Chapter 4 Moragahakanda Project

4-1 Development Plan

The Moragahakanda Project has very high priority, as undetstood from the fact that it is taken up as No. 3 project of Phase I in the Master Plan prepared by the UNDP/FAO team. This project is a dam project to close the Amban Ganga, tributary of the Mahaweli Ganga, being planned to be constructed at the site of 30 miles (approx. 48km) upstream from the river mouth. The major objectives of the project is to construct a dam with an effective storage capacity of 470×10^3 acre feet (approx. 580 million tons), for irrigation of newly developed area and water control of Elahera irrigation, and to establish a power plant with an equipment capacity of 40MW. The reservoir water of this dam originates from the outflow from its own catchment area and the water diverted from the Mahaweli Ganga at the Polgolla Head Works.

The order of development of the Mahaweli Ganga Development Program remains basically the same as that of the Master Plan prepared by the UNDP/FAO team even at present. That is, the development along the Mahaweli Ganga system is promoted first, and the development of the dry zone in the north is going to be made at the final stage. However, the agricultural development of the northern dry zone still has great significance for agriculture in Sri Lank.

At the initial stage of Mahaweli Ganga development, the beneficiary area covered by the Moragahakanda Dam along the Amban Ganga and the Mahaweli Ganga can be specified, but when the N.C.P. canal is completed, the water will be able to be transferred. The reasons are that the start point of the N.C.P. canal is located at a point directly below the Moragahakanda Dam, enabling to secure the required head, and that the implementation of the N.C.P. canal project will clarify the actual condition of water balance, which means that the water supplied to the northern region by this dam can be secured. Furthermore, this dam provides the additional function to secure open water for the beneficiary area covered by Elahera Head Works. Thus, the Moragahakanda Dam can be said to have a strategic position and functions among the Mahaweli Ganga Development Program as a whole.

This dam is a complex one consisting of three types of concrete gravity-type dam (constructed across the Amban Ganga), rockfill dam and earth dam. It has geological features that limestone stratum exists partially at the dam site (any measure must be taken against leakage), that the direction of fold structure is orthogonal to the dam axis (any measure must be taken against leakage), that the soil layer on the surface of bedrock is thin (the volume of earth for the dam construction is small), that the bedrock at the junction between the concrete and the rockfill dams is thin (any measure must be taken for junction), that there are two faults on the dam axis, and so on. The reservoir water of the dam originates from the outflow from its own catchment area and the flow diverted from the Mahaweli Ganga at the Polgalla head works.

4-2 Agriculture

The increase of self-supply rate of rice to which the highest important should be attached in agricultural production can be attained by raising the unit yield or expanding the area of arable land. At prosent, the average yield per acre of the country is about 45 bushels, and even in recent years, remarkable increase of yield has not been observed. For expanding the area of arable land, there is no space in the wet zone, but expectation can be held for the development of the dry zone, which is put into arable land only by 15% as mentioned before, Mahaweli region has potentiality of high agricultural productivity if irrigation facilities only are completed.

1) Mahaweli Ganga Development Program

According to the Master Plan of the UNDP/FAO in 1969, it is planned to make irrigation development to cover an irrigable land of 900,000 acres continuously for 30 years. Of the area, approx. 272,000 acres are the existing farmlands irrigated by large and small tanks, and 93% of the area (252,960 acres) is used for culturing paddy, upland crops and sugar cane. In 28,000 acres, upland rice, upland crops, coconut and pasture plants are cultured by rain fed water. The agricultural land newly irrigated and developed for settlement amounts to 600,000 acres.

The development of Polgolla, Bowatenna, Elahera and Sudu Ganga of Phase I was already completed in 1976. The enlargement of the Kalawewa and Huruluwewa Tanks and the development of new agricultural land are now being continued, and at the end of 1977, 5,544 families settled. Before the completion of Phase I, 91,000 acres of irrigable agricultural land is scheduled to be prepared.

However in November, 1977, the Government of Sri Lanka established an accelerated programme for the simultaneous start of 5 projects, wishing to complete the development in 5 to 6 years to come. According to the irrigation plan, the total irrigable area of irrigation systems A to J is 682,900 acres, and of it, the existing fields amount to 112,500 acres, and newly developed agricultural land amounts to 570,400 acres. As for the cropping in the newly developed land, double cropping covers 164,200 acres; two-crop system for paddy and upland crops, 100,200 acres; and upland crops only, 278,000 acres. The rate of upland crops is high. In addition, the developed land will be used also for livestock farming promotion accompanying the expansion of pasture and for the increased production of sugar by the expanded cropping of sugar cane.

2) Moragahakanda Multipurpose Dam Project

The water of the Moragahakanda Reservoir flows from the existing Elahera Head Works toward northeast by the Elahera-Kantalai Canal in the Polonnaruwa District, and is diverted to the Gilitalewewa and Minneriya Tanks, further being guided from the Minneriya Tank to the Kaudulla Tank, and then to the Kantalai Tank in the Trincomalee District. In this project area, there is Parakrama Samudra to which water is supplied from another head works of the Amban Ganga as another water system. The existing agricultural land irrigated by the above existing canals and reservoirs amounts to 73,200 acres, in most of which, settlement started from the 1930's, and 11,000 families settled in agricultural land of 56,200 acres until 1965. Agricultural level in this area is said to be the highest in Sri Lanka at present.

The newly developed land in this project means agricultural land changed from jungle, using the above irrigation systems, and covers total 46,200 acres in the Kaudulla Tank left bank zone (Balance D1), the Kantalai Tank right bank zone (A/D), and the Parakrama Samudra zone (Balance D2).

As shown in Table 4-1, in this area, paddy rice will be the main crop. In the Kantalai zone, large-scale farming of sugar cane is planned.

Table 4-1 Area of Systems and Cropping Pattern

System	Irrigable area	Paddy Paddy	Paddy Upland crop	Upland crop Upland crop	Sugar cane	Total area
Balance D_1	28,000	10,300	4,300	13,400		59,270
A/D	9,100	9,100				17,910
Balance D_2	9,100	9,100				24,704
Total	46,200	28,500	4,300	13,400		101,884

3) Agricultural Development System in the Beneficiary Area

According to this project, the executing agency of comprehensive agricultural development in the beneficiary area is MDB and covers the duties of land acquisition, settlement, agricultural development, water management, provision of public facilities, and operation and maintenance of irrigation systems (Fig. 4-1).

Settlement Plan: The beneficiary agricultural land allocated for each farm household is 2.5 acres of irrigable land and 0.5 acres of homestead. According to irrigation systems, a group of 100 to 125 farm households makes a hamlet, and 4 to 5 hamlets form one village, several villages forming one town. At the center of a village within about 3 miles from respective hamlets, a branch of agricultural cooperative association, storage facilities, farmers' training center, etc. will be established, and in a town where 3,000 to 4,000 settling farm households will be resident, the head office of the agricultural cooperative association, large-scale storage facilities, a rice mill and an agricultural service center will be established.

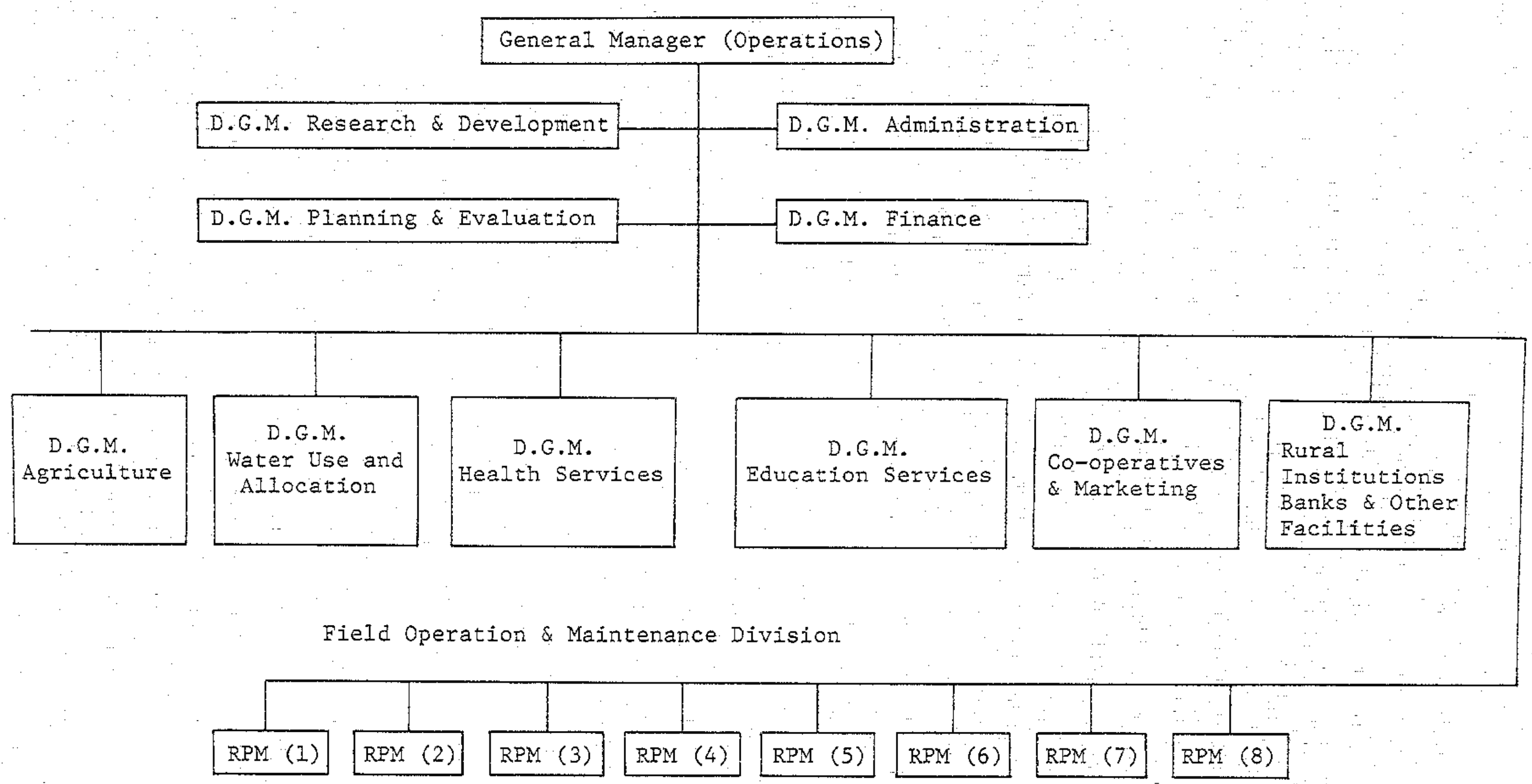
For selecting settlers, priority is given to the existing farmers in the beneficiary area and to the farmers inhabiting in the dam site. The selection standard for settlement is (1) farmers of 30 to 39 years old, (2) petty farmers, (3) those educated, (4) those with the experience of farming, and after they are preliminarily selected by a selection committee consisting of land officer, agricultural officer and comminity development officer, final selection will be made by the consultation among the cultivation committee, agricultural cooperative associations, and rural development committees.

Special aids will be provided for settlers. Each settler will be supplied Rs.100 as the construction cost of a hut, farming equipment corresponding to Rs.100, seeds and seedlings corresponding to Rs.230, and Rs.50 per month for 5 months as household expenses, and furthermore, according to the agreement with World Food Aid, a family of five people at the maximum will be supplied such foods as flour, Dhal, dried fish, sugar, etc.

In 46,200 acres of beneficiary area land, settlement of 17,504 families or 107,122 persons is anticipated. Agricultural Development: The improvement of agricultural production is expected to be successful, not only by the above measures, but also by agricultural technique extension services, effective irrigation systems, intensification of farmers' training, agricultural machines, appropriate supply, storage and processing of production materials, establishment of market facilities, effective sales measures, etc.

Administrative services by agricultural development are provided by the Settlement and Agricultural Development section of MDB. For the extension of agricultural techniques, Agricultural Department, the Ministry of Agriculture and Land despatches one KVS per 500 farm households and one agricultural officer per 3,500 to 4,000 farm households, within the organization of MDB, for the activities of extension, farmers' training, distribution of seeds of high yielding varieties and seedlings, etc.

Fig. 4-1 Mahaweli Development Board Proposed Organization Chart of the Settlement and Agricultural Development Section



Resident Project Manager's Division: This is established as a branch office of MDB at the center of the beneficiary area of this project including the existing farming land, the the adjustment and services concerning the extension of agricultural techniques, irrigation (operation and maintenance), social development and land administration (Fig. 4-2).

The jurisdiction is scheduled to cover 115,000 acres of agricultural land, 36,040 farm households and 234,804 population.
Public Facilities: The Settlement and Agricultural Development Section will establish welfare facilities such as hospitals, pharmacies and maternity clinics, educational institutions from primary schools to senior high schools, local offices, banks, transportation system, post offices, telephones, police stations, etc. for respective areas.

4) Soil Conditions of Beneficiary Area

The soil maps for the beneficiary areas D1 and A/D were made by the Land Use Division of ID in 1969, on a scale of 2 inches to 1 mile. Soil is classified to express the structures, in terms of soil series by developing from the same parent material under similar condition and the same sequence of soil profil. Here are described main individual types of soil.

a. Reddish Brown Earths (RBE)

This soil is usually neutral (pH6 to 7), slightly acidic in the wet zone and moderately alkaline in the dry zone, and contains small amounts of organic matter and nitrogen, a usually small amount of phosphoric acid and a little large amount of potassium. Since Ca and Mg are contained sufficiently, cation exchange capacity is high. It could be said to be fertile for tropical soil. In general, it is high in water dranage, and the available water capacity is 1.7 inch/ 1 foot depth of soil. When wet, it is fragile, and when dry, it is hard. Deep soil is suitable for culturing cotton, and the soil of medium depth, for chilies, onion, groundnuts, soybeans, cowpeas, green gram, Dhal, upland rice, corn, grain sorghum, sugar cane, tobacco, etc.

b. Low Humic Gley Soil (LHG)

In the horizon B, clear mottling are observed. Mottling form streaks or spots of red, yellow and brown on the ground of dull gray to Grayish brown. LHG is observed in the lowland of developed area, and RBE closely associated with and red yellow podzolic soil non-calcic brown soil. Its pH is neutral to weakly alkaline, and sometimes, salt accumulation is observed in a lower horizon of profil. Both in the Maha and Yala seasons the soil is suitable for rice planting by irrigation.

c. Alluvial Soil

This soil is water laid deposits of rivers, and though there is no profile, the accumulation of organic matter is observed in the horizon A. It greatly differs in soil texture, depth, drinage and color. Mostly, it is loam or clay and low drainage, with neutral pH, being suitable for culturing paddy.

d. Solidized Solanetz

The lower horizon soil is weakly or strongly alkaline, and contains very small amounts of organic matter, nitrogen and phosphoric acid and a large amount of potassium, being rich in Ca and Mg, and excessively in Sodium. When soluble salts are excessively accumulated, the soil is not suitable for growth of plants, and therefore, if Na and salts are removed by drainage and leaching, with a soil conditioner used, then paddy can be cultured with this soil.

