in the fields and so in the off-season period of irrigation, the operation hour is determined so as to be about 8 hours. According to this criteria, the irrigation operation per day in normal year is estimated as follows:

Average irrigation operation hours

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
12.0	7.9	3.7	1.3	4.5	10.5	8.2	7.1	10.5	16.0	14.0	12.8	9.0

5.2.5 Field layout

The field canal system consists of distribution canals from which water is supplied to the fields, a tertiary canal and a night storage pond. Typical field canal layouts are shown in Fig. 5-1.

As afore-mentioned, from the view point of the basic intake rate, any irrigation method can be used in the Project area. Also the furrow length can be taken at least 150 m in the Sanya plain and 100 m is marginally possible in the Boloti and Mungushi areas. From this analysis, the interval of distribution canals is determined 150 m in the Sanya plain and 100 m in the Boloti and Mungushi areas.

The distribution canals are laid in parallel to the furrow direction or nearly parallel to the contour line in the Sanya plain and in the areas having moderate slope less than 2 to 3 % in the Boloti and Mungushi areas. In the steep area in the Boloti and Mungushi areas, the distribution canals should be laid so as to intersect diagonally or nearly perpendicular to the contour lines.

The length of the distribution canals is determined to be 600 m in maximum, because the seepage losses in small earth canals are large as discussed in Section 5.2.

A tertiary canal, from which water is supplied to distribution canals are provided for every three to five distribution canals.

As mentioned in the previous section, day-time operation of irrigation water supply will be applied in on-farm level, while the conveyance system consisting of main and secondary canals will convey water 24 hours or tubewells will be operated 24 hours at peak irrigation season. Therefore, a night storage pond will be provided in the Sanya project area. In case of the Boloti and Mungushi areas, the conveyance system is not so long as compared with that in the Sanya plain. Thus it is recommended that daytime operation is carried out by intake gates.

Water management of each tertiary block will be carried out by a water user's association organized by farmers and conveyance system consisting of main and secondary canals will be managed by the District staffs. Thus the night storage pond will be provided at the head of each tertiary block along main or secondary canals at the point where high embankment more than 1.5 m in height in main or secondary canals can be avoided.

5.2.6 Canal layout

Irrigation canal system in the Sanya plain consists of a headworks, main canals, secondary canals, tertiary canals, and distribution canals. Night storage ponds are provided between secondary canals and tertiary canals. Tubewells are provided along the main or secondary canals in the groundwater-promising area in the downstream half of the Sanya plain.

Water taken at the Sanya Chini headworks is conveyed through main canals and secondary canals and then supplied through turnouts on main or secondary canals to night storage ponds. From the night storage ponds, water is distributed through tertiary and then distribution canals to respective fields during daytime. When surface water resource is deficit against the irrigation water requirements, the tubewells are operated and water is supplemented through main or secondary canals.

Considering the above irrigation system into account as well as the field canal layouts, conveyance system consisting of main and secondary canals is laid out on the detailed map on a scale of 1 : 5,000 so that the canals run along elevated fields. The proposed irrigation system is shown in Fig. 5-2.

5.3 Drainage Requirements

Drainage canals are not so important as irrigation canals in Sanya plain, because the rainfall is as little as about 500 mm/year and the period required for drain is normally limited two or three months; March, April and May. Drainage canals are designed so as to remove excess water from five-year probable four-hour rainfall within four hours.

Rainfall data for 17 years from 1972 to 1988 were obtained from KIA meteorological Station and Lerongo station. Based on these rainfall data, the probable rainfall is estimated by Iwai method. The results of probable rainfall at both stations are as follows:

Return Period	Probable daily rainfall	
	KIA	Lerongo
(year)	(mm/day)	(mm/day)
5	91	91
10	118	106
20	147	120

The results are almost the same at both stations. Thus the probable rainfall at KIA which is located near the Sanya plain is taken for estimate of drainage requirement.

Four-hour rainfall is estimated from daily rainfall by the following equation.

$$R4 = (R24/24) \times (24/4)^{0.5}$$

Where, R24: daily rainfall corresponding to 5 year probability of occurrence (mm)

Then, drainage requirements are estimated by the following equation.

$$Q = R4 \times f/4/3.6$$

Where, Q : Drainage requirement ($m^3/sec/km^2$)
R4: rainfall for four hours (mm)
f : surface run-off coefficient

In the above equation, run-off coefficient is estimated at 0.25 considering that the area is flat upland cropping area. Drainage requirement of 6.4 lit/sec/ha is obtained.

6. RURAL DEVELOPMENT

Domestic water supply system and electric supply system are not available in the Sanya plain. Roads are very poor and difficult to drive in the rainy season. The rural development of the Sanya plain is , therefore, indispensable to maintain the Project and successfully attain intensive irrigation farming in the Sanya plain. First of all, infrastructures such as road networks, domestic water supply system and electric supply facilities have to be improved or constructed.

6.1 Residential area

At present people are living scattering in the fields in the Sanya plain. The area relatively populated is only just the south of the Arusha-Moshi railway and near the Sanya Chini station where small water supply system is available. When groundwater is developed with the construction of tubewells, potable water can be easily obtained instead of river water which is nowadays used for drinking and domestic use. People are supposed to be settled by people's own accord near tubewell points to obtain potable water and small villages will be naturally created around them. In order to enhance such movement and to settle as planned, areas where tubewells will be constructed should be designated as a residential area. From the viewpoint of traffic and approach to their own fields, the proposed sites of tubewells are assessed as the best places, since the tubewells are located along major roads and major irrigation canals as shown in Fig. 5-2 and the interval between the tubewells ranges from 500 m to 1,000 m, by which is meant that distance between the communities to their farms is mostly within 1 km. Taking the above consideration into account, the places where tubewells will be installed are planned as residential areas. The number of tubewells required for irrigation is 11 to 12 which depends on the scale of development and will be studied in home office; five tubewells for the east bank of the Sanya river and six or seven wells for its west bank. Thus 11 to 12 small villages will be developed in the downstream area of the Sanya plain.

The small colony will include a housing area, public spaces, storehouses, a small workshop and a public hall and may include a church or a mosque.

As for upstream of the Sanya plain, most of the people are living in areas extending to the south along the Arusha-Moshi railway and near the Sanya Chini Station. The north side of the Sanya Chini Station is nominated as industrial development area in accordance with "Hai Township Master Plan" prepared by Capital Development Authority for Ministry of Lands, Natural Resources and Tourism, December, 1987 and is expected to be developed. Therefore the south of the Station is important for people working for the industrial zone as well. For domestic water supply, small pumps and distribution pipe lines are to be proposed for these areas.

6.2 Road networks

There is a highway which runs between Arusha and Moshi in the mid-northern part of the Lower Hai area in east-west direction. A road branching off from the above trunk road at Boma Ng'ombe, the Capital of Hai District runs to the north for Sanya Juu. A road to the Kilimanjaro International Airport branches away from the Arusha-Moshi highway at the western part of Sanya Chini. These are paved with asphalt.

An existing road connecting the Sanya plain through Sanya Chini railway station with Boma Ng'ombe will play an important role for transportation of agricultural products to Moshi, Arusha, and other areas. Accordingly the road will be widened and paved with morrum.

In the project area roads will be provided along irrigation canals for transportation of agricultural products and inputs as well as operation and maintenance of irrigation facilities. These roads will connect small communities formed around tubewell sites. All the existing roads are not well built up, and just have wheel tracks. So it is difficult to drive on traditional roads in the rainy season when the road surface is wet with rain water causing slippage even in four-wheel-drive vehicles. From such lesson in the fields, all the roads provided along canals will be paved with morrum materials.

For crossing the Sanya river and to approach Boma Ng'ombe with the shortest distance through the above-mentioned existing roads from the right bank area of the Sanya river, three submersible bridges (causeways) will be provided. Total length of roads to be improved or constructed is estimated about 36 km.

6.3 Electricity

There is an 11 kVA transmission line across the Sanya plain, from which energy for operation of tubewells will be supplied through a transformer and low tension line, three phase, 400 V. Therefore, the electrification of small communities to be formed at tubewell sites will be easily realized.

As for the Sanya Chini village, the distance from the 11 kVA line is about 2.5 km and so the 11 KV line will be branched off to near the village about 2 km, then from which the low tension line will be installed for distribution of electricity. The total length of low tension line is estimated at about 12 km.

6.4 Afforestation

There is little forest on the Sanya plain especially along the Sanya river and fire wood is obtained from bushes. Nowadays little forest resources is a not serious problem, however, when the Project will be realized, the demand of fire wood for cooking will considerably increase as the population increase. Therefore, afforestation should be carried out around the Project area. If the irrigation is actually practiced throughout a year, some of water percolated into soil without usage by crops and retained in its deep zone is expected to be efficiently used for growing trees. From this view point and the land classification, the areas along the drainage canals forming the western border of the Project area are recommendable for the afforestation. An afforestation office exists at Boma Ng'ombe and afforestation project is being carried out in the Sanya plain along the road branched off from the Arusha-Moshi highway to Kilimanjaro International Airport under the technical and financial assistance from FAO. Afforestation in the project area is expected to be assisted by this office.

7. RECOMMENDATION FOR MTAKUJA AREA

As described in Section 2.1, the existing irrigation system in the Mtakuja area commanding about 300 ha had been getting water from the Kikuletwa river mainly in the rainy season, but in recent years, no or little water can be gotten due to flood in Majengo and Kiteto villages, Arumeru District located in the upstream of Mtakuja village, which is mainly caused by heavy sedimentation of the Kikuletwa river.

Thus in order to get irrigation water in the Mtakuja area as well as to mitigate floods in both Majengo and Kiteto, river training works are indispensable. In order to roughly estimate the scale required for flood release in the rainy season, cross sections of the Kikuletwa river were measured at three points: (1) one is about 15 km upstream of Mtakuja, where no flood occurs in accordance with the information from inhabitants, (2) second is the upstream of No.9 canal in Majengo, which is about 9 km upstream of the Mtakuja, and (3) the third is in the Mtakuja area. The cross sections are shown in Fig. 7.1. Comparing the cross sections, the cross section (2) and (3) is extremely smaller than that of (1).

From cross section (1), the flow area required for conveying flood water safely downstream is estimated at about 36 m^2. Applying this necessary flow area into the downstream sections, the work volume is estimated assuming a bottom width of 10 m and side slope of 1 in vertical to 2 in horizontal. The work volume and direct construction cost are roughly estimated as follows:

Work Item	Work Volume	Direct Construction Cost (Tsh. million)
Clearing	200,000 m^2	2.0
Excavation	120,000 m^3	24.1
Embankment	60,000 m^3	32.8
Miscellaneous Works (10%)	-	5.9
Total	-	64.8

Note: Cost estimate is based on March 1990 level.

Table 2-1 WATER BALANCE CALCULATION IN SANYA RIVER AND BOLOTI SYSTEM AT PRESENT CONDITION

CROPPING AREA

Unit: ha

CROP	SANYA PLAIN	BOLOTI	MUNGUSHI AREA
MAIZE-1	740	150	90
MAIZE-2	0	0	0
SUNFLOWER-1	0	0	5
SUNFLOWER-2	0	0	0
BEANS-1	310	110	40
BEANS-2	0	0	0
BEANS-3	0	0	0
VEGETABLE-1	0	0	0
VEGETABLE-2	0	0	10
VEGETABLE-3	0	0	0
BANANA	0	0	25

RESULTS OF WATER BALANCE

Unit: MCM

YEAR	DEFICIT IN BOLOTI	DEFICIT IN MUNGUSHI	DEFICIT I SANYA
1972	1.30	0.01	3.51
1973	1.09	0.00	2.42
1974	1.14	0.33	2.88
1975	1.39	0.23	3.30
1976	1.65	0.73	7.03
1977	1.41	0.11	4.25
1978	1.08	0.00	1.89
1979	0.44	0.00	0.43
1980	0.87	0.00	0.52
1981	1.45	0.00	3.71
1982	0.93	0.16	2.98
1983	0.82	0.06	3.00
1984	0.74	0.11	2.20
1985	1.47	0.00	4.60
1986	0.89	0.01	2.84
1987	1.85	0.34	7.47
1988	1.10	0.36	5.27

Table 3-1 DISCHARGE AND WATER LEVEL MEASUREMENT IN BOLOTI SWAMP

DATE	INFLOW	OUTFLOW	WL1	WL2	WL3	REMARKS
	(m3/sec)	(m3/sec)	(cm)	(cm)	(cm)	
Jan.24						
Jan.26	0.042	0.025	263.5			
Jan.29		0.010 *1	282.0			Rain
Jan.31		0.010 *1	285.0			
Feb. 1	0.037	0.010 *1	284.5			
Feb. 2	0.047		284.3			outlet closed
Feb. 3			283.8	-27.1		
Feb. 6			283.7	-29.3	8.6	
Feb. 7			283.4	-28.8	8.1	
Feb. 8			283.4	-28.8	7.5	Rain
Feb. 9	0.040		283.2		8.4	
Feb.10			282.4	-30.0	6.3	
Feb.12			281.7	-31.0		
Feb.13	0.046		281.5	-31.3	5.5	
Feb.16	0.046		281.8	-34.0	5.9	
Feb.16	0.039		281.8			
Feb.17			281.8		5.2	
Feb.20	0.081					All gauges are stolen
Feb.27			80.9	123.8	26.4	reset gauges
Feb.28	0.034		80.8	123.5	26	
Mar.2	(0.080)		84.6	128.3	29.8	Heavy rain

Note: WL1 at outlet point. WL2 is at western end of the swamp near the highway. WL3 is at about 300 m upstream of WL1 point along the east shore of the swamp.

- Average inflow for 16 days from 1st Feb. to 16th Feb..	0.043 m3/sec	
	3.87 mm/day	converted assuming from detail topo. map that wetted area is 0.95 km2
- Change of water level		
at WL1	-1.80 mm/day	average for 15 days from Feb.1 to 16.
at WL2	-5.31 mm/day	average for 13 days from Feb.3 to 16.
at WL3	-2.70 mm/day	average for 10 days from Feb.6 to 16.
- Average decrease of water level	-3.27 mm/day	
- Loss in the swamp	7.13 mm/day	
- Evapolation	7.2 mm/day	estimated by Penman method by use of monthly meteorological data of K.I.A.

Table 3-2 DISCHARGE MEASUREMENT IN SANYA RIVER

DATE	UPSTREAM (1)	BIRIRI RIVER (2)	MUNGUSHI INTAKE (3)	DOWNSTREAM (4)	(5)= (1)+(2)	(6)= (3)+(4)	DIFFERENCE (7)= (6)-(5)	RATE
	(m3/sec)		(m3/sec)	(m3/sec)		(m3/sec)	(m3/sec)	
Jun.22.'89	1.15	0.15 *1	0.16	1.3	1.300	1.46	0.160	1.12
Jan.24.'90	0.315	0	0.105	0.118	0.315	0.223	-0.092	0.71
Feb.1	0.165	0	0.091	0.121	0.165	0.212	0.047	1.28
Feb.2	0.168	0	0.077	0.098	0.168	0.175	0.007	1.04
Feb.9	0.157	0	0.082	0.037	0.157	0.119	-0.038	0.76
Feb.13	0.178	0	0.065	0.073	0.178	0.138	-0.040	0.78
Feb.16	0.121	0	0.069	0.071	0.121	0.140	0.019	1.16
Feb.16	0.167	0	0.069	0.053	0.167	0.122	-0.045	0.73
Feb.20	0.144	0	0.096	0.078	0.144	0.174	0.030	1.21
Feb.27	0.506	0.6 *2	0.138	1.376	1.106	1.514	0.408	1.37
Feb.28	0.252	0.115	0.117	0.477	0.367	0.594	0.227	1.62
Average	0.302		0.097	0.346		0.443		1.07

Note: Upstream is just downstream of confluence with Lawati.
Downstream is just upstream of Arusha-Moshi highway.
*1 : measured on 2 June. *2: visual observation

Table 3-3 WATER BALANCE CALCULATION RESULTS,
CASE 1: WITHOUT RESERVOIR

CROPPING AREA
Unit: ha

CROP	SANYA PLAIN	MUNGUSHI AREA
MAIZE-1	130	90
MAIZE-2	0	0
SUNFLOWER-1	10	5
SUNFLOWER-2	0	0
BEANS-1	55	45
BEANS-2	0	0
BEANS-3	0	0
VEGETABLE-1	55	0
VEGETABLE-2	0	10
VEGETABLE-3	0	0
BANANA	0	25

Mungushi without development

RESULTS OF WATER BALANCE
Unit: MCM

YEAR	DEFICIT IN MUNGUSHI	DEFICIT IN SANYA
1972	0.01	0.00
1973	0.19	0.00
1974	0.33	0.01
1975	0.16	0.00
1976	0.73	0.28
1977	0.00	0.00
1978	0.00	0.00
1979	0.00	0.00
1980	0.00	0.00
1981	0.16	0.01
1982	0.00	0.00
1983	0.17	0.00
1984	0.00	0.00
1985	0.01	0.00
1986	0.00	0.01
1987	0.55	0.30
1988	0.15	0.14

Table 3-4 WATER BALANCE CALCULATION RESULTS,
CASE 2: WITH BOLOTI DAM CAPACITY OF 7.5 MCM

CROPPING AREA

Unit: ha

CROP	SANYA PLAIN	BOLOTI	MUNGUSHI AREA
MAIZE-1	530	160	90
MAIZE-2	220	0	0
SUNFLOWER-1	50	0	5
SUNFLOWER-2	20	0	0
BEANS-1	210	130	45
BEANS-2	90	0	0
BEANS-3	90	0	0
VEGETABLE-1	210	0	0
VEGETABLE-2	90	0	10
VEGETABLE-3	90	0	0
BANANA	20	0	25

Mungushi and Boloti without development

RESULTS OF WATER BALANCE

Unit: MCM

YEAR	DEFICIT IN BOLOTI	DEFICIT IN MUNGUSHI	DEFICIT IN SANYA
1972	0.00	0.00	0.00
1973	0.00	0.00	0.00
1974	0.00	0.00	0.48
1975	0.00	0.00	0.00
1976	0.00	0.51	4.52
1977	0.00	0.00	0.00
1978	0.00	0.00	0.00
1979	0.00	0.00	0.00
1980	0.00	0.00	0.00
1981	0.00	0.09	0.22
1982	0.00	0.00	0.00
1983	0.00	0.00	0.16
1984	0.00	0.00	0.00
1985	0.00	0.00	0.00
1986	0.00	0.00	0.00
1987	0.00	0.49	3.73
1988	0.00	0.00	0.00

Table 3-5 WATER BALANCE CALCULATION RESULTS,
CASE 3: WITH BOLOTI DAM CAPACITY OF 6.6 MCM

CROPPING AREA

Unit: ha

CROP	SANYA PLAIN	BOLOTI	MUNGUSHI AREA
MAIZE-1	530	160	90
MAIZE-2	220	0	0
SUNFLOWER-1	50	0	5
SUNFLOWER-2	20	0	0
BEANS-1	210	130	45
BEANS-2	90	0	0
BEANS-3	90	0	0
VEGETABLE-1	210	0	0
VEGETABLE-2	90	0	10
VEGETABLE-3	90	0	0
BANANA	20	0	25

RESULTS OF WATER BALANCE

Unit: MCM

YEAR	DEFICIT IN BOLOTI	DEFICIT IN MUNGUSHI	DEFICIT IN SANYA
1972	0.00	0.00	0.00
1973	0.00	0.00	0.00
1974	0.00	0.05	0.58
1975	0.00	0.00	0.00
1976	0.00	0.17	2.87
1977	0.00	0.00	0.00
1978	0.00	0.00	0.00
1979	0.00	0.00	0.00
1980	0.00	0.00	0.00
1981	0.00	0.00	0.00
1982	0.00	0.00	0.00
1983	0.00	0.00	0.07
1984	0.00	0.00	0.00
1985	0.00	0.00	0.00
1986	0.00	0.00	0.00
1987	0.00	1.17	2.53
1988	0.00	0.00	0.00

Table 3-6 WATER BALANCE CALCULATION RESULTS,
CASE 4: WITHOUT RESERVOIR, DEVELOPMENT ONLY IN SANYA DOWNSTREAM AREA BY CONJUNCTIVE USE OF SURFACE AND GROUNDWATER

CROPPING AREA

Unit: ha

CROP	SANYA UPSTREAM	SANYA DOWNSTREAM	MUNGUSHI AREA
MAIZE-1	340	290	90
MAIZE-2	0	290	0
SUNFLOWER-1	10	30	5
SUNFLOWER-2	0	30	0
BEANS-1	130	110	40
BEANS-2	0	110	0
BEANS-3	0	110	0
VEGETABLE-1	0	110	0
VEGETABLE-2	0	110	10
VEGETABLE-3	0	110	0
BANANA	0	30	25

Note: Sanya upstream and Mungushi are at present condition

RESULTS OF WATER BALANCE

Unit: MCM

YEAR	GROUNDWATER REQUIREMENT
1972	2.00
1973	6.20
1974	6.80
1975	6.46
1976	6.09
1977	3.37
1978	1.93
1979	3.19
1980	1.72
1981	6.43
1982	2.95
1983	6.97
1984	3.52
1985	4.56
1986	4.39
1987	8.23
1988	5.21
Average	4.71
(m3/ha)	8258

Table 3-7 WATER BALANCE CALCULATION RESULTS
CASE 5: WITH BOLOTI DAM CAPACITY OF 7.5 MCM, CONJUNCTIVE USE OF SURFACE AND GROUNDWATER

CROPPING AREA

Unit: ha

CROP	SANYA UPSTRM	SANYA DOWNSTRM	BOLOTI	MUNGUSHI AREA
MAIZE-1	220	310	160	90
MAIZE-2	220	310	0	0
SUNFLOWER-1	20	30	0	5
SUNFLOWER-2	20	30	0	0
BEANS-1	90	120	130	45
BEANS-2	90	120	0	0
BEANS-3	90	120	0	0
VEGETABLE-1	90	120	0	0
VEGETABLE-2	90	120	0	10
VEGETABLE-3	90	120	0	0
BANANA	20	30	0	25

RESULTS OF WATER BALANCE

Unit: MCM

YEAR	DEFICIT IN BOLOTI	DEFICIT IN MUNGUSHI	DEFICIT IN SANYA UPSTRM	G.WATER REQUIREMENT IN SANYA DOWNST.
1972	0.00	0.00	0.00	3.20
1973	0.00	0.00	0.20	6.10
1974	0.00	0.07	0.48	6.52
1975	0.00	0.00	0.00	7.45
1976	0.00	0.21	1.77	7.05
1977	0.00	0.00	0.00	4.63
1978	0.00	0.00	0.00	2.34
1979	0.00	0.00	0.00	2.64
1980	0.00	0.00	0.00	2.79
1981	0.00	0.00	0.00	7.16
1982	0.00	0.00	0.00	1.55
1983	0.00	0.00	0.13	7.06
1984	0.00	0.00	0.00	3.43
1985	0.00	0.00	0.00	4.85
1986	0.00	0.00	0.00	4.26
1987	0.00	0.49	3.71	9.12
1988	0.00	0.00	0.00	5.17
			Average	5.02
			(m3/ha)	8225

Table 3-7 WATER BALANCE CALCULATION RESULTS,
CASE 5: WITH BOLOTI DAM CAPACITY OF 7.5 MCM,
CONJUNCTIVE USE OF SURFACE AND GROUNDWATER

	SANYA UPSTREAM	SANYA DOWNSTRM	BOLOTI	MUNGUSHI
	(ha)	(ha)	(ha)	(ha)
MAIZE-1	220	310	160	90
MAIZE-2	220	310	0	0
SUNFLOWER-1	20	30	0	5
SUNFLOWER-2	20	30	0	0
BEANS-1	90	120	130	45
BEANS-2	90	120	0	0
BEANS-3	90	120	0	0
VEGETABLE-1	90	120	0	0
VEGETABLE-2	90	120	0	10
VEGETABLE-3	90	120	0	0
BANANA	20	30	0	25

YEAR	MONTH	RIVER DISCHARGE SANYA Q1	FUCA Q2	LAWATI Q3	RAWA-SHI Q4	IRRIGATION REQUIREMENT BOLOTI I1	MUNGUSHI I2	SANYA PLAIN I3	LAWATI TO BOLTI Q6	LAWATI TO SANYA R. Q5	TOTAL INFLOW BOLTI S. (Q6+Q4)	RELEASED TO SANYA RIVER Q7	LOSS IN BOLTI Q8	TOTAL OUTFLOW REQUIRED I1+Q7+Q8	DIFFERENCE INFLOW-OUTFLOW		ACCUMU-LATED	SPILL-OUT	DEFICIT IN BOLOTI	IN MUNGU-SHI	IN SANYA PLAIN	IRRIGABLE AREA BY S.WATER RESOURCES	REQUIRE-MENT OF GROUND-WATER
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)		
1972	1	0.02	0.01	0.02	0.01	0.00	0.00	0.00	0.02	0.00	0.03	0.00	0.03	0.03	0.00	0	0	0	0	0	0	UPSTREAM	0
	2	0.01	0.24	0.45	0.15	0.00	0.00	0.00	0.45	0.00	0.60	0.00	0.10	0.10	0.50	1201	1201	0	0	0	0	UPSTREAM	0
	3	0.17	0.13	0.25	0.08	0.01	0.05	0.04	0.25	0.00	0.33	0.00	0.09	0.09	0.24	632	1833	0	0	0	0	ALL AREA	0
	4	0.37	0.44	0.84	0.27	0.08	0.06	0.04	0.84	0.00	1.11	0.00	0.05	0.12	0.99	2562	4395	0	0	0	0	ALL AREA	0
	5	0.63	0.73	1.41	0.45	0.17	0.09	0.49	1.00	0.41	1.45	0.00	0.03	0.19	1.26	3365	7500	260	0	0	0	ALL AREA	0
	6	0.37	0.47	0.90	0.29	0.39	0.22	0.69	0.90	0.00	1.19	0.08	0.07	0.53	0.66	1702	7500	1702	0	0	0	ALL AREA	0
	7	0.09	0.18	0.35	0.11	0.30	0.19	0.53	0.35	0.00	0.46	0.45	0.07	0.82	-0.36	-951	6549	0	0	0	0	ALL AREA	0
	8	0.06	0.06	0.12	0.04	0.15	0.13	0.20	0.12	0.00	0.16	0.21	0.08	0.44	-0.28	-748	5801	0	0	0	0	UPSTREAM	733
	9	0.04	0.05	0.09	0.03	0.01	0.08	0.29	0.09	0.00	0.12	0.28	0.10	0.39	-0.27	-702	5099	0	0	0	0	UPSTREAM	1064
	10	0.23	0.24	0.46	0.15	0.00	0.07	0.47	0.46	0.00	0.61	0.08	0.10	0.17	0.44	1176	6275	0	0	0	0	UPSTREAM	1761

Case

YEAR	MONTH	RIVER DISCHARGE SANYA Q1	FUCA Q2	LAWATI Q3	RAWA-SHI Q4	IRRIGATION REQUIREMENT BOLOTI I1	MUNGUSHI I2	SANYA PLAIN I3	LAWATI TO BOLTI Q6	LAWATI TO SANYA R. Q5	TOTAL INFLOW BOLTI S. (Q6+Q4)	RELEASED TO SANYA RIVER Q7	LOSS IN BOLTI Q8	TOTAL OUTFLOW REQUIRED I1+Q7+Q8	DIFFERENCE INFLOW-OUTFLOW		ACCUMU-LATED	SPILL-OUT	DEFICIT IN BOLOTI	IN MUNGU-SHI	IN SANYA PLAIN	IRRIGABLE AREA BY S.WATER RESOURCES	REQUIRE-MENT OF GROUND-WATER
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)		(1000m3)
	11	2.91	1.01	1.93	0.62	0.00	0.04	0.89	1.00	0.93	1.62	0.00	0.07	0.07	1.55	4009	7500	2784	0	0	0	0 ALL AREA	0
	12	1.49	0.46	0.89	0.28	0.00	0.06	0.60	0.89	0.00	1.17	0.00	0.11	0.11	1.06	2836	7500	2836	0	0	0	0 ALL AREA	0
1973	1	1.60	0.41	0.79	0.25	0.00	0.03	0.39	0.79	0.00	1.04	0.00	0.07	0.07	0.97	2587	7500	2587	0	0	0	0 ALL AREA	0
	2	0.82	0.57	1.10	0.35	0.00	0.04	0.32	1.00	0.10	1.35	0.00	0.08	0.08	1.27	3084	7500	3084	0	0	0	0 ALL AREA	0
	3	0.44	0.38	0.73	0.24	0.01	0.06	0.28	0.73	0.00	0.97	0.00	0.10	0.11	0.86	2294	7500	2294	0	0	0	0 ALL AREA	0
	4	0.39	0.44	0.84	0.27	0.02	0.01	0.04	0.84	0.00	1.11	0.00	-0.01	0.01	1.10	2855	7500	2855	0	0	0	0 ALL AREA	0
	5	1.57	0.90	1.74	0.56	0.05	0.03	0.33	1.00	0.74	1.56	0.00	0.02	0.07	1.49	3999	7500	3999	0	0	0	0 ALL AREA	0
	6	0.42	0.40	0.77	0.25	0.39	0.22	0.58	0.77	0.00	1.02	0.00	0.06	0.45	0.57	1465	7500	1465	0	0	0	0 ALL AREA	0
	7	0.15	0.22	0.43	0.14	0.30	0.19	0.49	0.43	0.00	0.57	0.31	0.06	0.68	-0.11	-282	7218	0	0	0	0	0 ALL AREA	0
	8	0.12	0.13	0.24	0.08	0.15	0.13	0.31	0.24	0.00	0.32	0.19	0.08	0.42	-0.10	-268	6950	0	0	0	0	0 UPST+DOWN HLF	339
	9	0.09	0.09	0.18	0.06	0.01	0.08	0.45	0.18	0.00	0.24	0.35	0.10	0.46	-0.22	-579	6371	0	0	0	0	0 UPST+DOWN HLF	493
	10	0.05	0.06	0.11	0.03	0.00	0.08	0.70	0.11	0.00	0.14	0.67	0.12	0.79	-0.65	-1747	4624	0	0	0	0	0 UPST+DOWN HLF	766
	11	0.02	0.03	0.05	0.02	0.00	0.05	0.41	0.05	0.00	0.07	0.41	0.09	0.50	-0.43	-1109	3515	0	0	0	0	0 UPSTREAM	1555
	12	0.01	0.02	0.04	0.01	0.00	0.05	0.34	0.04	0.00	0.05	0.36	0.10	0.46	-0.41	-1086	2429	0	0	0	0	0 UPSTREAM	1278
1974	1	0.00	0.02	0.03	0.01	0.00	0.05	0.30	0.03	0.00	0.04	0.33	0.10	0.44	-0.40	-1067	1362	0	0	0	0	0 UPSTREAM	1107
	2	0.00	0.01	0.02	0.01	0.00	0.07	0.22	0.02	0.00	0.03	0.27	0.12	0.39	-0.36	-878	484	0	0	0	0	0 UPSTREAM	782
	3	0.00	0.01	0.02	0.01	0.01	0.06	0.13	0.02	0.00	0.03	0.17	0.10	0.29	-0.26	-684	0	0	0	0	0	200 UPSTREAM	461
	4	1.64	1.22	2.35	0.75	0.02	0.01	0.07	1.00	1.35	1.75	0.00	-0.03	-0.01	1.76	4568	4568	0	0	0	0	0 ALL AREA	0
	5	1.61	0.88	1.69	0.54	0.20	0.11	0.42	1.00	0.69	1.54	0.00	0.04	0.24	1.30	3481	7500	549	0	0	0	0 ALL AREA	0
	6	0.35	0.41	0.79	0.25	0.31	0.18	0.69	0.79	0.00	1.04	0.11	0.05	0.48	0.56	1458	7500	1458	0	0	0	0 ALL AREA	0
	7	0.13	0.25	0.48	0.15	0.30	0.19	0.53	0.48	0.00	0.63	0.34	0.07	0.71	-0.08	-201	7299	0	0	0	0	0 ALL AREA	0
	8	0.08	0.09	0.17	0.06	0.15	0.13	0.28	0.17	0.00	0.23	0.24	0.08	0.47	-0.24	-648	6651	0	0	0	0	0 UPST+DOWN HLF	307
	9	0.05	0.04	0.08	0.03	0.01	0.08	0.49	0.08	0.00	0.11	0.48	0.10	0.59	-0.48	-1243	5408	0	0	0	0	0 UPST+DOWN HLF	532
	10	0.01	0.02	0.04	0.01	0.00	0.08	0.42	0.04	0.00	0.05	0.47	0.12	0.59	-0.54	-1454	3954	0	0	0	0	0 UPSTREAM	1549
	11	0.00	0.02	0.03	0.01	0.00	0.06	0.37	0.03	0.00	0.04	0.41	0.10	0.50	-0.46	-1201	2753	0	0	0	0	0 UPSTREAM	1390
	12	0.00	0.01	0.02	0.01	0.00	0.06	0.32	0.02	0.00	0.03	0.36	0.11	0.47	-0.44	-1189	1564	0	0	0	0	0 UPSTREAM	1197
1975	1	0.00	0.01	0.02	0.01	0.00	0.06	0.34	0.02	0.00	0.03	0.40	0.11	0.51	-0.48	-1272	292	0	0	0	0	0 UPSTREAM	1274
	2	0.00	0.01	0.02	0.01	0.00	0.07	0.20	0.02	0.00	0.03	0.26	0.12	0.38	-0.35	-850	0	0	0	0	74	484 UPSTREAM	727
	3	2.02	0.37	0.71	0.23	0.01	0.06	0.07	0.71	0.00	0.94	0.00	0.10	0.11	0.83	2213	2213	0	0	0	0	0 UPSTREAM	259
	4	2.79	1.03	1.98	0.63	0.02	0.02	0.05	1.00	0.98	1.63	0.00	0.01	0.03	1.60	4158	6371	0	0	0	0	0 ALL AREA	0
	5	1.38	0.67	1.28	0.41	0.03	0.02	0.06	1.00	0.28	1.41	0.00	0.02	0.05	1.36	3642	7500	2513	0	0	0	0 ALL AREA	0

