design flood discharges at the intake and powerhouse sites on the Manuel Jorge River, estimations were made by the procedure below.

As mentioned in the preceding section, there are no discharge observation data available concerning high waters over long periods on the catchments of the Manuel Jorge River and neighboring rivers and streams which can be directly used for calculation of design flood discharges. Therefore, what was done in this case was to estimate flood discharge by the method using precipitation observation data from the vicinity of the catchment where comparatively long-term observations have been carried out.

(1) Make comparison studies of long-term annual maximum daily precipitations at a number of meteorological observation stations in the Manuel Jorge River surroundings to select a representative precipitation site.

(2) Estimate the probability precipitation at the representative precipitation (observation) site selected under (1).

(3) Estimate the relationship between precipitation at the representative precipitation site and the mean catchment precipitation at the flood discharge calculation site and determine the mean catchment probability precipitation of thecatchment concerned.

(4) Using the number of coefficients determined from the catchment characteristics of the river concerned and the catchment probability precipitation, calculate the probable flood discharges at the intake dam and powerhouse sites corresponding to the respective recurrence intervals byGumbel distribution.

7.5.2 Calculation of Probable Flood Discharge

(1) Selection of Representative Precipitation Site

There are five precipitation observation stations in the vicinity of the Manuel Jorge River as shown in Fig. 7-1, and these can be used for calculating probable precipitation. The daily maximum precipitations of the individual years are selected for these five observation stations and shown in Table Ap. 7-7. Bombaim Observation Station along the Abade River, and Monte Cafe and Morro de Trinidade Observation Stations located at the north side of the Manuel Jorge River have records which are for long periods (27, 24, and 18 years), and these three sites were selected as representative precipitation sites and their figures are given in Ap. Table 7-8.

On analyses of these values, the precipitations at the three sites mentioned above are found to be affected by the distance from Mt. Tome and this is distinctly evident in the values. That is, Bombaim Meteorological Observation Station closest to Mt. Tome has the most precipitation in every recurrence interval and the influence decreases in the order of Monte Cafe and Morro de Trinidade.

The Manuel Jorge No. 4 Project site is located at roughly the middle of the abovementioned three meteorological observation stations so that the average of the three was taken as the mean probable precipitation of the site used for design of generating facilities, the values being as given below.

Recurrence Interval (1/n yr)	Probable Precipitation at Project Site (mm/day)
5	128
10	154
20	179
50	212
100	236

(2) Estimation of Probable Flood Discharges at Manuel Jorge Intake Site and Powerhouse Site

As mentioned previously, it was decided to determine the design flood discharges from probable precipitation since there are no observation records of flood discharges of the

Manuel Jorge River and streams in the vicinity. In this case, the intake dam is of concrete, and since a low dam of run-of-river type is planned, there will be no problem even if the dam crest were to be overtopped by flood, but the powerhouse will have various kinds of electrical equipment, and it will be necessary for a construction or elevation with which entrance of flood into the powerhouse can be avoided to protect the equipment so that estimating the design flood discharge and flood water level will be of importance. For this case, it was decided that the object design flood discharge should be determined adopting the 100-year return period flood discharge (R_{24} = 236 mm/day) obtained in (1).

In calculation of this design flood discharge, since the catchment area of the powerhouse site is 10.8 km², the Rational Method applied when catchment area is comparatively small (not more than 50 square kilometers) was used.

$Q = 0.2778*f*r*A$

Q : design flood discharge (m³/sec)
f : runoff coefficient
r : precipitation intensity
A : catchment area (km²)
Intake site: 9.32 km²
Powerhouse site: 10.80 km²

The precipitation intensity in the above equation was obtained by the equation below.

$r = R_{24}*(24/T)^{2/3}/24$

R_{24} : daily maximum precipitation = 236 mm/day
T : time of flood concentration (sec)
$T =$ L/W (Rziha Formula)
$L =$ length of river channel (10 km)
$W =$ flood concentration speed (m/sec)
$= 20\,(H/L)^{0.6}$
$H =$ elevation difference (1,000 m)

1) Flood Discharge Calculation for Powerhouse Site

From the length of the river channel to the powerhouse site of 10 km and elevation difference of 1,000 m (EL. 1,400 m - 400 m), the flood concentration speed (W) will be $20\ (H/L)^{0.6} = 20\ (1{,}000/10{,}000)^{0.6} = 5.02$ m/sec.

Calculation of Flood Concentration Time (T)

$T = L/W = 10{,}000/5.02/3{,}600 = 0.55$ hr

with less than 1 hour considered as 1 hour.

Accordingly, to estimate the precipitation per hour from daily precipitation of a 100-year return period, it will be 81.8 mm/hr from the calculation below.

$$r = 236/24\ (24/1)^{2/3} = 81.8 \text{ mm/hr}$$

The 100-yr return period design flood discharge of the powerhouse site is estimated to be 210 m^3/sec (19.3 m^3/sec/km^2 in terms of specific discharge).

$$Q = 0.2778{*}f{*}r{*}A = 0.2778{*}0.85{*}81.8{*}10.8$$
$$= 208.6 \text{ m}^3\text{/sec} \quad \text{Say } Q = 210 \text{ m}^3\text{/sec}$$

2) Estimation of Flood Discharge at Intake Dam Site

The intake dam is located 1.3 km upstream from the powerhouse site with the length of the river channel 8.7 km and the catchment area 9.32 km^2. Accordingly, the flood discharge was determined from the catchment area ratio with the powerhouse site, and 180 m^3/sec was obtained.

3) Comparison of Gauged Discharges and Flood Discharges of Neighboring Streams

Comparisons are generally made with gauged data of the stream catchment concerned or of neighboring streams which are similar, or of their specific discharges in order to confirm the probable flood discharges obtained through the above calculations.

Flood analysis results are available for the Io Grande River, the largest stream on Sao Tome Island, which has its mouth approximately 22 km south of the Manuel Jorge River, and comparisons can be made with them.

In the case of the Io Grande River, a preliminary survey on the possibility for a hydroelectric power station was carried out from 1980 to 1985 by the U.S.S.R., and the results of the survey were put together in a report *7 in 1986. The results of gauging of the flood of May 14, 1985 (daily maximum precipitation of 226 mm/day) have been analyzed in this report. According to this, the probable flood discharge (maximum 10 years) is from 18.4 to 21.8 m^3/sec per unit area of catchment. The reason for the range in measurement values was that flood discharges were respectively calculated and verified by the four techniques which were applied.

Meanwhile, the 10-year probable maximum daily precipitation at the Manuel Jorge No. 4 site was daily maximum precipitation of 154 mm/day, which flood discharge was 12.7 m^3/sec at the powerhouse site. On simple comparison of flood discharges by daily maximum precipitation ratios, flood discharges of the Manuel Jorge River were 12.5 - 14.9 m^3/sec, which were not of large differences in terms of order of values determined by calculations, so that it was decided to adopt the abovementioned calculated value (210 m^3/sec) as the probable 100-year return period flood used in the feasibility design of intake facility.

It may be added that the Io Grande River is located south of Mt. Tome on Sao Tome Island, belongs to a heavy rainfall area (4,000 - 5,000 mm/yr), and is the longest river (24 km) with the largest catchment (102.5 km^2 at the power station site 3.2 km upstream of the river mouth).

*7 Ia Fase do Anteprojecto Tecnico, Vol. II, Condicoes Naturais Clima e Hidrologia, Argumentacao Geodesico Topografica, Central Hidroelectrica Io Grande-1, V/O,Techopromexport, USSR, 1986

7.6 Estimate of Sedimentation at Project Site

7.6.1 Outline of Sediment Component Supply Source in Upstream Area of ManuelJorge River

The area upstream of the site where the power station on the Manuel Jorge River is planned presents a mountainous topography with elevations mostly from 400 to 1,480 m. Cacao and coffee are grown at places of comparatively low elevations, but as elevation becomes higher, the area is covered by a virgin evergreen tropical rain forest.

The average river gradient of the Manuel Jorge River at the projected powerhouse site is approximately 1/16, while the average river gradient from the powerhouse site to the upstreammost part (farthest point of river channel-headwater point) is 1/10 (elevation difference 1,000 m, river channel length 10 km).

The slopes of the mountains on both sides of the river at the projected intake dam site are generally from 50 (right bank) de to 43 (left bank) de, and old landslide topographies or new collapsed structures can be seen at parts of the slopes. Boulders several tens of centimeters in diameter are scattered at the river bed, while hardly any small gravels, sand deposits or sand bars can be seen.

Because of such conditions, extremely swift flow velocities exceeding 5 m/sec are expected to occur at times of flood, and it is imagined that tractional force will be great. Surmised from marks of flooding, the flood characteristics of this stream are of occurrence in the rainy season when the ground surface holds ample moisture to be in a supersaturated condition. According to residents in the neighborhood the conditions become those of flash floods which occur in short periods of time and which recede very rapidly.

According to observations during field reconnaissances (Jul. 1996), the mountainland is steeply sloped at the surface, and it is possible that at times of extremely heavy rainfall, new collapses can occur at these slopes for soil and sand-gravel-rock to be supplied to the stream, and for sand, gravel, and rock of various sizes, large and small, deposited at the river bed to be carried down to the intake dam. That hardly any fines are seen is surmised to be due to soil, sand, gravel, and boulders being brought down during floods, with only part of the coarser materials remaining at the river bed, the fines being swept down to downstream parts of gentle gradient.

At the projected powerhouse site approximately 1.3 km downstream from the intake dam site, the river width is broadened somewhat (approximately 15 m), and little amounts of sand can be seen in the interstices of cobbles and gravels of 2 to 3 cm. The river bed is comparatively stable over the entire river channel, but small collapses can be seen here and there at cut surfaces of roads and waterways in the vicinity of the projected powerhouse site.

7.6.2 Estimate of Sediment Inflow Volume

This Project is a run-of-river type power generation scheme which does not have a reservoir, with the intake dam a low dam of height about 2 to 3 m, the capacity for storage of water upstream by the dam being extremely small because of the narrow width and steep gradient of the river. Therefore, it is not conceivable that suspended sediment will be settled in large quantity through storage of the streamflow. However, sand-gravel of large particle diameter will be obstructed from movement by the intake dam and will be deposited on the upstream side to a height greater than that of the dam.

(1) Estimate of Suspended Load

The only time that suspended load can be observed in the Manuel Jorge River is during flood, but since there are no observation records concerning suspended load, it is not possible to directly estimate inflow quantities of sand and sand-gravel. Therefore, it was decided to make estimates from the observation values published in the previously-mentioned report *7 prepared by the U.S.S.R. agency. In other words, it was decided that the specific suspended load per unit area of catchment was to be determined from the observation values *8 of daily discharges and suspended load contents from January to December at the site mentioned below during the 2-year period of 1981-1982 given in the attached table of the report, with this value applied to the power generation project on the Manuel Jorge River.

