JAPAN INTERNATIONAL COOPERATION AGENCY
IRRIGATION DEPARTMENT
MINISTRY OF IRRIGATION, POWER AND ENERGY
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR CONSTRUCTION OF THE MAHAWELI ROAD BRIDGE IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

FEBRUARY 1995

ORIENTAL CONSULTANTS CO., LTD.
in association with
CHIYODA ENGINEERING CONSULTANTS CO., LTD.

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PREFACE

In response to a request from the Government of The Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct a basic design study on The Project for Construction of the Mahaweli Road Bridge and entrusted the study to the Japan International Cooperation Agency (JICA).

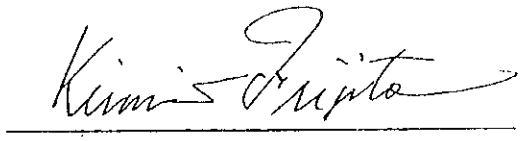
JICA sent to Sri Lanka a study team headed by Mr. Hideaki Hoshina, Development Specialist, JICA and constituted by members of Oriental Consultants Company Limited and Chiyoda Engineering Consultants Company Limited, from 23rd July to 1st September, 1994.

The team held discussions with the officials concerned of the Government of Sri Lanka, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Sri Lanka in order to discuss a draft report, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Democratic Socialist Republic of Sri Lanka for their close cooperation extended to the teams.

February, 1995



Kimio Fujita
President
Japan International Cooperation Agency

Mr. Kimio Fujita,
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

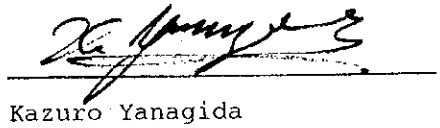
We are pleased to submit to you the basic design study report on the Project for Construction of the Mahaweli Road Bridge in The Democratic Socialist Republic of Sri Lanka.

This study was conducted by Oriental Consultants Company Limited in association with Chiyoda Engineering Consultants Company Limited, under a contract to JICA, during the period 15th July, 1994 to 24th February, 1995. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Sri Lanka and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

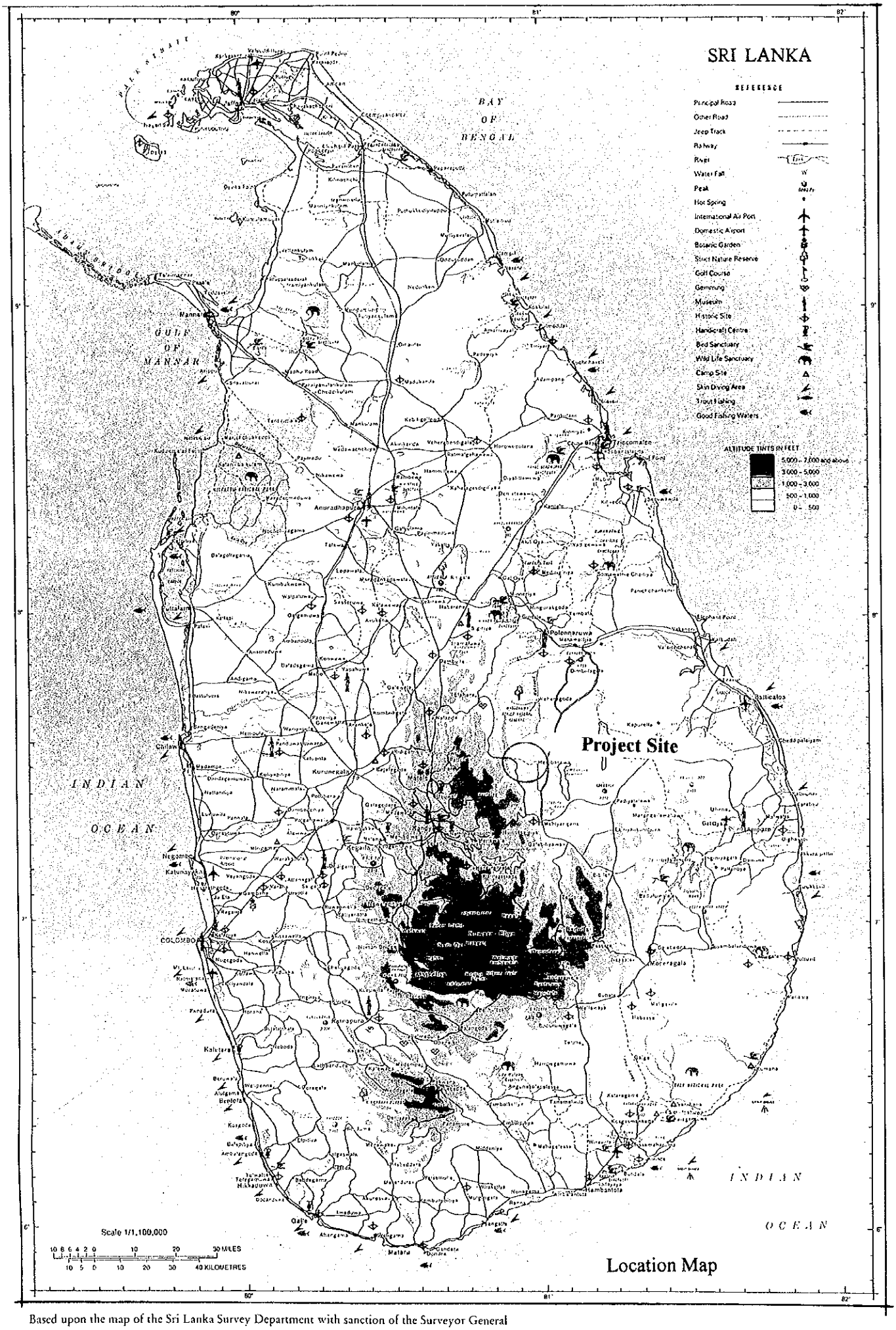
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and the Ministry of Construction. We would also like to express our gratitude to the officials concerned of Irrigation Department, the JICA Sri Lanka office, the Embassy of Japan in Sri Lanka for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to further promotion of the project.

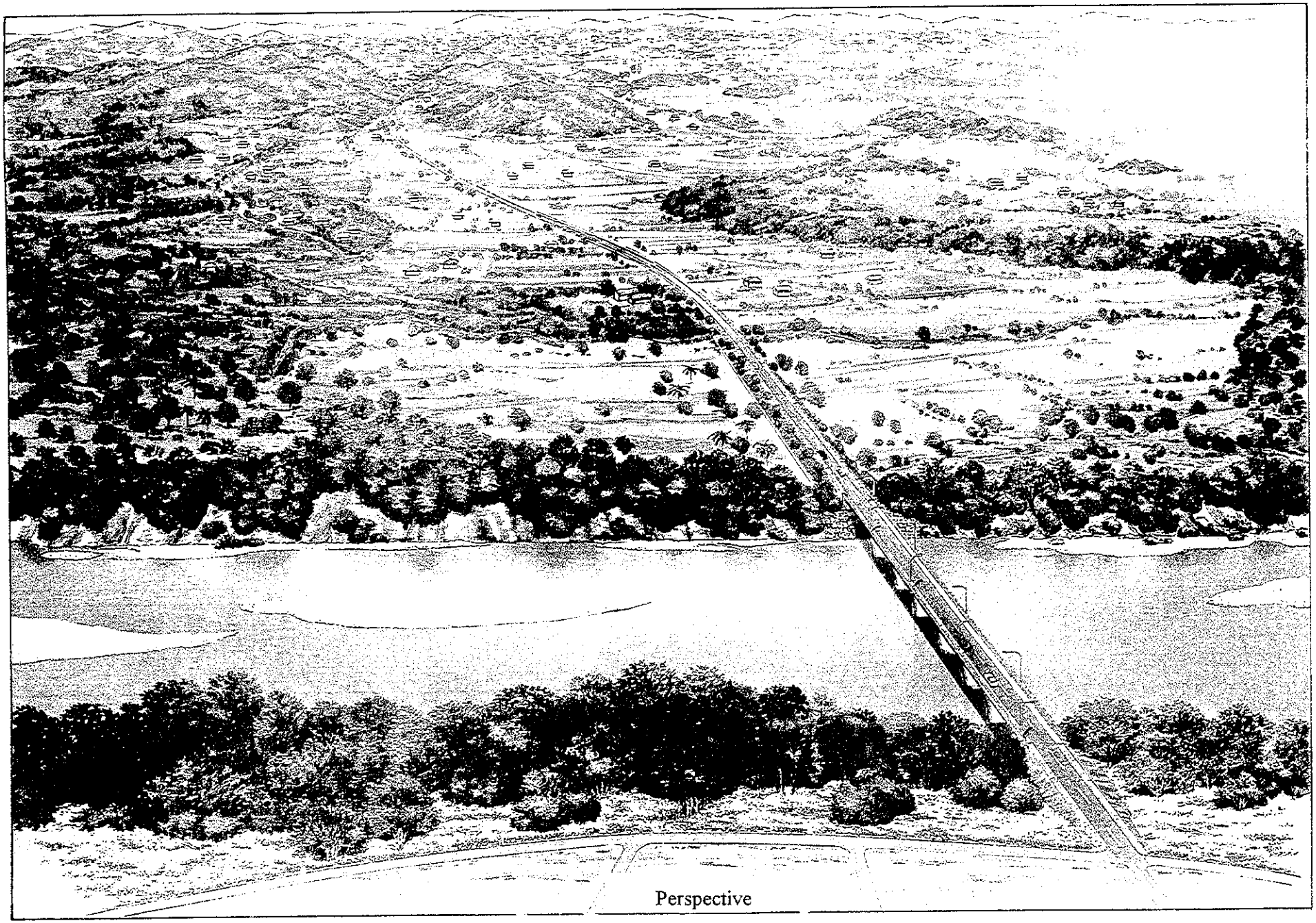
Very truly yours,



Kazuro Yanagida
Project manager,
Basic design study team on
the Project for Construction of
the Mahaweli Road Bridge in
the Democratic Socialist Republic of
Sri Lanka
Oriental Consultants Company Limited



Based upon the map of the Sri Lanka Survey Department with sanction of the Surveyor General



Perspective

SUMMARY

Sri Lanka is an island off the southeast coast of the Indian continent, with an area of approximately 65 thousand square km and a population of 1.8 million (1993). The southern half of the island is mountainous, and the northern half consists of flat terrain. The climate is tropical and temperatures and humidity are rather high. There are monsoons from the southwest during May to September and monsoons from the northeast during December to February. Although there are some ethnic troubles, the situation is relatively stable.

Agriculture, such as tea, rubber, coconuts and rice, is the major industry and accounts for 70% of all exports. Rice, however, is still supplemented by imports. Irrigation and other agricultural development is urgently needed. In fact, there are various projects assisted by international lending agencies to develop and rehabilitate agricultural facilities.

Most domestic transportation is road based and is supplemented by the railway. There are 95 thousand km of roads, of which 11 thousand km is national highway that is mostly paved. The road facilities, however, are rather deteriorated. The Government of Sri Lanka is focusing her efforts on rehabilitating these facilities and increasing capacity by constructing new roads.

The Minipe area is located on the left bank of the Mahaweli River and has a population of approximately 75,000 (1990). Its economy has remained stagnant and the standard of living and income of its farmers are relatively low compared to other areas of the country. This is due to a lack of agricultural and social infrastructure and to the insufficient development of the road network. In view of this situation, the Government of Sri Lanka requested the Japanese Government to execute a study to draw up a development plan for this area and the Nagadeepa area. Based on this request, the Japanese Government entrusted the implementation of the study to the Japan International Cooperation Agency (JICA), which carried out a feasibility study (F/S) on the development of farming areas from 1985 to 1986. JICA suggested after the F/S a

development plan to do the following:

1) Repair irrigation facilities
2) Develop infrastructure in farming areas
   - Improve water service facilities for daily use
   - Repair roads
   - Construct a bridge across the Mahaweli River
   - Develop pasture

To implement the contents of JICA's development plan, the Government of Sri Lanka requested the Japanese Government for economic assistance. After the Japanese Government examined the contents of the request, financial assistance began for repairs on irrigation facilities in 1988 and are still under way. As for infrastructure development in farming areas, the improvement of water service facilities for daily use and the repair of roads were executed under a grant from the Japanese Government.