Case

YEAR	MONTH	RIVER DISCHARGE SANYA Q1	FUCA Q2	LAWATI Q3	RAWA-SHI Q4	IRRIGATION REQUIREMENT BOLOTI I1	MUNGUSHI I2	SANYA PLAIN I3	LAWATI TO BOLTI Q6	LAWATI TO SANYA R. Q5	TOTAL INFLOW BOLTI S. (Q6+Q4)	RELEASED TO SANYA RIVER Q7	LOSS IN BOLTI Q8	TOTAL OUTFLOW REQUIRED I1+Q7+Q8	DIFFERENCE INFLOW-OUTFLOW		ACCUMU-LATED	SPILL-OUT	DEFICIT IN BOLOTI	IN MUNGU-SHI	IN SANYA PLAIN	IRRIGABLE AREA BY S.WATER RESOURCES	REQUIRE-MENT OF GROUND-WATER
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)		(1000m3)
	6	0.42	0.36	0.69	0.22	0.35	0.20	0.69	0.69	0.00	0.91	0.12	0.05	0.52	0.39	1009	7500	1009	0	0	0	ALL AREA	0
	7	0.13	0.18	0.35	0.11	0.30	0.19	0.53	0.35	0.00	0.46	0.41	0.06	0.77	-0.31	-834	6666	0	0	0	0	ALL AREA	0
	8	0.09	0.08	0.16	0.05	0.15	0.13	0.20	0.16	0.00	0.21	0.16	0.08	0.39	-0.18	-477	6189	0	0	0	0	UPSTREAM	733
	9	0.07	0.06	0.11	0.04	0.01	0.08	0.29	0.11	0.00	0.15	0.24	0.10	0.35	-0.20	-513	5676	0	0	0	0	UPSTREAM	1064
	10	0.04	0.02	0.04	0.01	0.00	0.08	0.33	0.04	0.00	0.05	0.36	0.12	0.48	-0.43	-1145	4531	0	0	0	0	UPSTREAM	1237
	11	0.01	0.02	0.03	0.01	0.00	0.07	0.39	0.03	0.00	0.04	0.43	0.12	0.55	-0.51	-1316	3215	0	0	0	0	UPSTREAM	1484
	12	0.00	0.01	0.02	0.01	0.00	0.04	0.37	0.02	0.00	0.03	0.40	0.07	0.47	-0.44	-1165	2050	0	0	0	0	UPSTREAM	1380
1976	1	0.00	0.01	0.01	0.00	0.00	0.06	0.39	0.01	0.00	0.01	0.45	0.12	0.57	-0.56	-1491	559	0	0	0	0	UPSTREAM	1444
	2	0.08	0.37	0.70	0.23	0.00	0.07	0.26	0.70	0.00	0.93	0.00	0.12	0.12	0.81	1950	2509	0	0	0	0	UPSTREAM	940
	3	0.01	0.06	0.11	0.04	0.01	0.07	0.20	0.11	0.00	0.15	0.19	0.12	0.33	-0.18	-468	2041	0	0	0	0	ALL AREA	0
	4	0.03	0.14	0.28	0.09	0.02	0.01	0.07	0.28	0.00	0.37	0.00	-0.01	0.00	0.37	946	2987	0	0	0	0	ALL AREA	0
	5	0.15	0.47	0.90	0.29	0.23	0.13	0.03	0.90	0.00	1.19	0.00	0.04	0.27	0.92	2460	5447	0	0	0	0	UPSTREAM	93
	6	0.09	0.24	0.47	0.15	0.31	0.18	0.26	0.47	0.00	0.62	0.11	0.05	0.47	0.15	382	5829	0	0	0	0	UPSTREAM	979
	7	0.03	0.07	0.14	0.05	0.30	0.19	0.18	0.14	0.00	0.19	0.27	0.06	0.63	-0.44	-1181	4648	0	0	0	0	UPSTREAM	675
	8	0.01	0.02	0.04	0.01	0.15	0.13	0.20	0.04	0.00	0.05	0.30	0.08	0.53	-0.48	-1283	3365	0	0	0	0	UPSTREAM	733
	9	0.00	0.01	0.03	0.01	0.01	0.08	0.27	0.03	0.00	0.04	0.34	0.10	0.45	-0.41	-1061	2304	0	0	0	0	UPSTREAM	985
	10	0.00	0.01	0.02	0.01	0.00	0.08	0.09	0.02	0.00	0.03	0.16	0.12	0.28	-0.25	-682	1622	0	0	0	0	UPSTREAM	330
	11	0.00	0.01	0.02	0.01	0.00	0.07	0.04	0.02	0.00	0.03	0.10	0.12	0.22	-0.19	-488	1134	0	0	0	0	UPSTREAM	162
	12	0.00	0.01	0.01	0.00	0.00	0.06	0.34	0.01	0.00	0.01	0.39	0.11	0.51	-0.50	-1330	0	0	0	0	197	UPSTREAM	1288
1977	1	0.01	0.01	0.01	0.00	0.00	0.06	0.39	0.01	0.00	0.01	0.43	0.01	0.44	-0.43	-1157	0	0	0	110	1047	UPSTREAM	1444
	2	0.00	0.02	0.03	0.01	0.00	0.06	0.22	0.03	0.00	0.04	0.26	0.04	0.30	-0.26	-623	0	0	0	103	521	UPSTREAM	782
	3	0.14	0.07	0.14	0.04	0.01	0.06	0.10	0.14	0.00	0.18	0.00	0.10	0.11	0.07	191	191	0	0	0	0	UPSTREAM	354
	4	1.62	1.13	2.18	0.70	0.02	0.01	0.30	1.00	1.18	1.70	0.00	-0.06	-0.04	1.74	4509	4700	0	0	0	0	ALL AREA	0
	5	1.63	0.84	1.61	0.52	0.20	0.11	0.25	1.00	0.61	1.52	0.00	0.04	0.23	1.29	3442	7500	642	0	0	0	ALL AREA	0
	6	0.31	0.35	0.68	0.22	0.35	0.20	0.56	0.68	0.00	0.90	0.10	0.06	0.51	0.39	1004	7500	1004	0	0	0	ALL AREA	0
	7	0.10	0.13	0.24	0.08	0.30	0.19	0.53	0.24	0.00	0.32	0.49	0.06	0.85	-0.53	-1418	6082	0	0	0	0	ALL AREA	0
	8	0.08	0.08	0.16	0.05	0.11	0.10	0.20	0.16	0.00	0.21	0.14	0.06	0.31	-0.10	-259	5823	0	0	0	0	UPSTREAM	733
	9	0.06	0.03	0.06	0.02	0.01	0.08	0.29	0.06	0.00	0.08	0.28	0.10	0.39	-0.31	-803	5020	0	0	0	0	UPSTREAM	1064
	10	0.03	0.04	0.07	0.02	0.00	0.07	0.47	0.07	0.00	0.09	0.47	0.09	0.56	-0.47	-1259	3761	0	0	0	0	UPSTREAM	1761
	11	0.16	0.26	0.49	0.16	0.00	0.06	0.42	0.49	0.00	0.65	0.06	0.09	0.15	0.50	1307	5068	0	0	0	0	UPSTREAM	1581
	12	0.25	0.17	0.33	0.11	0.00	0.04	0.65	0.33	0.00	0.44	0.27	0.07	0.34	0.10	266	5334	0	0	0	0	ALL AREA	0

YEAR	MONTH	RIVER DISCHARGE SANYA Q1	FUCA Q2	LAWATI Q3	RAWA-SHI Q4	IRRIGATION REQUIREMENT BOLOTI I1	MUNGUSHI I2	SANYA PLAIN I3	LAWATI TO BOLTI Q6	LAWATI TO SANYA R. Q5	TOTAL INFLOW BOLTI S. (Q6+Q4)	RELEASED TO SANYA RIVER Q7	LOSS IN BOLTI Q8	TOTAL OUTFLOW REQUIRED I1+Q7+Q8	DIFFERENCE INFLOW-OUTFLOW		ACCUMU-LATED	SPILL-OUT	DEFICIT IN BOLOTI	IN MUNGU-SHI	IN SANYA PLAIN	IRRIGABLE AREA BY S.WATER RESOURCES	REQUIRE-MENT OF GROUND-WATER
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)		(1000m3)
1978	1	0.38	0.16	0.30	0.10	0.00	0.06	0.21	0.30	0.00	0.40	0.00	0.11	0.11	0.29	772	6106	0	0	0	0	ALL AREA	0
	2	0.16	0.13	0.24	0.08	0.00	0.06	0.38	0.24	0.00	0.32	0.15	0.10	0.25	0.07	181	6287	0	0	0	0	ALL AREA	0
	3	0.47	0.23	0.45	0.14	0.00	0.04	0.04	0.45	0.00	0.59	0.00	0.06	0.06	0.53	1414	7500	201	0	0	0	ALL AREA	0
	4	1.14	0.55	1.07	0.34	0.02	0.01	0.04	1.00	0.07	1.34	0.00	0.02	0.04	1.30	3375	7500	3375	0	0	0	ALL AREA	0
	5	1.42	0.76	1.45	0.47	0.14	0.08	0.45	1.00	0.45	1.47	0.00	0.02	0.16	1.31	3517	7500	3517	0	0	0	ALL AREA	0
	6	0.59	0.44	0.85	0.27	0.35	0.20	0.64	0.85	0.00	1.12	0.00	0.05	0.40	0.72	1857	7500	1857	0	0	0	ALL AREA	0
	7	0.18	0.26	0.51	0.16	0.30	0.19	0.49	0.51	0.00	0.67	0.23	0.06	0.60	0.07	198	7500	198	0	0	0	ALL AREA	0
	8	0.13	0.13	0.25	0.08	0.15	0.13	0.43	0.25	0.00	0.33	0.31	0.08	0.53	-0.20	-547	6953	0	0	0	0	ALL AREA	0
	9	0.10	0.08	0.15	0.05	0.01	0.08	0.45	0.15	0.00	0.20	0.35	0.10	0.46	-0.26	-679	6274	0	0	0	0	UPST+DOWN HLF	493
	10	0.06	0.04	0.08	0.03	0.00	0.08	0.74	0.08	0.00	0.11	0.73	0.12	0.85	-0.74	-1973	4301	0	0	0	0	UPST+DOWN HLF	815
	11	0.70	0.26	0.49	0.16	0.00	0.04	0.34	0.49	0.00	0.65	0.00	0.06	0.06	0.59	1517	5818	0	0	0	0	UPSTREAM	1287
	12	3.14	0.74	1.43	0.46	0.00	0.04	0.55	1.00	0.43	1.46	0.00	0.06	0.06	1.40	3737	7500	2055	0	0	0	ALL AREA	0
1979	1	1.38	0.33	0.64	0.20	0.00	0.06	0.76	0.64	0.00	0.84	0.00	0.11	0.11	0.73	1954	7500	1954	0	0	0	ALL AREA	0
	2	1.05	0.57	1.09	0.35	0.00	0.05	0.38	1.00	0.09	1.35	0.00	0.08	0.08	1.27	3061	7500	3061	0	0	0	ALL AREA	0
	3	0.31	0.30	0.58	0.19	0.01	0.06	0.21	0.58	0.00	0.77	0.00	0.10	0.11	0.66	1779	7500	1779	0	0	0	ALL AREA	0
	4	0.84	0.58	1.11	0.36	0.02	0.01	0.04	1.00	0.11	1.36	0.00	-0.03	-0.01	1.37	3547	7500	3547	0	0	0	ALL AREA	0
	5	1.38	0.82	1.58	0.51	0.03	0.02	0.06	1.00	0.58	1.51	0.00	-0.07	-0.03	1.54	4134	7500	4134	0	0	0	ALL AREA	0
	6	1.23	0.69	1.33	0.43	0.28	0.16	0.52	1.00	0.33	1.43	0.00	0.04	0.31	1.12	2894	7500	2894	0	0	0	ALL AREA	0
	7	0.26	0.32	0.62	0.20	0.27	0.17	0.49	0.62	0.00	0.82	0.08	0.05	0.41	0.41	1102	7500	1102	0	0	0	ALL AREA	0
	8	0.16	0.20	0.38	0.12	0.14	0.12	0.43	0.38	0.00	0.50	0.20	0.08	0.41	0.09	235	7500	235	0	0	0	ALL AREA	0
	9	0.14	0.15	0.28	0.09	0.01	0.07	0.64	0.28	0.00	0.37	0.42	0.09	0.52	-0.15	-388	7112	0	0	0	0	ALL AREA	0
	10	0.11	0.11	0.21	0.07	0.00	0.08	1.05	0.21	0.00	0.28	0.92	0.12	1.03	-0.75	-2020	5092	0	0	0	0	ALL AREA	0
	11	0.07	0.08	0.15	0.05	0.00	0.06	0.37	0.15	0.00	0.20	0.27	0.09	0.36	-0.16	-416	4676	0	0	0	0	UPSTREAM	1374
	12	0.05	0.05	0.09	0.03	0.00	0.04	0.62	0.09	0.00	0.12	0.56	0.07	0.63	-0.51	-1376	3300	0	0	0	0	UPST+DOWN HLF	682
1980	1	0.03	0.02	0.05	0.02	0.00	0.06	0.47	0.05	0.00	0.07	0.48	0.11	0.59	-0.52	-1391	1909	0	0	0	0	UPST+DOWN HLF	513
	2	0.02	0.02	0.04	0.01	0.00	0.06	0.33	0.04	0.00	0.05	0.36	0.10	0.47	-0.42	-1006	903	0	0	0	0	UPST+DOWN HLF	362
	3	0.02	0.06	0.12	0.04	0.00	0.03	0.28	0.12	0.00	0.16	0.23	0.05	0.29	-0.13	-344	559	0	0	0	0	ALL AREA	0
	4	0.08	0.22	0.43	0.14	0.02	0.01	0.07	0.43	0.00	0.57	0.00	-0.02	0.00	0.57	1480	2039	0	0	0	0	ALL AREA	0
	5	1.55	1.20	2.31	0.74	0.03	0.02	0.16	1.00	1.31	1.74	0.00	-0.02	0.01	1.73	4635	6674	0	0	0	0	UPSTREAM	606
	6	0.59	0.55	1.06	0.34	0.39	0.22	0.64	1.00	0.06	1.34	0.00	0.06	0.45	0.89	2302	7500	1476	0	0	0	ALL AREA	0
	7	0.11	0.24	1.46	0.15	0.27	0.17	0.49	1.00	0.46	1.15	0.00	0.05	0.32	0.83	2211	7500	2211	0	0	0	ALL AREA	0

Case

YEAR	MONTH	RIVER DISCHARGE SANYA Q1	FUCA Q2	LAWATI Q3	RAWA-SHI Q4	IRRIGATION REQUIREMENT BOLOTI I1	MUNGUSHI I2	SANYA PLAIN I3	LAWATI TO BOLTI Q6	LAWATI TO SANYA R. Q5	TOTAL INFLOW BOLTI S. (Q6+Q4)	RELEASED TO SANYA RIVER Q7	LOSS IN BOLTI Q8	TOTAL OUTFLOW REQUIRED I1+Q7+Q8	DIFFERENCE INFLOW-OUTFLOW		ACCUMU-LATED	SPILL-OUT	DEFICIT IN BOLOTI	IN MUNGU-SHI	IN SANYA PLAIN	IRRIGABLE AREA BY S.WATER RESOURCES	REQUIRE-MENT OF GROUND-WATER
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)		
	8	0.08	0.14	0.26	0.09	0.12	0.11	0.36	0.26	0.00	0.35	0.26	0.07	0.45	-0.10	-270	7230	0	0	0	0	ALL AREA	0
	9	0.07	0.08	0.16	0.05	0.01	0.08	0.45	0.16	0.00	0.21	0.38	0.10	0.49	-0.28	-725	6505	0	0	0	0	UPST+DOWN HLF	493
	10	0.04	0.06	0.11	0.04	0.00	0.08	0.65	0.11	0.00	0.15	0.65	0.12	0.76	-0.61	-1638	4867	0	0	0	0	UPST+DOWN HLF	717
	11	0.09	0.17	0.33	0.11	0.00	0.03	0.34	0.33	0.00	0.44	0.11	0.04	0.14	0.30	767	5634	0	0	0	0	UPSTREAM	1287
	12	1.64	0.47	0.87	0.28	0.00	0.05	0.71	0.87	0.00	1.15	0.00	0.08	0.08	1.07	2859	7500	993	0	0	0	ALL AREA	0
1981	1	0.22	0.16	0.31	0.10	0.00	0.05	0.76	0.31	0.00	0.41	0.44	0.10	0.53	-0.12	-328	7172	0	0	0	0	ALL AREA	0
	2	0.08	0.04	0.07	0.02	0.00	0.07	0.44	0.07	0.00	0.09	0.39	0.11	0.50	-0.41	-996	6176	0	0	0	0	ALL AREA	0
	3	0.06	0.04	0.08	0.03	0.01	0.06	0.16	0.08	0.00	0.11	0.11	0.09	0.21	-0.10	-280	5896	0	0	0	0	ALL AREA	0
	4	0.21	0.33	0.63	0.20	0.08	0.06	0.04	0.63	0.00	0.83	0.00	0.04	0.12	0.71	1844	7500	240	0	0	0	ALL AREA	0
	5	1.25	0.96	1.84	0.59	0.03	0.02	0.06	1.00	0.84	1.59	0.00	-0.03	0.00	1.59	4251	7500	4251	0	0	0	ALL AREA	0
	6	0.35	0.41	0.79	0.25	0.39	0.22	0.64	0.79	0.00	1.04	0.11	0.06	0.55	0.49	1263	7500	1263	0	0	0	ALL AREA	0
	7	0.11	0.17	0.33	0.10	0.30	0.19	0.49	0.33	0.00	0.43	0.40	0.06	0.77	-0.34	-898	6602	0	0	0	0	ALL AREA	0
	8	0.08	0.07	0.13	0.04	0.15	0.13	0.18	0.13	0.00	0.17	0.17	0.08	0.39	-0.22	-596	6006	0	0	0	0	UPSTREAM	678
	9	0.16	0.05	0.10	0.03	0.01	0.08	0.27	0.10	0.00	0.13	0.14	0.10	0.24	-0.11	-297	5709	0	0	0	0	UPSTREAM	986
	10	0.04	0.03	0.06	0.02	0.00	0.07	0.31	0.06	0.00	0.08	0.31	0.09	0.40	-0.32	-847	4862	0	0	0	0	UPSTREAM	1146
	11	0.01	0.02	0.04	0.01	0.00	0.07	0.37	0.04	0.00	0.05	0.40	0.11	0.51	-0.46	-1194	3668	0	0	0	0	UPSTREAM	1374
	12	0.02	0.02	0.04	0.01	0.00	0.03	0.34	0.04	0.00	0.05	0.33	0.05	0.38	-0.33	-884	2784	0	0	0	0	UPSTREAM	1278
1982	1	0.00	0.01	0.03	0.01	0.00	0.06	0.36	0.03	0.00	0.04	0.41	0.11	0.52	-0.48	-1292	1492	0	0	0	0	UPSTREAM	1337
	2	0.00	0.02	0.04	0.01	0.00	0.07	0.24	0.04	0.00	0.05	0.29	0.11	0.39	-0.34	-833	659	0	0	0	0	UPSTREAM	870
	3	0.00	0.01	0.02	0.01	0.01	0.07	0.08	0.02	0.00	0.03	0.14	0.11	0.26	-0.23	-616	43	0	0	0	0	UPSTREAM	280
	4	0.13	0.26	0.51	0.16	0.02	0.01	0.07	0.51	0.00	0.67	0.00	-0.04	-0.02	0.69	1787	1830	0	0	0	0	ALL AREA	0
	5	0.64	0.80	1.54	0.49	0.03	0.02	0.02	1.00	0.54	1.49	0.00	-0.07	-0.04	1.53	4098	5928	0	0	0	0	UPSTREAM	86
	6	0.17	0.37	0.72	0.23	0.28	0.16	0.41	0.72	0.00	0.95	0.03	0.04	0.35	0.60	1566	7494	0	0	0	0	UPST+DOWN HLF	453
	7	0.08	0.20	0.38	0.12	0.22	0.13	0.40	0.38	0.00	0.50	0.25	0.04	0.51	-0.01	-14	7480	0	0	0	0	ALL AREA	0
	8	0.05	0.09	0.18	0.06	0.12	0.11	0.31	0.18	0.00	0.24	0.28	0.07	0.47	-0.23	-625	6855	0	0	0	0	UPST+DOWN HLF	339
	9	0.03	0.02	0.05	0.01	0.01	0.07	0.42	0.05	0.00	0.06	0.44	0.09	0.54	-0.48	-1239	5616	0	0	0	0	UPST+DOWN HLF	456
	10	0.03	0.07	0.14	0.05	0.00	0.05	0.08	0.14	0.00	0.19	0.03	0.07	0.10	0.09	239	5855	0	0	0	0	UPSTREAM	306
	11	0.27	0.23	0.45	0.14	0.00	0.02	0.07	0.45	0.00	0.59	0.00	0.01	0.01	0.58	1495	7350	0	0	0	0	UPST+DOWN HLF	75
	12	0.67	0.32	0.62	0.20	0.00	0.02	0.76	0.62	0.00	0.82	0.00	0.03	0.03	0.79	2109	7500	1959	0	0	0	ALL AREA	0
1983	1	0.08	0.04	0.09	0.03	0.00	0.06	0.86	0.09	0.00	0.12	0.81	0.12	0.93	-0.81	-2158	5342	0	0	0	0	ALL AREA	0

Case

YEAR	MONTH	RIVER DISCHARGE SANYA Q1	FUCA Q2	LAWATI Q3	RAWA-SHI Q4	IRRIGATION REQUIREMENT BOLOTI I1	MUNGUSHI I2	SANYA PLAIN I3	LAWATI TO BOLTI Q6	LAWATI TO SANYA R. Q5	TOTAL INFLOW BOLTI S. (Q6+Q4)	RELEASED TO SANYA RIVER Q7	LOSS IN BOLTI Q8	TOTAL OUTFLOW REQUIRED I1+Q7+Q8	DIFFERENCE INFLOW-OUTFLOW		ACCUMU-LATED	SPILL-OUT	DEFICIT IN BOLOTI	IN MUNGU-SHI	IN SANYA PLAIN	IRRIGABLE AREA BY S.WATER RESOURCES	REQUIRE-MENT OF GROUND-WATER
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)		
	2	0.03	0.02	0.03	0.01	0.00	0.06	0.47	0.03	0.00	0.04	0.48	0.10	0.59	-0.55	-1319	4023	0	0	0	0	ALL AREA	0
	3	0.03	0.04	0.09	0.03	0.01	0.06	0.21	0.09	0.00	0.12	0.19	0.09	0.30	-0.18	-478	3545	0	0	0	0	ALL AREA	0
	4	0.12	0.27	0.52	0.17	0.08	0.06	0.28	0.52	0.00	0.69	0.00	0.04	0.12	0.57	1482	5027	0	0	0	0	ALL AREA	0
	5	0.73	0.75	1.45	0.46	0.03	0.02	0.23	1.00	0.45	1.46	0.00	-0.05	-0.02	1.48	3965	7500	1492	0	0	0	ALL AREA	0
	6	0.22	0.46	0.88	0.28	0.17	0.10	0.52	0.88	0.00	1.16	0.00	0.02	0.19	0.97	2511	7500	2511	0	0	0	ALL AREA	0
	7	0.10	0.20	0.39	0.13	0.24	0.15	0.49	0.39	0.00	0.52	0.34	0.05	0.64	-0.12	-310	7190	0	0	0	0	ALL AREA	0
	8	0.07	0.09	0.17	0.05	0.15	0.13	0.31	0.17	0.00	0.22	0.29	0.08	0.51	-0.29	-784	6406	0	0	0	0	UPST+DOWN HLF	339
	9	0.05	0.04	0.07	0.02	0.01	0.07	0.27	0.07	0.00	0.09	0.26	0.09	0.36	-0.27	-697	5709	0	0	0	0	UPSTREAM	986
	10	0.02	0.02	0.04	0.01	0.00	0.08	0.44	0.04	0.00	0.05	0.49	0.12	0.60	-0.55	-1480	4229	0	0	0	0	UPSTREAM	1630
	11	0.00	0.02	0.03	0.01	0.00	0.06	0.39	0.03	0.00	0.04	0.44	0.10	0.54	-0.50	-1286	2943	0	0	0	0	UPSTREAM	1464
	12	0.01	0.02	0.03	0.01	0.00	0.04	0.25	0.03	0.00	0.04	0.27	0.07	0.33	-0.29	-785	2158	0	0	0	0	UPSTREAM	942
1984	1	0.00	0.01	0.02	0.01	0.00	0.06	0.32	0.02	0.00	0.03	0.36	0.11	0.47	-0.44	-1169	989	0	0	0	0	UPSTREAM	1179
	2	0.00	0.02	0.03	0.01	0.00	0.07	0.24	0.03	0.00	0.04	0.29	0.11	0.40	-0.36	-866	123	0	0	0	0	UPSTREAM	870
	3	0.08	0.04	0.07	0.02	0.01	0.06	0.12	0.07	0.00	0.09	0.06	0.11	0.19	-0.10	-256	0	0	0	0	134	UPSTREAM	427
	4	1.56	0.99	1.90	0.61	0.02	0.01	0.07	1.00	0.90	1.61	0.00	-0.19	-0.17	1.78	4603	4603	0	0	0	0	ALL AREA	0
	5	2.15	1.03	1.97	0.63	0.08	0.05	0.39	1.00	0.97	1.63	0.00	0.01	0.09	1.54	4128	7500	1231	0	0	0	ALL AREA	0
	6	0.42	0.42	0.81	0.26	0.24	0.14	0.64	0.81	0.00	1.07	0.00	0.03	0.27	0.80	2072	7500	2072	0	0	0	ALL AREA	0
	7	0.13	0.24	0.46	0.15	0.22	0.13	0.45	0.46	0.00	0.61	0.21	0.04	0.47	0.14	384	7500	384	0	0	0	ALL AREA	0
	8	0.08	0.09	0.18	0.06	0.15	0.13	0.43	0.18	0.00	0.24	0.39	0.08	0.62	-0.38	-1013	6487	0	0	0	0	ALL AREA	0
	9	0.06	0.04	0.08	0.03	0.01	0.07	0.27	0.08	0.00	0.11	0.25	0.09	0.35	-0.24	-614	5873	0	0	0	0	ALL AREA	0
	10	0.03	0.02	0.04	0.01	0.00	0.08	0.44	0.04	0.00	0.05	0.47	0.11	0.59	-0.54	-1436	4437	0	0	0	0	UPSTREAM	986
	11	0.14	0.22	0.43	0.14	0.00	0.03	0.32	0.43	0.00	0.57	0.00	0.03	0.03	0.54	1399	5836	0	0	0	0	UPSTREAM	1630
	12	0.38	0.19	0.36	0.12	0.00	0.05	0.82	0.36	0.00	0.48	0.30	0.08	0.38	0.10	272	6108	0	0	0	0	UPSTREAM	1197
1985	1	0.07	0.03	0.06	0.02	0.00	0.06	0.86	0.06	0.00	0.08	0.82	0.11	0.93	-0.85	-2280	3828	0	0	0	0	ALL AREA	0
	2	0.48	0.99	1.90	0.01	0.00	0.04	0.41	1.00	0.90	1.01	0.00	0.07	0.07	0.94	2281	6109	0	0	0	0	ALL AREA	0
	3	0.18	0.31	0.59	0.19	0.01	0.04	0.21	0.59	0.00	0.78	0.00	0.07	0.07	0.71	1890	7500	499	0	0	0	ALL AREA	0
	4	0.86	0.69	1.33	0.43	0.03	0.03	0.04	1.00	0.33	1.43	0.00	0.02	0.05	1.38	3583	7500	3583	0	0	0	ALL AREA	0
	5	0.67	0.61	1.18	0.38	0.03	0.02	0.23	1.00	0.18	1.38	0.00	-0.01	0.02	1.36	3641	7500	3641	0	0	0	ALL AREA	0
	6	0.22	0.34	0.65	0.21	0.39	0.22	0.64	0.65	0.00	0.86	0.31	0.06	0.76	0.10	251	7500	251	0	0	0	ALL AREA	0
	7	0.10	0.16	0.31	0.10	0.27	0.17	0.49	0.31	0.00	0.41	0.40	0.06	0.73	-0.32	-860	6640	0	0	0	0	ALL AREA	0

Case

YEAR	MONTH	RIVER DISCHARGE SANYA Q1	FUCA Q2	LAWATI Q3	RAWA-SHI Q4	IRRIGATION REQUIREMENT BOLOTI I1	MUNGUSHI I2	SANYA PLAIN I3	LAWATI TO BOLTI Q6	LAWATI TO SANYA R. Q5	TOTAL INFLOW BOLTI S. (Q6+Q4)	RELEASED TO SANYA RIVER Q7	LOSS IN BOLTI Q8	TOTAL OUTFLOW REQUIRED I1+Q7+Q8	DIFFERENCE INFLOW-OUTFLOW		ACCUMU-LATED	SPILL-OUT	DEFICIT IN BOLOTI	IN MUNGU-SHI	IN SANYA PLAIN	IRRIGABLE AREA BY S.WATER RESOURCES	REQUIRE-MENT OF GROUND-WATER
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)		
	8	0.08	0.08	0.15	0.05	0.15	0.13	0.18	0.15	0.00	0.20	0.16	0.08	0.38	-0.18	-491	6149	0	0	0	0	UPSTREAM	678
	9	0.05	0.05	0.10	0.03	0.01	0.08	0.27	0.10	0.00	0.13	0.24	0.10	0.35	-0.22	-573	5576	0	0	0	0	UPSTREAM	986
	10	0.23	0.02	0.05	0.01	0.00	0.08	0.39	0.05	0.00	0.06	0.22	0.11	0.33	-0.27	-732	4844	0	0	0	0	UPSTREAM	1435
	11	0.01	0.03	0.05	0.02	0.00	0.05	0.27	0.05	0.00	0.07	0.29	0.08	0.37	-0.30	-774	4070	0	0	0	0	UPSTREAM	1024
	12	0.10	0.04	0.09	0.03	0.00	0.05	0.27	0.09	0.00	0.12	0.18	0.09	0.27	-0.15	-407	3663	0	0	0	0	UPSTREAM	1024
1986	1	0.43	0.17	0.32	0.10	0.00	0.04	0.22	0.32	0.00	0.42	0.00	0.07	0.07	0.35	925	4588	0	0	0	0	UPST+DOWN HLF	242
	2	0.06	0.03	0.05	0.02	0.00	0.06	0.56	0.05	0.00	0.07	0.54	0.10	0.64	-0.57	-1389	3199	0	0	0	0	ALL AREA	0
	3	0.02	0.01	0.03	0.01	0.01	0.06	0.28	0.03	0.00	0.04	0.31	0.11	0.43	-0.39	-1049	2150	0	0	0	0	ALL AREA	0
	4	0.91	0.81	1.55	0.50	0.02	0.01	0.04	1.00	0.55	1.50	0.00	-0.11	-0.09	1.59	4130	6280	0	0	0	0	ALL AREA	0
	5	0.87	0.78	1.50	0.48	0.03	0.02	0.06	1.00	0.50	1.48	0.00	-0.11	-0.08	1.56	4181	7500	2961	0	0	0	ALL AREA	0
	6	0.45	0.50	0.95	0.30	0.17	0.10	0.58	0.95	0.00	1.25	0.00	0.01	0.19	1.06	2754	7500	2754	0	0	0	ALL AREA	0
	7	0.12	0.22	0.41	0.13	0.27	0.17	0.49	0.41	0.00	0.54	0.33	0.06	0.66	-0.12	-312	7188	0	0	0	0	ALL AREA	0
	8	0.08	0.07	0.14	0.05	0.15	0.13	0.26	0.14	0.00	0.19	0.24	0.08	0.47	-0.28	-745	6443	0	0	0	0	UPST+DOWN HLF	284
	9	0.05	0.04	0.07	0.02	0.01	0.08	0.27	0.07	0.00	0.09	0.27	0.10	0.37	-0.28	-735	5708	0	0	0	0	UPSTREAM	986
	10	0.02	0.03	0.05	0.02	0.00	0.07	0.41	0.05	0.00	0.07	0.44	0.10	0.53	-0.46	-1241	4467	0	0	0	0	UPSTREAM	1532
	11	0.02	0.04	0.08	0.02	0.00	0.05	0.34	0.08	0.00	0.10	0.33	0.07	0.40	-0.30	-786	3681	0	0	0	0	UPSTREAM	1287
	12	0.79	0.29	0.56	0.18	0.00	0.04	0.17	0.56	0.00	0.74	0.00	0.07	0.07	0.67	1787	5468	0	0	0	0	UPSTREAM	644
1987	1	0.15	0.10	0.19	0.06	0.00	0.06	0.52	0.19	0.00	0.25	0.33	0.11	0.44	-0.19	-507	4961	0	0	0	0	ALL AREA	0
	2	0.05	0.12	0.04	0.01	0.00	0.07	0.56	0.04	0.00	0.05	0.46	0.11	0.57	-0.52	-1260	3701	0	0	0	0	ALL AREA	0
	3	0.03	0.02	0.03	0.01	0.00	0.04	0.23	0.03	0.00	0.04	0.22	0.06	0.28	-0.24	-652	3049	0	0	0	0	ALL AREA	0
	4	0.02	0.04	0.07	0.02	0.09	0.07	0.09	0.07	0.00	0.09	0.11	0.05	0.24	-0.15	-399	2650	0	0	0	0	ALL AREA	0
	5	0.08	0.28	0.54	0.17	0.03	0.02	0.06	0.54	0.00	0.71	0.00	-0.02	0.01	0.70	1874	4524	0	0	0	0	UPSTREAM	207
	6	0.06	0.15	0.30	0.10	0.39	0.22	0.27	0.30	0.00	0.40	0.28	0.06	0.72	-0.32	-839	3685	0	0	0	0	UPSTREAM	1002
	7	0.03	0.03	0.05	0.02	0.24	0.15	0.20	0.05	0.00	0.07	0.30	0.05	0.59	-0.52	-1403	2282	0	0	0	0	UPSTREAM	770
	8	0.03	0.08	0.15	0.05	0.08	0.07	0.15	0.15	0.00	0.20	0.12	0.04	0.23	-0.03	-92	2190	0	0	0	0	UPSTREAM	568
	9	0.02	0.02	0.04	0.01	0.01	0.07	0.27	0.04	0.00	0.05	0.30	0.09	0.40	-0.35	-904	1286	0	0	0	0	UPSTREAM	986
	10	0.00	0.01	0.03	0.01	0.00	0.08	0.44	0.03	0.00	0.04	0.51	0.12	0.63	-0.59	-1579	0	0	0	0	294	UPSTREAM	1630
	11	0.00	0.01	0.02	0.01	0.00	0.06	0.34	0.02	0.00	0.03	0.38	0.03	0.41	-0.38	-997	0	0	0	111	887	UPSTREAM	1287
	12	0.00	0.01	0.02	0.01	0.00	0.05	0.39	0.02	0.00	0.03	0.43	0.03	0.46	-0.43	-1153	0	0	0	120	1034	UPSTREAM	1451
1988	1	0.00	0.01	0.01	0.00	0.00	0.05	0.34	0.01	0.00	0.01	0.38	0.01	0.39	-0.38	-1030	0	0	0	119	912	UPSTREAM	1257