Fig. 4-2 Organization Chart of a Resident Project Manager's Division

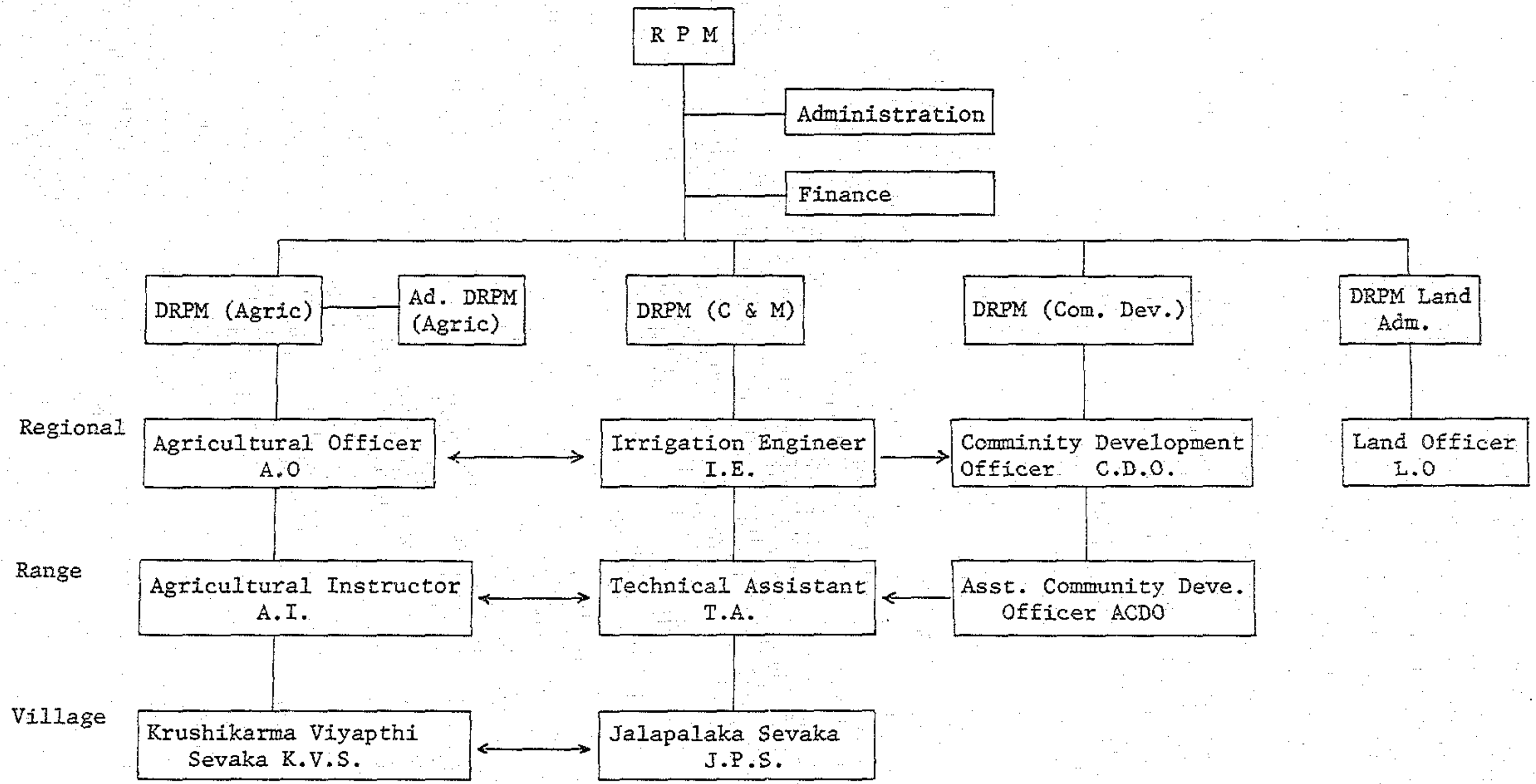


Table 4-2 Soil and Cropping Pattern on System D_1 & A/D

Soil	Drainage	System D_1 Average	System D_1 %	System A/D Average	System A/D %	Cropping Pattern Maha	Cropping Pattern Yala
RBE	Well	13,645	23	5,510	31	Upland crops	Upland crops
	Imperfectly	4,990	8	5,215	29	Paddy sugar cane	Upland rice
LHG	Imperfectly	17,065	29	1,260	7	Paddy	Paddy
Alluvial Soil	Imperfectly	16,540	28	3,760	21	Paddy	Paddy
Solidized Solonets	Imperfectly	2,825	5	-	-	Paddy	Paddy
Sub Total		55,065	93	15,745	88		
RBE, Gravel & Rock	Well	3,670	6	2,165	12	Settlement, Homestands Building Site	
Other		535	1				
Grand Total		59,270	100	17,910	100		

In the systems D_1 and A/D, soil with imperfect drainage accouts for 70% and 57% respectively, but after completion of the project, paddy will be the main crop in this area. Though soil data of the system D_2 area could not be obtained, the lowland on the left bank of the Mahaweli Ganga contains Villu zone covered with water by flooding during the Maha, and alluvial soil is mainly distributed.

5) Cropping Pattern

The cropping pattern depends upon soil of beneficiary area, irrigation and weather conditions, but basically there are three patterns such as the double cropping of paddy, the two-crop system for paddy and upland crops per year, and two upland crops in the respective cropping seasons of Maha and Yala.

a. Paddy and Paddy

This cropping pattern is suitable for mainly LHG and alluvial soil, and during the Maha, late and high yielding varities with growing period of 4 to 4.5 months such as BG11-11 and

BG90-2 can be planted, while during the Yala, early varities with the growing period of 3 to 3.5 months such as BG34-8, BG94-1 BG34-6 and H4 can be planted.

b. Paddy and Upland Crop

This cropping pattern is suitable for soil zone of RBE with imperfect drainage, and during the Maha, late varieties of paddy can be planted, while during the Yala, any pulses with the growing period of about 2.5 months, or upland rice, miner millet, onion, tobacco, vegetables, or cotton, etc with the growing period of about 4 months can be planted.

c. Upland Crop and Upland Crop

This cropping pattern is suitable for RBE zone with well drainage, and during the Maha, cereals such as corn and grain sorghum, pulses such as green gram, black grain, cowpeas, groundnuts and soybeans, vegetables of Cucurbitaceae or Solanaceae, and manior, etc can be planted, while during the Yala, cereals, pulse, vegetables, chillies, tobacco, cotton, etc can be planted. They can be combined according to difficulties in culture, labor force and economy.

d. Recommended Varieties of Upland Crops

Green Gram: 2.5 to 3 months ... MI-4, MI-1; yield is about 1,200 lbs/acre if irrigated, and 500 lbs/acre if not irrigated.
Black Gram: 2.5 to 3 months ... Type 9, MI; yield is 1,400 lbs/acre if irrigated, and 600 lbs/acre if not irrigated.
Cowpeas: 2.5 to 3 months ... MI-35, Bombay, Arlington; yield is 1,500 lbs/acre if irrigated, and 700 lbs/acre if not irrigated.
Groundnuts: 110 days ... Red spanish, Vgand Erect, A-20, A-92, MI-1; yield is 30 CWT/acre if irrigated, and 15 CWT/acre if not irrigated.
Soybeans: 82 days ... PBI; 90 to 92 days ... Davis, Bossiar, Hardie, Improved Pelican, SJ-2; yield is 1,000 to 2,000 lbs/acre.
Chillie: 4 months ... MI-1, MI-2; yield is 15 CWT/acre if irrigated.

Onion: 150 days ... Poona Red; yield is 4 tons/acre

Red onion: 80 to 90 days; yield is 6 to 10 lbs/30 feet^2 bed

e. Intensive Rice Cultivation Method in Mahaweli Region

Recommended Varities: 3 months ... BG34-8; 3.5 months ... BG34-6, BG94-1; 4 to 4.5 months ... BG90-2, BG11-11

Fertilization: Basal dressing ... 75kg/acre of VIC (ammonium sulfate 15 : superphosphate of lime 73 : potassium chloride 24) fertilizer; 1st side dressing ... 25kg/acre of urea; the 2nd side dressing ... 38kg (early variety) or 25kg (late variety) of urea; the 3rd side dressing ... 38kg (late variety only) of urea.

Weeding: Weeding before the 2nd side dressing; MCPA, 3-4DPA and Machete Saturn to be used for the 21st to the 30th days after seeding and on the 15th day after rice transplanting.

Pest Contral: Diazinon against rice stem borer and gall midge, Monocrotophos 60EC against leaf-eating and rolling Caterpillers and cabbage armyworms, Carboturan against rice leafhoppers, Dimithoate against rice thrips, and BHC against paddy bug.

6) Target Yield

The UNDP report of 1969 concluded that yields of 55 bushels in 1972 and 68 bushels in 1978 could be attained by advanced varieties, fertilization and agricultural techniques in future, since the average yield per acre had been 40 bushels in 1967. The F/S report for Stage II of Project I of SOGREAH concluded in 1972 that the yields for the 1st to the 5th years after settlement would be 46 bushels, and that the yields for 10th to 11th years at the completion time of development would be 90 bushels. According to the data submitted by MDB to the World Bank Appraisal Mission in 1976, the target yields at the completion time of development have been estimated to be 90 bushels of paddy, 15 CWT of chillies, 18 CWT of groundnuts, 10 CWT of cowpeas and 15 CWT of soybeans.

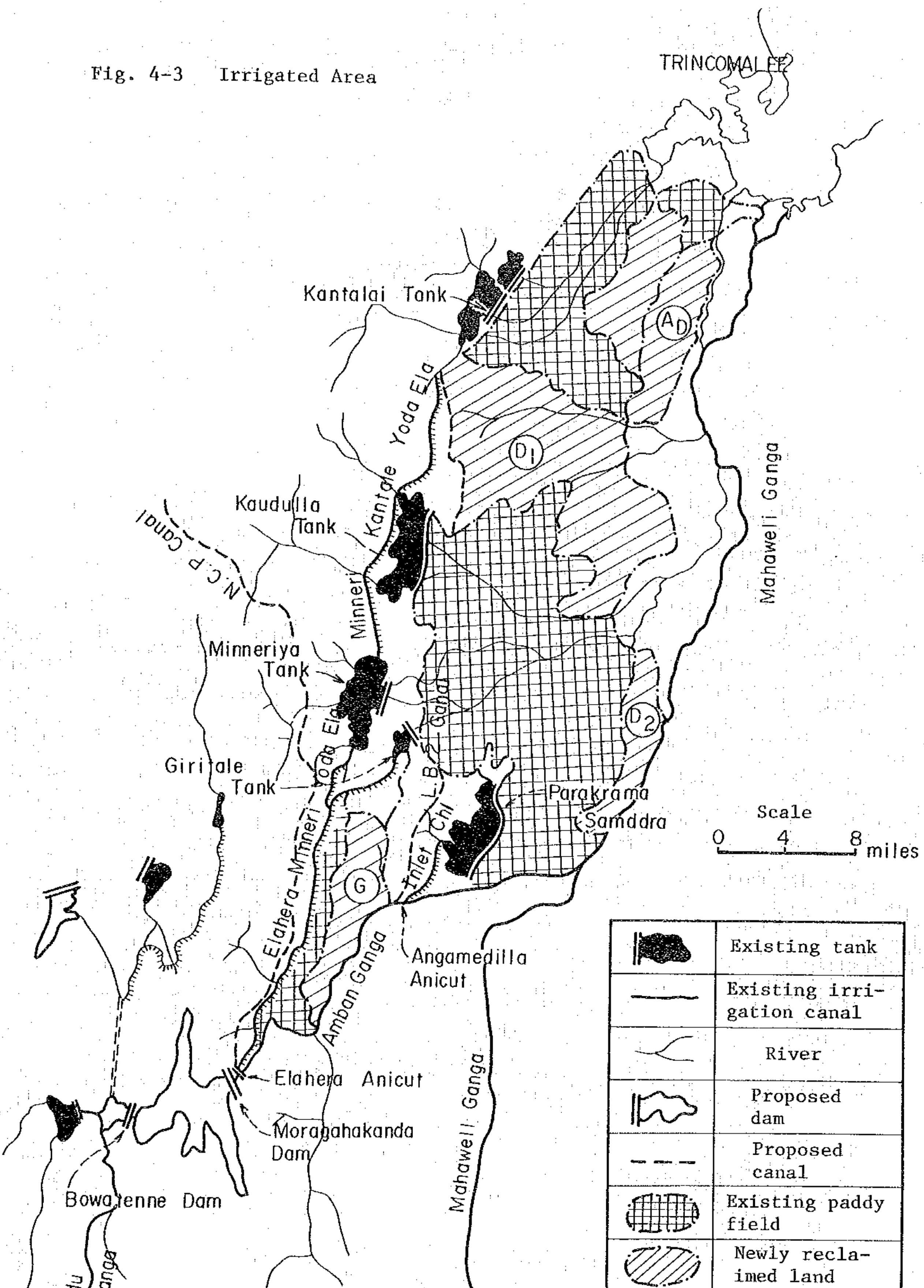
4-3 Irrigation

1) Command Area

The command area covered by the Moragahakanda Dam comprises the irrigated area covered by the irrigation systems of the main canal following the Elahera Head Works below the dam site, tanks and canals connecting them, and unreclaimed land adjacent to them. This corresponds to the area classified as the Systems D1, D2 and A/D in the Master Plan and belongs to the left bank side of the Mahaweli Ganga basin, excluding the partial lower reaches of the head works. This area has irrigation systems developed from a long time ago, and forms one of the prominent paddy field zones among all the islands of Sri Landa. These existing paddy fields are supplied water from large tanks such as Parakrama-Samudra, Minneriya, Kaudulla and Kantalai. After the construction of the Moragahadanda Dam, the Elahera Irrigation System will be united functionally with the dam. Therefore, the command area includes the existing paddy fields, newly developed agricultural land and unreclaimed land. The Moragahakanda Multipurpose Project report (March, 1978) specifies the beneficiary area covered by the dam as an unreclaimed land of 46,200 acres. The command area includes the following:

(a)	Existing paddy fields	73,200 acres (29,645ha)
(b)	Newly developed agricultural land	20,000 acres (8,100ha)
(c)	Unreclaimed land	46,200 acres (18,711ha)
	Total :	139,400 acres (56,457ha)

Fig. 4-3 Irrigated Area



The paddy fields of (a) are the existing paddy fields in the Systems D1, D2 and G and have been irrigated by the Elahera Irrigation System, irrespective of the progress of the Mahaweli Project. But the cropping area in the dry season has varied year by year. The agricultural land of (b) has been so newly developed as to meet the irrigation requirement increased due to the introduction of the main stream of the Mahaweli Ganga into the Amban Ganga by the completion of the Polgolla Diversion and the Bowatenna Complex, and including the arable land for sugar cane. The unreclaimed land of (c) remains so free from irrigation water even after the completion of Stage III of Project I (Polgolla Diversion, etc) and will be irrigated by the irrigation water increased by the construction of the Moragahakanda Dam, being the area designated as the beneficiary area covered by the Moragahakanda Dam Project.

Table 4-3 System-wise Command Area

(Unit 10^3 acres)

System	Project area			Unreclaimed land	Total
	Existing arable land	Newly developed agricultural land	Sub-total		
D_1	49.4	13.8	63.2	28.0	91.2
D_2	19.0	-	19.0	9.1	28.1
G	4.8	6.2	11.0	-	11.0
A/D	-	-	-	9.1	9.1

2) Water Requirement

The water requirement available for irrigation by the reservoir water of the Moragahakanda Dam is planned to be 1,396,000 ac. ft. (according to the Master Plan of UNDP/FAO) after the regulation of discharge of the Mahaweli Ganga by the construction of the Kotmale Dam, and this will be the irrigation requirement for the entire command area. In addition, the storage capacity of respective tanks will be added, but even if these are disregarded, the requirement would be deemed sufficient as the total irrigation requirement for the command area of 139,400 acres. The total irrigation water for the newly reclaimed land of 46,200 acreas which will be regarded as the beneficiary area afterwards, is estimated at 323,000 ac. ft. according to the report (March, 1978), and this is based on the following plan of the UNDP/FAO report.