The construction project of the bridge across the Mahaweli River is a part of the above mentioned request by the Government of Sri Lanka, in order to raise the standard of living, activate the economy, and improve the transportation system of the Minipe area.

After examining the request of the Government of Sri Lanka, the Japanese Government determined to clarify the objectives and effects of the project as well as the background and contents of the request. JICA then dispatched a preliminary study team to Sri Lanka from January 20 to February 12, 1994. The examination by the Preliminary Study Team indicated that the project was considered, from the beginning, to be part of the development project of the Minipe area, and that the agency in charge was the Irrigation Department. In addition, it was determined that this project, which would connect the Minipe and System-C areas, would develop the Minipe by improving its accessibility. This evaluation was supported by the National Planning Department of the Sri Lankan Ministry of Policy Planning and Implementation.

Construction of the Mahaweli Bridge will result in the

following benefits:

1) a permanent land link between the Minipe and System-C areas,
2) the ability to transport and consume the products of the Minipe area in the System-C area,
3) an improvement in the standard of living of people residing in Minipe,
   (by their being able to utilize hospitals, schools and markets in System-C),
4) the ability to process Minipe products in System-C,
5) the ability to transport products from Minipe to and around Matale, and
6) the mutual development of neighboring areas through economic interaction.

In addition to the above-mentioned direct effects, the expectations of the ministries and agencies concerned are high regarding the effects that the road network improvement will have on the central part of the country. Given this background, the Preliminary Study Team confirmed the propriety of the project based on necessity and beneficial effects in terms of national priorities.

The work in this report was executed based on the findings of the Preliminary Study.

A basic design study team was dispatched to Sri Lanka from July 23 to September 1, 1994. The Basic Design Study Team discussed the contents of the Sri Lankan request with the relevant Sri Lankan officials, investigated the environmental and hydrological situation, investigated the project site (which included surveys on traffic, road conditions, and supply lines for construction machinery and materials), and collected other relevant data and information. After considering the project location of the bridge, access roads, bridge length, road width, vertical and horizontal alignment, etc., the Team held discussions with the Government of Sri Lanka to clarify that government's scope of responsibility. Finally, " minutes of discussions" concerning the above was signed.

After finishing its field work, the Basic Design Study Team re-examined the bridge configuration and its access roads using the results of the site investigation. The Team also made a basic design and evaluated the project taking into consideration bridge and road design, the quantity of preliminary construction work, the implementation plan and approximate project cost. Then, a basic design study report was prepared.

The Team then visited Sri Lanka from November 21 to November 30, 1994 to present a draft final report. The Team, in addition to presenting the report, explained the Japanese Government's grant aid system. After discussing the Study's schedule with the Government of Sri Lanka, the Minutes of Discussion contained in the Appendix was signed.

The basic makeup of the project is as follows:

<Bridge name - Mahaweli Bridge>

Main bridge	:	Bridge Length : L=224m
		Effective width : W=10.4m
Superstructure	:	Continuous PC two-box girder bridge (7 spans)
Substructure	:	2 buttressed RC abutments, 6 reversed T-type RC piers
Foundation	:	Spread foundation
Access road	:	Length on left bank (west) 4.80km
		Length on right bank (east) 0.35km

The road and bridge link will become a part of class B road network after the completion of project. The basic design was conducted conforming with this policy.

The project consists of, after the Exchange of Notes (E/N) between the governments of Japan and Sri Lanka, detailed design and preparation of construction tender documents, construction tender procedure, construction bidding, bid evaluation, contract signing, and actual construction. Four months are needed for design and 32 months for construction.

The benefits of the project are expected to contribute greatly to meeting many of the basic human needs of the local people. As a result, the suitability of executing this project under the grant aid system of the Japanese Government is confirmed. With regard to the administration and management of the project, no problems are anticipated since the Sri Lankan side has sufficient personnel and funds. Therefore, an early execution of the project is desirable.

THE PROJECT FOR CONSTRUCTION OF THE MAHAWELI ROAD BRIDGE IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

BASIC DESIGN STUDY REPORT

CONTENTS

CHAPTER 1

CHAPTER 1 BACKGROUND OF THE PROJECT

1.1 BACKGROUND OF THE PROJECT

The Minipe area is located on the left bank of the Mahaweli River and has a population of approximately 75,000 (1990). Compared to the highly developed System-C area, which is a part of the Mahaweli Developmental Project located on the right bank of the river, the agricultural and social development of Minipe lags behind. Due to the severe terrain west of Minipe, the economy is stagnate, resulting in the standard of living and income of the farmers to be lower than that in other areas of the country. In view of this situation, the Government of Sri Lanka requested the Japanese Government to execute a study to draw up a development plan for this area and the Nagadeepa area. The Japanese Government then entrusted the implementation of the study to the Japan International Cooperation Agency (JICA), which carried out a feasibility study (F/S) on the development of farming areas from 1985 to 1986. JICA suggested after the F/S a development plan to roughly do the following:

1) Repair irrigation facilities
2) Develop infrastructure in farming areas
   - Improve water service facilities for daily use
   - Repair roads
   - Construct a bridge across the Mahaweli River
   - Develop pasture

Based on the above development plan, the Sri Lankan Government requested the Japanese Government in 1987 to restore irrigation facilities via loan assistance, and to carry out work on infrastructure in agricultural villages via grant aid. The former project began in 1988 and is still continuing. As for the latter project, it was considered to be too large in scale for grant aid if it were taken up all at once. The F/S concluded that grant aid would be practical if the development plan was divided into four components. As for the first step, the improvement of water service facilities and road repair work was selected, with the construction of the Mahaweli Bridge to be done later. The Sri

Lankan Government, however, objected to the construction of the Mahaweli Bridge being delayed and requested that it be built. This request is considered part of the above-mentioned development plan and the bridge is evaluated as a vital component for farming development, based on a suggestion made in JICA's F/S.

JICA then dispatched a preliminary study team headed by Mr. Shinya SUZUKI (Grant Aid Project Division, Economic Cooperation Department, Ministry of Foreign Affairs) to Sri Lanka to investigate the propriety of the bridge project in terms of its necessity and benefits from a national standpoint. The Team stayed in Sri Lanka from 20 January 1994 to 12 February 1994 to conduct a project site investigation and traffic surveys, as well as to hold meetings with the relevant parties and interview the local people.

The Study Team recognized that the bridge project is appropriate for receiving grant aid for the following reasons: ① estimated traffic volume is considerable; ② the new bridge will improve access for residents to go to hospitals, agricultural warehouses, markets, etc., and produce substantial social and economic benefits; ③ it will strengthen the road network, since as many as 300,000 residents are forced to make a detour of about 80km without the bridge; and ④ the project is specified in the National Investment Plan and a budget and the organizations to be in charge have already been designated. In addition, the Preliminary Study Team also indicated that there would be no difficulty with the project execution or its maintenance.

JICA has executed a basic design study based on results of the Preliminary Study, which confirmed the appropriateness of the Mahaweli Bridge construction in terms of necessity and benefits from a national standpoint.

The Member List of the Survey Team, the Survey Schedule, the Sri Lankan Member List, and the Minutes of Discussions are shown in the Appendix.

1.2 OUTLINE OF THE REQUEST AND MAIN COMPONENTS

1.2.1 Objectives of the Request

Some of Major development plans, advised through the JICA F/S, were requested by the Government of Sri Lanka to the Japanese Government for economic assistance in 1987. Those included the repair of irrigation facilities and the development of infrastructure in farming areas. After the Japanese Gevernment examined the contents of request, the economic and financial assistance began and some are still under way.

The construction project of the bridge across the Mahaweli River is the last part of the 1987 request by the Government of Sri Lanka for the regional development of the Minipe area.

1.2.2 Executing Agency

Irrigation Department, Ministry of Irrigation and Power and Energy

1.2.3 Contents of the Request

Bridge construction and repair of access roads

Bridge	Approx.	260m
Access roads	Approx.	5km (left bank approx. 4km, and right bank approx. 1km)

Project site

The left bank is located in Stage III and IV of the Minipe area, Wilgamuwa County, Matale Prefecture. The right bank is located in Zone II of the System-C area, Ridemariyadda County, Badulla Prefecture.

1.3 PROJECT AND/OR PROGRAM OF OTHER DONORS

There is no other country involved in the bridge project.

As for road work, road construction in Kandy, Nagadeepa, and Mahiyangana, which are located on the right bank of the Mahaweli River, will be undertaken with the financial assistance of Germany. Some irrigation schemes and a road improvement plan between Hettipola and Matale, as well as a road improvement plan in the System-C area, will be undertaken with EC financial assistance.

However, some of the plans have not been implemented because agreements have not yet been reached.

When construction on the Mahaweli Bridge and access roads begins, then the road improvement projects will be implemented to connect the access roads to trunk roads with EC financial assistance. On the left bank, the Irrigation Department (on behalf of the Road Development Authority) will be in charge, while on the right bank the Mahaweli Authority will be in charge.

CHAPTER 2

CHAPTER 2 OUTLINE OF THE PROJECT

2.1 OBJECTIVES OF THE PROJECT

The objectives of the project are, by constructing a bridge across the Mahaweli River, to raise the standard of living, to activate the economy, and to improve the traffic and transportation system of the whole Minipe area.

Consequently, the construction of the Mahaweli Bridge and the improvement (new construction in some parts) of access roads are the goals of the project.

2.2 STUDY AND EXAMINATION ON THE REQUEST

1) Evaluation in terms of the road network

By constructing the bridge, the travel length from the System-C area to core cities such as Matale and Dambulla will be much shorter. Also, it will provide another route to such cities as Kandy and Colombo from the right bank in addition to the existing two bridges (Mahiyangana, Manampitiya), which are located far away. Furthermore, transportation from the Colombo area to the major cities on the eastern bank will become more efficient and the national road system upgraded.

2) Opinions of relevant organizations

The relevant organizations in this project are, firstly, the Irrigation Department of the Ministry of Irrigation, Power and Energy, which will implement the project, secondly, the National Planning Department, Ministry of Policy Planning and Implementation, which decides the National Investment Plan, thirdly, the Mahaweli Development Authority, which is responsible for the development of the System-C area, and finally, the Road Development Authority, which manages the national highways. For this project, these organizations held a hearing, and all of them gave a positive answer. The following explains the intentions of each organization.

Irrigation Department:

This project will produce the following benefits: ① give Minipe farmers access to System-C area hospitals and to higher educational and market facilities, ② connect left bank agricultural production with factories on the right bank and facilitate the transportation of goods from the factories to consumers in Matale and Dambulla, ③ provide transportation not only during the dry season but throughout the year, ④ diffuse the agricultural techniques provided by Japanese technical assistance to the right bank to the left bank, and ⑤ promote trade between both banks, which will encourage the development of the whole area.

National Planning Department:

This project is essential in order to make use of past Japanese investment wisely.

Mahaweli Development Authority:

This project will promote the area's growth. When the bridge's construction is finished, there is a plan to repair the right bank from Girandrukotte in the System-C area to the bridge area using EC funds.

Road Development Authority:

The road system and transportation from the System-C area to major cities such as Matale, Kandy, and Colombo will be improved. In the past, there were not many residents and the need for a new bridge was small. However, due to immigration, the population has increased and is now above 300,000. Therefore, there is a need to have a bridge closer than the current one that is 80 km away.

3) Socioeconomic benefits of the project

The socioeconomic benefits of the project are as follows:

(1) The improvement of the road network in the System-C area will provide access to the Minipe area, which will raise the overall level of the living and economic environment.

(2) A direct route to such western cities as Matale and Dambulla will be created, making it possible to transport

products from the project area to consumers in the cities.

(3) Both sides of the river will develop through the encouragement of trade due to better access.

4) Population

The total population of the Minipe, Nagadeepa, and System-C areas is approximately 320,000 (1993).

5) Existing bridges

There are bridges that cross the Mahaweli River at Mahiyangana and Manampitiya, which are approximately 80km downstream. The bridge at Mahiyangana is crossable throughout the year, but the bridge at Manampitiya is sometimes closed during the rainy season. Also, the latter bridge handles both railway and road traffic, and it is inferior to an exclusive road bridge for processing road traffic.