Case

YEAR	MONTH	RIVER DISCHARGE SANYA Q1	FUCA Q2	LAWATI Q3	RAWA-SHI Q4	IRRIGATION REQUIREMENT BOLOTI I1	MUNGUSHI I2	SANYA PLAIN I3	LAWATI TO BOLTI Q6	LAWATI TO SANYA R. Q5	TOTAL INFLOW BOLTI S. (Q6+Q4)	RELEASED TO SANYA RIVER Q7	LOSS IN BOLTI Q8	TOTAL OUTFLOW REQUIRED I1+Q7+Q8	DIFFERENCE INFLOW-OUTFLOW		ACCUMU-LATED	SPILL-OUT	DEFICIT IN BOLOTI	IN MUNGU-SHI	IN SANYA PLAIN	IRRIGABLE AREA BY S.WATER RESOURCES	REQUIRE-MENT OF GROUND-WATER
		(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)	(1000m3)		
	2	0.00	0.00	0.01	0.00	0.00	0.06	0.24	0.01	0.00	0.01	0.30	0.01	0.31	-0.30	-721	0	0	0	141	580	UPSTREAM	870
	3	0.04	0.02	0.04	0.01	0.00	0.02	0.03	0.04	0.00	0.05	0.00	0.03	0.03	0.02	52	52	0	0	0	0	UPSTREAM	106
	4	1.40	0.89	1.72	0.55	0.02	0.01	0.04	1.00	0.72	1.55	0.00	-0.14	-0.12	1.67	4332	4384	0	0	0	0	ALL AREA	0
	5	0.96	0.59	1.14	0.37	0.17	0.09	0.51	1.00	0.14	1.37	0.00	0.03	0.19	1.18	3152	7500	36	0	0	0	ALL AREA	0
	6	0.19	0.28	0.53	0.17	0.11	0.06	0.58	0.53	0.00	0.70	0.18	0.00	0.29	0.41	1054	7500	1054	0	0	0	ALL AREA	0
	7	0.09	0.11	0.21	0.07	0.30	0.19	0.49	0.21	0.00	0.28	0.48	0.06	0.84	-0.56	-1496	6004	0	0	0	0	ALL AREA	0
	8	0.06	0.02	0.04	0.01	0.15	0.13	0.17	0.04	0.00	0.05	0.22	0.08	0.45	-0.40	-1061	4943	0	0	0	0	UPSTREAM	626
	9	0.03	0.02	0.03	0.01	0.01	0.07	0.27	0.03	0.00	0.04	0.28	0.08	0.37	-0.33	-866	4077	0	0	0	0	UPSTREAM	986
	10	0.01	0.01	0.02	0.01	0.00	0.08	0.44	0.02	0.00	0.03	0.51	0.12	0.62	-0.59	-1587	2490	0	0	0	0	UPSTREAM	1630
	11	0.01	0.02	0.03	0.01	0.00	0.05	0.41	0.03	0.00	0.04	0.44	0.07	0.51	-0.47	-1218	1272	0	0	0	0	UPSTREAM	1555
	12	0.03	0.02	0.05	0.01	0.00	0.02	0.25	0.05	0.00	0.06	0.22	0.03	0.25	-0.19	-504	768	0	0	0	0	UPSTREAM	942
																					3840		56836
																					349		5167

Table 3-8 DEVELOPMENT COST OF ALTERNATIVES

	ALTERNATIVE 2	ALTERNATIVE 4	ALTERNATIVE 5
DIRECT CONSTRUCTION COST			
DAM DEVELOPMENT	640	0	640
GROUNDWATER DEVELOPMENT	0	340	340
IRRIGATION AND DRAINAGE FACILITIES	680	410	680
OTHERS	160	120	170
TOTAL	1,480	870	1,830
ADMINISTRATION COST, ENGINEERING SERVICE AND PHISICAL CONTINGENCY	520	380	600
TOTAL	2,000 (1,490)	1,250 (930)	2,430 (1,800)

Note: Figures in parenthises indicate amounts in yen. Exchange rate adopted is Tsh.195 = Yen 145 = US$ 1.0.

Table 3-9 ANNUAL DISBURSEMENT SCHEDULE OF CONSTRUCTION COST (1/3)
(Case-2, without groundwater)

Unit : 1,000 TSh.

Work Item	Investment			1st Year			2nd Year			3rd Year		
	LC	FC	Total	LC	FC	Total	LC	FC	Total	LC	FC	Total
1. Preparatory Work	12,610	57,610	70,220	-	-	-	9,100	43,310	52,410	3,510	14,300	17,810
2. Boloti Reservoir												
Boloti Dam	29,500	440,960	470,460	-	-	-	29,500	440,960	470,460	-	-	-
Spillway	2,330	5,210	7,540	-	-	-	2,330	5,210	7,540	-	-	-
Lawati Diversion Weir	7,160	25,250	32,410	-	-	-	7,160	25,250	32,410	-	-	-
Lawati Diversion Canal	17,690	43,320	61,010	-	-	-	17,690	43,320	61,010	-	-	-
Outlet Structure	3,570	9,290	12,860	-	-	-	3,570	9,290	12,860	-	-	-
Outlet Canal	19,820	38,510	58,330	-	-	-	19,820	38,510	58,330	-	-	-
	(80,070)	(562,540)	(642,610)				(80,070)	(562,540)	(642,610)			
3. Tubewell, 12 Nos.+3 Nos.	-	-	-	-	-	-	-	-	-	-	-	-
4. Sanya Chini Irrigation System												
Headworks	3,360	11,790	15,150	-	-	-	3,360	11,790	15,150	-	-	-
Headreach, Left Main Canal	24,990	55,300	80,290	-	-	-	18,500	41,020	59,520	6,490	14,280	20,770
Right Main Canal	26,100	56,200	82,300	-	-	-	18,800	40,560	59,360	7,300	15,640	22,940
Left Secondary Canal	4,150	10,620	14,770	-	-	-	-	-	-	4,150	10,620	14,770
Right Secondary Canal	17,580	40,480	58,060	-	-	-	3,930	9,480	13,410	13,650	31,000	44,650
Drain	3,970	21,440	25,410	-	-	-	1,590	8,580	10,170	2,380	12,860	15,240
Road, 38 km	11,020	101,810	112,830	-	-	-	4,630	44,020	48,650	6,390	57,790	64,180
Night Storage Pond	10,350	82,610	92,960	-	-	-	4,690	37,670	42,360	5,660	44,940	50,600
Tertiary Development	37,250	144,840	182,090	-	-	-	15,900	62,930	78,830	21,350	81,910	103,260
Flood Dike	1,250	13,960	15,210	-	-	-	-	-	-	1,250	13,960	15,210
	(140,020)	(539,050)	(679,070)				(71,400)	(256,050)	(327,450)	(68,620)	(283,000)	(351,620)
5. Office and Quarter	32,700	50,500	83,200	-	-	-	30,900	47,500	78,400	1,800	3,000	4,800
Sub-total	265,400	1,209,700	1,475,100	-	-	-	191,470	909,400	1,100,870	73,930	300,300	374,230
6. O & M Equipment	-	92,400	92,400	-	-	-	-	46,200	46,200	-	46,200	46,200
7. Administration Expences	3,700	-	3,700	1,500	-	1,500	1,100	-	1,100	1,100	-	1,100
8. Engineering Services	-	245,300	245,300	-	104,700	104,700	-	70,300	70,300	-	70,300	70,300
Sub-total	269,100	1,547,400	1,816,500	1,500	104,700	106,200	192,570	1,025,900	1,218,470	75,030	416,800	491,830
9. Phisical Contingency	26,900	154,600	181,500	200	10,500	10,700	19,200	102,500	121,700	7,500	41,600	49,100
Total	296,000	1,702,000	1,998,000	1,700	115,200	116,900	211,770	1,128,400	1,340,170	82,530	458,400	540,930
10. Price Contingency	245,000	194,000	439,000	500	5,800	6,300	145,900	115,800	261,700	98,600	72,400	171,000
Grand Total	541,000	1,896,000	2,437,000	2,200	121,000	123,200	357,670	1,244,200	1,601,870	181,130	530,800	711,930

Note : Price contingency is estimated based on the annual increse rate of 5 % and 30 % for foreign currency portion and local currency portion respectively.
The conversion rates are US$1.00 = TSh.195.00 = Yen 145.00

Table 3-9 ANNUAL DISBURSEMENT SCHEDULE OF CONSTRUCTION COST (2/3)
(Case-4, without dam)

Unit : 1,000 TSh.

Work Item	Investment			1st Year			2nd Year			3rd Year		
	LC	FC	Total	LC	FC	Total	LC	FC	Total	LC	FC	Total
1. Preparatory Work	6,190	35,110	41,300	-	-	-	3,100	17,560	20,660	3,090	17,550	20,640
2. Boloti Reservoir												
Boloti Dam	-	-	-	-	-	-	-	-	-	-	-	-
Spillway	-	-	-	-	-	-	-	-	-	-	-	-
Lawati Diversion Weir	-	-	-	-	-	-	-	-	-	-	-	-
Lawati Diversion Canal	-	-	-	-	-	-	-	-	-	-	-	-
Outlet Structure	-	-	-	-	-	-	-	-	-	-	-	-
Outlet Canal	-	-	-	-	-	-	-	-	-	-	-	-
3. Tubewell, 12 Nos.+3 Nos.	13,140	326,700	339,840	-	-	-	6,570	163,350	169,920	6,570	163,350	169,920
4. Sanya Chini Irrigation System												
Headworks	10,740	32,180	42,920	-	-	-	5,370	16,090	21,460	5,370	16,090	21,460
Headreach, Left Main Canal	6,100	13,980	20,080	-	-	-	3,050	6,990	10,040	3,050	6,990	10,040
Right Main Canal	7,300	15,640	22,940	-	-	-	3,650	7,820	11,470	3,650	7,820	11,470
Left Secondary Canal	4,150	10,620	14,770	-	-	-	2,080	5,320	7,400	2,070	5,300	7,370
Right Secondary Canal	13,650	31,000	44,650	-	-	-	6,830	15,500	22,330	6,820	15,500	22,320
Drain	2,380	12,860	15,240	-	-	-	1,190	6,430	7,620	1,190	6,430	7,620
Road, 38 km	7,490	68,370	75,860	-	-	-	3,750	34,190	37,940	3,740	34,180	37,920
Night Storage Pond	5,660	47,940	53,600	-	-	-	2,830	23,970	26,800	2,830	23,970	26,800
Tertiary Development	20,550	81,340	101,890	-	-	-	10,280	40,670	50,950	10,270	40,670	50,940
Flood Dike	1,250	13,960	15,210	-	-	-	620	6,980	7,600	630	6,980	7,610
	(79,270)	(327,890)	(407,160)				(39,650)	(163,960)	(203,610)	(39,620)	(163,930)	(203,550)
5. Office and Quarter	30,900	47,500	78,400	-	-	-	15,500	23,800	39,300	15,400	23,700	39,100
Sub-total	129,500	737,200	866,700	-	-	-	64,820	368,670	433,490	64,680	368,530	433,210
6. O & M Equipment	-	92,400	92,400	-	-	-	-	46,200	46,200	-	46,200	46,200
7. Administration Expences	3,900	-	3,900	1,600	-	1,600	1,200	-	1,200	1,100	-	1,100
8. Engineering Services	-	168,700	168,700	-	72,000	72,000	-	48,400	48,400	-	48,300	48,300
Sub-total	133,400	998,300	1,131,700	1,600	72,000	73,600	66,020	463,270	529,290	65,780	463,030	528,810
9. Phisical Contingency	13,600	99,700	113,300	200	7,200	7,400	6,700	46,300	53,000	6,700	46,200	52,900
Total	147,000	1,098,000	1,245,000	1,800	79,200	81,000	72,720	509,570	582,290	72,480	509,230	581,710
10. Price Contingency	138,000	137,000	275,000	500	4,000	4,500	50,400	52,400	102,800	87,100	80,600	167,700
Grand Total	285,000	1,235,000	1,520,000	2,300	83,200	85,500	123,120	561,970	685,090	159,580	589,830	749,410

Note : Price contingency is estimated based on the annual increse rate of 5 % and 30 % for foreign currency portion and local currency portion respectively.
The conversion rates are US$1.00 = TSh.195.00 = Yen 145.00

Table 3-9 ANNUAL DISBURSEMENT SCHEDULE OF CONSTRUCTION COST (3/3)
(Case-5, Full development)

Unit : 1,000 TSh.

Work Item	Investment			1st Year			2nd Year			3rd Year		
	LC	FC	Total	LC	FC	Total	LC	FC	Total	LC	FC	Total
1. Preparatory Work	13,270	73,910	87,180	-	-	-	9,130	43,310	52,440	4,140	30,600	34,740
2. Boloti Reservoir												
Boloti Dam	29,500	440,960	470,460	-	-	-	29,500	440,960	470,460	-	-	-
Spillway	2,330	5,210	7,540	-	-	-	2,330	5,210	7,540	-	-	-
Lawati Diversion Weir	7,160	25,250	32,410	-	-	-	7,160	25,250	32,410	-	-	-
Lawati Diversion Canal	17,690	43,320	61,010	-	-	-	17,690	43,320	61,010	-	-	-
Outlet Structure	3,570	9,290	12,860	-	-	-	3,570	9,290	12,860	-	-	-
Outlet Canal	19,820	38,510	58,330	-	-	-	19,820	38,510	58,330	-	-	-
	(80,070)	(562,540)	(642,610)				(80,070)	(562,540)	(642,610)			
3. Tubewell, 12 Nos.+3 Nos.	13,140	326,700	339,840	-	-	-	-	-	-	13,140	326,700	339,840
4. Sanya Chini Irrigation System												
Headworks	3,360	11,790	15,150	-	-	-	3,360	11,790	15,150	-	-	-
Headreach, Left Main Canal	24,990	55,300	80,290	-	-	-	18,500	41,020	59,520	6,490	14,280	20,770
Right Main Canal	26,100	56,200	82,300	-	-	-	18,800	40,560	59,360	7,300	15,640	22,940
Left Secondary Canal	4,150	10,620	14,770	-	-	-	-	-	-	4,150	10,620	14,770
Right Secondary Canal	17,580	40,480	58,060	-	-	-	3,930	9,480	13,410	13,650	31,000	44,650
Drain	3,970	21,440	25,410	-	-	-	1,590	8,580	10,170	2,380	12,860	15,240
Road, 38 km	11,020	101,810	112,830	-	-	-	4,630	44,020	48,650	6,390	57,790	64,180
Night Storage Pond	10,350	82,610	92,960	-	-	-	4,690	37,670	42,360	5,660	44,940	50,600
Tertiary Development	37,250	144,840	182,090	-	-	-	15,900	62,930	78,830	21,350	81,910	103,260
Flood Dike	1,250	13,960	15,210	-	-	-	-	-	-	1,250	13,960	15,210
	(140,020)	(539,050)	(679,070)				(71,400)	(256,050)	(327,450)	(68,620)	(283,000)	(351,620)
5. Office and Quarter	32,700	50,500	83,200	-	-	-	30,900	47,500	78,400	1,800	3,000	4,800
Sub-total	279,200	1,552,700	1,831,900	-	-	-	191,500	909,400	1,100,900	87,700	643,300	731,000
6. O & M Equipment	-	92,400	92,400	-	-	-	-	46,200	46,200	-	46,200	46,200
7. Administration Expences	6,400	-	6,400	1,800	-	1,800	3,200	-	3,200	1,400	-	1,400
8. Engineering Services	-	274,400	274,400	-	79,500	79,500	-	117,300	117,300	-	77,600	77,600
Sub-total	285,600	1,919,500	2,205,100	1,800	79,500	81,300	194,700	1,072,900	1,267,600	89,100	767,100	856,200
9. Phisical Contingency	28,400	192,500	220,900	200	8,000	8,200	19,300	107,300	126,600	8,900	77,200	86,100
Total	314,000	2,112,000	2,426,000	2,000	87,500	89,500	214,000	1,180,200	1,394,200	98,000	844,300	942,300
10. Price Contingency	266,000	259,000	525,000	600	4,400	5,000	147,800	121,100	268,900	117,600	133,500	251,100
Grand Total	580,000	2,371,000	2,951,000	2,600	91,900	94,500	361,800	1,301,300	1,663,100	215,600	977,800	1,193,400

Note : Price contingency is estimated based on the annual increse rate of 5 % and 30 % for foreign currency portion and local currency portion respectively.
The conversion rates are US$1.00 = TSh.195.00 = Yen 145.00

Table 3-10 ANNUAL OPERATION AND MAINTENANCE COSTS

Unit: TSh.

Item	Case-2 without groundwater	Case-4 without dam	Case-5 Full development
1. Salary and Wages			
(1) Staff salaries	1,902,000	1,318,800	1,959,600
(2) Labour wages,	180,000	120,000	180,000
2. Office Expenses	500,000	500,000	500,000
3. Tubewell Operation Cost	0	1,220,000	1,220,000
4. Repair and Maintenance Cost (0.5 % of direct construction cost)			
(1) Boloti Dam	2,390,000	0	2,390,000
(2) Irrigation/Drainage Facilities and Road Network	4,177,000	2,268,000	4,177,000
(3) Tubewell	0	1,556,000	1,556,000
5. Miscellaneous	1,000,400	800,200	1,200,400
Total	10,149,400	7,783,000	13,183,000

Table 3-11 REPLACEMENT COST AND USEFUL LIFE

Item	Useful Life (year)	Replacement Cost (TSh.1,000)		
		Case-2 without groundwater	Case-4 without dam	Case-5 Full development
1. O & M Equipment				
(1) Heavy equipment	10	68,300	68,300	68,300
(2) Vehicle & small equipment	5	24,100	24,100	24,100
2. Project Facilities				
(1) Intake facilities, gate	25	8,600	2,900	8,600
(2) Irrigation facilities, gate	25	80,800	43,800	80,800
(3) Tubewell, pump and motor	25	0	79,400	79,400

Table 5-1 CALCULATION OF POTENTIAL EVAPORATION BY PENMAN METHOD (1/2)

Moshi

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmean	C	25.2	25.8	26.1	24.8	22.6	21.3	20.8	21.2	22.5	24.3	24.8	24.5
ea	mbar	32.1	33.2	33.8	31.3	27.4	25.4	24.6	25.2	27.3	30.4	31.3	30.8
Tdewpoint	C	15.6	15.7	15.8	18.3	18.1	15.5	14.2	13.8	13.4	13.5	15.9	16.6
ed	mbar	17.7	17.8	18.0	21.0	20.7	17.6	16.3	15.9	15.4	15.6	18.1	18.9
(ea-ed)		14.4	15.4	15.8	10.3	6.7	7.8	8.3	9.3	11.9	14.8	13.2	11.9
U5	km/day	181	181	225	138	104	78	78	104	181	251	190	156
U2	km/day	153	153	191	117	88	66	66	88	153	213	161	132
f(u)=0.27(1+U2/100)		0.68	0.68	0.79	0.59	0.51	0.45	0.45	0.51	0.68	0.85	0.70	0.63
W		0.76	0.77	0.77	0.76	0.74	0.72	0.72	0.72	0.74	0.75	0.76	0.76
(1-W)		0.24	0.23	0.23	0.24	0.26	0.28	0.28	0.28	0.26	0.25	0.24	0.24
(1-W)f(u)(ea-ed)		2.36	2.42	2.86	1.45	0.88	0.98	1.04	1.32	2.11	3.13	2.23	1.79
Latitude 3S													
Ra	mm/day	15.5	15.8	15.6	14.9	13.8	13.2	13.4	14.3	15.3	15.6	15.5	15.4
n	hr/day	9.1	9.1	7.9	6.4	4.5	4.5	4.5	5.1	7.7	7.7	8.0	8.2
N	hr/day	12.3	12.3	12.1	12.0	11.9	11.8	11.8	11.9	12.0	12.2	12.3	12.4
n/N		0.74	0.74	0.65	0.53	0.38	0.38	0.38	0.43	0.64	0.63	0.65	0.66
(0.25+0.50n/N)		0.62	0.62	0.58	0.52	0.44	0.44	0.44	0.46	0.57	0.57	0.58	0.58
Rs	mm/day	9.61	9.79	8.99	7.70	6.06	5.82	5.91	6.64	8.73	8.82	8.92	8.94
Rns	mm/day	7.21	7.35	6.74	5.77	4.54	4.36	4.43	4.98	6.55	6.62	6.69	6.71
f(T)		15.6	15.8	15.9	15.6	15.1	14.8	14.8	14.8	15.1	15.5	15.6	15.5
f(ed)=0.34-0.044 ed		0.15	0.15	0.15	0.14	0.14	0.16	0.16	0.16	0.17	0.17	0.15	0.15
f(n/N)=0.1+0.9n/N		0.77	0.77	0.69	0.58	0.44	0.44	0.44	0.49	0.68	0.67	0.69	0.70
Rnl=f(T)f(ed)f(n/N)	mm/day	1.85	1.87	1.68	1.25	0.93	1.02	1.07	1.18	1.71	1.72	1.63	1.60
Rn=Rns-Rnl		5.36	5.48	5.07	4.52	3.61	3.34	3.36	3.80	4.84	4.90	5.05	5.10
W.Rn		4.07	4.22	3.90	3.44	2.67	2.41	2.42	2.73	3.58	3.67	3.84	3.88
Uday/Unight=2													
c		1.10	1.10	1.10	1.05	1.00	1.00	1.00	1.00	1.10	1.10	1.10	1.10
ETO=c(W.Rn+(1-W)f(u)(ea-ed))	mm/day	7.1	7.3	7.4	5.1	3.6	3.4	3.5	4.1	6.3	7.5	6.7	6.2

Table 5-1 CALCULATION OF POTENTIAL EVAPORATION BY PENMAN METHOD (2/2)

Kilimanjaro Airport

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmean	C	24.9	25.3	25.8	24.4	22.3	20.4	20.0	20.7	22.1	23.9	24.8	24.8
ea	mbar	31.5	32.3	33.2	30.6	26.9	24.0	23.4	24.5	26.6	29.6	31.3	31.3
Tdewpoint	C	16.5	16.5	17.3	18.6	18.0	15.3	14.1	14.0	14.1	14.8	16.5	16.9
ed	mbar	18.8	18.8	19.8	21.4	20.6	17.4	16.2	16.1	16.2	16.8	18.8	19.3
(ea-ed)		12.7	13.5	13.4	9.2	6.3	6.6	7.2	8.4	10.4	12.8	12.5	12.0
U5	km/day	207	216	199	130	95	104	104	207	173	205	207	199
U2	km/day	175	183	169	110	80	88	88	175	147	174	175	169
f(u)=0.27(1+U2/100)		0.74	0.76	0.73	0.57	0.49	0.51	0.51	0.74	0.67	0.74	0.74	0.73
W		0.76	0.76	0.77	0.75	0.73	0.71	0.71	0.72	0.73	0.75	0.76	0.76
(1-W)		0.24	0.24	0.23	0.25	0.27	0.29	0.29	0.28	0.27	0.25	0.24	0.24
(1-W)f(u)(ea-ed)		2.26	2.48	2.24	1.30	0.83	0.97	1.06	1.75	1.87	2.37	2.23	2.09
Latitude 3S													
Ra	mm/day	15.5	15.8	15.6	14.9	13.8	13.2	13.4	14.3	15.3	15.6	15.5	15.4
n	hr/day	9.0	8.5	7.6	6.2	4.5	4.8	4.3	5.0	7.0	8.0	7.4	7.8
N	hr/day	12.3	12.3	12.1	12.0	11.9	11.8	11.8	11.9	12.0	12.2	12.3	12.4
n/N		0.73	0.69	0.63	0.52	0.38	0.41	0.36	0.42	0.58	0.66	0.60	0.63
(0.25+0.50n/N)		0.62	0.60	0.56	0.51	0.44	0.45	0.43	0.46	0.54	0.58	0.55	0.56
Rs	mm/day	9.55	9.41	8.80	7.57	6.06	5.98	5.79	6.58	8.29	9.01	8.54	8.69
Rns	mm/day	7.16	7.06	6.60	5.68	4.54	4.49	4.34	4.93	6.22	6.76	6.40	6.52
f(T)		15.6	15.7	15.9	15.5	15.1	14.7	14.6	14.7	15.0	15.4	15.6	15.6
f(ed)=0.34-0.044 ed		0.15	0.15	0.14	0.14	0.14	0.16	0.16	0.16	0.16	0.16	0.15	0.15
f(n/N)=0.1+0.9n/N		0.76	0.72	0.67	0.57	0.44	0.47	0.43	0.48	0.63	0.69	0.64	0.67
Rnl=f(T)f(ed)f(n/N)	mm/day	1.77	1.69	1.53	1.20	0.93	1.07	1.02	1.15	1.53	1.70	1.49	1.52
Rn=Rns-Rnl		5.39	5.37	5.07	4.49	3.61	3.42	3.33	3.79	4.69	5.06	4.91	5.00
W.Rn		4.10	4.08	3.91	3.36	2.64	2.43	2.36	2.73	3.42	3.80	3.73	3.80
Uday/Unight=2													
c		1.10	1.10	1.10	1.05	1.00	1.00	1.00	1.00	1.10	1.10	1.10	1.10
ETO=c(W.Rn+(1-W)f(u)(ea-ed))	mm/day	7.0	7.2	6.8	4.9	3.5	3.4	3.4	4.5	5.8	6.8	6.6	6.5

Table 5-2 ESTIMATE OF CROP WATER REQUIREMENT

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Potential Evapolation	mm/day	7.0	7.2	6.8	4.9	3.5	3.4	3.4	4.5	5.8	6.8	6.6	6.5
MAIZE-1													
Crop Coefficient		0.00	0.00	0.40	0.53	0.73	0.91	0.91	0.85	0.65	0.00	0.00	0.00
Crop Water Requirement	mm/day	0.0	0.0	2.7	2.6	2.6	3.1	3.1	3.8	3.8	0.0	0.0	0.0
	mm/month	0	0	42	77	80	93	96	118	57	0	0	0
MAIZE-2													
Crop Coefficient		0.95	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.68	0.82	0.93
Crop Water Requirement	mm/day	6.7	5.8	0.0	0.0	0.0	0.0	0.0	0.0	2.6	4.6	5.4	6.1
	mm/month	206	161	0	0	0	0	0	0	78	142	162	188
SUNFLOWER-1													
Crop Coefficient		0.00	0.00	0.40	0.53	0.73	0.90	0.82	0.70	0.40	0.00	0.00	0.00
Crop Water Requirement	mm/day	0.0	0.0	2.7	2.6	2.6	3.1	2.8	3.2	2.3	0.0	0.0	0.0
	mm/month	0	0	42	77	80	92	86	98	35	0	0	0
SUNFLOWER-2													
Crop Coefficient		0.88	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.68	0.82	0.88
Crop Water Requirement	mm/day	6.1	4.7	0.0	0.0	0.0	0.0	0.0	0.0	2.6	4.6	5.4	5.7
	mm/month	190	131	0	0	0	0	0	0	78	142	162	178
BEANS-1													
Crop Coefficient		0.00	0.00	0.40	0.63	0.80	0.83	0.83	0.60	0.00	0.00	0.00	0.00
Crop Water Requirement	mm/day	0.0	0.0	2.7	3.1	2.8	2.8	2.8	2.7	0.0	0.0	0.0	0.0
	mm/month	0	0	42	92	87	85	87	42	0	0	0	0
BEANS-2													
Crop Coefficient		0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.68	0.78	0.82	0.83	0.60
Crop Water Requirement	mm/day	0.0	0.0	0.0	0.0	0.0	0.0	1.9	3.0	4.5	5.6	5.4	3.9
	mm/month	0	0	0	0	0	0	29	94	136	172	163	60
BEANS-3													
Crop Coefficient		0.75	0.82	0.83	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.60
Crop Water Requirement	mm/day	5.3	5.9	5.6	2.9	0.0	0.0	0.0	0.0	0.0	0.0	2.6	3.9
	mm/month	163	165	174	44	0	0	0	0	0	0	40	121
VEGETABLE-1													
Crop Coefficient		0.00	0.00	0.40	0.63	0.80	0.83	0.83	0.60	0.00	0.00	0.00	0.00
Crop Water Requirement	mm/day	0.0	0.0	2.7	3.1	2.8	2.8	2.8	2.7	0.0	0.0	0.0	0.0
	mm/month	0	0	42	92	87	85	87	42	0	0	0	0
VEGETABLE-2													
Crop Coefficient		0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.68	0.78	0.82	0.83	0.60
Crop Water Requirement	mm/day	0.0	0.0	0.0	0.0	0.0	0.0	1.9	3.0	4.5	5.6	5.4	3.9
	mm/month	0	0	0	0	0	0	29	94	136	172	163	60
VEGETABLE-3													
Crop Coefficient		0.75	0.82	0.83	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.60
Crop Water Requirement	mm/day	5.3	5.9	5.6	2.9	0.0	0.0	0.0	0.0	0.0	0.0	2.6	3.9
	mm/month	163	165	174	44	0	0	0	0	0	0	40	121
BANANA													
Crop Coefficient		0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Crop Water Requirement	mm/day	5.6	5.8	5.4	3.9	2.8	2.7	2.7	3.6	4.6	5.4	5.3	5.2
	mm/month	174	161	169	118	87	82	84	112	139	169	158	161

Table 5-3 INFILTRATION TEST IN EXISTING EARTH CANAL NEAR SS 15 POINT

TIME	WATER LEVEL	RECESSION RATE	ACCUMU-LATED	WETTED PERIMETER	WATER DEPTH	WATER S.WIDTH	INFILTRATION AMOUNT EXPERIMENT	INFILTRATION AMOUNT SIMULATED
(min)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cc/m2)	(cc/m2)
0	15.0	0.0	0.0	185	21.6	180	0	
4	14.0	1.0	1.0	177	20.6	173	9732	
6	13.8	0.2	1.2	176	20.4	171	1947	
11	13.4	0.4	1.6	173	20.0	168	3894	
16	12.9	0.5	2.1	169	19.5	165	4869	
21	12.4	0.5	2.6	165	19.0	161	4870	
31	11.6	0.8	3.4	159	18.2	155	7794	
41	10.9	0.7	4.1	154	17.5	150	6823	
51	10.0	0.9	5.0	147	16.6	143	8776	
61	9.4	0.6	5.6	142	16.0	139	5854	
71	8.4	1.0	6.6	135	15.0	131	9761	
84	7.8	0.6	7.2	130	14.4	127	5860	
130	15.7		7.2	190	22.3	185		
140	15.0	0.7	7.9	185	21.6	180	6813	6656
150	14.3	0.7	8.6	180	20.9	175	6808	6552
160	13.2	1.1	9.7	172	19.8	167	10687	6457
170	12.9	0.3	10.0	170	19.5	165	2912	6369
180	12.2	0.7	10.7	165	18.8	160	6791	6287
190	11.6	0.6	11.3	160	18.2	155	5815	6210
200	11.0	0.6	11.9	156	17.6	151	5810	6138
210	10.2	0.8	12.7	150	16.8	145	7738	6071
360								5371
720								4589

Regression Output:

Constant	9.9245853	1.823
Std Err of Y Est	0.3958964	
R Squared	0.0076604	
No. of Observations	8	
Degrees of Freedom	6	