		D_1	D_2	A/D	Total
Paddy - Paddy	10^3Acs	10.3	9.1	9.1	28.5
Paddy - Upland	"	4.3	-	-	4.3
Upland - Upland	"	13.4	-	-	13.4
	Total :	28.0	9.1	9.1	46.2

According to this plan, the unit tank water requirement (proposed discharge from tank) is generally 7 ac. ft. on the average.

4-4 Power Generation

(1) Entire View of Power Generation Plan and Power Demand and Supply

The Mahaweli Ganga is a large river accounting for about 50% of the entire domestic water power resources, with approx. 207 miles of length and 4,034 square miles of drainage area (about 16% of the total area of the country), and in the drainage area, 820 square miles belong to a heavy rain zone, with an annual average rainfall of 1,880mm to 5,430mm.

For the Mahaweli Ganga Development Program, the UNDP/FAO took charge of its survey and prepared the Master Plan in 1969, and the Government took it up as the basic plan of the nation. The plan includes, 30-year development for irrigating 900,000 acres by 22 reservoirs and producing an electric power of 5,184MW by 12 points (As for the power generation plan, see Table 4-4).
In this plan, already completed has been the Ukuwela Power Plant with the maximum output of 40MW, which generates power, using the diversion tunnel from the Polgolla Diversion to the Amban Ganga,

tributary of the Mahaweli Ganga, constructed in the main steam of the Mahaweli Ganga. The Bowatenna Dam to store the water discharged from it (initially, the construction of power plant was not planned, but later with the plan changed, the Bowatenna Power Plant with an output of 40MW is being constructed) has been already completed.

Table 4-4 Mahaweli Master Plan — Main Parameters of Reservoirs

No.	Name of Reservoir	Name of River where it is located	Catchment Area Mls.	Cap: 10^3 Ac. ft. Gross	Active	Regulated flow 10^3 Ac.ft.	Power Installed MW	Energy GWh	Dam Length in Feet	Max. height in Feet	Type	Remarks
1	Polgolla Bar: ...	Mahaweli	499	1.9	1.0	830	40	168	685	65	Concrete gravity — Completed	1)
2	Bowatenne ...	Amban Ganga ...	188	37	21	1.210	—	—	880	137	.. ..	2)
3	Victoria	Mahaweli	730	415	390	926	120	469	1.400	338	Concrete gravity arch	
4	Ulhitiya	Ulhitiya Oya ...	109	88	61	908	—	—	19.260	90	Earthfill	
5	Moragahakanda ...	Amban Ganga ...	315	692	470	1.103	40	149	5.070	242	Conc. gravity. rockfill and earthfill	
6	Taldena	Badulu Oya ...	110	66	56	134	14.5	48	1.200	200	Earthfill	
7	Kotmale	Kotmale Oya ...	217	320	297	690	150	411	1.927	356	Rockfill	
8	Kalu Ganga ...	Kalu Ganga ...	73	208	188	172	1.9	..	8.975	165	Earthfill	
9	Rotalawela	Mahaweli	2.063	196	184	120	-	-	6.720	80	Earthfill	
10	Pallewela	Loggal Oya	80	87	46	134	10	34.5	5.425	200	Earthfill	
11	Randenigala ...	Mahaweli	900	629	374	562	75	282	1.740	277	Concrete gravity	
12	Upper Uma Oya ...	Uma Oya	195	52	40	205	25.5	95.5	1.110	280	Concrete gravity arch	
13	Lower Uma Oya ...	Uma Oya	273	36	31	112	30	113.3	845	175		
14	Heen Ganga ...	Heen Ganga ...	44	97	78	160	7	25.5	1.060	285	Rockfill	
15	Maduru Oya ...	Maduru Oya ...	175	324	288	562	4.5		1.780	150	Earthfill	
16	Malwatu Oya ...	Malwatu Oya ...	819	225	205	222	—	—	15.000	90	Earthfill	
17	Yan Oya	Yan Oya	506	208	189	170	—	—	12.000	90	..	
18	Kapirigama ...	Malwatu Oya ...	13	14	71	584	—	—	15.200	80	..	
19	Kitagala	Ma Oya	55	180	172	545	—	—	15.000	115	..	
20	Kanagarayan Aru ...	Kanagarayan Aru ...	33	112	112	102	—	—	11.000	85	..	
21	Parangi Aru ...	Parangi Aru ...	165	285	279	121	—	—	20.000	95	..	
22	Pali Aru	Pali Aru	35	180	172	50	—	—	15.000	115	..	
	Total		7,597	4,452.9	3,725	9,622	518.4	1,795.8				

*Construction is promoted as 5 major projects

1) Completed in 1976; the power plant named Ukuwela.

2) 40MW power plant is being constructed, though not planned initially.

The five major projects taken up to promote the Mahaweli Ganga Development Program in 1977 amount to the toal output of 390MW including the Moragahakanda Power Plant (the maximum output of 40MW), and they are scheduled to be completed in a short time of 5 to 6 years, together with 190MW of power plants now being constructed at 3 points separately from them. The details of these power plants now being planned and constructed are as shown in Table 4-5.

According to the estimate of power supply and demand (Table 4-6) in future by the Ministry of Irrigation, Power and Highways, the supply is a little insufficient in several years to come, but in several years when the above power plants are completed one after another, considerably surplus capacity is estimated to be available. However, if the situation progresses as it is, the supply is feared to be insufficient again from about 1989. In this demand and supply estimate, the annual demand increase rate is estimated at 11%, being excessive, compared with the actual increase rate of less than 8%, and on the other hand, it is assumed that firm output can be always secured, but not considering the variation due to drought at all. Therefore, this estimate should be examined thoroughly. The result of estimating the power demand and supply, assuming 8.5% as demand increase rate and 10% as drought (see Table 4-7) was not so different from the estimate of MIPH in general. This means that the construction of power plants must be planned also in future continuously, but since the new construction of steam power plant raises the power generation cost to about 50 cts/KWH due to expensive fuels, considerably higher than the present actual sales unit price of 16 cts/KWH, the construction of hydraulic power plants will have to be discussed in succession.

Table 4-5 Outline of Power Plants Being Planned and Constructed

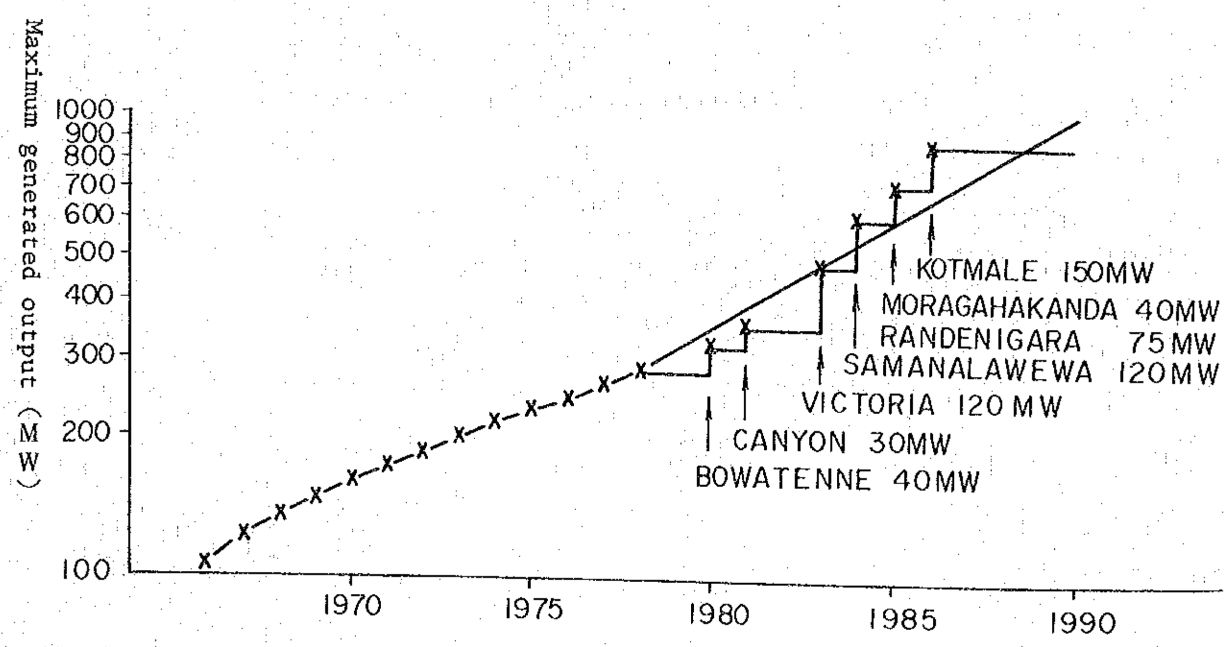
Name of Reservoir	Name of River	Catchment Mile^2	Dam Length ft.	Dam Height ft.	Dam Type ft.	Reservoir Effective Storage Capacity 10^3Ac.ft.	Headrace Length ft.	Headrace Diameter ft.	Steel Penstock Length ft.	Steel Penstock Diameter ft.	Effective Head ft.	Power Plant Max. Output MW	Power Plant Firm Output MW	Possible power generation, (value in the parentheses shows firm component) 10^6KWH	Scheduled year of completion
Victoria	Mahaweli	730	1,400	338	Concrete (arch)	390	14,720	21	800/ 1020		609	120	54	645 (528)	1983
Moragaha-kanda	Amban Ganga	315	1,660 1,350 2,160	242 183 101	Concrete Rockfill Earth-fill	470	-	-	200	8	174	40	18.9	206 (165)	1985
Randeni-gala	Mahaweli	900	1,740	277	Concrete	374	-	-	260	7.5	244	75	32.1	350 (264)	1985
Kotmale	Kotmale Oya	217	1,927	356	Rockfill	297	21,700	14	610	12.5	700	150	47.6	411 (380)	1986
Maduru Oya	Maduru Oya	175	1,780	150	Earth-fill	288						4.5	-	- (-)	
Total		2,337				1,819						389.5	152.6	(1,337)	
Bowatenna	Amban Ganga	188	771	103	Concrete	27.4	4,065	19	235	14.5	160	40	13	143 (108)	1980
Canyon	Mahaweli		615	135	Concrete	88	13,208	10	2,755	8	700	30	16.6	169 (144)	1980
Samanala-wewa	Walawe Ganga		1,400	314	Earth-fill Rockfill	177	18,500	12.5	480	6	1,080	120	48	600 (420)	1984
Total						292.4						190	77.6	912 (672)	
Grand Total						2,111.4						579.5	230.2	(2,009)	

Note: The Bowatenna Reservoir has been already completed as a part of the Mahaweli Ganga Development Program, and the Bowatenna Power Plant, which was not included in the Master Plan, was added in the plan and is now being constructed.

Table 4-6 Maximum Generated Output and Demand and Supply Balance

March, 1978 (In MW)

Year	Demand (at-site)	Service-ability	Contents of serviceability increase		Surplus or shortage of service-ability
1968	135				
69	147				
70	163				
71	173				
72					
73	199				
74	216				
75	230				
76	240				
77	261				
1978	280	280			-
79	310	280			Δ 30
80	345	320	BOWATENNA	40 MW	Δ 25
81	383	350	CANYON	30	Δ 33
82	425	350			Δ 75
83	472	470	VICTORIA	120	Δ 2
84	524	590	SAMANALAWEWA	120	66
85	581	705	MORAGAHAKANDA RANDENIGALA	40 75	124
86	645	855	KOTMALE	150	210
87	716	855			139
88	795	855			60
89	882	855			Δ 27
90	980	855			Δ 125



(2) Moragahakanda Power Plant

The Moragahakanda Reservoir covered by the current survey, whose total storage cpapcity is 692,000 ac. ft. (effective capacity of 470,000 ac. ft.), has been planned to make the effective use of irrigation and power generation by constructing a concrete gravity dam, rockfill dam and earthfill dam across the Amban Ganga, tributary of the Mahaweli Ganga. The Moragahadanda Power Plant is a dam-type power plant to take water directly from the dam by a 200 feet long and 8 feet diameter steel penstock, with the power station building constructed near the left bank immediately below the concrete gravity dam. After power generation, water will be discharged directly into the Amban Ganga.

At the power generation point, the drainage area of the Amban Ganga is 315 square miles ($816km^2$), and the annual discharge is as small as 720,000 ac. ft. (876 million m^3), but the water volume of 2,000 ft^3/sec ($56m^3/sec$) at the maximum is diverted to the upper reaches of the Amban Ganga from the Polgolla Diversion through the Ukuwela Power Plant. Of it, the water volume of 1,000 ft^3/sec ($28m^3/sec$) at the maximum is diverted to the System H area from the Bowatenna Dam immediately above this power plant. As a result of these diversions, the annual discharge available for this power plant will increase to 1,470,000 ac. ft. (1,790 million m^3). If the Kotmale Dam is constructed further above the Polgolla Diversion and the flow control of the main stream is executed, the annual discharge will increase further to 1,620,000 ac. ft. (1,970 million m^3). However, because these mutual relations of water use are complicated under the large variation between high water and low water, the available volume of water should be sufficiently discussed.

This power plant is so planned as to have 40MW of the maximum output, 18.9MW of firm output, and 206 million KWH of the annual possible power generation (of it, firm generation is 165.4 million KWH) (see Table 4-8). There exists the Elahera Intake Dam (the height of overflow section being 455.5 ft) immediately below this power plant, and in future a New Elahera Intake Dam (the height of overflow section is planned to be 470 ft) is planned to be provided further for intake into the N.C.P. canal. The influence of back water by them must be sufficiently taken into consideration in its design.

As mentined above, the water of this power plant will be discharged in relation with the intake of water for irrigation purpose in the lower reaches, and the great adjustment of generated output related mainly to power generation only can be said to be difficult.

Table 4-7 Discussion of Electric Power Demand and Supply in Future

Unit: Electric energy - Million KWH, Electric power - MW

	Results												
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
A. Possible hydraulic power generation (firm)	1,443	1,443	1,443	1,695	1,695	1,695	2,223	2,643	3,072	3,452	3,452	3,452	3,452
Name of power plant scheduled to be completed and possible power generation				Bowatenna 108 Canyon 104			Victoria 104	Samana-lawewa 420	Randeni-gala 264 Moragaha-kanda 165	Kotmale 380			
B. Amount corresponding to 90% of the above (assuming 10% drought)	1,299	1,299	1,299	1,526	1,526	1,526	2,001	2,379	2,765	3,107	3,107	3,107	3,107
C. Energy demand (at-site)	1,217	1,320	1,433	1,554	1,687	1,830	1,985	2,154	2,337	2,536	2,751	2,990	3,239
D. Surplus or shortage of energy (B - C)	82	Δ 21	Δ134	Δ 28	161	Δ304	16	225	428	571	356	117	Δ132
E. Maximum possible generated output	272	272	272	319	319	319	418	497	578	650	650	650	650
F. Maximum power demand (at-site)	261	283	307	333	362	426	462	462	501	543	590	640	695
G. Maximum surplus or shortage of power (E - F)	11	Δ11	Δ35	Δ14	Δ43	Δ73	Δ 8	35	77	107	60	10	Δ45

Notes:
1. Both the annual increase rates of energy demand and maximum energy demand were assumed to be 8.5%.
2. Maximum possible generated output was calculated by taking into consideration the amount corresponding to 90% of power generation at an annual load factor of 54.6% (actual).
3. The shortage of about 50MW beyond the maximum power is surmised to be able to be covered by steam power and diesel power plants.

