CEYLON

RECLAMATION OF MARSHES IN AND AROUND CITY OF COLOMBO

FEASIBILITY REPORT

Volume I LAND RECLAMATION

Prepared for

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

by

JAPANESE SURVEY TEAM

FOR LAND RECLAMATION IN COLOMBO AREA

MARCH 1971

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PREFACE

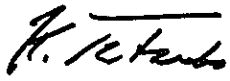
The Government of Japan, in response to the request of the Government of Ceylon, undertook to conduct a feasibility study for the reclamation and drainage project for the low-lying areas in and around Colombo City, the capital of Ceylon, the purpose of which is to provide land for residential, commercial and industrial districts in the future, and entrusted the implementation of the study to the Overseas Technical Cooperation Agency, an executing organization of the Japanese Government.

The Agency sent a seven-member survey team, headed by Professor Takashi Inoue at the University of Tokyo, to Ceylon over a period from March 30 to April 28, 1970, for the implementation of field survey. The survey team promptly summarized its findings into an interim report and submitted it to the Colombo District (Low-Lying Areas) Reclamation and Development Board during its stay in Ceylon.

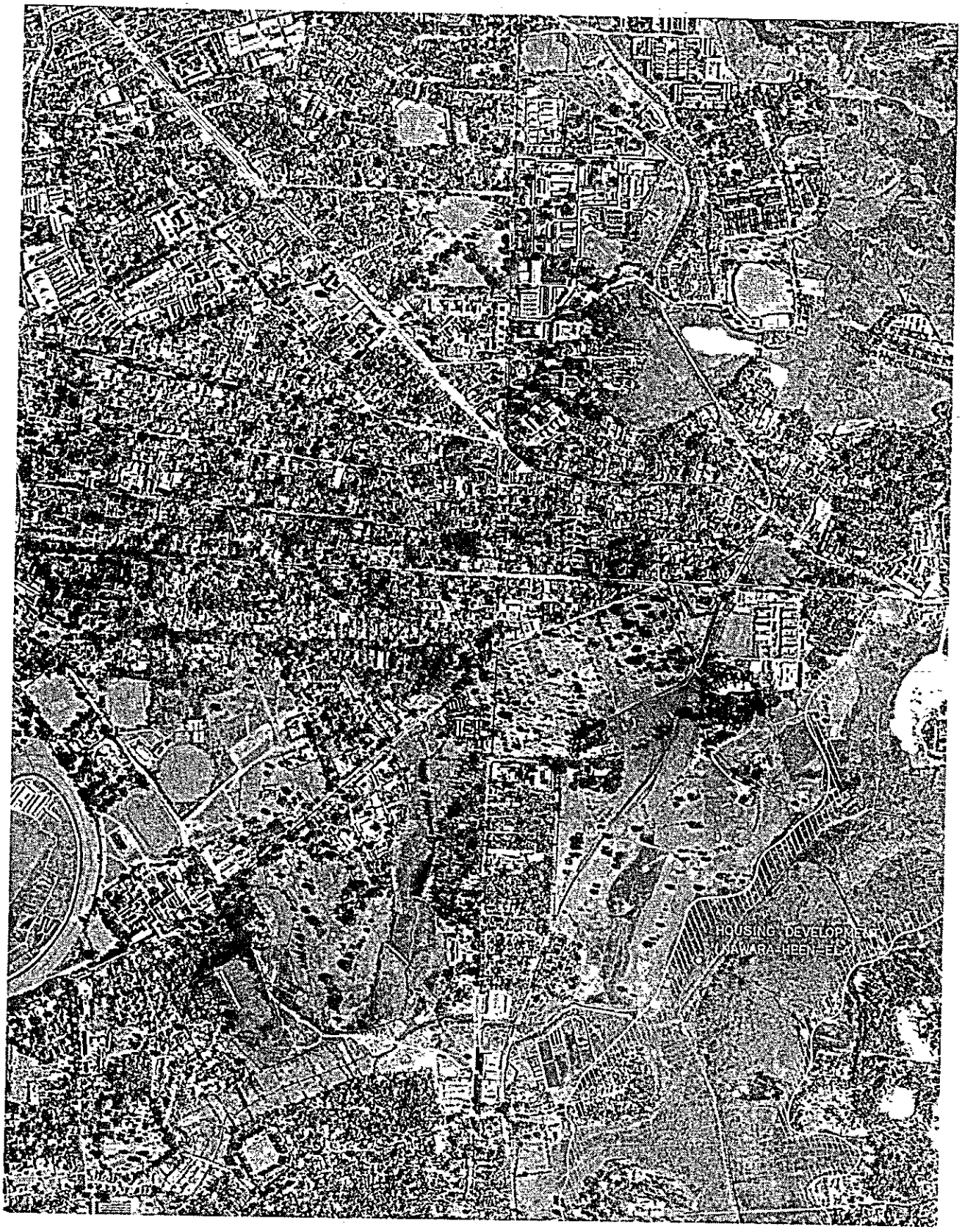
After its return to Japan, the team made various studies and analyses on the data and materials gathered in Ceylon in drafting the final report. Furthermore, the team invited Mr. K. D. P. Perera, Deputy General Manager & Irrigation Engineer of the above-mentioned board, to Japan for about a month from October 19, 1970, as a senior-level trainee for the Colombo Project and jointly reviewed the contents of the report. As a result, the final report has been completed and is herewith submitted to the Government of Ceylon. I sincerely hope that the report will contribute to the further growth of Colombo City, help solve the problem of land shortage in the city and surrounding area and serve in promoting friendly relations between Ceylon and Japan.

Finally, I wish to take this opportunity to express my sincere appreciation and gratitude to the officials of the Ceylon Government for their wholehearted support and cooperation in the execution of the survey.

March 1971



Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency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GENERAL

I. Introduction

1-1 Background

The Government of Japan, in response to the request of the Government of Ceylon, undertook to make a feasibility study on the development of low-lying areas in and around Colombo City, the capital of Ceylon, to form new land for use as residential, commercial and industrial districts, by constructing drainage system, as part of the reclamation project for the same area, and sent a survey team to that country for a period of one month from March 30, 1970.

The organization of the survey team and related functions were entrusted to the Overseas Technical Cooperation Agency, an executing organization of the Japanese Government.

1-2 Purpose and Scope of Survey

The purpose of the survey is to obtain necessary data for the planning of a reclamation project for 2,500 acres out of some 8,000 acres of low-lying land in and around Colombo City to form new land as a means of alleviating its serious land shortage brought about by the expansion of population in Colombo and the promotion of land development for industrial purpose in the surrounding area in recent years, and at the same time, to help establish a town planning project for the future of Colombo City as a whole including the area mentioned above.

To attain the above-mentioned objective, the following surveys and studies were made by the team.

1) Survey on natural conditions (meteorology, hydrology, hydraulics, topography, geology, etc.)

2) Field investigation of the reclamation project area (existing facilities, land use, etc.)

3) Formulation of a basic plan for land reclamation and estimation of cost of construction and maintenance

4) Formulation of a town planning project for the future of Colombo City

5) Economic and financial studies (economic effects, amortization plan, etc.)

1-3 Members of Survey Team

Name	Responsibility	Occupation
Head		
Takashi Inoue	Overall	Professor, Engineering Department, University of Tokyo
Deputy Head		
Yoshiaki Sadai	Town planning	First Coordinator, 2nd Planning Dept., National Capital Region Improvement Committee

Member		
Yoshikazu Yoshida	Drainage planning	Technical Section, Planning Dept., Agricultural Land Bureau, Ministry of Agriculture and Forestry
"		
Ryohei Kakino	Reclamation &. drainage	Project Engineer, Irrigation and Reclamation Engineering Dept., Japan Engineering Consultants Co., Ltd.
"		
Hiroshi Yamamoto	- " -	Project Engineer, Irrigation and Reclamation Engineering Dept., Japan Engineering Consultants Co., Ltd.
"		
Tsuyoshi Takahashi	City planning	Project Engineer, Urban Planning Dept., Japan Engineering Consultants Co., Ltd.
"		
Hiroshi Hashiura	Coordination	Planning Section, Development Research Department, Overseas Technical Cooperation Agency

1-4 Activities of Survey Team

The survey team was engaged in field investigation, gathering of necessary data and materials and exchanging of views with the officials of pertinent agencies during a period from March 30 to April 29, 1970, and submitted an interim report to the Colombo District (Low-lying Areas) Reclamation and Development Board. The following is a summary of its activities:

Date	Activities
Mar. 30, 1970 (Mon)	Departed from Tokyo and arrived in Colombo.
31, (Tue)	Made a courtesy call on Ambassador Yamamoto at the Japanese Embassy and had consultations with officials in charge on the itinerary of the team.
Apr. 1, (Wed)	Visited the Reclamation and Development Board, consulted with officials on details of the activities of the team; exchanged views and gathered necessary data and materials.
2, (Thu)	Gathered data and materials at the Board. Head Inoue and two other members met with Mr. Damiencki, U. N. Expert, Town Planning, and exchanged views and obtained necessary information.
3, (Fri)	Made field investigations at Crown Island, Urugadawatta and Mutuwal
4, (Sat)	Made field investigations at Madiwella, Gathatuwa, Kotte and Heen Ela.

Apr.	5,	(Sun)	Exchanged views among team members on the results of the field investigations made in the past two days and reviewed the data and materials gathered.
	6,	(Mon)	(Poya Day)
	7,	(Tue)	Gathered data and materials at the Board and the Publication Bureau. Head Inoue and two other members met with the Permanent Secretary of the Ministry of Land, Irrigation & Power.
	8,	(Wed)	Gathered data and materials and exchanged views with officials of the Ministry of Planning and Economic Affairs. Held final meeting with the Chairman of the Board and exchanged views with him prior to the departure of Head Inoue.
	9,	(Thu)	Head Inoue departed for Japan. The team was divided into two groups (A-Group for reclamation and drainage and B-Group for town planning). A-Group made a detailed survey in Madiwela District, while B-Group gathered data and materials and exchanged views with personnel concerned at the Ministry of Local Government.
	10,	(Fri)	A-Group continued the activities begun the previous day, while B-Group gathered data and information at the Publication Bureau.
	11,	(Sat)	A-Group conducted field investigation in the Old Kotte District, while B-Group gathered necessary data and materials at the Port Commission.
	12,	(Sun)	A-Group continued the same work as the previous day, while B-Group gathered data and materials at the Central Bank of Ceylon.
	13,	(Mon)	(New Year Day) Both A and B-Groups summarized and reviewed the data and materials gathered so far.
	14,	(Tue)	
	15,	(Wed)	A-Group continued the same work as the previous day, while B-Group conducted a survey on the arrangement of residential and commercial districts in Colombo City.
	16,	(Thu)	A-Group made a detailed field investigation in Gothatuwa District, while B-Group continued the survey in the same districts as the previous day.
	17,	(Fri)	Both A and B-Groups reviewed the gathered data and materials, exchanged views with officials of the Board and made a study on the supplemental data and materials needed in the future.

Apr. 18, 1970	(Sat)	A-Group made a detailed field investigation in Urugadawatt District, while B-Group gathered data and materials at JETRO Colombo Office.
19,	(Sun)	A-Group exchanged views with officials of the Board, while B-Group obtained necessary data and materials from the Resident Representative, U. N. Development Project, and the Chief Accountant, Ceylon Government Railway.
20,	(Mon)	Both A and B-Groups summarized and reviewed data and materials gathered so far.
21,	(Tue)	(Poya Day)
22,	(Wed)	A-Group reviewed data and materials gathered so far, started preparation of an interim report and had consultations at the Board, while B-Group met with the Director of the Valuation Dept. and Asst. Architect of Town & Country Planning and obtained necessary data and materials from them.
23,	(Thu)	A-Group continued the same work as the previous day, while B-Group met again with Mr. Damiencki, U. N. Expert and U.N.D.P. Representative, and exchanged views.
24,	(Fri)	A-Group engaged in translation and typing of the interim report, while B-Group gathered data and materials at the Plan Implementation Div., Foreign Air Investment Loans & Provincial Property Investment Finance Ltd.
25,	(Sat)	Both A and B-Groups worked together and completed the interim report.
26,	(Sun)	Submitted the interim report to the Board Chairman, made additional comments on the report and exchanged views with the Chairman.
27,	(Mon)	Started preparations for depatrure. Made calls on the Board and the Japanese Embassy to bid farewell.
28,	(Tue)	Departed Colombo and arrived in Singapore.
29,	(Wed)	Departed Singapore and arrived in Tokyo

1-5 Acknowledgements

In the course of the survey, kind cooperation and advice were extended to the survey team from various quarters. The team is particularly grateful to the personnel mentioned below and expresses its sincere gratitude and appreciation to them.

T.B.E. Seneviratne	Chairman, Colombo District (Low Lying Land) Reclamation and Development Board
K.D.P. Perera	Deputy General Manager, "
W.J.C.M. Wimalaratna	Architect, "
K.D.A.H. Hanayakkara	Engineer, "
N. Gunaratne	Director of Town & Country Planning
P.N. Virjesingke	Asst. Architect of Town & Country Planning
Mr. Damiencki	U. N. Expert, Town Planning
Ambassador Yamamoto	Japanese Embassy in Ceylon
Secretary Nakamura	" "
Attache Date	" "
Secretary Yokoyama	" "
Mr. Murase	Director, JETRO Colombo Office

It must also be noted that valuable advice was given to the survey team by officials concerned in various agencies of the Ceylon Government in addition to the gentlemen mentioned above. To them also, the team expresses its profound gratitude.

2. Summary of Findings

2-1 Land Reclamation

2-1-1 Hydrological Analysis

The results of rainfall and run-off analysis conducted on the basis of observation data provided by the Colombo Observatory may be summarized as follows:

i. Analysis of rainfall

a. Estimated design rainfall: 19.6 inch (4 days rainfall with 50-year return period)

15.7 inch (for reclamation projects, 4 days consecutive rainfall with 50-year return period, for Madiwela.

b. Heavy rainfall: 21.8 inch (4 days consecutive rainfall with 100-year return period.)

c. Extraordinary rainfall: 24.1 inch (4 days consecutive rainfall with 200-year return period.)

ii. Analysis of run off

Maximum discharge (peak of hydrograph) of each catchment by estimated design rainfall are as follows:

Mutwal	622 cusec
Urugodawatta	885 "
Gothatuwa	1,165 "
Kotte	1,576 "
Heen-Ela	1,316 "
High Level Area	1,488 "
Madiwela Catchment	5,802 "

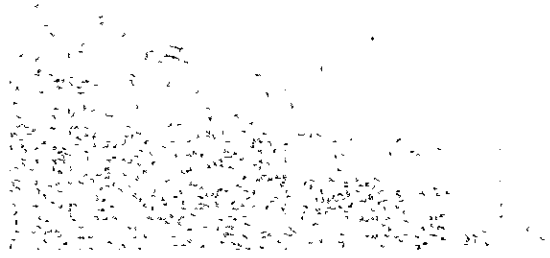
2-1-2 Isolation of Marshes and Proposed Drainage System

i. North Colombo

As a result of a detailed comparative study made from an economical and technical point of view, a system linking Mutwal and Urugodawatta with a culvert and draining with one pumping station, called a combined drainage system, has been adopted.

ii. South Colombo

After a detailed comparative study, the reclamation area in South Colombo was divided into three blocks - Gothatuwa, Kotte and Heen-Ela - as the areas to benefit directly from, the reclamation project, while the High Level Area and the Madiwela Catch. were selected as basins to benefit indirectly. For the three reclamation areas, a pumping drainage system is to be employed and for the two basins to benefit indirectly a gravity



Consolidated Table of Main Elements Under Overall Plan

Item	Name of basin	North Colombo	Gothatuwa	Heen-Ela	Kotte	High Level Area	Madiwela Diversion	Remarks
Area of drainage basin (ac)		1,850	1,352	1,140	1,450	3,436	12,160	
Maximum inflow (cusec)	Estimated design rainfall (50 year return period)	1,507	1,165	1,316	1,576	1,488	5,802	
	Heavy rainfall (100 year return period)	1,687	1,304	1,473	1,764	1,666	8,345	
	Maximum rainfall (200 year return period)	1,868	1,443	1,630	1,953	1,843	9,233	
Maximum outflow (cube)		350	200	200	250	1,066	460	
Cumulative storage (cube)	Estimated design rainfall (50 year return period)	449	503	386	490	–	9,520	
	Heavy rainfall (100 year return period)	500	638	458	594	–	12,790	
	Maximum rainfall (200 year return period)	634	763	563	730	–	14,897	
H. F. L. (M. S. L.)	Estimated design rainfall (50 year return period)	- 0.10	- 0.15	0.00	0.00	–	+6.80	
	Heaby rainfall (100 year return period)	+0.45	+1.40	+1.10	+1.25	–	+7.80	
	Maximum rainfall (200 year return period)	+1.90	+2.25	+2.05	+2.10	–	+8.40	
Volume of earthworks (cube)	Excavation	449,400	312,300	234,200	175,700	185,000	8,000	
	Filling and banking	203,200	255,700	145,300	113,900	60,700	5,000	
Surface dressing with gravel		188,440	254,000	178,200	205,500	–	–	
Pumping Unit equipment	Pumps fore and number	ϕ 42" x 4	32" x 4	ϕ32" x 4	ϕ 36" x 4	–	–	
	Motors output and number	Motor 213kw x 2 Engine 290ps x 2	96.6 kw x 2 131.4ps x 2	96.6 kw x 2 131.4ps x 2	120 kw x 2 163.2ps x 2	–	–	
Concrete revetment (ft)		59,600	25,000	45,400	37,800	87,000	0	
Rubble masonry (Sq.)		10,100	6,200	8,900	6,500	10,300	0	
Other facilities		Connecting culvert 2 Regulating flood gate 3 Emergency flood gate	Emergency flood gate	Emergency flood gate	Connecting Siphon Emergency flood gate	Regulating flood gate 2	–	
Direct cost of construction (Rs)		65,008,000	69,616,000	55,358,000	60,404,000	34,274,000	3,675,000	
Area of reclaimed land available for sale (ac)		324.5	437.3	306.8	353.8	–	–	

drainage system is to be employed. For the drainage in the Madiwela Catch., which plays a vital role in the drainage system for the entire project area, a short-cut drainage scheme by means of a tunnel has been adopted.

2-1-3 Economic Scales of Drainage Facilities

Since the capacity of drainage equipment (pumps) is closely related to flood detention facilities and the total area of reclamation, this must be determined so as to minimize the cost of reclamation per unit area. As a result of a detailed comparative study, the capacity of pumps has been determined as shown in the table below. The average pumping capacity per unit area varies with the each project area, ranging from approximately 0.15 to 0.18 cusec/ac.

Project	Economic capacity of pump	Economic flood detention capacity	Acreage of reclaimed land economically available
	(cusec)	(ac. ft)	(ac)
North Colombo	350	460	445
Gothatuwa	200	520	610
Kotte	250	500	521
Heen-Ela	200	380	413

2-1-4 Summary of Major Feature Works and Tentatively Estimated Cost

On the basis of the discussion in paragraphs 5-4 and 5-5, a general plan was worked out for the entire project area, and a cost estimation of the project was tentatively made. Major features of work and estimated costs of the project are summarized in the following table.

2-1-5 Economic Evaluation of Benefits of Project

A simple comparison of the cost of land reclamation and the revenue from the sale of reclaimed land for each project area is shown below. The cost of work shown in the following table contains an allocated cost of High Level Canal and Madiwela Diversion Works.

Project	Total cost of work	Direct gross revenue
North Colombo	65.0 $x10^6$Rs	181.7 $x10^6$Rs
Gothatuwa	82.9	139.9
Kotte	85.5	123.9
Heen-Ela	64.6	98.2
Total	298.0	643.7

The feasibility of each project as indicated by investment efficiency, which is calculated on the basis of the interest during construction, depreciation of facilities and annual expenditure including maintenance cost, is shown below. In this case, the volume of construction work that can be performed annually was presumed to be Rs. 9,500,000 in value, taking into account the current situation of civil works prevailing in the Colombo District.

Project	Investment efficiency
North Colombo	2.8
Gothatuwa	1.3
Kotte	1.2
Heen-Ela	1.5

The order of priority given to the projects, determined from a technical and economical point of view but not taking into account their relations with city planning or social conditions, is shown below.

Top priority: North Colombo (Urugodawatta is to be implemented first and Mutwal second.)

Second priority: Heen-Ela

Third priority: Gothatuwa

Fourth priority: Kotte

2-2 Town Planning

2-2-1 Present Population

The population of Colombo Region within a radius of 10 miles from Fort District as of 1968 was approximately one million, of which 900,000 people or about 90% concentrated within the 5 mile radius. The major cities located within the 5 mile radius are Colombo, Kolonawa, Kotte, Mt. Lavinia, Wattala and Moratuwa.

The present Colombo Municipality has a population of about 560,000 and covers an area of about 9,200 acres with an average population density of 61 persons/acre. The distribution of population within the city limits of Colombo shows an excessive concentration of population in and around Pettah District, which is adjacent to Colombo Harbour and has been a city area from old times, with a density of well over 200 persons per acre in some part.

Meanwhile, the area shouth of the central city area forms a high-class residential district where each housing has a spacious lot and there is such an extremely low density of population as 25 persons/acre in part.

2-2-2 Present Land Use

Within the city limits of Colombo the use zoning system is adopted. Of the total city area covering over 9,166 acres, about 6,500 acres of land or 2/3 is designated as residential area or proposed residential district and 1,441 acres of land or 15.7% is used for commercial district, with nearly no district specifically designated for industrial area.

As for the present land use, the district of Fort, which may be called the center of Colombo City, enjoys brisk commercial and business activities, besides it being the center of government activities. In the adjoining district of Pettah, land use is characterized by a strong commercial color.

The area surrounding Fort and Pettah districts forms a housing district for commercial and port laborers, where the living conditions are very poor and most of houses have turned to slums. The only land use for industrial purpose is seen in Colombo Port district where only a few port related industries are established.

Within the city limits there are some marshy lands, which can be expected for use as an urban area in the future, extending over 1,000 acres inclusive of the land being developed.

2-2-3 Present Traffic Facilities

The present trunk road network in Colombo City consists of 5 radial roads which link the CBD of Colombo City to the outlying cities. They are; (1) the route running north along the coast and reaching Negambo, (2) the route running northeast and reaching Kegalla and Kandy, (3) the route extending almost due south and reaching Avisawella, (4) the route stretching southeast and reaching Ratnapura and (5) the route running down south along the coast and reaching Kalutara and Galle.

All of these radial roads possess a character of national trunk road and have an important function to link the capital city with all major cities in Ceylon.

As for arterial roads within the city limits, meanwhile, there are three roads of 60~80 feet in width, including Base Line Road, taking the shape similar to a loop.

Regarding transport facilities for passenger service, both railways and bus service are available, but commuters use mainly bus service. Bus service network not only covers the city area of Colombo but also links with the urban surrounding zone. The number of bus trips arriving in Colombo City from outside of the city limits was about 5,200 daily on the average in 1970 and the number of

bus passengers was about 240,000. Meanwhile, the number of railway passengers arriving in Colombo City from outside of the city was only 20,000, according to a survey conducted in 1969.

The traffic of motor vehicles is fairly large in CBD, particularly in the morning rush hours and due to lack of off-street public parking facilities, there are many instances of on-street parking, which further intensify already worsened traffic congestion.

The number of motor vehicles parked on-street during the morning peak hour (10 A.M. ~ 11 A.M.) in Fort District alone was about 1,600 according to a survey made in 1955. In view of the fact that the number of motor vehicles has increased to 1.8 times since then, the number of vehicles parked on-street in Fort District during the peak hour is estimated at about 3,000.

3. Conclusions

3-1 Land Reclamation

The main purpose of this report is to provide a feasibility survey. After making a comparative study of various proposals for a reasonable and economically justifiable drainage system and facilities, a general scheme for the entire project area was framed out and an estimate on the cost of construction was made. Calculating investment efficiency based on the amount of investment and revenue resulting from the investment for all project areas, it was found that the investment efficiency of all these projects was more than 1.0 and that all of these projects were feasible, not only technically but also economically. In this type of project, the economic value can be further increased by curtailment of the construction period. The investment efficiency given in this report was calculated by taking into account the legal restrictions imposed on the amount of borrowings by the Reclamation Board and the number and capacity of construction machinery available in Ceylon. Therefore these projects, with the exception of the North Colombo Project, cannot be considered as having absolute certainty, though they are economically sound. If the curtailment of the construction period is realized through revision of the provisions of the Land Reclamation Act or through loans from international monetary institutions, the economic evaluation of these projects will be further increased.

3-2 Town Planning

3-2-1 Future Urban Picture of Colombo

Planning target year: 1990
Planning area: Area within a radius of 10 miles from the center of Colombo City, including Wattala, Kolonawa, Kotte, Mt. Lavinia and Moratuwa.

Future population: The present population of one million (1968) id expected to expand by 2.2 times to 2.2 million in 20 years.

The area within a radius of 10 miles from the center of Colombo City is to be disignated as the greater Colombo Region and the population in the region in 1990, 20 years hence, is expected to reach about 2.2 million. Of the total area of the region extending over 80,000 acres, about 70,000 acres of land is expected to be needed for urban area to accommodate the future population.

As for the directions of land use, formation of new urban area is to be contemplated by reclamation of low lying areas in and around Colombo City and at the same, redevelopment of CBD of Colombo City is to be attempted by improvements of the present deteriorated urban environments such as slums in the existing city area.

3-2-2 Directions of Land Use in Reclaimed Area

In planning land use of reclaimed land in low lying areas (Mutwal, Urugodwatta, Marigawatta, etc.) around the Port of Fort for urban area, the priority should be given to the establishment of residential quarters and the inhabitants are to be workers related with the Port of Colombo and those in commercial activities in Fort District. As most of the residents in the proposed residential district are expected to be low income earners, emphasis should be placed on construction of flats rather than detached houses with a garden to ensure intensive land use.

Meanwhile, as the districts of Nawala-Heen-Ela and Kotte, situated southeast of Colombo City, form a large development area, the development of these districts should aim not only at providing a function as bed town of Colombo City but also at promoting urban redevelopment incorporating urban facilities required for balanced function of Colombo City as a whole.