X Coefficient(s) -0.2273508
Std Err of Coef. 1.05638703

Table 5-4 ESTIMATE OF CONVEYANCE LOSS IN EARTH CANAL

FIRST SECTION (0 M - 250 M)				SECOND SECTION (250 - 500 M)					THIRD SECTION (500 - 750 M)				
Q	V	S	LOSS	Q	V	S	LOSS	Q	LOSS	V	S	LOSS	Q
(m3/s)	(m/sec)	(m)	(l/s)	(m3/s)	(m/sec)	(m)	(l/s)	(m3/s)	(%)	(m/sec)	(m)	(l/s)	(m3/s)
0.06	0.6	0.869	1.81	0.058	0.593	0.857	1.79	0.056	6.4	0.589	0.849	1.77	0.055
0.06	0.5	0.945	1.97	0.058	0.496	0.934	1.95	0.056	7.0	0.491	0.922	1.92	0.054
0.06	0.4	1.052	2.19	0.058	0.396	1.037	2.16	0.056	7.8	0.392	1.024	2.13	0.054
0.06	0.3	1.211	2.52	0.057	0.297	1.191	2.48	0.055	9.1	0.293	1.171	2.44	0.053

	FORTH SECTION (750 - 1,000 M)					FIFTH SECTION (1,000 - 1,250 M)				
LOSS	V	S	LOSS	Q	LOSS	V	S	LOSS	Q	LOSS
(%)	(m/sec)	(m)	(l/s)	(m3/s)	(%)	(m/sec)	(m)	(l/s)	(m3/s)	(%)
9.8	0.584	0.840	1.750	0.053	13.5	0.579	0.83	1.729	0.051	17.3
10.8	0.487	0.911	1.898	0.052	14.8	0.482	0.899	1.873	0.050	19.1
12.1	0.388	1.010	2.104	0.051	16.7	0.384	0.996	2.075	0.049	21.6
14.2	0.290	1.151	2.398	0.050	19.6	0.287	1.134	2.363	0.048	25.5

Table 5-5 SUMMARY OF IRRIGATION WATER REQUIREMENT IN SANYA PLAIN
(ALL AREAS ARE IRRIGATED THROUGH A YEAR) Unit: lit/ha/sec

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1972	0.771	0.478	0.190	0.043	0.053	0.612	0.468	0.414	0.562	0.879	0.573	0.725
1973	0.373	0.305	0.265	0.039	0.317	0.554	0.468	0.414	0.607	0.938	0.946	0.777
1974	0.821	0.359	0.251	0.040	0.485	0.612	0.468	0.414	0.607	0.998	0.946	0.883
1975	0.821	0.540	0.234	0.200	0.265	0.612	0.425	0.414	0.468	0.998	0.946	0.829
1976	0.821	0.280	0.251	0.063	0.265	0.612	0.468	0.414	0.514	0.998	0.946	0.777
1977	0.771	0.418	0.234	0.039	0.428	0.612	0.468	0.382	0.607	0.818	0.836	0.829
1978	0.196	0.359	0.033	0.039	0.428	0.612	0.468	0.414	0.607	0.998	0.783	0.524
1979	0.724	0.359	0.203	0.039	0.053	0.495	0.468	0.414	0.607	0.998	0.836	0.829
1980	0.629	0.449	0.265	0.063	0.371	0.612	0.468	0.347	0.607	0.879	0.783	0.673
1981	0.724	0.418	0.149	0.043	0.053	0.612	0.468	0.414	0.607	0.702	0.836	0.777
1982	0.821	0.540	0.174	0.063	0.053	0.554	0.380	0.414	0.562	0.188	0.091	0.725
1983	0.821	0.449	0.203	0.265	0.218	0.495	0.468	0.414	0.607	0.998	0.890	0.572
1984	0.724	0.540	0.265	0.063	0.371	0.612	0.425	0.414	0.607	0.998	0.728	0.777
1985	0.821	0.389	0.203	0.043	0.218	0.612	0.468	0.414	0.607	0.879	0.622	0.622
1986	0.297	0.540	0.265	0.039	0.053	0.554	0.468	0.347	0.607	0.938	0.783	0.391
1987	0.495	0.540	0.220	0.089	0.126	0.612	0.468	0.347	0.607	0.998	0.783	0.883
1988	0.771	0.540	0.065	0.039	0.485	0.554	0.468	0.382	0.607	0.998	0.946	0.572

PLANTING LATE	
MAIZE-1	0.50
MAIZE-2	0.50
SUNFLOWER-1	0.05
SUNFLOWER-2	0.05
BEANS-1	0.20
BEANS-2	0.20
BEANS-3	0.20
VEGETABLES-1	0.20
VEGETABLES-2	0.20
VEGETABLES-3	0.20
BANANA	0.05

Table 5-6 SUMMARY OF IRRIGATION WATER REQUIREMENT IN SANYA PLAIN
(IN DRY SEASON, UPSTREAM AREA ONLY BE IRRIGATED) Unit: lit/ha/sec

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1972	0.322	0.199	0.085	0.036	0.050	0.595	0.448	0.303	0.242	0.367	0.240	0.303
1973	0.156	0.126	0.120	0.034	0.306	0.539	0.448	0.303	0.261	0.392	0.396	0.325
1974	0.342	0.149	0.114	0.035	0.469	0.595	0.448	0.303	0.261	0.417	0.396	0.370
1975	0.342	0.224	0.105	0.181	0.256	0.595	0.407	0.303	0.201	0.417	0.396	0.347
1976	0.342	0.116	0.114	0.053	0.256	0.595	0.448	0.303	0.221	0.417	0.396	0.325
1977	0.322	0.173	0.105	0.034	0.414	0.595	0.448	0.280	0.261	0.341	0.350	0.347
1978	0.082	0.149	0.018	0.034	0.414	0.595	0.448	0.303	0.261	0.417	0.328	0.219
1979	0.302	0.149	0.091	0.034	0.050	0.481	0.448	0.303	0.261	0.417	0.350	0.347
1980	0.262	0.187	0.120	0.053	0.359	0.595	0.448	0.255	0.261	0.367	0.328	0.282
1981	0.302	0.173	0.066	0.036	0.050	0.595	0.448	0.303	0.261	0.293	0.350	0.325
1982	0.342	0.224	0.077	0.053	0.050	0.539	0.364	0.303	0.242	0.078	0.038	0.303
1983	0.342	0.187	0.091	0.242	0.210	0.481	0.448	0.303	0.261	0.417	0.373	0.239
1984	0.302	0.224	0.120	0.053	0.359	0.595	0.407	0.303	0.261	0.417	0.305	0.325
1985	0.342	0.161	0.091	0.036	0.210	0.595	0.448	0.303	0.261	0.367	0.261	0.260
1986	0.124	0.224	0.120	0.034	0.050	0.539	0.448	0.255	0.261	0.392	0.328	0.163
1987	0.206	0.224	0.100	0.077	0.122	0.595	0.448	0.255	0.261	0.417	0.328	0.370
1988	0.322	0.224	0.031	0.034	0.469	0.539	0.448	0.280	0.261	0.417	0.396	0.239

PLANTING LATE	
MAIZE-1	0.50
MAIZE-2	0.21
SUNFLOWER-1	0.05
SUNFLOWER-2	0.02
BEANS-1	0.20
BEANS-2	0.08
BEANS-3	0.08
VEGETABLES-1	0.20
VEGETABLES-2	0.08
VEGETABLES-3	0.08
BANANA	0.02

Table 5-7 SUMMARY OF IRRIGATION WATER REQUIREMENT IN BOLOTI AREA
(PRESENT CONDITION) Unit: lit/ha/sec

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1972	0	0	0.025	0.262	0.570	1.344	1.033	0.502	0.030	0	0	0
1973	0	0	0.032	0.067	0.177	1.344	1.033	0.502	0.030	0	0	0
1974	0	0	0.032	0.067	0.682	1.081	1.033	0.502	0.030	0	0	0
1975	0	0	0.032	0.067	0.114	1.213	1.033	0.502	0.030	0	0	0
1976	0	0	0.039	0.067	0.799	1.081	1.033	0.502	0.030	0	0	0
1977	0	0	0.032	0.067	0.682	1.213	1.033	0.386	0.030	0	0	0
1978	0	0	0.015	0.067	0.469	1.213	1.033	0.502	0.030	0	0	0
1979	0	0	0.032	0.067	0.114	0.950	0.937	0.465	0.030	0	0	0
1980	0	0	0.015	0.067	0.114	1.344	0.937	0.425	0.030	0	0	0
1981	0	0	0.032	0.262	0.114	1.344	1.033	0.502	0.030	0	0	0
1982	0	0	0.039	0.067	0.114	0.950	0.743	0.425	0.030	0	0	0
1983	0	0	0.032	0.262	0.114	0.597	0.839	0.502	0.030	0	0	0
1984	0	0	0.039	0.067	0.273	0.826	0.743	0.502	0.030	0	0	0
1985	0	0	0.018	0.102	0.114	1.344	0.937	0.502	0.030	0	0	0
1986	0	0	0.039	0.067	0.114	0.597	0.937	0.502	0.030	0	0	0
1987	0	0	0.015	0.318	0.114	1.344	0.839	0.276	0.030	0	0	0
1988	0	0	0.015	0.067	0.570	0.387	1.033	0.502	0.026	0	0	0

PLANTING LATE	
MAIZE-1	0.55
MAIZE-2	0.00
SUNFLOWER-1	0.00
SUNFLOWER-2	0.00
BEANS-1	0.45
BEANS-2	0.00
BEANS-3	0.00
VEGETABLES-1	0.00
VEGETABLES-2	0.00
VEGETABLES-3	0.00
BANANA	0.00

Table 5-8 SUMMARY OF IRRIGATION WATER REQUIREMENT IN BOLOTI AREA
(WITH PROJECT CONDITION) Unit: lit/ha/sec

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1972	0	0	0.015	0.164	0.356	0.840	0.645	0.313	0.019	0	0	0
1973	0	0	0.020	0.042	0.110	0.840	0.645	0.313	0.019	0	0	0
1974	0	0	0.020	0.042	0.426	0.675	0.645	0.313	0.019	0	0	0
1975	0	0	0.020	0.042	0.071	0.758	0.645	0.313	0.019	0	0	0
1976	0	0	0.024	0.042	0.499	0.675	0.645	0.313	0.019	0	0	0
1977	0	0	0.020	0.042	0.426	0.758	0.645	0.241	0.019	0	0	0
1978	0	0	0.009	0.042	0.293	0.758	0.645	0.313	0.019	0	0	0
1979	0	0	0.020	0.042	0.071	0.594	0.585	0.290	0.019	0	0	0
1980	0	0	0.009	0.042	0.071	0.840	0.585	0.265	0.019	0	0	0
1981	0	0	0.020	0.164	0.071	0.840	0.645	0.313	0.019	0	0	0
1982	0	0	0.024	0.042	0.071	0.594	0.464	0.265	0.019	0	0	0
1983	0	0	0.020	0.164	0.071	0.373	0.524	0.313	0.019	0	0	0
1984	0	0	0.024	0.042	0.170	0.516	0.464	0.313	0.019	0	0	0
1985	0	0	0.011	0.063	0.071	0.840	0.585	0.313	0.019	0	0	0
1986	0	0	0.024	0.042	0.071	0.373	0.585	0.313	0.019	0	0	0
1987	0	0	0.009	0.198	0.071	0.840	0.524	0.172	0.019	0	0	0
1988	0	0	0.009	0.042	0.356	0.242	0.645	0.313	0.016	0	0	0

PLATING LATE	
MAIZE-1	0.55
MAIZE-2	0.00
SUNFLOWER-1	0.00
SUNFLOWER-2	0.00
BEANS-1	0.45
BEANS-2	0.00
BEANS-3	0.00
VEGETABLES-1	0.00
VEGETABLES-2	0.00
VEGETABLES-3	0.00
BANANA	0.00

Table 5-9 SUMMARY OF IRRIGATION WATER REQUIREMENT IN MUNGUSHI AREA
(PRESENT CONDITION) Unit: lit/ha/sec

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1972	0.324	0.326	0.312	0.362	0.574	1.353	1.136	0.798	0.451	0.405	0.257	0.360
1973	0.204	0.215	0.340	0.086	0.177	1.353	1.136	0.798	0.451	0.487	0.279	0.295
1974	0.324	0.399	0.340	0.086	0.687	1.087	1.136	0.798	0.451	0.487	0.328	0.338
1975	0.389	0.399	0.362	0.112	0.113	1.221	1.136	0.798	0.451	0.487	0.402	0.231
1976	0.389	0.399	0.412	0.086	0.805	1.087	1.136	0.798	0.451	0.487	0.402	0.360
1977	0.367	0.374	0.340	0.086	0.687	1.221	1.136	0.607	0.451	0.377	0.328	0.231
1978	0.367	0.350	0.225	0.086	0.472	1.221	1.136	0.798	0.451	0.487	0.257	0.212
1979	0.367	0.302	0.340	0.086	0.113	0.955	1.028	0.736	0.423	0.487	0.328	0.252
1980	0.367	0.374	0.207	0.086	0.113	1.353	1.028	0.672	0.451	0.487	0.153	0.273
1981	0.324	0.399	0.340	0.362	0.113	1.353	1.136	0.798	0.451	0.377	0.402	0.175
1982	0.367	0.399	0.412	0.086	0.113	0.955	0.811	0.672	0.423	0.300	0.099	0.139
1983	0.389	0.374	0.340	0.362	0.113	0.599	0.919	0.798	0.423	0.487	0.376	0.231
1984	0.345	0.399	0.389	0.086	0.273	0.829	0.811	0.798	0.423	0.459	0.153	0.273
1985	0.367	0.256	0.246	0.173	0.113	1.353	1.028	0.798	0.451	0.487	0.303	0.295
1986	0.260	0.374	0.389	0.086	0.113	0.599	1.028	0.798	0.451	0.405	0.279	0.231
1987	0.345	0.399	0.225	0.428	0.113	1.353	0.919	0.429	0.423	0.487	0.328	0.316
1988	0.302	0.374	0.139	0.086	0.574	0.386	1.136	0.798	0.390	0.487	0.279	0.123

PLANTING LATE	
MAIZE-1	0.53
MAIZE-2	0.00
SUNFLOWER-1	0.05
SUNFLOWER-2	0.00
BEANS-1	0.28
BEANS-2	0.00
BEANS-3	0.00
VEGETABLES-1	0.00
VEGETABLES-2	0.05
VEGETABLES-3	0.00
BANANA	0.15

Table 5-10 SUMMARY OF IRRIGATION WATER REQUIREMENT IN MUNGUSHI AREA
(WITH PROJECT CONDITION) Unit: lit/ha/sec

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1972	0.202	0.204	0.195	0.226	0.358	0.845	0.710	0.499	0.281	0.253	0.160	0.225
1973	0.128	0.134	0.212	0.054	0.110	0.845	0.710	0.499	0.281	0.304	0.174	0.184
1974	0.202	0.249	0.212	0.054	0.429	0.679	0.710	0.499	0.281	0.304	0.205	0.211
1975	0.243	0.249	0.226	0.070	0.070	0.763	0.710	0.499	0.281	0.304	0.251	0.144
1976	0.243	0.249	0.257	0.054	0.503	0.679	0.710	0.499	0.281	0.304	0.251	0.225
1977	0.229	0.234	0.212	0.054	0.429	0.763	0.710	0.379	0.281	0.236	0.205	0.144
1978	0.229	0.219	0.141	0.054	0.295	0.763	0.710	0.499	0.281	0.304	0.160	0.133
1979	0.229	0.189	0.212	0.054	0.070	0.597	0.642	0.460	0.264	0.304	0.205	0.157
1980	0.229	0.234	0.129	0.054	0.070	0.845	0.642	0.420	0.281	0.304	0.095	0.170
1981	0.202	0.249	0.212	0.226	0.070	0.845	0.710	0.499	0.281	0.236	0.251	0.109
1982	0.229	0.249	0.257	0.054	0.070	0.597	0.507	0.420	0.264	0.188	0.062	0.087
1983	0.243	0.234	0.212	0.226	0.070	0.374	0.574	0.499	0.264	0.304	0.235	0.144
1984	0.216	0.249	0.243	0.054	0.171	0.518	0.507	0.499	0.264	0.287	0.095	0.170
1985	0.229	0.160	0.153	0.108	0.070	0.845	0.642	0.499	0.281	0.304	0.189	0.184
1986	0.163	0.234	0.243	0.054	0.070	0.374	0.642	0.499	0.281	0.253	0.174	0.144
1987	0.216	0.249	0.141	0.267	0.070	0.845	0.574	0.268	0.264	0.304	0.205	0.197
1988	0.189	0.234	0.086	0.054	0.358	0.241	0.710	0.499	0.244	0.304	0.174	0.077

PLANTING LATE	
MAIZE-1	0.53
MAIZE-2	0.00
SUNFLOWER-1	0.05
SUNFLOWER-2	0.00
BEANS-1	0.28
BEANS-2	0.00
BEANS-3	0.00
VEGETABLES-1	0.00
VEGETABLES-2	0.05
VEGETABLES-3	0.00
BANANA	0.15

Table 5-11 IRRIGATION APPLICATION DEPTH AND IRRIGATION INTERVAL

CROP	p *1	AVAILABLE WATER	ROOTING DEPTH	APPLICATION EFFICIENCY	DEPTH OF IRRIGATION	ET CROP	IRRIGATION INTERVAL
		(mm/m)	(cm)		(mm)	(mm/day)	(day)
MAIZE-1	0.60	177	80	0.7	121	3.8	22
MAIZE-2	0.60	177	80	0.7	121	6.6	13
SUNFLOWER-1	0.45	177	80	0.7	91	3.2	20
SUNFLOWER-2	0.45	177	80	0.7	91	6.1	10
BEANS-1	0.45	177	50	0.7	57	3.1	13
BEANS-2	0.45	177	50	0.7	57	5.5	7
BEANS-3	0.45	177	50	0.7	57	5.6	7
VEGETABLES-1	0.40	177	30	0.7	30	3.1	7
VEGETABLES-2	0.40	177	30	0.7	30	5.5	4
VEGETABLES-3	0.40	177	30	0.7	30	5.6	4
BANANA	0.35	177	60	0.7	53	5.6	7

*1 : Fraction of available soil moiture, refer to Table 38 of "Crop Water Requirements" FAO.