Table 4-8 Outline of the Moragahakanda Power Plant

River	Amban Ganga, tributary of the Mahaweli Ganga	
Catchment area		315 mile^2 (815.9 Km^2)
Annual discharge	Amban Ganga	720 x 10^{3}ac.ft (876 million m^3
	With diversion from the Polgolla Reservoir	1,470 x 10^{3}ac.ft (1,788 million m^3)
	With additional flow control by the Kotmale Reservoir	1,620 x 10^{3}ac.ft (1,970 million m^3)
Dam	Concrete gravity	Length 1,660 ft. Height 242 ft.
	Rockfill	1,350 ft. 183 ft.
	Earthfill	2,160 ft. 101 ft.
Reservoir	Maximum water surface elevation	640 ft. (194.6 m)
	Minimum available water surface elevation	573 ft. (174.2 m)
	Water surface elevation of diversion channel	470 ft. (142.9 m)
	Total hydrostatic pressure	170 ft. (51.7 m)
	Total storage capacity	692 x 10^{3}ac.ft. (841.5 million m^3)
	Effective storage capacity	470 x 10^{3}ac.ft. (571.5 million m^3)

Steel penstock	Length	200 ft (60 m)
	Diameter	8 ft (2.4 m)
Effective head	Annual average	153 ft (46.5 m)
	Firm	137 ft (41.6 m)
Turbine discharge	Max.	3,632 ft.^{3}/sec. (102.1 m^3/sec.)
	Firm	1,918 ft.^{3}/sec. (53.9 m^3/sec.)
Output	Max.	40 MW
	Firm	18.9 MW
Annual possible	Annual average	206 million KWH
	Firm	165.4 million KWH
Main equipment	Hydraulic turbine	40 MW x 1 set

As the main equipment for power generation, initially 4 sets of 10MW equipment were planned, but changed to 1 set of 40MW equipment recently. Accordingly, the general design change including the building for power station is required. As for the geology for the site of power station building, boring is scheduled to be executed by the local authorities simultaneously for the dam site.

Outdoor steel construction and switch gear and the like are planned to be constructed on a hill on the left bank below the power station building.

The generated output of this power plant is planned to be boosted to 132KV, and to be connected by the 132KV transmission line to be newly provided, to the existing 132KV transmission line through the outdoor switching station of the Bowatenna Power Plant now being constructed at a place of about 5 miles (8km) apart. Where the transmission is to be passed has not been decided yet, but there seems no particular problem for topography and geology in the rural area.

According to the Master Plan prepared in 1969, the total construction cost for this point is Rs.560 million, of which Rs.195 million is appropriated to the power generation section, but of it, Rs.24 million is appropriated as the constriction cost of power station building and main equipment. According to the review of the construction cost by the World Bank in May, 1978, the total construction cost greatly increases to Rs.1,350 million (including the foreign currency portion of Rs.900 million).

4-5 Dam

4-5-1 Dam body

(1) Outline

The Moragahakanda Dam is planned as a dam with the largest storage capacity among the dams planned to be constructed in the Mahaweli Ganga Development Program. This dam will close the Amban Ganga, tributary of the Mahaweli Ganga, to store water, and the dam site is located 30 miles (about 48km) upstream from the river mouth. The principal sources of water are the main stream of the Mahaweli Ganga, diverted from the Polgolla Diversion, and the runoff of the Amban Ganga itself. Unlike the Victoria and Randenigala Dams constructed closing the main stream of the Mahaweli Ganga, this dam will be constructed in the relatively falt hilly country of the dry zone. Partly because it is located near the beneficiary area in the northern dry zone, among main dams, it is planned to serve as a source dam for irrigation water in the northern area when all the dams are completed, according to the Master Plan of the UNDP/FAO.

Table 4-9 Storage Capacities of Main Dams

	Total storage capacity (Unit: million tons)	Effective storage capacity (Unit: million tons)
Moragahadanda Dam	853	580
Kotmale "	395	366
Victoria "	512	481
Randenigala "	756	461

The Moragahakanda Dam is a complex dam planned to close the Amban Ganga by a concrete gravity dam and to close the adjacent dells on the left bank side respectively by rockfill dam and earth dam. According to the Master Plan of the UNDP/FAO, the scale and specification of the dam are as follows.

(2) The concrete dam is a gravity dam with 506m of crest length and 73.8m of the maximum dam height. It consists of overflow and non-overflow sections, and the overflow section forms a gate-control spillway. The generator room is provided at the downstream end of the dam. At the dam bottom, there is a conduit section for drainage during the construction period and as an emergency outlet, being designed to be controlled by four sluice gates.

(3) Rockfill Dam

This is designed as a center core type rockfill dam with 411m of crest length and 55.7m of the maximum dam height. On the foundation, an inspection gallery is provided to cope with the water permeability of foundation bedrock and the expected void in limestones by means of grouting, etc.

(4) Earth Dam

The earth dam is located on the left bank side of the rockfill dam, being designed as a uniform type with 658m of crest length and 30.8m of the maximum dam height.

(5) Statistical Data of the Moragahakanda Dam

Drainage area:	315 sq. miles		($816 km^2$)
Annual average inflow: (own catchment area only)	720×10^3 Ac - ft		($888 \times 10^3 m^3$)
Annual designed inflow:	$1,396 \times 10^3$	"	($1722 \times 10^6 m^3$)
Total storage capacity:	692×10^3	"	($853 \times 10^6 m^3$)
Effective storage capacity	470×10^3	"	($580 \times 10^6 m^3$)
Silt volume:	222×10^3		($274 \times 10^6 m^3$)
Normal maximum water surface elevation:	640 ft		(195m)
Minimum operating water surface elevation:	573 "		(173m)

(power generation)		
Tail elevation:	470 ft	(142m)
Crest elevation:	660 "	(200m)
Dam height		
Concrete:	242 "	(73.8m)
Rockfill:	183 "	(55.7m)
Earth:	101 "	(30.8m)
Crest length		
Concrete:	1,660 "	(506m)
Rockfill:	1,350 "	(411m)
Earth:	2,160 "	(658m)

(6) Main Construction Quantities

a)	Foundation excavation (earth)	1,030,000 Cuyd	787,000m^3
b)	Foundation excavation (bedrock)	698,000 "	534,000m^3
c)	Concrete	552,000 "	422,000m^3
d)	Rockfill	975,000 "	745,000m^3
e)	Earthfill	1,120,000 "	856,000m^3
f)	Cement		91,500 tons
g)	Steel		730 tons

(7) Construction Cost

With respect to the construction cost of this dam, the current prices have been estimated by multiplying the construction cost based on the year 1968 calculated by the Master Plan of the UNDP/FAO, by the inflation rate. According to the prices, the total construction cost is Rs.1,350 million (US$90 million), of which the foreign exchange component is Rs.9 million.

4-5-2 Geological Survey

(1) Progress

The geological survey in the vicinity of the Moragahakanda Dam site was conducted since 1959 as part of "Mahaweli Ganga Irrigation and Hydro-Power Survey" by the UNDP/FAO, and the results of the survey which was completed in 1968, are summarized in the Annex Vol. IV "Engineering Geology" of the above report.

The contents of the geological survey conducted by the UNDP/FAO were (1) the preparation of a geological map in and around the reservoir area based on the topographic map of 1 inch to 1/2 mile, and (2) the preparation of a geologic map including the results of 40 borings with a maximum depth of 370 feet and 9 trenches, based on the topographic map of 1 inch to 200 feet.

The data available at present are the above report and the boring records (including field permeability test) and electric prospecting records stored by ID. The data of seismic prospecting surmised to have been conducted at that time have been lost.

In 1978, CECB prepared topographic maps of reservoir area of 1/10,000 and 1/5,000, and is now preparing a topographic map of 1/500 of the dam site. The ID additionally bored at 29 points and dug 3 trenches up to July, 1978 at the sites of the main dam and the first auxiliary dam including the point at which power plant will be constructed, and the reservoir area. During the survey period of the team, 11 test pits were excavated and examined in the borrowing pit on the downstream side of the dam site. Boring survey is still being continued at the dam site.

(2) Geology of Reservoir Area

The topography from the Moragahakanda dam site to the vicinity of reservoir area is featured by considerably dissected hills of later stage of maturity and the stage of old age, drained by the meandering Amban Ganga and its tributaries. The Amban Ganga flows almost from south to north, though it flows eastward from the vicinity of the Bowatenna Dam to the vicinity of Elahera, and its tributaries also tend to flow from south to north.

The directivity from south to north of the rivers and hills is surmised to have been caused, being governed by the structures of gneisses and crystalline limestones.

The geology in and around the reservoir area is composed of gneisses such as charnockite gneisses, biotite gneisses and quartzite, crystalline limestones, accompanied by aplite dyks. Various gneisses show banded texture. Some gneisses show obscure bands where one kind of gneiss gradually changes into another kind of gneiss over a certain range, and other gneisses show sudden change on the joint walls. These gradual change are also found in between crystalline limestones and gneisses, and some are clear, as shown in boring DM29, while there are cases as observed in boring DM26 core where quartz between biotite bands gradually changes into calcite, gradually transferring into crystalline limestone.

The strikes of these gneisses and crystalline limestones are almost from south to north. The dips of schistosity are 15 to 30 degrees westward in the reservoir area, but near the dam site, they are observed to change from horizontal to rather eastward dip over the anticlinal axis.

On the hill in the south of the dam site, two parallel anticlinal axes and one synclinal axis are extending from south to north. On the other hand, in the north of the dam site, an anticlinal axis extends from south to north on the left bank side of the second auxiliary dam, and due to the unreasonableness that the extension of this axis appears to hit the synclinal axis on the south hill, the existence of two or three faults in and around the dam site is assumed in the geologic map of 1 inch to 1/2 mile, Attached Drawing 1 of "Engineering Geology".

Several minor faults of NW-SE trend are assumed near the reservoir area, according to the geological map of 1 inch to 1 mile (original map not yet published) of Geological Survey, but relatively near the reservoir, only one fault extending southeast from the Kambarawa Hamlet along the Kambarawa Ganga, tributary of the Amban Ganga above the dam site is assumed.

However, no faults were observed clearly on the ground surface, and no collapse topography showing topographical fracture zone was observed. It is considered that there is no remarkable fault in the reservoir area which threatens to cause landslide or collapse.

The hill extending over both banks of the dam site from south to north, to form a watershed between the reservoir side and the downstream side comprises mainly gneisses, and crystalline limestones are distributed only partially on the mountainous area of the left bank and partially on the ridge of the right bank. The crystalline limestones on the left bank side continue from the inside of reservoir area to the outside downstream, but the crystalline limestones observed in the reservoir bed are distributed, as long lenticular form between gneiss.

Gneisses are very solid and sound rocks, and the fresh bodrock is impermeable, and can be said to be quite free from the fear of leakage from the reservoir bed.

Also with regard to crystalline limestones, the rocks themselves are impermeable, but it must be noted that the rocks have the nature of being corroded by the flow of ground water, to form cavities. Small corroded cavities of about 30cm diameter are observed in the streams of rain water on exposed rocks, though very rarely, and as described in the Paragraph for the geology of dam, cavities are found by boring. Thus, there is certainly possibility that cavities exist inside crystalline limestones.

In spite of extensive exposure of the crystalline limestone on the left bank of the first auxiliary damsite, there is no sign to show development of continuous cavities; Among many test borings, under ground cavities were observed only at the left abutment of the first auxiliary dam; No collapse topography or dolines to show the existence of corroded cavities, was observed over the crystalline limestone area; No sizable spring is found in the area. These facts show that the possibility of leakage through the crystalline limestones is very low.

As described in the Paragraph of geology of the first auxiliary dam site, the ground water level in the crystalline limestones near the first auxiliary dam is very higher compared with the water level of the Amban Ganga, and if the reservoir water level is lower than the ground water level, there is no possibility of leakage from the vicinity of the dam site. Furthermore, the apparent thickness of crystalline limestone layer is about 350 feet, and their distribution range is limited. From these, even if leakage occurs from any undiscovered cavity, the range will be limited, and any countermeasure will be able to be taken.

According to the above-mentined report prepared by the UNDP/FAO, "Engineering Geology", the leakage through the foundation below the dam body is estimated to be 3,500 ac. ft./year (0.137m^3/sec), but this was calculated for sound rocks, without expecting limestone caves.

(3) Geology of the Moragahakanda Dam Site

In the Moragahakanda dam site, a hilly ridge approaches from the right bank and a mountainous ridge approaches similarly from the left bank side, to form topography of narrowed valley, being favorable as a dam site. The ridge from the left bank side has reliefs of two saddles (passes) and two isolated hills.

The Amban Ganga flows as an about 50m wide channel between the isolated hills at the tips of the ridge from the right bank side and the ridge from the left bank side. The river bed elevation of the Amban Ganga at the dam site is about 445 feet (136m). In the order from it, the elevation of the first isolated hill on the left bank side is 649 feet (198m) on the present dam axis; the elevation of the first saddle on the left bank side is 493 feet (150m); the elevation of the second isolated hill on the left bank side is 831 feet (253m); and the elevation of the second saddle is 585 feet (178m). Beyond them, exists a high hill with its higher elevation.

Therefore, if the elevation of maximum water surface is assumed to be 640 feet (195m), two auxiliary dams are required, in addition to the main dam constructed across the Amban Ganga. Here, they are called the first auxiliary dam and the second auxiliary dam from the side of the Amban Ganga for the sake of convenience (see Attached Drawing, "Geological Map of the Moragahakanda Dam Site").

As geological survey of the dam site, the UNDP/FAO conducted reconnaissance, geophysical prospecting, and test boring including permeability test. But today, the geologycal map of 1 inch to 200 feet and geological columner sections (showing the result of permeability test, but not ground water level) attached in the above report "Engineering Geology" are only available, and the other records and data disappear, with imperfect preservation of boring cores.

In 1978, ID started boring, and drilled 29 holes. For this, they used diamond bits, and the core recovering technique was favorable, recovered cores being preserved cleanly at the dam site. Permeability test was conducted on 65mm (BX size) and 55mm (AX size) holes.

(a) Geology of the Main Dam Site

At the main dam site, including the crest of the left bank and the site used power station site selected at the left bank toe of the dam, 31 holes were drilled, covering the total length of 2,843 feet (866m). Test pits were excavated, but remained in the bedrock considerably weathered, not reaching sound rocks. Test adits have not yet dug. At present, the conditions of fresh bedrock, joints and change of weathering conditions cannot be observed directly.

The geology of the foundation for the main dam comprises siliceous gneisses, as far as known through reconnaissance and boring, and is estimated not to contain crystalline limestones to the extent of the depth usually considered as the ordinary foundation of dam.

On the slope of the right bank, surface soil and weathered rocks would be distributed with about 35 feet in depth on the upper part and 30 feet on the lower part, and sound rocks underlying them. On the mid-slope, small faults are anticipated to exist from the result of geophysical prospecting.

Since boring is not made on the river bed, particularly on the channel, the thickness of bed sediment and weathered belt is not known. According to the data of boring made on both the banks, it is estimated that the sound rocks of gneisses can be reached below 35 to 40 feet.