6) Condition of ferryboats

There are ferries at 3 locations: the project site and 6.5km and 10km downstream from the project site. Excluding the times when the ferries shut down due to flooding and drought, they run approximately 260 days per year. From these 3 locations, approximately 240,000 people use a ferry annually. Due to drought, approximately 260,000 people annually walk across the bridge construction site.

7) Condition of facilities

(1) Hospitals

There are hospitals on both banks, but they are small and are not in good condition. Especially, serum treatment for snake bites is only done at the hospital on the right bank.

(2) Agricultural facilities

There are rice polishing facilities on each side of the river, but the warehouses and processing factories are mainly located on the right bank.

(3) Educational facilities

A university and other educational facilities (e.g.,

Training Center) are located on the right bank. With technical cooperation from the Japan International Cooperation Agency, a pilot farm was constructed on the right bank to help improve agricultural techniques.

8) Evaluation in terms of the national investment plan

The project bridge is part of the National Investment Plan (1993 - 1997) and is a component of "The Minipe and Nagadeepa Agricultural Maintenance Plan", with expenditures having been estimated at 4 million rupees for the 3-year period of 1994-1997. Of the total 4 million rupees (approx. 920 million yen), 3 million rupees (approx. 810 million yen) is planned to be foreign investment. The National Planning Department (Ministry of Policy Planning and Implementation), which is in charge of the National Investment Plan, is taking this project from the development plan for the Minipe, Nagadeepa, and System-C areas and separating it from the Road Development Authority's bridge projects for national roads. The Planning Department feels there is a need to attract enough investment to make this plan work.

9) Management and maintenance plan

The roads, including the project bridge, will be maintained by the Road Development Authority as a national road (Class B) after the project is over. Technologically, the Road Development Authority is capable of maintaining a concrete bridge.

2.3 PROJECT DESCRIPTION

2.3.1 Executing Agency and Operational Structure

1) Irrigation Department

The Irrigation Department of the Ministry of Irrigation, Power and Energy is responsible for executing the construction work. It is difficult to know exactly what kind of jurisdiction the Irrigation Department has because in Sri Lanka the scope of control in each ministry has been changing as the government changes.

The organizational chart of the Irrigation Department is shown

in Figure-2.3.1. Under the authority of a director there are six departments, namely, Planning Design and Specialized Services, Rehabilitation, Personnel and Administration, Operation and Maintenance, Plan Implementation, and Finance. The Irrigation Department employs approximately 4,000 personnel in total, with the number of executives being about 200.

2) Road Development Authority

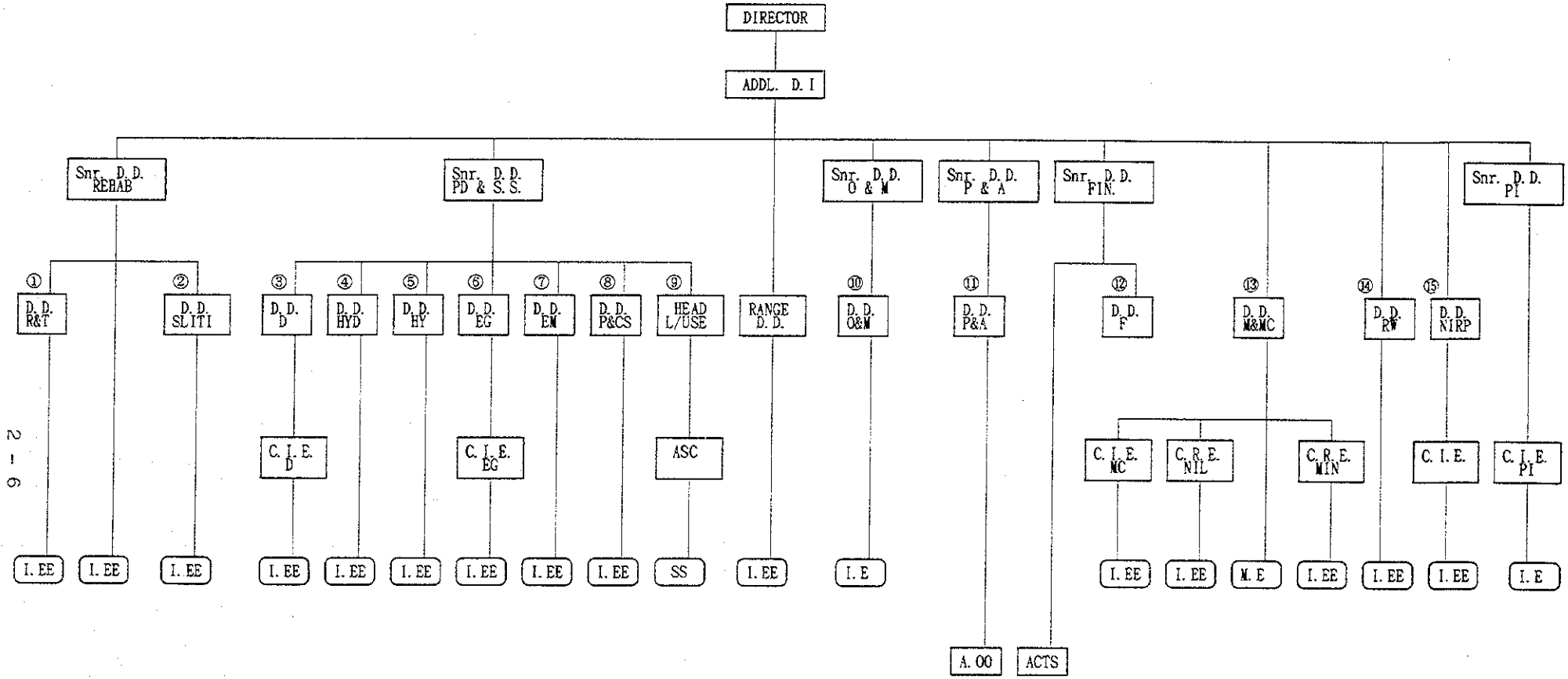
When the construction of the bridge is completed and it comes into use, its management will be transferred to RDA (Road Development Authority, Ministry of Transport, Highways, Environment and Women's Affairs). The organizational chart of RDA is shown in Figure-2.3.2.

RDA is composed of 11 departments under the authority of a general manager. According to its 1990 Annual Report, it has 1,551 personnel, although there are 1,916 job slots. RDA is engaged in the development and administration of both Class A and B national roads that have a total length of approximately 10,450km.

2.3.2 Plan of Operation (Activity)

The project bridge is part of the National Investment Plan (1993 - 1997) and is a component of "The Minipe and Nagadeepa Agricultural Maintenance Plan", which has an estimated cost of 4 million rupees. Of the total 4 million rupees (approx. 920 million yen), 3 million rupees (approx. 810 million yen) is planned to come from external sources. The National Planning Department (Ministry of Policy Planning and Implementation), which is in charge of the National Investment Plan, regards this project as part of the development plan for the Minipe, Nagadeepa, and System-C areas, and has separated it from the RDA's bridge projects for national roads.

The planning of this project started with the development program for the left bank of the river, which was under the control of the Irrigation Department. Therefore, there is an understanding that the Irrigation Department will take charge in carrying out the responsibilities of the Sri Lankan side with regard to the project. To be precise, these responsibilities consist of site preparation,



① RESEARCH AND TRAINING
② SRI LANKA IRRIGATION TRAINING INSTITUTE
③ DESIGN
④ HYDROLOGY
⑤ HYDRULIES
⑥ GEOLOGY
⑦ MATERIAL ENGINEERING
⑧ PLANNING AND COMPUTER SERVICES
⑨ HEAD LAND USE
⑩ OPERATION AND MAINTENANCE
⑪ PERSONNEL AND ADMINISTRATION
⑫ FINANCE
⑬ MACHINERY AND MAJOR CONSTRUCTION
⑭ REGIONAL WORK
⑮ NATIONAL IRRIGATION REHABILITATION PROJECT

Figure-2.3.1 Organization of Irrigation Department

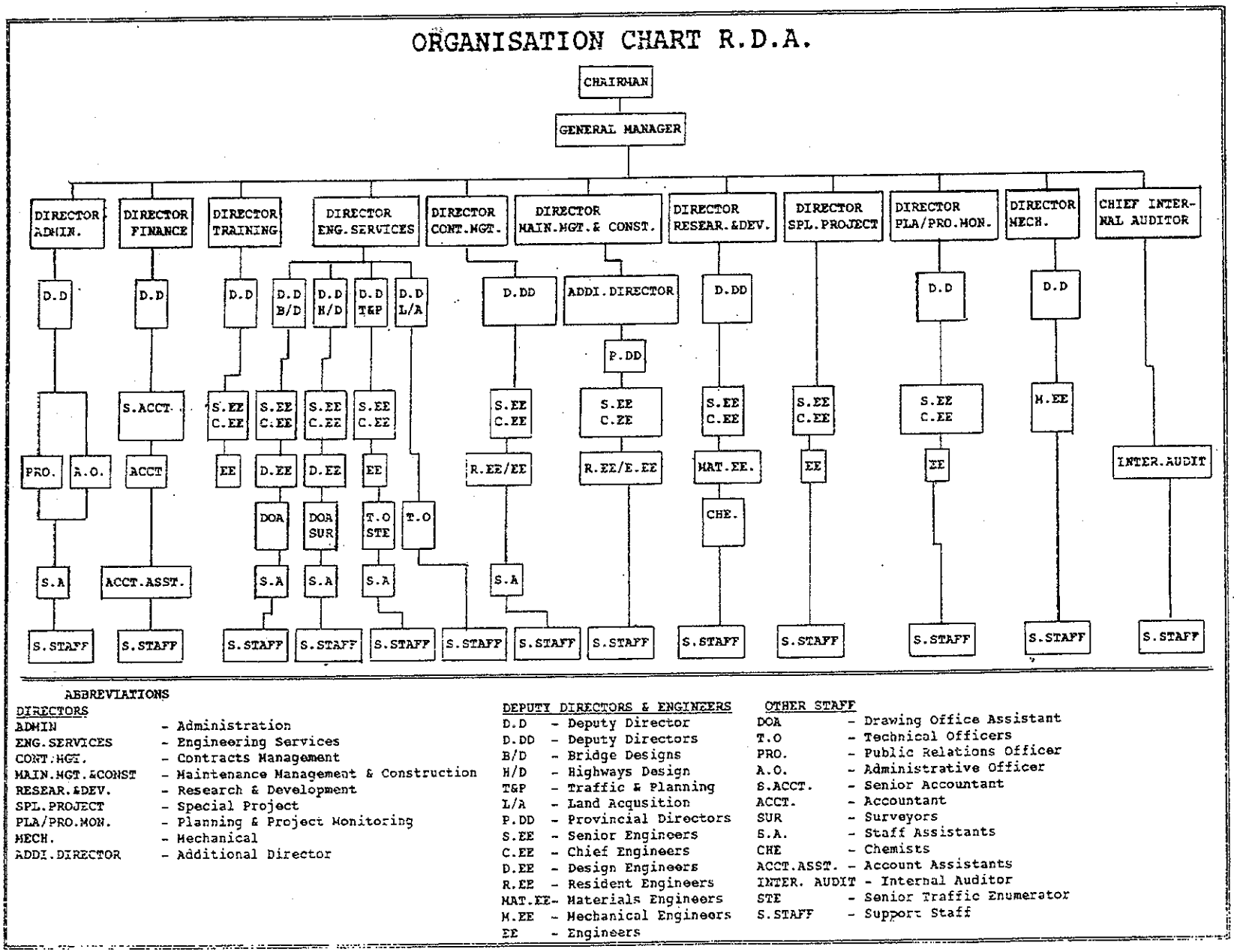


Figure-2.3.2 Organization of Road Department Authority

acquisition and compensation, preparation of public facilities for construction (electricity, water, communication, etc.), and the preparation of other necessary facilities.

In terms of the Irrigation Department's organization, branch offices in each region are in charge of carrying out projects under the instructions of the head office. In the case of this project, the Planning & Design and Special Services departments of the head office are in charge overall, while the Major Construction Department of the head office is responsible for the budget. As for on-site arrangements, the Minipe Development Office in Hasalaka is in charge.

2.3.3 Location and Condition of Project Site

The project site is located close to the center of Sri Lanka (north latitude 7° 32', east longitude 80° 58') about 135km northeast of Colombo. The Mahaweli River flows north-south at the project site and the Wilgamuwa Assistant Government Agents Division (AGA Division) for the Central Province's Matale District is located on the left bank (the west side) of the river. On the right bank, there is the Mahiyangana AGA Division for the Uva Province's Badulla District.