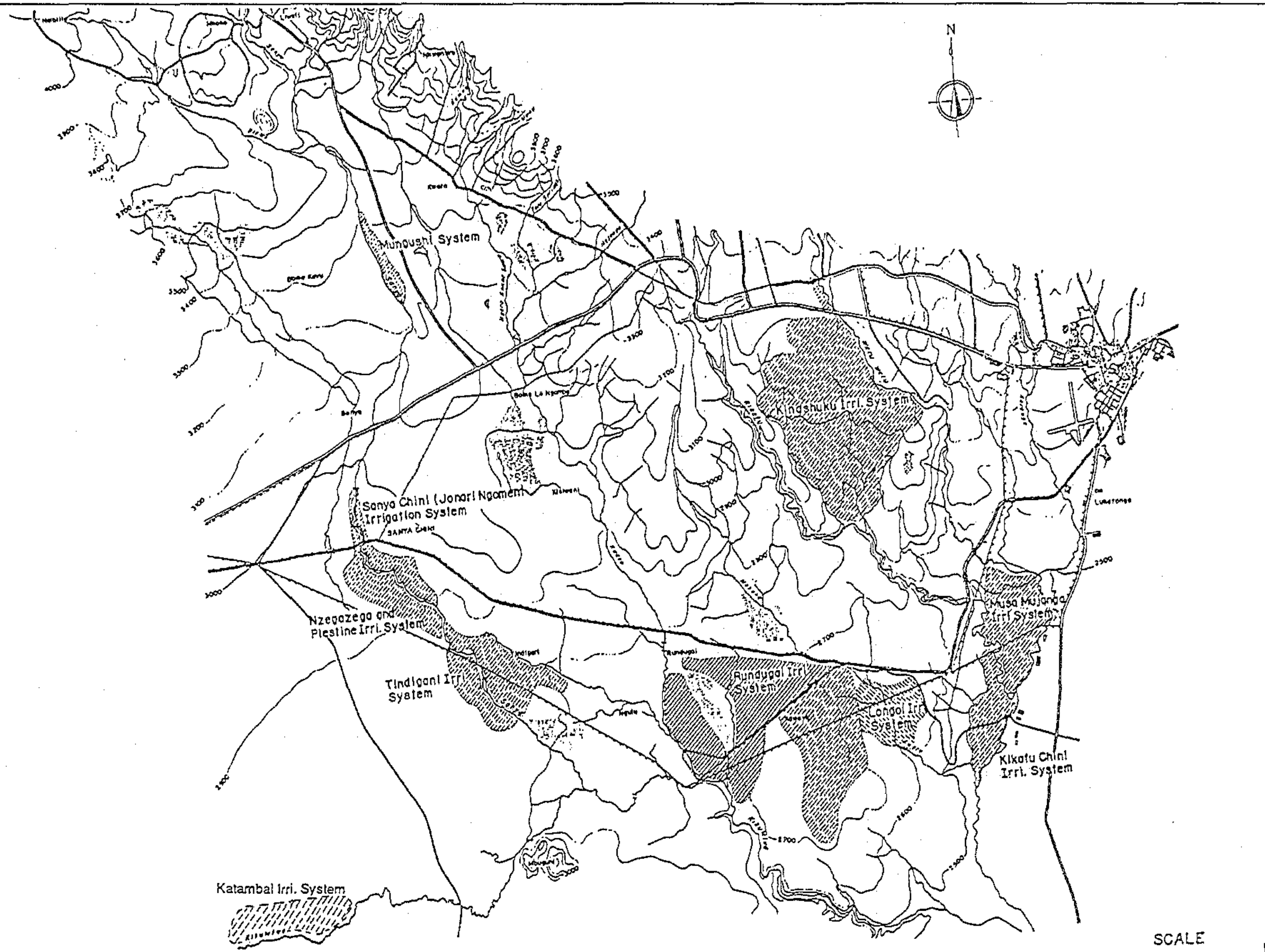


Fig. 2-1 MAJOR IRRIGATION AREA IN LOWER HAI AREA

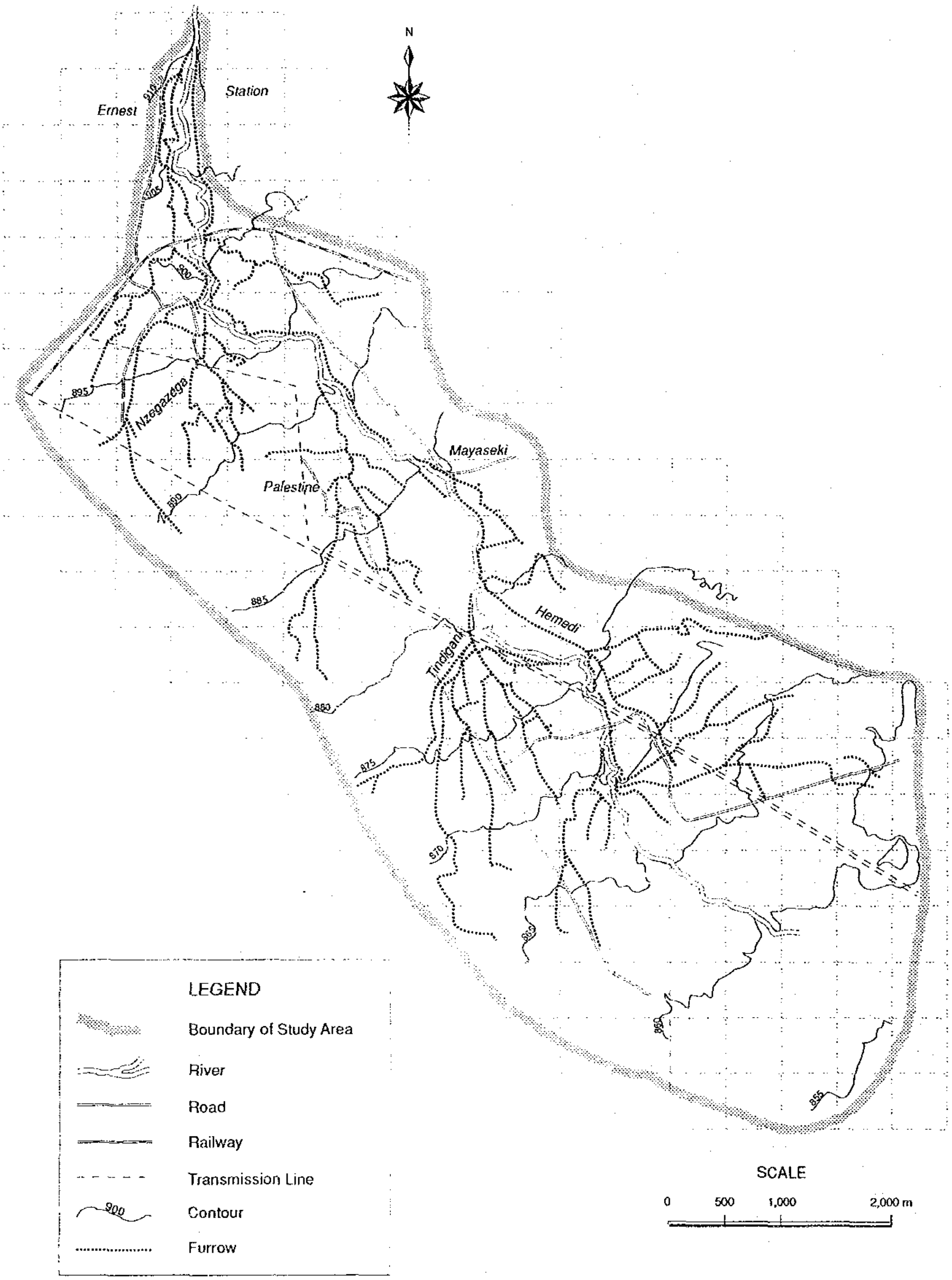


Fig. 2-2 EXISTING IRRIGATION SYSTEM IN SANYA PLAIN

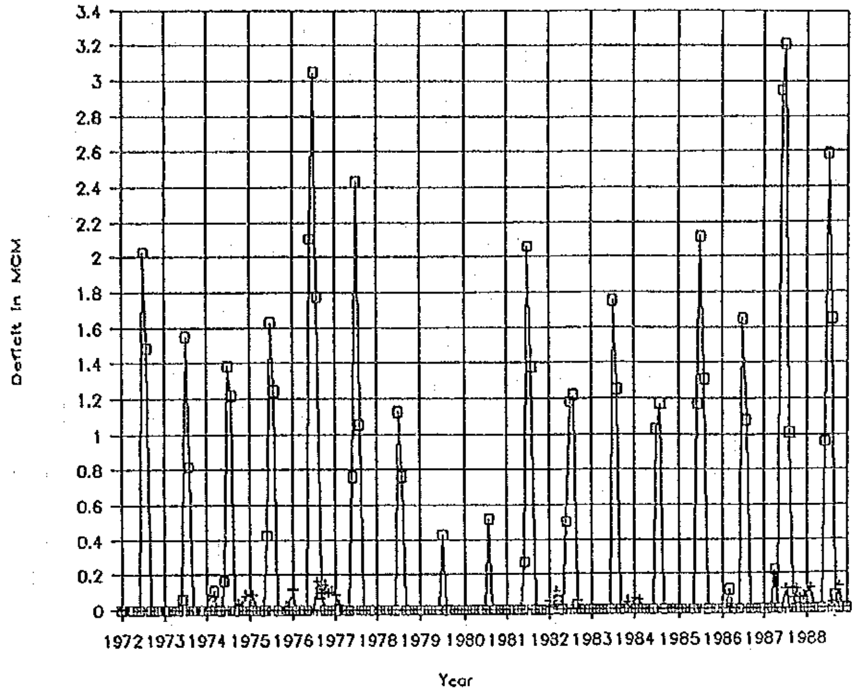


Fig. 2-3 DEFICIT OF WATER IN SANYA RIVER BASIN AND BOLOTI AREA AT PRESENT CONDITION

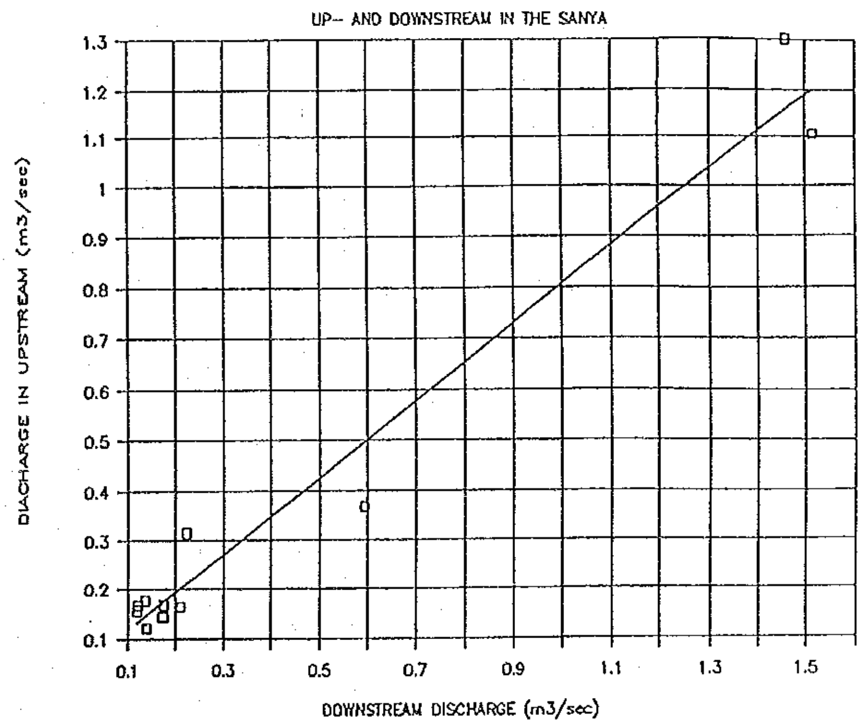


Fig. 3-1 COMPARISON OF DISCHARGE BETWEEN UPSTREAM AND DOWN STREAM POINTS IN SANYA RIVER

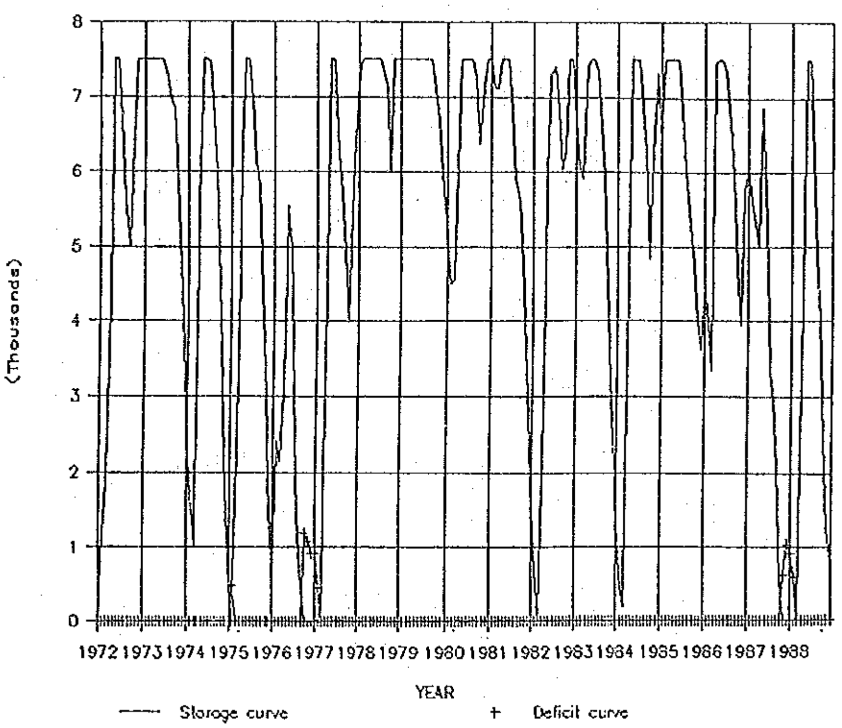


Fig. 3-2 VARIATION OF RESERVOIR STORAGE IN CASE 2

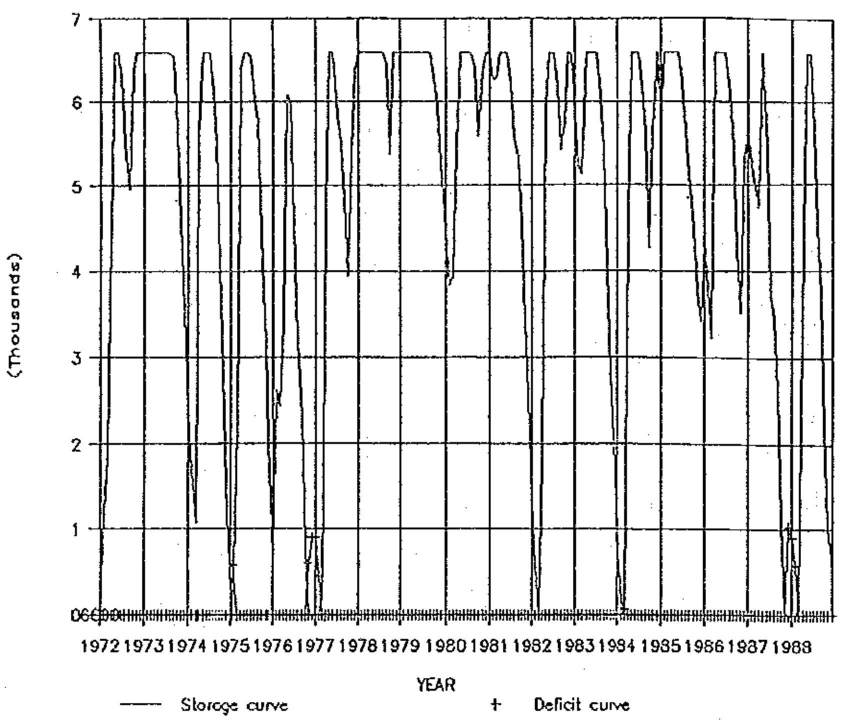


Fig. 3-3 VARIATION OF RESERVOIR STORAGE IN CASE 3

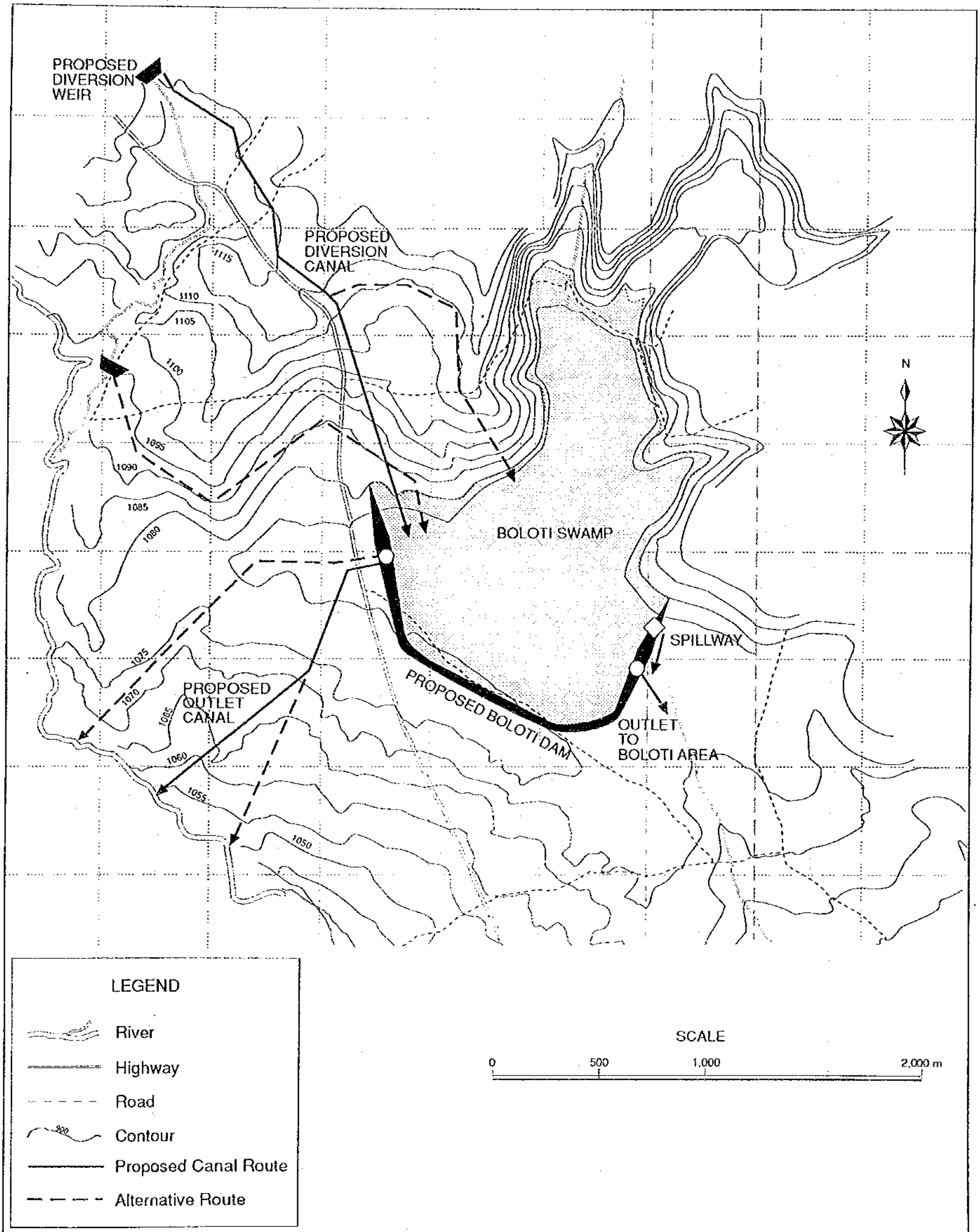


Fig.4-1 DEVELOPMENT PLAN OF BOLOTI SWAMP AREA

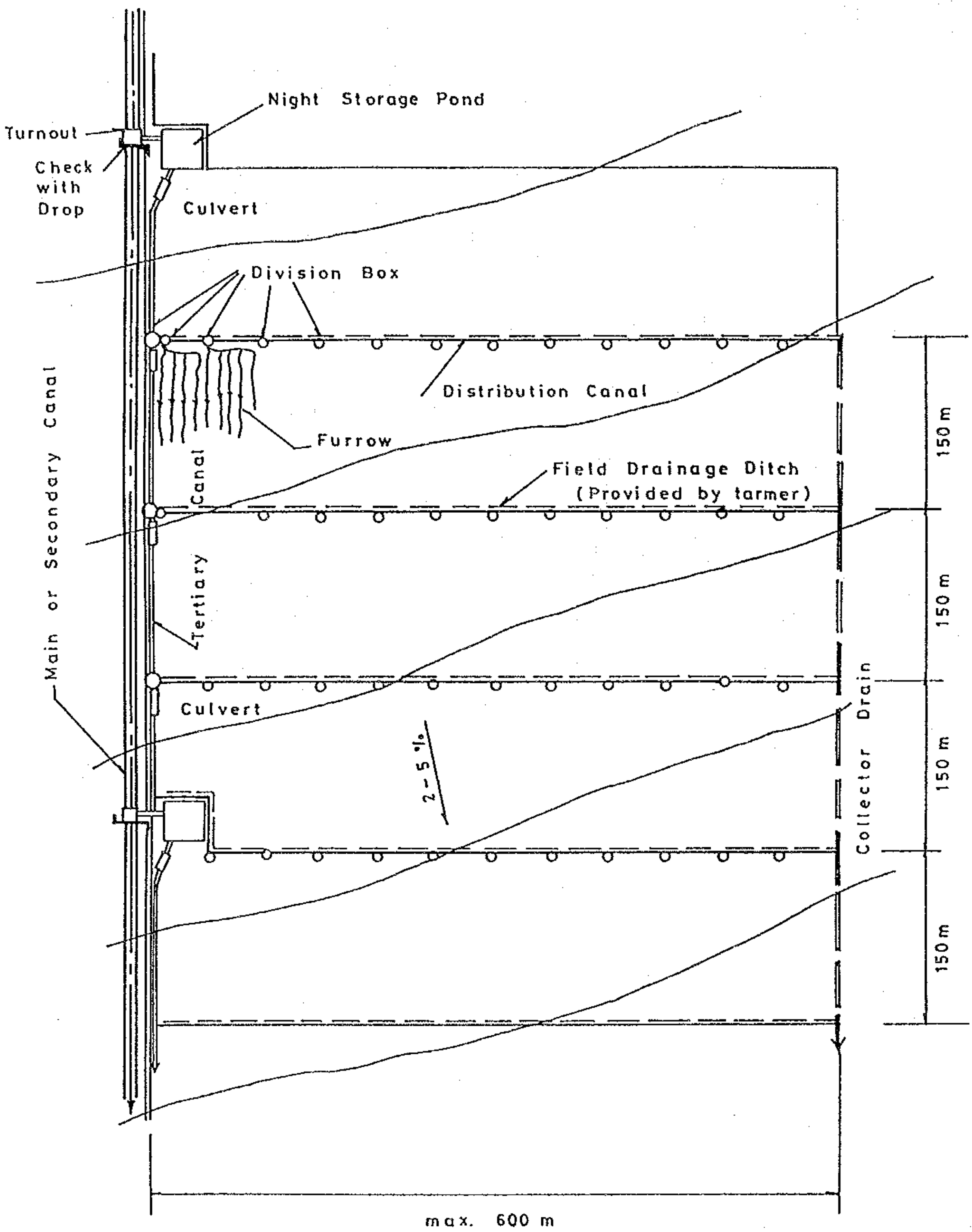


Fig. 5-1 TYPICAL FIELD LAYOUT

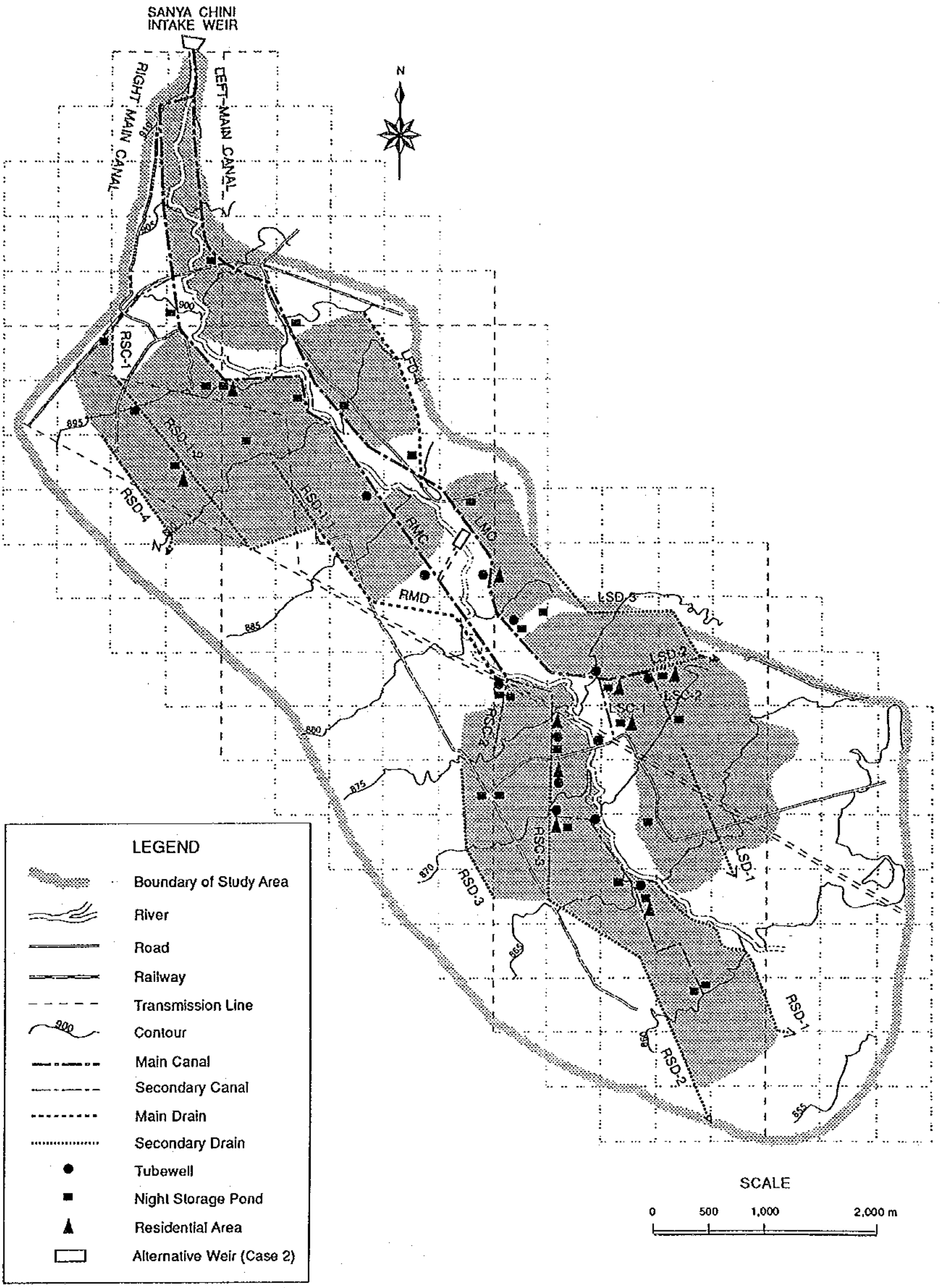
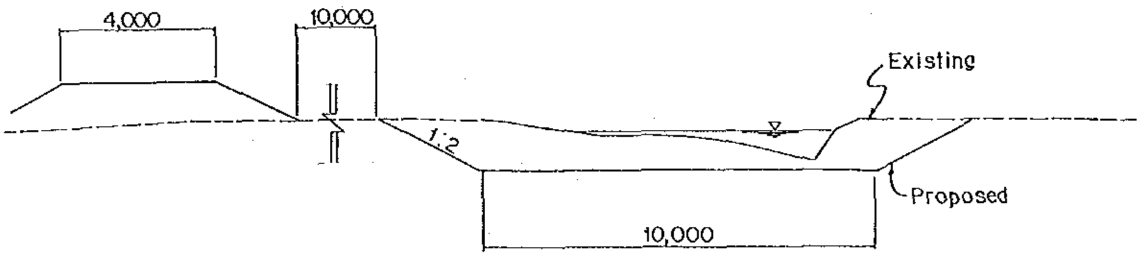


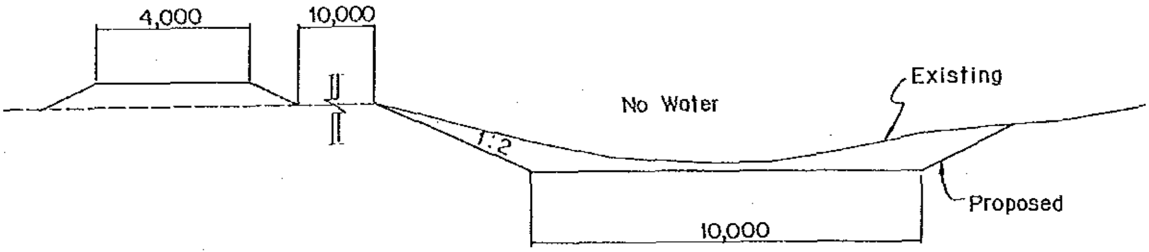
Fig. 5-2 GENERAL LAYOUT OF PROJECT FACILITIES IN SANYA PLAIN

(1) About 15km Upstream of Mtakuja

(2) About 9 km Upstream of Mtakuja



(3) Middle in Mtakuja



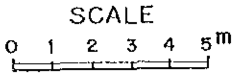


Fig. 7-1 CROSS SECTION OF KIKULETWA RIVER

ANNEX G

ENGINEERING DESIGN

ANNEX G

ENGINEERING DESIGN

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1. GENERAL

Preliminary design of project facilities is made based on the optimum development plan in Sanya plain. The project works consist of the Boloti dam and reservoir and the related structures such as the Lawati diversion works, outlet works and spillway, irrigation and drainage facilities, tubewells, and road networks. Main features of the facilities are summarized in Table 1-1.

2. SOIL MECHANICS

2.1 General

Soil mechanics investigations were carried out before preliminary design of project facilities, especially for development of the Boloti dam. The main objectives :

(1) To clarify the foundation conditions of the proposed Boloti Dam,
(2) To clarify the soil mechanics characteristics of embankment materials for the dam and canals, and
(3) To identify the proposed borrow areas of the earth materials for embankments and the quarry sites for concrete aggregates.

The field investigations on site were carried out at feasibility level at the proposed dam site, intake sites, canal routes, and borrow area. Laboratory tests on the soil samples obtained at the test pits were conducted at the Material Testing Section of Ministry of Water, Dar es Salaam. The laboratory testing items were as follows :

(1) Gradation analysis,
(2) Compaction tests,
(3) Permeability tests,
(4) Shearing tests,
(5) Consolidation tests, and
(6) Consistency tests.

2.2 Foundation of Dam

Test pits about 2.5 m deep were dug at three points along the axis of the proposed dam. Also for making the permeability tests, borings were made at five points along the dam axis and east edge of the Boloti swamp. The locations are shown in Fig. 2-1.

The proposed dam axis is covered by top soil of which the thickness is around 0.3 m only. Then grayish cemented soil layer is observed underneath the top soil at all the points examined. The soil contains many stones and is firmly compacted. The thickness of the cemented soil is at least 5 m judging from the boring results. The bearing capacity is strong enough to support a low dam.

The permeability test was carried out in the cemented soil layer. After washing the bore hole with clean water, a perforated pipe was installed and filter gravel was filled around the perforated pipe. Then groundwater level was examined, but except at A- and E-points, there was no groundwater within the borehole depth. Water was supplied constantly to the borehole. The discharge and the water level were measured at the time when the water level in the borehole became constant. Calculation of permeability coefficient was made by the following equations.

When groundwater level is deeper than three times the water depth of bore hole,

$$k = Q/6.283/h^2 \times (\ln (h/r+/1+(h/r)^2)-1)$$

When groundwater level exists in-between water depth in bore hole and three times the water depth of borehole,

$$k = (3 \times Q \times \ln (h/r)/(3.1416 \times h (h + 2 \times Tu))$$

When groundwater level exists in bore hole,

$$k = (Q \times \ln (h/r)/(3.1416 \times Tu (2 \times h - Tu))$$

Where,
- k : permeability coefficient
- Q : discharge
- h : water depth in bore hole
- r : radius of bore hole
- Tu: groundwater level below water surface in borehole

The results of permeability tests are shown in Table 2-1. The biggest permeability observed was 6.4×10^{-5} cm/sec at C2 point and the lowest was 2.2×10^{-5} cm/sec at F-point. The average is 3.9×10^{-5} cm/sec. It is judged from these results that the cemented soil layer has low and constant permeability along the dam axis.

2.3 Dam Embankment Materials

In order to find a borrow area for the dam embankment material and to clarify the soil mechanics characteristics as dam embankment materials, 13 test pits in total were dug on both sides of Boloti Swamp and along the proposed diversion canal route. From the test pits, twelve soil samples were sent to the Laboratory of Ministry of Water in Dar es Salaam, and laboratory tests were carried out. The results of these tests are summarized in Table 2-2 and the location of the sampling pits are shown on Fig. 2-1.

As seen in the Table and grain size distribution on Fig. 2-2, samples taken at BO6 point, contain much silt and clay, 80 % of all and little sand less than 15 %. Other samples taken around the Boloti swamp contains much gravels ranging from 40 % to 64 %, sand from 23 % to 40 %, and silt including clay 9 to 36 %.

Fig. 2-3 shows compaction curves of samples carried out by means of standard Proctor test. As shown in Table 2-2, the result shows that the samples from BO5, BO7 and BO8 are relatively high dry density more than 1.75 g/cm^3 with low values of optimum moisture content from 17 % to 24 %.

Direct shearing tests were conducted on the soils and the results indicate high angles of internal friction, 33.5° to 43.5° except sample of BO6, and low cohesion around 0.1 to 0.2 kg/cm^2.

From the proctor tests and the direct shearing tests, the samples taken from BO7, BO8, and BO9 are considered to be suitable for dam embankment material in terms of structural strength. Also the laboratory test results of permeability of compacted soil indicate that these are low enough to adopt it for dam embankment. Based on the soil mechanic test mentioned above, proposed borrow areas are conceivable at the shoulder of and along the proposed dam axis as shown on Fig. 2-1.

2.4 Canal Embankment Material

In order to examine its suitability for canal embankment, soil samples were taken at three points in the Sanya plain as shown in Fig. 3-1 of Annex D and were sent to the Soil Laboratory of Ministry of Water. The results obtained are shown in Table 2-2. They indicate that the samples contain silt and clay as much as around 80 % and about 15 % of sand on an average. Though these soils are little bit weak structually, they are acceptable to be used for canal embankment in the Project because of low height of embankment, 2 m or less at maximum, particularly in lined canals proposed.

2.5 Fine Aggregate

For the purpose of classification as fine aggregate for concrete, gradation analysis was made of the sand materials obtained at Kiteto quarry site located near the Kikuletwa. At that site, sand is conveyed by the seasonal river in the rainy season and deposited 10 - 30 m in width along the river. The grain size distribution of the sand shows a good grading curve for concrete fine aggregate as shown on Fig. 2-4.

2.6 Coarse Aggregate

In Boma Ng'ombe, a private company is producing coarse aggregate by a crushing plant having a capacity of 5 m^3/hr. According to information from the company, materials such as boulders and cobble stones are collected by tipper from lahar especially Rundugai. An other source is the Karanga river and the Weru Weru river but these sites are far from the Project area.

3. BOLOTI DAM AND THE RELATED FACILITIES

The design of the Boloti dam and related facilities was made in accordance with the optimum development plan selected based on the water balance simulation study described in Annex F.

3.1 Boloti Reservoir

The area-elevation and the storage volume-elevation curves in the Boloti reservoir were developed by use of a detailed topographic map at a scale of 1 : 5,000. They are shown in Fig. 3-1.

Based on the capacity required for the reservoir estimated by the water balance study and the above-mentioned curves, the features of the reservoir was determined as follows:

Effective storage capacity	:	7.5 MCM
Dead storage capacity	:	0.6 MCM
Water surface area at HWL	:	1.7 km^2
Low water level (LWL)	:	1,072.6 m
High water level (HWL)	:	1,078.0 m
Flood water level (FWL) (Refer to Section 3.3)	:	1,078.38 m

3.2 Boloti Dam

3.2.1 Freeboard and dam crest elevation

The crest elevation of the dam was determined to be more than the flood water surface plus a freeboard consisting of wave height and some allowance as shown in the following calculation :

$$Hc = Hd + hw + 1 \text{ or}$$
$$Hc = Hd + 2, \text{ if } hw < 1.0$$

where, Hd : Design flood water level (m)
hw : Height of wave due to wind (m)
V : Wind velocity (m/sec)
F : Fetch (m)
hi : Allowance according to type of dam (1.0 m in case of fill type dam)

As described in Section 3.3, the peak overflow depth is estimated at 0.38 m and the high water level is 1,078.0 m. Thus the flood water level is 1,078.38 m.

The height of wave is estimated at 0.5 m by S.M.B and Saville method on the assumption of the wind velocity of 20 m/sec and the maximum fetch of 2,000 m from the dam to the opposite shore. Thus from the second equation, the dam crest elevation is determined to be 1,080.4 m, and the maximum dam height from the present river bed becomes 7.8 m from the ground surface.

3.2.2 Dam type and the design

The dam type was determined from the economic view point considering the availability of construction materials and also the geological and topographical conditions. Based on the results of geological and soil mechanics investigations as described above, the dam type is decided to be of homogeneous earth fill to be built by soil available at the shoulder of and along the dam site as shown on Fig. 2-1. For protection of upstream slope against sliding and erosion, rock riprap protection is provided. The thickness is determined to be 50 cm. Features of the Boloti dam are shown in Fig. 3-2.

(1) Stability

The upstream and downstream slopes are determined to be 1:2.2 and 1:2.0, respectively on the basis of the stability analysis explained below:

1) Unit weight of soil : 2.04
2) Internal friction angle : 35°
3) Cohesion of earth : 0.07 ton/m^2
4) Calculation conditions
   - Case-1 : Full water with seismic condition
   - Case-2 : Rapid drawdown (-2 m)
   - Case-3 : Empty (after construction) with seismic condition
5) Calculation results : See Fig. 3-3
6) Safety factor:

Slope	Upstream (1:2.2)	Downstream (1:2.0)
Case-1	2.9	1.6
Case-2	1.4	1.4
Case-3	1.3	1.2

(3) Seepage loss

The results of the laboratory tests show to be of permeability order of 10^{-5} cm/sec, which are almost the same as those of the dam foundation. Thus the following equation is applied to estimate the seepage losses through the dam and the foundation.

$$Q = (4 \times k \times H^2 / 9 / l + k \times H \times h / l) \times L$$

Where, Q : seepage losses
k : permeability coefficient
H : average water depth in pond

l : horizontal length of seepage line
h : depth of impermeable layer from the bottom of the pond
L : length of pond embankment

The seepage losses through the dam embankment and the foundation is estimated at 302 m^3/day on the following conditions:

1) permeability of dam embankment: the same of that of the foundation,
2) water depth: 4.5 m,
3) horizontal length of seepage line in the embankment: 27.6 m
4) depth of impermeable layer: 20 m, and
5) length of the dam: 2,500 m.

3.3 Spillway

Design flood for the spillway was determined on the basis of peak flood discharge of 200-year probability of occurrence considering the storage effect of the reservoir. The peak flood discharge of the Rawashi river inflow to the reservoir is estimated at 41 m^3/sec by means of Rational formula using the rainfall data of the Masama Sawe rainfall station as described in Annex B. The design peak discharge of spillway is estimated at 4.6 m^3/sec flowing over the spillway of 10 m overflow section at maximum depth of only 38 cm.

Ungated overflow type concrete weir is adopted so as to naturally release excess water whenever the reservoir water level exceeds the normal high water level. The proposed spillway is designed on the left side of dam and consists of an overflow section, chute section, and stilling basin. The length of the overflow section is determined to be 10 m so as to drain excess water within 2 days.

3.4 Outlet Works

Two outlet works are provided in the proposed dam. One is the outlet to the Sanya river through the outlet canal for the water diversion to the downstream irrigation systems, and the other is the outlet to the Boloti irrigation area located immediately downstream of the proposed dam site. These layouts are shown in Fig. 3-2.

(1) Outlet and the canal to the Sanya river

The design discharge is the maximum diversion requirement estimated at 0.7 m^3/sec in the water balance study. The outlet structure will consist of a gated inlet, a conduit and an outlet. The conduit will be made by precast concrete pipe of 0.8 m diameter wrapped with reinforced concrete. The outlet will be furnished with a measuring device. The upstream half of the outlet canal is trapezoidal lined canal and the downstream half, which is steep in the longitudinal section, is designed as a rectangular chute. The total length is about 1.4 km.

(2) Outlet structure to the Boloti area

The outlet structure is almost the same as that to the Sanya river. The outlet canal will connect to the existing canal immediately after the outlet structure.

3.5 Lawati Diversion Weir and Diversion Canal

(1) Diversion point and diversion canal route

A diversion weir and a diversion canal is provided to convey the water from the Lawati river to the Boloti reservoir. Two alternatives are conceivable in the route of the diversion canal. One is the route running along the asphalt-paved road connecting Sanya Juu with Boma Ng'ombe and another is the route diverted at about 1 km upstream of the confluence of the Sanya river and detouring to avoid eminence existing between the Lawati river and the Boloti Swamp.

Both routes were examined by use of detail topographic maps at a scale of 1 : 5,000 and field reconnaissance. The former route is about 2.6 km long and requires a steep canal gradient or many drops to dissipate high hydraulic heads in the downstream half of the route, but the diversion weir is expected to become the smallest, because of the shallow depth and narrow width of the river and firm foundation consisting of tuff. The latter route is about 2 km and instead of steep canal gradient or many drops, requires rather high diversion weir as high as some 8 m, because the river forms deep gorge of about 10 m depth. From the view points of the easiness of the construction works and the costs, the former route is selected for the diversion canal.

The diversion weir is proposed at about 800 m upstream from the bridge on the Lawati river crossing Sanya-Juu road, where the depth of the river is about 5 m from the both banks and the bottom width is about 6 m. In the both banks and river bed, weathered tuff is partly exposed. In order to confirm the location of the tuff, a pit was dug at the river bank of proposed intake site and the weathered tuff was found at about 0.6 m below the ground surface.

The preliminary design of the diversion weir was made, taking these topographic and foundation conditions into account.

(2) Weir

The proposed weir is of fixed overflow weir type. The height of the weir is determined to be 2.3 m above the downstream apron, considering the intake water level. The crest length of the weir is determined at 16 m by the following equation so that the the length of the overflow section should be sufficient for passing the flood discharge, 56 m^3/sec of 50-year probability of occurrence estimated by the rational formula in Annex B, without appreciable back water effects to the upstream.

$$B = Q/CH^{3/2}$$

Where, B : Crest length required (m)
C : Discharge coefficient (= 2.0)
H : Overflow depth (m)
Q : Flood discharge (m^3/sec)

The length of downstream apron is determined at 3.6 m based on the estimation by Bligh's method as follows:

$$L = 0.6 \times C \times (D)^{0.5}$$

where, L : Length of front apron
C : Bligh's C (assumed at 4)
D : height of weir from the end of apron

A scouring sluice equipped with a slide gate; width of 1.6 m and height of 2.3 m will be provided in front of the inlet.

(3) Intake structure

The design of the intake structures based on the diversion requirement of 3.0 m^3/sec obtained from water balance study. The water level at the head of intake is decided to be 1,153.3 m in elevation, taking into account the velocity of flow less than 1 m/sec at the inlet of the intake structure together with the topographic conditions.

Intake structure consists of a inlet equipped with two slide gates, a rectangular-shaped channel, and sand settling basin.

Inlet gate	:	2.3 m H x 1.6 m W x 2 nos
Sand settling basin	:	rectangular concrete flume 5 m wide x (2.1 - 3.1 m high) x 80 m long

(4) Diversion canal

Trapezoidal lined canal type will be adopted in the upstream half where the ground surface slope is gentle and chute being rectangular flume type will be adopted in the downstream half where the ground surface slope is rather steep. At the end of the chute, a stilling basin Type III of USBR type will be provided. The total length of the diversion canal is about 2.7 km. On the way, three culverts and three drop will be provided for crossing existing roads and for dissipating excess energy. The box type of culvert will be adopted considering the design discharge of 3 m^3/sec.

4. GROUNDWATER DEVELOPMENT

4.1 General

Groundwater development potential in Lower Hai and Lower Rombo areas was studied with respect to the potential area, the availability, and the quality. Promising groundwater development area for irrigation development was selected in the lower Sanya river plain and the features of tubewells are determined based on the test-drilling and pump-up tests and electric prospecting survey as described in Annex C and as summarized below:

Design discharge	:	50 lit/sec on an average
Depth of tubewell	:	65 m on an average
Drilling diameter	:	500 mm
Casing diameter	:	350 mm
Head	:	20 m on an average
Filter	:	Gravel filling
Spacing between tubewells	:	500 m at minimum

4.2 Number of Tubewells and the Layout

The area to be served by groundwater resources as well as surface water resources is 610 ha in total consisting of 370 ha in the west bank of the Sanya river, and 240 ha in its east bank determined from land resources and groundwater promising area. Peak irrigation requirement is 0.9 lit/sec/ha. Thus the required amount of water is 0.33 m^3/sec for the irrigation in the west bank, or 0.22 m^3/sec for the east bank area. Each tubewell will have a capacity of 50 liter per second on average. Thus the required number of tubewells is seven in the west bank area and five in the east bank area. The tubewells will be laid along main and secondary canals at intervals of more than 500 m within the groundwater-promising area.

4.3 Pump and Electric Facilities

The total head required for pumping-up differs from place to place and is estimated at 10.1 m in the downstream area and at 30.5 m in the most upstream tubewell as listed in Table 4-1, on the assumption that the groundwater surface is level. Principal features of pumps are as follows:

Type	:	submersible
Discharge	:	30 - 70 lit/sec
Total head	:	10.1 to 30.5 m
Motor output	:	30 kW
Synchronous speed	:	2,860 rpm

The pump is manually started and stopped from the pump house, further it can be automatically stopped when water level in the well exceeds the allowable low level. In order to maintain the proper and the efficient operation, a check valve, a sluice valve, an air valve, a compound gauge, etc., will be furnished. Fig. 4-1 shows features of the typical tubewell.

33 kV electric transmission line from Kikuletwa hydropower station to Arusha runs across the center of the Sanya plain from south-east to north-west. Considering the location of this line and the proposed tubewells and the distance from the line to the tubewells, the electric distribution lines from the 33 KV line to tubewells were laid out as shown in Fig. 5-2 of Annex F in consultation with TANESCO. Three transformers having a capacity of 250 kVA in each, which includes the capacity of the domestic supply of electricity about 50 kVA, are proposed to be provided along the 33 KV line and the distribution lines are to be branched off from these transformers. The lines are three phase low tension of 400 V and the total length is estimated at about 12 km.

5. IRRIGATION AND DRAINAGE SYSTEMS

5.1 Irrigation System

5.1.1 Sanya Chini headworks

The Sanya Chini headworks will be used as the intake structure for the Sanya plain after its rehabilitation and the improvement. Only one inlet structure is provided at the left bank and the water is diverted to the right command area at the 400 m downstream point through the syphon crossing the Sanya river. Present inlet will be demolished and scouring sluice equipped with a slide gate will be provided at present left intake point. New inlet equipped with a slide gate will be built just upstream of the new scouring sluice in perpendicular to the river flow direction. The downstream apron will be reinforced with concrete, and the both banks will be heightened by about 1 m to drain flood safely to downstream. immediately after the inlet, a sand trap pond will be provided so as to catch sediment having a particle size over 0.3 mm. The main features are shown below:

Design flood	:	170 m^3/sec (See Annex B)
Design intake discharge	:	1.05 m^3/sec
Intake water level	:	EL. 910.16 m (Weir crest)
Weir	:	height; 1.6 m above the downstream apron, crest length; 26.9 m
Scouring sluice	:	slide gate, 1.0 m W x 1.8 m H
Inlet	:	slide gate, 2.0 m W x 0.8 m H
Sand trap pond	:	rectangular length; 16.0 m, width;1.5 m, height; 1.2 m - 1.7 m sand-flushing gate; dia.0.6 m

5.1.2 Irrigation canal

Open canal system is adopted, since it is very familiar in Kilimanjaro Region and is easy in maintenance.

(1) Design discharge

In case of main and secondary canals, water is conveyed on a 24 hour basis. Thus the design discharge of the main and secondary canals is the product of peak irrigation water requirement of 1.0 lit/sec/ha and the canal-commanding area.