The thickness of surface soil and weathered belt on the slope of the left bank is almost the same as that of the right bank, and there are sound rocks of gneisses below. On the top of isolated hill on the slope of the left bank, the thickness of weathered rocks is 38 feet, and the sound rock line is estimated at an elevation of 611 feet. Since this is lower than the design maximum water surface (640 feet elevation), the main dam and the first auxiliary dam will have to be connected.

Also with regard to the foundation of the planned power plant, test boring is drilled now, and at depths of 25 to 35 feet, reached sound foundations of gneisses.

For permeability test, inlet pressures of 10 to 15 psi (7 to $10kg/cm^2$) were applied for every 10 feet boring length in fresh bedrock, showing that the water permeability was very small.

As described above, in the whole neighborhood of the dam site, solid gneisses with small permeability are distributed and only small faults are observed. If proper foundation excavating lines are selected with proper foundation treatment applied, the construction of concrete gravity dam can be sufficiently materialized.

(b) Geology of the First Auxiliary Dam Site

The first auxiliary dam is planned as rockfill type constructed on the saddle between two isolated hills on the left bank of the Amban Ganga. The saddle is higher than the Amban Ganga at the dam center by about 48 feet (about 14m).

Seventeen bore holes were drilled, covering 2,593 feet (790m). Four test pits were made, but remain in weathered rocks, not reaching fresh bedrock.

About 359m both up- and down-stream of the dam axis, there are outcrops of crystalline limestones, and on the downstream side of the right bank, an outcrop of gneisses is observed.

On the slope of the right bank, gneisses form the base rock, according to geological reconnaissance, but due to lack of boring and test adit on the hillside, the thickness of surface soil and weathered belt is unknown. However, from the conditions on the slope of the left bank of the main dam, the sound rocks of the first isolated hill are anticipated to be thin.

The foundation of the saddle is composed of crystalline limestones. From the right bank to the lower part of hillside, they are extending under gneisses, but this relation has not yet been confirmed. The thickness of surface soil and weathered belt is about 30 feet. The depth of crystalline limestones is as large as 358 feet from the ground surface according to boring DH118.

The second isolated hill on the left bank forms generally the alteration of strata of gneisses and crystalline limestones, but the abutment of the dam is all composed of crystalline limestones according to the boring data. The thickness of surface soil and weathered belt is 30 to 45 feet.

The most important is that the existence of cavities in crystalline limestones is known by boring at 4 points along the dam axis. According to the UNDP/FAO report, the existence of a fault in this location is anticipated, but there is no possible ground for identifying the cavities as a fault, leaving the nature of the cavities unknown.

Apart from the cavities, as a result of premeability test, the permeability of the sound rocks of crystalline limestones is as very small as gneisses.

The ground water level on the left bank of the first auxiliary dam is estimated at an elevation of about 490 feet, being a little lower than the discovered cavities, and much higher than the water level of the Amban Ganga, nearby.

It was reported that there was artesian water in cracks in crystalline limestones in a hole (DH122) bored on exposed rocks of limestones near the area of 1,000 feet upstream of the first auxiliary dam, and that it slightly flowed out on the ground in the rainy season and remained in the hole with its water level lowered, in the dry season. At the beginning of July, 1978, the water was about 1 inch below the hole mouth of the bedrock surface (480 feet elevation). A small amount of water was pumped up, then. The water level was promptly recovered after pumping up.

These ground water behaviour show that though the ground water may move through void in limestone, the void is not always so frequent as to be connected to the nearby ground surface and river.

Therefore, though there still remain unknown points on the sound rock lines, the construction of a rockfill dam is possible, if any measure can be taken to close the cavities in crystalline limestones.

(c) Geology of the Second Auxiliary Dam Site

The second auxiliary dam is planned to be constructed on the saddle between the mountainous ridge and the second isolated hill on the left bank. The saddle is higher than the Amban Ganga by about 140 feet.

So far, the dam axis is curved, being placed on the topographic saddle, but the dam axis is not always required to be placed on the saddle, but can be placed to attian the shortest dam length, descending the valley a little toward the reservoir side off the saddle. The dam height becomes a little higher, but the dam length becomes about half of the present design line 2,160 feet.

The geological condition is almost the same for both the dam axes. The mountain of the left bank comprises crystalline limestones, and the saddle and valley are formed by gneisses, the isolated hill on the right bank side being composed of the alteration of strata of crystalline limestones and gneisses.

As for boring at the second auxiliary dam site, 7 holes covering total depth of 588 feet (179m) were made on the saddle, and 6 holes with the total depth of 781 feet were made near the shortest line of the dam length. But no boring was made near the crest abutment on either bank. Depth of each bore hole is rather insufficient to confirm distribution of crystalline limestone.

The thickness of surface soil and weathered rocks is about 40 feet at the saddle and is as shallow as 30 feet at the valley near the shortest line of the dam length, though not obvious above the mid-slope on both banks. As a result of permeability test in the bored holes, water permeability for sound rocks of both gneisses and crystalline limestones are very low. However, there are no available records concerning ground water level.

So far, no cavities have been found in crystalline limestones, and as far as the bedrock as observed in the past boring results continues, the construction of a fill dam is possible.

As an alternative dam type, a rockfill one should be comparatively studies, since the earth used for the dam construction is located far and rock materials are very likely to be obtained nearby.

(4) Materials for the Dam Construction

(a) Concrete Aggregate

Since the deposition of gravel useful as concrete aggregate can be little found on the bed of nearby river, it must be taken from a mountain quarry. In general, limestones are worn heavily and are not efficient especially for the production of fine aggregate and sand, while gneisses are advantageous as concrete aggregate.

As a place which is closely located and has gneisses distributed with thin surface covering, there is a hill about 1 mile upstream from the dam site on the right bank. According to boring DM29 made on the mid-slope of the hill, the portion as far as almost the level of flat land at the foot of the hill is composed of gneisses, while the portion below it crystalline limestones. At least the slope on the west of the hill may be able to allow quarrying of gneisses, and must be the place to be examined first. Apart from it, there are other mountainous areas of gneisses, and for example, the hill on the west of Moragahakanda can be recommended for survey.

(b) Sand

Sand is considered to be available on the bed of the Amban Ganga, but since exposed rocks are observed here and there on the bed, the deposition of sand is shallow, necessitating the collection of sand from a very wide rnage. In downstream area, the grain size of sand tends to be smaller.

The grain size of sand and the collection place should be examined as soon as possible, and depending on the results sand may have to be produced from rocks.

(c) Rock Material

As the quarry for rock material of the rockfill dam, the slope near about 1,500 feet upstream from the second auxiliary dam on the left bank seems favorable. The slope in the vicinity shows a large quantity of exposed rocks comprised of crystalline limestones, covered with thin surface soil, and joint intervals of rocks are wide. Therefore, large lumps of crystalline limestones are considered to be easily obtainable. The compressive strength of fresh crystalline limestones is as very large as 1,000 to 2,000kg/cm^2. Gneisses are surmised to exist between crystalline limestones, and their compressive strength is surmised almost the same. As for the distributions and quantity ratio of crystalline limestones and gneisses, the details are not known since geological survey has not been conducted, but from the conditions of outcrops, a large quantity of crystalline limestones are surmised to exist.

As for the place of quarrying, any slope on the portion above the maximum design water surface elevation should be selected as a quarry, for the convenience of transportation of rock material and not to shorten the seepage length to the outside of downstream drainage area. The required quantity of rock material now estimated is about one million cub. yd. which would be deemed obtainable sufficiently.

(d) Earth and Core Material for the Earth Dam

From the bases of mountains to flat land in and around the dam site, residual soil and weathered rock forms a soil stratum useful as core material. As far as observed on the spot, soil stratum is thick in the area with gneisses distributed, and much earth cannot be expected on crystalline limestones which are covered with slight surface soil or exposed.

In this initial plan of the UNDP/FAO, earth was planned to be collected from a wide range up- and downstream of the dam site, but this plan has the following problems.

First, since crystalline limestones are distributed immediately upstream of the dam, the surface soil, if left as it is, will close the cracks which may rarely exist in crystalline limestones, serving to prevent leakage. Second, the earth layer especially on the downstream side is generally thin. On the downstream side, 10 test pits were made on the flat land during the current survey, and the average thickness of soil stratum underlying the surface soil was 85cm, with gravel found in the middle at 3 pits. One pit made on a hill showed much gravel in the weathered rocks immediately below the surface soil, and did not show any favorable earth.

Considering the above situations, any other place should be considered as land for collecting the earth.

From the flat land of more than 2 miles upstream the dam site to the bases of mountains, gneisses are distributed as the base rock, and considerable covering of soil stratum is observed on it. This area is considered necessary to be investigated as the land for collecting the earth. The foundation of gneisses is judged not to cause the problem of leakage.

Chapter 5 Matters To Be Discussed

5-1 Agriculture

(1) Settlement and Agricultural Development Program

As described in the Paragraph of agricultural development, development is promoted under the cooperation between MDB and the authorities concerned of the Government. However, as observed in the existing settlement irrigation system H area for which development has been making since 1974, there are cases where planting was abandoned or harvest after planting could not be made due to the shortage of water, because the improvement of irrigation facilities was not in time for the planting after settlement. According to a settlement plan, it is scheduled to make settlement after the completion of main canals and 3 months before planting season. It will be necessary to make a minute step-wise schedule for the improvement of irigation facilities, land reclamation and settlement.

For early stability of settling farmers and agricultural productivity, the way of governmental aid and farming size, too, should be taken into consideration.

(2) Farming Service System

Agricultural extension: In the existing agricultural land, there is little contact between KVS and farmers, and technical guidance is not made widely. By training KVS and securing its mobility, it is demanded to attain wide extension activities for this project. Agricultural cooperative associations: Agricultural cooperative associations governed by the Government function with the supply of materials and the provision of loanable funds to farmers and the collection and purchase of products. However, because of insufficient management abilities, insufficient funds to purchase paddy, imperfect storage facilities and transportation system, etc, farmers do not use the associations so much and the associations do not achieve satisfuctory results.

For the management of agricultural cooperative associations, it will be necessary to educate staffs, to improve organizations and facilities and to prepare sufficient funds.

Agricultural finance: The cultivation loans for respective crops are effective as reproduction funds for petty farmers, but due to easygoing use by farmers and unstable crop situations, the repayment rate drops year by year, requiring to review the way of cultivation loans. However, for settlers poor in funds, cultivation loans are necessary, and more effective application would be desired.

(3) Soil Conditions

Beneficiary area generally belongs to fertile soil regions, and agricultural development for the area can be expected.

The arable land area by the soil survey is wider than the planed land area of this project, and the expansion of arable land area can be considered at least in the Maha season.

Since the drainage property, fertility, and Na and salts accumulation of each soil have not been investigated, detailed investigation is still required to be conducted. Though the data obtained by the investigation are insufficient, the system D2 is a fertile zone of alluvial soil.

(4) Cropping Pattern

According to the project, the double-cropping of paddy covers more than 60% of the area, making the area mainly based on paddy.

In Sri Lanka, paddy culture is economically the most stable, and many settlers take preference of rice culture. Even in upland area, the planting of upland rice is considered during the Maha.

As upland crops, various crops can be considered as mentioned above, and as for crops with guarantee price, it must be guaranteed to purchase all the quantities of the products. For other crops, the trends of demand at domertic and abroad must be investigated, and new markets must be opened up to establish the channels of circulation. For the purpose of achieving stable production, it is mecessary to study cultivation techniques and establish an agricultural extension system.

Settlers will decide crops by taking into consideration marketability, easiness of culture, production cost, labor force, etc.

The crops stable at this moment are pulses, onions, chillies, tobacco, etc.

(5) Agricultural Mechanization

When cultivation depends on the amount of rainfall during the Maha under imperfect irrigation facilities, working is concentrated in a short period of time, and tractors are required for expeditions field preparation and planting. Delayed plowing and the missing of the optimum time of planting lead to decreased yields, upsetting future planting plans for several years.

At the time of settlement, it is difficult to secure not only tractors but also bufaloes. Required is any organization for lending these agricultural machines or special financne for purchasing them. For the introduction of tractors, the organization of services ans repairs and the supply system of parts must be established.

(6) Cultivation techniques

Irrigation: Under continuous irrigation, ponding is kept throughout the cultivation period. Water should be supplied and withdrawn to raise the activities of roots and to save water. By simultaneout planting of all the farmers within a certain period, the considerable volume of water would be deemed savable.

Fertilization: The fertilization based on the optimum recommended rate cannot be attained immediately, due to insufficient funds and imperfect supply system. Moreover, 60% increase of the price is considered to lead to a decrease in its consumption.

Rice transplanting: Rice transplanting is effective for weed control and management, and allows higher yields, compared with the cultivation by direct sowing. But it requires employed labor force considerably, raising the production cost. In settlement, cooperative work, etc should be tried.

If weed control can be performed effectively even by the cultivation by direct sowing, high yiels will be attainable, and the development of a high yielding technique concerning the cultivation by direct sowing would be desirable.

Control of plant poests: In the existing settlement, paddy borers have occurred over a very wide range, but no effective measure has been taken for it. In the developed region, it is necessary to establish countermeasures and guidance system concerning prevention and extermination of plant pests for the whole region.

(7) Target Yields and Agricultureal Production Costs

By taking into account the average yields of the Polonnaruwa Dirstrict and the ideal yields of the Maha Illuppallawa Agricultural Research station, the target yields of respective crops at the initial stage and the final stage of development of the beneficiary area are estimated as shown in Table 5-1.

Table 5-1 Estimation of Target Yield per Acre

Crop	Sri Lanka	Polonnaruwa	Maha Illuppallum	Target Yield Short Term	Target Yield Full Development
Paddy*	47.17	80.77	150	58	115
Maize**	7.2	15.5	35	12.5	25
Green Gram	5.0	6.0	15	5.0	10
Cow Pea	6.3	10.0	20	7.5	15
Ground Nut	9.9	15.5	38	13.5	27
Soya Bean	8.4	8.0	25	8.0	16
Chillies (Dried)	4.9	3.5	25	7	14
Red Onion	44.2	66.5	160	57	113
Cotton (Seed cotton)			38	10	20

* Yields are average yield (bushels) of Maha 1975/76.

** Unit use CWT except paddy.

In the system H area where settlement started from 1972, 80 bushels per acre, which are almost equivalent to the target yield at the final stage, were attained within 5 years after the settlement, and this beneficiary area is in the Polonnaruwa District which is the most advanced in agricultural technique in Sri Lanka and attains high average yields. Therefore, the target yields in the beneficiary area are surmised to be reached early.

As for the agricultural production cost of paddy, as shown in Table 3-19 (data in Maha, 1977), cash expenses of the Polonnaruwa District amount to Rs.1,162 per acre, producing the yield of 76 bushels per acre. There is a correlation between production cost and yield, and if a settleing farmer cultures paddy, investing Rs.765 under cultivation loan, the short-term target yield of 58 bushels will be almost attainable. In Maha, as net in come per acre, Rs.1,555 can be obtained.

As for upland crops, the net in come of pulse, stc excluding chillies and onions, is lower than that of paddy (Rs. 1,000 per acre in the case of short-term target yield), and without the security of markets and the perfection of circulation system, large-scale planting would be deemed impossible.