There is a 1,500m high mountain on the east side of the project site, and from the base of the mountain to the river there is a 10km - 30km smooth inclination administrated by the Irrigation Department as the Minipe development area. The land is gently rolling and there are many places where rocks suddenly appear, creating a unique view. The Hasalaka and Heen rivers flow to the east and are tributaries of the Mahaweli River. Most of the land consists of paddy fields, but some places are dry and do not have enough water during the dry season.

The Wasgamuwa National Reserve is located about 15km north of the project site, and is an area where development is restricted.

To the east of the Mahaweli development area there is the System-C area, which is mostly flat and always well irrigated and

green, the results of 15 years of development efforts. The paddy fields, which account for most of the land, are tri-annual in some areas.

The project site is located between a dry zone and wet zone, which has 1,800mm - 2,000mm rainfall a year, although this varies greatly from year to year.

There are no recent statistics for the project site, but by 1990 there will be 320,000 people living in the Mahaweli River basin, of which one fourth will be living on the western bank. The main industry is farming and approximately 70% of the people living on the banks are connected in some way with farming.

During the planting and harvesting seasons there are not enough workers, while during the rest of the year there are many jobless.

The project area therefore has large seasonal unemployment. These unemployed have to go out of town for jobs, and it is said that there are 5,000 people per day who will work out of town just in the System-C area alone.

1) Traffic Conditions of Project Site

(1) Existing studies

Traffic volume at the project site was stated in the Preliminary Study Report. A spot traffic volume count was conducted at the bridge on Route A26 between Hasalaka and Mahiyangana on January 26, 1994 (Tuesday) during the rainy season. The following is the results of the count.

Table-2.3.1 Daily traffic volume by vehicle type

Vehicle Type / Model Split	Motorcycle	Automobile	Bus (Passenger Use)	Truck	Total
No. of Vehicles (Veh./Day)	794	736	523	708	2,761
% of Total	28.8	26.7	18.9	25.7	

Source: Preliminary Study Report (March 1994, Japan International Cooperation Agency)

Table-2.3.2 Daily traffic volume by vehicle type (converted into PCU)

Vehicle Type Model Split	Motorcycle	Automobile	Bus (Passenger Use)	Truck	Total
No. of Vehicles (Veh./Day)	556	736	1,046	1,416	3,754
% of Total	14.8	19.6	27.9	37.7	

PCU Conversion:Motorcycle:0.7, Automobile:1.0, Bus:2.0, Truck:2.0
Source: Preliminary Study Report (March 1994, Japan International Cooperation Agency)

(2) Outline of the Investigation

A spot traffic volume count was conducted by this Study to clarify the following, which was not addressed in the Preliminary Study.

- Large vehicle (commercial vehicle) composition

  In the Preliminary Study, 4 vehicle types were considered whereas 5 types are taken up in this Study.

- Seasonal variation

  The Preliminary Study was conducted during the wet season whereas this investigation was undertaken during the dry season. This enables seasonal variation to be considered.

The traffic volume count was conducted under the conditions shown in Table-2.3.3.

Table-2.3.3 Outline of Traffic Volume Count

Investigation Date	Thursday, July 28, 1994
Investigation Time	5:00 - 19:00 (14 hours)
Investigation Place	Mahiyangana Bridge on Route A26 (Same as the Preliminary Study)
Investigation Taken	Traffic Volume for both directions every 30 minutes
Vehicle Types	① Motorcycle ② Automobile ③ Bus ④ Truck (two axles) ⑤ Truck (three axles or more)

(3) Traffic Analysis

A summary of the traffic volume count is shown in Table-2.3.4, with details shown in Table-2.3.5. From the tables and the conditions encountered during the investigations, the following can be stated:

- 14-hour traffic volume (both directions) was 2,371, or 3,478 PCUs

- Directional flow ratio was 0.51
- The large vehicle (bus or truck) ratio was 53.6%
- The ratio of trucks with more than 2 axles was only 2.4%. Most of these were trailers for cultivation.

Table-2.3.4 Summary of Traffic Volume Count

Vehicle Type / Model Split	Motorcycle	Automobile	Bus	Truck			Total
				2 axles	more than 2 axles	Subtotal	
No. of Vehicles (Veh./14hours)	555	545	593	621	58	679	2,372
% of Total	23.4	23.0	25.0	26.2	2.4	28.6	
PCU Conversion	389	545	1,186	1,242	116	1,358	3,478

PCU Conversion: Motorcycle:0.7, Automobile:1.0, Bus:2.0, Truck:2.0
Source: This Investigation (July 28, 1994)

(4) Project Site Traffic

i) Seasonal variation

The ratio of this Study's 14-hour traffic volume (5:00 - 19:00) to the Preliminary Study's 24-hour traffic volume is 0.894. Taking this into account, the 24-hour traffic volume for this Study is as shown in Table-2.3.5, or 2653 vehicles per day (3890 PCUs per day). The results for the Preliminary Study are shown in Tables 2.3.1 - 2.3.2 (2761 vehicles per day, 3754 PCUs per day), and are very similar to the results of this Study. Therefore, the traffic volume of the rainy season and dry season does not vary greatly.

Table-2.3.5 The Estimated Amount of Traffic Volume Per Day

Vehicle Type / Model Split	Motorcycle	Automobile	Bus	Truck			Total
				2 axles	more than 2 axles	Subtotal	
No. of Vehicles (Veh./14hours)	621	610	663	695	65	760	2,653
PCU (PCU/Day)	435	545	1,326	1,390	130	1,520	3,890

PCU Conversion: Motorcycle:0.7, Automobile:1.0, Bus:2.0, Truck:2.0
Source: This Investigation (July 28th, 1994)

ii) Large vehicles

The large vehicle ratio for buses and trucks was 53.6% and 28.6% for trucks only. For trucks with more than 2 axles, the ratio was a negligible 2.4%.

2) Topographic and Geological Features

(1) Topographic Features

There is a mountainous district 1,000 - 2,000m above sea level along the coastal plain that is located in the south-central area of Sri Lanka. In the north, there is a large plain that occupies one third of the country.

There are 15 rivers that are 100km or longer and whose origins are in the mountainous district. The Mahaweli River is the largest river in the country.

The bridge construction site is located between the Minipe (west side) and System-C areas of the Mahaweli development (east side). An outline of the area is shown in Figure-2.3.3.

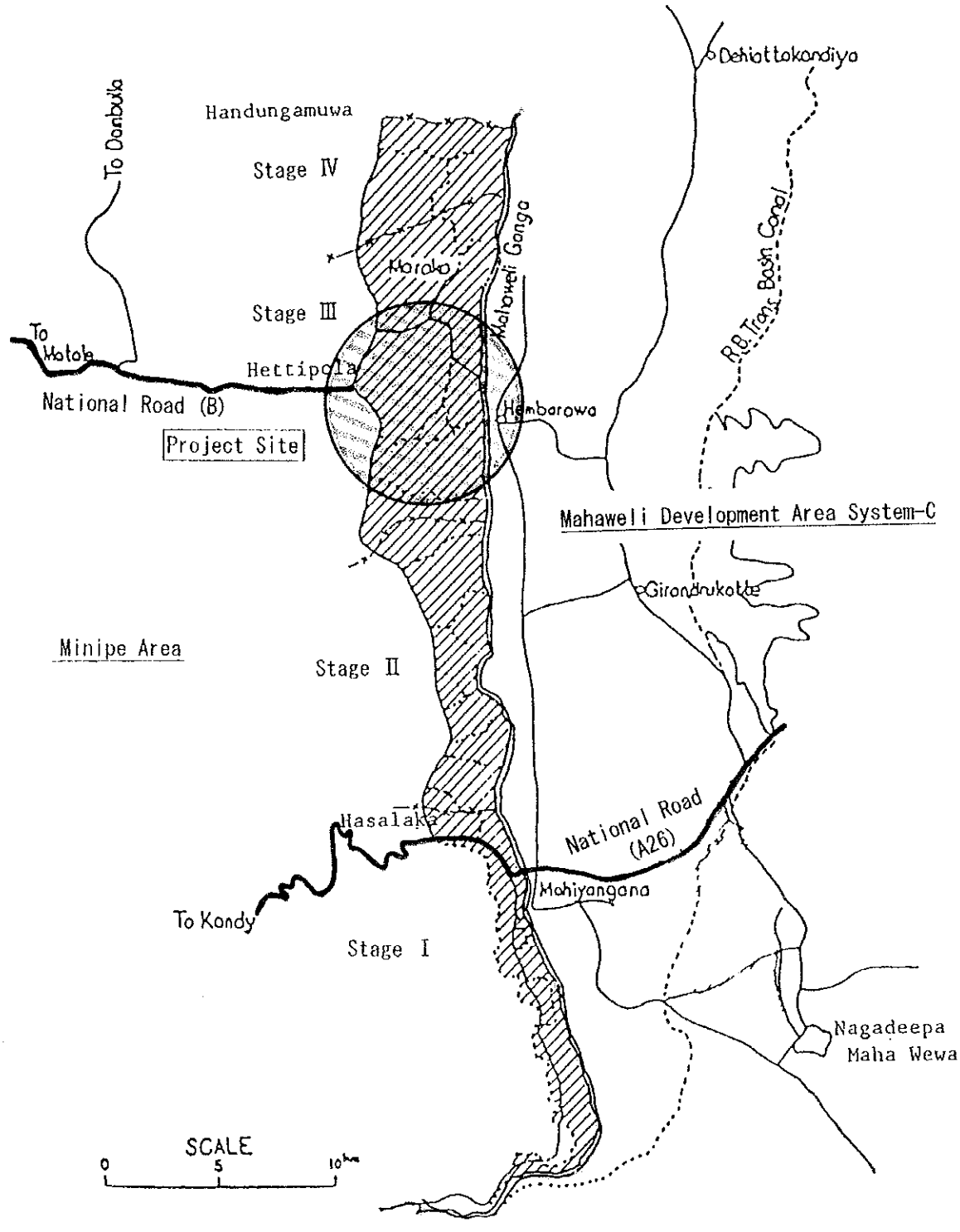
(Minipe Area)

To the east of Minipe is the Mahaweli River serving as a boundary, while on the west there is the Minipe arterial waterway (total 74km) with a mountainous area beyond that. At the very northern end of the waterway, there is the Wasgomuwa Strict Natural Reserve. The topography of the area consists of a slope that gently inclines towards the mountainous area in the west (60m above sea level).

On the west side of the arterial waterway of Stage III and Stage IV it is rather hilly, while the east side of the area is slightly inclined but mainly a flat plain (75m above sea level), having distinctive erosion of 20~130m that has created fresh rock hills.

(System-C Area of Mahaweli Developmental Area)

Having the Mahaweli River as a boundary, the east side(the System-C area) is mainly a flat plain, with the Madura Oya National Park further to the east. As in the Minipe area, this area has many rock hills.



THE GOVERNMENT OF THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	**Figure-2.3.3 Minipe and System-C Area**

(2) Geological Features

A geological map of Sri Lanka is shown in Figure-2.3.4. As this figure shows, the main geological feature of the construction site is Chamosite. Furthermore, it can be seen that the left and right banks of the construction site have gneiss (gneissic shale) hills. A soil map of Sri Lanka is shown in Figure-2.3.5. The project site is identified as containing alluvial soils of variable texture.

The results of boring at the construction site is shown in Appendix 7a.

The geological features of the left bank abutment and the right bank abutment are similar having 8 - 9m deep silty sand (mixture of clay and sand). From 12 - 13m until bedrock is reached there is fine to coarse sand, and the N value is more than 50. The rock boring depth was 5m, which discovered unmixed intimate gneiss rock.

As for the Mahaweli river, there are rocks 5-7m beneath its riverbed. The material is intimate gneiss rock.

Rock shall be the bearing strata for the foundations.

(3) Land Use

(Minipe Area)

Among the Stage III and Stage IV areas on the west side of the arterial waterway, there are many private houses and a large area for farming.

The eastern area is a flat plain having a few gneiss rock hills and reservoirs and looks very simple overall.