*8 Attached Tables 12 (Runoff) and 15 (Suspended Sediment Content) of U.S.R.R. report

Site	Catchment Area (km^2)	Annual Inflow ($10^6 m^3$)	Av. Concentration of Suspended Load (g/m^3)	Annual Suspended Load Inflow (ton/yr)	Specific Suspended Load (ton/yr/km^2)
Manuel Caroca	102.5	370	156	69,000	673

(2) Estimate of Bed Load

Estimating the bed load of a natural stream is very difficult, and it is not possible for a quantitative prediction to be made, but from the fact that it was thought tractional force at the upstream part of the Manuel Jorge River was considerably great, it was decided to make an estimate applying the abovementioned value per unit area of catchment (673 m^3/yr/km^2). In general, it is said bed load does not exceed 25% of suspended load, and applying this hypothesis, it is estimated that annual bed load inflow will be about 6,200 applying this hypothesis, it is estimated that annual bed load inflow will be about 6,200 ton/yr. Although depending to an extent on the gradation of sand-gravel, in case it is assumed that average unit density is 1.7 ton/m^3 with all of this deposited, the volume is estimated will be 3,600/yr at the dam site so that it is expected that a low dam will have sediment deposited to the dam crest with just several floods, after which traction sand will almost all be transported downstream of the dam.

In this Project, suspended load will be a problem when a settling basin is planned, it being the relationship between type and particle size of suspended load contained in flowing water. Data on these factors do not exist for the Manuel Jorge River so that it was decided to apply the analysis results of the Io Grande River which is similar in topography and stratigraphical form to the Manuel Jorge River at its upstream part. Data of the Io Grande River are given in the table below, and according to these results, particle diameters less than 0.1 mm make up 92.3%, of which those of 0.05 to 0.01 mm account for 36 percentage points.

It has been reported that the weight per unit volume, or specific gravity, of this sample is 2.90.

Particle size (mm)	0.5 - 0.25	0.25 - 0.10	0.10 - 0.05	0.05 - 0.01	0.01 - 0.005	0.005 - 0.002	Under 0.002	Specific Gravity (g/cm^3)
Particle size (%)	0.7	7.0	16.3	36.0	16.3	13.5	10.2	2.90

Table 7–1 Characteristics of Typical Meteorological Stations in Sao Tome

Note : Figures indicated in the below Talble were observed in August 1994

No.	Name of Station	Altitude (m)	recipitatio (mm)	Temperature (℃)	Evaporation (mm)	R. Humidity (%)	Sunshaine (Hours)	(%)
1	Agua Ize	15.0	9.7	23.8	22.0	83.0	2.3	19
2	Angolares	30.0	63.9	23.0	13.1	85.0		
3	Angostinho Neto	167.0	0.9	23.6	23.9	79.0		
4	Boa Nova	310.0	2.9	22.6	14.1	83.0	3.1	26
5	Bombaim	445.0	18.9	20.1	10.2	91.0		
6	Cruaeiro	380.0	55.5	20.4	5.4	93.0		
7	Diogo Vaz	83.0	2.3	23.7	27.4	80.0		
8	Dona Augusta	140.0	52.4	22.3	16.7	88.0	1.4	12
9	E.P.P. Lumumba	4.0	1.2	25.0	31.1	79.0		
10	Lagoa Amelia	1488.0	14.0	16.4	7.1	92.0		
11	Monte Cafe	690.0	6.7	20.3	13.7	88.0	1.7	14
12	Morro Trindade	348.0	4.0	23.2	17.7	80.0		
13	Mestre Antonio	74.0	18.8	23.8	21.4	83.0		
14	Neves	7.0	1.2	24.6	31.0	78.0	5.1	42
15	Ponta Figo	100.0	0.3	24.2	29.0	79.0		
16	Porto Alegre	9.0	10.8	23.8	22.7	85.0	2.0	17
17	Santa Catarina	42.0	13.1	24.0	23.9	80.0	4.1	34
18	Uba Budo	243.0	4.1	22.7	18.6	82.0		
19	Air Port	8.0	1.8	24.3	31.9	76.0	5.0	42

Data source: Instituto National de Meteorologia

Table 7-2 Characteristics of Stream Gauge Stations in Sao Tome

Name of Station	Name of River	Catchment Area (km2)	Latitude-N	Longtude-E	Altitude (m)	Initial Observation *1 (Year)
Agua Ize	Abade	36.5	00-14	06-44	58	1988
Bombaim	Abade	12.0	00-15	06-39	500	1989
Madalena	Agua Palito	21.7	00-19-45	06-41	200	1988
Lucian Cola	Agua Grande	23.2	00-20	06-14	25	1988
Santa Catalina (Ponte Rodoviaria)	Cantador	9.0	00-15-40	06-28-20	20	1989
Ponta Figo	Contador		00-18-30	06-34	700	1988
Manuel Caroca	Io Grande	103.2	00-07-15	06-38-45	12	1988
Santa Jose	Lemba	31.9	00-13-30	06-30	100	1989
Pian-Pian (Canal)	Manuel Jorge	22.6	00-16-45	06-42	200	1988
Pian-Pian (Ponte)	Manuel Jorge	22.6	00-16-45	06-42	200	1988
Boa Esperanca	Du Ouro	13.8	00-19-45	06-38	400	1988
Central A. Neto	Du Ouro	48.0	00-22	06-39	160	1988

*1: Initial observation on daily discharge by Secretaria de Estado do Ambiente e Recursos Naturais . Portugal
Data source : "Caudais". Ano Hidrologico 1988 - 1989

Table 7-3 Daily Discharge Calculation at Boa Esperanca Gauging Station on Do Ouro River

(Period: 1988-1992)

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= -3.687+4.858*H-1.132*H^2

Daily Discharge Calculation in m^3/ Sec
River: Du Ouro Year: 1988
Gauging Station: Boa Esperanc Catchment Area : 13.8 Sq.Km

	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
Day	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	Q	Q
1															1.250	0.617			1.210	0.534	1.270	0.657	1.360	0.826	2.634	0.658
2															1.250	0.617			1.230	0.576	1.250	0.617	1.320	0.753	2.562	0.641
3															1.250	0.617			1.220	0.555	1.300	0.715	1.310	0.734	2.621	0.655
4															1.270	0.657			1.210	0.534	1.270	0.657	1.300	0.715	2.563	0.641
5															1.270	0.657			1.210	0.534	1.260	0.637	1.350	0.808	2.636	0.659
6															1.260	0.637			1.220	0.555	1.260	0.637	1.340	0.790	2.619	0.655
7															1.260	0.637			1.230	0.576	1.310	0.734	1.320	0.753	2.700	0.675
8															1.250	0.617			1.240	0.596	1.300	0.715	1.360	0.826	2.755	0.689
9															1.260	0.637			1.250	0.617	1.300	0.715	1.340	0.790	2.759	0.690
10															1.260	0.637			1.280	0.677	1.300	0.715	1.340	0.790	2.819	0.705
11															1.260	0.637			1.240	0.596	1.300	0.715	1.320	0.753	2.702	0.675
12															1.260	0.637			1.240	0.596	1.300	0.715	1.320	0.753	2.702	0.675
13															1.260	0.637			1.240	0.596	1.280	0.677	1.420	0.929	2.839	0.710
14															1.260	0.637			1.230	0.576	1.280	0.677	1.320	0.753	2.642	0.661
15															1.260	0.637			1.240	0.596	1.290	0.696	1.310	0.734	2.664	0.666
16															1.250	0.617			1.240	0.596	1.300	0.715	1.320	0.753	2.682	0.670
17															1.230	0.576			1.260	0.637	1.410	0.912	1.310	0.734	2.859	0.715
18															1.230	0.576			1.290	0.696	1.370	0.844	1.300	0.715	2.831	0.708
19															1.230	0.576					1.330	0.772	1.290	0.696	2.044	0.681
20															1.230	0.576			1.260	0.637	1.320	0.753	1.290	0.696	2.662	0.665
21															1.230	0.576			1.260	0.637	1.300	0.715	1.280	0.677	2.605	0.651
22															1.230	0.576			1.260	0.637	1.310	0.734			1.947	0.974
23															1.250	0.617			1.250	0.617	1.390	0.878			2.112	1.056
24																			1.270	0.657	1.370	0.844			1.501	0.750
25																			1.290	0.696	1.360	0.826			1.522	0.761
26																			1.280	0.677	1.350	0.808			1.485	0.742
27																			1.270	0.657	1.340	0.790			1.447	0.723
28																			1.270	0.657	1.320	0.753	1.290	0.696	2.106	0.702
29																	1.210	0.534	1.310	0.734	1.310	0.734	1.320	0.753	2.756	0.689
30																	1.210	0.534	1.290	0.696	1.300	0.715	1.300	0.715	2.661	0.665
31																			1.280	0.677			1.280	0.677	1.353	0.677
Total		0.000		0.000		0.000		0.000		0.000		0.000		0.000		14.201		1.068		18.621		22.075		18.822	74.787	
Average(A)		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.617		0.534		0.621		0.736		0.753		0.680
No. of Days/M		0		0		0		0		0		0		0		23		2		30		30		25		110

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= -3.687+4.858*H-1.132*H^2

Daily Discharge Calculation in m^3/ Sec
River: Du Ouro Year: 1989
Gauging Station: Boa Esperanc Catchment Area : 13.8 Sq.Km