In other words, development of these districts should be studied with a view of providing the districts on important role as part of a comprehensive urban development project to accelerate relocation of government facilities now located in Fort District or to secure land space for distribution facilities to help promote smooth function of distribution system and instead of getting through with providing "housing complexes" for those suffering from a shortage of housing, it is essential to promote town making by incorporating more positive meaning.

3-2-3 Model Pattern of Housing Development (Nawala, Heen-Ela)

Location: Narahenpita of Colombo City and Welikada of Kotte U.C.
Total area to be developed: 750 acres
Population to be accommodated: 40,000

The planning area is situated within a radius of 4 miles from CBD of Colombo City and can be reached in half an hour by bus. The main objective of development is to provide a residential quarter for commuters to CBD of Colombo City and Mt. Lavinia but the project also aims at providing various public facilities for the residents of the project area in an attempt to create a community with better environment. Consideration was also given to the establishment of wide area urban facilities (government facilities, parks, etc.) for the benefit of residents outside of the planning area.

The proposed development area extending over 750 acres includes the existing urban area in the high land in addition to the planned reclaimed land. As the living environment in the existing urban area is very poor, a proposal was made for redevelopment of hign land simultaneously with the development of low lying areas by means of reclamation, to provide mainly detached houses with a garden in the low lying area and flats in the high land. As a river flows from north to south almost in the center of the planning area, a wide area trunk road was planned in parallel to the river.

Accordingly, a plan was made to use the strip of these public facilities as a dividing line of neighborhood so that the trunk road will not run through neighborhood. The population of one neighborhood was set at 8,000 ~ 12,000.

4. Recommendation

4-1 Land Reclamation

As previously stated, the City of Colombo and its suburbs are situated in a vast lowland area where there are many marshes left abandoned. Run-off water from the catchment flows over into these low-lying marshes before being discharged gradually into the sea through drainage canals as the surrounding water-level decreases. Therefore, the marshes, though seemingly left unexploited, function as a detention reservoir and play a vital role in protecting the surrounding developed area from the threat of flood. In other words, it seems that in the City of Colombo and its outlying areas, flood damages are kept to a minimum by the balance of three factors, namely, the flood inflow, outflow and the detention capacity of existing marshes which act as a detention reservoir.

Such being the case, it is important to avoid a reduction in the existing capacity of these marshes in planning reclamation projects. It should be kept in mind that any development scheme which disregards this point will result in making the drainage situation in the developed area worse. Some small reclamation projects, which depend solely on filling, and take no account of the overall drainage system, have been undertaken by private enterprises in and around the City of Colombo. This type of works destroys the balance between the inflow and outflow of flood water and the flood-regulating function of the marshes. Therefore such works should be prohibited from the standpoint of the overall development of the Colombo Region, by legislation or regulation if necessary.

In planning a reclamation project, therefore, even if it is a small project or a project undertaken by private sectors, there must always be a scheme for a detention reservoir with adequate function and capacity corresponding to or exceeding that of the existing marshes. When a reduction in the flood detention capacity of the marshes is contemplated, the plan must provide for the installation of additional pumps to compensate for the reduction in the flood detention capacity of the marshes. These are the points which were first to be important by the survey team during the field investigation of the project area and to which the agencies concerned as well as the Board should pay particular attention.

The next important subject is the views concerning the diversion plan of the Madiwela Catchment, which has an important bearing on the entire project, particularly on the reclamation project in South Colombo, and plays as important role in its success or failure. As a result of economic comparisons of various drainage systems, the short cut, using the route of the Old Moat, has been adopted. As stated in the staging program of the project, the reclamation works in Colombo North, Heen-Ela and Gothatuwa can be accomplished without diversion of the Madiwela Catchment. After completion of the reclamation projects for the above-mentioned area, the run-off water from the Madiwela Catchment will flow through Kotte Lake and Kirillapone Canal and then will be discharged into sea at the Wellawatta outlet and Dehiwela outlet, following the existing drainage canal traces. With the growth of demand for more land following the concentration of the population in the city area and the expansion of commerce and industry,

reclamation in Kotte will also have to be considered. To reclaim the marshy land in Kotte, the diversion work of Madiwela Catchment must be carried out by means of a tunnel as mentioned in the general plan. This route is considered to be most reasonable and economic at present. However, it will pose some problems in the future when the development of the Madiwela Catchment for housing development is taken into consideration.

The first problem likely to be encountered following the progress of the development in the Madiwela Catchment is an increase in run-off coefficient caused by changes of surface material in the basin. The area around the Kirillapone Canal and Wellawatta Canal are highly developed, making it very difficult or almost impossible, to widen these canals.

In view of these factors, the most ideal way would be build a diversion canal from the south end of the Madiwela Catchment and to discharge into Weras Ganga as described in the I.D. Report.

The third question is the groundwater in the surrounding area. All reclamation areas in this project will depend on a pumping system. Originally, it was proposed to maintain the estimated normal water level in the detention facilities at -6 MSL or -8 MSL. However, due to the fall down of ground water level in the surrounding area, it is quite possible that the ground level will subside owing to consolidation of the foundation. Accordingly, it was proposed to maintain the normal water level at 0 MSL during dry weather and to lower it to -6 or -8 MSL by pumping immediately before the start of run-off following rainfall. Judging from the data of daily precipitation, a considerably heavy rainfall is expected almost every day during the rainy season. To ensure the safety of the reclaimed land, therefore, it is necessary to maintain the normal water level at -6 or -8 MSL as far as the rainy season is concerned. Since the groundwater gets a sufficient supply of rain water during the rainy season, the lowering of water level in the scheme would not cause serious effects on the surrounding area of the project.

The surface soil layer in a depth of 10 feet consists mainly of clay, silt and peat in entire project area and the coefficient of permeability is considered to be relatively small. Though a definite conclusion cannot be made because of a total lack of data on the fluctuation of the groundwater, the influence of a mere 8 feet downward in the water level at the drainage canal will not cause any serious problems as the need for payment of compensation for the subsidence of ground level and the lack of groundwater. In any event, the fluctuation of the groundwater caused by a lowering of the water level in the detention facilities is a matter of great concern for the residents in the surrounding area. In implementing a reclamation project, therefore, it is important first to obtain the understanding and cooperation of the residents of the area by providing satisfactory technical explanation. For this reason, it is necessary to make efforts to analyze this problem in detail in the near future while gathering data on the fluctuation of the groundwater.

The fourth question is concerns the quality of the redish brown soil brought in for dressing ground surface. Though a definite conclusion cannot be made on the quality of this soil at present because data on soil dynamics is not available, the soil appears to have a tendency to become very muddy and sticky when wet. It is considered advisable, therefore, to spread sand about 6 inches in thickness for the surface dressing, if possible, to ensure better environment upon completion of land reclamation.

Fortunately, sand bars, which develop to such an extent as to close up the outlet of the canals, are found on the coast of Colombo, and therefore there is no difficulty in obtaining sand. The distance between the beach and the reclamation ar a is relatively short and the cost involved is not considered to be expensive compared with the transport cost of the redish brown soils. As the soil for surface dressing is required in large quantities and is one of the materials that have an important bearing on the economy of the project, any use of sand for dressing materials should be preceded by making a comparison of unit cost between the so soil and sand, and the proportion of sand in the mixture must be determined so as not to upset the balance of the economy of the project.

The fifth question concerns the concrete revetment for canals and lakes. Under the existing condition, many of the concrete revetments provided for part of the main drainage canals have tilted or have fallen and are not functioning well. The main cause of this failure is presumed to be the insufficient depth of the footing of the revetment post. In designing the revetment, therefore, it will be necessary to make a stability analysis by taking into account the surcharge over the bank and the groundwater pressure. In Japan, there are many cases where steel sheet piles are employed for the protection of canals. The design incorporating the use of steel sheet piles might appears to be expensive, but they are more durable, stable and workable and are most satisfactory both from the standpoint of hydrography in canal and maintenance. Since the project, including urban drainage, requires stability over a long period of time, the use of such dependable materials as sheet piles will be more economical in the long run.

The sixth question is the management and maintenance of the drainage system upon completion of the project. The main drainage canals in and around the City of Colombo are under the jurisdiction of the Irrigation Dept., but the annual budget for the maintenance of these canals seems to be very small. Taking the Dutch Canal, for example, it is believed that the canal had sufficient depth at the initial stage and that the flood detention reservoirs including Kotte Lake, had a fairly large detention capacity. However, because of a lack of proper management and maintenance, the capacity of these canals and detention reservoirs has gradually deteriorated, and at present, even the land of +6 MSL, which otherwide could be available for use as a residential or industrial area in respect to the elevation, is being flooded, inundated, and still remains a complete marshy land. It must be remembered, therefore, that even a splendid land successfully reclaimed under the project might revert to the situation of marshes before long if and when proper supervision and maintenance are ignored upon completion of the project. According to the estimate on the economic evaluation of the project, all the management and maintenance cost are to be formed by each project. In actuality, however, the drainage system under this project is only a part of the overall drainage system for the entire Colombo Region. Therefore, most of the management and maintenance costs should be borne by the Government or public organizations.

The maintenance of such main structures as pump stations and regulators offers little problem because they are easily noticeable. However, the degree of silting in the drainage canal or in the detention lake is not as conspicuous and is therefore often neglected. It is advisable, therefore, to purchase several small amphibious self-moving dredgers equipped with a Fathometer, a device which is capable of recording the degree of silting accurately and promptly, and to use these dredgers for desilting by assigning them on patrol missions for all drainage canals and detention lakes.

There are many other points to be kept in mind in connection with the maintenance of the drainage system. No matter how reasonable and sound the project may be and how carefully it may be implemented, its overall success will be denied if proper maintenance is not provided following the compeltion of the work.

In fact, looking over the existing condition of the drainage canals in and around the City of Colombo, the need of full maintenance after completion of the project is deeply felt.

The seventh question is the necessity of gathering long-range observation data which may be used as the basis of the scheme in working out a large project such as this one. Though hydrologic data is available in relative abundance even at present, the data, particularly data on the run-off coefficient and on the discharge of each canal, which are most needed for the project, is very scarce. The data on the coefficient of run-off may be obtained easily by selecting a model area of small catchment and observing the discharge at the run-off outlet. An accurate measurement of the discharge in the drainage canal is made difficult by the hydraulic condition of back-water in the slow gradient stream. However, a fairly accurate estimate may be obtained by installing a pair of automatic water level gauges at intervals of about 1/2 mile. Thus, the trend of flow in the Colombo Region during floods may be grasped.

The eighth point is the question concerning the procurement of funds for the project. Under the current Reclamation Board Act, the amount of Government-guaranteed loans is limited. As a result, the staging of the project is so restricted that the implementation of the whole project will require more than 30 years.

As mentioned previously in reference to investment efficiency, the economic evaluation of the project may be increased through the reduction of interest paid by shortening the construction period through the mobilization of all available construction machinery. Therefore, a substantial curtailment of the construction period should be attained through an increase in the amount of land by revising the provisions of the Reclamation Board Act or by seeking loans from international monetary organizations. Recommendations on this project may be summarized as follows.

1) As the existing marshes play a vital role in flood detention for the entire Colombo Region as detention reservoirs, full efforts should be made so as not to decrease this detention capacity in implementing a reclamation project. Particularly, unplanned land reclamation by the private sector should be restricted.

2) The decision on the Madiwela diversion route in this report has been made on the assumption that there will be no land development scheme in Modiwela even in future. Accordingly, if such a scheme is planned for the Modiwela catchment in the future as a result of the concentration of the population in the Colombo Region and the expansion of commerce and industry, the Modiwela diversion scheme to Weras Ganga as suggested in the I.D. Report, would be better than any other proposal due to the lack of conveyance capacity of Kirillapone canal and Welawatta canal.

3) The influence of the reclamation project on the groundwater in surrounding area is not considered as causing any serious problem from a geohydrological

point of view, However it will be necessary for the purpose of obtaining the understanding and cooperation of the surrounding residents.

4) As sand of good quality is available at a relatively short distance from the location it should be used as part of the soil for dressing ground surface to ensure good drainage conditions of the reclaimed land.

5) Durable drainage facilities must be provided by placing emphasis on the dependability required of the urban drainage system even though such facility may entail higher cost.

6) Although the main purpose of the project is land reclamation, its ultimate result will be to serve as the urban drainage for the entire Colombo Region. Therefore, most of management and maintenance costs should be borne at public expense. It should be well recognized that the management and maintenance of the system after its completion will determine the success or failure of the project.

7) Efforts should be made to gather various kinds of observation data, which may serve as the basis for planning the project, in order to make this large scale project a success.

8) As a curtailment of the construction period is most essential to ensure the economic soundness of the project, consideration should be given to obtaining loans from international monetary institutions.

4-2 Town Planning

It has already been mentioned that the current survey in Colombo City and the surrounding area included a study on the project area from the standpoint of town planning in addition to studies on reclamation, drainage and land formation projects.

The points which must be given special attention in the future in relation to these studies and projects are described later. The points which should be given particular emphasis above all may be summarized as follows: (1) In planning the future of Colombo City and the surrounding area, it is essential that it be dealt with from a broad point of view as the capital city of the nation, instead of limiting the scope of the study to its administrative jurisdiction; (2) it is desirable to establish an executive organ directly under the Prime Minister to assume the responsibility for controling development projects and construction in these areas; and (3) the Board, which is responsible for planning projects and implementing the work, should not be confined to reclamation in its activity but should be given expanded functions so that it may also be able to participate in the comprehensive town planning project and give positive cooperation in solving the problem of "Shanties" which is expected to become a serious issue in the future. The following is an outline of the recommendations made by the survey team.

(1) In order to make the area a place conductive for healthy and affluent living standards, a basic plan for the Greater Colombo Region, most suited to the natural features of Ceylon, and plans for its implementation must be formulated as soon as possible. For that purpose, it is essential to determine the framework of the project, including housing construction,

improvement of transport facilities and the preservation of park areas, and to consider the establishment of an executive organ equipped with co-ordinating functions directly under the Prime Minister. It is also important to establish clear-out lines to determine the role and function of land re-claimed by the Board in the Greater Colombo Metropolitan Area Project.

(2) As the establishment of good residential districts cannot be accomplished only through reclamation work in the Board, it is desireable to carry out land readjustment in the surrounding areas, including districts where shanties exist, in order to create a community with good environment (Nawala Heen Ela for example). This will make it possible eliminate existing and to establish better neighbourhoods as the nucleus in the re-construction of the capital city.

The development of surrounding area, including the districts where shanties exist, serves the double purpose of eliminating slums and improving the environment in the reclaimed land. Furhtermore it is felt that the time is opportune for the redevelopment of urban area. It is earnestly hoped, therefore, that the matter is dealt with in a manner which will leave no source of trouble for the future.

It is also recommended that plans for the establishment of an industrial complex along with the residential district be adopted so that the residents in the project area may be provided with housing as well as employment opportunities.

(3) For the planning of a feasible and reasonable town planning project, many basic data on such items as population, present state of land use, transport facilities, traffic volume, origin and destination survey, industrial activities and economic statistics are indispensable. At present, however, such data is not sufficiently available and it is essential that efforts be made to gather necessary data and materials and make required surveys.

(4) In order to solve the traffic problem in CBD, it is recommended that such measures as the enforcement of one-way traffic, prohibiting of traffic control, establishment of off-street parking facilities, redevelopment of delinquent districts, relocation of government and public buildings, alteration of design and improvement of facilities for the bus terminal in front of Fort Station and reorganization of bus service network be taken.

(5) It is advisable that necessary studies be made on the feasibility of delegating more extensive and powerful authority to the Board in order to entrust to the responsibility for public undertakings as well as land readjustment in the reclaimed land and the surrounding area. It is particularly important to assign the Board the responsibility for providing public housing for small and medium income classes in the area so that it will be enabled to play a greater role in the city facility improvement project and, at the same time, to adopt a forward looking attitude in studying the advisability of granting subsidies. For this purpose, it will be necessary to revise the provisions of Act No. 15 of 1968 and related regulations and to reorganize and expand the structure of the Board.

(6) It is understandable that the acquisition of working funds for the Board, particularly the required foreign currency, will be extremely difficult

in the face of the acute financial situation of the nation and continued deficits in the trade balance. It is strongly hoped, however, that the Government will utmost effort to secure the necessary funds for the Board which is charged with the urgent task of solving a serious housing problem and a chronic unemployment problem brought about by the intensified concentration of population in Colombo City. Since the acquisition of foreign currencies depends on foreign aids, it will be necessary for the Government to seek the source of required foreign currencies in the World Bank or the Asian Bank, through bilateral aid programs, or importing necessary machinery and equipment through aid in goods.

On the other hand, it is also important for the parties concerned to make every efforts to save foreign currencies through originality and ingenuity in the selection of the construction method and materials and the introduction of new construction techniques and materials. Therefore, it is desirable that efforts be made for the establishment and promotion of domestic industry.

(7) As for the project assigned to the Board, it is essential to avoid a sudden expansion but to make a gradual expansion of the work so as to facilitate the acquisition of required capital and engineers. While energitic and capable high-class engineers are available in the field of reclamation and town planning, there is a shortage of lower-class engineers. It is desirable, therefore, to give special consideration to the training of many lower-class engineers.

For the efficient implementation of the project, the personnel assigned to the Board should be kept to a minimum as practically as possible to increase the productivity of each employee. At the same time, flexible measures should be taken in the employment of personnel, short-term transfer of personnel from other agencies should be avoided and salaries for the staff should be better than government employees.

(8) It is essential for the Board to formulate a 3 - 5 year program to increase the number of personnel, expand the organization of the Board and for fund-raising.

As for the implementation of the project, it is desirable for the Board to set up regulations for accounting and contracting procedures; establish standards for compensation for land and buildings and a guideline for computing of compensation; and prepare standard designs for structures, standard work specifications, construction management and supervision manuals, so that the project may be handled efficiently and smoothly in a business-like manner.

PART II LAND RECLAMATION SCHEME

CHAPTER 1. SOCIAL AND ECONOMIC BACKGROUND OF THE PROJECT

The City of Colombo is the center of commercial, industrial and trading activities in Ceylon both domestically and internationally, and this state has been brought mainly by the concentration of the population in this city. The population of Ceylon has more than doubled, over the last 50 years and is still increasing steadily at a rapid rate. Under the circumstances, the government housing policy has become the center of public attention as an urgent issue of the day. The problem of housing shortage in Ceylon is so important that it must be solved by the government. The Special Housing Committee estimated the number of housings required to accommodate the increased portion of the population during a 1962~1972 period at nearly one million. A target of 1 million new houses may appear to be small as compared with the housing requirement of some of large countries but it must be acquired that the target has a major significance for Ceylon with a population of only 11 million. In the figure of one million in shortage of housing about one-third is in the urban and the balance in the rural areas. In Colombo there are about 70,000 Shanties within and around the area administrated by the Municipal Council. Some of these Shanties are in low-lying areas and are exposed to flooding during wet weather. Consequently, when these Shanties suffer from the damage of flood, the government is burned with the responsibility for the relief of residents living in Shanties. The key to the solution of this urgent problem is the acquisition of land for housing construction. Fortunately, many tracts of land totaling about 2,500 acres within and around Colombo, are remained abandoned under permanently water logged or without being provided with adequate draining facilities. The problem of a shortage of land for housing construction, therefore, will be solved readily by the reclamation of these abandoned lands.

In addition to the land shortage, the City of Colombo and its outlying area being situated in flat land of low elevation, coupled with inadequate drainage facilities, suffer from deteriorated environments with the approach of the rainy season. It is evident, therefore, that this project is entrusted with two important missions, namely, the land reclamation to solve a housing problem and the improvement of drainage system to create better city environments.

CHAPTER 2. ANTICIPATED BENEFITS

2-1 Estimated Acreage of Reclaimed Land Upon Completion of the Project

The total area of the marshes covered by the reclamation project is as follows:

Project area	Total area of marshes (ac.)
Mutwal	142
Urugodawatta	400
Gothatuwa	707
Kotte	606
Heen-Ela	493
Total	2,383 ac.

Of this, approximately 500-acre is expected to be used for drainage canals and flood detention lake and the balanced area is estimated at about 1,900 acres.

2-2 Economic Effect Resulting from the Improvement of Drainage System

Though the main purpose of this project is to reclaim the marshes, which remain abandoned, the project also has an important bearing on the comprhensive drainage improvement plan in and around the City of Colombo. When viewed from a different angle, it may even be said that the main object of the project is the improvement of drainage system in the Colombo Region and that reclaimed land is only a by-product of the drainage work.

Recently, the efficiency of drainage system in the Colombo Region, particularly capacity of the drainage canals has been so decreased that even the developed city area suffers from inundation by a heavy rainfall and this fact seems to be a major obstacle to the improvement of city life. The drainage system reorganized systematically by the project is expected to make a great contribution to the improvement of the city environments of the entire Colombo Region. This benefit, together with the direct benefit derived from land reclamation under the project, should be highly evaluated.

2-3 Evaluation of Anticipated Benefit

The direct benefit derived from the project is the revenue from sale of reclaimed land. The area of land available for sale is estimated at about 1,400 acres after deducting 25% from the total area of reclaimed land for roads and other public service utilities. Assuming that the average unit price is Rs. 400,000 per acre the direct revenues amounting to about Rs. 560,000,000 may be expected. Though it is extremely difficult to make an accurate estimate on the indirect benefit such as the decrease in damage caused by flood and the reduction in the expenditure for flood relief work, due to lack of data, the total loss due to flood is estimated at Rs. 2,000,000~ Rs. 7,000,000 annually judging from "the expenditure for flood relief work" in the past.

CHAPTER 3. EXISTING CONDITION OF PROJECT AREA

3-1 Location

The City of Colombo is located on the west coast of Ceylon and the project area including the city and its surroundings occupies southern side of the delta formed by the Kelani Ganga, the second largest river in Ceylon.

3-2 Project Area

The project covers a total area of 36.5 sq. miles, extending from the left bank of the Kelani Ganga toward the south. The north end of the project area is Mutuwal which is included in the City area of Colombo and from there such vast marshes as Urugodawatta, Gothatuwa, Kotte and Heen-Ela extend to the south. The south of the project area is bordered by Wellawatta and Kirillapone canals. These marshes extend from north to south almost in a belt-shape and on the west and east sides of this stretch, High Level Area and Madiwela Catchment, designated as indirect area in the project, and located respectively.

3-3 Topography and Weather Conditions

The majority of marshes covered by the reclamation project are flat and low-lying and the mean elevation of these marshes is estimated about 0. MSL. Even the land located on an elevation ranging from 0. MSL to 6. MSL is inundated during flood due to inadequate capacity of drainage facilities and left abandoned without being developed. In the area where the elevation is above 6. MSL, particularly the High Level Area on the west side of the project area, development of land for housing is now in progress. In the vast Madiwela Catchment stretching out in southeast of the project area, the flat land is being utilized as rice paddies and the hilly area is being developed as estates for coconut plantation.

The entire project area is under the influence of the tropical climate and the monthly or seasonal fluctuation of atmospheric temperature is in the range of 70°~90°F at the most and the mean annual precipitation is 86 inch. As for the distribution of rainfall, about 56% of annual rainfall concentrate in an April ~ May period and in an October~ November period. Consequently, the dry season and the rainy season come alternately twice a year, but there seem to be a slight change in the start of the season depending on the year.

3-4 Present System of Drainage

The surface drainage system of Colombo and its immediate neighbourhood is mainly effected through the Dutch Canals between Kelani Ganga and Weras Ganga. These are a part of the system of Canals constructed by the Dutch for the purpose of inland transport and navigation.

The Dutch canal system from Kelani Ganga down to Weras Ganga has been renamed into different sections for the convenience in reconditioning and maintenance. Please see the drawing No. 2.

San Sebastian Canal starts from Kelani Ganga near Grand Pass and joins up with Beira Lake which is being maintained at +6MSL by the Port Commission.

The locks at San Sebastian Hill have been provided for this difference in water level. However at present there is no traffic in the Canal which requires

the services of this lock. The canal is named as San Sebastian Canal North and San Sebastian Canal South.

A short distance to the south of Stace Road bridge San Sebastian canal branches off and flows in a southerly direction. The start of this branch is named Urugodawatte. Starting from Urugodawatte the southerly direction of flow is maintained through Dematagoda Canal North, Demetagoda Canal South, Kolonnawa Canal North, Kolonnawa Canal South, Kotte Canal, Kirillapone Canal, Dehiwela Canal North and South and Bolgoda Canal. Bolgoda Canal at the southern end terminates by joining Weras Ganga. Weras Ganga joins Bolgoda Lake and finally flows into the sea at Panadura through Panadura Ganga.

At the end of Kirillapone Canal Wellawatte Canal connects the Dutch Canal with the sea at Wellawatte. The groynes at Wellawatte Canal outlet helps to keep this outlet open for most part of the year and is really the most effective and useful drainage outlet for the entire area. At the end of Dehiwela Canal South the Dutch Canal is again connected to the sea by Dehiwela Canal. However the sea outlet of this canal is always blocked by a sand bar except at times of heavy floods. Therefore the usefulness of this outlet is very limited at present.

At Prince of Wales Avenue there is a culvert which connects San Sebastian Canal North with Mutwal marshes lying between Prince of Wales Avenue and Blomendhl Road. At this point Mutwal Main Drain starts and flows in a northerly direction up to Alutmawatte Road where it joins the Mutwal Tunnel. Mutwal Tunnel is a 6' diameter concrete lined tunnel going under the Rock House Battery Hill and falling into the sea between the Colombo Harbour North Jetty and Fisheries Harbour South Jetty. The opening into the sea is exposed to the full force of the sea and is very often blocked by a sand bank. Therefore the effectiveness of this outlet too is limited.

Before the construction of the Fisheries Harbour the tunnel ended up at a point which is at present inside the Fisheries Harbour. When this harbour was constructed the outlet was closed and the exit deviated to join the sea at the present position. It is know that the original outlet of the tunnel was not blocked by a sand bar and at the time the tunnel functioned better than at present.

Mahawatte Canal is a secondary drainage canal starting near the Ayurvedic Hospital and flowing in a northerly direction to join Dematagoda Canal South near Wanathamulla. A short distance above this confluence a canal draining Maradana and Wanathamulla area joins this canal.

Heen Ela starts opposite the Ayurvedic Hospital to the South of Cotta Road and flows in a southerly direction to join Kirillapone Canal at Nawala.