(System-C Area of Mahaweli Development Area)

The System-C area is located on the project site on the right bank of the Mahaweli River. Its total area is 66,100ha with 24,100ha under irrigation as part of a large agricultural development. Total immigration is estimated at 30,000 (including 6,000 non-agricultural jobs). Immigration started in 1980 and by 1987 there were 14,000 new arrivals. The area

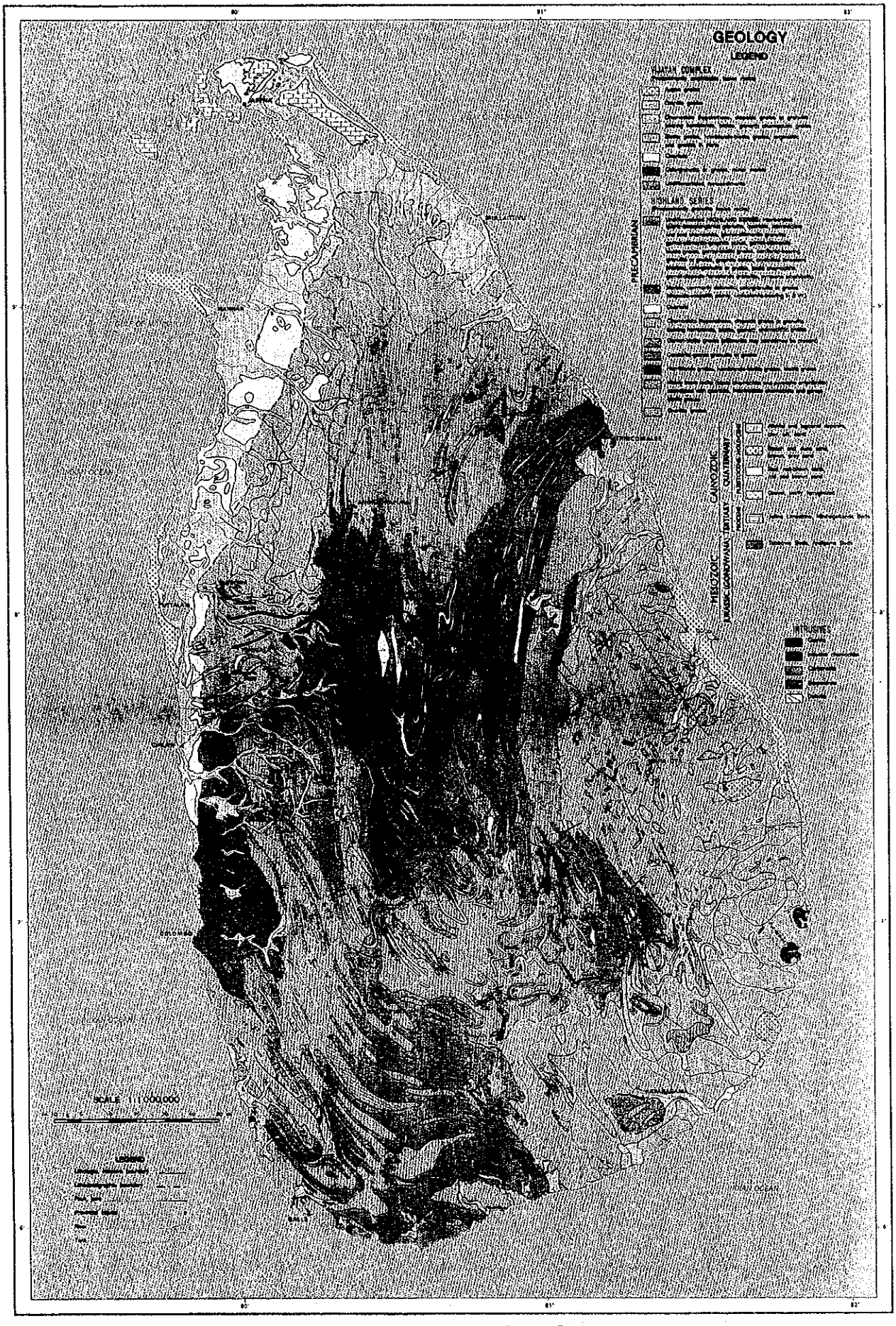


Figure-2.3.4 Geological Map

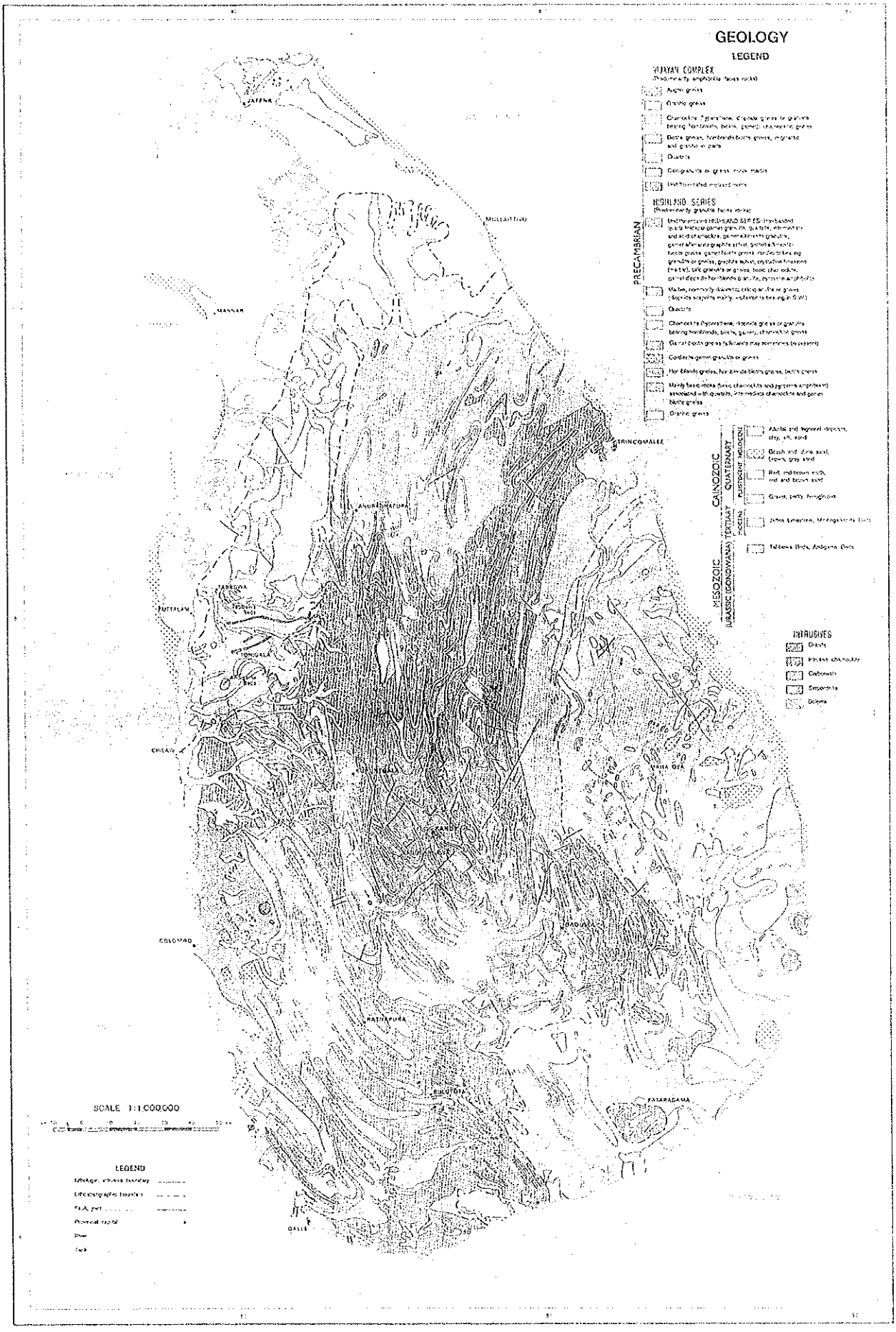


Figure-2.3.4 Geological Map

3.4

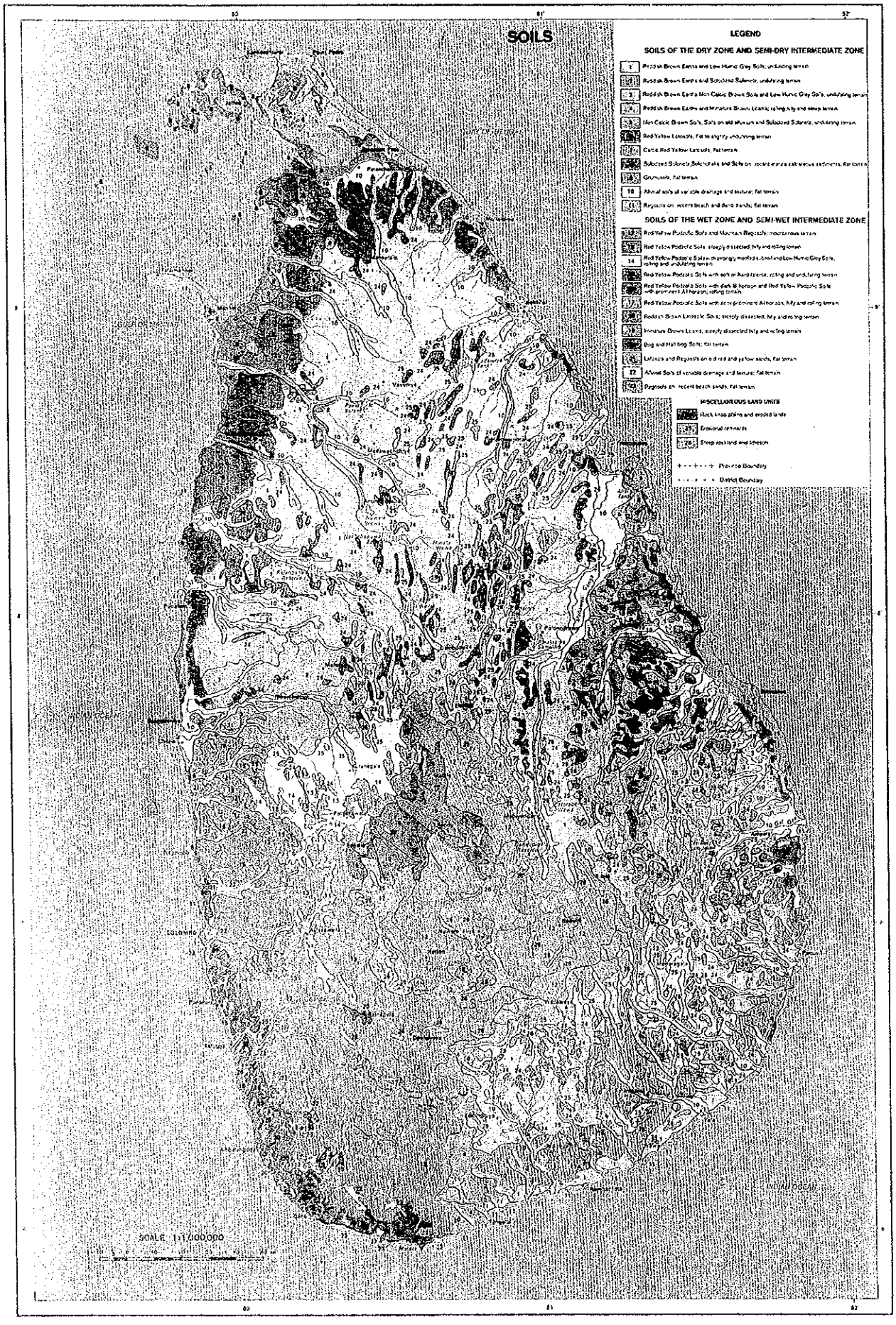


Figure-2.3.5 Soil Map

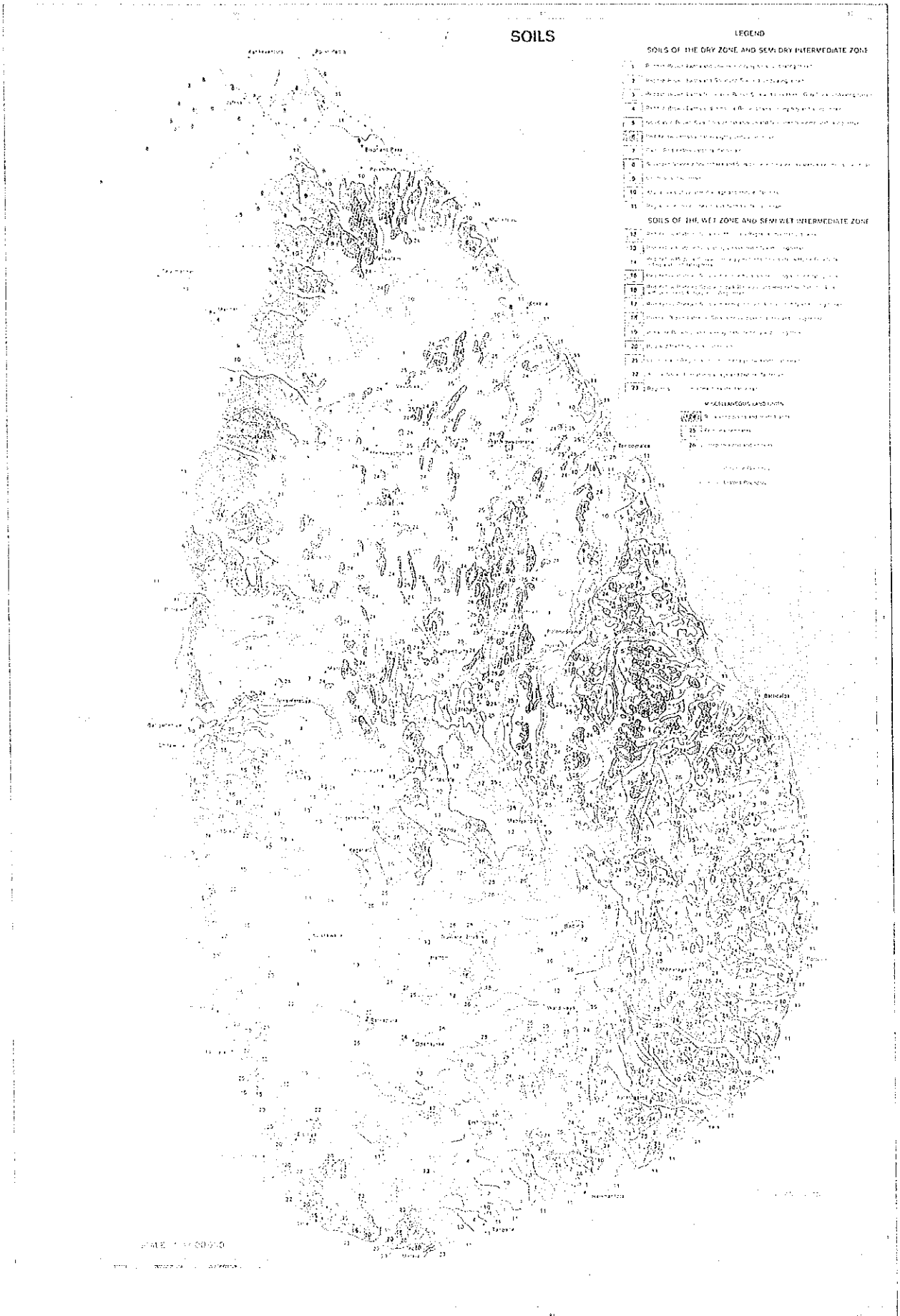


Figure-2.3.5 Soil Map

is still being developed and it is the largest food production zone of all dry zone areas.

The area has nicely maintained paddy fields, plowed fields, and grazing lands, as well as many private homes, schools, hospitals, military facilities, and economic facilities.

(4) Results of hydrological survey

The hydrological survey results for the project bridge are shown in Appendix 7d.

As of 1989, there were 4 dams on the Mahaweli River (upstream). Flood volume has not been analyzed due to dam control. Therefore, the data is based on results taken at survey stations.

(a) Choosing survey stations

Two survey stations near the construction site were selected as shown in Table-2.3.6.

Table-2.3.6 Survey Stations

River Name / Survey Station	Mahaweli River	Mahaweli River
Survey station name	Welaganntota Scaling Point (Mahiyangana)	Manamupitiya Scaling Point
Location	Approx. 23km upstream from the construction site	Approx. 50km downstream from the construction site
Scale of basin	4092.2km^2	7417km^2

(b) Relation between water level and discharge

Figure-2.3.6 shows the relation between monthly average water level and the monthly average discharge observed at the Mahaweli survey station. The graph indicates that the correlation of the two is sufficient, and that the data is reliable. The average water level was mostly under 2.60m and the average discharge was under 4,000,000m^3.

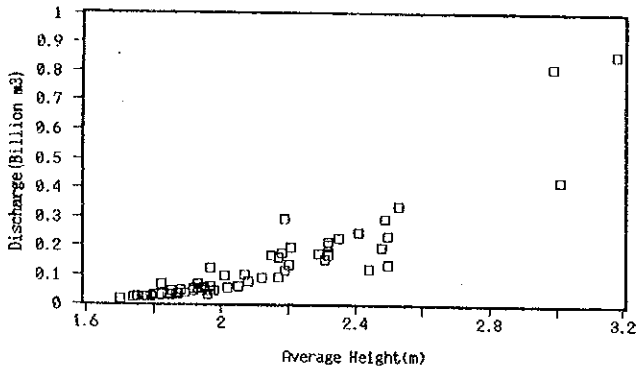


Figure-2.3.6 Height-Discharge Mahiyangana (1989-1993)

(c) Annual average discharge

Figure-2.3.7 shows the differences in annual average discharge. As indicated below, from 1984 the average discharge has decreased. The reason for this is not clear, but the river water level could have decreased because of the increase in irrigation or because of the dams.

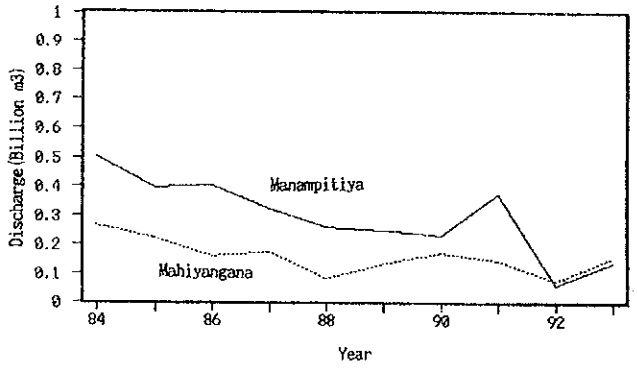


Figure-2.3.7 Average Annual Discharge

(d) Water level

The monthly average water level is shown in Figure-2.3.8. The water level rises from November to February, but annually there is not much variation and usually it stays around 2-3m. Looking at the amount of rainfall, water level should vary more, but this might be due to the influence of the dams.

Since 1989, the highest water level has been 7.6m (1990), but there was a 9m record before that. As shown in Figure-2.3.9, in December and January the water level increases, whereas in the other months it remains at a level of 2-3m.

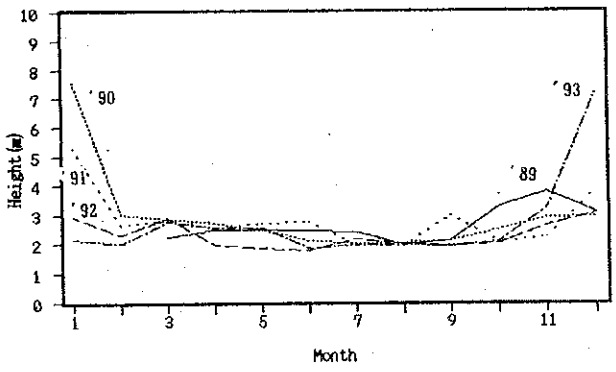


Figure-2.3.8 Monthly Maximum Height (m) Mahiyangana (1989-1993)

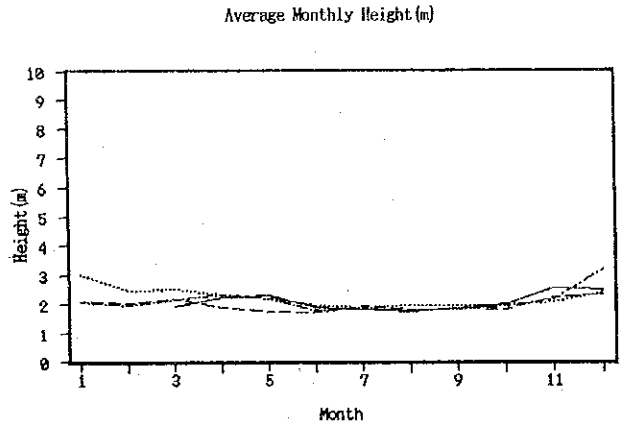


Figure-2.3.9 Average Monthly Height (m) Mahiyangana (1989-1993)

(e) What to consider for bridge planning

From the above results, the following should be considered during the bridge's planning (especially during profile planning).

i) Clearance of girders

Since the completion of the dams, flood control has been conducted and the highest water level since 1989 has been 7.6m, but statistics alone are not enough. It is advisable that the highest recorded water level of 9m be considered due to the topography of the construction site area. The clearance of girders should be 2m freeboard to take into account the possibilities of big trees being washed away.