	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
Day	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	X	Q	H	Q	Q	Q
1	1.280	0.677					1.220	0.555	1.300	0.715	1.280	0.677	1.130	0.357			1.080	0.239	1.100	0.287	1.300	0.715	1.180	0.469	4.691	1.173
2	1.270	0.657					1.220	0.555	1.280	0.677	1.270	0.657	1.130	0.357			1.080	0.239	1.100	0.287	1.380	0.861	1.220	0.555	4.845	1.211
3	1.270	0.657					1.220	0.555	1.260	0.637	1.260	0.637	1.120	0.334			1.090	0.263	1.120	0.334	1.330	0.772	1.180	0.469	4.658	1.164
4	1.280	0.677					1.220	0.555	1.260	0.637	1.240	0.596	1.120	0.334			1.090	0.263	1.120	0.334	1.300	0.715	1.180	0.469	4.581	1.145
5	1.280	0.677					1.200	0.513	1.340	0.700	1.240	0.596	1.120	0.334			1.090	0.263	1.160	0.425	1.290	0.696	1.150	0.403	4.697	1.174
6	1.280	0.677					1.210	0.534	1.260	0.637	1.230	0.576	1.120	0.334			1.090	0.263	1.120	0.334	1.280	0.677	1.140	0.380	4.411	1.103
7	1.270	0.657							1.230	0.576	1.220	0.555	1.120	0.334			1.090	0.263	1.130	0.357	1.580	1.163	1.220	0.555	4.459	1.115
8	1.280	0.677							1.210	0.534	1.200	0.696	1.120	0.334			1.090	0.263	1.130	0.357	1.420	0.929	1.400	0.895	4.685	1.171
9	1.270	0.657							1.200	0.513	1.280	0.677	1.120	0.334			1.080	0.239	1.140	0.380	1.330	0.772	1.210	0.534	4.105	1.026
10	1.270	0.657							1.220	0.555	1.280	0.677	1.120	0.334			1.080	0.239	1.150	0.403	1.300	0.715	1.180	0.469	4.049	1.012
11	1.260	0.637							1.190	0.491	1.280	0.677	1.120	0.334	1.100	0.287	1.100	0.287	1.130	0.357	1.280	0.677	1.170	0.447	4.194	1.048
12	1.270	0.657					1.230	0.576	1.200	0.513	1.280	0.677	1.110	0.311	1.100	0.287	1.100	0.287	1.120	0.334	1.260	0.637	1.260	0.637	4.914	1.229
13	1.270	0.657					1.230	0.576	1.230	0.576	1.270	0.657	1.100	0.287	1.100	0.287	1.100	0.287	1.250	0.617	1.260	0.637	1.210	0.534	5.114	1.278
14	1.260	0.637					1.230	0.576	1.230	0.576	1.250	0.617			1.100	0.287	1.100	0.287	1.320	0.753	1.300	0.715	1.200	0.513	4.960	1.240
15	1.260	0.637					1.450	0.977	1.230	0.576	1.260	0.637			1.090	0.263	1.080	0.239	1.360	0.826	1.300	0.715	1.190	0.491	5.362	1.340
16	1.260	0.637			1.270	0.657	1.250	0.617	1.210	0.534	1.250	0.617			1.090	0.263	1.080	0.239	1.360	0.826	1.260	0.637	1.190	0.491	5.518	1.379
17	1.260	0.637			1.260	0.637	1.240	0.596	1.150	0.403	1.240	0.596			1.000	0.263	1.080	0.239	1.300	0.715	1.250	0.617	1.180	0.469	5.173	1.293
18	1.260	0.637			1.260	0.637	1.240	0.596	1.170	0.447	1.180	0.469			1.090	0.263	1.090	0.263	1.600	1.188	1.240	0.596	1.180	0.469	5.567	1.392
19	1.260	0.637			1.260	0.637	1.240	0.596	1.170	0.447	1.140	0.380			1.080	0.239	1.090	0.263	1.320	0.753	1.230	0.576	1.180	0.469	4.998	1.666
20	1.260	0.637			1.270	0.657	1.250	0.617	1.160	0.425	1.140	0.380			1.080	0.239	1.090	0.263	1.280	0.677	1.260	0.637	1.170	0.447	4.979	1.245
21	1.260	0.637			1.260	0.637	1.280	0.677	1.150	0.403	1.140	0.380			1.080	0.239	1.000	0.263	1.280	0.677	1.240	0.596			4.509	1.127
22	1.260	0.637			1.260	0.637	1.260	0.637	1.290	0.696	1.140	0.380			1.080	0.239	1.090	0.263	1.260	0.637	1.220	0.555			4.681	2.341
23	1.280	0.677			1.260	0.637	1.260	0.637	1.240	0.596	1.140	0.380			1.080	0.239	1.080	0.239	1.260	0.637	1.210	0.534			4.576	2.288
24	1.290	0.696			1.260	0.637	1.310	0.734	1.220	0.555	1.140	0.380			1.080	0.239	1.080	0.239	1.540	1.110	1.200	0.513			5.103	2.551
25	1.300	0.715			1.260	0.637	1.270	0.657	1.220	0.555	1.140	0.380			1.080	0.239	1.090	0.263	1.280	0.677	1.200	0.513			4.636	2.318
26					1.250	0.617	1.260	0.637	1.210	0.534	1.130	0.357			1.080	0.239	1.090	0.263	1.280	0.677	1.190	0.491			3.815	1.907
27					1.250	0.617	1.260	0.637	1.240	0.506	1.130	0.357			1.080	0.239	1.090	0.263	1.280	0.677	1.200	0.513			3.899	1.949
28					1.250	0.617	1.260	0.637	1.240	0.596	1.130	0.357			1.090	0.263	1.000	0.263	1.390	0.878	1.180	0.469			4.081	1.360
29					1.240	0.596	1.300	0.715	1.220	0.555	1.130	0.357			1.090	0.263	1.090	0.263	1.260	0.637	1.210	0.534			3.921	0.980
30					1.240	0.596	1.270	0.657	1.360	0.820	1.130	0.357			1.090	0.263	1.090	0.263	1.250	0.617	1.200	0.513			4.092	1.023
31					1.230	0.576			1.300	0.715					1.080	0.239			1.240	0.596					2.127	1.063
Total		16.438		0.000		10.028		15.617		17.884		15.734		4.318		5.384		7.778		18.362		19.688		10.166	141.397	
Average		0.658		0.000		0.627		0.625		0.577		0.524		0.332		0.256		0.259		0.592		1.641		0.508		0.557
No. of Days/M		25		0		16		25		31		30		13		21		30		31		12		20		254

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= -3.687+4.858*H-1.132*H^2

Daily Discharge Calculation in m^3/ Sec
River: Du Ouro Year: 1990
Gauging Station: Boa Esperanc Catchment Area : 13.8 Sq. Km

	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
Day	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	Q	Q
1			1.170	0.447	1.110	0.311	1.130	0.357	1.190	0.491	1.260	0.637	1.160	0.425					1.110	0.311	1.280	0.677	1.200	0.513	4.168	0.463
2			1.150	0.403	1.090	0.263	1.130	0.357	1.180	0.469	1.260	0.637	1.160	0.425	1.120	0.334			1.100	0.287	1.230	0.576	1.200	0.513	4.264	0.426
3			1.140	0.380	1.160	0.425	1.130	0.357	1.170	0.447	1.250	0.617	1.160	0.425	1.120	0.334			1.120	0.334	1.200	0.513	1.180	0.469	4.301	0.430
4			1.140	0.380	1.100	0.287	1.130	0.357	1.160	0.425	1.260	0.637	1.160	0.425	1.120	0.334			1.120	0.334	1.180	0.469	1.180	0.469	4.118	0.412
5			1.140	0.380	1.100	0.287	1.130	0.357	1.150	0.403	1.250	0.617	1.160	0.425	1.120	0.334			1.140	0.380	1.180	0.469	1.230	0.576	4.228	0.423
6			1.140	0.380	1.000	0.263	1.130	0.357	1.150	0.403	1.250	0.617	1.160	0.425	1.130	0.357			1.120	0.334	1.200	0.513	1.180	0.469	4.118	0.412
7			1.130	0.357	1.110	0.311	1.210	0.534	1.140	0.380	1.240	0.596	1.160	0.425	1.120	0.334			1.140	0.380	1.180	0.469	1.180	0.469	4.255	0.426
8			1.100	0.287	1.100	0.287	1.230	0.576	1.150	0.403	1.220	0.555	1.160	0.425	1.140	0.380			1.130	0.357	1.170	0.447	1.160	0.425	4.142	0.414
9			1.110	0.311	1.090	0.263	1.180	0.469	1.180	0.469	1.210	0.534	1.160	0.425	1.120	0.334			1.140	0.380	1.180	0.469	1.170	0.447	4.102	0.410
10			1.100	0.287	1.110	0.311	1.130	0.357	1.230	0.576	1.210	0.534	1.160	0.425	1.120	0.334			1.110	0.311	1.190	0.491	1.240	0.596	4.221	0.422
11			1.120	0.334	1.100	0.287	1.130	0.357	1.180	0.469	1.210	0.534	1.130	0.357	1.130	0.357			1.110	0.311	1.250	0.617	1.180	0.469	4.092	0.409
12			1.120	0.334	1.100	0.287	1.120	0.334	1.220	0.555	1.210	0.534	1.130	0.357	1.130	0.357			1.140	0.380	1.190	0.491	1.180	0.469	4.098	0.410
13			1.130	0.357	1.110	0.311	1.120	0.334	1.190	0.491	1.200	0.513	1.130	0.357	1.130	0.357			1.130	0.357	1.220	0.555	1.160	0.425	4.056	0.406
14			1.100	0.287	1.120	0.334	1.120	0.334	1.170	0.447	1.200	0.513	1.130	0.357	1.140	0.380			1.120	0.334	1.180	0.469	1.160	0.425	3.880	0.388
15			1.100	0.287	1.140	0.380	1.110	0.311	1.670	1.269	1.190	0.491	1.130	0.357	1.140	0.380			1.120	0.334	1.180	0.469	1.200	0.513	4.790	0.479
16			1.100	0.287	1.130	0.357	1.110	0.311	1.240	0.596	1.180	0.469	1.150	0.403	1.130	0.357			1.120	0.334	1.180	0.469	1.180	0.469	4.053	0.405
17			1.100	0.287	1.130	0.357	1.340	0.790	1.230	0.576	1.180	0.469	1.150	0.403	1.130	0.357			1.110	0.311	1.190	0.491	1.180	0.469	4.510	0.451
18			1.100	0.287	1.120	0.334	1.140	0.380	1.210	0.534	1.180	0.469	1.150	0.403					1.120	0.334	1.180	0.469	1.160	0.425	3.635	0.404
19			1.120	0.334	1.290	0.696	1.160	0.425	1.200	0.513	1.170	0.447	1.150	0.403					1.120	0.334	1.200	0.513	1.160	0.425	4.089	0.454
20			1.120	0.334	1.220	0.555	1.230	0.576	1.190	0.491	1.180	0.469	1.150	0.403					1.130	0.357	1.180	0.469	1.160	0.425	4.079	0.453
21			1.120	0.334	1.240	0.596	1.210	0.534	1.220	0.555	1.170	0.447	1.150	0.403					1.160	0.425	1.180	0.469	1.160	0.425	4.188	0.465
22			1.090	0.263	1.210	0.534	1.180	0.469	1.250	0.617	1.160	0.425	1.150	0.403					1.220	0.555	1.250	0.617	1.160	0.425	4.307	0.479
23			1.090	0.263	1.190	0.491	1.160	0.425	1.220	0.555	1.170	0.447	1.150	0.403					1.160	0.425	1.840	1.419	1.150	0.403	4.831	0.537
24			1.130	0.357	1.180	0.469	1.160	0.425	1.210	0.534	1.160	0.425	1.150	0.403					1.140	0.380	1.230	0.576	1.150	0.403	3.971	0.441
25			1.180	0.469	1.170	0.447	1.160	0.425	1.230	0.576	1.160	0.425	1.150	0.403					1.160	0.425	1.210	0.534	1.160	0.425	4.129	0.459
26			1.130	0.357	1.170	0.447	1.180	0.469	1.340	0.790	1.160	0.425	1.140	0.380			1.140	0.380	1.200	0.513	1.240	0.596	2.740	1.125	5.483	0.548
27			1.110	0.311	1.170	0.447	1.160	0.425	1.480	1.023	1.160	0.425	1.140	0.380			1.140	0.380	1.180	0.469	1.200	0.513	1.920	1.467	5.840	0.584
28			1.110	0.311	1.160	0.425	1.170	0.447	1.490	1.038	1.160	0.425	1.140	0.380			1.160	0.425	1.180	0.469	1.360	0.826	1.600	1.188	5.935	0.593
29					1.140	0.380	1.170	0.447	1.320	0.753	1.160	0.425	1.140	0.380			1.140	0.380	1.160	0.425	1.220	0.555	1.290	0.696	4.441	0.444
30					1.130	0.357	1.160	0.425	1.300	0.715	1.160	0.425	1.140	0.380			1.120	0.334	1.170	0.447	1.220	0.555	1.240	0.596	4.235	0.423
31					1.130	0.357			1.270	0.657			1.140	0.380					2.200	1.522			1.220	0.555	3.471	0.694
Total		0.000		9.405		11.857		12.722		18.219		15.183		12.342		5.620		1.899		12.848		16.765		17.170	134.030	
Average		0.000		0.336		0.382		0.424		0.588		0.506		0.398		0.351		0.380		0.414		0.559		0.554		0.456
No. of Days/M		0		28		31		30		31		30		31		16		5		31		30		31		294