3-5 Drainage Outlets

From the foregoing information it is seen that the drainage outlets of the Colombo catchment are as follows:

(a) Mutwal Tunnel
(b) San Sebastian Canal North
(c) Wellawatte Canal
(d) Dehiwela Canal
(e) Panadura Ganga

3-5-1 Mutwal Tunnel

This is the only outlet draining the northern area to the sea. At times of floods in Kelani Ganga when North Lock is closed, this outlet helps the drainage water in Mutwal marsh to escape into the sea. However, the tunnel is only 6 feet in diameter and the amount of water that can flow through is very small. Further the sand bar at the outlet end too, is an obstruction to the efficient functioning of the tunnel.

The culverts at Blomendahl Road, railway line and Alutmawatte Road are small and constitute a restriction. The people living on the canal banks use the canal as a refuse dump. Due to these reasons this canal and tunnel do not function efficiently.

Therefore it is evident that the usefulness of this outlet is very limited. However at times of flood when north lock is closed this outlet does give a certain measure of relief at least to the area around the Mutwal marsh.

3-5-2 San Sebastian Canal North

San Sebastian Canal drains into Kelani Ganga through the North Lock. During the period when Kelani Ganga is low the North Lock gates are kept open and water in San Sebastian Canal drains into the river. It is usual that at such times the amount of dry weather drainage water in San Sebastian Canal is small and there is no problem of draining the low lying areas. But when it rains in the Colombo catchment drainage through the North Lock is inadequate. The situation becomes even worse as there is generally a rise in the Kelani Ganga, consequent to side spread rainfall in the river catchment itself. The catchment of Kelani Ganga and that of Colombo are both in the western Wet Zone area of Ceylon and is exposed to the same monsoonal rainfall. When the level of Kelani Ganga rises above the water level in the canal the lock gates have to be closed to prevent the backflow of Kelani water into the protected area. At such times this canal ceases to function as a drainage outlet, which is really the most important stage. It is therefore seen that this outlet is useful only as a dry weather outlet and not as a flood outlet. Hence its usefulness is very limited.

3-5-3 Wellawatte Canal

This canal is on the southern side of the city and functions throughout the year. The outlet is protected by two jetties which prevent the formation of the sandbar and thus helps to keep the canal mouth open to the sea. At times of extended drought this mouth gets blocked by a low sand bar for a short time, but does not create a flood hazard as it usually breaks out by the time the water level in Wellawatte Canal rises to about +3MSL.

At times of flood in the catchment this is the most effective outlet and caters for about 90% of the volume of flood discharge. The SWE structure at Havelock Town is a minor obstruction to the free flow.

3-5-4 Dehiwela Canal

This outlet does not function at all at normal times since the canal mouth is totally blocked by a sand bar. However at times of heavy floods when the water level in the canal rised over the sand bar the outlet opens and starts functioning. At such time a great deal of water escapes this way and its effect is felt up to the start of Dehiwela Canal North in the northern reach. The canal

itself is very wide and the volume of discharge is considerable. The effectiveness of this outlet is limited only to the period of heavy floods.

3-5-5 Panadura Ganga and Bolgoda Basin Outlets

Panadura Ganga joins the sea at Panadura. This is the only effective drainage outlet for the entire Bolgoda Basin which is 158 sq. miles in area. The distance of this outlet from the city along the water way is about 20 miles and therefore does not form an efficient direct outlet for drainage of the city area. The large area under Bolgoda Lake is an effective flood detention for the run off in Dehiwela, Ratmalana. Attidiya and Borelesgamuwa Areas, which escape into the sea via Panadura Outlet. This eases the situation in the Colombo Area during periods of widespread rainfall in these sectors.

At present this outlet is not protected from sand bar formation and at certain times of the year when the flow in Panadura Ganga is very low the mouth gets blocked by a sand bar either partially or completely depending on the duration of the dry weather period.

It is proposed that the Panadura Ganga sea outlet should be protected by the construction of jetties to prevent the formation of the sand bar.

Talpitiya Outlet is the closest outlet for Bolgoda Lake South. But this is permanently closed by a high sand bar. If this outlet is also protected with jetties it will no doubt serve as an additional flood outlet for the Bolgoda Basins, but will tend to negative the efficiency of the works proposed to arrest sand bar formation at the Panadura Outlet.

3-6 Location of Marshes

3-6-1 Mutwal Marsh

The marsh in Mutwal Area is between Prince of Wales Avenue, Blomendahl Road and Madampitiya Road. The railway line from Kolonnawa to the Harbour passes through this marsh and divides it in the middle. The section to the north of the railway line is known as Kimbulawala and is lower than the rest of the marsh. At present this marsh is completely abandoned except for small sections on the periphery where grass is grown.

The marsh to the south of the railway line is larger and is grown with grass in most parts. A small area close to Blomendahl Road is being cultivated with vegetables. Certain sections along the boundary of this marsh are being filled up for building purposes. In fact Sugathadasa Stadium and a part of the surrounding built-up area is standing on land reclaimed from this marsh by filling largely with municipal refuse and finished with a blanket of earth.

The total extent covered by this marsh is about 177 acres.

3-6-2 Urugodawatte Marsh

This consists of the entire area of low-lying lands to the south of the Kelani Ganga flood protection bund at Sedawatta and extending up to Skinners Road in a S. W. direction and up to the railway main line in a S. E. direction. The approach roads to the new Kelani Bridge have gone through this marsh and have divided it into a number of segments.

The area on the right bank of San Sebastian North and just to the south of the lock is about 40 acres in extent. A part of this marsh near the south abutment of New Kelani Bridge has been utilized by the Electrical Department to construct the new "Kelani Tissa" Thermal Power Station. The rest of the marsh is cultivated with vegetables (Keera) and grass.

The marsh to the south of this area and on the R. B. of San Sebastian Canal is also about 40 acres in extent. A small part of this area is filled up and buildings have been put up. The balance is all vegetable land. The low-lying area to the L. B. of the canal is being filled up at present and a small area is still under vegetable cultivation.

The area to the east of the Kelani approach road -- Base line road extension -- and to the north of Ratnapura Low Level Road is mostly abandoned land. An area adjacent to the approach road has been filled up for the Forest Department timber depot. A narrow strip along the Low Level Road is built up with dwelling houses.

The section to the south of the Low Level Road extending up to Urugodawatte Canal is cultivated with vegetables and grass. The narrow strip bordering the road is built up.

The Maligawatte Section of marsh is the largest block of marsh and Maligawatte Housing Scheme is situated in a section of this area near Base Line Road. The temporary houses in the low areas are built on wooden piles, and the floor kept well above the surrounding gardens, most of which are at present exposed to flooding during very wet weather.

The greater part of this land still remains an abandoned marsh.

The total area of the marsh is about 200 acres.

3-6-3 Dematagoda Marsh

South of the railway bridge there is a comparatively small extent of marsh on either side of Dematagoda Canal. About half the extent is cultivated with vegetables and the balance is grass. This marsh extends up to Dematagoda Bridge in a thin strip along the canal banks.

From this bridge up to the south lock the canal passes through a heavyly built-up area, and the banks are high.

3-6-4 Gothatuwa Marsh

Gothatuwa Marsh starts at south lock and extends southwards up to Welikada-Kalapaluwawa Road Bridge along the canal banks and up to Cotta Road along the banks of Mahawatte Canal. This is the largest extent of marsh and is completely water-logged almost throughout the year. A large part of the area is abandoned while along the periphery grass is grown in a comparatively small area.

The total extent is about 700 acres.

3-6-5 Kotte Marsh

This marsh starts below Gothatuwa Marsh at Welikada-Kalapaluwawa

Road Bridge and extends along the banks of Kotte Canal and Kirillapone Canal upto the confluence of Dehiwela Canal and Wellawatte Canal. The area in the upper reaches is almost abandoned but the banks of Kirillapone Canal are cultivated with grass and vegetables.

The total area is about 600 acres.

3-6-6 Heen Ela Marsh

This marsh is isolated by Narahenpita Road in the west, Cotta Road on the North Welikada-Nugegoda Road in the east and Narahenpita-Nawala Road on the south. The total area is about 500 acres. Practically the whole area is abandoned. Towards the lower reaches grass is grown and there are also small patches of vegetable gardens. Drainage water from Bullers Road and Jawatte Area gets into this marsh before escaping into Kirillapone Canal.

3-7 Present Position of the Drainage Canals

The existing system of drainage canals is shown in drawing No. 2.

The Dutch Canal from Kelani Ganga to Weras Ganga was under the care of the P.W.D. upto September, 1964. Thereafter the canal was taken over for maintenance by the Irrigation Department. An investigation at the stage revealed that the canal was in a very poor condition. A survey conducted by the Survey Department testified to the extensive silting that had taken place. In many places the canal had been obliterated.

Since the taking over of the canal by this department, action was taken to commence reconditioning, as a first and necessary step in arresting the flood situation that was going from bad to worse in and around the city.

The deepening of the canals had to be done mostly by machinery as manual labour would not and often could not satisfactorily do the job. Since the department had no floating dredgers, two dragline excavators were deployed for this work.

The possibility of working with these machines is very limited since the canal banks in most places are marshy. In the few places where the canal passes through hard ground there are either permanent houses or shanties of squatters built right upto the edge of the canal bank. Thus in most places it is impossible for the machines even to approach the canal banks.

In some places, such as a part of Urugodawatte Canal and San Sebastian Canal North and South, the excavators were utilized after making roads on the banks. In marshy sections wooden rafts were used for the machines to work on. Even in this way it was not possible to deepen the full width of the canal as the booms on the machines were not long enough to reach the further bank.

However, a fair amount of work was done in this manner and its benefit was seen during the recent floods. In October, 1964, an old dredger was re-conditioned and handed over to this department by the P.W.D. This machine was used to deepen the canal section from Base Line Road Bridge downwards.

Towards the end of 1965 a dredger received by L.D.D. as a gift from Netherlands was handed over to this department. This dredger had to undergo a number of repairs right from the start. It has therefore not been able to do

much useful work. But it is expected that this will prove to be useful to deepen the San Sebastian Canal, once the necessary repairs, etc., are completed.

Given below is a detail account of the condition of the canals.

3-8 Dutch Canal System
(Taken over by the I. D. from the P. W. D.)

3-8-1 San Sebastian Canal North

This canal starts from Kelani Ganga near Sedwatte and extends upto Maligawatte. The total length is 1 mile. 10 chains and the canal is about 50 feet.

Sadawatte Bridge crosses the canal near the northern end while Stace Road Bridge is near the southern end. North Lock is also located on this canal and is nearer to the former bridge. The two bridges mentioned do not obstruct the flow in the canal to any appreciable extent. There is sufficient clearance under the bridges for a dredger to pass through.

The width of the North Lock is 16 feet. The gates on North Lock are used to regulate the direction of flow in the canal. At times of floods in Kelani Ganga these gates are closed to prevent the back flow the Kelani water getting into the canal and flooding the low-lying areas on the canal banks.

3-8-2 San Sebastian Canal South

This canal extends from Maligawatte upto San Sebastian Lock near Beira Lake. The total length is 1 m. 15 chs. and the area draining into it is about 610 acres. Starting from Maligawatte and this canal has been deepened with dragline excavators upto the Skinner's Road Bridge. Even here it was not possible to deepen the full width of the canal since the excavator boom was not long enough to reach the further bank of the canal. However the work done so far has greatly improved the drainage of the locality. The section of the canal from Skinner's Road Bridge upto San Sebastian Locks is passing through a heavily built-up area and buildings have come right upto the edge of the canal.

The canal sections from Maligawatte upto Skinner's Road Bridge is passing through a low-lying area but the canal banks are stable due to the concrete rivetments already constructed.

3-8-3 Urugodawatte Canal

The length of this section of Dutch Canal is 40 chains and the area drained directly into the canal is about 210 acres. The canal starts off from San Sebastian Canal at Maligawatta and ends up at railway bridge on the main line. A part of the canal to the west of Baseline Road Bridge has been deepened with the excavator while the balance has been deepened with the dredger taken over from the P.W.D. The work in this section of the canal is complete. The Baseline Road Bridge across the canal does not restrict the flow of water. But the clearance from the normal water level upto the underside of the bridge deck is very small and it is not possible for a dredger to go under this bridge. This is a disadvantage. The canal banks on marshy areas have been protected with bamboo rivetments.

3-8-4 Dematagoda Canal North

The length of this section is 43 chains and the total area draining into the canal is about 300 acres. The average width of the canal is about 70 feet and is passing through grass and vegetable lands. The banks are comparatively stable and in less stable sections bamboo revetment have been constructed.

The deepening of the canal was done with the dredger. For the present only half the width of the canal was deepened. A section of the canal about 10 chs. long and adjacent to the Stanley Power Station was left undone since we were informed that live electric cables go across the canal in this section. Therefore mechanical dredging is very dangerous and hence not resorted to in this section of canal.

3-8-5 Dematagoda Canal South

The length of this canal is about 38 chains and the area draining directly into the canal is about 200 acres. The section of canal is from Kolonnawa Road Bridge upto its confluence with Mahawatte Canal.

The average width of the canal is about 60 feet from Kolonnawa Road Bridge upto the south lock and is passing through a heavily built up area on the western bank and the oil installations on the eastern bank. The banks are sufficiently firm.

The width of the lock is 16 feet and the sill is at -4MSL.

The section of canal from the south lock upto the confluence with Mahawatte Canal is passing through low-lying marsh. The width of the canal is not quite defined.

3-8-6 Kolonnawa Ela North and South

The total length of this section is 3m. 30 chs. and the area drained direct is about 140 acres. The canal is passing through Gothatuwa Marsh and at present the entire area is covered with grass and other weeds which forms a thick floating mass. In certain sections it is so thick that a man could walk on this flexible mat of grass.

A water pipe going from Obeysekera Town to Kolonnawa crosses the canal about 30 chains above Mahawatte confluence. This pipe is about 2 feet above the normal water level and the dredger can come only upto this point. For the dredger to go cross this obstacle either the pipe line or the dredger will have to be dismantled. The road way formed along the trace of the pipe line is an obstruction to the free flow of water and no doubt contributes to the heading up of water in the area.

No work has been done so far in this section of the canal.

3-8-7 Kotte Canal

This canal is 2 miles long and has an area about 1,400 acres draining directly into the canal. In addition the drainage water from 19 sq. mls. of catchment in Madiwela and Battaramulla also comes into this.

The canal trace from the Welikada-Kalapaluwawa Road Bridge upto about 10 chains is completely covered with a thick grass mat, similar to the Gothatuwa Marsh. From there onwards, i.e., from the point where Madiwela Canal joins, the canal trace is fairly clear. The average width of canal is about 50 feet upto about 60 chs. Then the canal enlarges to form Kotte Lake.

The entire length of the canal banks and the banks of Kotte Lake are in low-lying marshy lands lying abandoned. At present no work has been done on this section.

3-8-8 Kirillapone Canal

This canal starts where Kotte Canal ends and is so named upto the confluence of Wellawatte Canal and Dehiwela Canal. The total length is 1m. 37 chs. The area draining direct into the canal is about 800 acres.

The average width of the canal is about 70 feet and is in fairly good condition. The canal is deep with an average bed level of about -2 MSL.

The present condition of the canal may be due to the fact that this canal frequently discharges large volume of flood water and even the normal discharge is more than any other canal except Wellawatte Canal which is actually an extension of this canal to the sea.

The canal passes through low-lying land which consists mainly of grass fields and a few plots of vegetables. At Nawala, Heen Ela flows into this canal.

The banks are sufficiently stable.

3-8-9 Dehiwela Canal North and South

The total length of Dehiwela Canal North and South is 2 mls. and has an area of about 1,000 acres draining directly into the canal. The average width is about 40 feet and the canal banks are comparatively stable. About 50% of the length of canal banks have been provided with concrete revetments and retaining walls. At the time of take-over this canal was completely covered with water hyacinth and other weeds. The bed was heavily silted and the canal functioned only at times of flood. Close to Dehiwela Outlet near about Vihara Lane Bridge the canal is passing through an area with very steep banks. During heavy rains in the area these banks get scoured by the rain water and the silt comes into the canal.

The reconditioning of the canal was done by manual labour in certain sections and by machine in the other sections.

At present the canal is functioning satisfactorily.

3-8-10 Bolgoda Canal

Bolgoda Canal starts at the end of Dehiwela Canal South and extends upto Weras Ganga.

The section of canal from Dehiwela upto Nedimala is passing through high ground and the banks are about 8 feet high. The average width of canal is

about 40 feet and in certain section retaining walls have been constructed to protect the banks.

The balance section upto Weras Ganga passes through Attidiya Marsh. The average width is about 50 feet. The canal banks are stable and is provided with concrete revetments in most section.

The reconditioning of the canal was done in 1964 using dragline excavators in certain sections and manual labour in other sections.

The entire length is in fairly good condition and functions satisfactorily.

3-9 Other Canals

3-9-1 Mutwal Main Drain and Tunnel

This canal is draining an area of about 700 acres located north of Prince of Wales Avenue to the sea at Mutwal. The canal starts at Prince of Wales Avenue, and is connected to San Sebastian Canal North through a culvert consisting of 2 Nos. 6'ϕ pipes. The canal flows in a north-weterly direction and crosses Blomendahl Road, Harbour-Kolonnawa Railway Line and Alutmawata Road. About 6 chs. below Alutmawata Road culvert the canal joins the tunnel. This is a 6'ϕ concrete lined tunnel 1,920 feet long. The sill is at -5.0 MSL. The length of canal from Prince of Wales Avenue to Blomendahl Road passes through a very bad section of the marsh and the maintenance of the canal is a problem. The canal banks are being stabilized with bamboo revetments, inspite of which grass grows into the canal and covers the surface. Water hyacinth grows very rapidly and removal of this pest is very expensive and laborious.

The canal from Blomendahl Road upto the tunnel is passing through thickly populated areas. Particularly, the section from Alutmawata Road upto the tunnel is crowded with shanties of either side. The banks on this section were protected with bamboo revetments. But they have all been removed for firewood by people of the area.

In addition these people use the canal as the dumping ground for their domestic and personal refuse. The maintenance of this canal, particularly the end section, which is the most important, presents a problem in deriving the maximum benefit of the tunnel outlet for drainage at present.

3-9-2 Mahawatte Canal

This canal starts near the Ayurvedic Hospital and flows in a northerly direction to join the Dutch Canal near Wanathamulla. The total length of the canal is 1m. 31 chs. This canal was completely covered with grass and water weeds and now it has been fully reconditioned. In certain sections of the canal where the banks were unstable bamboo revetments have been constructed. Here too the shanty dwellers in the vicinity remove these for firewood, and this prevents the satisfactory consolidation of the newly formed banks to give the channel a permanent shape and form.

Water hyacinth was removed from the canal a number of times but again and again it grows to cover the entire surface, the removal of the revetments is aggravating the situation.

Three timber foot-bridges were constructed to replace the 'edandas' which were an obstruction to drainage. Light vehicular traffic now passes over these bridges.

The entire trace is passing through a very marshy land and the rate of siltation cannot be checked to a reasonable degree, unless bank revetments remain in position.

3-9-3 Heen Ela

Heen Ela too starts near the Ayurvedic Hospital but on the opposite side of Cotta Road and flows in a southerly direction to join the Dutch Canal at Nawala. Earlier Heen Ela and Mahawatte Canals were connected near the Ayurvedic Hospital by a culvert across Cotta Road. But now this culvert has been removed and the two canals function separately.

The total length of Heen Ela is 2 miles. A drainage canal draining Torrington Avenue area joins Heen Ela near Manning Town.

The entire canal runs through swampy ground and therefore the maintenance is a problem. The banks are very soft and therefore bomboo revetments have been constructed. It is not possible to walk on the banks, the only convenient approach is to go in the canal itself by boat.

The canal was deepened and reconditioned and at present it is functioning satisfactorily.

3-9-4 Wellawatte Canal

This is the outlet canal joining the Dutch Canal with the sea at Wellawatte, and is the only outlet which functions satisfactorily at times of floods.

The sea outlet is protected with groynes to prevent the formation of a sand bar. Therefore the river mouth is open about throughout the year except when there is a severe drought.

The canal is passing through a residential area and the canal banks are high and steep. In certain sections the bank is not very stable and has started scouring.

3-9-5 Dehiwela Canal

This canal joins the Dutch Canal to the sea at Dehiwela. The total length of the canal is 20 chains and the average width is about 80 feet. This canal does not function at all during normal time, since the mouth is blocked by a big sand bar. At times of heavy rain and floods the sand bar opens or is cut and the flood water gushes out. But as the discharge reduces the sand bar forms again to close the canal mouth.

At present the usefulness of this canal is very limited.

3-10 Catchment Area

The catchment area affecting the drainage of the city can be broadly divided into 4 segments. Please see the drawing No. 1.

(a) Madiwela Catchment
(b) Colombo North Catchment
(c) Colombo South Catchment
(d) High Level Catchment

3-10-1 Madiwela Catchment

This catchment is by comparison the largest and covers an extent of 19 sq. miles. The entire catchment lies outside the City of Colombo. The shape is fairly regular and has a maximum length of about 6-1/2 mls. and a maximum width of about 3-1/2 mls.

The upper reaches of this catchment extend upto Pannipitiya and Kootawa. The western ridge of the catchment runs close to the main road from Welikada to Nawinna via Kotte, Mirihana and Udahamulla. The southern boundary runs close to High Level Road from Nawinna to Kootawa. The eastern boundary is on the ridge passing through Kottawa, Mirihana, Hokandara North and Talangama North. The northern boundary is along the road from Welikade to Kalapaluwawa and the Kalapaluwawa Ridge.

The catchment is highly developed. The highlands are mainly cultivated with coconut and rubber. The low-lying areas adjoining the streams draining the area are cultivated with paddy. Towards the lower reaches near Etul Kotte and Battaramulla the lands are to marshy for cultivation and hence abandoned. Most of the time water stagnates here, the tidal effects along the Dutch Canal being one cause for this. The main catchment which lies to the south of Etul Kotte-Battaramulla Road flows through a P.W.D. Road Bridge 113 feet long and a culvert 12 feet long.

The catchment lying approximately between Welikada-Kalapaluwawa Road and Battaramulla Road drains along a canal flowing in a westerly direction and joins the main stream down stream of the Battaramulla Bridge.

The main drainage stream joins the Dutch Canal at a point between Welikada-Kalapaluwawa Road Bridge and Etul Kotte Bridge.

3-10-2 Colombo North Catchment

Cotta Road which runs from Borella to Welikada is on a low ridge which divides the catchment of Colombo. The segment to the north of this dividing line is referred to here as Colombo North Catchment and the segment to the south is referred to as Colombo South Catchment.

Colombo North Catchment extends from Cotta Road in the south upto Kelani Ganga flood protection bund in the north. The area of the catchment is 7.3 sq. miles. The average length is about 4 miles and about 2 miles wide. The entire catchment is heavily built up except the area coming within the marshes. The Dutch Canals and Mutwal Main Drain are the main drainage lines while Mahawatte Ela is a secondary channel draining into the Dutch Canal. The main drainage outlets are to the Kelani Ganga through North Lock, and to the sea at Mutwal through the tunnel.

3-10-3 Colombo South Catchment and High Level Catchment

The area extending south of Cotta Road upto Wellawatte is referred to

as Colombo South Catchment. The total area is 10.2 sq. miles. The entire area is heavily built up except for the marshes. The length of the catchment is about 3-1/2 miles and about 3 miles is the average width.

The main drainage canal is the Dutch Canal and Heen Ela is a secondary canal draining a part of the catchment and joining the main canal at Nawala. The main outlets to the sea are through Wellawatte and Dehiwela canals.

3-11 Drainage Pattern

The entire catchment area comprising of the four segments mentioned before is 36.5 sq. miles. The furthermost point of the catchment is near Kottawa. Normal dry weather flow is very small probably because the extent of land that is available for base flow is comparatively small.

A part of the low-lying catchment is a tidal estuary. The depth of water in the canals in Colombo Area and the ground water level in the surrounding low-lying land remained at or about M.S.L. even during long dry weather periods.

However during the rainy season the precipitation is fairly evenly distributed and practically the whole catchment gets rain. At such times the yield is high.

At times of intensive precipitation the entire flood flow from Madiwela Catchment gets collected in Madiwela Canal and discharges through the bridge on Battaramulla Roads. This flood discharge is one of the main factors contributing greatly to the inundation of the low-lying areas in Colombo.

The flood discharge from Madiwela comes into the Dutch Canal in the section between Kotte Bridge and the bridge on Welikada-Kalapaluwawa Road. A part of this water flows into Colombo North Catchment through the Welikada-Kalapaluwawa Road Bridge and inundates the entire Gothatuwa Marsh. Before the construction of Gothatuwa flood bund this water would have escaped into Kelani Ganga provided the water level in Kelani was sufficiently low, this of course, would have been very rare. As at present, Gothatuwa Marsh first gets inundated and then the flood starts flowing north along the Dutch Canal up to Kelani Ganga via San Sebastian Canal. In Gothatuwa Marsh there is not even a visible trace of canal. The entire canal and marsh is thickly overgrown with grass and other weeds. The flood water of Colombo North Catchment too would be added to the flood water from Madiwela and the entire flood discharge has to find its way into the Kelani Ganga through the North Lock. But usually at such times Kelani too is in flood and North Lock gates have to be closed. Therefore the flood water has no escape and consequently it starts building up and inundating the low-lying lands in Colombo North.

Mutwal Main Drain and tunnel cannot help very much to relieve the pressure of flood water in San Sebastian Canal since the conveyance capacity of the Main Drain and tunnel is inadequate to meet this situation.

With the consequent heading up of the water the greater part of the flood discharge from Madiwela turns south and flows through Kotte Bridge. The flood water flowing out through Kotte Bridge inundates Kotte Lake and the marshes in Kotte Area and comes into Wellawatte Canal via Kirillapone Canal. At Wellawatta Sea Outfall the flood water gets into the sea. During normal annual floods the water level in Wellawatte Canal near the Havelock Town Bridge comes upto about 4 MSL.

At times when Dehiwela Outlet is open a part of the water in Wellawatte Canal gets into Dehiwela Canal and flows out into the sea. But instances of Dehiwela Outlet being open are rare and therefore this is not the normal pattern.

According to the present pattern of flood drainage the extent of built up land that gets inundated in Colombo North Catchment is more than in Colombo South. As long as Kelani Ganga water level is high and North Lock is closed the main outlet for flood water is through Wellawatta. At such times the direction of flow is towards Wellawatta even as far as San Sebastian Canal North.