ii) Bridge abutment location

The longitudinal grade of the Mahaweli River is very gentle and the water velocity rather slow, and there is little scouring of the river banks. Since this river is a natural river, the topography of both banks has to be taken into account to decide the bridge abutment points.

2.3.4 Outline of Facilities and Equipment

Concerning this project, its execution under the Japanese Grant Aid Program is considered to be appropriate.

The following facilities were examined:

Bridge across the Mahaweli River: Approx. 224m long

Access roads: Approx. 4.8km (west bank)

0.35km(east bank)

2.3.5 Operation and Maintenance Plan

The Maintenance Management and Construction Department of the RDA will take charge of maintaining and managing the facilities after completion of construction. In order to carry out actual operations, there are nine provincial branch bureaus and 22 district offices. Each district office has provincial officials in charge of managing of their area.

Actual maintenance and management works are carried out on a contractual basis by RC&DC (Road Construction and Development Company). RDA owns 51% of its stock. With regard to the project, there is an asphalt-mixing plant owned by RC&DC near the construction site. Though the plant generally provides materials only to RDA-related work, it has been confirmed by letter that there exists the possibility of the plant providing supplies to this project.

2.4 ENVIRONMENTAL ASSESSMENT

Environmental assessment in Sri Lanka is stated in the National Environmental Act, No.47 of 1980 (The Order of Government), which was published in October 31, 1980. Its actual application started in June 18, 1993, with a government notification from the Minister of Environment and Parliament Affairs. Therefore, there were no environmental assessments before June 1993.

An environmental assessment must be conducted for trunk roads, national roads, and state roads when the newly constructed length is over 10km or when so designated.

Each ministry and department has an environment assessment cell: (EAC), with experts from the Ministry of Environment involved in the assessments. The contents of an assessment are as follows:

1) The propriety of the evaluation process
2) The propriety of the evaluation method
3) The propriety of the evaluation in relation to the subject matter

Environment Assessment Reports shall be submitted to an EAC.

1) Initial Environmental Assessment Report (Pre-F/S stage)
2) Detailed Environmental Assessment Report (F/S stage)

Assessment reports will be evaluated each time they are submitted to an EAC, and there will be comments when revisions are necessary.

EACs are responsible for supervising all the operations made by ministries and departments and can give information out on environmental assessment to enterprises that do not fit into the categories of the government's notice published in June 1993. Also, when needed, it can hold a public hearing for the Project Proponent.

The environmental assessment report that passes an EAC review is submitted to the Project Approving Agency to receive final approval by the Project Proponent. The Project Approving Agency's head is normally the head of the ministry or department (such as a cabinet member) that the Project Proponent belongs to. However, since the report has passed an EAC review, it does not have many problems gaining approval here.

For the following reasons, environmental problems will not occur in this project:

1) The project is not large enough as a target for an environmental assessment (road extension is less than 10km).
2) The design is such that the effect on the environment is minimal.
3) Because the area is not a major residential area, the project will not affect a residential environment.
4) Compensation for land and housing acquisition are planned taking into consideration counterpart opinions and the opinions of residents in the area.