In case of tertiary and distribution canals, the operating hours are 16 hour a day at peak irrigation season and the peak irrigation water requirement is 0.9 lit/sec/ha. The design discharge of tertiary canals is calculated by multiplying the peak irrigation water requirement by hourly factor of operation and the irrigation area of the tertiary block. In a tertiary block, rotational irrigation will be applied, thus the distribution canals should have the same capacity as the tertiary canals. According to the canal layout, the largest tertiary block commands 45 ha and thus the design discharge is about 60 lit/sec, which is small enough to be conveyed by a small canal. Thus the design discharge of tertiary and distribution canals is decided to be 60 lit/sec.

The design discharge of the irrigation canals are shown in Fig. 5-1 and summarized as follows:

Left Main Canal	:	0.17 m^3/sec to 0.41 m^3/sec
Right Main Canal	:	0.33 m^3/sec to 0.64 m^3/sec
Secondary canals	:	0.06 m^3/sec to 0.21 m^3/sec
Tertiary and distribution canals	:	0.06 m^3/sec

(2) Canal lining

The water available for irrigation is limited. Furthermore, results of soil tests indicate that soils in the area have rather high permeability and that have a low resistance to erosion. Consequently, canal lining is introduced for water saving and canal protection in the main, secondary and major tertiary canals. The precast concrete block lining, which is very familiar in Kilimanjaro region, is used. No lining is made on distribution canals.

(3) Design criteria

Allowable velocities and roughness coefficient

Type of canal	Maximum velocity	Minimum velocity	Roughness Coefficient
Lined canal	1.5 m/sec or 2/3 of critical velocity, whichever smaller	0.3 m/sec	0.015
Unlined canal	0.9 m/sec	0.3 m/sec	0.030

Inside and outside slopes

Type of canal	Inside Slope	Outside Slope
Lined canal	1 : 1.0	1 : 1.5
Unlined canal	1 : 1.5	1 : 1.5

(4) Design

In accordance with the design criteria and based on the topographic conditions, headreach and East and West Main Canals and their secondary canals were designed as shown in the Drawings. Also tertiary canals and distribution canals were uniformly designed. The typical cross section of irrigation canals are shown in Fig. 5-2.

The main features of canals are shown below:

Headreach	:	Length;	0.4	km
		Canal bottom width;	0.7	m
		Canal height;	0.9	m
East Main Canal	:	Length; 6.7 km		
		Canal bottom width;	0.4-0.3	m
		Canal height;	0.7-0.6	m
West Main Canal	:	Length; 6.8 km		
		Canal bottom width;	0.5-0.4	m
		Canal height;	0.8-0.7	m
Secondary canals	:	Nos of canal;	5	
		Total length;	7.6	km
		Canal bottom width;	0.4-0.3	m
		Canal height;	0.6-0.4	m
Tertiary canals	:	Nos of canal;	32	
		Total length;	21.2	km
		Canal bottom width;	0.3	m
		Canal height;	0.4	m

5.1.3 Related structures

Various kinds of structures such as turnouts, checks, drops, culverts, and spillways are required for efficiently and safe conveyance of irrigation water.

(1) Siphon

In order to convey the water crossing the Sanya river, an inverted siphon will be provided on the Right main canal, 40 m downstream from the Beginning point of RMC. The siphon consists of inlet and outlet pits, and siphon barrel. The pits are of reinforced concrete construction, and the syphon barrel is of precast concrete pipe of 0.8 m diameter.

(2) Turnout

Turnouts will be provided to divert water from main or secondary canals to night storage ponds or directly to tertiary canals. The turnout will consist of an inlet equipped with a slide gate, a barrel made of precast pipes, and an outlet box having an overflow section to measure the inflow discharge.

(3) Check

Checks will be provided just downstream of turnout points on main and secondary canals to control water level so as to be able to divert water to night storage ponds or directly to tertiary canals through turnouts. The check is equipped with a slide gate to control water level and in order to avoid accidental water rising and overtopping canal banks, and to reduce the operation of the check gate, overflowing sections are provided in both sides of the gate portion.

(4) Drop

Drops will be provided at steep gradients to despite the excessive hydraulic head and to maintain canal flow velocity within the allowable limit. A vertical type drop is adopted since even the main canals are small-scale in design discharge and the fall of drops is 1 m or less.

(5) Culvert

Culverts will be provided at road-crossing points. The culvert consists of wing-walls at the both ends and a barrel built by precast concrete pipes. The size of the barrel is determined so that the velocity in the barrel ranges from 1.1 times to 1.3 times velocity of the upstream and the downstream.

(6) Canal spillway

Spillways will be provided to drain excess water on main canals. The type is side-channel overflow type with or without a gated structure to drain canal water entirely.

(7) Night storage pond

Night storage ponds will be provided at tertiary canal heads, where water carried through main or secondary canals is diverted through turnouts, to tentatively store water at night time when irrigation operation is ceased. Effective depth of night storage pond is determined to be 1 m considering the small storage requirements and avoiding high embankment in the parent canal as well as the pond itself, and deep cut in the off-taking tertiary canal. The inside slope of pond embankment is decided at 1 in vertical to 2 in horizontal. The outside slope is 1 : 1.5. The inlet consists of fixed overflow weir, conduit and outlet. The outlet structure will be equipped with an automatic gate keeping constant water level in the downstream canal so as to keep constant discharge. Fig. 5-13 shows the typical night storage pond. In order to drain excess inflow, a spillway to return excess water to the parent canal will be provided. It is only a barrel made by precast concrete pipes.

The capacity of night storage ponds is estimated by the following equation:

$$Qc = 36,000 \times IRp \times A \times (24 - T2) \times (1 + f)$$

Where, Qc : capacity of pond (m^3)
IRp: peak irrigation requirement (0.9 lit/sec/ha)
A : irrigation area (ha)
T2 : daily operation hours, 16 hours at peak
f : allowance of capacity, 0.1

The capacity of each pond is shown in Table 5-1.

(8) Division box

Division boxes will be provided on tertiary canals at the diversion points to the distribution canals and on distribution canals at an interval of about 100 m to supply water to fields. It will be provided with stoplogs.

5.2 Drainage System

5.2.1 Drainage canal

(1) Design discharge

Design discharge of drainage canals is the product of drainage requirement, 6.4 lit/sec/ha and the command area. The design discharge of drains is shown in Fig. 5-1.

(2) Design criteria

Canal type	:	Trapezoidal section, earthen canal
Side slope	:	1 : 1.5
Allowable velocity		
Maximum velocity	:	0.9 m/sec
Minimum velocity	:	0.3 m/sec
Roughness coefficient	:	0.035 for Manning formula

(3) Design

Main drains, corresponding to main to tertiary irrigation canals will be constructed. The total length is about 18.1 km and the drainage features are as follows:

Canal bottom width	:	0.5 - 1.0 m
Canal depth	:	0.4 - 1.5 m

5.2.2 Flood protection dike

The Sanya river is flooding every year in the lower reaches and the most downstream of the west bank of the project area is affected by this flooding. According to the evidence of villagers, the flooding water depth is knee high. Thus, in order to protect the project area against flooding, a flood protection dike is proposed to be built about 2 km along the west bank of the Sanya river, having a height of 1.3 m on average and a crest width of 3 m.

5.2.3 Related structures

Drainage canals requires drop structures, culverts, and junction protections for dissipating excess hydraulic head, road and canal crossing, and protecting drainage canals against erosion at major junction points, respectively.

The drop structures and junction protections will be built by use of gabions. The culverts will be of two types; one is precast concrete pipe type in case of small design discharge less than 1 m^3/sec and the other is box concrete type where the design discharge is over 1 m^3/sec. The culvert's inlet and outlet are protected by gabion or rock riprap.

6 ROAD

6.1 Road

All the roads to be provided in the project area and an access road to Boma Ng'ombe are planned to have a total width of 7 m and to be paved with marrum material.

6.2 Related Structures

Structures related to the roads are irrigation and drainage culverts, which have been already described in Chapter 5, and river-crossing structures to be provided across the Sanya river at three points. Alternatives for the river-crossing will be an ordinary bridge crossing over the river and a submersible causeway. The Submersible way is the more economical. In this case, the discharge of the Sanya river is expected to be little for most of the year except during storm time downstream of the Sanya Chini headworks. Accordingly, the submersible way is introduced for the river-crossing. It will be protected by concrete against scour and equipped with a pipe culvert to convey river water downstream without submergence of the road surface in time of low river flow.

Table 1-1 MAIN FEATURES OF PROJECT FACILITIES (1/2)

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1. Lawati Diversion Weir and Diversion Canal

1.1 Lawati diversion weir

(1) Catchment area	: 41 km2
(2) Design discharge	: 56 m3/sec
(3) Weir type	: Fixed overflow type concrete weir
(4) Weir height x crest length	: 2.3 m x 16.0 m

1.2 Lawati diversion canal

(1) Canal type	: Torapezoidal concrete lined canal
(2) Design discharge	: 3.0 m3/sec
(3) Canal length	: 2.7 km
(4) Related structure	
- Chute	: 1 nos.
- Drop	: 3 nos.
- Culvert	: 3 nos.

2. Boloti Reservoir

2.1 Boloti dam

(1) Catchment area	: 14 km2
(2) Effective storage capacity	: 7,500,000 m3
(3) Dead water capacity	: 600,000 m3
(4) Maximum dam height x crest length	: 7.8 x 2,450 m
(5) High water level	: 1,078.0 m
(6) Low water level	: 1,072.6 m
(7) Crest elevation	: 1,080.4 m

2.2 Spillway

(1) Spillway type	: Ungated overflow concrete type
(2) Design flood discharge	: 4.6 m3/sec
(3) Crest length	: 10.0 m

2.3 Outlet works : 2 nos.

2.4 Outlet Canal

(1) Canal type	: Torapezoidal concrete lined canal
(2) Design discharge	: 0.7 m3/sec
(3) Canal length	: 1.4 km
(4) Related structure	
- Chute	: 2 nos.
- Drop	: 2 nos.
- Culvert	: 4 nos.

5. Sanya Irrigation System

5.1 Sanya Chini intake weir (Rehabilitation)

(1) Design discharge	: 170 m3/sec
(2) Weir type	: Fixed concrete weir
(3) Weir height x crest length	: 1.6 m x 26.9 m

Table 1-1 MAIN FEATURES OF PROJECT FACILITIES (2/2)

5.2 Headreach and main canal	
(1) Canal type	: Torapezoidal concrete lined canal
(2) Design discharge	: 1.05 m3/sec - 0.17 m3/sec
(3) Canal length	: 13.9 km
(4) Related structure	
- Siphon	: 1 nos.
- Drop	: 42 nos.
- Culvert	: 10 nos.
- Check	: 15 nos.
- Turnout	: 21 nos.
- Spillway	: 4 nos.
5.3 Secondary canal	
(1) Canal type	: Torapezoidal concrete lined canal
(2) Design discharge	: 0.207 m3/sec - 0.054 m3/sec
(3) Canal length	: 7.6 km
(4) Related structure	
- Drop	: 23 nos.
- Culvert	: 5 nos.
- Check	: 8 nos.
- Turnout	: 19 nos.
5.4 Tubewell (12 nos.)	
(1) Design discharge	: 50 lit/sec on an average
(2) Depth of tubewell	: 65 m on an average
(3) Head	: 10.1 m - 30.5 m (20 m on an average)
(4) Pump type	: Submergible
(5) Motor output	: 30 kW
5.5 Night storage pond (32 nos.)	
(1) Effective capacity	: 1,740 m3 - 340 m3
5.6 Drainage canal	
(1) Canal type	: Trapezoidal unlined canal
(2) Design discharge	: 1.65 m3/sec - 0.23 m3/sec
(3) Canal length	: 18.1 km
(4) Related structure	
- Drop	: 22 nos.
- Culvert	: 7 nos.
6. Road Network	
(1) Length x width	: 38.0 km x 6 m
(2) Pavement	: Morrum pavement
(3) Related structure	
- Submergible way	: 3 nos.
7. Flood Dike	
(1) Length	: 2.0 km
(2) Crest width	: 3.0 m

Table 2-1 PERMEABILITY TEST RESULT IN BOLOTI

Point	Depth if Drilling (cm)	Hole Dia. (cm)	G.water Level (cm)	ho (cm)	Q (cc/min)	Q (cc/sec)	Tu (cm)	k (cm/sec)
A1	350 *1	10.0	314	261.0	120.4	2.0	226	3.4E-05
A2	130	10.5	314	92.0	77.4	1.3	272	4.6E-05
B	430	14.0	450 *2	341.4	210.0	3.5	411	2.7E-05
C1	130	11.5		86.0	84.9	1.4		5.2E-05
C2	120	12.5		82.0	103.2	1.7		6.4E-05
D	420	11.5	450 *2	315.0	222.0	3.7	395	3.4E-05
E	130	9.0	124	93.0	22.8	0.4	87	3.4E-05
F	430	11.5	450 *2	361.1	180.0	3.0	431	2.2E-05
Average								3.9E-05

Remarks :*1: There exists sandy residual below 2.6 m to 3.5 m.
*2: Groundwater level was not confirmed and supposed 5.0 m below the ground surface.

Table 2-2 SOIL MECHANICS TEST RESULTS

Sample No.	B02	B03	B04	B05	B06	B07	B08	B09
Gradation								
Gravel	44.3	-	40.7	64.0	11.0	-	44.8	-
Sand	37.4	-	23.3	26.6	9.1	-	33.8	-
Silt and clay	18.3	-	36.0	9.4	79.9	-	11.4	-
Natural Moisture Content (%)	12.5	22.1	9.2	11.2	32.1	8.2	6.9	15.4
Compaction Test								
Optimum moisture content(%)	23.0	33.4	22.5	24.2	37.0	22.0	17.0	22.9
Maximum dry density(g/cm3)	1.58	1.35	1.51	1.80	1.47	1.76	2.02	1.72
Consolidation								
Compression index(cm2/kg)	0.0163	-	0.0494	-	0.0383	-	-	-
Shearing Straight								
Cohesion(kg/cm2)	0.18	0.16	0.11	-	0.26	0.05	0.10	0.10
Internal friction angle([)	33.5	38.5	36.0	-	21.0	43.5	37.0	37
Permeability (cm/sec)	3.6E-05	1.0E-05	8.6E-07	-	1.0E-05	2.9E-05	-	1.6E-05
Consistency Limit								
Liquid limit	-	-	-	-	63.8	-	-	40.0
Plastic limit	-	-	-	-	24.5	-	-	32.2
Plasticity index	-	-	-	-	39.3	-	-	7.8

Sample No.	B010	B011	A-point	E-point	SS5	SS7	SS15
Gradation							
Gravel	-	-	44	51	0.2	1.5	0.1
Sand	-	-	40	33	23.0	14.0	10.7
Silt and clay	-	-	16	16	76.8	84.0	89.2
Natural Moisture Content (%)	-	-	-	-	26.5	15.8	26.9
Compaction Test							
Optimum moisture content(%)	38.5	-	-	-	24.2	28.0	-
Maximum dry density(g/cm3)	1.30	-	-	-	1.80	1.68	-
Consolidation							
Compression index(cm2/kg)	-	-	-	-	-	-	-
Shearing Straight							
Cohesion(kg/cm2)	-	-	0.09	0.11	-	-	-
Internal friction angle([)	-	-	42.5	43	-	-	-
Permeability (cm/sec)	-	-	-	-	-	-	-
Consistency Limit							
Liquid limit	49.0	44.6	-	-	-	-	52.4
Plastic limit	35.9	29.3	-	-	-	-	33.1
Plasticity index	13.1	15.3	-	-	-	-	19.3

NOTE: Locations of sampling points of BO series, A and E points are shown on Fig. 2-1 and SS series on Fig. 3-1 of Annex D. These soil tests were made in Soil Mechanics Laboratory, Material Testing Section, Ubungo, Ministry of Water

Table 4-1 REQUIRED HEAD OF EACH TUBEWELL

Unit : m

Tubewell	Ground Surface Elevation	Static Water Level	Static Water Depth	Drawdown	Head Loss and Allowance	Required Head
JC2	869.0	866.0	-3.0	7	3	13.0
R1	886.5	866.0	-20.5	7	3	30.5
R2	881.5	866.0	-15.5	7	3	25.5
R3	881.0	866.0	-15.0	7	3	25.0
R4	879.0	866.0	-13.0	7	3	23.0
R5	874.2	866.0	-8.2	7	3	18.2
R6	868.5	866.0	-2.5	7	3	12.5
R7	868.1	866.0	-2.1	7	3	12.1
R8	866.1	866.0	-0.1	7	3	10.1
L1	882.2	866.0	-16.2	7	3	26.2
L2	880.2	866.0	-14.2	7	3	24.2
L3	875.9	866.0	-9.9	7	3	19.9
L4	873.5	866.0	-7.5	7	3	17.5
L5	873.2	866.0	-7.2	7	3	17.2
	Average head required					19.6
					≒	20

Note : Static groundwater level is assumed EL.866 m in all the area from the observation at JC2.
Drawdown is estimated from t-s curve of JC2 well (Fig.8 of main text of Interim report) assuming that the design yield is 50 lit/sec and elapsed time of 6 months.

Table 5-1 CAPACITY OF NIGHT STORAGE PONDS

No. of Tertiary Block	Parent Canal	Off-taking Canal	Irrigation Area (ha)	Capacity of Pond (m3)
Left Main Canal System				
LTC-0-2	LMC	LTC-0-2	30	860
LTC-0-3	LMC	LTC-0-3	41	1,170
LTC-0-4	LMC	LTC-0-4	39	1,110
LTC-0-5	LMC	LTC-0-5	21	600
LTC-0-6	LMC	LTC-0-6	26	740
LTC-0-7	LMC	LTC-0-7	42	1,200
LTC-0-8	LMC	LTC-0-8	30	860
LTC-1-1	LSC-1	LTC-1-1	25	710
LTC-1-2	LSC-1	LTC-1-2	30	860
LTC-1-3	LSC-1	LTC-1-3	25	710
LTC-2-1	LSC-2	LTC-2-1	31	880
LTC-2-2	LSC-2	LTC-2-2	61	1,740
Right Main Canal System				
RTC-0-3	RMC	RTC-0-3	32	910
RTC-0-4	RMC	RTC-0-4	32	910
RTC-0-5	RMC	RTC-0-5	32	910
RTC-0-6	RMC	RTC-0-6	34	970
RTC-0-7	RMC	RTC-0-7	35	1,000
RTC-0-8	RMC	RTC-0-8	40	1,140
RTC-1-1	RSC-1	RTC-1-1	34	970
RTC-1-2	RSC-1	RTC-1-2	34	970
RTC-1-3	RSC-1	RTC-1-3	20	570
RTC-2-1	RSC-2	RTC-2-1	25	710
RTC-2-2	RSC-2	RTC-2-2	41	1,170
RTC-2-3	RSC-2	RTC-2-3	12	340
RTC-2-4	RSC-2	RTC-2-4	41	1,170
RTC-3-1	RSC-3	RTC-3-1	23	660
RTC-3-2	RSC-3	RTC-3-2	22	630
RTC-3-3	RSC-3	RTC-3-3	33	940
RTC-3-4	RSC-3	RTC-3-4	27	770
RTC-3-5	RSC-3	RTC-3-5	34	970
RTC-3-6	RSC-3	RTC-3-6	34	970
RTC-3-7	RSC-3	RTC-3-7	34	970

Note : LMC and RMC; Left and Right main canals
LSC and RSC; Left and Right secondary canals