CHAPTER 4. SURVEYS, RECOMMENDATIONS AND CONSTRUCTION WORKS RELATED TO THE PROJECT IN THE PAST

4-1 Surveys and Recommendations Made in the Past

4-1-1 Kennedy-Kitching Recommendation

During 1930 the drinage problems in the Colombo Region have received considerable attention by the Ministry of Lands and the Irrigation Department and in 1937 Messrs. Kennedy and Kitching of the Department framed a final proposals on the subject. The main items of the reclamation scheme recommended are as follows.

i. To construct bunds and control sluices to divide the basin into separate areas

ii. To excavate a cut to link Kotte Lake with Kawaiwala

iii. To improve the existing canal extending from Kotte Lake to Wellawatta and Dehiwela

iv. To provide a lock at the north end of Kotte Lake and the other at the south end of Dehiwela

v. Improvements to Heen-Ela

4-1-2 Indian Consulting Engineers' Report (1939)

In addition to the Kennedy-Kitching recommendation, an Indian consultant recommended construction of a jetty at the Wellawatta Outlet to prevent closure of the estuary.

4-1-3 A Scheme Proposed by the Irrigation Department

This scheme, deviating from the agricultural drainage system of the past, was aimed at developing land for buildings. Under the plan a total of about 1,700 ac of marshes in Colombo, Kolonawa and Kotte was to be reclaimed by means of pumping drainage. The details of the scheme are described in Sessional Paper XXVI - 1961 "Technical Report on Reclamation of Swamps in and around the City of Colombo", and the outline of the scheme is as follows.

Through a complete diversion of the Madiwela Catch, the damage of floods to other basins may be lessened greatly. After diverting the Madiwela Catch into Weras Ganga, the drainage basin is to be divided into the following three drainage blocks.

(a) Mutuwal flanked by Prince of Wales Street and Aluthmawata Street

(b) Urgodawatta comprising Urgodawatta, Weragoda and Maligawatta marshes

(c) Gothatuwa, Kotte and Heen-Ela districts

The drainage of these isolated districts depends on pumping system. The existing canal is to be widened and dredged.

The capacity of pump and the detention reservoir is to be so designed that the high-water level at the rainfall of 200 year return period will be at 0.MSL.

(a) Diversion canal for Madiwela Catch

Bed width	100 ft.
Depth	8 ft.
Length	7 miles and 1,820 ft.
Estimated cost in 1966:	Rs. 4,000,000

(b) High Level Canal

Bed width	100 ft
Length	4 miles and 1,050 ft.
Reclaimed land	44 ac.
Estimated cost in 1966:	Rs. 3,750,000

(c) Mutuwal

Lakes and Waterways	37.7 ac.
Bed level	-12.0 MSL
Normal water level	-6.0 MSL
Flood detention area	22.1 ac.
Ground elevation	-40 MSL
Reclaimed land	117.0 ac.
Ground elevation	+4.0 MSL
High flood level	0.0 MSL
Capacity of pump	170 cusec
Estimated cost in 1966:	Rs. 5,500,000

(d) Urugodawatta

Lake and Waterways	29.6 ac.
Bed level	-12.0 MSL
Normal water level	-6.0 MSL
Flood detention area	49.0 ac.
Ground level	-4.0 MSL
Reclaimed area	310 ac.
Ground level	+4.0 MSL
High flood level	0.0 MSL
Capacity of pump	275 cusec
Estimated cost in 1966	Rs. 8,500,000

(e) Gothatuwa, Heen-Ela, Kotte

Lakes and Waterways	227 ac.
Bed level	-12.0 MSL
Normal	-6.0 MSL
Flood detention area	305 ac.
Ground level	-4.0 MSL
Reclaimed area	1,258 ac.
Ground level	+4 MSL
High flood level	0.0 MSL
Capacity of pump	600 cusec
Estimated cost in 1966:	Rs. 38,000,000

Total cost of the scheme in 1966: Rs. 60,000,000

Total area of reclamation: 1,700 ac.

4-2 Related Works and Survey Report

The related works and surveys implemented in the past for the prevention of of frequent flood disasters or for the improvement of drainage system in the Colombo Region are described below.

4-2-1 Kelani Ganga Flood Protection

The history behind the attempts made to reclaim these marshes commenced in 1926 with the construction of the flood protection bunds on the left bank of the Kelani Ganga. The land which remains today is also a portion of the vast extent which was exposed to the flood level of +13 MSL. The work has been playing a vital role in the prevention of floods of the Kelani Ganga, as well as in the promotion of land reclamation project for the Colombo District. The direct causes of inundation today are the runoff from the protected area itself and the poor elevation of the whole region. The indirect causes may be said to be an inadequate capacity of waterways and the closure of the drainage outlets.

4-2-2 Rock House Tunnel

In the course of the flood control work for the Kelani Ganga there was a requirement for an additional outlet to discharge run off water, particularly that in the North Colombo. To meet this requirement, a tunnel was excavated under Rock House in the district of Mutuwal.

4-2-3 Harbour Development Works

The construction of locks and spillway to maintain a water level of +6.0 MSL in the Beira was a major work in the development of the south-west lake to serve the additional requirements of the port even from early stage. The locks provided between Beira Lake and the port was only capable to let through the 45 ton class lighters then but now it is capable to let through the 80 ton class lighters. Though the locks provided between Beira Lake and San Sebastian Canal is capable to let through the 45 ton class lighters, the canal is not used, due to the canal being out of use for navigation. To maintain required water level of Beira Lake during the period of dry season, the port authorities operate a pumping unit installed at the lock.

4-2-4 Improvement of Wellawatta Outlet

Construction of a jetty was recommended by Kennedy-Kitching proposal to solve the problem of closure of the Wellawatta Outlet.

Based on this recommendation, studies and experiments on the prevention of sand-bar formation by means of a jetty were carried out in the Hydraulic Laboratory of the Department during the early 1940. Thereafter two jetties were constructed at the Wellawata Outfall. As a result, the problem of closure of the Wellawatta Outlet was solved and at present the outlet is capable to drain even to the water level of +2 MSL during post-flood period.

Besides, the demolition of the Have Lock Road Bridge and the installation of a regulator were implemented in compliance with the Kennedy-Kitching recommendltion.

CHAPTER 5. ENGINEERING ASPECTS AND TECHNICAL SOUNDNESS OF LAND RECLAMATION PROJECT

5-1 Presentation of Problems from the Technical Viewpoint

In consequence of the grass-root field investigation carried out for about one month during the period from March to April 1970, following technical problems for implementation of the project are brought up, based upon various proposals made in the past, the Technical Report prepared by Irrigation Department for the purpose of organizing the Reclamation Board and the scheme that Reclamation Board is now making up.

5-1-1 Reconsideration of Precipitation Return Period

According to the Report of Irrigation Department (hereinafter referred to as I.D. Report), 4-day consecutive rainfall with 200-year return period is to be adopted for the estimated design rainfall of the Project area. The return period of 200 years may not be excessive for the project proposed for mainly land reclamation and drainage improvement of urban area; however, return period of 50-year seems to be suitable for the project in consideration of the economic condition of Ceylon, urgency of the project due to lack of building site and the present status of development of the entire Colombo urban area. When a overall development scheme is implemented for Colombo City as the Metropolitan Region in the near future in accordance with economic growth of Ceylon, the return period of precipitation may be changed to about 200 years for implementation of such a scheme as urban drainage for Colombo Area including reclaimed land.

In short, the area reclaimed by the project should be maintained under similar condition during flood with the surrounding area ready developed. In the Madiwela catchment allowance for flood disaster is very much larger than that in the case of urban drainage area and furthermore a great amount of inundation is allowable. Therefore, the return period of about 15 years that is applied for agricultural drainage system of paddy fields in Japan is considered to be sufficient for the catchment.

5-1-2 Comparison of Drainage Systems from Comprehensive Viewpoint

Technical and economical soundness of the project shall be affected mostly by such factors as the way of isolation of marshes scattered in and around Colombo City and organization of drainage systems for flood. Accordingly, technically possible isolation of marshes and drainage systems must be assumed, their economical merits are relatively reviewed, and most rational drainage system must be decided from the viewpoints of technique, social economy and city planning.

5-1-3 Rational Scales of Drainage System

Main drainage facility of land reclamation project are drainage pump, flood detention lake, drainage canal and regulator. Scales of these facilities are in close correlation, and must be made so as to make the cost for land reclamation and development minimum. Therefore, it is necessary to estimate the costs for various combinations of different scales of facilities, to find out a most economical combination.

5-2 Design Criteria

Criteria and conditions for comparative study overall design are as follows:

i) Design rainfall -- * Areas for land reclamation and High Level --- 4-day consecutive rainfall with 50-year return period

* Madiwela area --- 4-day consecutive rainfall with 15-year return period

ii) Roughness coefficient --- n = 0.025

iii) Allowable maximum velocity of drainage canal --- v = 3.5 ft/sec.

iv) Allowable inundated water level in Madiwela catch. --- (+)7.0 MSL.

v) Subsidence ratio ------- - 15%

vi) Boundary of marshes ----- below (+) 6.0 MSL. of contour line

vii) Free board of flood detention lake and drainage canal shall be 2.0 ft. as standard.

viii) High water level in lakes and canals

* below 0 MSL by rainfall with 50-year return period

* below the proposed ground level (2.0 MSL) by rainfall with 100-year return period

* below 3.0 MSL, namely the proposed ground level (+2.0 MSL) plus 1.0 feet, by rainfall with 200-year return period

ix) Side slope of drainage canal ------ 1:1.0

5-3 Hydrological Analysis

5-3-1 Rainfall Analysis

The provability analysis of diurnal and 2-day, 3-day and 4-day consecutive rainfall were made on the basis of the rainfall data for the past sixty-nine years recorded by the Colombo Observatory, and their results are as follows.

Provability / Continuity	15 years	50 years	100 years	200 years
Diurnal rainfall	8.8"	10.9"	12.2"	13.5"
2-day consecutive rainfall	12.0	15.3	17.1	18.9
3-day consecutive rainfall	14.3	18.0	20.2	22.4
4-day consecutive rainfall	15.7	19.6	21.8	24.1

5-3-2 Determination of Design Rainfall Pattern

1. Consecutiveness of rainfall in the project area

The investigation into the frequency of rainfall consecutiveness in the recent five years in Colombo revealed that the rainfall of up to 4-day consecutiveness accounted 82% of the total rainfall. Also long consecutive rainfall is suitable as the design rainfall for such area as the low lying land where is, in general, inundated or water-logged for a long time. Based on the above points, the 4-day consecutive rainfall is to be adopted as the estimated design rainfall.

2. Return period and inundated water level

Considering that the objects of this project is the urban drainage and the land reclamation for building, the 50-year return period is to be adopted, and the planning is to be made so that, in the case of the 100-year return period high water level in the lake and canal can be kept within the free-board and the 200 year return period, to be inundated, 1 foot in depth over the proposed ground level.

In the Madiwela Catchment, as the greater part of low lying land is paddy field and the reclamation project for building will not be proposed, the objects may be attained adequately by applying the 15-year return period.

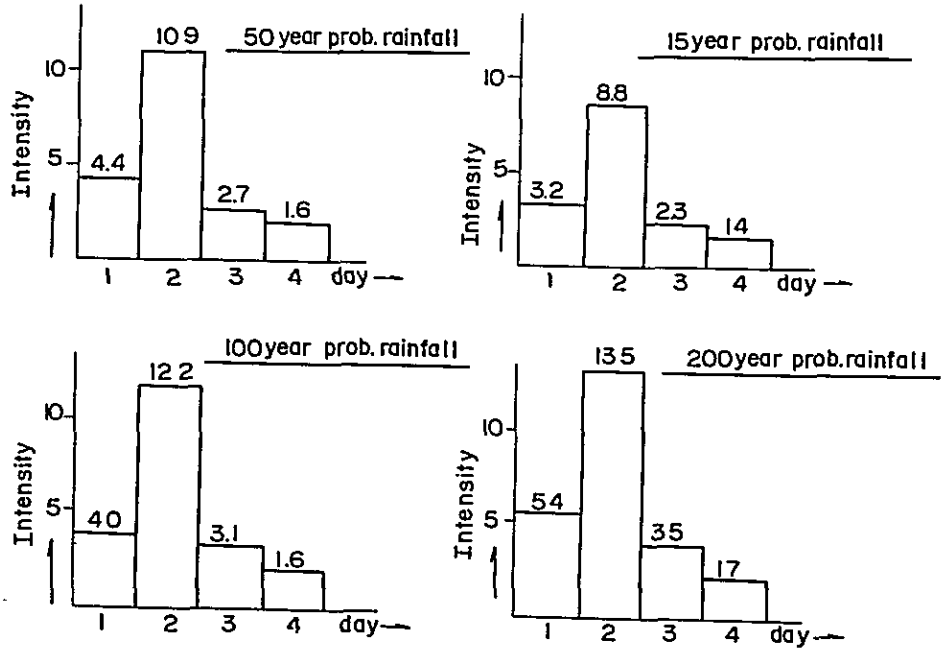
3. Day intensities

a) The 50-year probability diurnal rainfall is distributed to the second day.

b) The difference of 2-day consecutive and diurnal rainfalls with 50-year return period is distributed to the first day.

c) The difference of 3-day and 2-day consecutive rainfalls with 50-year return period is distributed to the third day.

d) The difference of 4-day and 3-day consecutive rainfalls with 50-year return period is distributed to the fourth day.



4. Hour rainfall intensity

The following empirical formula is used as the hour intensity formula.

$$Rt = R_{24}(t/24)^k$$

Rt : Maximum intensity during t, hours

R_{24}: Amount of 24-hour rainfall

k : Constant 0.3

(As the maximum hour intensity recorded by the Colombo Observatory in the past is 4.0 inches the constant k found by substituting t = 1 R_{24} = 10.9" is 0.3.)

The hour distribution was found by the above formula according to the diurnal rainfall distribution as determined in the preceding paragraph. The results are as shown in Fig. II-1.

5-3-3 Runoff Analysis

1. Lag time

Lag time is divided into two terms; namely, concentration time required for rainwater to run off the hill to the basin, and travel time required to flow through the drainage canal to the discharge point.

a) Concentration time

The following 2 empirical formulas were used for estimation of the concentration time, and approximately mean values were applied.

* $tp = Ct\,(L.Lc/s)^n$ where, n = 0.38

Ct = 0.72

L : small river mileage from the given station to the upstream limits of the drainage area

Lc: river mileage from the given station to Center of gravity of the drainage area

* $tc = C_2 L^x / \sigma^{y \cdot s^2}$

where, tc = the time of overland flow in min.

L = length of overland flow in ft.

= the supply rate of rainfall exess in in/min.

S = the slope of the surface in percentage

C, X, Y, Z = Coefficient which depend on surface materials, assumed 0.34, 0.298, 0.785, 0.302 respectively, on clipped sad.

b) Travel time

Travel time was calculated by assuming the mean velocity of flow through drainage canal during flood as 1.0 m/sec (or 3.28ft/sec) and measuring the length of canal trace from the topographic map.

Finally, the lag time was found out as the sum of concentration time and travel time.

The following Table shows lag time in the river basins:

Basin	lag time (in hour)
Mutuwal	1.48
Urugodawatta	1.80
Gothatuwa	1.94
Kotte	1.41
Heen Ela	1.28
High level	4.27
Madiwela	3.22

2) Runoff coefficient

Due to the complete lack of data on run off coefficient, it was assumed as 70% on the entire project area, by experience and from topography, condition of ground surface and geology.

3) Hydrograph

Run off was calculated according to Sato-Kikkawa's run off function method, mentioned hereunder.

$$q = 0.2778f \cdot r \cdot A \cdot \exp(t-1/T+1) - \exp(t/T+1)$$

where, q = discharge at an arbitrary time, t.

f = run off coefficient

r = rainfall intensity at an arbitrary time, t.

t = arbitrary time.

T: Lag time

A: catchment area

As rainfall distribution, lag time, run off coefficient and catchment area are already available, the run off at an arbitrary time can be calculated by substituting these data for the above-mentioned formula.

Actual calculation was conducted by applying a program about run off function method to a computer. Results of computation is given in Fig. II-2.

5-4 Comparative Study on Drainage System

According to the present topography, practice of drainage and the existing drainage system, Colombo Region can be roughly divided into two drainage blocks namely, Northern and Southern blocks.

North Colombo

This area is located north to the Colombo-Candy Railway Line and covers Mutwall and Urugodawatta Areas which are suitable for land reclamation. Flood water is drained mainly through North Lock to Kelani Ganga.

South Colombo

This is an extensive area including High Level Area developed for residential lots in the south of Colombo - Kandy Railway Line, Gothatuwa, Kotte and Heen Ela areas suitable for land reclamation and Madiwela Basin as an indirect basin for the project. Flood water in the drainage block is drained into the sea through Wellawatta outlet, Dehiwela Outlet and Weras Ganga.

5-4-1 Isolation of Land Reclamation Areas

Though, as shown in Drawing No. 1, there are many swamps suitable for land reclamation project in and around Colombo City, following 5 areas shall be subject to the project, according to Isolation of I.D. Report, except smaller areas.

* North Colombo
  - i) Mutwal
  - ii) Urugodawatta

* South Colombo
  - i) Gothatuwa
  - ii) Kotte
  - iii) Heen Ela

In the balanced area of the above two of Northern Colombo, flood water is drained direct to Beira Lake or Colombo Port. And, no construction work is required for particular embankment (Bund) or alteration of river basin (diversion) for the purpose of isolation of the said two areas as individual reclamation areas. Meanwhile, as for South Colombo, main construction works mentioned hereunder shall be required to isolate the above 3 areas as fully independent reclamation projects from the viewpoints of topography and the present drainage system.

The balanced area of the said 3 areas of Southern Colombo Area consists of the High Level Area already developed for residential lots along the western coast and Madiwela Basin developed as a vast paddy field in the east. In the High Level Area, high level canal shall be constructed to prevent run off water from flowing into reclamation area. Run off water from Madiwela catchment flows into the reclamation area these days; accordingly, a certain suitable measure, e.g. alteration of river basin (diversion), shall be required to prevent such inflow to reclamation areas.

For the purpose of isolating the said 5 areas as independent projects, following incidental works shall be indispensable:

a) construction of new high level canals
b) scheme for alteration of Madiwela Basin (or Madiwela Diversion scheme)

5-4-2 Comparative Proposal of Drainage System

1. North Colombo Area

This area is divided into 2 drainage blocks completely independent from the existing topography Ground level of both Mutuwal and Urugodawatta

is about 0 MSL. High water level of 12 MSL will be anticipated at Kelani Ganga. Accordingly, if a gravity drainage system is proposed in this area, the filling of marshes must be made up to at least (+)14. MSL, taking into account the head loss of drainage culvert and others. It is clear that this proposal is impossible.

Accordingly, pump drainage system must be applied to the both areas; two comparative proposals are under consideration; one is to drain both areas individually, and the other is to drain the 2 areas en block either in Urugodawatta area or Mutuwal area by combining the 2 areas with a connecting culvert under Prince of Wales Ave.

a) Individual pumping drainage
b) Combined " "

2. South Colombo Area

The most important for this area is how to determine the canal trace alteration or diversion of Madiwela catchment, which is a prerequisite for success in the 3 projects in this area.

Based upon the results of field reconnaisance or various proposals already made, the following 3 proposals can be supposed about the divension of Madiwela catch.

a) I. D. Report Proposal

A new drainage canal is excavated for a diversion to the south of the vast Madiwela Catchment where flood water is drained to Kelani Ganga through Dutch Canal or to the sea through drainage outlets of Wellawatta or Dehiwela at the existing condition, and then, flood water in this area is drained into Weras Ganga.

b) Proposal based upon the present drainage system

This may be called Reclamation Board Draft; in this proposal, flood water from Madiwela, which at present goes north and is drained to Kelani Ganga, will be checked by Isolation Bund of Gothatuwa Project, and drained to the sea through drainage outlets of Wellawatta and Dehiwella via Lake Kotte and Kirillapone drainage canal.

c) Short cut proposal

In the foregoing 2 proposals the canal trace to the sea is too long. This proposal is to drain run off water from Madiwela Catchment in a shorter period of time and without any direct influence upon the adjoining reclamation project areas. Old moat in Pitta Kotte, which are said to have been constructed by the old dynasty, will be restored to drain the flood water to the open sea through a shorter canal trace.

As mentioned above, 3 proposals are supposed according to methods of treatment of the flood from Madiwela Catchment. And according to the 3 proposals, comparative proposals for 14 cases were supposed as shown in Fig. II-3, based upon drainage method of reclamation project areas (gravity drainage, or pumping drainage), combination of drainage canal and drainage points. (location of pumping station).

5-4-3 Results of Comparison and Review

1. North Colombo

For both individual drainage system and combined drainage system, the initial costs, exclusive of pump stations, including civil engineering costs for drainage canal and flood detention lake, concrete revetment and gravel and other materials are considered to be almost equal. Following is the results of comparison between the 2 systems mainly centering on pump stations which are different between them.

a. Initial cost

In case where is pumped for a definite volume at a definite lift, the cost of mechanical facility will be more required if the pumping system is divided into a larger number of pumps; therefore, according to an estimated drainage capacity in Mutwal and Urugodawatta areas, it is considered that the cost of mechanical facilities for an combined drainage system be smaller by about 30% than that for individual drainage system.

As for foundation work and building of the pump station, similar projects in Japan show that the cost for combined system is smaller by about 40% than that for individual system.

In the case of the combined proposal, it is necessary to install under Prince of Wales Ave. a connecting culvert between Mutwal Area and Urugodawatta Area with a sufficient cross-section so as not to bring about a large difference in water level.

The cost of connecting culvert, which is necessary in the combined system, shall be well set off with the long drainage culvert to be installed at Mutwal in the proposal of individual system.

According to above-mentioned, two drainage systems are compared as follows:

Comparison of Initial Cost

		Cost for mechanical equipment	Cost for foundation work & building	Total	Remarks
Individual system	Mutuwal	1,000,000	800,000	4,300,000	
	Urugodawatta	1,400,000	1,100,000		
Combined system	Northern Colombo	1,700,000	1,100,000	2,800,000	

As clear in the above Table, it is considered that the cost for the combined system will be smaller by at least Rs. 1,500,000 than that of the individual system.

b) Annual running cost

Operation cost shall be almost equal for both plans, because their total motor outputs are almost equal.

It is estimated that among annual running cost, depreciation costs for various equipments and maintenance and management costs will be different. These can be curtailed so much in the combined system. It is estimated that these costs can be curtailed in such amounts as follows:

* Annual depreciation cost for machinery:

  If the average durable years of machinery is assumed to be 20 years, (2,400,000 - 1,700,000)/20 = Rs 35,000.

* Annual depreciation cost for foundation and building of pump station:

  If the average durable years is assumed to be 20 years, (1,900,000 - 1,100,000)/20 = Rs 40,000

* Curtailment of maintenance and management cost:

  It is considered that the combined system will have the mechanical cost and management cost, and these costs can be reduced by about Rs 10,000 annually according to actual records in Japan.

As mentioned above, the combined system will bring forth a total curtailment of about Rs 85,000 annually.

(Summary)

Compared with individual system, the combined system will bring forth curtailment of about Rs 1,500,000 in the initial cost and Rs 85,000 in annual maintenance and management cost; and also in consideration of loan interests etc., the total cost can be largely curtailed. It is, however, considered that in the combined system the drainage effect will be a little lower at a point far away the pump station; this will not be any fatal defect from the technical viewpoint. Therefore, it is comprehensively summarized from technical and economical viewpoints that in North Colombo Area the conventional individual systems must be abolished and a monoblock drainage system must be proposed for the combination of Mutuwal Area and Urugodawatta Area.

c) Selection of pump station site

In planning the combined drainage system discussed in the foregoing paragraph, it will be an important problem to determine the location of the pump station. According to the topography, the following 3 sites shall be suitable for drainage pump:

Site 1: Pump station be constructed at Kelani Ganga bank of Urugodawatta side, and drainage be made to Kelani Ganga.

Site 2: Pump station be constructed at the inlet of the existing tunnel at Mutuwal side, and drainage is made through the tunnel to Colombo Fishery Harbour.

Site 3: Pump station be constructed at the southern end of San Sebastian Canal in Urugodawatta, and drainage is made to Beira Lake.

* Cost comparison

Site 1:

Maximum actual lift = highest level of Kelani Ganga + head loss through culvert - water level of suction side

= +12 +1.0 - (-)5.0

= 18 ft.

In consideration of fluctuation of flood level, inside and outside water levels, and efficiency of pump, the required actual lift is made 80% of the maximum actual lift.

Required actual lift - - - - - 18 x 0.6 ≒ 14 ft.

If losses of suction pipe and delivery pipe of pump is made about 6 ft to the required actual lift,

Design total lift - - - - - - - 14 + 6 = 20 ft = 6.10 m

Required drainage discharge Q = 350 cusec = 600 m^3/min

Therefore, engine output Pm = 1335 ps ($\because \frac{0.222 \times 1.0 \times 600 \times 6.10\ (1+0.15)}{0.7}$)

If 4 pumps are installed, each of them is provided with about 330 ps. According to experience in Japan, an engine of 330 ps will cost about Rs. 40,000, namely Rs. 160,000 for 4 engines.

Annual operating time is estimated 300 hrs, judging from rainfall records. Accordingly, running cost will be about Rs. 37,000.

$$\frac{1.66^{Rs.} \times 1,335^{Ps.}}{4.546\ell} \times 0.25^{\ell/Ps.\cdot hr.} \times 300 = 3,651^{Rs.}$$

Site 2:

In utilizing the tunnel for drainage, as the area of existing tunnel cross section is fixed, it is necessaary to secure a head sufficient for passage of the required drainage discharge.

Required drainage discharge - - - - - 350 cusec
Area of tunnel cross section - - - - - A = 28.3 ft^2

Head $h = \frac{14.3\ V^2}{64}$

If h = 36 ft, then V = 12.7 ft/sec

Q = A.V = 28.3 x 12.7 = 359 cusec

Therefore, maximum actual lift = sea level + head required for tunnel - water level of suction side

= +1 +36 - (-5)

= + 42 ft

Required actual lift will be made 80% of max. actual lift, like Site 1.