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= -3.687+4.858*H-1.132*H^2

Daily Discharge Calculation in m^3/ Sec
River: Du Ouro Year: 1991
Gauging Station: Boa Esperanc Catchment Area : 13.8 Sq. Km

Day	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	Q	Q
1	1.220	0.555	1.140	0.380	1.140	0.380	1.220	0.555	1.300	0.715	1.370	0.844	1.220	0.555	1.170	0.447	1.140	0.380	1.130	0.357	1.260	0.637	1.180	0.469	6.274	0.523
2	1.210	0.534	1.130	0.357	1.130	0.357	1.300	0.715	1.360	0.826	1.340	0.790	1.220	0.555	1.170	0.447	1.140	0.380	1.120	0.334	1.250	0.617	1.180	0.469	6.382	0.532
3	1.230	0.576	1.130	0.357	1.210	0.534	1.230	0.576	1.330	0.772	1.440	0.961	1.220	0.555	1.170	0.447	1.140	0.380	1.130	0.357	1.240	0.596	1.180	0.469	6.580	0.548
4	1.210	0.534	1.130	0.357	1.160	0.425	1.220	0.555	1.320	0.753	1.330	0.772	1.220	0.555	1.170	0.447	1.160	0.425	1.140	0.380	1.240	0.596	1.180	0.469	6.269	0.522
5	1.200	0.513	1.130	0.357	1.140	0.380	1.220	0.555	1.330	0.772	1.310	0.734	1.220	0.555	1.170	0.447	1.140	0.380	1.130	0.357	1.230	0.576	1.180	0.469	6.095	0.508
6	1.200	0.513	1.140	0.380	1.140	0.380	1.200	0.513	1.300	0.715	1.340	0.790	1.210	0.534	1.170	0.447	1.140	0.380	1.130	0.357	1.230	0.576	1.180	0.469	6.054	0.504
7	1.200	0.513	1.140	0.380	1.130	0.357	1.220	0.555	1.320	0.753	1.370	0.844	1.210	0.534	1.160	0.425	1.140	0.380	1.140	0.380	1.220	0.555	1.190	0.491	6.166	0.514
8	1.180	0.469	1.130	0.357	1.220	0.555	1.290	0.696	1.300	0.715	1.310	0.734	1.210	0.534	1.160	0.425	1.130	0.357	1.200	0.513	1.220	0.555	1.180	0.469	6.380	0.532
9	1.210	0.534	1.120	0.334	1.230	0.576	1.240	0.596	1.290	0.696	1.320	0.753	1.210	0.534	1.160	0.425	1.130	0.357	1.190	0.491	1.230	0.576	1.170	0.447	6.319	0.527
10	1.420	0.929	1.120	0.334	1.190	0.491			1.280	0.677	1.310	0.734	1.200	0.513	1.160	0.425	1.130	0.357	1.140	0.380	1.300	0.715	1.180	0.469	6.024	0.548
11	1.190	0.491	1.280	0.677	1.180	0.469			1.280	0.677	1.300	0.715	1.200	0.513	1.160	0.425	1.130	0.357	1.130	0.357	1.260	0.637	1.160	0.425	5.742	0.522
12	1.180	0.469	1.130	0.357	1.360	0.826			1.280	0.677	1.300	0.715	1.200	0.513	1.160	0.425	1.130	0.357	1.270	0.657	1.200	0.513	1.180	0.469	5.978	0.543
13	1.180	0.469	1.130	0.357	1.260	0.637			1.340	0.790	1.300	0.715	1.200	0.513	1.180	0.469	1.130	0.357	1.170	0.447	1.230	0.576	1.220	0.555	5.885	0.535
14	1.180	0.469	1.120	0.334	1.230	0.576			1.350	0.808	1.300	0.715	1.200	0.513	1.160	0.425	1.130	0.357	1.160	0.425	1.220	0.555	1.180	0.469	5.646	0.513
15	1.460	0.993	1.130	0.357	1.310	0.734			1.380	0.861	1.280	0.677	1.190	0.491	1.160	0.425	1.130	0.357	1.580	1.163	1.210	0.534	1.180	0.469	7.061	0.642
16	1.200	0.513	1.120	0.334	1.220	0.555			1.320	0.753	1.270	0.657	1.190	0.491	1.160	0.425	1.140	0.380	1.320	0.753	1.210	0.534	1.180	0.469	5.264	0.533
17	1.190	0.491	1.120	0.334	1.210	0.534	1.320	0.753	1.430	0.945	1.270	0.657	1.190	0.491	1.160	0.425	1.130	0.357	1.260	0.637	1.200	0.513	1.180	0.469	6.606	0.550
18	1.190	0.491	1.120	0.334	1.380	0.861	1.310	0.734	1.330	0.772	1.260	0.637	1.190	0.491	1.160	0.425	1.130	0.357	1.230	0.576	1.200	0.513	1.180	0.469	6.660	0.555
19	1.180	0.469	1.120	0.334	1.290	0.696	1.300	0.715	1.350	0.808	1.260	0.637	1.190	0.491	1.160	0.425	1.130	0.357	1.210	0.534	1.200	0.513	1.180	0.469	6.448	0.537
20	1.170	0.447	1.120	0.334	1.260	0.637	1.460	0.993	1.320	0.753	1.200	0.637	1.180	0.469	1.100	0.425	1.130	0.357	1.190	0.491	1.200	0.512	1.190	0.491	6.547	0.546
21	1.280	0.677	1.140	0.380	1.250	0.617	1.320	0.753	1.300	0.715	1.260	0.637	1.180	0.469	1.150	0.403	1.120	0.334	1.360	0.826	1.200	0.513	1.170	0.447	6.770	0.564
22	1.200	0.513	1.140	0.380	1.320	0.753	1.300	0.715	1.310	0.734	1.260	0.637	1.180	0.469	1.150	0.403	1.120	0.334			1.190	0.491	1.160	0.425	5.854	0.532
23	1.180	0.469	1.120	0.334	1.500	1.053	1.300	0.715	1.320	0.753	1.250	0.617	1.180	0.469	1.140	0.380	1.120	0.334			1.190	0.491	1.160	0.425	6.041	0.549
24	1.170	0.447	1.120	0.334	1.300	0.715	1.380	0.861	1.320	0.753	1.250	0.617	1.180	0.469	1.140	0.380	1.120	0.334	1.340	0.790	1.180	0.469	1.210	0.534	6.704	0.559
25	1.160	0.425	1.120	0.334	1.280	0.677	1.300	0.715	1.300	0.715	1.240	0.596	1.180	0.469	1.140	0.380	1.130	0.357	1.350	0.808	1.180	0.469	1.180	0.469	0.416	0.535
26	1.160	0.425	1.120	0.334	1.260	0.637	1.290	0.696	1.300	0.715	1.240	0.596	1.180	0.469	1.140	0.380	1.120	0.334	1.380	0.861	1.200	0.513	1.180	0.469	6.430	0.536
27	1.140	0.380	1.120	0.334	1.250	0.617	1.300	0.715	1.310	0.734	1.240	0.596	1.180	0.469	1.140	0.380	1.120	0.334	1.340	0.790	1.180	0.469	1.240	0.596	6.416	0.535
28	1.140	0.380	1.200	0.513	1.240	0.596	1.320	0.753	1.300	0.715	1.230	0.576	1.180	0.469	1.140	0.380	1.120	0.334	1.310	0.734	1.180	0.469	1.170	0.447	6.367	0.531
29	1.140	0.380			1.240	0.596	1.300	0.715	1.630	1.224	1.230	0.576	1.180	0.469	1.140	0.380	1.120	0.334	1.290	0.696	1.180	0.790	1.180	0.469	6.630	0.603
30	1.140	0.380			1.240	0.596	1.310	0.734	1.330	0.772	1.230	0.576	1.170	0.447	1.140	0.380	1.120	0.334	1.280	0.677	1.340	0.790	1.160	0.425	6.111	0.556
31	1.140	0.380			1.230	0.576			1.370	0.844			1.170	0.447	1.140	0.380			1.270	0.657			1.160	0.425	3.709	0.530
Total		15.826		10.267		18.303		15.886		23.914		20.743		15.514		12.904		10.733		16.785		16.861		14.581	192.426	
Average		0.511		0.367		0.593		0.691		0.771		0.691		0.500		0.416		0.358		0.579		0.562		0.470		0.541
No. of Days/M		31		28		31		23		31		30		31		31		30		29		30		31		356

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= -3.687+4.858*H-1.132*H^2

Daily Discharge Calculation in m^3/ Sec
River: Du Ouro   Year: 1992
Gauging Station: Boa Esperanc Catchment Area : 13.8 Sq.Km