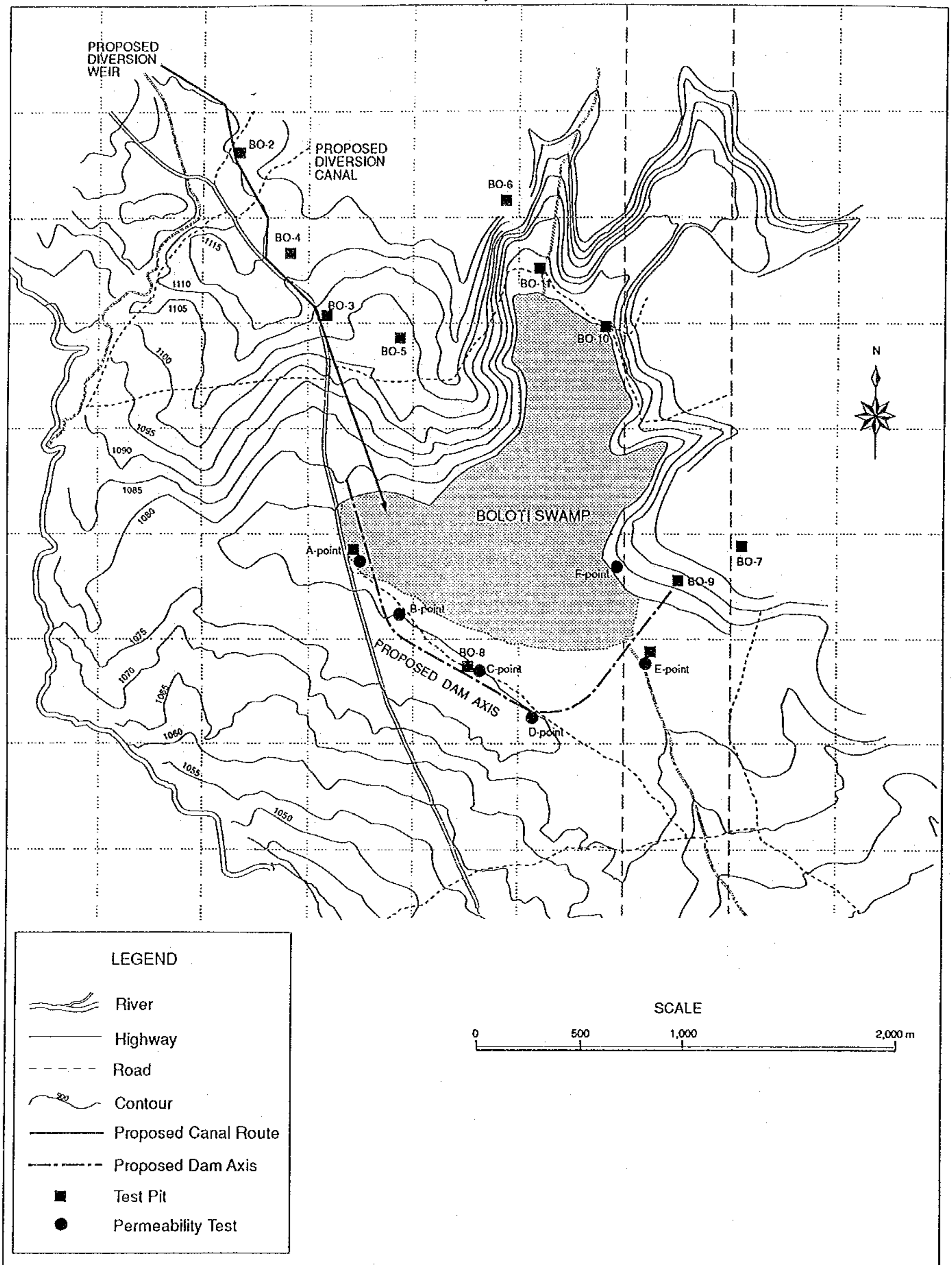


Fig. 2-1 LOCATION MAP OF SOIL MECHANIC INVESTIGATIONS

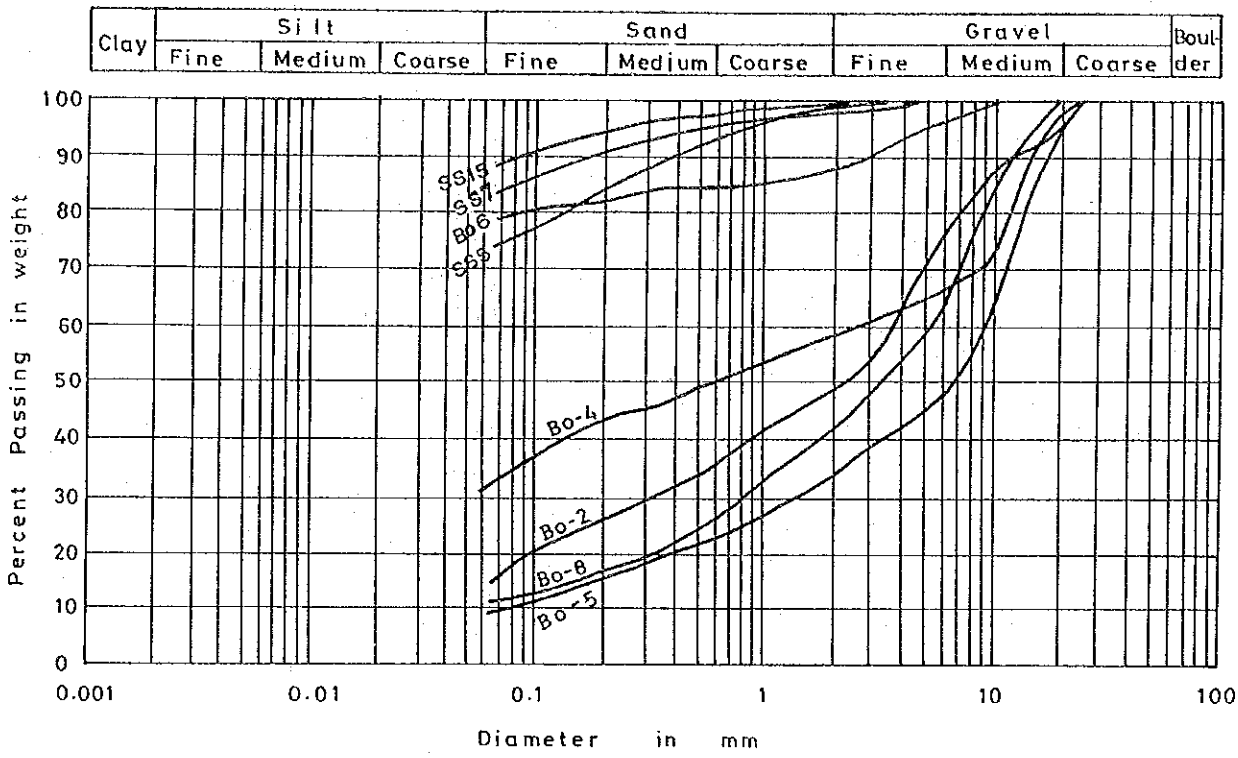


Fig. 2-2 GRAIN SIZE DISTRIBUTION OF EARTH MATERIAL

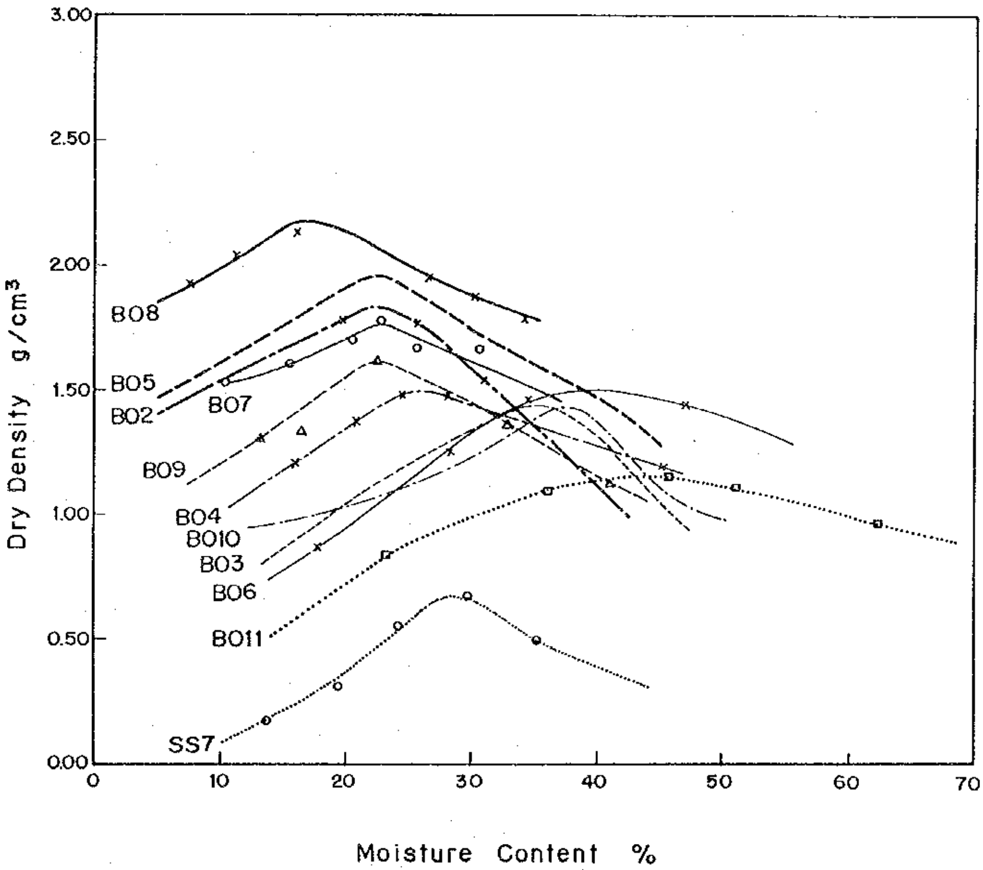


Fig. 2-3 PROCTOR TEST RESULTS

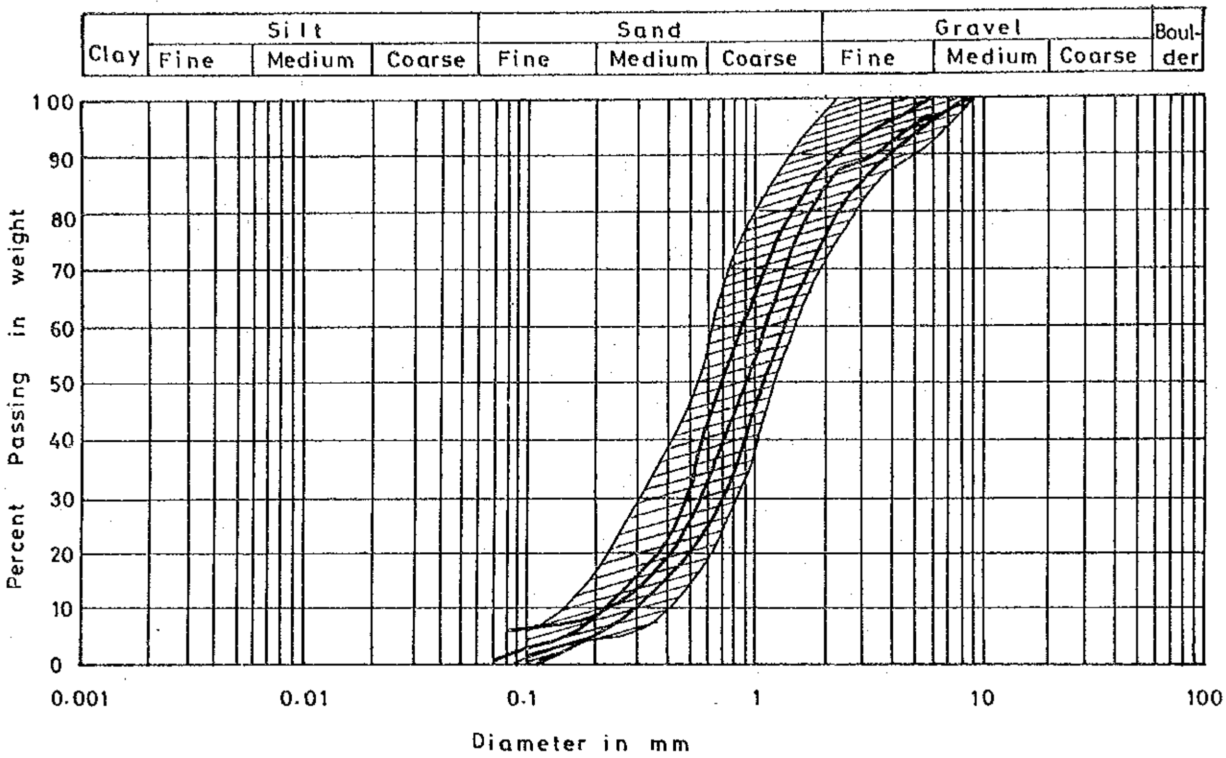


Fig. 2-4 GRAIN SIZE DISTRIBUTION OF FINE AGGREGATE

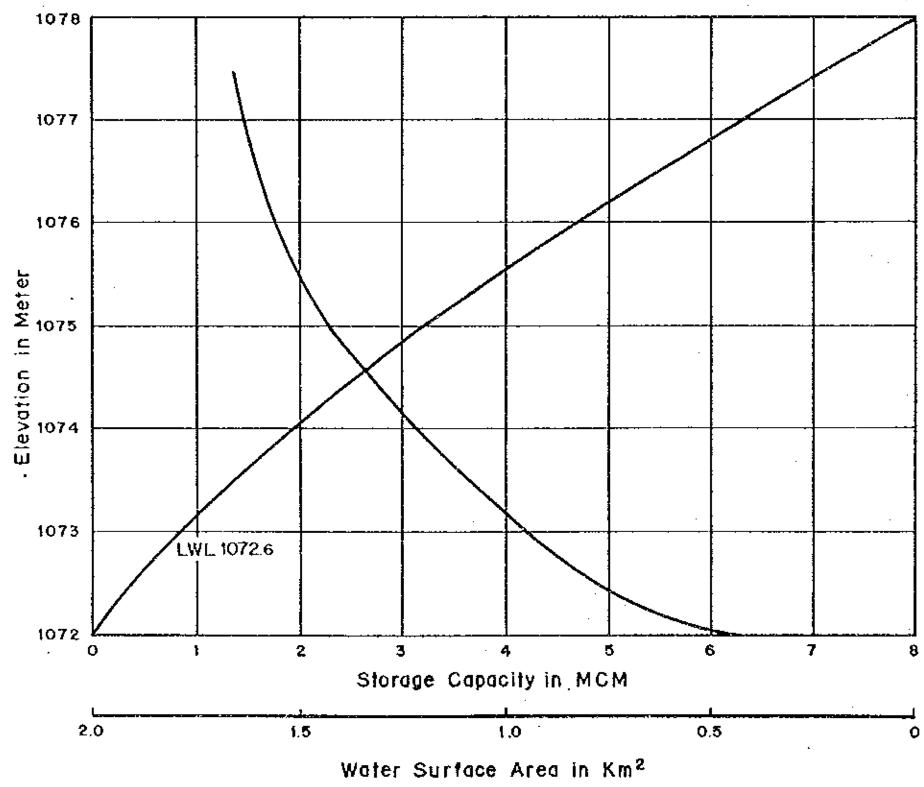


Fig. 3-1 AREA-STORAGE CURVE OF BOLOTI RESERVOIR

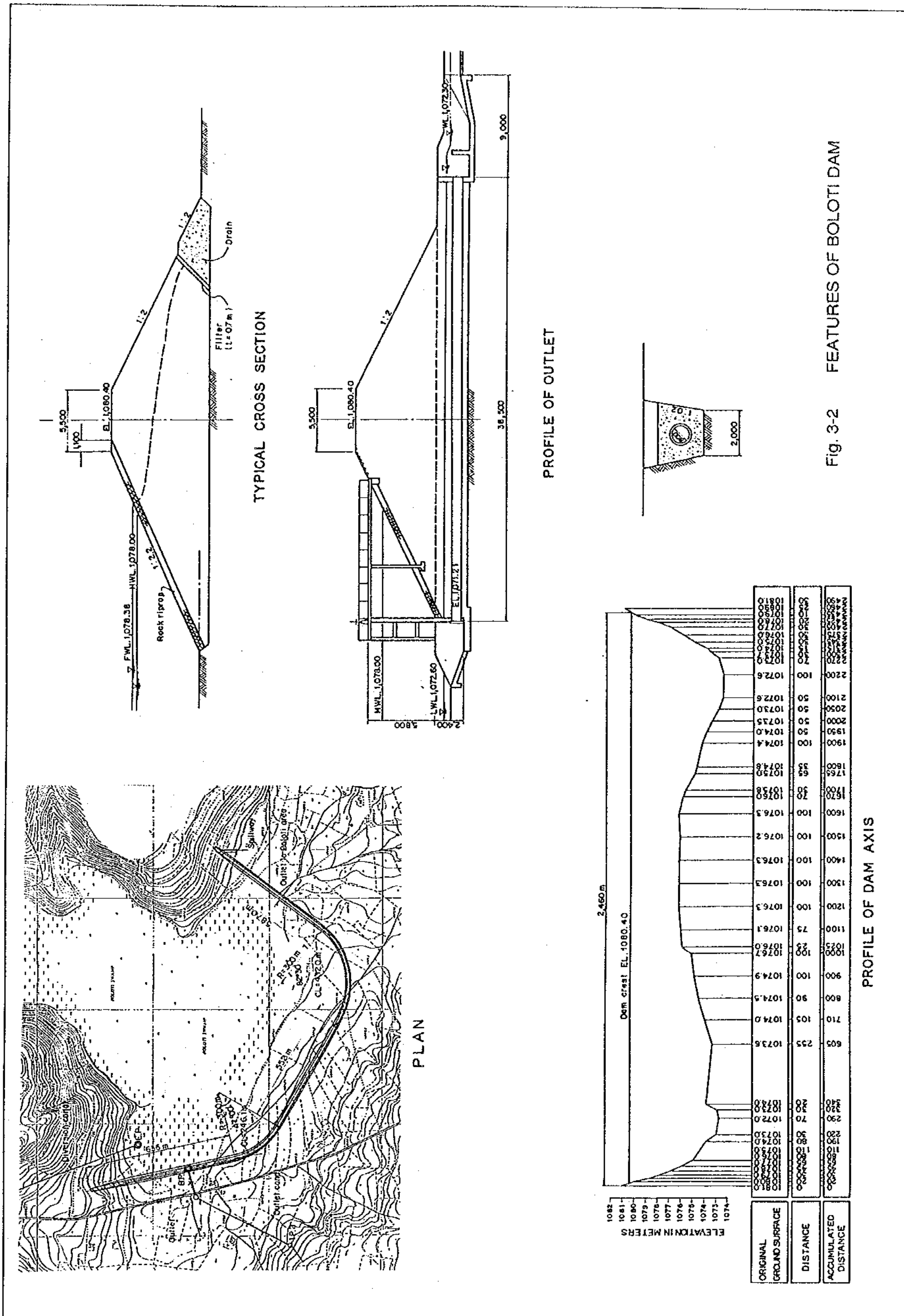
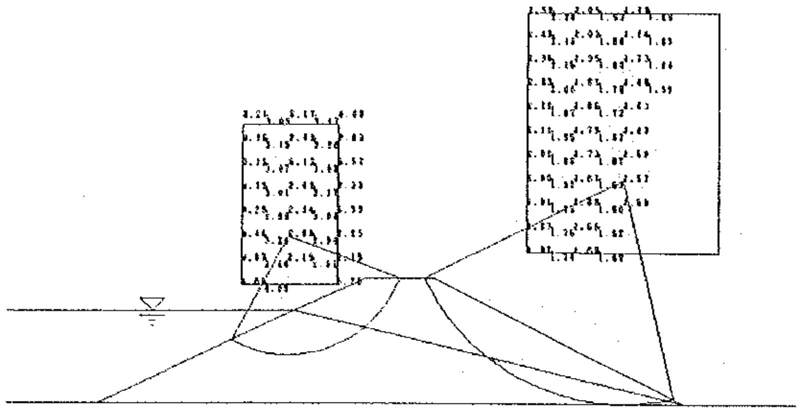


Fig. 3-2 FEATURES OF BOLOTI DAM

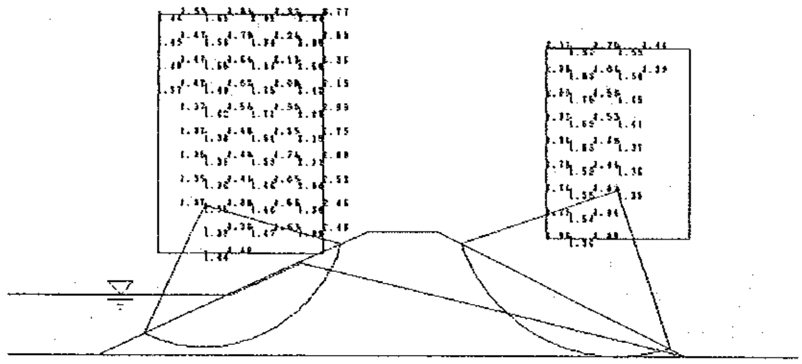


CASE 1 FULL WATER

0 20.0 M
SCALE=1/400

MATERIAL	COHESION (T/M^2)	FRICTION (DEG)	W(WET) (T/M^3)	W(SAT) (T/M^3)	W(SUB) (T/M^3)
1	0.07	35.00	2.04	2.13	1.13
ACCELERATION OF EARTHQUAKE				0.020	

MINIMUM SAFETY FACTOR (SEISMIC)	
UP STREAM SIDE	DOWN STREAM SIDE
2.896	1.569

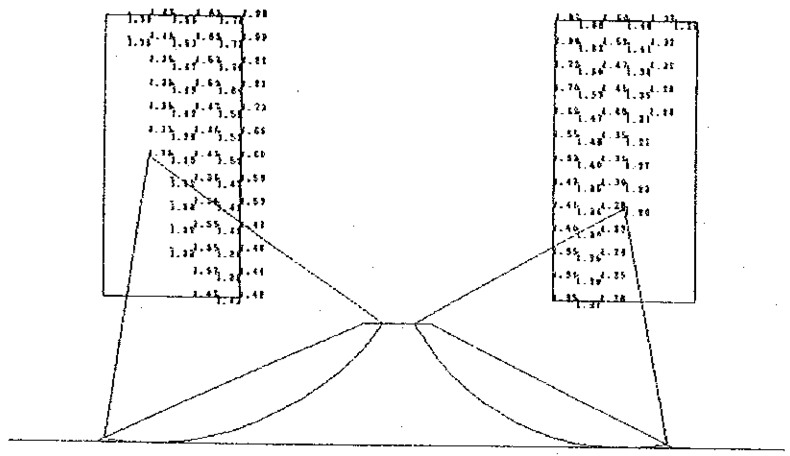


CASE 2 RAPID DRAWDOWN

0 20.0 M
SCALE=1/400

MATERIAL	COHESION (T/M^2)	FRICTION (DEG)	W(WET) (T/M^3)	W(SAT) (T/M^3)	W(SUB) (T/M^3)
1	0.07	35.00	2.04	2.13	1.13
ACCELERATION OF EARTHQUAKE				0.020	

MINIMUM SAFETY FACTOR (NORMAL)	
UP STREAM SIDE	DOWN STREAM SIDE
1.351	1.355



CASE 3 EMPTY

0 20.0 M
SCALE=1/400

MATERIAL	COHESION (T/M^2)	FRICTION (DEG)	W(WET) (T/M^3)	W(SAT) (T/M^3)	W(SUB) (T/M^3)
1	0.07	35.00	2.04	2.13	1.13
ACCELERATION OF EARTHQUAKE				0.020	

MINIMUM SAFETY FACTOR (SEISMIC)	
UP STREAM SIDE	DOWN STREAM SIDE
1.297	1.203

Fig. 3-3 STABILITY OF BOLOTI DAM

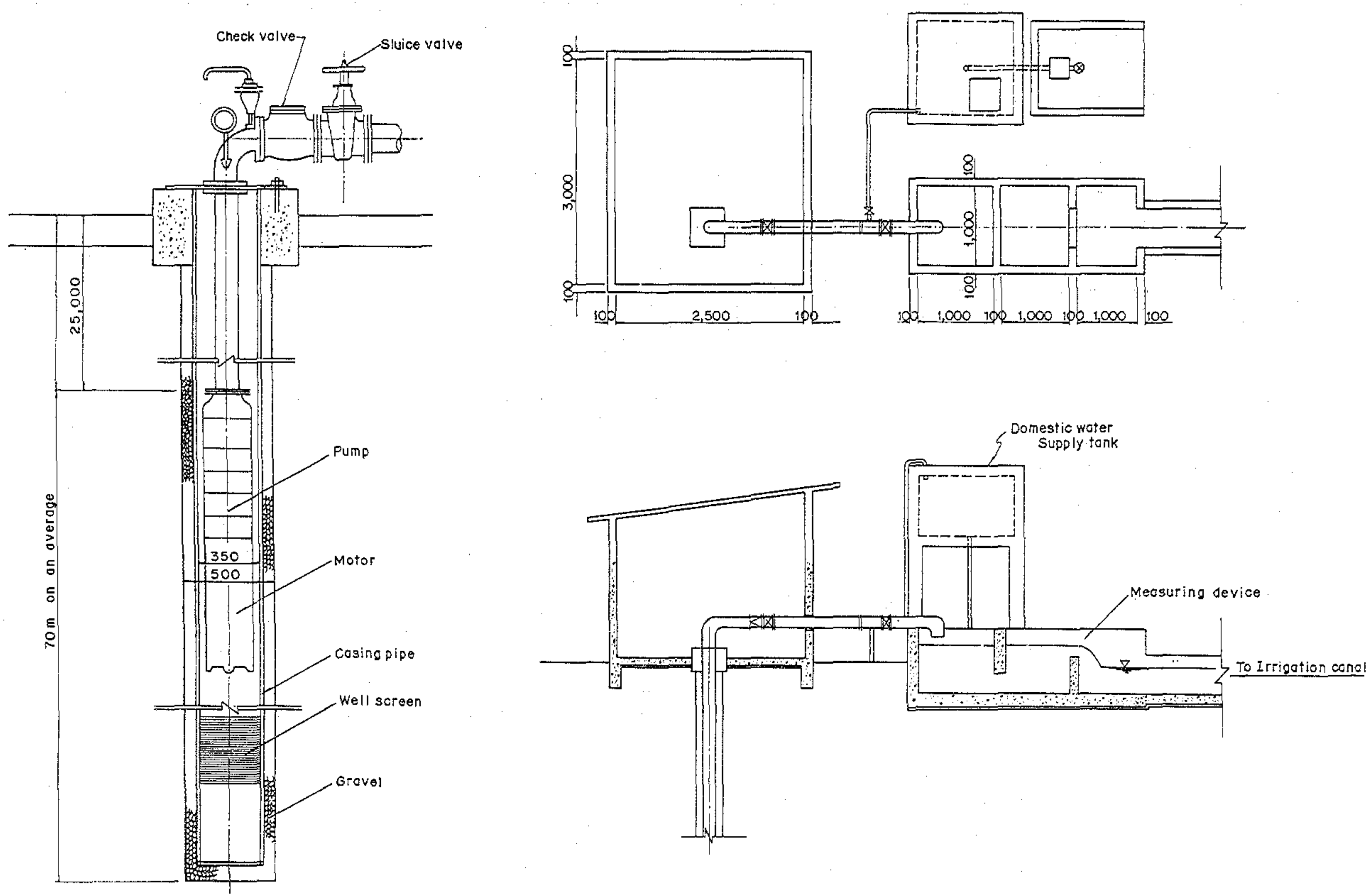


Fig. 4-1 FEATURES OF TUBEWELL

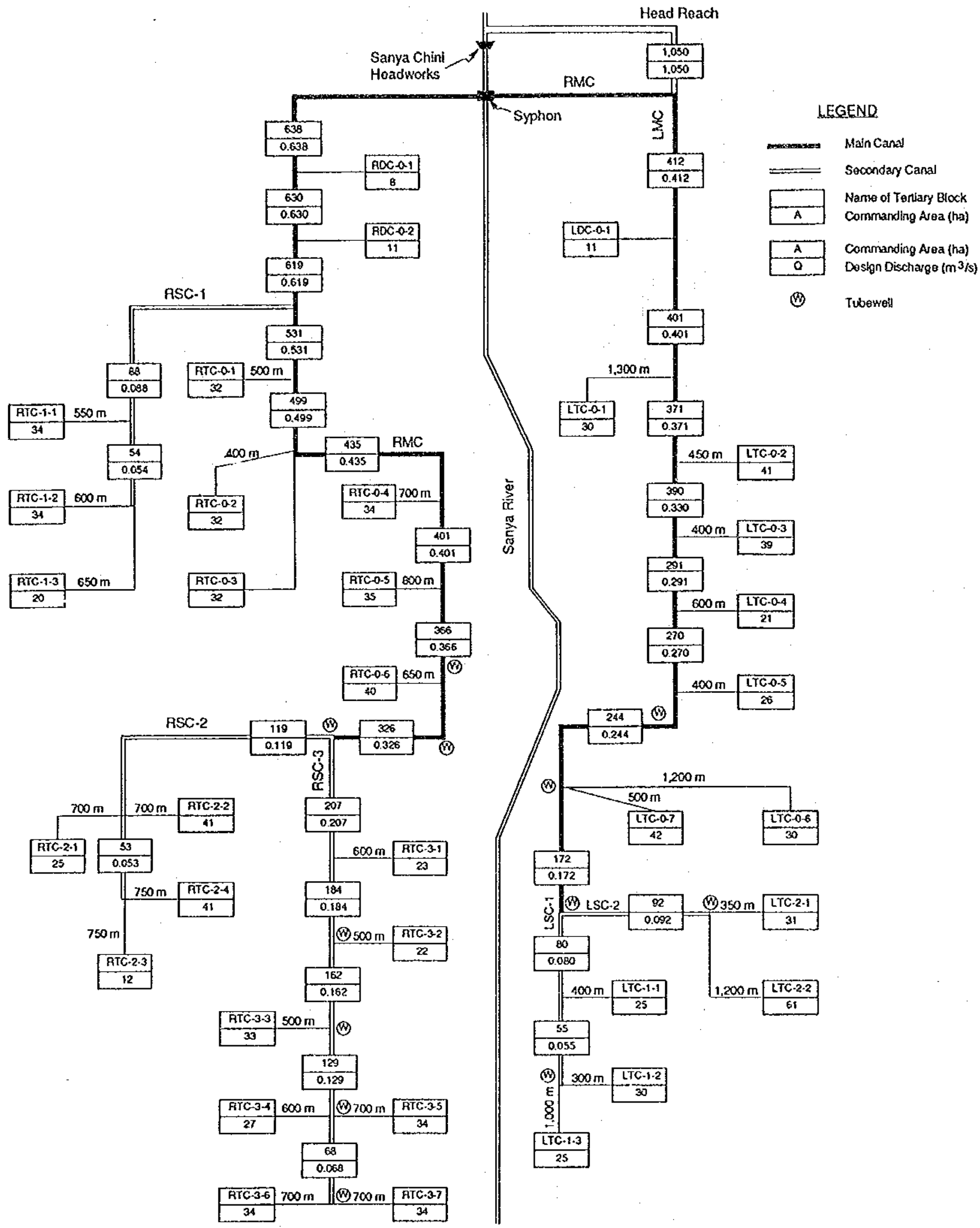
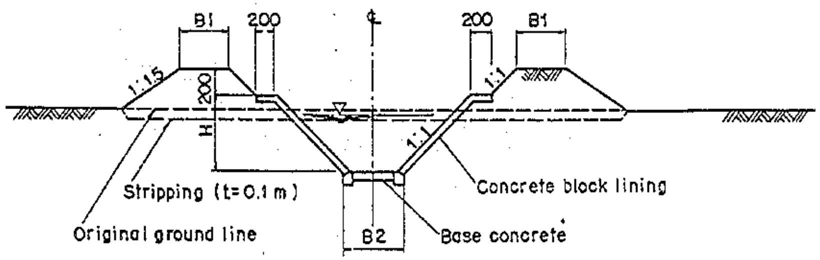
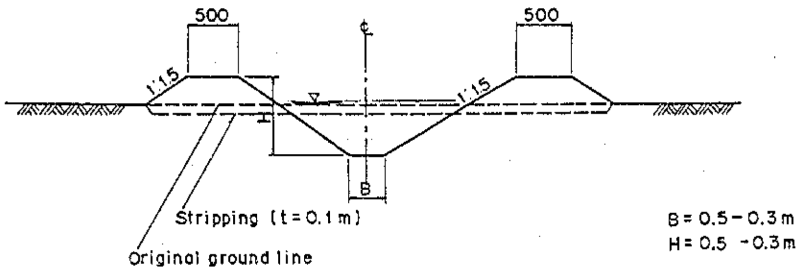


Fig. 5-1 IRRIGATION FLOW DIAGRAM
(SANYA SCHEME)

IRRIGATION CANAL



CONCRETE LINED CANAL



B = 0.5 − 0.3 m
H = 0.5 − 0.3 m

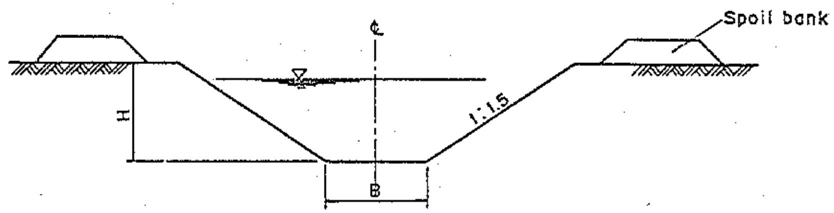
UNLINED CANAL

DIMENSION OF LINED CANAL
UNIT:m

TYPE	B2	H
A-1	1.0	1.4
B-1	0.7	0.9
C-1	0.5	0.8
D-1	0.4	0.8
D-2		0.7
D-3		0.6
D-4		0.5
E-1	0.3	0.6
E-2		0.5
E-3		0.4

	B1
Main Canal	1.0
Secondary Canal	0.5

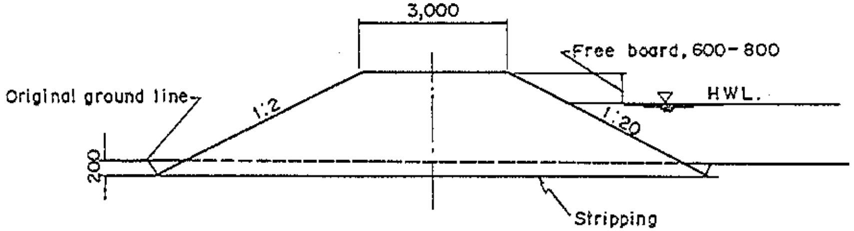
DRAINAGE CANAL



DIMENSION OF DRAINAGE CANAL
UNIT:m

TYPE	B	H
I	1.00	min.0.65
II	0.70	min.0.45
III	0.50	min.0.34

FLOOD DIKE



FARM ROAD

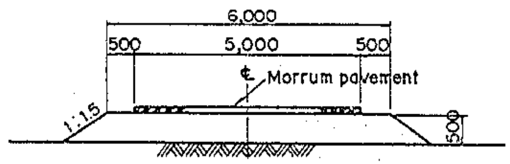
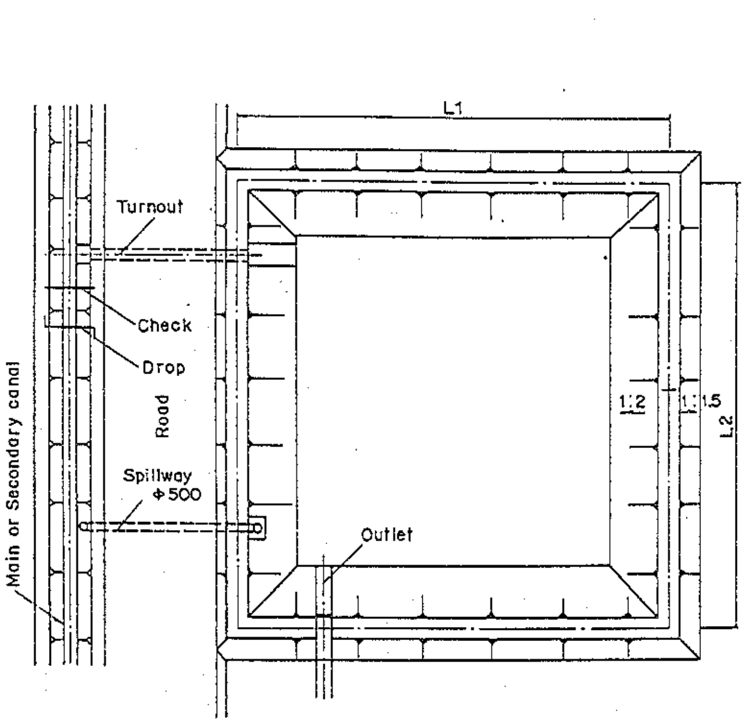
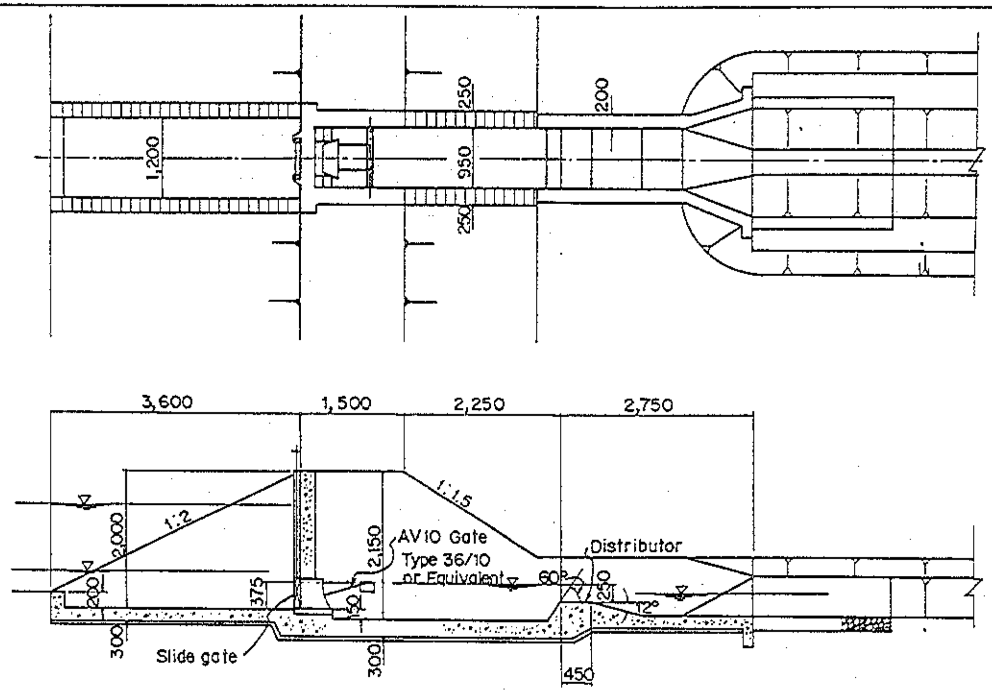


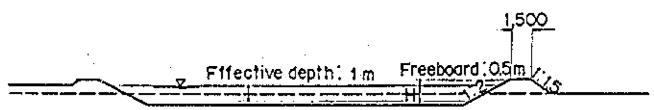
Fig. 5-2 TYPICAL CROSS SECTION OF CANAL



PLAN



Outlet of Night Storage Pond



PROFILE

DIMENSION OF NIGHT STORAGE POND

L1	L2	H
4,000 ~ 3,000	4,000 ~ 3,000	1,800 ~ 1,500

LIST OF NIGHT STORAGE POND

NO. OF CANAL	PARENT CANAL	OFF-TAKING CANAL	REQUIRED STORAGE(M3)
L-0-2	LMC	LTC-0-2	860
L-0-3	LMC	LTC-0-3	1,170
L-0-4	LMC	LTC-0-4	1,110
L-0-5	LMC	LTC-0-5	600
L-0-6	LMC	LTC-0-6	740
L-0-7	LMC	LTC-0-7	1,200
L-0-8	LMC	LTC-0-8	860
L-1-1	LSC-1	LTC-1-1	710
L-1-2	LSC-1	LTC-1-2	860
L-1-3	LSC-1	LTC-1-3	710
L-2-1	LSC-2	LTC-2-1	880
L-2-2	LSC-2	LTC-2-2	1,740
R-0-3	RMC	RTC-0-3	910
R-0-4	RMC	RTC-0-4	910
R-0-5	RMC	RTC-0-5	910
R-0-6	RMC	RTC-0-6	970
R-0-7	RMC	RTC-0-7	1,000
R-0-8	RMC	RTC-0-8	1,140

NO. OF CANAL	PARENT CANAL	OFF-TAKING CANAL	REQUIRED STORAGE(M3)
R-1-1	RSC-1	RTC-1-1	970
R-1-2	RSC-1	RTC-1-2	970
R-1-3	RSC-1	RTC-1-3	570
R-2-1	RSC-2	RTC-2-1	710
R-2-2	RSC-2	RTC-2-2	1,170
R-2-3	RSC-2	RTC-2-3	340
R-2-4	RSC-2	RTC-2-4	1,170
R-3-1	RSC-3	RTC-3-1	860
R-3-2	RSC-3	RTC-3-2	630
R-3-3	RSC-3	RTC-3-3	940
R-3-4	RSC-3	RTC-3-4	770
R-3-5	RSC-3	RTC-3-5	970
R-3-6	RSC-3	RTC-3-6	970
R-3-7	RSC-3	RTC-3-7	970

Fig. 5-3 TYPICAL LAYOUT OF NIGHT STORAGE POND

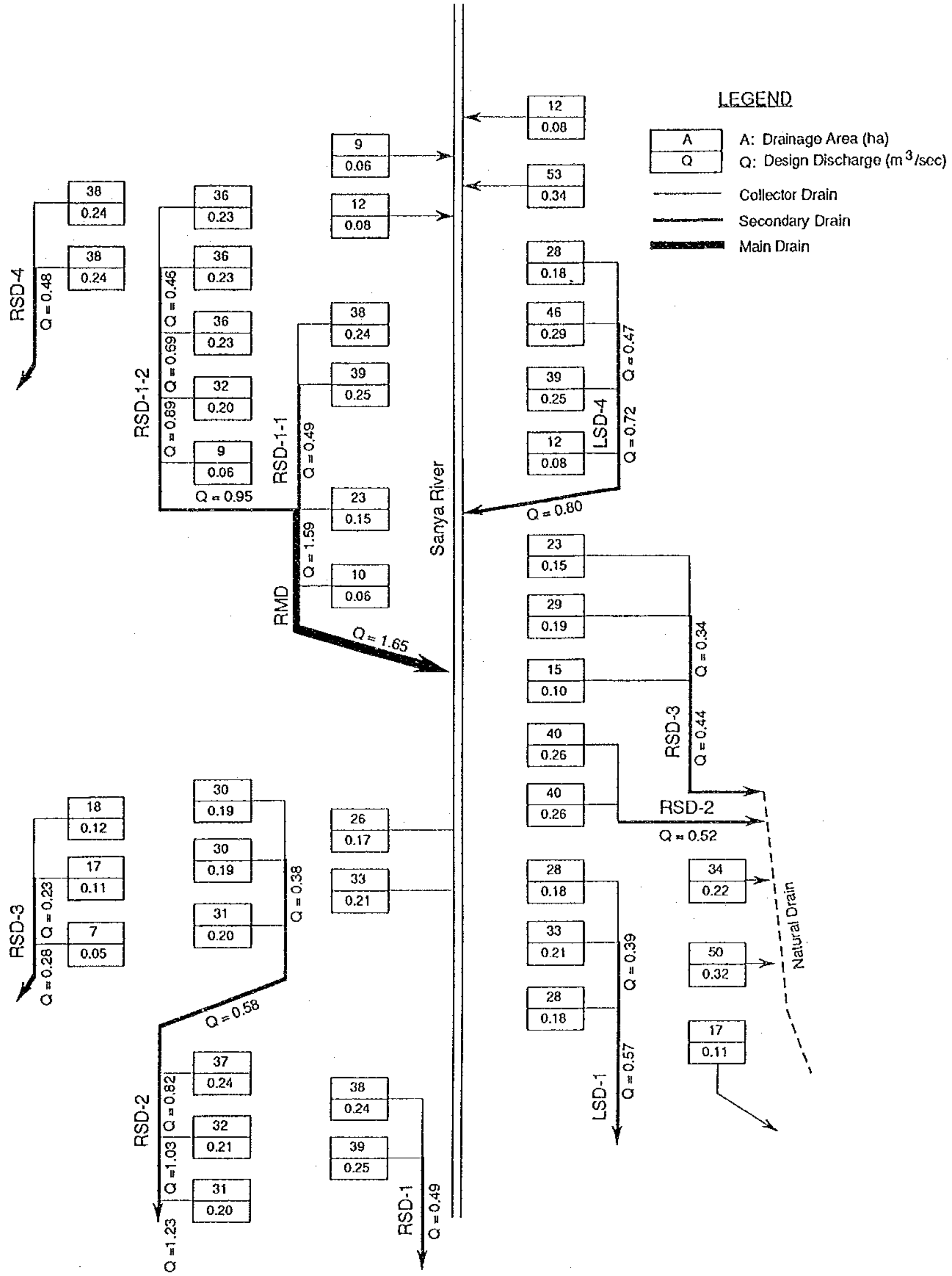


Fig. 5-4 DRAINAGE FLOW DIAGRAM
(SANYA SCHEME)

ANNEX H

PROJECT ORGANIZATION AND MANAGEMENT

ANNEX H

PROJECT ORGANIZATION AND MANAGEMENT

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1. ORGANIZATION AND STAFFING FOR PROJECT IMPLEMENTATION

For the implementation of the Project, it is proposed to establish an Executing Organization tentatively called the Project Office under the jurisdiction of the Regional Development Director (RDD). To coordinate, guide, and assist the Project Office in the implementation, an Executive Committee will also be organized under the RDD. The Committee will constitute representatives concerned such as Regional Planning Officer, Regional Administrative Officer, Regional Irrigation Engineer, Regional Agricultural Officer, Regional Accountant, District Executive Director, Zonal Irrigation Engineer and Village Chief of the Project area.

The main functions of the Project Office will be as follows:

(1) Design and construction supervision of the project works such as the Boloti dam, tubewells, irrigation and drainage facilities and road facilities.

(2) Accounting and administrative management of the construction works as well as office operation.

The Project Office will consist of one main office and two branch offices. The main office will be situated at Boma Ng'ombe adjacent to the District Office. The branch offices will be situated at Boloti dam site and in Sanya plain near the Village Office of Sanya Chini.

The Project Office will have five working sections such as (1) Survey and Design Section, (2) Construction Supervision Section, (3) Mechanical Section, (4) Accounting Section, and (5) Administration Section under the Project Manager to be appointed by the RDD. Fig. 1-1 shows the organization chart.

The Survey and Design Section will carry out surveys and investigations for design of the project facilities. The detailed design and preparation of tender documents during detailed design stage and checking of investigation and setting out survey results to be carried out by the contractor(s) who use them for preparation of working drawings of project facilities will be also carried out during construction stage.

The Construction Supervision Section will supervise the construction works such as construction quality, construction progress, and measurement of work quantities is responsible for contract administration. Staffs of this section will consist mainly of a construction engineer and quantity surveyors.

The Mechanical Section will be responsible for maintenance of project-owned vehicles and equipment. The Accounting Section and the Administration Section will be responsible for accounting, budgeting, logistics, personal affairs, etc. The staffs of these sections will consist of an accountant, an administrator, clerks, typists and drivers.