Required actual lift - - - - - - 42 x 0.8 = 34 ft

If the head loss of pump facility is about 6 ft

Required total lift H = 34 + 6 = 40 ft = 12.20 m

Required drainage discharge Q = 350 cusec ≒ 600 m^3/min.

Engine output: Pm = 2789 ps ($\because \frac{0.222 \times 1.0 \times 600 \times 12.2\ (1 + 0.15)}{0.7}$) like Site 1.

Initial cost - - - - - - Rs. 327,000 Rs

Running cost - - - - Rs. about 76,000 Rs

$$\frac{1.66^{Rs.}}{4.546\ell} \times 2789^{Ps.} \times 0.25^{\ell/Ps.\cdot hr.} \times 300^{hr.} = 76,381^{Rs.}$$

Site 3:

Water level at Beira Lake is maintained at +6 MSL in average.

Max. actual lift = water level at Beira Lake + head loss of culvert + water level of suction side

= +6 + 1 - (-5) = 12 ft

In consideration of fluctuation of inside water level, efficiency of pump required actual lift is made 90% of max. actual lift.

Required actual lift - - - - - - 12 x 0.9 = 11 ft

If losses of suction pipe and delivery pipe of pump is made about 6 ft to the required actual lift,

Required total lift H = 11 + 6 = 17 ft = 5.18 m
Required drainage discharge Q = 350 cusec ≒ 600 m^3/min

Therefore, if engine output is Pm

Pm = 1183 ps ($\frac{0.222 \times 1.0 \times 600 \times 5.18 \times (1 + 0.15)}{0.7}$)

If 4 pumps are proposed, initial cost will be as follows, according to experience in Japan:

Initial cost - - - - - - - - Rs 147,000

Annual operating time of 300 hrs. is estimated, judging from rainfall data. Accordingly, running cost will be about Rs. 32,000.

$$(\because \frac{1.66^{Rs.}}{4.546\ell} \times 1183^{Ps.} \times 0.25^{\ell/Ps.\cdot hr.} \times 300 = 32,398^{Rs.})$$

The outcome of comparison of above-mentioned 3 pumping station site is summarized in the following table.

	Total lift H	Drainage discharge Q	Output required	Initial cost	Running cost
Site 1	20 ft	350 cusec	1335 ps	Rs 160,000	Rs 37,000
Site 2	40 ft	350 cusec	2789 ps	Rs 327,000	Rs 76,000
Site 3	17 ft	350 cusec	1183 ps	Rs 147,000	Rs 32,000

When the above three pumping sites are compared against one another, it is known that Site 2 requires a greater lift than the other two sites and as a result, entails higher initial cost and running cost.

Therefore, the choice must be made between the remaining two sites, Site 1 and Site 3. As far as the above table is concerned, the Site 3 which calls for discharge of drain water into Beira Lake seems to be somewhat advantageous economically. However, when the space of the pump station and other factors are taken into account, the Site 3 has already been developed as a residential area and is surrounded by houses standing close together. It is considered extremely difficult therefore to secure land space for construction of pump station.

The Site 1, meanwhile, though disadvantageous in respect of running cost and initial cost compared with the Site 3, covers an unexploited area and is far advantageous in respect of acquisition of the space of the station.

For this reason, the Site 1 is to be adopted for the project.

2. South Colombo

a. Hydraulic condition of comparative proposal

Water levels of the proposals were obtained by calculation of non-uniform flow, based upon the hydrograph derived from the results of hydrologic analysis. In hydraulic calculation, sections close to the existing condition were used for calculation for those sections of which enlargement is impossible; and for others, secitons were assumed as practically proposed ones in consideration of discharge etc. As for discharge, the peak discharge of hydrograph was use for areas of gravity drainage, and required capacity to be proposed in future was assumed for areas of pump drainage. Roughness coefficient was assumed as 0.025, and actual calculation was made by computer.

Assumed discharges and computed water levels of the comparative proposals are shown in Fig. II-4.

b. Comparison of construction cost

Estimation of construction cost was summed up about excavation, embankment, gravels concrete revetment, pump, control sluice, bridges, land aquisition and tunnel excavation these are largest factors in comparison of construction work. Unit costs indicated by Reclamation Board were used for cost estimation and unit costs in Japan were converted into Ceylon currency for those parts relied upon foreign currency.

Results of calculation are given in the following Table. High level canals are excluded because little difference will be anticipated in the cost of each comparative proposal. For details of cost estimation, reference should be made to "Comparative Study on Drainage System."

Comparative Proposal	Estimated Construction Cost				Total Construction Cost
	Gothatuwa	Kotte	Heen Ela	Diversion of Madiwela Catch.	
	x10^{3}Rs	x10^{3}Rs	x10^{3}Rs	x10^{3}Rs	x10^{3}Rs
1-1	20,500	17,500	17,400	7,200	62,600
1-2	20,500	37,900	17,400	7,200	83,000
1-3	20,500	43,800	45,000	7,200	116,500
1-4	20,500	37,900	17,400	7,200	83,000
1-5	65,700	68,300	45,000	7,200	186,200
2-1	20,500	44,900	17,400	500	83,300
2-2	20,500	68,300	45,000	500	134,300
2-3	20,500	68,300	45,000	500	134,300
2-4	20,500	43,800	17,400	500	82,200
2-5	50,900	68,300	64,900	500	184,600
3-1	20,500	17,500	17,400	1,700	57,100
3-2	20,500	44,900	17,400	1,700	84,500
3-3	20,500	17,500	42,400	1,700	82,100
3-4	50,900	68,300	64,900	1,700	185,800

c) Area of reclaimed land

Since the comparative proposals have a different detention capacity and a different drainage system each other, then its land eclaimed by each proposal is quite different in the area. The followint Table shows area of land to be reclaimed according to the results of comparative study.

Comparative Proposal	Area of land to be reclaimed			Total reclaimed area
	Gothatuwa	Kotte	Heen Ela	
	ac.	ac.	ac.	ac.
1-1	597	482	381	1,460
1-2	597	508	381	1,486
1-3	597	508	462	1,567
1-4	597	508	381	1,486
1-5	663	506	462	1,681
2-1	597	508	381	1,486
2-2	597	506	462	1,565
2-3	597	506	462	1,565
2-4	597	508	381	1,486
2-5	590	506	459	1,555
3-1	597	482	381	1,460
3-2	597	508	381	1,486
3-3	597	482	463	1,542
3-4	590	506	459	1,555

d) Comparison of the proposals

Such a drainage system shall be more advantageous as that a larger land be reclaimed with less amount of construction cost, namely, the unit cost for land reclamation be smaller. Accordingly, apparent unit cost for land reclamation can be obtained by dividing the estimated construction costs mentioned in Paragraph b) by the areas of land to be reclaimed mentioned in Paragraph c) and then, precedence of the comparative proposals can be indicated in the following Table.

(NOTE) --- Estimated construction cost is only an apparent cost, because it does not include the cost for High Level Canal and only works required for comparison were estimated. Therefore, cost for unit area is only an index to indicate economical priority.

Comparative Proposal	Estimated Construction cost Rs x 10^3	Area of land to be reclaimed Rs x 10^3	Cost for unit area Rs x 10^3	Order of economical priority
1-1	62,600	1,460	43	2 *
1-2	83,000	1,486	56	5
1-3	116,500	1,567	74	9
1-4	83,000	1,486	56	5
1-5	186,200	1,681	111	12
2-1	83,300	1,486	56	5
2-2	134,300	1,565	86	10
2-3	134,300	1,565	86	10
2-4	82,200	1,486	55	4
2-5	184,600	1,555	119	13
3-1	57,100	1,460	39	1 *
3-2	84,500	1,486	57	8
3-3	82,100	1,542	53	3 *
3-4	185,800	1,555	119	13

According to the above-mentioned review, the proposal 3-1 is the most economical, followed by 1-2, 3-3 and then 2-4.

As mentioned in Comparison for North Colombo Area, it is more economical to combine two drainage blocks: in South Colombo Area, however, conveyance capacity of Kirillapone Canal has a certain limit, and individual drainage system seems to be more economical. It is considered that this area is not suitable to have a pump station of a large capacity integrated en bloc, because, unlike North Colombo Area, bearing force of foundation is in question.

Based upon the above-mentioned comparative review, the most economical proposal 3-1 should be adopted.

5-4-4 Decision of Proposed Drainage System

As a result of comparative study in Paragraph 5-4-3, it was decided to adopt a combined drainage system for Mutuwal and Urugodawatta drainage areas in Northern Colombo, and the Proposal (3-1) shall be adopted for South Colombo. Drainage system for the entire project area is shown in Fig. II-5.

5-5 Comparative Study on the Scale of Economical Drainage Facility

Capacity of drainage pumps, flood detention capacity and area of land to be reclaimed by such facilities are in close relation. In short, if the capacity of drainage pumps is proposed smaller, the required flood detention capacity will be larger and the area of land to be developed will be decreased.

Contrarily, if the capacity of drainage pumps is proposed larger, the required flood detention capacity will be smaller and the area of land to be developed will be increased.

Accordingly, a project should be proposed in a certain proper scale so that the reclamation cost per unit area be minimum by analysing the corelation of these 3 factors.

For determining the scale of an economical drainage facility, estimation of construction cost was made in the following order of procedure:

* Construction costs of flood detention facility of various types are estimated by varying the ratio (n) between waterway section and flood stage as flood detention facility.

* Required capacity to be reserved by flood detention facility is computed, according to the hydrograph as a result of hydrological analysis, and the cost of flood detention facility is estimated tentatively.

* Costs required for reclaiming the area of a marsh reduced the area of the flood detention facility are estimated about such main works as filling, grovel concrete revetting, turfing etc.

* Various total costs for various combinations of scales of drainage facility are estimated and divided by the area of land to be reclaimed for the purpose of computing the reclamation cost per unit area.

Results of computation for the projects are as follows: As for the details of computation, reference must be made to "Comparative Study on Scale of Economical Drainage Facility".

By referring to Table II-1 and Fig. II-6, scales of economical drainage facility of the projects are summarized as follows:

Project	Drainage pump capacity	Required flood control capacity	Reclaimed land area
	cusec	ac.ft.	ac.
Mutuwal	150 ~ 200	160 ~ 130	105 ~ 115
Urugodawatta	200 ~ 300	300 ~ 200	325 ~ 350
Gothatuwa	200 ~ 250	520 ~ 430	600 ~ 620
Heen Ela	200 ~ 350	380 ~ 280	
Kotte	250 ~ 350	500 ~ 430	520 ~ 530

The above Table shows the most economical factors for drainage facility, and the results of comparison of only initial costs. In consideration of running cost and maintenance and management costs, it will be more economical with a similar capacity of drainage pump and a larger flood detention capacity.

Accordingly, the minimum values of drainage pump capacity in the above table must be adopted. Furthermore, the data on rainfall during the period from 1965 to 1969 shows that in wet season the next rainfall arised within 3 or 4 days after the preceding rainfall was over. It is, therefore, necessary to drain the water stored in flood detention facilities within 3 days, restore the storage water level to the normal water level, for preparations for the next rainfall.

With consideration of the above points, scales of proposed detention facility of the projects were determined, and the drainage time was calculated by dividing the flood detention capacity by the drainage pump capacity to see if it is within the allowable pumping time (3 days after the preceding rainfall). The results are summarized in the following table.

Project	Design drainage capacity	Design flood detention capacity	Required time to lower water level to L.W.L.
	cusec	ac.ft.	
Northern Colombo (Mutuwal, Urugodawatta)	150, 200) 350	460	15.9 hrs (0.7 days)
Gothatuwa	200	520	31.5 " (1.3 ")
Heen Ela	200	380	23.0 " (0.9 ")
Kotte	250	500	24.2 "

As clear in the above table, the proposed drainage pump capacity shall be economically satisfactory and also thoroughly safe against the succeeding rain-rainfalls. Therefore, general plans for the projects was proceeded on the basis of the drainage pump capacity.

5-6 General Planning and the Tentative Estimate of Construction Cost

On the basis of the scale of drainage system and facilities as determined by the comparative study described in 5-4 and 5-5 above, the general planning and the tentative estimate of construction cost for each of the project were made, which are shown in the following.

5-6-1 Land Reclamation Project for North Colombo

In the present condition the Project Area is divided into Mutuwal and Urugodawatta which are connected with each other through a culvert running under the Prince of Wales Ave. As the adoption of the combined drainage system has been decided for this project area based on the comparative study, such measure should be taken as to provide the smooth drainage of rainwater put in both areas; the laying of new connecting culvert be proposed to integrate them; and such provision be made as to enable the discharge of storm sewage by giving as small a head loss as possible.

The project contemplates to improve the cross sections of the existing drainage canals in the areas and to provide a flood detention lake in the part of low elevation area where is permanently water-logged. Although the existing tunnel is to be restored by removing sand deposited in it to use as an additional outlet of gravity drainage system, its capacity is to be deemed as that in reserve and not taken into account for the planning purpose.

1. Cross sections of flood detention facilities

The Project Area has 532 acres of marshes comprising 142 acres of Mutuwal and 390 acres of Urugodawatta. The approximate storage capacity needed for the flood detention facilities was estimated on the basis of the pump capacity of 350 cusec and the hydrograph as determined previously and it was found that such capacity of 449 ac.ft. will be required in the North Colombo Area.

Therefore, the respective cross sections is to be determined so that the flood detention lake and canals can have the total storage capacity of about 449 ac.ft. in total. In determining the cross sections, the following procedures are followed:

- o Existing ground elevation:

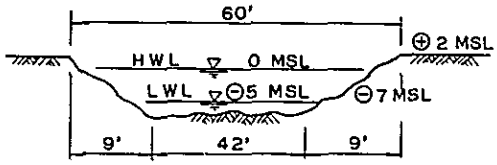
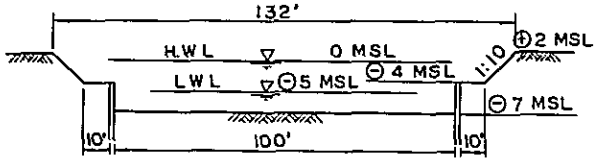
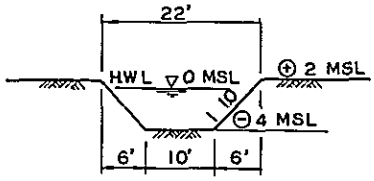
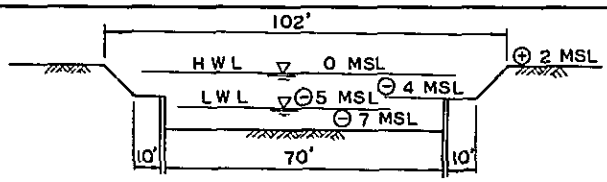
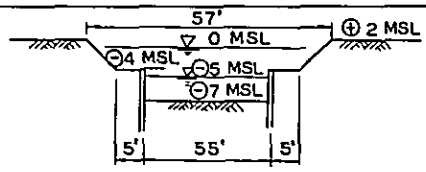
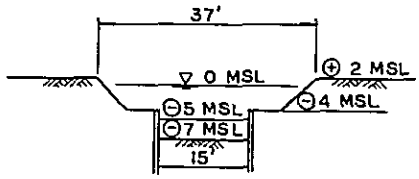
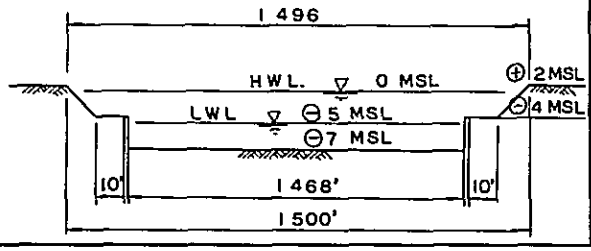
  The existing ground elevation in the marshy land is presumed to be 0 MSL.

- o Estimated high-water level:

  The normal water level is taken at 0 MSL taking into consideration the lowering of ground water level in the surrounding site; and the water surface is lowered to (-)5 MSL just before an anticipated rainfall. The highest high-water levels to be allowed in the lake are 0 MSL, (+)2 MSL (within freeboard) and (+)3 MSL respectively for fifty-year, one-hundred-year and two-hundred-year precipitation return period.

- o Proposed ground elevation:

  The proposed ground elevation is fixed at (+)2 MSL taking into account the balancing of the volumes of excavation and filling.

	Name of canal	Typical cross section	Length of canal	Detention capacity
			(ft)	(ac-ft)
Urugodawatta	Existing drainage canal in the area		3.742	21
	Main canal		16.500	225 8
	Lateral		8.728	Detention capacity in not taken in to account to provide safety factor.
Mutuwal	Main canal		1.195	12 2
	Lateral I		4.885	25.9
	Lateral II		4.885	14.7
	Detention lake		900	151.5

Total detention capacity=451.1

o Bottom elevation of canals:

The bottom elevation of the flood detention lake and main canal are proposed to attain (-)7 MSL and that of the lateral (-)4 MSL. Therefore, the flood detention capacity is calculated at above (-)5 MSL.

For the proposed flood detention facilities, the total detention capacity of 451.1 ac. will be sufficient to meet the need, as against 449 ac.ft. mentioned already.

2. Balance calculation of inflow and outflow

The volumes of detention at various water stages are calculated with the aid of the cross sections of flood detention facilities, determined in the preceding paragraph, to plot a curve (H—V) of detention corresponding to each water level. (Fig. II-7).

The inflow and outflow of flood were calculated on the basis of the H—V curve as well as the hydrograph and the capacity of pump determined already. The result of calculation is shown in Fig. II-8, and the principal factors of the calculation are summarized in the following table. For the details of such calculation, see "the volume of general plan".

	Maximum inflow (cusec)	Maximum outflow (pumping capacity) (cusec)	Cumulative maximum detention (ac.ft)	Highest impounding water level (MSL)
Estimated standard rainfall (50-year return period)	1,507	350	449	(-)0.10
Heavy rainfall (100-year return period)	1,687	350	500	(+)0.45
Extraodinary rainfall(200-year return period)	1,868	350	634	(+)1.90

The highest impounding water stage at the time of estimated design rainfall (fifty-year return period) approximates the estimated high-water level (0 MSL); the highest high-water level is maintained within freeboard during heavy rainfall and even extraordinary rainfall (two-hundred-year return period), without causing any water to be inundated on the reclaimed land. Therefore, it may be siad that both the pump and the flood detention facilities are proposed based on an economic and safe capacity.

3. Quantities of earthwork and revetment work

A general plan of 4-chs, which is attached herewith as an appended drawing No. II-4, was prepared on the basis of the planning factors as determined in paragraphs 1 and 2 above. Based on this general plan, the computation was made to estimate the quantities of earthwork, gravel, masonry work

and concrete revetment, etc. The details are described in the volume of general plan and the results of such calculation are summarized in the following table.

Excavation	Suction dredger	216,600 cube
	Grab dredger	232,800
Filling		203,200
Gravel		188,400
Rubble masonry work		10,100 squ.
Concrete revetment		59,600 ft

4. Factors of pump

a) Proposed drainage discharge

The proposed pumping capacity for the North Colombo is 350 cusec which was determined based on the economic comparison of different sizes of drainage facilities.

b) Lift

The highest high-water level of the Kelani Liver recorded in the past being (+)12 MSL, if the friction loss in drain culvert is assumed to be about 1.0 ft, the maximum actual lift will be as follows.

Maximum actual lift = Highest high-water level of the Kelani Ganga + friction loss of drain culvert - water level of the area inside.

= (+)12.0 + 1.0 - (-)5.0

= 18 ft.

In view of the highest flood level, fluctuation of high-water level inside and outside and effective operation of pump, etc., the proposed actual lift is to be fixed at 80% of the maximum actual lift. Thus;

Proposed actual lift = 18 x 0.80 ≒ 14 ft.

If the presumed loss of head, i.e. about 6 ft., from the suction and delivery pipes of pump and others, is added to the proposed actual lift;

Proposed total lift = 14 + 6 = 20 ft.

c) No. of units and bore

Four pumps of the same bore is to be installed in parallel taking into account the proposed drainage discharge (350 cusec) as well as their operation and handling, maintenance, economy and the dispersion of danger in the event of emergency. Therefore, the drainage discharge per unit is 87.2 cusec. The allowable velocity of flow in the pipe of pump being about 9 ft/sec., the required diameter of pump, D is;

$$\frac{87.2}{\frac{\pi D^2}{4}} = 9 \text{ ft/sec}$$

$$D \fallingdotseq 3.5'$$

$$\fallingdotseq 42'' \ (\phi 1100)$$

Accordingly, the pump for the area is to be proposed on the basis of $\phi 42''$ x 4 units.

d) Class and type of pump

Mixed flow pump with horizontal shaft is to be adopted based on the economic consideration of suction head, capacity of pump and others.

e) Prime mover and its type

From the economic and technical points of view such as initial and running costs, maintenance and supervision, operation and handling and repair, it is more advantageous to adopt electric motor as prime mover. However, taking into consideration the power situation in Colombo City, especially service interruption due to lightening during the rainy season, and the importance of urban drainage it is proposed to install each two units of electric motor and engine with the main object being to insure the safety in emergencies.

The capacity of prime mover is determined by the following formula.

For electric motor;

$$Pm = \frac{0.163 \gamma Q H (1 + \alpha)}{\eta p \times \eta t}$$

Pm: motor output (KW)

γ : unit weight of water 1.0 (kg/ℓ)

Q : drainage discharge(m^3/min)
87.2 cusec $\fallingdotseq$ 150 m^3/min

H:: total lift (m) 20 ft = 6.10

α : allowance ratio 15%

ηp : efficiency of pump 85%

ηt : transmission efficiency 95% (gear reduction)

$$Pm = \frac{0.163 \times 1.0 \times 150 \times 6.10 (1 + 0.15)}{0.85 \times 0.99} = 212.5 \text{ (KW)}$$

For engine;

$$Pe = \frac{0.222 \times 1.0 \times 150 \times 6.10 (1 + 0.15)}{0.85 \times 0.99} = 289.5 \text{ (Ps)}$$

Based on the above results, the required prime movers are to be proposed as follows:

Electric motor (213) KW x 2 units
Engine (290) ps x 2 units

5. Tentative estimate of direct construction cost

The direct construction cost is computed with the aid of the quantities of flood detention facilities and the factors of pump which were found already. The unit costs applied to various works are those supplied by the Reclamation Board; for the items to be paid in foreign currency, their unit costs prevailing in our country were converted into international currency. As regards various expenditures incidental to the works, they were calculated referring to the I.D. Report. The results of estimates are shown in the following table with the total amount being about Rs. 65,000,000.

6. Area of reclaimed land

The area of marshy land lower than (+) 6 MSL, in the Project Area, is 532 acres, of which 99.4 acres will be required for the flood detention facilities; thus the area of land which can be reclaimed will be 432.6 acres. It is necessary to take into account the area of land to be used for roads, sewers and other public facilities covered by the land readjustment which will be carried out after the completion of land reclamation work. The area available for sale seems to be about 75% of that of the reclaimed land, inferring from the actual results of the building site creation project in Japan. Therefore, the saleable area of reclaimed land which constitutes the profit from the project in the North Colombo Area will be 324.5 acres. For the details of area calculation, see the volume general plan.

Tentative estimate of the expenses necessary to be incurred for the reclamation of Mutwal and Urugodawatta Marshes

Item	Quantity	Unit	Rate Rs	Amount Rs
Earth excavation in the formation of lake water-ways and flood detention areas and using the spoil for filling the land to be reclaimed	232,800 (grab drager)	Cube	14	3,259,200
	216,600 (suction drager)	Cube	18	3,898,800
Excavation, transport and spreading 1 ft. layer of good quality gravel on the reclaimed land	188,400	Cube	35	6,594,000
Constructions of concrete revetments along canal and lake banks	59,600	L.ft.	65	3,874,000
Construction of a pumping station including buildings, pumps-diesel and other equipments	350	cusec	7,000	2,450,000
Construction of 3 nos. control regulators	3	Nos.	27,000	81,000
Construction of an emergency control regulator	1	"	27,000	27,000
Construction of 2 culverts across the Harbour-Kollonnawa Railway Line connecting the 2 lakes and across the Prince of Wales Ave. connecting Mutuwal to Urugodawatta	1	"	Sum	496,000
	1	"	"	143,000

Item	Quantity	Unit	Rate Rs	Amount Rs
Improvements of one bridge	1	Nos.	Sum	125,000
Rundam rubble masonry for the canal protection	10,100	square	250	2,525,000
Desilting of the tunnel	1	Nos.	Sum	8,000
Acquisition of private lands in the area to be reclaimed,proposed canals, lakes and for all other requirements during construction			Sum	1,500,000
Supervision, wathcers etc.			Sum	500,000
Welfare,accidents, holiday and idle pay			Sum	500,000
Setting out, testing inspection			Sum	500,000
Local transport and contingencies			Sum	3,355,000
Allotment and consolidation	324.5	ac	75,000	24,337, 500
Sub-total				54,173,500
Overhead for contractor (20%)				10,834,700
Total				65,008,200

5-6-2 Reclamation Project of Gothatuwa

With the Dutch Canal running through it, Gothatuwa has already a comparatively larger flood detention capacity. In order to implement an independent reclamation project for this area, an Isolation Bund must be constructed beside Battaramulla Bridge to prevent the inflow from Madiwela and Kotte Areas. Since the existing canal in this area has a quite sufficient width, the drainage canal will be proposed by widening the cross section of the existing canal only in small degree. Then, the proposed drainage canal will be provided with a considerable flood detention capacity. A flood detention lake shall be constructed to meet the shortage in the required detention capacity.

By making the best use of the existing canal trace, the quantities of earthworks can be largely reduced. In addition, it is the most suitable for hydraulic excavation and the construction period can be largely reduced.

The pump station shall be constructed at the site where flood water of this area can be discharged into High Level Canal, as determined in comparative study of drainage system.

1) Typical cross section of drainage canal

The flood detention capacity required for the Gothatuwa was estimated as about 500 ac.ft.with the hydrograph and pumping capacity of 200 cusec determined by the comperative study of scales of drainage facilities. Therefore, the respective cross sections of flood detention lake and drainage canals are to be proposed as the storage capacities amount to about 500 ac.ft. in all. The determination of the cross sections is made on the following bases.

o Existing ground elevation

As it is not clear due to lack of accurate contour map, it is assumed that the existing ground elevation in the marshy land is about 0 MSL in average.

o Estimated high-water level

Taking into consideration the lowering of groundwater stage in the surrounding area, the normal water level is taken at 0. MSL and the water surface is to be lowered to (-)6 MSL by pumping just before an anticipated rainfall. The highest high-water level in the pond and drainage canals is to allow for 0 MSL, (+) 2 MSL (within freeboard) and (+) 5 MSL respectively for fifty-year, one-hundred-year and two-hundred-year precipitation return period.