	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
Day	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	Q	Q
1	1.160	0.425	1.170	0.447	1.110	0.311	1.540	1.110	1.220	0.555	1.190	0.491													3.339	0.556
2	1.220	0.555	1.160	0.425	1.210	0.534	1.270	0.657	1.200	0.513	1.190	0.491													3.174	0.529
3	1.180	0.469	1.160	0.425	1.120	0.334	1.600	1.188	1.210	0.534	1.190	0.491													3.441	0.573
4	1.170	0.447	1.160	0.425	1.110	0.311	1.320	0.753	1.200	0.513	1.190	0.491													2.940	0.490
5	1.170	0.447	1.160	0.425	1.110	0.311	1.780	1.374	1.200	0.513	1.190	0.491													3.560	0.593
6	1.160	0.425	1.160	0.425	1.110	0.311	1.340	0.790	1.200	0.513	1.190	0.491													2.954	0.492
7	1.160	0.425	1.150	0.403	1.110	0.311	1.320	0.753	1.190	0.491	1.190	0.491													2.873	0.479
8	1.160	0.425	1.150	0.403	1.110	0.311	1.290	0.696	1.230	0.576	1.190	0.491													2.901	0.484
9	1.150	0.403	1.150	0.403	1.110	0.311	1.280	0.677	1.200	0.513	1.190	0.491													2.796	0.466
10	1.150	0.403	1.140	0.380	1.100	0.287	1.270	0.657	1.190	0.491	1.190	0.491													2.709	0.451
11	1.150	0.403	1.140	0.380	1.310	0.734	1.310	0.734	1.190	0.491	1.180	0.469													3.212	0.535
12	1.170	0.447	1.140	0.380	1.190	0.491	1.430	0.945	1.180	0.469	1.180	0.469													3.202	0.534
13	1.160	0.425	1.140	0.380	1.240	0.506	1.300	0.715	1.210	0.534	1.180	0.460													3.120	0.520
14	1.150	0.403	1.140	0.380	1.200	0.513	1.260	0.637	1.180	0.469	1.180	0.469													2.871	0.478
15	1.160	0.425	1.160	0.425	1.200	0.513	1.260	0.637	1.240	0.596	1.180	0.469													3.065	0.511
16	1.150	0.403	1.130	0.357	1.300	0.715	1.240	0.596	1.240	0.596	1.170	0.447													3.115	0.519
17	1.180	0.469	1.120	0.334	1.240	0.596	1.240	0.596	1.230	0.576	1.170	0.447													3.019	0.503
18	1.160	0.425	1.120	0.334	1.210	0.534	1.240	0.596	1.230	0.576	1.170	0.447													2.912	0.485
19	1.160	0.425	1.180	0.460	1.340	0.790	1.240	0.596	1.230	0.576	1.170	0.447													3.304	0.551
20	1.160	0.425	1.130	0.357	1.300	0.715	1.240	0.596	1.220	0.555	1.160	0.425													3.074	0.512
21	1.210	0.534	1.130	0.357	1.250	0.617	1.220	0.555	1.220	0.555	1.160	0.425													3.043	0.507
22	1.180	0.469	1.120	0.334	2.470	1.406	1.220	0.555	1.220	0.555	1.160	0.425													3.744	0.624
23	1.180	0.469	1.120	0.334	1.370	0.844	1.210	0.534	1.220	0.555	1.160	0.425													3.161	0.527
24	1.400	0.895	1.120	0.334	1.370	0.844	1.210	0.534	1.210	0.534	1.160	0.425													3.566	0.594
25	1.190	0.491	1.110	0.311	1.340	0.790	1.210	0.534	1.210	0.534	1.160	0.425													3.084	0.514
26	1.180	0.469	1.110	0.311	1.320	0.753	1.210	0.534	1.260	0.637	1.160	0.425													3.129	0.521
27	1.170	0.447	1.190	0.491	1.290	0.696	1.200	0.513	1.230	0.576	1.169	0.425													3.148	0.525
28	1.190	0.491	1.120	0.334	1.280	0.677	1.200	0.513	1.220	0.555	1.160	0.425													2.994	0.499
29	1.160	0.425	1.110	0.311	1.250	0.617	1.190	0.491	1.210	0.534	1.160	0.425													2.802	0.467
30	1.160	0.425			1.240	0.506	1.250	0.617	1.200	0.513	1.160	0.425													2.576	0.515
31	1.180	0.469			1.230	0.576			1.200	0.513															1.558	0.519
Total		14.260		11.073		17.942		20.682		16.706		13.721		0.000		0.000		0.000		0.000		0.000		0.000	94.383	
Average		0.460		0.382		0.579		0.689		0.539		0.457		0.000		0.000		0.000		0.000		0.000		0.000		0.519
No. of Days/M		31		29		31		30		31		30		0		0		0		0		0		0		182

Table 7-4 Daily Discharge Calculation at Central A. Neto Gauging Station on Do Ouro River

(Period: 1988-1992)

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= 0.007-4.908*H+4.302*H^2

Daily Discharge Calculation in m^3/ Sec
River: Du Ouro
Gauging Station: C. H. (Central A. Neto)
Year: 1988
Catchment Area : 48.0 Sq. Km

	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
Day	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	Q	Q
1																			1.220	0.349	1.300	0.819	1.320	0.945	2.113	0.704
2																			1.220	0.349	1.360	1.207	1.290	0.757	2.314	0.771
3																			1.220	0.349	1.360	1.207	1.290	0.757	2.314	0.771
4																			1.220	0.349	1.340	1.075	1.360	1.207	2.631	0.877
5																			1.230	0.405	1.300	0.819	1.330	1.009	2.233	0.744
6																			1.230	0.405	1.320	0.945	1.310	0.882	2.231	0.744
7																			1.240	0.461	1.370	1.275	1.350	1.141	2.877	0.959
8																			1.280	0.696	1.400	1.484	1.340	1.075	3.255	1.085
9																			1.290	0.757	1.340	1.075	1.320	0.945	2.777	0.926
10																			1.330	1.009	1.280	0.696	1.310	0.882	2.587	0.862
11																			1.280	0.696	1.300	0.819	1.300	0.819	2.334	0.778
12																			1.280	0.696	1.330	1.009	1.290	0.757	2.463	0.821
13																			1.240	0.461	1.390	1.413	1.360	1.207	3.082	1.027
14																			1.220	0.349	1.440	1.774	1.300	0.819	2.942	0.981
15																			1.220	0.349	1.470	2.000	1.300	0.819	3.168	1.056
16																			1.220	0.349	1.520	2.395	1.290	0.757	3.501	1.167
17																			1.300	0.819	1.420	1.627	1.270	0.636	3.082	1.027
18																			1.390	1.413	1.360	1.207	1.260	0.577	3.198	1.066
19																			1.310	0.882	1.330	1.009	1.260	0.577	2.468	0.823
20																			1.300	0.819	1.320	0.945	1.260	0.577	2.341	0.780
21																			1.290	0.757	1.350	1.141	1.260	0.577	2.475	0.825
22																			1.290	0.757	1.420	1.627	1.300	0.819	3.203	1.068
23																			1.330	1.009	1.360	1.207	1.340	1.075	3.291	1.097
24																			1.400	1.484	1.380	1.344	1.340	1.075	3.902	1.301
25																			1.330	1.009	1.380	1.344	1.330	1.009	3.363	1.121
26																			1.320	0.945	1.370	1.275	1.310	0.882	3.102	1.034
27																			1.310	0.882	1.370	1.275	1.310	0.882	3.038	1.013
28																			1.310	0.882	1.370	1.275	1.310	0.882	3.038	1.013
29																			1.330	1.009	1.360	1.207	1.320	0.945	3.162	1.054
30																			1.320	0.945	1.330	1.009	1.280	0.696	2.651	0.884
31																			1.310	0.882			1.220	0.349	1.231	0.615
Total		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		22.526		37.508		26.336	86.370	
Average(A)		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.727		1.250		0.850		0.939
No. of Days/M		0		0		0		0		0		0		0		0		0		31		30		31		92

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= 0.007-4.968*H+4.302*H^2

Daily Discharge Calculation in m^3/ Sec
River: Du Ouro
Gauging Station: C. H. (Central A. Neto)

Year: 1989
Catchment Area : 48.0 Sq. Km

	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
Day	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	Q	Q
1	1.200	0.240	1.200	0.240			1.210	0.294	1.280	0.696	1.360	1.207	1.220	0.349	1.240	0.461	1.240	0.461	1.230	0.405	1.410	1.555	1.320	0.945	6.856	0.623
2	1.190	0.187					1.200	0.240	1.280	0.696	1.320	0.945	1.230	0.405	1.240	0.461	1.230	0.405	1.240	0.461	1.410	1.555	1.320	0.945	6.301	0.630
3	1.260	0.577					1.220	0.349	1.280	0.696	1.340	1.075	1.220	0.349	1.240	0.461	1.240	0.461	1.240	0.461	1.420	1.627	1.320	0.945	7.003	0.700
4	1.280	0.696					1.190	0.187	1.280	0.696	1.320	0.945	1.220	0.349	1.240	0.461	1.220	0.349	1.240	0.461	1.400	1.484	1.330	1.009	6.639	0.664
5	1.260	0.577					1.200	0.240	1.420	1.627	1.320	0.945	1.220	0.349	1.240	0.461	1.230	0.405	1.240	0.461	1.390	1.413	1.320	0.945	7.425	0.742
6	1.210	0.294					1.200	0.240	1.360	1.207	1.320	0.945	1.230	0.405	1.240	0.461	1.230	0.405	1.240	0.461	1.380	1.344	1.330	1.009	6.773	0.677
7	1.200	0.240					1.210	0.294	1.340	1.075	1.310	0.882	1.230	0.405	1.240	0.461	1.230	0.405	1.240	0.461	1.420	1.627	1.380	1.344	7.194	0.719
8	1.200	0.240					1.200	0.240	1.320	0.945	1.300	0.819	1.230	0.405	1.240	0.461	1.220	0.349	1.240	0.461	1.520	2.395	1.360	1.207	7.524	0.752
9	1.200	0.240			1.270	0.636	1.210	0.294	1.310	0.882	1.250	0.519	1.220	0.349	1.230	0.405	1.220	0.349	1.250	0.519	1.430	1.700	1.370	1.275	7.169	0.652
10	1.220	0.349			1.220	0.349	1.220	0.349	1.300	0.819	1.240	0.461	1.220	0.349	1.210	0.294	1.210	0.294	1.260	0.577	1.400	1.484	1.350	1.141	6.467	0.588
11	1.200	0.240			1.220	0.349	1.220	0.349	1.330	1.009	1.240	0.461	1.220	0.349	1.220	0.349	1.230	0.405	1.260	0.577	1.390	1.413	1.340	1.075	6.578	0.598
12	1.210	0.294			1.220	0.349	1.210	0.294	1.320	0.945	1.240	0.461	1.210	0.294	1.260	0.577	1.220	0.349	1.240	0.461	1.380	1.344	1.540	2.550	7.929	0.721
13	1.200	0.240			1.220	0.349	1.200	0.240	1.310	0.882	1.230	0.405	1.220	0.349	1.240	0.461	1.230	0.405	1.410	1.555	1.370	1.275	1.360	1.207	7.369	0.670
14	1.200	0.240			1.220	0.349	1.200	0.240	1.280	0.696	1.230	0.405	1.210	0.294	1.240	0.461	1.230	0.405	1.510	2.314	1.430	1.700	1.340	1.075	8.180	0.744
15	1.190	0.187			1.270	0.636	1.220	0.349	1.260	0.577	1.240	0.461	1.210	0.294	1.240	0.461	1.230	0.405	1.460	1.924	1.420	1.627	1.340	1.075	7.997	0.727
16	1.200	0.240			1.270	0.636	1.180	0.135	1.320	0.945	1.230	0.405	1.220	0.349	1.240	0.461	1.220	0.349	1.460	1.924	1.370	1.275	1.340	1.075	7.795	0.709
17	1.190	0.187			1.260	0.577	1.190	0.187	1.300	0.819	1.220	0.349	1.220	0.349	1.230	0.405	1.230	0.405	1.410	1.555	1.350	1.141	1.330	1.009	6.983	0.635
18	1.190	0.187			1.260	0.577	1.200	0.240	1.340	1.075	1.220	0.349	1.220	0.349	1.230	0.405	1.230	0.405	1.400	1.484	1.350	1.141	1.320	0.945	7.156	0.651
19	1.240	0.461			1.190	0.187	1.280	0.696	1.330	1.009	1.220	0.349	1.220	0.349	1.220	0.349	1.240	0.461	1.390	1.413	1.350	1.141	1.340	1.075	7.492	0.681
20	1.180	0.135			1.200	0.240	1.260	0.577	1.320	0.945	1.220	0.349	1.220	0.349	1.220	0.349	1.240	0.461	1.420	1.627	1.360	1.207	1.260	0.577	6.818	0.620
21	1.160	0.033			1.200	0.240	1.280	0.696	1.300	0.819	1.220	0.349	1.220	0.349	1.220	0.349	1.240	0.461	1.410	1.555	1.350	1.141			5.993	0.599
22	1.160	0.033			1.200	0.240	1.200	0.240	1.400	1.484	1.260	0.577	1.220	0.349	1.220	0.349	1.230	0.405	1.520	2.395	1.340	1.075			7.147	0.715
23	1.180	0.135			1.200	0.240	1.190	0.187	1.360	1.207	1.250	0.519	1.220	0.349	1.220	0.349	1.230	0.405	1.460	1.924	1.330	1.009			6.325	0.633
24	1.250	0.519			1.190	0.187	1.160	0.033	1.340	1.075	1.260	0.577	1.220	0.349	1.220	0.349	1.230	0.405	1.460	1.924	1.370	1.275			6.693	0.669
25	1.260	0.577			1.200	0.240	1.160	0.033	1.330	1.009	1.240	0.461	1.220	0.349	1.220	0.349	1.240	0.405	1.410	1.555	1.320	0.945			5.924	0.592
26	1.200	0.240			1.190	0.187	1.270	0.636	1.320	0.945	1.250	0.519	1.220	0.349	1.220	0.349	1.230	0.461	1.680	3.803	1.320	0.945			8.435	0.844
27	1.200	0.240			1.200	0.240	1.260	0.577	1.360	1.207	1.250	0.519	1.230	0.405	1.210	0.294	1.240	0.405	1.450	1.848	1.310	0.882			6.618	0.662
28	1.220	0.349			1.200	0.240	1.280	0.696	1.350	1.141	1.240	0.461	1.230	0.405	1.220	0.349	1.240	0.461	1.420	1.627	1.300	0.819			6.549	0.655
29	1.260	0.577			1.200	0.240	1.300	0.819	1.350	1.141	1.230	0.405	1.220	0.349	1.220	0.349	1.230	0.461	1.420	1.627	1.310	0.882			6.850	0.685
30	1.220	0.349			1.200	0.240	1.240	0.461	1.420	1.627	1.230	0.405	1.220	0.349	1.230	0.405	1.230	0.576	1.390	1.413	1.280	0.696			6.522	0.652
31	1.200	0.240			1.200	0.240			1.370	0.844			1.240	0.461	1.230	0.405			1.420	1.627					3.818	0.636
Total		9.348		0.240		7.773		10.418		30.741		17.531		11.105		12.568		12.380		40.864		39.116		22.437	214.522	
Average		0.302		0.240		0.338		0.347		0.902		0.584		0.358		0.405		0.413		1.318		1.304		1.122		0.672
No. of Days/M		31		1		23		30		31		30		31		31		30		31		30		20		319