5-2 Irrigation

(1) Water Requirement

As a principal source of irrigation, the total annual discharge has been assumed to be 1,470 x 10^3 ac. ft. by adding the intake from the Mahaweli Ganga and the annual discharge of the Amban Ganga, 720 x 10^3 ac. ft., and also assuming 90% frequency, it has been estimated at 1,103 x 10^3 ac. ft. (without Kotwale Dem) and 1,396 x 10^3 ac. ft. (with Kotwale Dam). The calculation standard has been analyzed by using the hydrological data available in 1965 to 1968 when the Master Plan of UNDP/FAO was preprared.

These data are observation values for a period of 20 years before 1964. The river discharge has been observed continuously even after the preparation of the Master Plan, and with regard to the available volume of source, observation values for 30 years with the data since then added are available. Comparing the discharge of the Mahaweli Ganga with that of the Amban Ganga according to before and after 1965, there is a increasing tendency of appearing dry year in the last 10 years. Therefore, in calculating the proposed water requirements, year-wise unbalances as well as the examination of diversion plans worked out for major points in the Mahaweli Ganga Program as a whole, must be considered, and particularly the frequency of dry year must be examined sufficiently.

(2) Present Situatuins of Water Supply

The area covered by the Moragahakanda Project is comprised of (a) the existing paddy fields, (b) newly reclaimed agricultural land and (c) unreclaimed land.

Of the above, the existion fields and newly reclaimed agricultural land are assumed to perfectly allow the double cropping of paddy rice by the introduction of the main stream of the Mahaweli Ganga into the area through the completion of Phase I Projeat III of the Mahaweli Ganga Development Program, and the incremental area by the dam cinstruction is assumed to cover 46,200 acres of unreclaimed land which is regarded as the beneficiary area covered by the dam (with project). Hawever, it is necessary to grasp the present situations of irrigation and yields in the areas (a) and (b) especially in dry years. Also in light of the functions of the irrigation facilities, the area (c) will take the discharge from the dam through the existing canal network, and the effect of the Moragahakanda Dam Project must be analyzed in relation with the three areas of (a), (b) and (c), also in view of the acquired right of priority for intake, etc.

(3) Facilities Planning

The irrigation facilities in the project areas (a) and (b) have developed since old times, and its system is complicated in relation with the typical tanks. Therefore, the intake into the beneficiary area cannot be executed, without considering the conventional right of intake and practice in this system sufficiently. For facilities planning, all the functions of the existing facilities must be examined.

5-3 Power Generation

The output of the Moragahakanda Power Plant is, as mentioned above, affected not only by the flow of the Amban Ganga itself, but also by the flow control by the Kotmale Dam constructed across the main stream of the Mahaweli Ganga, diversion from the Plogolla Diversion through the Ukuwela Power Plant, and diversion for irrigation water to the other areas from the Bowatenna Dam, and in addition, the variation due to precipitation irregularity is surmised to be very large. Therefore, in future, these hydrological data should be suffiently analyzed to thoroughly discuss the verious performances of the power plant.

The quantity of main equipment installed in the power plant has been recently changed from 4 sets of 10MW to 1 set of 40MW. However, considering that the firm output is 18.9 MW, that wide output regulation may be impossible in relation with irrigation, as well as it's operation and maintenance, an alternative plan of in stalling two sets of 20MW should also be discussed. It will be necessary to prepare any device to allow the flow of water required for irrigation even if the hydraulic turbine or the generator stops. With these changes of design in mind, the construction cost including the building should be reexamined.

If the generated output increases quickly and greatly through the progress of the Mahaweli Ganga Development Program and the other power supply development, the power system becomes complicated, and therefore, feed operation must be mechanized and unified by a remote monitor, etc, to smoothen power demand and supply and particularly to meet possible failures promptly. The C.E.B. seems to intend to construct a central load-dispatching office near Colombo to meet this requirement, and for constructing individual power stations, this point should be borne in mind in designing.

5-4 Dam

(1) Design of Foundation

A principal matter to be discussed for the dam must be how to meet the void anticipated to exist in the crystalline limestones as the foundation bedrock. According to the investigations made so far, no large cavity has been found, and the possibility of the existence of large cavity seems to be much low. In such geological conditions, water cutoff by curtain grout would be deemed effective. To increase the effectiveness of grout, grouting from the grout cap or inspection gallery should be planned. Furthermore, short consolidation grout ahould be applied to the entire width of the center core of rockfill in order to intensify the resistance against the infiltration into the foundation. If the surface soil and earth on the bedrock is excavated for the above foundation treatment, the conditions of foundation can be confirmed directly, and therefore, it is surmised possible to secure safety against infiltration into the foundation, without overlooking large geological problems. For employing the above treatment, since the quality of grout occupies a large proportion of the construction cost, grout test should be conducted at the F/S stage to obtain general idea about the hole intervals, grout injection volume and effectiveness.

As dams constructed in limestones, there are Benito Juarez Dam, Manuel Avila Camacho Dam and Presidente Aleman Dam in Mexico which are all treated by grout. Other examples are shown below.

Pinopolis Dam (completed in 1942)

Location: Southeast, South Carolina, USA

Foundation: Marl and soft limestones underlying clay and sand stratum with a thickness of about 20 feet.

Treatment: Clay grount was used, and the compasition was sandy clay containing 10% by volume of cement. Grout was injected into the portions where it seemed necessary, as follows: At first, it was injected at 80 feet intervals, and the intervals were made shorter by half each time, until the injected amount became less than 5 cubic yards per hole. The minimum intervals were 5 feet. According to a recent investigation, the volume of infiltration did not exceed its initial volume.

Gathright Lake Project

Location: West Verginia, USA

Scale: Dam length 1,270 feet (387.1m), dam height 257 feet (78.3m)

Foundation: Bedrock of limestones

Treatment: In 1967 to 1968, the earth and sand at the wings were removed to investigate the weathering conditions of rocks, and furthermore, cave investigation was made. At the right wing, drainage by use of grout and caves was judged sufficient. On the other hand, a cavity found at the left wing was treated by setting a concrete cutff wall with a maximum length of 101 feet (30.8m) and a length of 730 feet (222.5m).

(2) Design of Dam Body

(a) Earth Dam (Second Auxiliary Dam)

The earth dam (the decond auxiliary dam) is desirable to be changed in its dam type on the ground that the soil stratum of the borrowing pit near the dam site has been found to thin in the current preliminary survey. As an alterantive plan, a center core type rockfill dam can be considered. The dam axis curves about 45 degrees at the joint of the left wing, and in this portion stress concentration will be caused, and tensile force will act. The curve of the axis is not preferable particularly when a highly rigid core compacted at less than the optimum moisture content is used, and therefore, the dam axis is desirable to be straight.

(b) Rockfill Dam (First Auxiliary Dam)

The designed dumped rockfill should be changed into rolling rockfill, and 1 to 1.5m lift anould be used for spreading and rolling to demonstrate high internal friction. The core crest width should be 4m at the minimum for the necessity of machine works. Also with regard to the filter, etc, the diminution of width makes the execution of works only difficult and is meaningless and therefore, the width should be 2m. This applies also to the transition, and constant width should be secured.

The inspection gallery should be provided by excavating the foundation bedrock. The form of protrusion causes stress concentration and unequal sinking inside the core, being liable to cause hydraulic fracturing. On the other hand, the foundation bedrock can be investigated directly by conducting trench excavation.

(c) Concrete Gravity Dam (Main Dam)

The foundation bedrock is generally composed of gneisses, and the fresh bedrock is favorable as a foundation for the concrete gravity dam. The surface soil and weathered belt at both wings are 30 to 38 feet (9.1 to 11.6m) thick.

Since at an upper portion of the left bank, sound rocks do not reach the maximum water surface elevation, the concrete gravity dam is combined with the rockfill dam, viz the second auxiliary dam. As a comparative plan, the spillway may be moved to the junction between the rockfill and the concrete dams so as to design the main dam, too, as a rockfill dam.

It seems necessary to discuss this plan in relation with the construction cost and power generation facilities.

(3) Geology of the Dam Site

(a) Location of the Foundation Bedrock for the Dam

The foundation bedrock of the dam is being investigated by boring, and the existence of sound rocks becomes obvious.

However, in the sites for the main dam bed, the levee remains, the right bank of the first auxiliary dam and the second auxiliary dam, boring is insufficient as far as the identification of the foundation lines is concerned.

The boring data obtained by the UNDP/FAO lack the records concerning the water levels in the holes (ground water levels), and therefore, additional boring should be carried out to confirm the ground water levels together with the depths up to sound rocks.

For determining the foundation lines, the conditions of exposed rocks should be observed directly in order to know the shift from weathered rocks to fresh bedrock and the nature of estimated faults, and to judge the locations of excavation lines and treatment techniques, and how such characteristics continue under the around must be sought.

So far pits have been dug along the dam axis line, but they were all left inside weathered rocks, and did not reach sound rocks. Furthermoer, caves were not excavated, and the data concerning seismic prospecting were lost.

Therefore, to determine the location of foundation bedrock, these investigations must be made additionally.

(b) Strength of Foundation Bedrock

The foundation bedrock the dam is composed of solidified gneisses and crystalline limestones, and is judged to be a favorable foundation for fill type dam just be removing the surface soil, excluding the portion of cutoff wall.

Fresh bedrock is surmised to have sufficient strength as the foundation bedrock also for the concrete gravity dam. The location of bedrock with the strength required for the concrete gravity dam construction, viz, sound rock lines can be almost indicated by caves, boring, and seismic velocity, but for dam design, static elastic modulus and shearing atrength of the bedrock as the foundation of a dam are required. These design values must be obtained by measuring in the typical bedrock within the estimated sound rock lines in the caves at the lower portions of the slopes on both bank sides to which relatively large dam load applies.

(c) Permeability of Foundation

With regard to the permeability of foundation bedrock, field permeability test has been conducted byusing bored holes and it is known that the permeability of fresh bedrock is very samll. Also in the boring to be made in future for investigating sound rock lines, the field permeability test will be made continuously.

The results of the permeability tests conducted so far are left in ID as recorded in the original materials and not arranged, and they must be arranged for use for the design of dam foundation. This arrangement requires the record of ground water levels, and since the past boring data lack the records of ground water levels, the ground water levels must be known for reference, by boring to be made in future. A shallow portion of the foundation bedrock naturally has joints and cracks, even if it is fresh, and therefore must be improved by grouting. In addition to joints and cracks, it is known that the crystalline limestones on the left bank of the first auxiliary dam have cavities.

Such cavities may exist also in the other places, too, in the crystalline limestones near the ground surface, and it is necessary to study the possibility of closing the cavities, together with the grouting for joints and cracks.

(4) Materials for Dam Construction

With regard to materials used for the dam construction, only the reserves and soil of the earth in the vicinity of the dam site have been investigated by the UNDP/FAO.

Since the investigation on the gathering places and materials of stones, sand and earth has not been made yet, the possible areas for gathering must be found approximately, and then based on a topographic map of 1/2,000, reserves and gathering zones must be determined by the performance of reconnaissence, boring, test pits, etc, material tests being conducted simultaneously.

Since the possible places for gathering materials used for the dam construction has been almost found by the current survey, as mentioned above, investigarions will have to be made mainly in these places.

The ID facilities in Colombo can be used for the material tests of earth, stones, etc.

Chapter 6 Matters to be investigated in future

6-1 Agriculture

(1) Settlement and Agricultural Developmet plan: Investigation of progress of development in the existing settlements and grasp of a settlement schedule in this prokect area

(2) Soil: Collection and investigation of the data relating to soil in the Systems D2 and G. Investigation of drainage property, fertility and chemical properties of each group of soil in each system.

(3) Cropping Pattern: Investigation of marketability and demand trends of upland crops. Investigation of irrigation water requirement for respective crops under various soil conditions. Establishment of cropping patterns (combination of crops) based on the above investigations.

(4) Farm Management: Grasp of technical standards and farming situations of farmers by village survey.

(5) Agricultural Mechanization and Agricultural Materials: Fact-finding survey concerning the spread rates and shortage of tractors and buffaloes. Investigation concerning the future plan for the shortage of draught power and concerning the actual situations of demand and supply of agricultural materials and their supply system.

(6) Farming Services: Fact-finding survey concerning the organizations, activities and effects of extension offices and agricultural cooperative associations, and investigation concerning the future plan.

(7) Agricultural Finance: Organizations and use of finances.

Fact-finging survey concerning various problems of repayment.

(8) Fact-finding Survey Cincerning Strage Facilities, transportation system, and circulation system, and the future plan.

6-2 Irrigation

(1) Confirmation of topographic maps of the project area (the area covered by the Moragahakanda Dam).

(2) Investigation of the existing irrigation and drainage facilities and irrigation cum drainage systems, particularly the situations and practice of water use.

(3) Investigation concerning the intake capabilities of the existing facilities and the flow capabilities of canals, such as Elahera Anicut, Elahara-Minneri Yoda Ela and Minneri-Knatale Yoda Ela.

(4) Incestigation concerning the storage capacities, catchment areas, reservoir water levels, intake bed elevations, etc of the existing tanks.

(5) Confirmation of annual and seasonal possible inflows into the Moragahakanda Dam.

6-3 Dam

(1) Geologic Survey of the Dam Site

(i) Boring and Caves

To observes the conditions of weathering and cracks of foundation bedrock at the sites of the main dam and the auxiliary dams, to condirm the location of sound rock lines and to clarify the permeability of bedrock and ground water levels, the following boring (including permeability tests) and cave excavations should be conducted in addition to the investigations made so far.

Main dam site

Cave: Five caves with a total depth of 650 feet

Boring: Five holes with a total depth of about 475 feet (river bed portion)

First auxiliary dam site

Cave: Three caves with a total depth of about 500 feet

Boring: One hole with a depth of about 200 feet (right bank)

Second auxiliary dam site

Boring: Three holes with a total depth of about 520 feet (To be conducted after studying the dam axis line)

(ii) Seismic Prospecting

Seismic prospecting should be conducted for about 4Km, to confirm the seismic velocities, geological structures and continuity of the upstream and downstream sides of the dam site such as the dam axis line and levee remains portion and the locations proposed for main related structures such as power station, at the sites of the main dam and the auxiliary dams.

(iii) Grout Test

Mainly cement should be injectes into the joints usually existing in bedrock and in the cavities in crystalline limestones, on the left bank of the first auxiliary dam, as a grout test for improving cavity closure and permeability.

Boring, cement injection, six permeability tests, total 720 feet.

(iv) In-situ Bedrock Shearing Test

A shearing test of 4 blocks should be conducted respectively in the assumed excavation lines in the lower caves on the left and right bank sides of the main dam site in order to measure the shearing strengths of the concrete gravity dam foundation.

(v) Completion of the Geological Surveys

Respective investigation, of reconnaissance, boring, permeability test, cave excavation, seismic prospecting, etc should be arranged based on the topographic map of 1/500, to judge the various properties and distribution of bedrock and the location of sound rock lines, to determine foundation treatment measures, and to instruct investigations if any supplementary investigations become necessary during the dam design.

(2) Investigations of Materials for the Dam Construction

(i) Investigation of concrete Aggregate

Selection of mountainous slopes of gneisses by reconnaissance, confirmation of lithology and reserves by two or more borings. Material test of stones.

(ii) Investigation of Rocks

The hilly slope on the left bank of the dam site is near by distance, and the surface soil covering is thin.