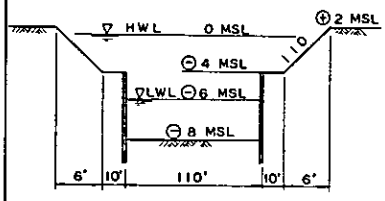
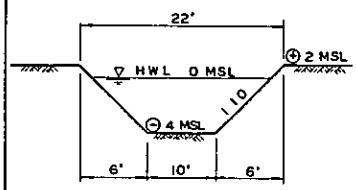
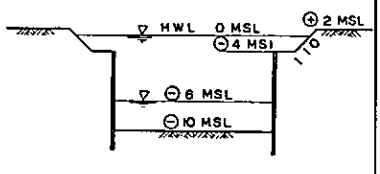
o Proposed ground elevation

Taking into account the balancing of volumes of excavation and filling, the proposed elevation of ground is to be taken at (+) 2 MSL.

o Bottom elevation of canals

The bottom elevation is to be proposed at (-)10 MSL for the flood detention lake, at (-) 8 MSL for the main canal and at (-)4 MSL for the lateral.

The cross sections of drainage facilities determined taking into consideration the required storage capacity of 500 ac.ft. are as follows:

Name of waterway	Standard cross section	Length of waterway	Storage capacity
		(ft)	(ac ft)
Main drainage canal		12 480	217
Lateral		65 300	The storage capacity is left as a safty factor
Flood detention		4 130 4 300	286
		Total	503 ac·ft

2) Balance calculation of inflow and outflow

With the aid of the cross sections of flood detention facilities as determined in the preceding paragraph, a curve of water level is volume of impounded water (H-V curve) was plotted by calculating such volumes corresponding to various water stages (Fig. II-7-2). The results of calculation of flood inflow and outflow made on the bases of the hydrograph and the capacity of pumps are as shown in Fig. II-8-2, and its principal factors are summarized intthe followmg table. For the details of calculation of inflow and outflow, see the volume of general plan.

	Maximum inflow	Maximum outflow (pumping capacity)	Cumulative maximum volume of inundated water	Highest inundated water level
	cusec	cusec	ac. ft.	MSL
Estimated design rainfall (50-year return period)	1,316	200	386	0.00
Heavy rainfall (100-year return period)	1,473	200	458	1.10
Extraordinary rainfall (200-year return period)	1,630	200	563	2.05

The highest high-water level at the time of the estimated design rainfall (fifty-year return period) is a little lower than the standard water level (0 M. S. L.) and even at the time of heavy rainfall (one-hundred-year return period), it is kept within freeboard.

At time of extraordinary flood (two-hundred-year return period), it is by far below the estimated standard water level ((+)3 MSL) with only small volume of water inundated,on the reclaimed land ((+)2 MSL). Therefore, both the flood detention facilities and pumps are economic and adequately safe ones.

3) Quantities of earthwork and revetment

The factors of drainage facilities determined in paragraphs 1) and 2) above are laid out on a 4-chs map which is as shown in the drawing No. II-7. Based on this plan, the quantities of earthwork, gravel, masonry and concrete revetment were calculated. The details are described in the volume general plan, and the results of calculation are summarized in the following table.

Kind of work	Quantity
Excavation (suction dredger)	249,600 cube
Excavation (Grab dredger)	62,700 "
Filling earth for reclamation	255,700 "
Gravels	254,000 "
Concrete revetment	25,000 ft
Rubble masonry	6,200 sq.

4) Pumping Station

a) Proposed drainage discharge

The proposed capacity of pumps for Gothatuwa is 200 cusec, which was determined as a result of economic comparison of different scales of drainage facilities.

b) Lift

The highest high-water level of the Mahawatta Canal during flood is approximately (+)6 MSL at the utmost. Therefore, the highest lift including a head loss of about 1.0 ft. in the outlet culvert is,

(+) 6 MSL - (-) 6 MSL + 1.0 = 13 ft.

If the proposed actual lift is presumed at about 80% of the highest actual lift, taking into account the fluctuation of water stages inside and outside, it produces 10.4 ft.

The proposed total lift is added with about 6 ft. presumed as head loss in suction and delivery pipes of pump and others; thus, proposed total lift = 10.4 + 6 ≒ 16 ft.

c) Number of units and bore

Four units of pump of the same bore are to be installed taking into consideration such factors as the proposed drainage capacity (200 cu. sec.), operating and handling, upkeeping, economy and dispersion of danger in the event of emergency. Therefore, the drainage capacity per unit of pump is 50 cusec. as the allowable flow velocity in the tube of pump is generally 9 ft/sec, the required diameter D is,

$$\frac{50 \text{ cusec}}{\frac{\pi D^2}{4}} \fallingdotseq 9 \text{ ft/sec}$$

D : 2.66' = 32" (ϕ 800)

Therefore, the pumping units for this area is proposed as ϕ32" (ϕ 800) x 4 units.

d) Class and type of pumps

A mixed flow pump with horizontal shaft type is to be adopted taking into account the suction head, total lift and capacity.

e) Prime mover and its capacity

From the economic and technical points of view such as initial and running costs, maintenance and supervision, operating and handling and upkeeping it is advantageous to adopt electric motor; however, in view of the electric power situation in Colombo City, specially the service disruption due to lightening and the importance of urban drainage during the rainy season, it is to be proposed to install each two units of electric motor and engine to insure the safety in emergencies. The capacity of prime mover is computed by the following formula.

For electric motor;

$$Pm = \frac{0.163 \gamma QH (1 + d)}{\eta P \times \eta t}$$

Here,

Pm : Output of motor (KW)
γ : Unit weight of water 1.0
Q : Drainage discharge (m^3/min)
50 cusec ≒ 85m^3/min
H : Total lift 16 ft ≒ 4.9 m
d : Allowance ratio 15%
ηP : Pumping efficiency 85%
ηt : Transmission efficiency 95%

Therefore,

$$PM = \frac{0.163 \times 1.0 \times 85 \times 4.9 (1 + 0.15)}{0.85 \times 0.95} = 96.6 \text{ KW}$$

The capacity of engine is found by converting the output of electric motor into horsepower.

For engine;

Pe = 1.36 x 96.6 = 131.4 ps

Based on the above calculation, the prime mover for this area is to be proposed as follows:

Electric motor	96.6 KW x 2 units
Engine	131.4 Ps x 2 units

5) Tentative estimate of direct construction cost

The direct construction cost is estimated on the basis of the quantities of flood detention facilities and factors of pumps. The unit costs used here for various works are those supplied by the Reclamation Board and for items to be paid in foreign currency, the unit costs prevailing in our country were converted into the international currency. Various expenditures incidental to the works were estimated referring to the I.D. Report. The result of estimate is as shown in the following table and the total amount is about Rs. 70,000,000.

6) Area of reclaimed land

The area of marshy land lower than (+)6 MSL in elevation in this area is 707 acres, from which reduction is made of 124 acres to use for the flood detention facilities leaving 583 acres of reclaimable area. On this acreage an allowance should be made for the area to be taken up by the roads, sewers and other public facilities covered by the land readjustment to be carried out after the completion of reclamation work. Judging from the implemented instances of the projects for reclaiming residential lots in our country, it seems that the area available for sale is about 75% of reclaimed land. Therefore, the saleable area is 437.3 acres which constitutes the revenue from the project for the Gothatuwa.

For the breakdowns of acreage calculation, see the volume of general plan.

Tentative estimate of the expense necessary to be incurred for the reclamation of Gothatuwa Marshes

Items	Quantity	Unit	Rate Rs	Amount Rs
Earth excavation in waterways, lakes, flood detention area and using the soil for filling reclaimed land	249,600	Cube	18	4,492,800
	62,700	Cube	14	877,800
Gravelling the surface of the reclaimed land	254,000	Cube	35	8,890,000
Construction of concrete revetments along the canal and lake banks	25,000	L.ft.	65	1,625,000
Construction of a bund	700	Cube	27	189,000
Construction of a pumping station 200 cusecs	200	cusec	7,000	1,400,000
Random rubble masonry for the canal protection	6,200	Square	250	1,550,000
Improvement of 2 Nos. bridges	2	Nos.	Sum	734,000
Land acquisition			Sum	1,667,000
Construction of a emergency control regulator	1	Nos.	Sum	27,000
Supervision, watches etc.			Sum	210,000
Welfare accident pay, holiday pay, and idle pay			Sum	210,000
Setting out, testing inspection, etc.			Sum	210,000
Local transport and contingencies			Sum	3,156,000
Allotment and consolidation	437.0	Ac.	75,000	32,775,000
Sub-total				58,013,600
Overhead for contractor				11,602,720
Total				69,616,320

5-6-3 Reclamation Project of Kotte

The Dutch Canal runs through approximately the center of this area in which Kotte Lake lies and has a large storage capacity. At present, this lake is connected to the Madiwela, Gothatuwa and even for lying North Colombo through Dutch Canal. This project area is to be isolated from the Gothatuwa and and North Colombo area by the isolation bund proposed in the Gothatuwa reclamation project, and in addition, it can be isolated from the Madiwera Catch. by the diversion scheme and by the closure of regulator proposed near the

Battaramulla Bridge. As previously mentioned, this area has such natural facilities for flood detention as Kotte Lake. Accordingly, this area can be provided with a large flood detention capability by dredging its bottom and lowering its water stage by pumping. Any deficiency of storage capacity can be made up by improving and revetting the existing Dutch Canal. A catcher is built on the border between the marshes and the surrounding hilly area to collect the inflow water from the latter.

On the basis of comparison of drainage system, the pumping station is established adjacent to the Kirillaponc Canal in the southern part of the area and an emergency regulator is included in the station to provide against emergencies due to the trouble of pumping facilities and etc.

1) Typical cross section of drainage canal

The storage capacity of flood detention facilities required for the Kotte was estimated with the aid of the hydrograph and the pumping capacity of 250 cusec determined by the comparative study of scales of drainage facilities, and it was concluded to be of about 490 ac. ft. Therefore, the respective cross sections of flood detention lake and drainage canal are to be determined so that the storage capacities amounts to about 490 ac. ft. in total.

The determination of cross sections is made on the following basis.

- o Existing ground elevation

  As it is not clear due to lack of accurate contour map, it is assumed that the existing ground elevation in the marshes is about 0 MSL in average and the bottom elevation of Kotte Lake is about (-)4 MSL in average.

- o Extimated high-water level

  Taking into consideration the lowering of groundwater stage in the surrounding area, the normal water level is taken at 0 MSL and the water surface is lowered to (-7) MSL by pumping at the start of rainy season. The highest high-water level in the lake and drainage canal is to allow for 0 MSL, (+) 2 MSL (within freeboard) and (+)5 MSL respectively for fifty-year, one-hundred-year and two-hundred-year precipitation return period.

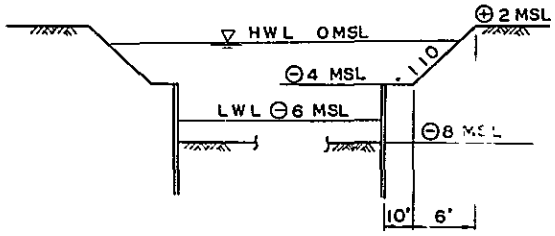
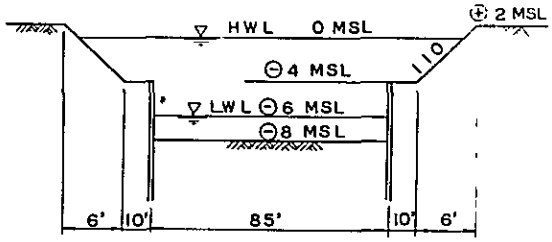
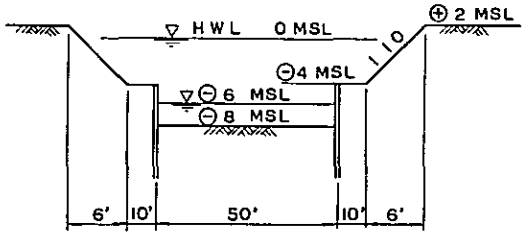
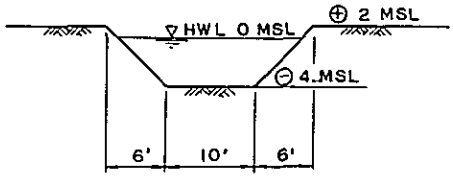
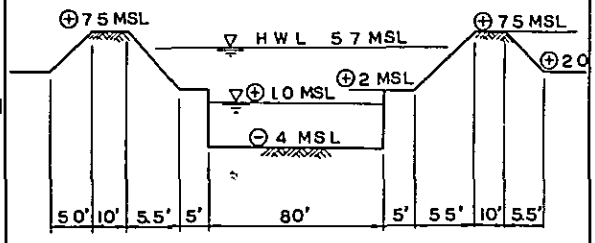
- o Proposed ground elevation

  Taking into account the balancing of volumes of excavation and filling, the proposed ground elevation is taken at (+)2 MSL.

- o Bottom elevation of canal

  The bottom elevation of canal is proposed at (-)8 MSL for flood detention lake and main canal and (-)4 MSL for laterals.

According to the above planning, the flood detention capacity is calculated above (-)6 MSL. The cross sections of drainage facilities determined taking into consideration the required detention capacity of 490 ac. ft. are as follows.

Name of canal	Typical cross section	Length of canal	Storage capacity
		(ft)	(ac ft)
Kotte lake		10 400 (Circum-ference)	411
Main canal		5 700	79
Lateral I		3 300	To be on the safety side, storage capacity is not taken in to account
Lateral II		28.400	"
Kirillapone canal		4. 700	"
		Total	490 (ac·ft)

2) Balance calculation of inflow and outflow

With the aid of the cross sections of flood detention facilities as determined in the preceding paragraph, a curve of water level, volume of inundated water (H—V) was plotted by calculating those volumes corresponding to various stages (Fig. II-7-3). The result of calculation of flood inflow and outflow made on the basis of the hydrograph and the capacity of pump is as shown in Fig. II-8-3, and its principal factors are summarized in the following table. For the details of the calculation, see the volume of general plan.

	Maximum inflow cusec	Maximum outflow (pumping capacity) cusec	Cumulative maximum volume of detention ac. ft.	Highest impounding water level MSL
Estimated standard rainfall (50-year return period)	1,576	250	490	0.00
Heavy rainfall (100-year return period)	1,764	250	594	(+)1.25
Extraordinary rainfall (200-year return period)	1,953	250	730	(+)2.10

The highest impounding water level at the time of the estimated design rainfall (fifty-year return period) agrees with the estimated high-water level (0 MSL), and during heavy rainfall and even extraordinary rainfall, it is suffificently lower than the standard high-water levels (respectively (+)2 MSL and (+)3 MSL), remaining almost within freeboard. It is that both the flood detention facilities and pumps are proposed on the economic as well as sufficiently safe capacity.

3) Quantities of earthwork and revetment

The proposed factors determined in paragraphs 1) and 2) above are laid out on a 4-chs map which is attached herewith as drawing No. II-9. Based on this plan, the quantities of earthwork, gravel, masonry and concrete revetment were calculated. The details are described in the volume of general plan, and the results of calculation are summarized in the following table.

Kind of work	Quantity
Excavation (suction dredger)	130,000 cube
Excavation (grab dredger)	45,600 "
Filling and banking	114,800 "
Gravel	205,500 "
Concrete revetment	37,800 ft
Rubble masonry	6,500 S8ua
Turfing	1,000 "

4) Factors of pump

a) Proposed drainage discharge

The proposed capacity of pump for Kotte is 250 cusec. which was determined as the result of economic comparison of different scales of drainage facilities.

b) Lift

The highest high-water level of the Kirillapone Canal during flood is (+)6 MSL at the utmost. Therefore, the highest actual lift with the head loss in the outlet pipe allowed for about 1.0 ft. is,

(+) 6 MSL - (-) 6 MSL + 1.0 = 13 ft.

If the proposed actual lift is computed at 80% of the highest actual lift taking into account the fluctuation of water stages inside and outside, it becomes 10.4 ft. to which is added with about 6 ft. presumed as head loss in the suction and delivery tube of pump and others; thus,

Proposed total lift = 10.4 + 6 ≒ 16 ft.

c) Number of units and bore

Four units of pump of the same bore are installed taking into consideration such factors as the proposed drainage capacity (250 cusec), operation and handling, up-keeping, economy and dispersion of danger in the event of emergency. Therefore, the drainage discharge per unit of pump is 62.5 cusec. Generally, the allowable flow velocity in the tube of pump is about 9 ft/sec. Accordingly, the required diameter is,

$$\frac{62.5 \text{ cusec}}{\frac{D^2}{4}} \fallingdotseq 9 \text{ ft/sec.}$$

Therefore, D ≒ 2.97 = 36" (ϕ 900)

Hence the pump for this area is proposed on the basis of ϕ 36" (ϕ 900) x 4 units.

d) Class and type of pump

A mixed flow pump with horizontal shaft which is economical is adopted taking into account the suction head, total lift and capacity.

e) Prime mover and its capacity

From the economic and technical points of view such as initial and running costs, maintenance and supervision, operating and handling and upkeeping it is advantageous to adopt electric motor; however, in view of the electric power situation in Colombo City, especially the service obstruction due to lightening and the importance of urban drainage during the rainy season, it is to be proposed to install each two units of electric motor and engine to insure the safety in emergencies.

The capacity of prime mover is worked out by the following formula.

For electric motor:

$$Pm = \frac{0.163\,\gamma QH\,(1+\alpha)}{\eta p \cdot \eta t}$$

Here,

Pm : Output of motor (KW)
γ : Unit weight of water 1.0
Q : Drainage discharge (m^3/min.)
62.5 cusec ≒ 105.6 m^3/min.
H : Total lift (m)
16 ft. ≒ 4.9 m
α : Allowance ratio 15%
ηp : Pumping efficiency 85%
ηt : Transmission efficiency: 95% in gear reduction system

Therefore

$$Pm = \frac{0.163 \times 1.0 \times 105.6 \times 4.9 \times (1 + 0.15)}{0.85 \times 0.95} \fallingdotseq 120.0 \text{ KW}$$

The capacity of engine is found by converting the output of electric motor into horsepower.

For engine:

$$Pe = 1.36 \times 120.0 = 163.2 \text{ Ps}$$

Based on the above calculation, the prime mover for this area is proposed as follows:

Electric motor	120.0 KW x 2 units
Engine	163.2 Ps x 2 units

5) Inverted siphon work connecting to the southern part of Kotte

In order to connect the Kirillapone Canal of which highest flood water level rises near to (+)6 M.S.L. to the diversion tunnel of the Madiwela catchment area, bunds are built to (+)7.7 M.S.L. on its both sides. Due to them the southern part of Kotte is isolated by the canal and the flowing out to the pumping-station side becomes impossible. Therefore, an inverted siphon is provided under the link canal to obtain the connection.

Presuming that the head loss in the siphon is 0.5 ft. the scale of siphon is to be of box culvert, 6.5' x 6.5' in its cross section, made of reinforced concrete.

Quantities of earthwork and others are summarized in the table below.

Kind of work	Quantities	Remarks
Excavation	510 cube	
Back filling and banking	460 cube	
Concrete	3,000 ft^3	
Pile-driving	18	Reinforced concrete pile
Regulating gate	a complete set	Steel gate
Sheet-pile (Provisional)		Steel sheet pile

(For particulars, see the volume of general plan.)

6) Tentative estimate of direct construction cost

The direct construction cost is estimated on the basis of the quantities of flood regulating facilities, factors of pump and amount of siphon work. The unit costs used here for various works are those supplied by the Reclamation Board and for items to be paid in foreign currency, the unit costs prevailing in our country were converted into the international currency. Various expenditures incidental to the works were estimated referring to the I.D. Report. The results of estimate are as shown in the following table and the total amount is about Rs. 60,000,000.

7) Area of created land and available for sale

The area of marshes lower than (+)6 M.S.L. in elevation in this district is 606 acres, from which reduction is made of 134.2 acres to use for the flood detention facilities leaving 471.8 acres of reclaimed land by draining. If the allowance is made for the area to be taken up for the roads, sewers and other public facilities covered by the land readjustment to be carried out after the completion of reclamation work, the area of reclaimed land available for sale seems to be about 75% of it. Therefore, the saleable area is 353.8 acres which constitutes the revenue from the project for Kotte.

Tentative estimate of the expence necessary to be incurred for the reclamation of Kotte Marshes

Items	Quantity	Unit	Rate Rs	Amount Rs
Earth excavation in waterway, lake, flood detention areas and using the soil for filling reclaimed land	45,600	Cube	14	638,400
	130,100	"	18	2,341,800
Gravelling the surface of the reclaimed land	205,500	Cube	35	7,192,500
Construction of concrete revetment along the canal and lake banks	37,800	L.ft.	65	2,457,000
Construction of a pumping station 250 cusec.	250	7,000	Sum	1,750,000

Items	Quantity	Unit	Rate Rs	Amount Rs
Construction of a emergency control regulator	1	Nos.	Sum	27,000
Random rubble masonry for the canal protection	6,500	Squ.	250	1,625,000
Land acquisition			Sum	2,000,000
Improvement of one bridge				700,000
Filling of the bank along Kirillapone canal	14,700	Cube	27	396,900
Supervision and watchers, etc.			Sum	260,000
Welfare accidents pay and idle pay			Sum	260,000
Local transport and contingencies			Sum	3,600,000
Setting out testing inspection			Sum	260,000
Allotment and consolidation	353.8	ac	75,000	2,535,000
Turfing of the bank slope	1,000	sq.	9	9,000
The siphon of the South Kotte			Sum	284,400
Sub-total				50,337,000
Overhead for contractor				10,067,400
Total				60,404,000

5-6-4 Reclamation Project of Heen Ela

The vast marshes in this area play a role as a flood detention reservoir for the run off water from the High Level Area already developed for residential lots. Therefore, this area can be an independent reclamation project area by constructing a catch along its western boundary to prevent the flood from the High Level Area.

As already decided, drainage system shall be of pumping drainage system, and run off water in the area shall be discharged into Kirillapone Canal. The existing condition of the area is that the most part consists of low flat marsh without any particular drainage canal or lake. Accordingly, flood detention shall be totally conducted in the proposed drainage canal and no flood detention lake shall be constructed. A catch shall be arranged along the boundary between the low lying area and the high elevated area to catch the inflow from the surrounding hill of the catchment.

The pump station shall be constructed near the dike of Kirillapone Canal, and provided with an emergency regulator for the safety against possible troubles on drainage pump facility.

1) Cross section of drainage canal and lake

The required storage capacity of the flood regulating facilities for the Heen Ela was estimated with the aid of the pumping capacity of 200 cu. sec.

and the hydrograph determined by the comparative study of scales of draining facilities and it was concluded to be of about 390 ac. ft. Therefore, the cross sections of drainage canals and lake are respectively to be determined so that the total storage capacity amounts to 390 ac. ft.

The cross sections are determined on the following bases.

- o Existing ground elevation

  As it is not clear due to lack of accurate contour map, it is assumed that the existing ground elevation in the swamps is about 0 MSL in average.

- o Estimated high-water level

  Taking into consideration the lowering of groundwater stage in the surrounding area, the normal water level is presumed at 0 MSL and the water surface is to be lowered to (-) 6 MSL by pumping at the start of rainy season. The highest high-water level in the drainage canals is to allow for 0 MSL, (+)2 MSL (within freeboard) and (+)3 MSL respectively for fifty-year, one-hundred-year and two-hundred-year return period.

- o Proposed ground elevation

  Taking into account the balancing of volumes of excavation and filling, the proposed elevation of ground is to be taken at (+)2 MSL.

- o Bottom elevation of canals

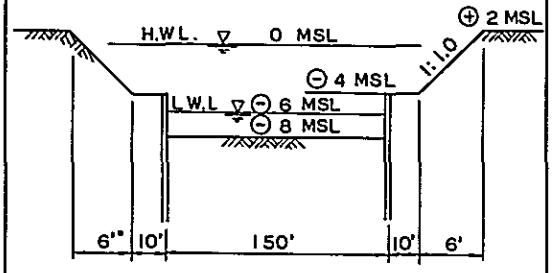
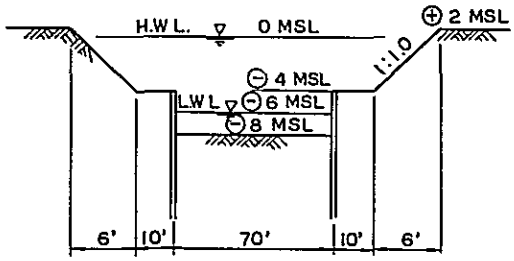
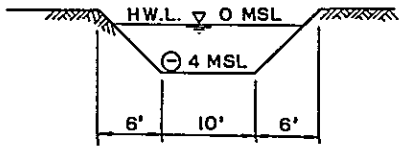
  The bottom elevation of canal is to be proposed at (-)8 MSL for the main and lateral I and at (-)4 MSL for lateral II.

The cross sections of drainage canals determined taking into account the required storage capacity of 390 ac. ft. are as follows:

2) Balance calculation of inflow and outflow

With the aid of the cross sections of flood detention facilities determined in the preceding paragraph, a capacity curve (H~V) was plotted by calculating such volumes corresponding to various water stages (Fig. II-7-4). The results of calculation made on the basis of this curve together with the hydrograph and the capacity of pump are as shown in Fig. II-8-4, and its principal factors the calculation are summarized in the following table.

For the details of balance calculation of inflow and outflow, see the volume of general plan.