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= -2.712+2.504*H-0.014*H^2

Daily Discharge Calculation in m^3/ Sec
River: Du Ouro
Gauging Station: C. H. (Central A. Neto)
Year: 1990
Catchment Area : 48.0 Sq.Km

Day	January H	January Q	February H	February Q	March H	March Q	April H	April Q	May H	May Q	June H	June Q	July H	July Q	August H	August Q	September H	September Q	October H	October Q	November H	November Q	December H	December Q	Total Q	Average Q
1			1.280	0.470	1.270	0.445	1.280	0.470	1.300	0.520	1.370	0.692	1.260	0.421	1.300	0.520			1.280	0.470	1.400	0.766	1.350	0.643	5.417	0.542
2			1.260	0.421	1.260	0.421	1.270	0.445	1.310	0.544	1.330	0.594	1.260	0.421	1.290	0.495			1.280	0.470	1.340	0.618	1.340	0.618	5.047	0.505
3			1.230	0.347	1.290	0.495	1.260	0.421	1.300	0.520	1.330	0.594	1.260	0.421	1.290	0.495			1.290	0.495	1.320	0.569	1.340	0.618	4.973	0.497
4			1.250	0.396	1.260	0.421	1.270	0.445	1.290	0.495	1.360	0.668	1.260	0.421	1.300	0.520			1.290	0.495	1.300	0.520	1.340	0.618	4.998	0.500
5			1.230	0.347	1.260	0.421	1.260	0.421	1.260	0.421	1.350	0.643	1.260	0.421	1.290	0.495			1.290	0.495	1.280	0.470	1.340	0.618	4.751	0.475
6			1.220	0.322	1.270	0.445	1.260	0.421	1.250	0.396	1.350	0.643	1.260	0.421	1.290	0.495			1.290	0.495	1.290	0.495	1.340	0.618	4.751	0.475
7			1.210	0.297	1.270	0.445	1.250	0.396	1.310	0.544	1.340	0.618	1.270	0.445	1.290	0.495			1.290	0.495	1.280	0.470	1.340	0.618	4.825	0.483
8			1.240	0.371	1.270	0.445	1.260	0.421	1.310	0.544	1.330	0.594	1.270	0.445	1.300	0.520			1.290	0.495	1.270	0.445	1.260	0.421	4.702	0.470
9			1.260	0.421	1.380	0.717	1.250	0.396	1.300	0.520	1.330	0.594	1.270	0.445	1.290	0.495			1.290	0.495	1.280	0.470	1.260	0.421	4.973	0.497
10			1.260	0.421	1.380	0.717	1.250	0.396	1.310	0.544	1.320	0.569	1.270	0.445	1.290	0.495			1.220	0.322	1.320	0.569	1.280	0.470	4.948	0.495
11			1.260	0.421	1.380	0.717	1.250	0.396	1.320	0.569	1.320	0.569	1.270	0.445	1.300	0.520			1.220	0.322	1.420	0.815	1.340	0.618	5.302	0.530
12			1.270	0.445	1.380	0.717	1.250	0.396	1.350	0.643	1.320	0.569	1.270	0.445	1.280	0.470			1.300	0.520	1.340	0.618	1.270	0.445	5.209	0.527
13			1.280	0.470	1.280	0.470	1.250	0.396	1.320	0.569	1.310	0.544	1.280	0.470	1.300	0.520			1.310	0.544	1.340	0.618	1.280	0.470	5.072	0.507
14			1.260	0.421	1.290	0.495	1.250	0.396	1.320	0.569	1.320	0.569	1.280	0.470	1.300	0.520			1.270	0.445	1.360	0.668	1.280	0.470	5.023	0.502
15			1.270	0.445	1.280	0.470	1.250	0.396	1.400	0.766	1.310	0.544	1.280	0.470	1.290	0.495			1.290	0.495	1.340	0.618	1.300	0.520	5.220	0.522
16			1.280	0.470	1.270	0.445	1.260	0.421	1.370	0.692	1.310	0.544	1.280	0.470	1.290	0.495			1.290	0.495	1.320	0.569	1.340	0.618	5.220	0.522
17			1.270	0.445	1.270	0.445	1.260	0.421	1.340	0.618	1.280	0.470	1.280	0.470	1.270	0.445			1.300	0.520	1.340	0.618	1.340	0.618	5.072	0.507
18			1.260	0.421	1.260	0.421	1.310	0.544	1.340	0.618	1.300	0.520	1.290	0.495	1.260	0.421			1.260	0.421	1.320	0.569	1.340	0.618	5.047	0.505
19			1.280	0.470	1.400	0.766	1.320	0.569	1.320	0.569	1.300	0.520	1.290	0.495	1.260	0.421			1.260	0.421	1.360	0.668	1.330	0.594	5.491	0.549
20			1.280	0.470	1.300	0.520	1.330	0.594	1.310	0.544	1.300	0.520	1.290	0.495	1.270	0.445			1.270	0.445	1.340	0.618	1.340	0.618	5.269	0.527
21			1.280	0.470	1.370	0.692	1.320	0.569	1.350	0.643	1.290	0.495	1.290	0.495	1.270	0.445			1.290	0.495	1.330	0.594	1.320	0.569	5.467	0.547
22			1.270	0.445	1.330	0.594	1.310	0.544	1.380	0.717	1.290	0.495	1.290	0.495	1.270	0.445			1.300	0.520	1.450	0.889	1.320	0.569	5.713	0.571
23			1.270	0.445	1.310	0.544	1.290	0.495	1.340	0.618	1.290	0.495	1.290	0.495	1.270	0.445			1.230	0.347	1.580	1.209	1.320	0.569	5.663	0.566
24			1.270	0.445	1.310	0.544	1.310	0.544	1.360	0.668	1.260	0.421	1.290	0.495	1.260	0.421			1.250	0.396	1.360	0.668	1.300	0.520	5.121	0.512
25			1.270	0.445	1.290	0.495	1.300	0.520	1.340	0.618	1.290	0.495	1.300	0.520	1.270	0.445			1.260	0.421	1.360	0.668	1.280	0.470	5.097	0.510
26			1.300	0.520	1.290	0.495	1.290	0.495	1.410	0.791	1.300	0.520	1.300	0.520	1.260	0.421			1.320	0.569	1.370	0.692	1.320	0.569	5.590	0.559
27			1.300	0.520	1.230	0.347	1.290	0.495	1.480	0.963	1.290	0.495	1.300	0.520	1.250	0.396	1.270	0.445	1.330	0.594	1.300	0.520	1.380	0.717	6.010	0.546
28			1.280	0.470	1.300	0.520	1.270	0.445	1.420	0.815	1.270	0.445	1.300	0.520	1.280	0.470	1.270	0.445	1.340	0.618	1.340	0.618	1.380	0.717	6.085	0.553
29					1.280	0.470	1.270	0.445	1.430	0.840	1.260	0.421	1.300	0.520			1.330	0.594	1.330	0.594	1.360	0.668	1.400	0.766	5.317	0.591
30					1.240	0.371	1.280	0.470	1.400	0.766	1.260	0.421	1.300	0.520			1.280	0.470	1.330	0.594	1.350	0.643	1.340	0.618	4.873	0.541
31					1.270	0.445			1.380	0.717			1.300	0.520					2.220	2.778			1.320	0.569	5.029	1.006
Total		0.000		12.054		15.057		13.784		19.361		16.277		14.650		13.264		1.955		17.278		18.940		17.906	161.425	
Average		0.000		0.431		0.515		0.459		0.625		0.543		0.473		0.474		0.489		0.557		0.631		0.578		0.529
No. of Days/M		0		28		31		30		31		30		31		28		4		31		30		31		305

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= -3.294+3.426*H-0.394*H^2

Daily Discharge Calculation in m^3/ Sec
River: Du Ouro
Gauging Station: C. H. (Central A. Neto)