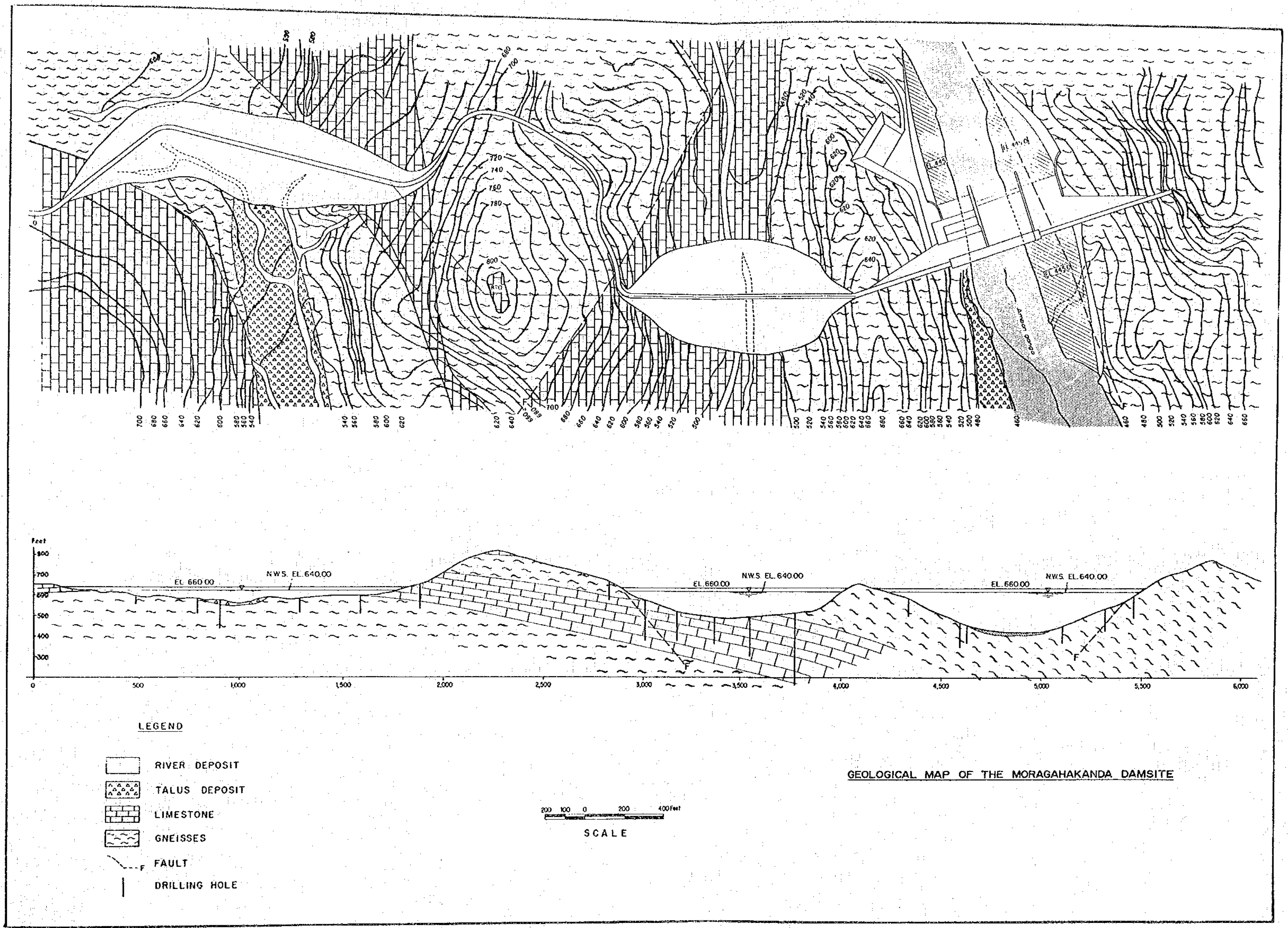
Therefore, it would be deemed favorable as a quarry for rocks, and the gathering range and reserves should be confirmed by two borings with a total depth of about 600 feet, to conduct stone material tests.

(iii) Investigation of River Sand

The area where river sand can be gathered should be selected by reconnaissance, and the reserves should be found,with tests conducted on the grain size, material, etc of the sand.

(iv) Investigation of Earth Used for the Dam Constrution

Relatively favorable soil stratum is found to develop more than 2 miles upstream from the dam site, and 10 or more test pits should be excavated, with complementary auger boring made, to determine the area to allow gathering, and to confirm the reserves. Simultaneously, soil tests should be conducted on the earth taken from the test pits.



GEOLOGICAL MAP OF THE MORAGAHAKANDA DAMSITE

ANNEX 1

SUMMARY MINUTES OF DISCUSSIONS BETWEEN THE GOVERNMENT OF SRI LANKA AND THE JAPANESE PRELIMINARY SURVEY TEAM FOR THE MAHAWELI GANGA DEVELOPMENT PROJECT.

At the request of the Government of Sri Lanka, the Government of Japan, through Japan International Co-operation Agency (JICA), dispatched a Team of experts headed by Mr. Akira Arimatsu, Executive Director of JICA to Sri Lanka from 13th June to 23rd July, 1978, to conduct preliminary survey for the possible technical cooperation by Japan to the planning of the Moragahakanda Multipurpose Project of the Mahaweli Ganga Development Program.

During its stay in Sri Lanka, the Japanese Survey Team (hereinafter referred to as "the Team") visited the Project sites and the area to be covered by it, collected data for further study and discussed on the possible technical and economic study to be conducted by Japan for the planning of the Project with officials of the Ministry of Irrigation, Power and Highways (hereinafter referred to as "MIPH") of the Government of Sri Lanka.

The following is the summary of the discussions made by the officials of MIPH and the Team:

1. The Team found that the subject of the technical and economic study of the Project to be conducted by Japan should be concentrated on the Moragahakanda Multipurpose Project for which the Government of Sri Lanka had requested the Government of Japan.

2. It was agreed that the review and updating of the technical and economic feasibility and the cost estimate of the Project, for which certain studies had already been done by International Agencies and the Government of Sri Lanka, were necessary before a further stage of possible cooperation by the Government of Japan, and this kind of study would be done as the Feasibility Study by JICA.

3. MIPH requested the Team that the Feasibility Study should be started as soon as possible and the draft report thereof including the cost

estimate of the Project should be received by March 1979. The Team informed MIPH that the Feasibility Study in association with the Central Engineering Consultancy Bureau would be started at around the beginning of October 1978 and the draft report could be submitted in March 1979 as requested by MIPH.

4. The scope of the Feasibility Study which has been tentatively defined to include the Moragahakanda multipurpose Reservoir and its benifitted area, will include the following items:

   i) Determine optimum capacity of the reservoir in both irrigation supply and power generation through a series of study on optimum yield regulating of Mahaweli river and its tributaries.

   ii) Identify the benefitted area under the Project corresponding to its water availability.

   iii) Prepare feasibility level layout and design on dams and Hydro unit based on preliminary investigation for dam foundation and embankment materials.

   iv) Establish suitable overall irrigation and drainage system and practical agricultural development programs in the project area.

   v) Analyse functional role and weight of Moragahakanda Dam in the Mahaweli Ganga Development Accelerated Program.

   vi) Estimate project costs and evaluate project economic and financial viability, based on benefit from irrigation and power generation.

5. MIPH informed the Team that it was the strong desire of the Government of Sli Lanka that the construction work of the Project be started as early as possible and that the engineering works necessary for the starting of the construction be conducted immediately. MIPH also told the Team that such engineering works would be desirable to be done on grant basis in view of the economic and financial situation affected by the acceleration of the Development Program.

6. The Team expressed its readiness to convey the wish of the Government of Sli Lanka regarding the engineering works as mentioned above to the Government of Japan and to advise her for positive consideration. As

to the timing of such works, the Team informed MIPH that it would recommend the Government of Japan that these works should be started immediately following the Feasibility Study and completed within one year.

7. It was agreed that MIPH would make arrangements and provide assistance to the Feasibility Study Team whenever necessary to facilitate the smooth and effective performance of the Study. The following matters will be included in these arrangements and assistance to be extended by MIPH:

i) MIPH will arrange the provision of the following, the expenditure for which will be borne by the Study Team:

a) accommodation for field and desk work.

b) labourers for field survey.

c) Jeeps with drivers.

d) procurement and handling of explosives necessary for the investigation.

e) mapping.

ii) MIPH will carry out boring, grout test and digging of adits in cooperation with the study Team.

iii) MIPH will provide available existing data and materials including reports, papers, maps and serial photographs necessary for the study, and permit the Team to retain copies thereof.

iv) In order to facilitate the works of further engineering study, MIPH will prepare additional data and maps necessary for such works by the time of the starting of the Feasibility Study.

v) MIPH will provide its staff for fully cooperating with the Team and from time to time reviewing the work upon Team's request.

vi) MIPH will give necessary permission required for the study for entering the Project area and for carrying out works which may require use of explosives at the country side.

vii) MIPH will arrange for the Government of Sri Lanka to exempt the Study Team for any taxes and duties which may be imposed on personnel, material and equipment to be brought into Sri Lanka by the Study Team, provided it is exported out of the country after the completion of the Assignment.

Date 20th July, 1978.

T. SIVAGNANAM. Secretary, Ministry of Irrigation, Power & Highways.	A. ARIMATSU. Leader of the Japanese, Preliminary Survey Team.

ANNEX 2

REPORT ON PRELIMINARY SURVEY

MAHAWELI GANGA DEVELOPMENT PROGRAM

SRI LANKA

Japanese Survey Team

JAPAN INTERNATIONAL COOPERATION AGENCY

Colombo, July 21, 1978

July 21, 1978

Mr. T. Sivagnanam
Secretary
Ministry of Irrigation,
Power & Highways.

RE: THE RESULTS OF JAPANESE PRELIMINARY SURVEY FOR THE MAHAWELI GANGA DEVELOPMENT PROGRAM

Dear Sir,

I have the pleasure to submit herewith the "REPORT ON PRELIMINARY SURVEY, MAHAWELI GANGA DEVELOPMENT PROGRAM, SRI LANKA", containing the outline of the result of the survey and suggestion for the next phase of the Program, on behalf of Japanese Preliminary Survey Team for the Mahaweli Ganga Development Project in the Republic of Sri Lanka.

I take this opportunity to express my heartfelt thanks for your active cooperation extended to us and I also expect the friendship and cooperation between the Republic of Sri Lanka and Japan will be strengthened further.

Yours faithfully

Akira Arimatsu
Leader of
Japanese Preliminary Survey
Team for the Mahaweli Ganga
Development Project

CONTENTS

I. OBJECTIVES OF THE SURVEY

In response to the request of the Government of Sri Lanka, the Government of Japan decided to send a preliminary team, through the Japan International Cooperation Agency (JICA), for technical cooperation to the planning of a certain project in the Mahaweli Ganga Development Program.

The team stayed in Sri Lanka from June 13th to July 23rd, 1978 and conducted studies in connection with the following objectives:

To discuss with the authorities concerned of the Government of Sri Lanka on the contents of her request for possible technical cooperation by the Government of Japan to a certain project of the Mahaweli Ganga Development Program.

To study the significance of the overall sheme of the Mahaweli Ganga Development Program to the economic development of Sri Lanka.

To select a certain Project in the program for further technical and economic investigations to be taken up as the feasibility study.

II. FINDINGS AND SUGGESTIONS

1. Introduction

The Government of Sri Lanka has given top priority to the implementation of the Mahaweli Ganga Development Program in as short a time as possible.

This strategy aims at solving the two major problems facing Sri Lanka which are the unemployment and need for import substitution in rice and other agricultural products.

The Government set for the goal of achievement in 5 - 6 years by depending largely on the support from Aid Group Members.

Thus the Sri Lanka Government has eagerly requested the Japanese Government's co-operation on accelerating the Mahaweli Program.

In response to the request, the Japanese Government dispatched the pre-feasibility team to Sri Lanka.

The Team has been conducting, since its arrival in Sri Lanka on June 13th, 1978, the field surveys, data collection, observations, conferences and study activities mainly on the Moragahakanda Project with the officials of the Government of Sri Lanka.

Through these activities, the Team's understandings regarding the Program and the Moragahakanda Project are summarized as below:

2. General

(1) The present basic program is described in "Summary Reports on Mahaweli Development, Sri Lanka" prepared by the Mahaweli Development Board in November 1977.

According to this new program named as "Accelerated Program of Implementation of the Mahaweli Development Project", the rest of the work envisaged under the UNDP/FAO Master Plan has now been re-grouped as twelve projects and can be implemented in 5 to 6 years.

(2) In May 1978, the Government decided to launch simultaneously the construction of the five major reservoirs including irrigation systems about 340,000 acres of new land.

The major five reservoir projects are as follows:

(i) Victoria Reservoir and Power plant - Minipe Diversion Complex,

(ii) Randenigala Reservoir and Power plant,

(iii) Maduru-oya Reservoir,

(iv) Kotmale Reservoir and Power plant,

(v) Moragahakanda Reservoir and Power plant.

Included in these projects would be the irrigation systems, land development, social infrastructure, settlement, agricultural extension and support services for the benefitted area in System C(74,000 acres), System B(118,000 acres), System A(100,000 acres) and System D(46,200 acres).

(3) The cost of these projects including land development, social infrastructure and settlement, is estimated at Rs. 9 billion (US$ 600 million) at 1978 prices, or Rs. 12 billion (US$ 800 million) at current prices of which about 50% will be foreign component.

These projects are proposed to be substantially completed by the end of 1983 with the provision of about Rs. 8.0 billion in 1978 prices, or Rs. 11.0 billion in current prices over the next 5 - 6 years. (both domestic and foreign resources).

(4) Organizations for implementing the Mahaweli Project are:

(i) Cabinet Sub-Committee,

(ii) the Mahaweli Ganga Development Task Force,

(iii) the Mahaweli Development Board (MDB),

(iv) Central Engineering Consultancy Bureau (CECB),

(v) Irrigation Department (ID),

(vi) River Valleys Development Board (RVDB), and

(vii) The Ceylon Electricity Board (CEB).

*(iii) to (vii) belong to the Ministry of Irrigation, Power and Highways.

(5) Achieving these major five projects would require a lot of senior and middle grade irrigation engineers who have gone abroad. The Government has recently tried to persuade some experienced engineers to return and, at the same time, recruited some foreign specialists.

(6) Several Projects in the Program have been offered to provide both technical co-operation and financing by the countries as below:

Victoria Reservoir Project	United Kingdom

Randenigala Reservoir Project	Federal Republic of Germany
Kotmale Reservoir Project	Sweden
Maduru-oya Project excluding the reservoir	Canada

(7) The Moragahakanda Multipurpose Project was originally scheduled as the Project 3 in Phase 1 under the UNDP/FAO Master Plan.

The works in Phase 1 were proposed as follows:

Project 1 Polgolla hydro-unit, with the system in its command, System D-1, G and H (70%)

Project 2 Victoria hydro-unit, with Minipe Diversion, system C and E

Project 3 Moragahakanda hydro-unit, and irrigation system A/D, H(30%) D-2 and I/H.

The Moragahakanda Project in the Accelerated Program was briefly described in the paper prepared by the Ministry of Irrigation, Power and Highways in March 1978.

Major components indicated in the paper are:

(i) A concrete dam across the Amban Ganga section, a rock-fill dam on the first saddle on the L.B. and an earth-fill dam across the second saddle on the L.B.

(ii) A power house located at the foot of the concrete dam and installed capacity of 40 MW.

(iii) Benefitted new land of 46,200 acres (D_1-28,000 acres, A/D 9,100 acres, D_2 9,100 acres).