	Typical cross section	Length of canal	Detention capacity
		(ft)	(ac-ft)
Main canal		10.600	240
Lateral I		12.100	146
Lateral II (catch drain)		22.600	To be on the safety side, detention capacity is not taken in to account

Total detention cap. 386 ac-ft

	Maximum inflow (cusec)	Maximum outflow (pumping capacity) (cusec)	Cumulative maximum volume of de detention water (ac. ft)	Highest impounding water level (MSL)
Estimated design rainfall (50-year return period)	1,316	200	386	0.00
Heavy rainfall (100-year return period)	1,473	200	458	1.10
Extraordinary rainfall (200-year return period)	1,630	200	563	2.05

The highest detention water level at the case of the estimated design rainfall (fifty-year return period) agrees to the estimated standard water level; and such level at the case of heavy rainfall or even of extraordinary flood is sufficiently lower than the standard water level ((+)2 MSL and (+)3 MSL, respectively), being kept almost within freeboard. That is, both the flood detention facilities and the pumping capacity are proposed on economic and adequately safe basis.

3) Quantities of earthwork and revetment work

The factors for planning determined in paragraphs 1) and 2) above are laid out on a 4-chs map which is shown as Drawing No. II-11. The quantities of earthwork, gravel, masonry and concrete revetment were calculated based on the Drawing.

The details are described in the volume of general plan, and the results of calculation are summarized in the following table.

Kind of work	Quantity
Excavation (suction dredger)	212,500 cube
Excavation (grab dredger)	21,700 "
Filling	145,300 "
Gravel	178,200 "
Rubble masonry	8,900 Sq.
Concrete revetment	45,400 ft.

(For breakdowns, see the volume of general plan).

4) Factors of pumping facility

a) Proposed capacity of pump

The proposed capacity of pump for Heen Ela is to be 200 cu. sec. which was determined as a result of economic comparison of various scales of drainage facilities.

b) Lift

The highest high-water level of the Kirillapone Canal during a flood is

(+)6 MSL at the utmost. Therefore, the maximum actual lift with a loss in the outlet pipe allowed for 1.0 ft. is,

(+)6 MSL - (-)6 MSL + 1.0 = 13 ft.

If the proposed actual lift is taken at about 80% of the maximum actual lift taking into account the fluctuation of water stages inside and outside, it becomes 10.4 ft. Presuming the loss due to suction and delivery pipes of pump and others to be about 6 ft.,

Proposed total lift = 10.4 + 6 ≒ 16 ft.

c) Number of units and bore

Four units of pump of the same bore are to be installed taking into consideration such factors as the proposed capacity of pump (200 cu. sec.), operation and handling, economy and dispersion of danger in the event of emergency. Therefore, the drainage discharge per unit of pump is 50 cu. sec. As the allowable velocity in the tube of pump is generally about 9 ft/sec., the required diameter, D is,

$$\frac{50 \text{ cu. sec.}}{\frac{\pi D^2}{4}} = 9 \text{ ft/sec.}$$

$$D \doteqdot 2.66' = 32'' \ (\phi 800)$$

Therefore, the pump for this area is proposed on the basis of $\phi 32''$ ($\phi 800$) x 4 units.

d) Class and type of pump

A mixed flow pump with horizontal shaft which is economical is to be adopted taking into account the suction head, total lift and capacity.

e) Prime mover and its capacity

From the economic and technical points of view such as initial and running costs, maintenance and supervision, operation and handling and upkeeping it is advantageous to adopt electric motor; however, in view of the electric power situation in Colombo City, especially the service disruption due to lightening and the importance of urban drainage during the rainy season, it is to be proposed to install each two units of electric motor and engine to insure the safety in emergencies.

The capacity of prime mover is computed by the following formula.

For electric motor;

$$Pm = \frac{0.163 \gamma QH (1 + 2)}{\eta p \cdot \eta t}$$

Here,

Pm : Output of motor (KW)
γ : Unit weight of water 1.0

Q : Drainage discharge (m^3/min) 50 cu.sec. ≒ 85 m^3/min.
H : Total lift 16 ft. ≒ 4.9 m
α : Allowable ratio 15%
ηp : Pumping efficiency 85%
ηt : Transmission efficiency 95%

Therefore,

$$Pm = \frac{0.163 \times 1.0 \times 85 \times 4.9 (1 + 0.15)}{0.85 \times 0.95} \fallingdotseq 96.6 \text{ (KW)}$$

The capacity of engine is found by converting the output of electric motor into horsepower.

For engine;

Pe = 1.36 x 96.6 = 131.4 p.s.

Based on the above calculation, the prime mover for this project is to be proposed as follows:

Electric motor	96.6 KW x 2 units
Engine	131.4 p.s. x 2 units

5) Tentative estimate of direct construction cost

The direct construction cost is estimated on the basis of the quantities of flood detention facilities and pumping capacity already found. The unit costs used here for various works are those supplied by the Reclamation Board and for the items to be paid in foreign currency, the unit costs prevailing in our country were converted into the international currency. Various expenditures incidental to the works were estimated referring to the I.D. Report .

The result of estimate is as shown in the following table and the total amount is about Rs. 55,000,000.

6) Area of reclaimed land

The area of marshy land lower than (+) 6 MSL in elevation in this area is 493 acres, from which 84 acres is to be reduced to use for the drainage canals with 409 acres left as reclaimable area. On this acreage an allowance should be made for the area to be taken up by the roads, sewers and other public facilities covered by the land readjustment to be carried out after the completion of land reclamation work. Judging from the actual results of the project for creating residential lots in Japan, it seems that the area available for sale is about 75% of reclaimed land. Therefore, the saleable area is 306.8 acres which constitutes the revenue from the project for the Heen Ela.

For the breakdown of acreage calculation, see the volume of general plan.

Tentative estimate of the expense necessary to be incurred for the reclamation of Heen Ela Marshes

Item	Quantity	Unit	Rate Rs.	Amount Rs.
Earth excavation in waterway, flood distention areas and using the soil for filling reclaimed land	212,500	Cube	18	3,825,000
	21,700	"	14	303,800
Gravelling the surface of the reclaimed land	178,200	"	35	6,237,000
Construction of concrete revetment along the canal banks	45,400	L.ft.	65	2,951,000
Construction of a pumping station 200 cusecs	200	cusec	7,000	1,400,000
Random rubble masonry for the canal protection	8,900	Square	250	2,225,000
Improvements of one bridge	1	Nos.	Sum.	700,000
Construction of a emergency control regulator	1	Nos.	Sum.	27,000
Land acquisition	1	No.	Sum.	1,667,000
Supervision watchers, etc.	1	No.	Sum.	210,000
Welfare accidents pay and idle pay	1	No.	Sum.	210,000
Local transport and contingencies	1	No.	Sum.	3,156,000
Setting out testing, inspections	1	No.	Sum.	210,000
Allotment and consolidation	306.8	Ac	75,000	23,010,000
Sub-total				46,131,800
Overhead for contractor				9,226,200
Total				55,358,000

5-6-5 High Level Canal

The provision of canal for high level area is an essential work to materialize the land reclamation project for the Gothatuwa and Heen Ela.

The High Level Area at present is highly developed as a residential area. The run-off water from the area is once stored in the marshy lands in Gothatuwa and Heen Ela, and is drained by gravity system into the sea after the water stage of the Kelani River has lowered or the discharge at the drain outlets of Wellawatta and Dehiwela decreased. In other words, the marshes in Gothatuwa and Heen Ela play the role of flood detention reservoir for the High Level Area. Therefore, the drainage condition in this area must not be deteriorated also after the reclamation of these marsh lands. From this point of view, the proposed canal for the High Level Area should meet a condition that any flood can be discharged into the sea faster than in any other area without permitting it to be stored in the channel. To satisfy this requirement, the

High Level Canal is to be protected with concrete revetment along its whole length and its roughness be improved so that conveyance capacity may be increased. Starting at the Dematagoda Railway Bridge to reach the drainage outlets at Wellawatta and Dehiwela, the canal are to flow exactly the routes as determined in the I.D. Report.

The most reasonable division proposed on the basis of hydraulic calculation is to be formed for both drainage outlets at Dehiwela and Wellawatta which have the largest influence on the drainage condition. A jetty is to be built to prevent any estuary closure at the Dehiwela drainage outlet which is closed at normal times. The route of the High Level Canal and the drainage system of neighbouring area are illustrated in Fig. II-9.

1) Typical cross section of canal

a) Wellawatta Canal (f–g section)

At present, the width of Wellawatta canal is about 70 feet and its widening is almost impossible because of closely crowded residential area on its both banks. As its side-slopes have broken down severly and are unstable, concrete revetment work is to be carried out. The present canal bottom elevation is about (-)2 MSL and it is proposed to dredge it to (-)4 MSL. The length of the canal is 5,600 feet.

b) Dehiwela Canal (f - h section)

This canal is proposed to make up the defficiency in the drainage capacity of the Wellawatta canal enough. At present, the section of about 10,000 feet upstream from the dividing point of the Bolgoda canal has a width of about 40 feet; however, as its right-bank side has been developed as residential site, the width is to be widened up to 80 feet toward the left-bank side. Concrete revetment work is to be constructed on both banks in order to stabilize the side-slopes and improve conveyance capacity. Although the section of about 2,000 feet downstream from the confluence with Bolgoda canal has even at present a width of 80 feet and does not need any special widening of it, the shape of its cross section is to be readjusted and concrete revetment work to be constructed.

According to the areal fluctuation of rainfall intensity, it is possible to discharge rainwater into the Weras Ganga through the Bolgoda Canal and, at the same time, its reverse flow into the Dehiwella Canal from the said lake is also possible. Therefore, a regulator preventing reverse flow is to be provided at the confluence of Dehiwela and Bolgoda Canals.

c) Kirillapone Canal (f– e section)

As the residential sites have been well developed on both banks of the canal, it is impossible to widen the cross section greatly. The present canal width of about 90 feet is to be increased to 100 feet and concrete revetment work to be constructed on both banks. The present canal bottom elevation is (-)2 MSL, and it is proposed to dredge it to (-)4 MSL.

d) Narahenpita Canal

It is a new canal to be constructed between Manning Town and the confluence with the Kirillapone Canal. For the upstream section, the existing marshes are to be dredged to utilize it as canal trace.

As the midstream section of 400 feet passes through the area near the Narahenpita Railway Station where residential site has been well developed, a canal of 50 feet in width is proposed, being infeasible to provide a large cross section. For the downstream section of 700 feet, a waterway of 100 feet in width is proposed utilizing the existing marshes.

Whole section from upper to lower stream is to be revetted. The proposed elevation of canal bed is (-)4 MSL.

e) Heen Ela Canal (c— d section)

This section is to utilize the existing marshes and a isolation bund is to be built for the Heen Ela land reclamation project. The isolation bund is proposed with the crest elevation of (+)5 MSL, crest width of 12 MSL and side-slope of 1:1.

f) Mahawatta Waterway (b — c section)

Starting at the South Lock, this canal extends for about 7, 700 feet to reach the Cotta Road. Taking into consideration the topography and the situation of development in its vicinity, the canal is proposed with the width of 100 ft for 6, 500 feet, section of upper reach and 50 feet for 1, 200 feet section of lower reach.

As this canal passes throughjthe marshy area, bunds are to be built on its both banks. The proposed elevation of their crests is (+)5 MSL and that of the canal bottom is (-)4 MSL. These levees play the role as an isolation bunds for the Gothatuwa Land Reclamation Project.

g) Dematagoda Canal (a— b section)

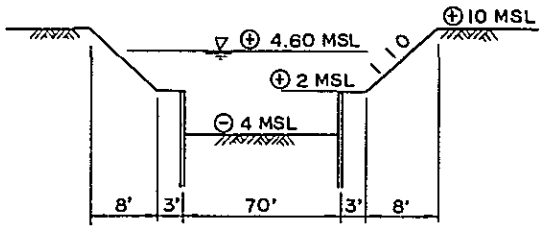
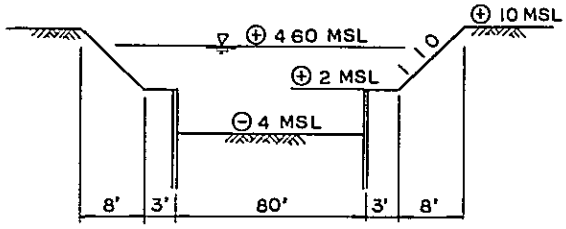
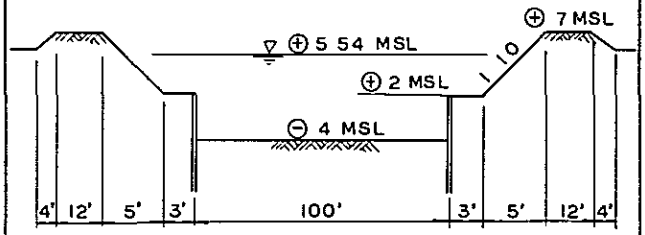
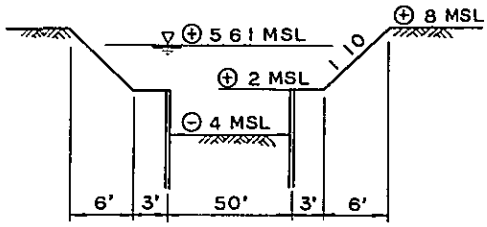
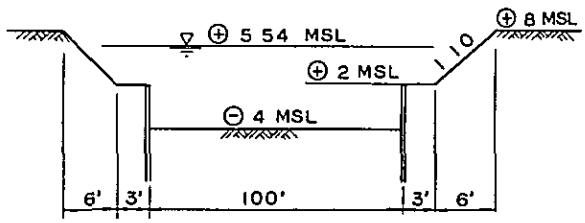
This canal starts at the Dematagoda Railway Station to extend for 5, 580 feet to the South Lock. The existing Dematagoda Canal has a width of about 100 feet which is sufficient, while the present canal bottom is to be dredged from (-)2 MSL to (-)4 MSL and concrete revetment work to be constructed.

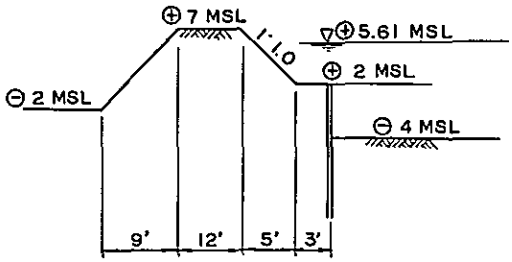
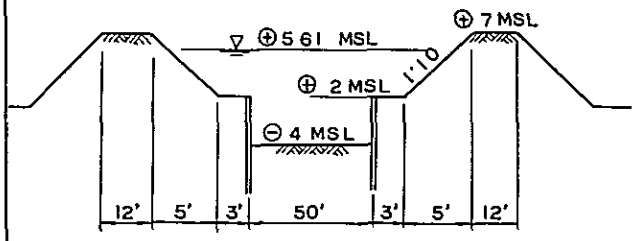
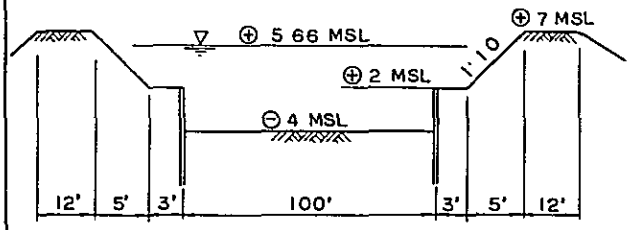
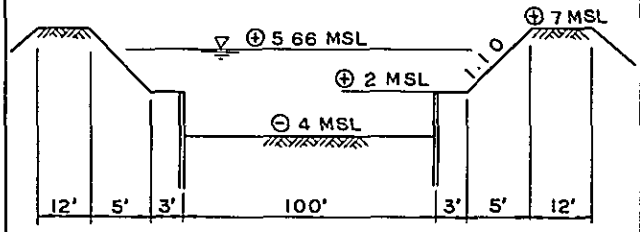
The typical cross sections of canals described in the above are shown together in the following figures.

2) Hydraulic calculation

The drain water from High Level Area is diverged into the Wellawatta Canal and the Dehiwela Canal before discharged into the sea. The proposed discharge in High Level Canal will include the drainage from Gothatuwa, namely it be added the discharge of 200 cusec equal to the pump capacity of Gothatuwa, to the peak of hydrograph of High Level Canal.

In the hydraulic calculation for a comparative study the water level at the

Name of canal		Typical cross section	Length (ft)
Wellawatta			5 612
Dehiwela			12.700
Kirillapone			3.300
Narahenpita	Upper reach		400
	Lower reach		2 200

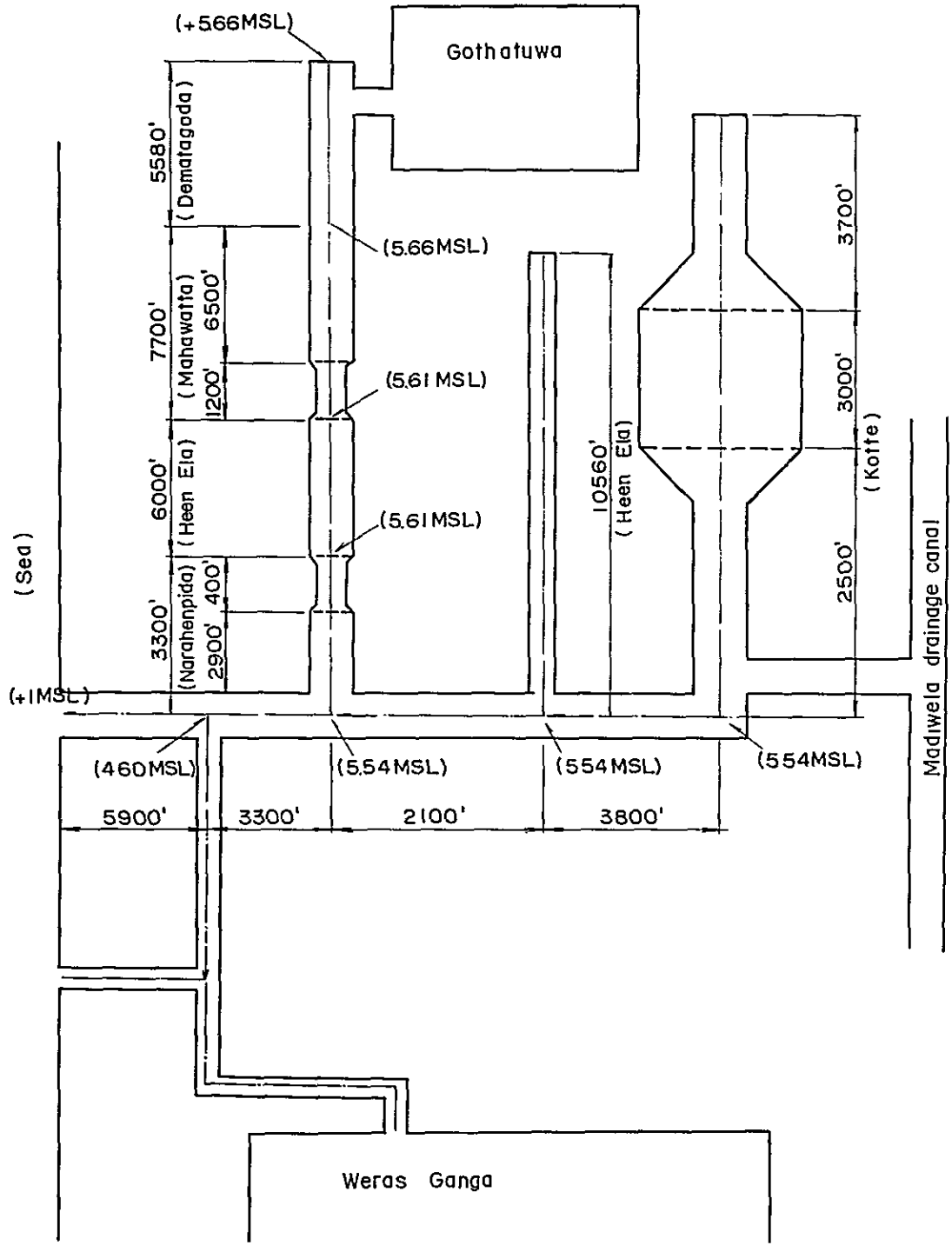
Name of canal		Typical cross section	Length (ft)
Heen eta			6.000
Mahawatta	Lower reach		1. 200
	Upper reach		6.500
Dematagoda			5.580

CALCULATION OF WATER PROFILE (M2)

Q0= 1266.00 H0= 5.54

NU	KL	GHL	H	A	P	R	N	Q	V	E	VOL	SUMVOL	J
M2-1	0.0	-4.000	5.540	1136.02	142.66	7.96	0.0250	1266.00	1.114	5.561	0.0	0.0	0
M2-2	2700.00	-4.000	5.540	1136.02	142.66	7.96	0.0250	1266.00	1.114	5.561	0.3067E 07	0.3067E 07	00000
M2-3	100.00	-4.000	5.470	522.11	82.94	6.29	0.0250	1266.00	2.425	5.571	0.8291E 05	0.3150E 07	0
M2-4	400.00	-4.000	5.528	525.77	83.06	6.33	0.0250	1266.00	2.408	5.627	0.2096E 06	0.3360E 07	0
M2-5	100.00	-4.000	5.614	1146.22	142.99	8.02	0.0250	1266.00	1.105	5.635	0.8360E 05	0.3443E 07	0
M2-6	0.0	-4.000	5.614	1146.22	142.99	8.02	0.0250	778.00	0.679	5.622	0.0	0.3443E 07	0
M2-7	6000.00	-4.000	5.614	1146.22	142.99	8.02	0.0250	778.00	0.679	5.622	0.6877E 07	0.1032E 08	0000000000
M2-8	0.0	-4.000	5.614	1146.22	142.99	8.02	0.0250	646.00	0.564	5.619	0.0	0.1032E 08	0
M2-9	100.00	-4.000	5.596	530.14	83.19	6.37	0.0250	646.00	1.219	5.621	0.8382E 05	0.1040E 08	0
M2-10	1200.00	-4.000	5.636	532.86	83.28	6.40	0.0250	646.00	1.212	5.664	0.6378E 06	0.1104E 08	00
M2-11	100.00	-4.000	5.660	1152.66	143.20	8.05	0.0250	646.00	0.560	5.666	0.8428E 05	0.1113E 08	0
M2-12	6300.00	-4.000	5.660	1152.66	143.20	8.05	0.0250	646.00	0.560	5.666	0.7262E 07	0.1839E 08	0000000000
M2-13	0.0	-4.000	5.660	1152.66	143.20	8.05	0.0250	130.00	0.113	5.660	0.0	0.1839E 08	0
M2-14	5580.00	-4.000	5.660	1152.66	143.20	8.05	0.0250	130.00	0.113	5.660	0.6432E 07	0.2482E 08	0000000000

Water-level of discharge canal in high levels area



confluence of High Level Canal and the Kirillapone Canal described in proposal 3-1 is +5.54 MSL. Therefore, the hydraulic calculation for the High Level Canal is to be made with the waterlevel at the starting point (confluence with Kirillapone Canal) set at 5.54 MSL.

For the calculation, the following formula was used.

$$h = H_1 - H_2 = Z_2 - Z_1 + \alpha\frac{Q^2}{2y}\left(\frac{1}{A_2^2} - \frac{1}{A_1^2}\right) - \frac{1}{2}\left(\frac{1}{R_1^{4/3}A_1^2} + \frac{1}{R_2^{4/3}A_2^2}\right) n^2 Q^2 \Delta X$$

Calculation using the above formula was made with the use of an-computor.

The results of calculation are shown below.

3) Earthwork and revetment work

The quantities of earthworks and revetment works were estimated on the basis of the standard cross section of canal determined in the above paragraph 1). While their breakdowns are shown in the volume of general plan, the results of calculation may be summarized as shown in the following table.

Name of waterway	Excavation (cube)	Banking (cube)	Concrete revetment (ft)	Rubble masonry (square)	Remarks
Wellawatta	7,900		11,200	1,600	
Dehiwela					
Lower reach (2,000 ft)	3,200		4,000	570	
Upper reach (10,700 ft)	68,500		21,400	3,060	
Kirillapone	7,300	4,400	6,600	480	
Narahenpita					
Upper reach (400 ft)	2,700		800	90	
Middle reach (700 ft)	2,800			160	
Lower reach (2,200 ft)	28,000		4,400	510	
Heen Ela	39,200	13,000	12,000	1,200	
Mahawatta					
Lower reach (1,200 ft)	1,200	3,900	2,400	240	
Upper reach (6,500 ft)	13,000	21,200	13,000	1,310	
Dematagoda	11,200	18,200	11,200	1,120	
Total	185,000	60,700	87,000	10,340	

4) Dehiwela Jetty

At present the Dehiwela drain outlet is normally in a almost closed condition due to sand bar formation, while it is said that the sand-bar is easily flushed in the event of flood so that no flow obstruction may not be caused. Therefore, it is believed that its function can be satisfactorily filled without proposing any special work to improve the estuary; but that the estuary is normally closed is not desirable for the maintenance of the drainage canal especially because of the sedimentation of silt.

In view of the importance of the role which the Dehiwela and Wellawatta drain outlets play for the drainage of the entire Colombo Area including the Land Reclamation Project, a jetty is to be built to keep the estuary constantly in the same good condition as that of the Wellawatta drain outlet. The volume of jetty is to be about 6,000 cube.

5) Wellawatta-Dehiwela Division scheme

All drained water from the High Level Canal and the catchment area of Gothatuwa, Kotte, Heen Ela and Madiwela is discharged into the sea at the Wellawatta and Dehiwela drain outlets through the Kirillapone canal. At present the Wellawatta of course constitutes the main drain outlet, but as the Dehiwela canal and its outlet are to be improved in the project, the dividing of drainage water to both outlets should be proposed most reasonably taking the hydraulic condition into account.

The aggregate peak outflow from the four catchments is 1,935 cusec (see the hydrological analysis) and the length of canal from the dividing point to the estuary is;

Wellawatta:	5,612 ft.
Dehiwela:	12,700 ft.

A ratio of discharge which will produce the same hydraulic heads in the above sections of both canals were calculated. The result is as follows:

Mahawatta: Dehiwella = 1,095 cusec : 840 cusec

= 56.6% : 43.4%

In calculating this dividend ratio the discharge into Weras Ganga was left out of consideration. However, if the drainage into Weras Ganga is possible through the Bolgoda canal, the discharge into Dehiwela outlet will increase and this seems to cause the dividend ratio to change substantially. (For the details of the hydraulic calculation, see the volume of general plan).

6) Aquisition of land

In providing the High Level Canal, considerable area of land should be purchased for constructing new canal and for substantially widening the cross sections of the existing canals. The breakdowns of the land area to be acquired is shown in the following table.