Year: 1991
Catchment Area : 48.0 Sq. Km

	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
Day	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	Q	Q
1	1.320	0.542	1.280	0.446	1.310	0.518	1.480	0.913	1.340	0.589					1.280	0.446			1.270	0.422	1.290	0.470	1.240	0.348	4.694	0.522
2	1.200	0.470	1.280	0.446	1.310	0.518	1.480	0.913	1.400	0.730					1.280	0.446			1.280	0.446	1.290	0.470	1.230	0.324	4.762	0.529
3	1.340	0.589	1.290	0.470	1.320	0.542	1.490	0.936	1.360	0.637					1.270	0.422			1.270	0.422	1.280	0.446	1.240	0.348	4.811	0.535
4	1.320	0.542	1.230	0.324	1.280	0.446	1.460	0.868	1.350	0.613					1.270	0.422			1.270	0.422	1.270	0.422	1.240	0.348	4.406	0.490
5	1.300	0.494	1.240	0.348	1.280	0.446	1.500	0.958	1.360	0.637					1.270	0.422			1.270	0.422	1.270	0.422			4.148	0.518
6	1.300	0.494	1.250	0.373	1.280	0.446	1.460	0.868	1.340	0.589					1.270	0.422			1.270	0.422	1.280	0.446			4.050	0.507
7	1.300	0.494	1.240	0.348	1.260	0.397	1.480	0.913	1.360	0.637					1.270	0.422			1.270	0.422	1.270	0.422			4.054	0.507
8	1.300	0.494	1.240	0.348	1.360	0.637	1.480	0.913	1.360	0.637					1.280	0.446			1.280	0.446	1.270	0.422			4.342	0.543
9	1.300	0.494	1.240	0.348	1.280	0.446			1.330	0.566					1.270	0.422			1.260	0.397	1.260	0.397			3.070	0.439
10	1.310	0.518	1.240	0.348	1.290	0.470			1.340	0.589			1.260	0.397	1.260	0.397			1.270	0.422	1.320	0.542			3.683	0.460
11	1.320	0.542	1.250	0.373	1.280	0.446			1.360	0.637			1.280	0.446	1.260	0.397			1.270	0.422	1.300	0.494			3.756	0.469
12	1.300	0.494	1.250	0.373	1.470	0.891	1.400	0.730	1.310	0.518	1.360	0.637	1.280	0.446	1.260	0.397			1.370	0.660	1.280	0.446			5.591	0.559
13	1.260	0.397	1.250	0.373	1.330	0.566	1.400	0.730	1.380	0.684	1.350	0.613	1.280	0.446	1.280	0.446			1.310	0.518			1.280	0.446	5.218	0.522
14	1.240	0.348	1.250	0.373	1.270	0.422	1.380	0.684	1.370	0.660	1.320	0.542	1.290	0.470	1.250	0.373			1.300	0.494			1.280	0.446	4.811	0.481
15	1.220	0.299	1.240	0.348	1.360	0.637	1.390	0.707	1.410	0.753	1.310	0.518	1.280	0.446					1.520	1.003			1.280	0.446	5.157	0.573
16	1.220	0.299	1.240	0.348	1.260	0.397	1.370	0.660	1.380	0.684	1.300	0.494	1.280	0.446					1.390	0.707			1.280	0.446	4.481	0.498
17	1.220	0.290	1.240	0.348	1.260	0.397	1.340	0.589	1.440	0.822	1.300	0.494	1.290	0.470					1.350	0.613			1.300	0.494	4.528	0.503
18	1.260	0.397	1.240	0.348	1.430	0.799	1.350	0.613	1.360	0.637	1.300	0.494	1.290	0.470			1.200	0.250	1.340	0.589			1.280	0.446	5.044	0.504
19	1.300	0.494	1.230	0.324	1.390	0.707	1.310	0.518	1.420	0.776	1.300	0.494	1.280	0.446			1.260	0.397	1.320	0.542			1.280	0.446	5.144	0.514
20	1.200	0.470	1.250	0.373	1.330	0.566	1.470	0.891			1.300	0.494	1.280	0.446			1.260	0.397	1.320	0.542			1.280	0.446	4.624	0.514
21	1.370	0.660	1.260	0.397	1.330	0.566	1.360	0.637					1.200	0.470			1.270	0.422	1.440	0.822			1.300	0.494	4.467	0.558
22	1.120	0.049	1.260	0.397	1.400	0.730	1.350	0.613					1.280	0.446			1.260	0.397	1.360	0.637			1.280	0.446	3.715	0.464
23	1.100	-0.002	1.250	0.373	1.620	1.222	1.350	0.613					1.280	0.446			1.260	0.397	1.370	0.660			1.280	0.445	4.155	0.519
24	1.190	0.225	1.250	0.373	1.300	0.494	1.350	0.613					1.280	0.446			1.270	0.422	1.330	0.566			1.320	0.542	3.680	0.460
25	1.140	0.100	1.210	0.275	1.300	0.494	1.340	0.589					1.280	0.446			1.260	0.397	1.340	0.589			1.280	0.446	3.336	0.417
26	1.200	0.250	1.220	0.299	1.340	0.589	1.340	0.589					1.280	0.446			1.270	0.422	1.360	0.637			1.280	0.446	3.678	0.460
27	1.140	0.100	1.240	0.348	1.340	0.589	1.340	0.589					1.280	0.446			1.250	0.373	1.330	0.566			1.280	0.446	3.457	0.432
28	1.190	0.225	1.360	0.637	1.380	0.684	1.350	0.613					1.280	0.446			1.260	0.397	1.320	0.542			1.280	0.446	3.980	0.499
29	1.200	0.250			1.460	0.868	1.370	0.660					1.280	0.446			1.250	0.373	1.300	0.494			1.280	0.446	3.536	0.505
30	1.140	0.100			1.480	0.913	1.360	0.637					1.280	0.446			1.260	0.397	1.300	0.494			1.280	0.446	3.432	0.490
31	1.180	0.200			1.480	0.913							1.280	0.446					1.280	0.446			1.280	0.446	2.451	0.490
Total		11.326		10.481		18.754		19.500		12.394		4.779		9.855		5.877		5.041		16.781		5.306		10.031	130.276	
Average		0.365		0.374		0.605		0.724		0.652		0.531		0.469		0.420		0.388		0.541		0.450		0.436		0.503
No. of Days/X		31		28		31		27		19		9		21		14		13		31		12		23		259

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= -3.294+3.426*H-0.394*H^2

Daily Discharge Calculation in m^3/ Sec
River: Du Ouro
Gauging Station: C. H.(Central A. Neto)

Year: 1992
Catchment Area : 48.0 Sq.Km

	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
Day	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	Q	Q
1	1.260	0.397	1.240	0.348	1.250	0.373			1.380	0.684	1.260	0.397													2.812	0.562
2	1.280	0.446	1.240	0.348	1.340	0.589			1.340	0.589	1.270	0.422													3.007	0.601
3	1.280	0.446	1.240	0.348	1.200	0.250			1.330	0.566	1.290	0.470													2.621	0.524
4	1.280	0.446	1.290	0.470	1.250	0.373			1.360	0.637	1.290	0.470													2.937	0.587
5	1.280	0.446	1.290	0.470	1.260	0.397			1.360	0.637	1.290	0.470													3.009	0.602
6	1.280	0.446	1.250	0.373	1.260	0.397			1.360	0.637	1.290	0.470													2.912	0.582
7	1.280	0.446	1.240	0.348	1.260	0.397			1.340	0.589	1.290	0.470													2.792	0.558
8	1.280	0.446	1.240	0.348	1.260	0.397			1.360	0.637	1.290	0.470													2.887	0.577
9	1.280	0.446	1.230	0.324	1.270	0.422			1.300	0.494	1.250	0.373													2.695	0.539
10	1.260	0.397	1.250	0.373	1.270	0.422			1.290	0.470	1.250	0.373													2.600	0.520
11	1.270	0.422	1.250	0.373	1.390	0.707			1.340	0.589	1.250	0.373													3.053	0.611
12	1.240	0.348	1.250	0.373	1.310	0.518			1.330	0.566	1.290	0.470													2.911	0.728
13			1.260	0.397	1.350	0.613			1.340	0.589	1.280	0.446													2.682	0.671
14			1.250	0.373	1.260	0.397			1.330	0.566	1.280	0.446													2.395	0.599
15			1.260	0.397	1.250	0.373			1.330	0.566	1.280	0.446													2.488	0.622
16			1.240	0.348	1.380	0.684	1.350	0.613	1.320	0.542	1.280	0.446													2.020	0.404
17	1.280	0.446	1.250	0.373	1.320	0.542	1.350	0.613	1.270	0.422	1.280	0.446													2.228	0.371
18	1.280	0.446	1.260	0.397	1.300	0.494	1.320	0.542	1.270	0.422	1.250	0.373													11.136	1.856
19	1.250	0.373	1.260	0.397	1.320	0.542	1.320	0.542	1.320	0.542	1.250	0.373													2.827	0.471
20	1.250	0.373	1.270	0.422	1.370	0.660	1.340	0.589	1.300	0.494	1.250	0.373													17.321	2.887
21	1.260	0.397	1.260	0.397	1.330	0.566	1.340	0.589	1.300	0.494	1.270	0.422													2.276	0.379
22	1.260	0.397	1.260	0.397	2.040	2.055	1.320	0.542	1.260	0.397	1.270	0.422													3.669	0.611
23	1.270	0.422	1.250	0.373			1.340	0.589	1.250	0.373	1.270	0.422													1.589	0.318
24	1.440	0.822	1.260	0.397			1.360	0.637	1.250	0.373	1.270	0.422													2.014	0.403
25	1.280	0.446	1.260	0.397			1.330	0.566	1.320	0.542	1.250	0.373													1.758	0.352
26	1.260	0.397	1.260	0.397			1.340	0.589	1.320	0.542	1.240	0.348													1.685	0.337
27	1.300	0.494	1.260	0.397			1.360	0.637	1.270	0.422	1.240	0.348													1.661	0.332
28	1.300	0.494	1.260	0.397			1.360	0.637	1.250	0.373	1.240	0.348													1.612	0.322
29	1.290	0.470	1.260	0.397			1.350	0.613	1.250	0.373	1.240	0.348													1.588	0.318
30	1.300	0.494					1.390	0.707	1.250	0.373	1.240	0.348													1.215	0.304
31	1.290	0.470							1.250	0.373															0.843	0.421
Total		12.071		11.153		12.167		9.004		15.868		12.375		0.000		0.000		0.000		0.000		0.000		0.000	97.243	
Average		0.447		0.385		0.553		0.600		0.512		0.413		0.000		0.000		0.000		0.000		0.000		0.000		0.631
No. of Days/M		27		20		22		15		31		30		0		0		0		0		0		0		154

Table 7–5 Daily Discharge Calculation of Pian Pian (Ponte) Gauging Station on Manuel Jorge River

(Period: 1990–1991)

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= -0.725+0.860*H+0.015*H^2

Daily Discharge Calculation in m^3/ Sec
River:Manuel Gorge Year: 1990
Gauging Station: Pian- Pian " Ponte "