The parameters on dams and hydro power unit in this paper follow the UNDP/FAO Team's proposal.
Project cost estimates were up-dated by means of multipling 1968 year's construction costs by escalation ratio.

3. ENGINEERING AND AGRICULTURAL ASPECTS

(1) Geological Conditions

The Team identified problematic sub-surface condition at damsite by reconnaissance and review of data.

Some core boxes, under additional drillings executed by Irrigation Department indicate poor recovery portions in relation to presumable karsts.

The Team proposed further investigations including drillings with water pressure and grouting tests, so as to clarify foundation treatment against defective portions.

This sub-surface condition would cause to increase construction cost, but would not be a marginal factor.

(2) Dam

Concrete dam and rock-fill dam proposed in the previous study are basically acceptable regarding type and axis, but earth dam should be re-examined on account of the following findings:

(i) The Team pointed out that proposed soil borrow area, extending down stream from the axis was presumed to be thin soil layer.

Ten borrow pits were thus cut in the area keeping around 500 meters intervals each other.

As the results of survey, thin soil layer, 2-3 feet was recognized insufficient for designed earth dam and center core of rock-fill dam.

Alternative design in connection with additional borrow area should be considered at further study.

(ii) Two quarry areas for rock material had been proposed at about half a mile upstream from the axis.

Hill portion next to left side of earch dam was found to be more advantageous than the said quarry; less distance and down gradient at full loading.

(3) Hydro Unit

The Government promotes hydro power development by constructing the five major dams including Moragahakanda dam. Thermal current cost comes more expensive almost three times than that of hydro power.

The summary report in 1977 indicates that allocation rate of the construction cost of Moragahakanda Project is estimated to be around 35 per cent in power and 65 per cent in irrigation.

Moragahakanda hydro unit will be operated under regulating regime of the overall Mahaweli Unit.

Moragahakanda has advantage of power connection close to Bowatenna Unit.

(4) Irrigation and Agriculture

The benefitted area under the Project is characterized to have the major four tanks limited by canal system.

These four tanks are:

Kaudulla Tank	Capacity 104,000 Ac.feet
Minneriya Tank	Capacity 110,000 Ac.feet
Kantalai Tank	Capacity 109,500 Ac.feet
Parakrama Samudra Tank	Capacity 109,000 Ac.feet
	Total 432,500 Ac.feet

Total capacity of these tanks corresponds to around 90% of Moragahakanda active storage capacity (470,000 Ac.feet).

Irrigation system for new land is essential to coordinate with the existing system on the base of effective regulating issue (combination with Dam issuing and local yields).

The increase in quality and reliability of irrigation supply would be the main factors which would contribute to increase yields.

The proper management of irrigation water and better cultivation practices would make possible deversification of cropping pattern.

Proposed cropping pattern in Maduru Oya Basin will be adopted in the project area without any remarkable changes at this stage.

(i) Upland Rice - Pulses
Upland Rice - Ground nuts
Upland Rice - Chillies

(ii) Upland Rice - Upland Rice

(iii) Low land Rice - Low land Rice

(iv) Sugar cane

(v) Low land Rice - Upland Rice

(iii), (iv) pattern will require almost twice of water demands comparing with others.

Pattern (i), (ii) are considered to be suitable, in the first instance, for new developed land under the project.

So as to achieve such shortened crop cycles over the project area would require much greater discipline of farm operation.

Farmers in the existing irrigation area will be required in proper water management techniques for efficient use of the irrigation water.

Before construction of the reservoir, such training should be taken up.

The settlement Planning and Development Division of MDB would be responsible for implementing the settlement program in the project area.

Each settler would be given 2.5 acres of irrigable land in one unit and 0.5 acre homestead lot.

At entry of settlers, the new land should be cleared and stumped and irrigation water supply be timed.

Agricultural Development Program in the project area would be referred to the preceeding area, Project II System (H).

Paddy production increase per acre exceeded the expected amount in above area, this achievement would be more viable to the project.

4. Data Sources

(1) Mapping

Topographical Map 1:5,000scale with 2 meter contour covering Moragahakanda Dam catchment area were completed in July 1978 before the Team's leaving.

Map comprises 20 sheets.

These maps cover catchment area but were lack on contour at the area of quarry proposed by the Team.

Another two sheets from dam axis should be added on covering borrow area.

This map was based on aerialphotos 1:40,000 scale altitude of 20,000 ft. taken in 1956.

Map on damsite 1:1,200 scale is also available.

Map on damsite 1:500 scale is going on inking (to be completed by the end of September).

(2) Geological Data

Investigation has been resumed at Moragahakanda Damsite by Irrigation Department: 29 drillings, 3 test pits were added to the previous 40 drillings and 9 trenches executed at the period of UNDP/FAO Team's activities. These data are available.

Core samples of the 29 drillings are well kept in the damsite office.

3 test pits were also identified by the Team at the damsite.

(3) Hydrological Data

Main gauging stations along Mahaweli Ganga and its tributaries have been operated since their commencement indicated in the UNDP/FAO Report.

Amban Ganga gauging station at the damsite and the Elahera Diversion site were identified.

Damsite station has 10 measuring points on flow velocity across the river and its records since 1964.

Diverting discharge records after completion of Polgolla and Bowatenne diversion are available.

Biggest flood records on both stations should be deemed carefully because such flood sometimes caused to discontinue recording.

5. Proposal on further Investigations and Studies

Further studies are called for completion by the end of a Feasibility Team's field survey period.

Site investigations, material testing, laboratory tests and mapping will be carried out by the Sri Lanka Government.

(1) Topography

Aerial photos 1:25,000 scale covering catchment area. Map 1:2,000 scale covering dam axies, quarry and borrow area. Map 1:10,000 scale covering benefitted area.

(2) Geological Investigations and Tests

(i) Adit, drilling and test

(a) Proposed concrete damsite
5 adits, totalling 650 ft. 5 additional drillings at the river bed including water pressure tests, totalling 475 ft.

(b) Proposed Rock fill damsite
3 adits totalling 500 ft. 1 drilling of 200 ft. with water pressure tests and grout test with depth of 120 ft.

(c) Proposed Earth damsite
3 drillings, totalling 520 ft. with water pressure tests.

(ii) Embankment Materials and concrete aggregate

(a) Soil
Borrow area should be determined by conducting the following works: 10 points of test pits (additional points would be added according to soil layer conditions). Laboratory tests.

(b) Rock

Quarry was proposed by the Team at left abutment of earth dam. Drillings, totalling 600 ft. Laboratory tests.

(c) Sand and concrete aggregate

Field investigation for confirmation of available quantity. Laboratory tests.

(3) In execution of Feasibility Study, its scope of work would be proposed as described in the following "Draft Scope of Work on Moragahakanda Multi-purpose Dam Project".

(DRAFT)

SCOPE OF WORK FEASIBILITY STUDY ON MORAGAHAKANDA MULTIPURPOSE PROJECT

The Feasibility Study which will be carried out in cooperation with CECB and MDB, will include, but not limited, the following items:

1. Review works already carried out.

2. Clarify optimum yield regulating of Mahaweli Ganga and its tributaries by operation of Polgolla Complex and the major dams proposed.

   Review on-going studies in relation to above subject according to necessity.

3. Determine optimum capacity of the Moragahakanda reservoir on both irrigation supply and power generation.

4. Prepare feasibility level layout and design on dams and hydro unit by conducting studies as follows:

   (1) Review proposed dam axis and previous investigations and test on foundation and embankment materials.

   (2) Identification of quarry and borrow areas.

   (3) Alternative study on selecting dam type.

   (4) Analysis on Amban Ganga flood flow.

   (5) Carry out the power potential studies, including effective flow, capacity of power plant and annual energy output.

5. Determine location and scope of area to be served under the Project in connection with crop water requirement and system delivery requirement to meet soil conditions.

6. Establish suitable overall irrigation and drainage plan and layout for the proposed Area in relation to the existing tank systems.

7. Review practical agricultural development programs such as;

(1) Formulation of cropping pattern including crop diversification,

(2) Improvement of farming practices, and

(3) Improvement of rural institutions and social infrastructures through studies of farmers' organizations, credit system and marketing.

8. Prepare construction schedule.

9. Estimate project costs giving foreign and local components including adequate allowances for price escalation and physical contingency.

10. Estimate recurring costs for project operation, maintenance and replacement.

11. Provide recommendations regarding application of water charges under the project.

12. Evaluate project economic and financial viability including sensitivity tests.

13. Review the measures to be taken by the Government of Sri Lanka for the resettlement of inhabitants in the reservoir area and compensation to them, and for re-location of the existing road.

III. LIST OF MEMBERS OF JAPANESE PRELIMINARY SURVEY TEAM FOR THE MAHAWELI GANGA DEVELOPMENT PROJECT IN THE REPUBLIC OF SRI LANKA

Assignment	Name	Present Position
Leader	Mr. Akira Arimatsu	Executive Director Japan International Cooperation Agency
Development Planning	Mr. Tadashi Sakamoto	Deputy Director Design Division Construction Department Agricultural Structure Improvement Bureau Ministry of Agriculture and Forestry
Cooperation Planning	Mr. Yasumi Yamaguchi	Senior Officer International Cooperation Division International Affairs Department Ministry of Agriculture and Forestry
Irrigation & Hydrology	Mr. Akihiko Yasuda	Section Chief Provincial Project Section Land Development Division Agricultural Structure Improvement Bureau Ministry of Agriculture and Forestry
Dam & Irrigation Facilities	Mr. Masamitsu Fujioka	Irrigation and Drainage Engineer Agriculture Development Consultants Association
Geology	Dr. Noboru Miyamoto	Geologist Agriculture Development Consultants Association
Power Generation	Mr. Nobuo Hirosawa	Electrician Mining & Industrial Planning and Survey Department Japan International Cooperation Agency
Agronomy & Soil Science	Mr. Kozo Toshimitsu	Senior Instructor Uchihara International Agriculture Training Center Japan International Cooperation Agency
Coordination	Mr. Yoshihiko Nishimura	Officer Technical Affairs Division Agricultural & Forestry Planning and Survey Department Japan International Cooperation Agency

IV. SURVEY ACTIVITIES

Date	Activity
June 13 (Tue.)	Arrived in Colombo.
14 (Wed.)	Preparation of survey.
15 (Thu.)	Discussion with NEDECO. (2nd Team arrived in Colombo)
16 (Fri.)	Courtesy call on Honurable Minister of Irrigation, Power & Highways and discussion with CECB and ID.
17 (Sat.)	Discussion with Secretary of MIPH.
18 (Sun.)	Started the 1st Field Trip.
19 (Mon.)	Visited Victoria and Randenigala Project Areas.
20 (Tue.)	Visited Polgolla Dam, Ukuwela, Bowatenne construction areas.
21 (Wed.)	Visited Moragahakanda Project Area.
22 (Thu.)	Visited Kotmale Project Area.
23 (Fri.)	Discussion with Secretary of MIPH.
25 (Sun.)	Team Leader left for Japan.
26 (Mon.)	Data Analysis.
27 (Tue.)	Started the 2nd Field Trip. (1st Team conducted the investigation of Geology and Agriculture in Moragahakanda Area) 2nd Team conducted the survey on Moragahakanda, Yan Oya, Kapirigama, Malwatu Oya.
July 1 (Sat.)	Mr. Hirosawa arrived in Colombo.
3 (Mon.)	Discussion with MIPH.
4 (Tue.)	Started the 3rd Field Trip. (1st Team conducted the investigation of Geology and Hydrology in Moragahakanda Area Mr. Yamaguchi left for Japan) 2nd Team conducted the survey on Power Generation of Laxapana, New Laxapana, Ukuwela Bowatenne Power Station and Moragahakanda.
8 (Sat.)	3rd Team conducted the Investigation of Agriculture in Project area of the Island.

Date	Activity
July 10 (Mon.)	Discussion with MIPH.
11 (Tue.)	Data analysis.
15 (Sat.)	Team Leader returned from Japan.
16 (Sun.)	4th Field trip by part of the Team to conduct the investigation of Geology.
17 (Mon.)	Preparation of the report.
18 (Tue.)	Discussion with Secretary of MIPH Preparation of the report.
19 (Wed.)	Preparation of the report.
20 (Thu.)	Discussion with Secretary MIPH Signing of Summary Minutes of Discussions between MIPH and the Team.
21 (Fri.)	Submittal of the report.
23 (Sun.)	Leaving Colombo.

Annex I

LIST OF PARTICIPANTS

Name	Post
His Excellency Gamini Dissanayake	Minister of Irrigation, Power and Highways
Mr. T. Sivagnanam	Secretary, Ministry of Irrigation Power and Highways
Mr. K.H.S. Gunatillake	Additional Secretary, MIPH
Mr. N.G.P. Panditharatna	Chief Co-ordinator, Mahaweli Task Force
Mr. Ratna S. Cooke	Special Advisor to the Minister

Central Engineering Consultancy Bureau

Mr. A.N.S. Kulasinghe	Chairman
Mr. G.V. Gunawardena	General Manager
Mr. K. Kulawardarasah	Chief Project Engineer for Moragahakanda
Mr. U.N.S. Wickramaarachchi	Chief Resident Engineer for Moragahakanda
Mr. B. Kumaraparati	Electric Engineer
Mr. Nadarasa	Engineering Designs

Mahaweli Development Board

Mr. Douglas Ladduwahetty	Chairman
Dr. Walter Abeygunawardena	General Manager
Mr. K. Satgunasingham	Deputy General Manager (Engineering)
Mr. Kotalawala	Assistant General Manager (Agriculture)
Mr. Gunawardena	Design Engineering

Name	Post
	Irrigation Department
Mr. A. Maheswaran	Director, Irrigation Department
Mr. R.U. Fernando	Deputy Director, ID
Mr. T. Thurairajah	Chief Engineer (Geology)
Dr. K. Vigneswaran	Chief Engineer (Soil & Concrete)
	Ceylon Electricity Board
Dr. Susantha Gunatilleke	Vice Chairman
	River Valleys Development Board
Mr. Tilak Palankumbura	Chairman
	Ministry of Planning
Mr. S. Velayuthan	Director External Resources
	Survey Department
Mr. S.J. Munasinghe	Surveyor General
	The World Bank
Mr. Kanok Pranich	
Mr. George A. McBride	
	NEDECO Study Group
Mr. E.H. Mulder	
Mr. J.F.P. Kreuze	
	SOGREAH Consultants
Mr. F. Guigon	

Annex II

LIST OF COLLECTED DATA

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2. Sri Lanka Appraisal of Mahaweli Ganga Development Project II (March 31, 1977) Document of the World Bank
3. Mahaweli Ganga Irrigation and Hydropower Survey Final Report Volume 1 General
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8. Volume III Soils
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12. Volume VI Irrigation (Parts IV & V)
13. Volume VII Dams and Hydro Electric Station
14. Volume VIII(A) Agriculture Economics
15. Volume VIII(B) Agriculture Economics
16. Volume IX Hydro Power
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52. Bulletin on Vital Statistics 1976 Dept. of Census & Statistics

53. Drilling Logs (Moragahakanda Dam) - ID

54. 1/10,000 Topo. Map Reservoir Area

55. 1 inch/100 feet Topo. Map - Dam Site

56. Repulbic of Sri Lanka Irrigation Department Hydrological Annual 1973/1974

57. Report on the Colombo Observatory for 1967 (with maps and Statistics)

58. Hydro Data Moragahakanda Project.

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