The required number of staffs for the design stage and the construction stage are 24 and 17 in total respectively, of which breakdown is presented in Table 1-1.

In the project implementation stage, expatriate experts and specialists would have to be required for assistance to the Project Office in design and construction supervision in order to cope with the shortage of qualified engineers in Tanzania. Their required number and specialities are listed in Table 1-2.

2. ORGANIZATION AND STAFFING FOR OPERATION AND MAINTENANCE

2.1 Organization and Staffing of Operation and Maintenance Office

Upon the completion of the construction works of Phase 1, which will consist of the construction works of the Boloti dam and irrigation and drainage facilities of the upper half of the Sanya plain as described in Annex I PROJECT IMPLEMENTATION AND COST, operation and maintenance (O&M) works for completed facilities will be commenced. For this purpose, O&M office have to be established in the Project office. After completion of the construction works, the Project Office will be reorganized into the O&M office having five working sections such as (1) Operation Section, (2) Maintenance Section, (3) Mechanical Section, (4) Accounting Section, and (5) Administration Section.

The O&M Office will be responsible for the operation and maintenance of the Boloti dam and the related facilities, tubewells, major irrigation and drainage facilities, and road networks. The maintenance of electric lines and their electric facilities are left to TANESCO. The operation and maintenance of tertiary blocks will be entrusted to water users' associations to be organized by farmers themselves.

The O&M Office will consist of one main office, two branch offices, and four watching stations. The main office,the same as in the construction stage will be stationed adjacent to the District Office in Boma Ng'ombe. The branch offices are proposed at the Boloti dam site and near Sanya Chini Village Office. The watching stations will be built at the Lawati diversion weir, the Sanya Chini headworks, and west and east bank areas of the Sanya downstream area.

The main office will be responsible for overall activities necessary for proper operation and maintenance of project facilities including preparation of overall operation and maintenance program, irrigation schedule and water distribution schedule from the Lawati, the Boloti reservoir to night storage ponds, directing and supervising branch offices, design of repair works, budgeting and training of staffs, etc. The Boloti branch office and the Lawati watching station will be responsible for the operation and maintenance of Boloti dam and the reservoir, Lawati diversion weir and the diversion canal, and the outlet canal to the Sanya river and the outlet structure to the canal conveying water to Boloti area and Mungushi intake. The Sanya Chini branch office and its three watching stations will carry out the operation and maintenance of irrigation and drainage facilities with tubewells and roads. The proposed organization of the O&M office is shown in Fig. 2-1.

Required number of permanent staffs at full development stage of the Project will be 38 in total consisting of 14 in the main office, two in Boloti office, and 22 in Sanya Chini office including 18 operators of tubewells and gates as shown in Table 2-1. In addition, labourer will be seasonally required for maintenance and repair works.

2.2 Organization and Staffing for Operation and Maintenance of Tertiary Blocks

At the farmers' level, a water users' association will be organized in each of tertiary blocks for operation and maintenance of tertiary systems except night storage ponds of which operation and maintenance will be exclusively made by the O&M Project office. The water users' association will be similar to the existing traditional water committee carrying out operation and maintenance of traditional furrow system existing along the Sanya river. The association will be composed of all the farmers in each of tertiary blocks as members and the working group consists of a chief, a canal inspector, a water allocator, an alarm man who calls people for work, and a security guard, who are elected every five years.

There will be 36 water users' associations in the Sanya Plain area.

2.3 Operation and Maintenance Equipment

The O&M works of the project facilities are largely divided into earthworks, concrete works, and metal and electric works.

Maintenance and repair of earthworks are carried out to maintain the canals and roads as constructed. Major works are weeding, maintenance and repair of canal embankment and inside cross section, and maintenance of roads. The most of canals are small. Weeding and small repair of canals and roads will be carried out manually by farmers and labourers. Only major repairs of earthworks i.e, repair against sliding of canal banks and removal of heavy sediments, need heavy equipment, however these works are limited since most of canals are small. Thus least equipment will be provided for such works. As for the roads which is very important to communicate in and around the project area and between the project area and outside in terms of transportation of goods, and operation and maintenance of the project facilities, they should be maintained periodically to secure the good traffic condition. For this purpose, a motor grader and a road roller are required to be procured. For the concrete works, which is rather durable, and considering minor repairs, only a small portable concrete mixer will be provided.

The metal works are mainly intake, check, and turnout gates and valves and pipes of tubewells for which maintenance works are mainly painting against rust and oiling in the movement portions as well as regular cleaning. These works require only small tools and materials. The maintenance of electric works such as transformers, electric lines, and electric control systems of tubewells are mainly maintained in collaboration with TANESCO and the maker, if necessary.

For transportation of equipment, materials, and labourers, a dump truck, a ordinary truck, and a light truck will be provided. For operation works, vehicles of four-wheel drive, motor bikes and bicycles will be provided. Walkie-talkie will be furnished as well. These O&M equipments are listed in Table 2-2.

2.4 Office and Quarters

There will be a head office, Boloti branch office, Sanya branch office, and four watching stations for the project management as described in previous section. Quarters for permanent staffs are required as well. The scale of these offices and quarters is approximately estimated considering the number of staffs to be engaged in project management. Workshop will be also required for the maintenance of O&M equipment.

Item	Unit	Quantity
Main office	m^2	300
Boloti office	m^2	50
Sanya office	m^2	100
Watching stations	m^2	200
Workshop	m^2	200
Quarters	m^2	1,000

3. ORGANIZATION FOR MANAGEMENT OF CROP PRODUCTION

Management aspects are of fundamental importance to the success of the agricultural development plan. The true measure of success of an irrigation project is not the completion of the construction aspects but the way in which the water and land resources are subsequently used for the benefit of the locality. It is the duty of management to ensure the optimum use of these resources. In this connection, establishment of the "Operation and Maintenance (O&M) Office" will be proposed for management of efficient utilization of water resources for the project. The detailed function of O&M office is mentioned in Chapter 2.

Besides, realization of full exploitation of the agricultural potential, assurance of proper land preparation, farm input supply and marketing especially for vegetables to the farmers in the project area is indispensable. Therefore, it is recommended that the present cooperative societies; KNCU branch office at Boma Ng'ombe, Nkwansira rural cooperative society, Mungushi rural cooperative society, and Sanya and KIA cooperative society, will be reorganized and combined into single organization to fulfill the function of one cooperative society for the whole of the Sanya river basin. This cooperative, Sanya River Basin Cooperative Society (SRBC), would function not only rural cooperative society but also KNCU branch office for supporting of efficient management of crop production and marketing.

The tasks of SRBC to the farmers would be:

(1) to supply farm inputs,
(2) to provide timely tractor ploughing,
(3) to purchase, store and sell the crops, and
(4) to promote the sales of vegetables.

SRBC will consists of a main office and three (3) branch offices. From the efficient management and marketing point of view, the main office of SRBC will be established at present KNCU branch office in Boma Ng'ombe adjacent to the Hai district office. The branch offices will be located at the same rural cooperative society offices. The main office will have the following four (4) sections:

(1) Production section

Production section will be responsible to tractor services. The tractor services will be relied upon during dry season because of no tractor service requirements for land preparation of the customers outside the project area. However, during the rainy season reliable tractor services will not be expected. Therefore, it is recommended that SRBC would have own tractors for assurance of land preparation in the project area. The tractors' purchasing could be financed trough CRDB or through special credit of regional farm mechanization programme. The tractor service would be required not only for the project area but also for other areas. So that the capital cost of tractors' purchasing can be covered by service charges through full utilization. This section will also order to procure agricultural inputs such as improved seeds, fertilizers, agro-chemicals and equipments in the quantity and quality necessary to meet proposed farming practices.and supply these farm inputs to the farmers through branch offices.

(2) Marketing section

Marketing section will purchase the marketable surpluses of crops from farmers. Primary the crops will be gathered at the collecting point in each residential area by farmers' association which is organized in each tertiary block mentioned in Section 2.2. Secondary, the crops will be collected by the branch offices and will be concentrated at main office in Boma Ng'ombe. The collected crops will be stored at the main office and sell possible maximum amount. Besides, the section will promote the sales of vegetables for regional trade and export through the following activities:

1) to associate processor, traders and exporters with the ultimate aim of attaining increased production and support from the government concerned.
2) to establish a systematic exchange of information and experiences,
3) to assist in the research for vegetables markets, and
4) to bring the quality improvement by providing the necessary information on production, grading and pricing.

(3) Accounting section

Accounting section will arrange the credits covering the input requirement applied by farmers in a particular season from CRDB and/or NBC. The repayment of the credit to CRDB and/or NBC will be made by SRBC on behalf of farmers. Repayments on loan from farmers will be undertaken at the end harvesting in cash or in kind. Accounting section will also keep the accounts for income and expenditure of SRBC.

(4) Administration section

Administration section will perform all administrative or organizational duties.

For smooth operation and management, all the farmers having the lands in the project area will have to be members of SRBC and are to make maximum use of the facilities and equipments which will be established or purchased by SRBC. The organizational structure of SRBC is illustrated on Fig. 3-1.

To facilitate timely land preparation, easy access to agro-inputs and market outlets, it is recommended that the privately owned tractors, transportation and storage be used by the CRBC. The desirable tractors, transportation and storage area listed below:

Item	Quantity
Tractors (50 HP) with attachment*	14
Truck (5 ton)**	4
Storage (1,325 ton)***	640 m^2

Remarks:
- * ; See Section 5.2.3 in Annex E.
- ** ; The number of truck for transportation was estimated on the basis of agricultural production under with project condition, distance from the Project area to Boma Ng'ombe and handling time.
- *** ; The storage capacity was decide based on grain (maize) quantity produced in the Project area under with project condition during a harvesting month.

Table 1-1 REQUIRED NUMBER OF PROJECT STAFFS IN PROJECT. IMPLEMENTATION STAGE

PROJECT STAFF	DESIGN STAGE	CONSTRUCTION STAGE
Project Manager (Senior Irrigation Engineer)	1	1
Irrigation Engineer	1	0
Construction Engineer	0	1
Design Engineer	4	1
Electric Engineer	(1)	(1)
Metal Engineer	(1)	(1)
Hydro-geologist	1	1
Boring technician	3	0
Mechanic	1	1
Topo-surveyor	2	2
Draftsman	2	0
Administrator	1	1
Accountant	1	1
Clerk/Typist	2	2
Driver	2	3

Table 1-2 REQUIRED NUMBER OF FOREIGN CONSULTANTS

PROJECT STAFF	DESIGN STAGE	CONSTRUCTION STAGE
Team Leader (Irrigation Engineer)	1	1
Design Engineer	1	1
Specification Writer	1	0
Electric Engineer	1	1
Metal Engineer	1	1
Engineering Geologist	1	0
Hydro-geologist	1	0
Construction Engineer	0	1
O&M Expert	1	0
Specialist as required	L.S	L.S

Table 2-1 REQUIRED NUMBER OF PROJECT STAFFS IN OPERATION AND MAINTENANCE STAGE

PROJECT STAFF	REQUIRED NUMBER
Project Manager (senior irrigation engineer)	1
Irrigation Engineer	1
Electrician	1
Mechanic	2
Computer operator	1
Irrigation Technician	3
Tubewell and Gate Operator	8
Administrator	1
Accountant	1
Clerk/Typist	2
Equipment Operator	3
Driver	4

Table 2-2 LIST OF OPERATION AND MAINTENANCE EQUIPMENT

Equipment	Spec	Quantity	Remarks
Backhoe	0.15 m^3	1	earth excavation, loading
Tamper	80 kg	2	earth compaction
Motor grader	3.7 m	1	earth spreading, shaping especially for road maintenance
Road roller	8 ton	1	compaction of road embankment
Portable concrete	0.05 m^3	1	repair of concrete works mixer
Dump truck	5 ton	1	hauling of earth material
Ordinary truck with crane	5 ton	1	transportation of equipment, materials, labours
Ordinary truck	10 ton	1	transportation of heavy equipments
Light truck	1 ton	1	miscellaneous use
Vehicle	4-wheel	1	inspection
Motor bicycle	90 cc	5	inspection and data transfer
Bicycle		18	local inspection and operation
Desk-top type Computer	16 bits	1	data processing especially for irrigation scheduling
Walkie-talkie		3	communication
Workshop tools and spareparts			

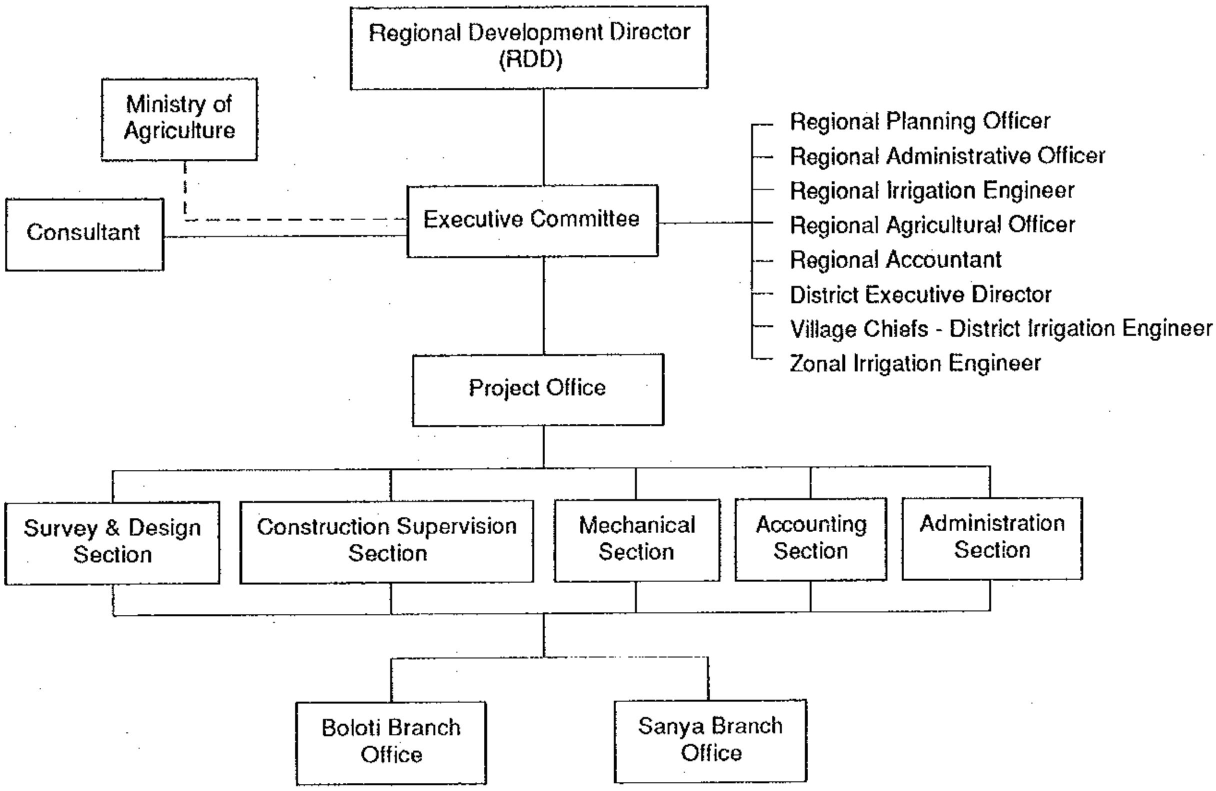

Fig. 1-1 ORGANIZATION CHART FOR PROJECT IMPLEMENTATION

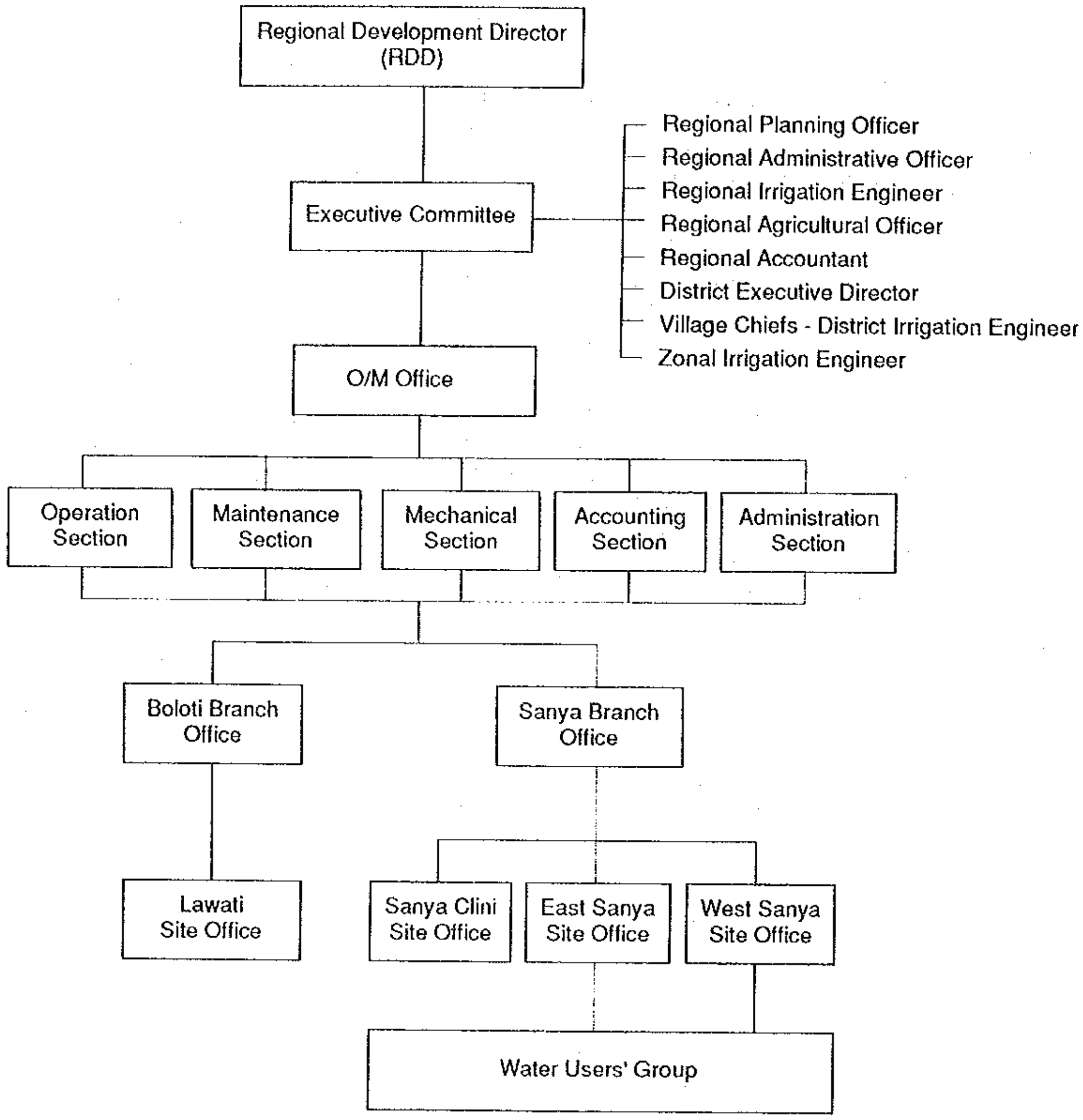

Fig. 2-1 ORGANIZATION CHART FOR OPERATION AND MAINTENANCE

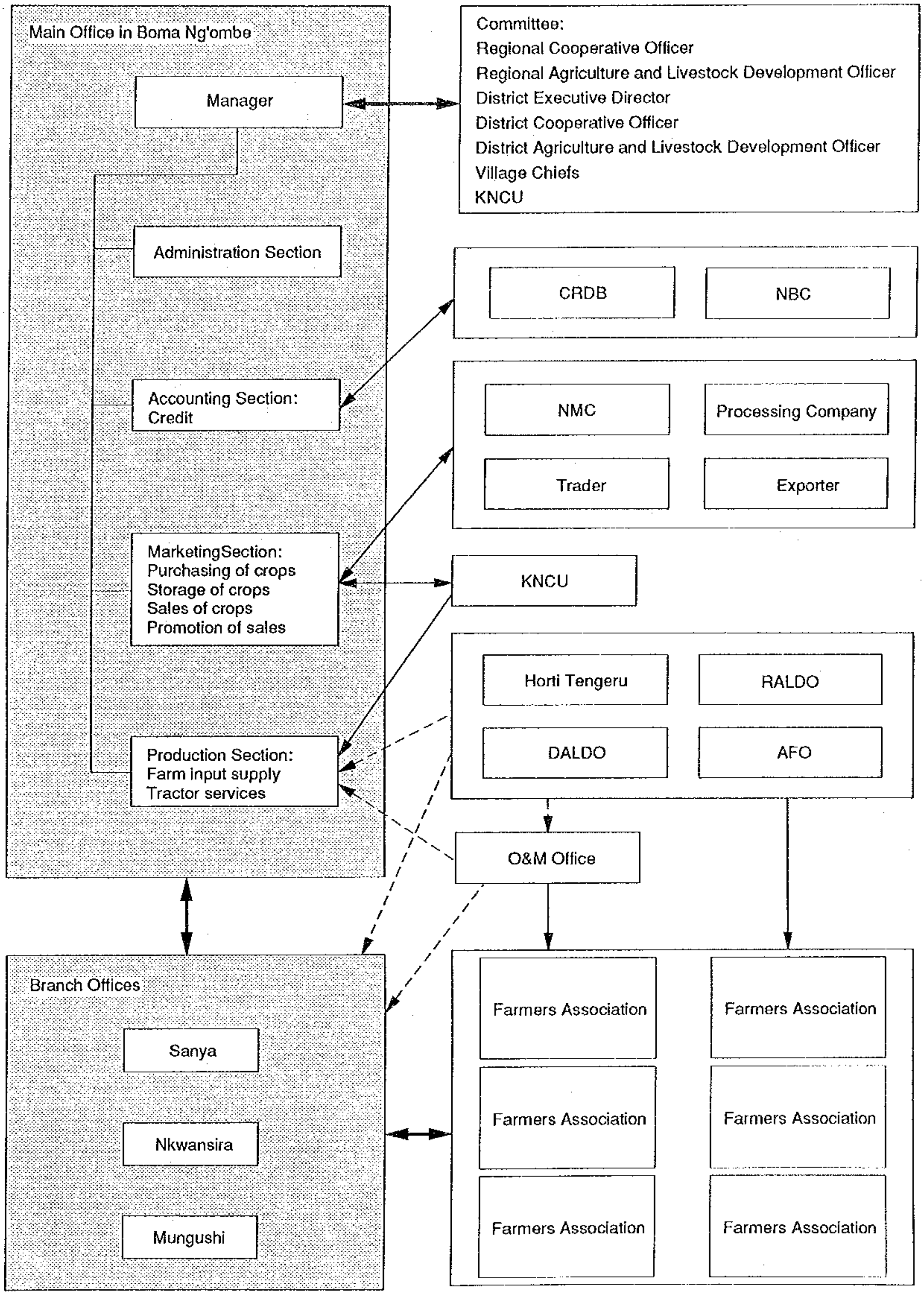

Fig. 3-1 ORGANIZATION STRUCTURE OF SRBC

ANNEX I

PROJECT IMPLEMENTATION AND COST

ANNEX I

PROJECT IMPLEMENTATION AND PROJECT COST

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1. PROJECT IMPLEMENTATION

1.1 Basic Consideration of Project Implementation

The Project implementation plan was formulated on the basis of the following considerations:

(1) Mechanized construction methods will be used in the dam construction and major irrigation and drainage facilities including tubewells and roads. Manual construction will be adopted in the construction of small canals and structures in order to increase job opportunities.

(2) The construction works will be undertaken by qualified international contractors selected through international competitive bidding.

(3) The project water management will be rather complicated due to the conjunctive use of surface and ground water resources and also the large scale irrigation application for upland crops will be a first experience for Tanzania. Therefore, stage-wise development is considered.

(4) A consultant will assist the Project Office in the preparation of detailed design and tender documents, and the supervision of the construction works of the project facilities.

1.2 Implementation Schedule

The Project is formulated for the conjunctive use of surface and ground water resources, of which water management is rather complicated and a first experience in Tanzania. It is, therefore noted that a certain period will be required for getting know-how the proper water management and farming practices. Therefore, stage-wise development divided into two phases is proposed.

The Sanya area is divided into two; the 440 ha upper half to be served by surface water resources and the 610 ha lower half to be served by surface and ground water resources. Water management in the upper half will be easier than that in the lower half. Therefore development of the upper half with the Boloti dam is proposed as Phase I work. Phase II work with consist of the development of the lower half with tubewell construction. The implementation schedule is shown in Fig. 1-1.

Each of phase includes detailed design, project preparatory works and the construction works. The construction works will take 24 months. The total period required for completion of the construction works of Phase I will be two years from the commencement of the works, and for Phase II will be also two years. The detailed design work for Phase II can be carried out in parallel with the construction works of Phase I. Thus the total period required for completion of all the works from the beginning of detailed design is estimated at three years.

1.3 Work Quantities and Construction Materials

The quantities of major works and major construction materials may be summarized as shown in the following table.

Works	Quantity	
Boloti dam and spillway		
Excavation	38,400	m^3
Earth embankment	265,000	m^3
Rock riprap in upstream face	35,800	m^3
Sod facing in downstream face	34,800	m^2
Concrete volume	250	m^3
Lawati diversion weir and diversion canal		
Excavation	21,400	m^3
Concrete	1,600	m^3
Outlet structure and outlet canal		
Excavation	10,300	m^3
Concrete	1,990	m^3
Improvement of Sanya Chini headworks		
Excavation	1,630	m^3
Concrete	308	m^3
Sluice gates	1	nos
Intake gates	1	nos
Main and secondary canals		
Excavation	19,540	m^3
Embankment	32,800	m^3
Lining concrete	4,940	m^3
Their related structures		
Concrete	450	m^3
Slide gates	57	nos
Drains		
Excavation	32,200	m^3
Sod facing	54,400	m^3
Roads		
Embankment	60,800	m^3
Morrum pavement	38,000	m^3
Night storage ponds		
Excavation	25,100	m^3
Embankment	16,400	m^3
Concrete	490	m^3
Slide gates	32	nos
Automatic gate to keep downstream water level	32	nos
Tertiary and distributory		
Excavation	16,200	m^3
Embankment	85,900	m^3
Concrete	2,650	m^3
Land clearing	421,000	m^2
Tubewells	12	nos
Low tension electric line, 400 V	12	km

1.4 Construction Plan

The workable days was estimated and a construction plan of the main works was studied for estimating the required construction equipment and construction costs.

(1) Workable days

Work progress is much affected by rainfall. Workable days for each month are estimated based on daily rainfall data obtained from the K.I.A meteorological station on the following conditions:

Daily rainfall depth (mm)	Time to be suspended (days)
3 - 10	0.5
10 - 30	1.0
30 - 50	1.5
more than 50	2.0

Then holidays are deducted from the workable day. Details are shown in Table 1-1. The workable days a year are estimated at 271 days. The construction plan of the project works is prepared on the basis of these workable days a year except for river structures and embankment and excavation works of the Boloti dam. The workable day for the Lawati diversion works and the embankment of the Boloti dam is estimated at 244 days a year.

(2) Earth works

The earthworks of project facilities except for small scale facilities such as tertiary canals and distribution canals are planned to be mostly executed by heavy construction equipment. The tertiary canals and distribution canals are to be constructed mainly by man power.

1) Boloti dam

Earthworks of the Boloti dam consist of foundation excavation, earth embankment, filter material embankment, and rock riprap construction.

The foundation excavation depth is estimated at about 0.3 m to 0.5 m as described in the Annex G "Engineering Design" and the excavation area is wide and very long. The earth contains many stones. Taking these conditions into account, bulldozers with rippers are planned to be introduced. For excavation in the spillway site, a backhoe will be introduced together with a bulldozer. The excavated materials will be spread along the dam.

Earth embankment materials can be obtained near the proposed dam site. The hauling distance is estimated at about 1.5 km on average. The soils are hard with many stones. Thus in the borrow areas, introduction of a bulldozers equipped with rippers is proposed for loosing hard soils. After loosing soils, water will be supplied by water tankers to control the soil moisture, if necessary. The loosed and moistened soils will be loaded by dozer shovels to dump trucks. Soils unloaded at the dam embankment site will be spread over by bulldozers and compacted by vibrating rollers.

The stones separated from soils in the borrow area will be used for rock riprap together with rocks obtained from villagers who are collecting stones for payment in and around the area. Construction of filter zone will be carried out in parallel with the earth embankment by bulldozers and vibrating rollers.

Sod facing in the downstream slope will be carried out upon the completion of dam embankment.

Embankment works and excavation works should be ceased during the main rainy season, April and May.

2) Lawati diversion weir, the diversion canal and the outlet canal

At the proposed site of the weir, basaltic rock lies near the surface. The excavation will be carried out by a bulldozer with a ripper and/or air compressed picks. Backfill materials which will be obtained from excavated earth will be placed by a backhoe or a small bulldozer and man power a layer by a layer and compacted by tampers.

The diversion canal and the outlet canal from the Boloti dam will be excavated by a backhoe. When rock, which lies underneath shallow soils near the weir is found and cannot be removed by a backhoe, air-compressed picks will be used, then removed by a backhoe. Excavated earth except rock will be spread on either side of the canal route by a bulldozer.

Construction of the Lawati diversion weir should be carried out avoiding the flood season usually from April to May.

3) Sanya Chini headworks

Excavation will be done by backhoe and the excavated materials will be spread over on barren fields near the headworks site except for materials required for earth filling. The members of the structures to be replaced will be demolished by compressed air picks and hauled by man power or a backhoe. Backfill works will be carried out in the same manner as that of the Lawati diversion weir. The improvement of the headworks should be completed in the river portion of the works by the end of March when the flood season starts.

4) Irrigation canals

Clearing and stripping will be carried out by bulldozers. Then embankments of canal banks will be constructed out including the canal flow section. Most of the materials will be obtained along canal routes. The materials will be dug and placed by using backhoes, then spread by bulldozers and compacted by rollers. Water will be provided by water tankers to moisten the materials, if necessary. The canal flow area including original excavation section will be excavated by backhoes. The borrow pits will be filled with spoils obtained by stripping and canal excavation by bulldozers. In case of small canals, excavation will be made by man power.

5) Drains

Drains will be excavated in the same manner as the Lawati diversion canal or the outlet canal.

6) Roads

After clearing the right of way, road embankment will be carried out by the same manner as the canal embankment. Pavement materials will be hauled from borrow pits by dump trucks, spread by bulldozers and compacted by rollers. In the borrow pits, excavation and loading to dump trucks will be carried out by backhoes. Water tankers will be employed to moisten the materials.

7) Night storage ponds

After clearing and stripping the site by bulldozers, excavation inside the proposed pond site, hauling of excavated material from the excavation site to the embankment site, and placing of materials will be carried out by bulldozers. The compaction will be executed by rollers.

(3) Concrete works

Concrete works are largely divided into in-situ concrete works and precast concrete works.

The in-situ concrete works are generally rather large scale structures consisting of the Lawati diversion weir, the dam spillway, the outlet, the Sanya Chini headworks, and irrigation and drainage structures. Producing of concrete and arrangement of reinforcement bars are proposed to be executed at the site office of the contractor which is assumed to be built in Boma Ng'ombe where the Arusha-Moshi highway runs and which is situated in the middle point between the Boloti dam site and the Sanya plain site. Fresh concrete will be transported by an agitator truck.

Pre-cast products may consist of concrete lining blocks, small scale concrete slabs used for operation deck and footpath bridge, and the division boxes to be provided on distribution canals. These pre-cast products will be produced at the site of the contractor's office and transported by a truck to the respective sites. At the sites, they will be installed by hand in case of concrete lining blocks and by a truck-mounted crane or a crane in case of heavy products.

(4) Tubewells

For drilling, a truck-mounted percussion type drilling machine is considered for the cost estimate.

1.5 Construction Machinery

The type and the number of construction machinery required for major works are estimated based on the work quantities, construction period, and physical conditions of the project area are shown in Table 1-2.

2. PROJECT COST

2.1 Conditions

The cost for implementation of the project is estimated based on the preliminary design of project facilities and the following assumptions, taking into account the construction method, productivity of labour and construction machinery

(1) The exchange rate used in the estimate is determined considering current exchange rate as follows: US$ 1.00 = Tsh. 195 = Yen 145

(2) The construction works will be carried out by constructor(s) selected through international bidding.

(3) The construction machinery and equipment and construction material little available in local markets will be imported by contractor(s).

(4) Taxes on the construction materials, construction machinery and equipment to be imported from abroad are exempted.

(5) The unit prices are divided into local and foreign currency portions. Local currency portion at estimated based on the current prices in the beginning of 1990 in Kilimanjaro region, and on the cost data of on-going projects. Foreign currency portion is estimated based on the CIF prices at Tanga, making reference to FOB prices of materials and equipment in Japan in 1989.

(6) No-compensation will be considered for the land acquisition and right of way for the project facilities.

(7) The classification of local and foreign currency portions is defined as follows:

1) Local currency portion
   - a) Labour force,
   - b) Sand, gravel, rock, earth and wooden materials,
   - c) Inland transportation cost,
   - d) Administration expenses.

2) Foreign currency portion
   - a) Reinforcement bars and structural steels including gates,
   - b) Fuel, oil, etc.,
   - c) Cement,
   - d) PVC pipe and steel pipe,
   - e) Depreciation costs of construction machinery and equipment,
   - f) Contractor's general expenses and profits for contractor(s),
   - g) Expenses and fees of engineering services of consultant(s),

(8) Physical contingencies to the variation of work quantities, 10 % of direct construction cost,