Day	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	Q	Q
1	1.120	0.257	1.220	0.347	1.260	0.382	1.330	0.445	1.870	0.890	1.800	0.872	1.750	0.826	1.630	0.717	1.590	0.680	1.440	0.545	1.860	0.926	1.860	0.926	7.813	0.651
2	1.100	0.239	1.220	0.347	1.260	0.382	1.300	0.418	1.820	0.890	1.790	0.862	1.750	0.826	1.630	0.717	1.590	0.680	1.430	0.535	1.800	0.872	1.860	0.926	7.695	0.641
3	1.080	0.221	1.220	0.347	1.250	0.373	1.300	0.418	1.800	0.872	1.830	0.899	1.740	0.817	1.620	0.708	1.570	0.662	1.510	0.608	1.880	0.945	1.870	0.936	7.805	0.650
4	1.080	0.221	1.390	0.499	1.270	0.391	1.280	0.400	1.810	0.881	2.080	1.129	1.730	0.808	1.630	0.717	1.570	0.662	1.490	0.590	1.910	0.972	1.890	0.954	8.224	0.685
5	1.080	0.221	1.380	0.490	1.260	0.382	1.320	0.436	1.800	0.872	1.880	0.945	1.720	0.799	1.620	0.708	1.570	0.662	1.490	0.590	1.910	0.972	1.950	1.009	8.086	0.674
6	1.070	0.212	1.240	0.364	1.240	0.364	1.320	0.436	1.790	0.862	1.810	0.881	1.740	0.817	1.620	0.708	1.560	0.653	1.490	0.590	1.920	0.981	1.860	0.926	7.736	0.650
7	1.060	0.203	1.180	0.311	1.240	0.364	1.330	0.445	1.780	0.853	1.800	0.872	1.720	0.799	1.620	0.708	1.560	0.653	1.490	0.590	1.920	0.981	1.740	0.817	7.596	0.633
8	1.040	0.186	1.180	0.311	1.270	0.391	1.280	0.400	1.780	0.853	1.800	0.872	1.720	0.799	1.630	0.717	1.550	0.644	1.470	0.572	1.920	0.981	1.760	0.835	7.560	0.630
9	1.350	0.463	1.200	0.329	1.240	0.364	1.270	0.391	2.540	1.556	1.800	0.872	1.710	0.789	1.630	0.717	1.550	0.644	1.480	0.581	1.930	0.991	1.760	0.835	8.532	0.711
10	1.460	0.563	1.320	0.436	1.230	0.355	1.280	0.400	1.770	0.844	1.800	0.872	1.710	0.789	1.670	0.753	1.550	0.644	1.460	0.563	1.920	0.981	1.720	0.799	8.000	0.667
11			1.320	0.436	1.260	0.382	1.300	0.418	1.730	0.808	1.790	0.862	1.710	0.789	1.650	0.735	1.550	0.644	1.480	0.581	1.880	0.945	1.720	0.799	7.400	0.673
12			1.260	0.382	1.500	0.599	1.840	0.908	1.560	0.653	1.830	0.899	1.710	0.789	1.650	0.735	1.550	0.644	1.630	0.717	1.820	0.890	1.750	0.826	8.042	0.731
13			1.460	0.563	1.470	0.572	1.810	0.881	1.560	0.653	1.840	0.908	1.710	0.789	1.650	0.735	1.540	0.635	1.630	0.717	1.840	0.908	1.760	0.835	8.195	0.745
14			1.290	0.409	1.170	0.302	1.810	0.881	1.740	0.817	1.830	0.899	1.700	0.780	1.670	0.753	1.540	0.635	1.640	0.726	1.820	0.890	1.770	0.844	7.936	0.721
15			1.280	0.400	1.160	0.293	1.800	0.872	1.870	0.936	1.830	0.899	1.710	0.789	1.690	0.771	1.530	0.626	1.630	0.717	1.780	0.853	1.770	0.844	8.000	0.727
16			1.290	0.409	1.160	0.293	1.800	0.872	1.960	1.018	1.840	0.908	1.710	0.789	1.690	0.771	1.530	0.626	1.630	0.717	1.770	0.844	1.780	0.853	8.101	0.736
17			1.330	0.445	1.160	0.293	1.760	0.835	2.000	1.055	1.840	0.908	1.710	0.789	1.690	0.771	1.550	0.644	1.630	0.717	1.740	0.817	1.760	0.835	8.137	0.740
18			1.260	0.382	1.160	0.293	1.700	0.780	2.000	1.055	1.850	0.917	1.710	0.789	1.690	0.771	1.530	0.626	1.640	0.726	1.750	0.826	1.780	0.853	8.010	0.728
19			1.290	0.409	2.020	1.073	1.760	0.835	2.000	1.055	1.840	0.908	1.700	0.780	1.690	0.771	1.510	0.608	1.620	0.708	1.740	0.817	1.780	0.853	8.827	0.802
20			1.330	0.445	1.980	1.037	1.810	0.881	2.010	1.064	1.850	0.917	1.710	0.789	1.690	0.771	1.510	0.608	1.620	0.708	1.710	0.789	1.770	0.844	8.881	0.807
21			1.300	0.418	1.450	0.554	1.800	0.872	1.970	1.027	1.840	0.908	1.660	0.744	1.660	0.744	1.500	0.599	1.630	0.717	1.760	0.835	1.770	0.844	8.216	0.747
22			1.340	0.454	1.420	0.526	1.780	0.853	1.960	1.018	1.830	0.899	1.670	0.753	1.650	0.735	1.490	0.590	1.620	0.708	1.760	0.835	1.770	0.844	8.216	0.747
23			1.300	0.418	1.400	0.508	1.760	0.835	1.760	0.835	1.830	0.899	1.660	0.744	1.650	0.735	1.510	0.608	1.610	0.698	1.780	0.853	1.760	0.835	7.951	0.723
24			1.330	0.445	1.400	0.508	1.760	0.835	1.770	0.844	1.830	0.899	1.660	0.744	1.650	0.735	1.490	0.590	1.610	0.698	1.700	0.780	1.620	0.708	7.860	0.715
25			1.290	0.409	1.390	0.499	1.980	1.037	1.740	0.817	1.830	0.899	1.660	0.744	1.640	0.726	1.490	0.590	1.630	0.717	1.740	0.817	1.580	0.671	7.889	0.717
26			1.280	0.400	1.390	0.499	1.790	0.862	1.730	0.808	1.810	0.881	1.650	0.735	1.630	0.717	1.480	0.581	2.140	1.184	1.800	0.872	1.600	0.689	8.173	0.743
27			1.240	0.364	1.380	0.490	1.740	0.817	1.800	0.872	1.790	0.862	1.640	0.726	1.630	0.717	1.470	0.572	2.100	1.147	1.740	0.817	1.610	0.698	8.137	0.740
28			1.260	0.382	0.820	-0.010	1.780	0.853	1.800	0.872	1.790	0.862	1.640	0.726	1.600	0.689	1.470	0.572	2.100	1.147	1.870	0.936	1.620	0.708	7.618	0.693
29					0.820	-0.010	1.790	0.862	1.800	0.872	1.730	0.808	1.640	0.726	1.600	0.689	1.470	0.572	2.110	1.156	1.830	0.899	1.640	0.726	7.337	0.734
30					0.820	-0.010	1.800	0.872	1.790	0.862	1.740	0.817	1.630	0.717	1.600	0.689	1.450	0.554	2.110	1.156	1.840	0.908	1.620	0.708	7.264	0.726
31	1.220	0.347							1.800	0.872			1.630	0.717	1.590	0.680			2.060	1.110			1.590	0.680	4.406	0.734
Total		3.134		11.356		12.445		21.053		28.185		26.835		24.018		22.608		18.706		23.231		26.735		25.462	243.705	
Average		0.285		0.406		0.415		0.702		0.909		0.895		0.775		0.729		0.624		0.749		0.891		0.821		0.708

Calculation of Daily Discharge (m^3/ Sec) by The Least Squares Method

Applied Formula: Q= 5.768-7.833*H+2.802*H^2

Daily Discharge Calculation in m^3/ Sec
River:Manuel Gorge   Year: 1991
Gauging Station: Pian- Pian " Ponte "

Day	January		February		March		April		May		June		July		August		September		October		November		December		Total	Average
	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	Q	Q
1	1.660	0.486	1.500	0.323	1.800	0.747	1.860	0.892	1.720	0.585															3.034	0.607
2	1.680	0.517	1.510	0.329	1.800	0.747	1.860	0.892	1.960	1.179															3.665	0.733
3	1.640	0.458	1.500	0.323	1.800	0.747	1.900	1.001	1.940	1.118															3.646	0.729
4	1.680	0.517	1.510	0.329	1.780	0.703	1.890	0.973	1.920	1.058															3.580	0.716
5	1.670	0.501	1.500	0.323	1.770	0.687	1.860	0.892	1.920	1.058															3.457	0.691
6	1.670	0.501	1.500	0.323	1.760	0.661	1.860	0.892																	2.378	0.595
7	1.660	0.486	1.500	0.323	1.750	0.641	1.850	0.867																	2.318	0.579
8	1.660	0.486	1.500	0.323	1.750	0.641	1.920	1.058																	2.509	0.627
9	1.500	0.323	1.500	0.323	1.740	0.622	1.840	0.842																	2.110	0.527
10	1.480	0.313	1.500	0.323	1.740	0.622	1.890	0.973																	2.230	0.558
11	1.460	0.305	1.490	0.318	1.730	0.603	1.880	0.945																	2.170	0.543
12	1.470	0.308	1.500	0.323	1.850	0.867	1.860	0.892																	2.391	0.598
13	1.480	0.313	1.500	0.323	1.870	0.793	1.770	0.682																	2.111	0.528
14	1.480	0.313	1.500	0.323	1.810	0.770	1.760	0.661																	2.067	0.517
15	1.460	0.305	1.510	0.329	1.920	1.058	1.790	0.725																	2.416	0.604
16	1.470	0.308	1.500	0.323	1.830	0.817	1.760	0.661																	2.110	0.527
17	1.470	0.308	1.460	0.305	1.840	0.842	1.760	0.661																	2.116	0.529
18	1.470	0.308	1.460	0.305	2.000	1.310	1.760	0.661																	2.584	0.646
19	1.470	0.308	1.450	0.301	1.920	1.058	1.760	0.661																	2.329	0.582
20	1.460	0.305	1.450	0.301	1.910	1.029	1.940	1.118																	2.752	0.688
21	1.860	0.892	1.460	0.305	1.900	1.001	1.860	0.892																	3.090	0.772
22	1.570	0.377	1.770	0.682	1.730	0.603	1.860	0.892																	2.554	0.639
23	1.510	0.329	1.770	0.682	2.140	1.837	1.850	0.867																	3.715	0.929
24	1.520	0.336	1.790	0.725	1.900	1.001	1.900	1.001																	3.061	0.765
25	1.500	0.323	1.790	0.725	1.870	0.919	1.720	0.585																	2.551	0.638
26	1.500	0.323	1.780	0.703	1.890	0.973	1.720	0.585																	2.583	0.646
27	1.500	0.323	1.740	0.622	1.860	0.892	1.670	0.501																	2.339	0.585
28	1.500	0.323	1.880	0.945	1.860	0.892	1.670	0.501																	2.662	0.666
29	1.500	0.323			1.860	0.892	1.660	0.486																	1.702	0.567
30	1.520	0.336			1.860	0.892	1.760	0.661																	1.889	0.630
31	1.520	0.519			1.860	0.892																			1.411	0.706
Total		12.073		11.781		20.756		23.923		4.998		0.000		0.000		0.000		0.000		0.000		0.000		0.000	79.531	
Average		0.389		0.421		0.863		0.797		1.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.641