CHAPTER 3

CHAPTER 3 BASIC DESIGN

3.1 DESIGN POLICY

The following is the basic design policy and takes into consideration various factors, such as the natural conditions for construction and procurement, the scale of the bridge and access roads, the types of materials for the superstructure, substructure, and foundation, as well as the transportation of construction machinery to the construction site and their maintenance.

1) The project site is located on a climatic boundary in Sri Lanka and annual rainfall fluctuates rather sharply; although, the wet season is clearly distinguished from the dry season and this is reflected in the construction schedule. In those years when there is much rain, the Mahaweli River rises considerably and this should be taken into account when considering what type of bridge to build.

2) In general, there are no design countermeasures for earthquakes in Sri Lanka. Judging from past statistics and the recent experiences with weak earthquakes, some people are of the opinion that the design should be aseismatic. Thus, an aseismic design has been included.

3) Most construction materials are imported and are available throughout the local market. However, it is still necessary to confirm the market availability of construction materials for the project, which is taken up later on in the study.

4) As for importing steel materials from a third country, the supply situation is instable and the quality is not guaranteed. Therefore, this type of construction material will basically be procured from Japan.

5) Equipment will be leased as much as possible from sources within Sri Lanka.

6) Consultants and contractors in Sri Lanka have experience in constructing small and medium-sized bridges, but their experience with larger-sized bridges like the one proposed for this project is rather limited. Consequently, the project will be designed in Japan in such a manner that Japanese engineers are directly involved in the important aspects of the construction process.

7) The ability of the Sri Lankans to carry out maintenance is sufficient, but their financial backing is rather weak. Thus, maintenance-free features are considered to be one of the important criteria in determining the type of bridge to construct.

8) Upon completion, the roads and bridge will be categorized as Class B national highways, and it is necessary to make sure they meet the standards of this class.

9) Keeping in mind that this project is a grant aid program of the Japanese Government, due consideration will be given to designing and executing the project economically and completing it within the shortest time possible. In addition, an attempt will be made to utilize as much as possible the materials available in Sri Lanka and to adopt the methods of construction readily available there that meet on-site requirements. Furthermore, the dry season will be taken advantage of to the greatest extent possible.

3.2 STUDY AND EXAMINATION ON DESIGN CRITERIA

As for the design standards, etc., to execute the basic design for the project, intensive discussions were held between the Japanese Study Team and the officials of Irrigation Department supported by the Road Development Authority of Sri Lanka. An agreement has been reached among the parties concerned, on the basis of the results of the traffic volume count survey and current road conditions, to basically adopt the following standards of a Class B national highway.

1) Highway geometric design standards

The project shall fundamentally comply with the highway geometric design standards prevailing in Sri Lanka.

Table-3.2.1 Highway geometric design standards

Class	B
Design Speed	60km/h
Carriageway Width	7.4m
Sidewalk Width	1.5m x 2
Road Shoulder Width	1.8m
Max. Longitudinal Grade	4%
Sight Distance	90m or more

Road width was set based on the results of the traffic volume survey for existing roads, with future traffic estimated at more than 8,001 vehicles but less than 12,000 vehicles, and in compliance with RDA standards.

In response to the desire expressed by the RDA to provide the bridge with a sidewalk width between 1.20m and 1.75m, it was determined to construct a sidewalk 1.5m in width on both sides to meet future requirements.

Figure-3.2.1 shows the specified widths for the bridge and earthworks.

2) Bridge design standard

As regards bridge design, an agreement has been reached with the RDA to apply in principle the Japanese standard.

(1) Design live load: Type-A live load (as per Japanese Specification for Highway Bridges)

Although the British Standard, B.S.5400 (Part 1-10), has been used in Sri Lanka, the Japanese Specification for Highway Bridges will apply for the following reasons:

* The results of the traffic survey has revealed that the axle load of vehicles in Sri Lanka, after taking possible overloading into account, is lighter than that in Japan.
* It is reasonably assumed that the loads of those vehicles, which will pass over the bridge, will remain basically the same.
* What has been mentioned above has led us to believe that the application of the Japanese Specification for Highway Bridges to roads in Sri Lanka will be sufficient enough to meet both current and future requirements there.

(2) Seismic load: KH = 0.1 (design lateral seismic coefficient)

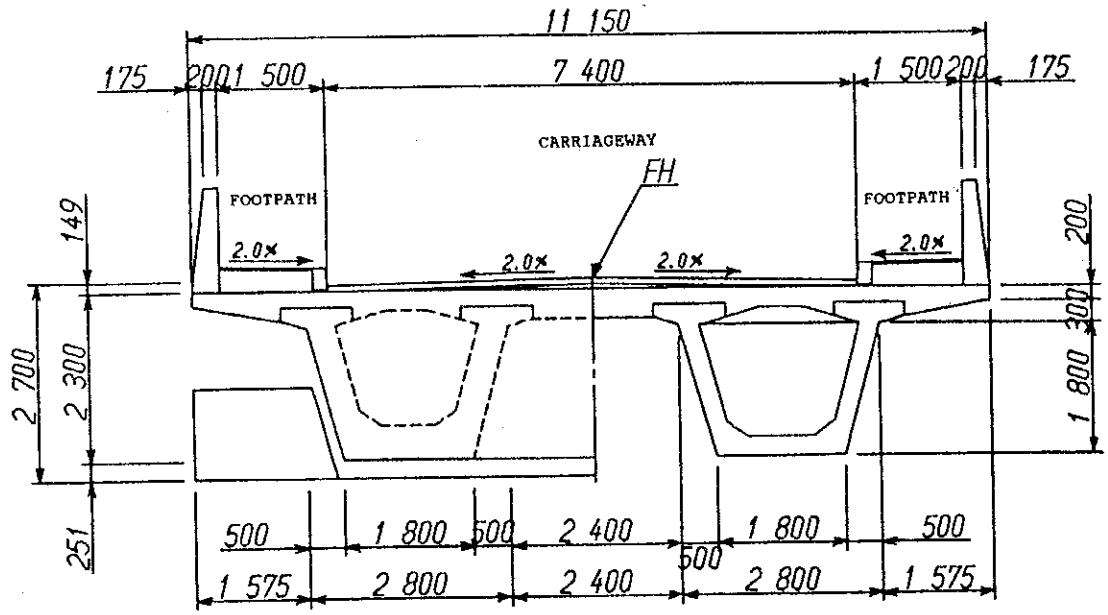
Generally, seismic load is not considered in Sri Lanka, although the country is not free from earthquakes. Actually, earthquakes occur on a periodic basis. Thus, the value mentioned above should at least be considered.

(3) Others

Japanese standards and guidelines will be applied to the design for the bridge and other structures where no standards or guidelines are readily available.

Loads applicable to the project design are classified into 3 categories depending on how their effects apply, how often

TYPICAL CROSS SECTION
OF
BRIDGE



BASIC DESIGN STUDY ON
THE PROJECT FOR CONSTRUCTION OF
THE MAHAWELI ROAD BRIDGE
IN THE DEMOCRATIC SOCIALIST REPUBLIC OF
SRI LANKA

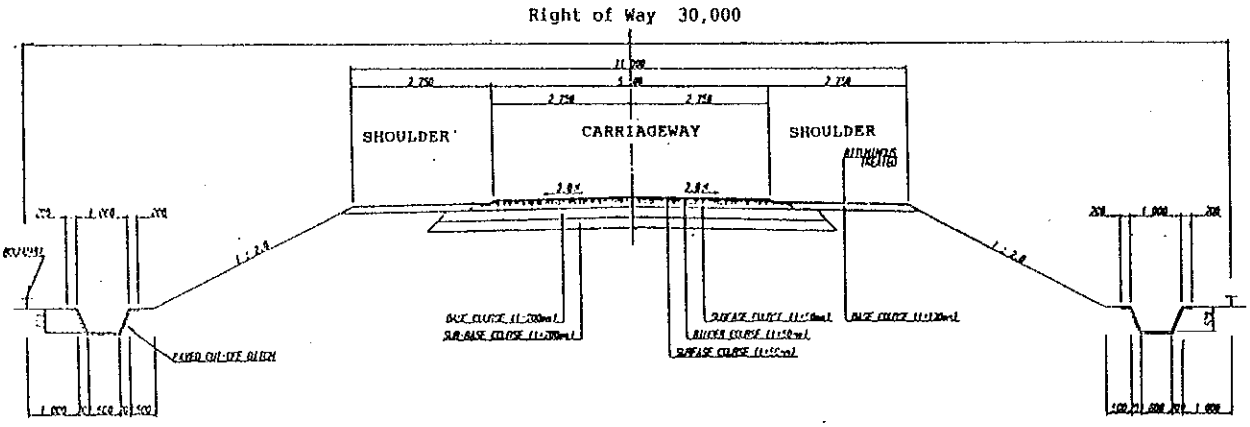
Figure-3.2.1.a Typical Cross Section

TYPICAL CROSS SECTION

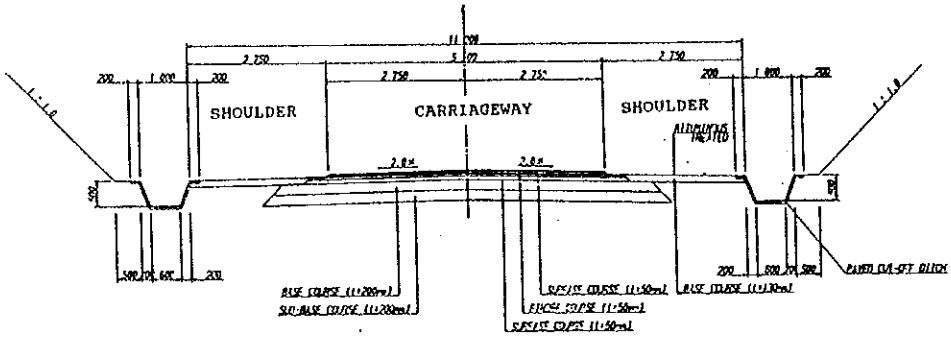
OF

EARTH WORK

STANDARD SECTION (EMBANKMENT)



CUTTING



BASIC DESIGN STUDY ON
THE PROJECT FOR CONSTRUCTION OF
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Figure-3.2.1.b Typical Cross Section

they apply, and what impact they have, i.e., primary load, secondary load, and particular load.

a) Primary load

This is load should be taken into account at all times when the main structure of the bridge is designed.

1) Dead load
2) Live load
3) Impact load
4) Prestressing force
5) Creeping effect of concrete
6) Shrinkage due to drying of concrete
7) Earth pressure
8) Water pressure
9) Buoyancy or uplift

b) Secondary load

A load that should be considered without failure for combined loads.

1) Wind load
2) Effects of temperature changes
3) Effects of earthquakes

c) Particular load

A load that needs to be considered in connection with the requirements for a particular bridge type, structure type, and bridge location.

1) Effect of ground movement
2) Effect of support movement
3) Braking load
4) Construction load
5) Collision load
6) Others

d) Dead load

The dead load includes the weight of the bridge, plus that of other additional items, and is calculated on the basis of unit weights as shown in Table-3.2.2.

Table-3.2.2 Unit Weight of Material

Material	Unit Wgt. kgf/m^3	Material	Unit Wgt. kgf/m^3
Iron, cast steel, forged steel	7,850	Ferro-concrete	2,350
Cast iron	7,250	Cement mortar	2,150
Aluminum	2,800	Asphalt concrete for pavement	2,300
Ferro-concrete	2,500	Cement concrete for pavement	2,350
Prestressed concrete	2,500	Lumber	800

e) Live load

The live load consists of the vehicle load (Type-A live load) and the sidewalk load.

3.3 BASIC PLAN

3.3.1 Bridge Plan

1) Route location

After comparing routes for the project bridge, a route has been selected that will connect the town of Hettipola on the left bank of the Mahaweli River with the town of Hembarawa on the right bank for the following reasons below.

(1) The amount of new road construction, the expense involved in land acquisition and relocation, and the cost of construction are the smallest.

(2) This route is most suitable for the trunk road network system, since it provides easy access to the System-C area and the shortest route to the Minipe area from Matale or Kandy.

(3) The bridge is nearest the point just between the Minipe and System-C areas and will produce direct benefits for both areas.

(4) Other alternate routes are located extremely close to the Wasgomuwa District Natural Reserve, and the construction of a bridge there will not be suitable for the development of the northern district.

(5) The construction of the bridge on the proposed route will stimulate the "entire area's economy," and it is not close to any restricted areas.

2) Bridge location

The location of the bridge has been selected so that it will connect with the paved local road along National Highway AB44 in the System-C area for the following reasons:

(1) In general, the topographical and geological conditions

along the Mahaweli River are such that there is little difference between the areas upstream and downstream; therefore, the location of the bridge can be determined freely.

(2) It is possible to connect local trunk roads with the highway network system in this area.

(3) The construction of the bridge will have little effect on current land use. Furthermore, there are no major buildings in sight along the banks of the construction site.

Table-3.3.1 Comparative Table for Route Location

Item	Proposed Route	Route Near Natural Park
Road Construction	New road construction Access road expansion: (4.7+0.3) km Road improvement Canal administration road on left bank: 3km Local highway on left bank: 5km	New road construction Access road expansion: (5+3) km Road improvement Canal administration road on left bank: 3km Unpaved road on right bank: 8km
Access to Road Network	Connects directly with routes B36 and AB44 and provides the shortest access to Matale, Kandy, Dambulla, and Dahiattakandiya	Approx. 10km away from Route B36. Requires large road improvement work to Dahiattakandiya to connect with Route AB, which will result in improved connections with Matale, Kandy, and Dambulla.
Socioeconomic Impact	Located in the center of the distribution of population in the Minipe and System-C areas.	Located close to the Natural Reserve, and bridge construction will favor a limited number of people. The Mahiyangana Bridge is still used today by a large number of people.
Natural Reserve	Not located near the Natural Reserve. Therefore, there are no special or environmental restrictions.	The Wasgomuwa Natural Reserve located close to the north of the left bank of the river. It is evident that bridge construction will soon put the Natural Reserve in jeopardy.
Local Development	No social or geographical restrictions currently present or forecasted for the future for both sides of the Mahaweli River.	Footprints of wild elephants identified on both sides of the river. With bridge construction, area development will have a negative impact on the environment.
Cultural Value	Bridge construction will contribute to cultural development in the area. The bridge is located at an advantageous site from the point of view of population distribution and access to neighboring villages.	The area is subjected to many restrictions on future development. Bridge construction will not contribute to the culture.

3) Bridge design

The Mahaweli River has remained basically unchanged, and there

is no man-made protection for embankments. This is true for the area in the vicinity of the bridge as well. With this in mind, it is extremely dangerous for the abutments to be near the bank protection line. Taking this and topographical conditions into account, the abutments are to be placed back from the shoreline and bridge length set at 224 meters.

Geological conditions at the bridging point are such that there is a sound rock strata about five to six meters below the riverbed. This means the construction cost of the substructures will be relatively low; in which case, it is generally more economical to shorten the span. On the other hand, the river current will be a problem if the span is too short. In this connection, a six-span (span: 37.3m, river current interference rate: 5%) or seven-span (span: 32.0m, river current interference rate: 6%) bridge is considered to be appropriate. The type of superstructure will dictate the number of spans, and the economic balance between superstructure and substructure, as well as other factors, is considered below to decide span number.

3.3.2 Bridge Superstructure Planning

As mentioned above, a six-span (span: 37.3 meters) or seven-span bridge (span: 32 meters) is desirable for this project. The types of superstructure suitable for this number of spans are as follows:

1) Continuous PC composite I-girder bridge
2) Continuous PC one-box girder bridge
3) Continuous steel I-girder bridge
4) Continuous PC composite two-box girder bridge

(a) Continuous PC composite I-girder bridge

Precast I-girders will be produced at a yard near the construction site and will be erected with an erection girder.

Girders will be continuous in structure with no expansion joints at the halfway points in order to reduce maintenance work, resist earthquakes, and provide maneuverability. Seven spans, each less than 35m in length, is an economical length

for I-girders. The erection girder will be transported from Japan.

(b) Continuous PC one-box girder bridge

Due to cost factors, the shorter the span the more economical a bridge will be. In view of the river current interference rate, however, the bridge will have seven continuous type spans. Due to span-related factors, construction will be done by the incremental launching method. In this method, girders produced behind an abutment are set out incrementally using an erection girder. Launching equipment and the erection girder will be sent in from Japan.

(c) Continuous steel I-girder bridge

The girders produced behind an abutment are assembled and the bridge built by having the girders set out with an erection girder. From an economical viewpoint, the bridge should have six spans (span: 37.3m) with steel I-girders. The required steel will be procured and manufactured in Japan. This is because the production of large steel girders is more difficult in Sri Lanka. In addition, Japan has been chosen as the site of procurement to make sure that the construction schedule is met and quality maintained.

(d) Continuous PC composite two-box girder bridge

Fundamentally, this is no different from the PC composite I-girder bridge, except that two I-girders are combined to make U-shaped girder sections. The U-shaped girders will be produced at a yard near the job site and erected with an erection girder.

The girders will be a continuous-type structure with no expansion joints at the halfway points, in order to reduce maintenance work, resist earthquakes, and provide maneuverability. Seven spans will be used to achieve the economical length for U-girders of 35m or less. An erection girder will be sent in from Japan.

Table-3.3.2 compares the above-mentioned bridge superstructure plans. In view of the economics involved, it is more advantageous to have a concrete girder bridge with either four or two main girders. However, one dry season will not be long enough to erect four main girders and place slab, which may result in the construction schedule having to be extended. This has led to the adoption of a bridge with two main girders.

3.3.3 Bridge Substructure (foundation structure)

Most of the time the Mahaweli River is approximately 3m deep, and the bearing strata on which the foundation is to lay about 5-6 meters below the riverbed. Considering that excavation will be 8-9 meters below the river's surface, the open caisson, cofferdam excavation, and multi-column foundation methods are proposed. These methods are compared in Table-3.3.3.

After evaluating these alternatives, the direct foundation method has been chosen, since it will affect the river flow least after completion and has a construction period similar to the other methods.

3.3.4 Access Roads

In order to determine access road alignment, a plan has been worked out whereby existing roads are used as much as possible and their continued use avoided. The following has been identified as important points:

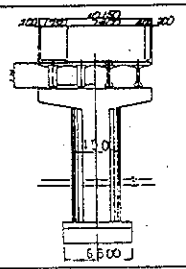
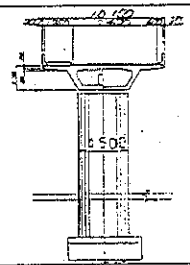
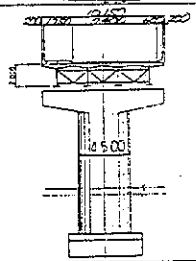
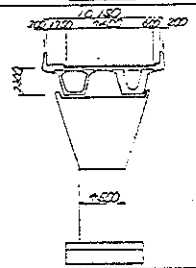
1) Geological disturbances .....rocky mountains, rivers, ponds, etc.
2) Villages, houses, and other buildings
3) Main waterways and facilities

The main items for planning roads are as follows:

a) Horizontal alignment

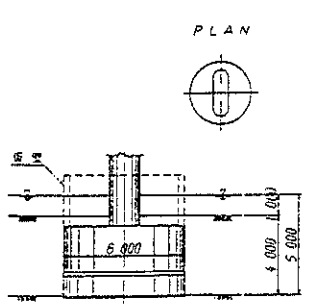
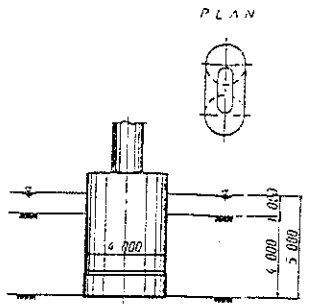
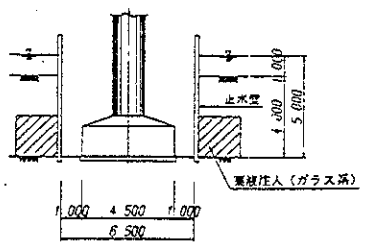
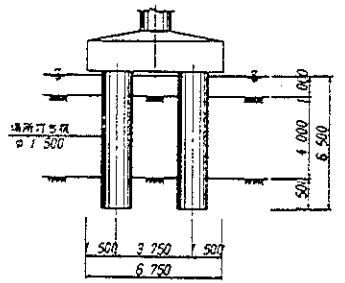
It is stipulated in a Japanese road structure ordinance that a transition curve may be dispensed with when the radius is in excess of 1,000 meters (desirable value) for a design speed of 60km/h, which leads to the adoption of large curve radii.

Table-3.3.2 Comparisons of Bridge Types

	Cross section	Quantities			Comparison Items	Evaluation	Characteristics and Overall Evaluation
PC Composite I-shaped Girder		Superstructure	Concrete	1580m³	Economy	◎	・Since girders are built locally, employment in Sri Lanka will increase. ・Construction Possible only if such materials as PC steel and reinforcement and erecting machinery are procurable. ・Small amount of maintenace. ・Large erecting machinery will be needed.
			PC steel	50t	Constructability	◎	
			Reinforcement	275t	Construction period	○	
			Formwork	7310m²	Technology transferability	○	
		Substructure	Concrete σ_{ck}=240kgf/cm²	2640m³	Aesthetic	○	
			Reinforcement	210t	Job oportunities	◎	
			Formwork	3060m²	Maintenance	◎	○
PC Box Girder		Superstructure	Concrete	1550m³	Economy	△	・All construction work can be performed on site, which will promote employment in Sri Lanka. ・Cyclic operations wil enhance worker proficiency. ・The technological level of Sri Lanka could be raised. ・Construction possible only if such materials as PC steel and reinforcement and erecting machinery are procurable. ・Small amount of maintenance.
			PC steel	47t	Constructability	○	
			Reinforcement	230t	Construction period	○	
			Formwork	9220m²	Technology transferability	○	
		Substructure	Concrete σ_{ck}=240kgf/cm²	2430m³	Aesthetic	◎	
			Reinforcement	195t	Job opportunities	◎	
			Formwork	2950m²	Maintenance	◎	○
Steel Composite Girder		Superstructure	Steel	390t	Economy	△	・Steel girders will be produced abroad and then transported to the site. ・Most material will be imported from overseas. ・Inferior in terms of employment promotion and technology transfer. ・Periodical maintenance will be necessary (painting etc.) ・Superior constructability.
			Concrete	520m³	Constructability	◎	
			Reinforcement	125t	Construction period	◎	
			Painting area	7000m²	Technology transferability	○	
		Substructure	Concrete σ_{ck}=240kgf/cm²	2410m³	Aesthetic	△	
			Reinforcement	195t	Job opportunities	△	
			Formwork	2740m²	Maintenance	△	△
PC Composite U-shaped Girder		Superstructure	Concrete	1580m³	Economy	◎	・Since girders are produced locally, employment in Sri Lanka will increase. ・Construction possible only if such materials as PC steel and reinforcement and erecting machinery are procurable. ・Small amount of maintenance. ・Large erecting machinery will be needed.
			PC steel	50t	Constructability	○	
			Reinforcement	275t	Construction period	○	
			Formwork	7310m²	Technology transferability	◎	
		Substructure	Concrete σ_{ck}=240kgf/cm²	2640m³	Aesthetic	◎	
			Reinforcement	210t	Job opportunities	◎	
			Formwork	3060m²	Maintenance	◎	◎

Legend: ◎ Optimum
○ Fair
△ Not Recommended

Table-3.3.3 Comparative Study of Foundation Types

	1. Open Caisson (single)	2. Open Caisson (twin)	3. Spread Foundation	4. Cast-in-place Concrete Pile
Typical Cross Section				
Provisional Equipment	- Provisional landing stage - Earth-fill cofferdam	- Provisional landing stage - Earth-fill cofferdam	- Provisional landing stage - Sheet piling - Ground improvement	- Provisional landing stage - Standing pipes
Characteristics	- Cast-in-place caisson - Cut-off wall necessary - Small horizontal displacement - Aesthetic	- Precast concrete caisson - Highquality caisson - River flow grenthy affected - Not so aesthetic	- Quality control is easy - Bedrock Confirmation possible - Construction is easy - Aesthetic	- Bedrock excavation necessary - Large horizontal displacement - River flow greatly affected - Not so aesthetic
Impact on Rivers	◎	△	◎	△
Construction Period	○	○	○	◎
Economical Aspects	△	○	○	○
Evaluation	○	○	◎	○

Legend: ◎ Optimum
○ Fair
△ Not Recommended