Name of canal	Breakdown	Area
Dehiwela Canal Section 2	40 ft x 10700 ft	428,000 ft^2
Kirillapone Canal	10 x 3300	33,000
Narahenpita Canal	(50+9x2) x 400	27,200
	(100+9x2) x 2200	259,600
Mahawatta Canal (50 ft width portion only)	(50+23x2) x 1200	115,200
	Total	863,000 ft^2
		= 3,200(parch)

7) Tentative estimate of direct construction cost

The direct construction cost was computed on the basis of the quantities of earthworks and revetment works already calculated. The unit costs of various works are those supplied by the Reclamation Board, and for the items to be paid in foreign currency their unit costs prevailing in our country were converted into international currency.

As regards various expenditures incidental to the works, they were calculated referring to the I.D. Report. The results of estimates are shown in the following table, with the total amount being about Rs. 34,000,000.

Tentative estimate of the expense necessary to be incurred for the construction of the High Level Canal from Dematagoda to Wellawatta.

Item	Quantity	Unit	Rate Rs	Amount Rs
Item I				
Canal from regulator on railway bridge to South Lock				
Clearing of Low Jangles and shrub on the canal banks			Sum	2,500
Earth excavation of the canal bed for deepening	11,200	Cube	18	201,600
Earth filling on the canal banks	(18,200) 7,000	Cube	23	161,000
Construction of concrete revetments along the canal banks	11,200	L.ft.	50	560,000
Rundom rubble masonry for the canal protection	1,120	square	250	280,000

Item	Quantity	Unit	Rate Rs	Amount Rs
Item II Canal from South Lock to Cotta Road				
Clearing of low jungle and shrub on the canal trace			Sum	7,500
Earth excavation of the canal bed for deepening	14,200	Cube	18	255,600
Filling of the canal banks	(25,200) 11,000	Cube	23	253,000
Bridge on the Cotta Road	1	Nos.	Sum	217,000
Rundam rubble masonry	1,550	Squ.	250	387,500
Concrete revetments on the canal banks	15,400	L. ft.	50	770,000
Item III Canal from Cotta Road to Manning Town				
Clearing of low jungle and shrub on the canal trace			Sum	7,500
Earth excavation of the canal	39,200	Cube	18	705,600
Filling of the bund	(13,000) 0	Cube	23	0
Rundam rubble masonry	1,210	Square	250	302,500
Bridge on Mahawatta Road	1	Nos.	Sum	338,000
Concrete revetments on canal banks	12,000	L. ft.	50	600,000
Item IV Canal from Manning Town to Kirillapone Canal				
Clearing of low jungle and shrub on canal trace			Sum	5,000
Earth excavation of the new canal	30,700	Cube	14	429,800
Earth excavation of the lake	2,800	Cube	18	50,400
Concrete revetment along the canal banks	5,200	L. ft.	50	260,000
Rundam rubble masonry	760	Square	250	190,000
Bridge on Milk Board Road and Nawala Road	2	Nos.	Sum	675,000

Item	Quantity	Unit	Rate Rs	Amount Rs
Item V Canal from Narahenpita Canal to Dehiwela Canal				
Earth excavation of the canal for deepening	7,300	Cube	18	131,400
Filling of the banks	(4,400) 0	Cube	23	0
Concrete revetments on canal banks	6,600	L. ft.	50	330,000
Rundam rubble masonry	480	Square	250	120,000
Bridge on Mavata Road	1	Nos.	Sum	275,000
Railway bridge	1	Nos.	Sum	275,000
Construction of a control regulator	1	Nos.	Sum	89,000
Item VI Canal from Dehiwela Canal to Sea				
Earth excavation of the canal bed for deepening	7,900	Cube	18	142,200
Concrete revetments of the canal banks	11,200	L. ft.	50	560,000
Rundam rubble masonry	1,600	Square	250	400,000
Improvement of 2 Nos. bridges	2	Nos	Sum	550,000
Item VII Dehiwela Canal				
Earth excavation of the canal bed for for deepening and widening	71,700	Cube	18	1,290,600
Concrete revetments of the canal banks	25,400	L. ft.	50	1,270,000
Rundam rubble masonry	3,630	Square	250	907,500
Improvement of 6 Nos. bridges	6	Nos.	Sum	1,650,000
Construction of jetties at the mouth of Dehiwela Canal			Sum	2,940,000
Construction of a control regulator	1	Nos.	Sum	33,000
Item VIII General Charge				
Acquisition of private lands in the canal and bund reservation	3,200	parch	300	9,600,000
Supervision and watchers, etc.			Sum	187,000

Item	Quantity	Unit	Rate Rs.	Amount Rs.
Welfare accident pay, idle pay etc.			Sum.	187,000
Setting out, testing and inspection etc.			Sum.	187,000
Local transport and contingencies			Sum.	800,000
Sub-total				28,584,200
Overhead for contractor				5,716,800
Total				34,301,000

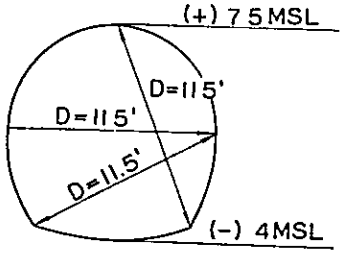
5-6-6 Madiwela Diversion Scheme

The Madiwela diversion scheme is very closely related to the land reclamation project for the South Colombo and has such an important bearing on the latter project that affects on its success or failure. Various proposals were worked out to select the route for the diversion and after the detailed comparative study was made, the short cut that excavates a tunnel along the route of Old Moat at Pitta Kotte to connect to the Kirillapone Canal, was finally adopted as the most advantageous one both economically and technically.

As already described, the bulk of the vast flat part of the Madiwela Catchment Area is the paddy field and there is no public facility as such whatever, not to speak of any hamlet. Therefore, the estimated design rainfall to be adopted for the project in this catchment area is the fifteen-year return period according to the criteria for paddy field drainage. This means that one or two occurrences of flood are anticipated during one generation of cultivation. Furthermore, based on the facts that the majority of hamlets in the catchment area are scattered over the ground of 10. MSL or more in elevation and that any inundation of paddy for few days are permissible although the yield will decrease somewhat, it is to be proposed with the allowable level of inundated water in the catchment area taken at 7. MSL.

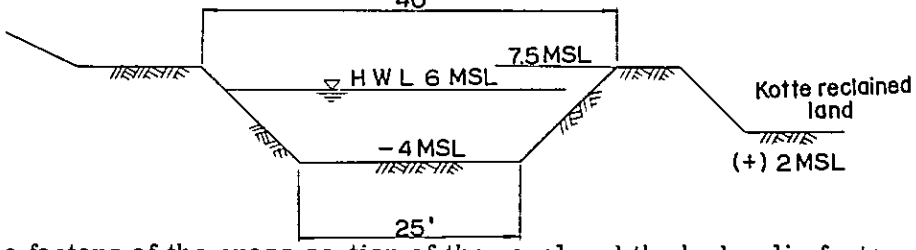
1) Cross Section of Diversion Tunnel

The standard horseshoe cross section of 3.5 m (11.5 ft.) in diameter is to be adopted taking into consideration the allowable level of inundated water (7 MSL) in the catchment area and the anticipated highest flood level of the Kirillapone Canal. While it is not possible to make any conclusion due to the lack of geological data, the excavation of tunnel seems to be conducted through silt and clay under a great deal of ground water. Therefore, in exavating the tunnel, sufficient timbering is to be provided and concrete lining be applied to the entire cross section. The typical cross section of tunnel is as shown below.



2) Cross section of link canal

A link canal is to be built from the outlet of the tunnel along the hill of Kotte to connect to the Kirillapone canal. The typical cross section of the canal is determined as follows taking into account the highest flood level of the Kirillapone canal and the run-off from the Madiwela catchment area.



The factors of the cross section of the canal and the hydraulic factors are as shown below.

Bottom width of canal	25'
Length of canal	3,934'
Gradient of side-slope	1 : 1.0
Crest height	7.5 MSL
Bottom elevation	(-) 4 MSL
Maximum discharge	450 cusec.
Hydraulic head	0.25'

As the use of this canal will be made very infrequently, the side-slopes are protected with turfing.

3) Hydraulic Calculation

a) Tunnel Flow Capacity Curve

When the conveyance capacity of tunnel becomes insufficient, the water level of Madiwela is caused to rise and there is a possibility that it exceed (+)7 MSL of the allowable inundated water level. Therefore, the calculation of inflow and outflow is to be conducted to examine the size of tunnel cross section and the inundated water level of Madiwela Although it is believed that the tunnel will not be in a full flow condition judging from its elevation, the formula of invested siphon is used presuming such condition, in order to be on the conservative side. Thus;

$$\Delta H = \frac{8}{n^2 g}\left(1 + fo + \Sigma fb + f\frac{L}{D}\right)\frac{Q^2}{D^4}$$

in the above,

ΔH : Water level difference between inlet and outlet of tunnel (m)
fo : Coefficient of inflow loss 0.5
fb : Coefficient of curve loss 0
f : Coefficient of friction loss, if,n = 0.015, f = 0.01842
D : Diameter of tunnel 3.5 m
L : Length of tunnel 396.5 m
Q : Rate of discharge m^3/sec

While the proposed cross section of the tunnel is of the standard horse-shoe type, it is deemed to be of a round shape to simplify the calculation.

Therefore, the above formula with respective values substituted for is as follows:

$$H = 0.00198\ Q^2$$

By plotting this correlation on a graph, the curve of tunnel flow capacity can be obtained. The result is as shown in Fig. II-10.

b) H - Q curve at the outlet of tunnel

In calculating the volume of inflow and outflow, the fluctuations of water levels in the tunnel and at its outlet must be estimated. Earlier, when the comparison of various drainage systems was made, the hydraulic calculation was carried out with different combinations of discharge from the respective areas. The calculation data used for the above study was employed to obtain the water level and discharge curve (H–Q) at the outlet of tunnel. The result is as shown in Fig. II-11.

c) H - V curve of Madiwela Area

For the correlation between the inundated water level and the storage capacity in the Madiwela catchment area, the curve shown in the I.D. Report is used intact as there is no minute contour map. It is illustrated in Fig. II-12.

The calculation of inflow and outflow was made with the aid of the curves obtained in a), b) and c) above and the hydrograph found by the hydrological analysis.

The results are as shown in Fig. II-8. The principal factors of the results calculated are summarized in the following table.

	Maximum inflow (cusec)	Maximum outflow (cusec)	Cumulative maximum detention capacity (ac. ft)	Highest inundated water level (MSL)
Estimated design rainfall (15-year return period)	5,802	460	9,520	6.80
Heavy rainfall (100-year return period)	8,345	640	12,790	7.80
Extraordinary rainfall (200-year return period)	9,233	685	14,897	8.40

4) Quantities of earthwork and others

The quantity of earthwork is calculated on the basis of the proposed factors determined in the preceding paragraph. The breakdowns of the earthwork quantity are as shown in the volume of general plan, and they are summarized in the following,

Excavation (grab dredger)	8,000 cube
Banking	5,000 cube

The embankment is provided with turfing over the area of 300 Sq. The total length of excavation of tunnel is 1, 300 ft.

5) Land acquisition

The land must be purchased to construct the link canal from the outlet of tunnel to connect to the Kirillapone canal. The details of area calculation are as shown in the volume of general plan, and it needs to purchase 21 acres.

6) Direct construction cost

The unit cost of tunnel construction in Japan is Rs. 1,270/ft. for silt and clay excavation tunnel with the cross section of standard horseshoe type of D = 11.5 ft.(13.5 m). The cost of earthwork can be calculated in the same may as other areas. The results of estimate are shown in the following table, and the total amount is about Rs. 4,000,000.

Tentative estimate of the expense necessary to be incurred for diversion of Madiwela Catchment to Kotte

Item	Quantity	Unit	Rate Rs.	Amount Rs.
Clearing of light jungle and shrub on the canal trace	1	set	Sum.	30,000
Earth excavation in new canal from Madiwela to Kotte and forming bunds on both banks	8,000	cube	18	144,000
Turfing on the bund slope of canal from Madiwela to Kotte	1,300	square	9	11,700
Acquisition of land for canal traces bunds structures, etc.	722	parch	300	216,000
Supervision and watchers, etc.			Sum.	300,000
Welfare, accident pay, holiday pay etc.			Sum.	300,000
Setting out, testing inspection, etc.			Sum.	300,000
Local transport and contingencies			Sum.	90,000
Construction of tunnel				1,950,000
Sub-total				3,342,300
Overhead for contractor				668,500
Total				4,010,800

5-7 Annual Expenditure

The annual expenditure needed to maintain the completed project, as well as the direct construction cost estimated in paragraph 5-6 above, are an important factors which affect the financial soundness of this project. The items that account for large percentages of the annual expenditures of the project are the operating cost of pumping facilities, supervising cost of regulating sluice and desilting work for maintaining the drainage canal and detention lake.

5-7-1 North Colombo

The mean total annual precipitation of 1965 - 1969 obtained from the observation data is about 99.5 ≒ 2,500 mm. If the mean coefficient of annual run-off is presumed to be about 60%, the annual volume of run-off can be estimated as follows:

$$V = r \cdot f \cdot A$$

In the above formula,

V : Volume of run-off (m^3)
r : Precipitation (m)
f : Coefficient of run-off 0.60
A : Catchment area (m^2)

Therefore,

$$V = 2.5 \times 0.6 \times \left(\frac{700 \text{ ac.} + 1150 \text{ ac.}}{247.1} \times 10^6 \right)$$

$$= 12.23 \times 10^6 m^3$$

This is converted into the mean annual flow as follows:

$$Q = 12.23 \times 10^6 m^3 / 365 \text{ day} \times 86,400 \text{ sec.} = 0.388 \ m^3/\text{sec}$$

If the total head is presumed to be 6.5 m,

mean annual needed output is:
$P = 9.8 \times 0.388 \ m^3/\text{sec} \times 6.5 m = 24.7 \text{ KW} \quad 34 \text{ ps.}$

annual needed power is:
$W = 34 \text{ ps} \times (365 \times 24) \text{ hr} = 297,840 \text{ ps.hr.}$

As the total proposed power of pumps is about 300 ps x 4 units = 1,200 ps,

annual operating time of pumps is:
$T' = 297,840 \text{ ps.hr.} / 1,200 \text{ ps.} = 248 \text{ hr.}$

If 52 hrs. are allowed for "break-in operation" for regulating the engines,

annual operating time is:
T = 300 hr.

a) Estimation of Annual Operating Cost of Pump

- Fuel cost

  The total output of engines is 1,200 ps., the fuel consumption per 1 ps. per 1 hr. is 0.25 / ps.hr., and the rate of disoline indicated by the Reclamation Board is Rs. 1.66/gal.

Therefore, the annual cost of fuel consumed is:

$$\frac{1.66 \text{Rs./gal.}}{4,546} \times 1,200 \text{ ps.} \times 0.25 \text{ /ps.hr.} \times 300 \text{ hr.} \fallingdotseq \text{Rs. } 33,000$$

o Personnel expenses

Four persons in total, that is two operators and two watchmen are to be employed.

Operator	2 person x 250 Rs./month x 12 month =	6,000 Rs.
Watchmen	2 person x 200 Rs./month x 12 month =	4,800 Rs.
	(Total)	Rs.10,800

o Upkeeping material cost

If the mean monthly cost is presumed to be Rs. 400, the annual cost is:

400 x 12 = Rs4,800

Summing up the above figures, the operating, maintenance and supervising costs of the pumping facilities are Rs. 48,600.

b) Desilting Expenses of Drainage Canals in the Catchment Area

Since the success or failure of this project depends on the maintenance and supervision of drainage canals in the catchment area, these canals must be constantly maintained in good condition even at a huge cost. Although various experimental equations are available to estimate the annual volume of sedimentation in the drainage canals, they are not quite reliable in that the results of calculation varies sharply due to many assumptions attached thereto. Therefore, taking into consideration the vegetable growing condition, topography and soil texture in the district, it is presumed empirically that the annual volume of sedimentation will be about 700 m^3/km^2. year = 1.0 cube/ac. year. Accordingly, the annual volume of sedimentation can be estimated as follows:

1.0 cube/ac. x 1,850 ac = 1,850 cube/year.

As the desilting cost is 18 Rs/cube, the annual maintenance cost of draomage canal is,

1,850 cube x 18 Rs/cube = Rs. 33,300

The annual expenditure of the North Colombo district calculated from the above figures is Rs. 81,900.

5-7-2 Gothatuwa

As the precipitation of this district is the same and there is no great difference in the unit capacity per acre of pump as compared with those of the North Colombo, the operating time of pump may well be reckoned to be 300 hours as in the later.

a) Annual Operating Cost of Pump

The total output of engines is 131.4 x 4 ≒ 526 ps., fuel consumption per 1 ps. per 1 hr. is 0.25 /ps.hr. and the price of disoline indicated by the Reclamation Board is Rs. 1.66/gal. Therefore, the annual fuel cost is,

$$\frac{1.66 \text{ Rs./gal.}}{4,546} \times 526 \text{ ps.} \times 0.25 \text{ /ps.hr.} \times 300 \text{ hr.} \fallingdotseq \text{Rs. } 14,500$$

o It is believed that the personnal expenses and the upkeeping material cost are of the same level as that (Rs. 15,600) of the North Colombo district. Therefore, the operating, maintenance and supervising costs of the pumping station is Rs. 30,000.

b) Dredging Expenses of Drainage Canals in the Region

The annual volume of silting in the canal is estimated at about 700 m^3/km^2 year ≒ 1.0 cube/ac. year in the similar way as in the North Colombo district. The annual volume of silting of this district is,

1.0 cube/ac. year x 1,352 = 1,352 cube/year.

As the rate of desilting is 18 Rs. /cube, the annual maintenance cost of drainage canal is,

1,352 cube/year x 18 Rs./cube ≒ Rs. 24,300

The annual expenditure calculated from the above figures is Rs. 54,300.

5-7-3 Hean Ela

a) Annual Operating Cost of Pump

As the pump capacity is quite the same as that in the Gothatuwa the annual operating cost of pump is estimated at Rs. 30,000 in the same way.

b) Dredging of Drainage Canal in the District

The annual volume of silting is estimated in the same way as for the North Colombo, thus:

1.0 cube/year x 1,140 ac.= 1,140 cebe/year

Therefore, the annual maintenance cost is,

1,140 cube/year x 18 Rs./cube ≒ Rs. 20,500

For the Heen Ela, the annual expenditure calculated from the above figures is Rs. 50,500.

5-7-4 Kotte

As the precipitation of this district is the same and there is no great difference in the unit capacity per acre of pump as compared with those of the North Colombo, the operating time of pump may well be reckoned to be 300 hours as in the latter district.

a) Annual operating cost of pump

- o Fuel cost

  The total output of engines is 163.2 ps x 4 units = 652.8 ps., the fuel consumption per 1 ps, per 1 hr. is 0.25 /ps.hr, and the price of disoline indicated by the Reclamation Board is Rs. 1.66/gal.

  Therefore, the annual cost of fuel consumed is:

  $$\frac{1.66\,\text{Rs./gal.}}{4.546} \times 652\ \text{ps.} \times 0.25\ \text{/ps.hr.} \times 300\ \text{hr.} = \text{Rs. } 18,000$$

- o The personnal expenses and the upkeeping material cost are deemed to be of the same level (Rs. 15, 600) as those of the North Colombo district.

  Therefore, the operating, maintenance and supervising costs of pumping station is Rs. 33, 600.

b) Dredging expenses of drainage canals in the district

The annual volume of silting is estimated at about 1.0 cube/ac. year in the same way as in the North Colombo. The dredging cost for the annual volume of silting in this district is,

1.0 cube/ac. year x 1, 454 ac. x 18 Rs./cube = Rs. 26, 000

The annual expenditure of the Kotte derived from the above calculation is Rs. 59, 600.

5-7-5 High Level Area and Madiwela Catchment Area

In both areas as well, the principal maintenance and supervision is concerned with the drainage canals. The annual dredging cost is estimated as follows in the same way as in the North Colombo.

For high level area;

1.0 cube/ac. year x 3, 450 ac. x 18 Rs./cube = Rs. 62, 100

For Madiwela catchment area;

1.0 cube/ac. year x 12, 160 ac. x 18 Rs./cube = Rs. 218, 900

5-7-6 Summarization of Annual Expenditures

In the above paragraphs, the annual expenditures of the principal facilities were calculated by districts. However, the expenses to maintain and supervise the regulating sluices and such costs for maintaining culverts, brdiges, revetment works and other various drainage facilities should be taken into account for all districts. Therefore, the annual expenditures calculated already by districts are added with the allowance of about 30% to determine their final amounts as follows:

Name of District	Annual expenditure (Rs.)
North Colombo	106,000
Gothatuwa	71,000
Heen Ela	66,000
Kotte	77,000
High Level	81,000
Madiwela	285,000
Total annual expenditure	Rs. 686,000

CHAPTER 6. PROPER AMOUNT OF INVESTMENT

6-1 Allocation of Construction Cost

The construction of High Level Canal and the diversion scheme for the Madiwela Catchment are not the land reclamation project itself but are the works merely needed for isolating the reclamation project areas. Therefore, the costs of these works should be shared by those reclaimed areas that receive the benefits from the said works. Various methods are conceivable for the allocation of such construction works, but a method conforming to the benefit method is to be employed due to lack of adequate data. That is, the works will be allocated among the reclamation project area in proportion to each gross revenue from the sale of reclaimed land respectively.

The direct construction costs and the annual maintenance and supervision expenditures of the High Level Canal and the diversion project of the Madiwela Catchment area are as follows:

Kind of Work	Direct construction cost	Annual maintenance and supervision exps.
High Level Canal	34,301,000 Rs	81,000 Rs
Madiwela diversion	4,011,000	285,000
Total	38,312,000	366,000

6-1-1 Cost Allocation of Drainage Canal in High Level Area

Seeing from the existing system of drainage canals, it cannot be said that the North Colombo is completely separated from the damage due to run-off water from the High Level Area, but the inflow from the South Colombo can be prevented by closing the proposed Dematagoda regulator or the South Lock.

Therefore, the North Colombo land reclamation project can be materialized without the construction of High Level Canal.

From the above standpoint, the construction cost of new drainage canal in the High Level Area should be shared by the Gothatuwa, Heen Ela and Kotte which receive the most strong influence directly and indirectly from the said canal construction and of which land reclamation projects cannot be materialized without it. In proportion to the benefits which these areas receive from it, the shares of these costs allocated to the three areas are as follows:

Name of area	Saleable area	Per cent of benefit (%)	Allocation of direct construction cost	Allocation of annual maintenance expenditure
Gothatuwa	437.3	39.8	13,652,000	32,000
Heen Ela	306.8	27.9	9,570,000	23,000
Kotte	353.8	32.3	11,079,000	26,000
Total (Drainage canal of High Level Area)	1,097.9	100	34,301,000	81,000

6-1-2 Cost Allocation of Madiwela Diversion

Although indirectly all the areas covered by the land reclamation project are influenced by the run-off from the Madiwela Catchment, the land reclamation projects except that of the Kotte can be materialized without the diversion scheme. Because, if the flood run-off from the Madiwela Catchment is discharged from the Battaramulla Bridge point, through Kotte Lake and the Kirillapone Canal, into the sea, three areas except the Kotte will be entirely isolated from the said catchment area.

From the above viewpoints whole of the cost for the Madiwela diversion should be born by the Kotte.

6-2 Total Construction Cost by Reclamation Project Area

The shares of expenditures of the High Level Canal and the Madiwela diversion scheme determined in the preceding paragraph were added to the direct construction costs and the direct annual maintenance expenditures to calculate the total construction cost and the total annual maintenance expenditure for each land reclamation project area, as shown in the following table.

Districts	Total construction cost			Total annual maintenance expenditure		
	Direct cost	Allotted cost	Total	Direct expenditure	Allotted expenditure	Total
North Colombo	65,008,000		65,008,000	106,000		106,000
Gothatuwa	69,616,000	13,652.000	83,268,000	71,000	32,000	103,000
Heen Ela	55,358,000	9,570,000	64,928,000	66,000	23,000	89,000
Kotte	60,815,000	11,079,000 4,011,000	75,905,000	77,000	26,000 285,000	288,000
Total			297,998,000			686,000

6-3 Revenue from the Land Reclamation Project

6-3-1 Indirect Revenues

While the main object for the present project area is originally to reclaim land, the project has an important meaning as a phase of the urban drainage improvement scheme in the entire Colombo Metropolitan Districts, which including the project area has suffered severe damages from flood year by year, and the alleviation of such damages will result in the improvement of urban environment and should be highly appraised as the indirect social and economic revenues of the project. However, it is extremely difficult to estimate the amount of indirect revenues of the project because any adequate data are not available to evaluate quantitatively the total annually amount of flood damages and the improvement in urban living after the completion of reclamation project. For reference, the expenditure for flood relief work in the Colombo Metropolitan District is as shown in the following table.

Year	Expenditure for flood relief
1963 ~ 1964	497,900
1964 ~ 1965	not available
1965 ~ 1966	229,390
1966 ~ 1967	702,637
1967 ~ 1968	720,180

The amounts shown in the above table are only those paid by the government for flood relief and are not the total amounts of flood damages. It is very difficult to estimate the latter; but judging from the fact that these amounts are said to be about 5 ~ 10 times of the relief amounts shown in the above table, the total amount of flood damages suffered are believed to be Rs. 2,000,000 ~ Rs. 7,000,000 per year.

In any case, as it is very difficult to estimate the indirect revenues, above-mentioned, these revenues are not taken into account in appraising the economic effects of the project in order to be on the conservative side.

6-3-2 Direct Revenue

The yields from the sale of land to be reclaimed after the completion of works are the direct revenues of the project which constitute the important factor that decides the success or failure of the project. The following are the direct revenues shown by land reclamation projects.

Project	Area of reclaimed land	Unit sale price Rs/ac.	Direct revenue $x10^3$Rs
North Colombo	324.5 (ac)	560,000	181,720
Gothatuwa	437.3	320,000	139,936
Heen Ela	306.8	320,000	98,176
Kotte	353.8	320,000	113,216
Total	1,422.4		533,048

6-4 Proper Amount of Investment and Efficiency of Investment

6-4-1 Interest on the Construction Fund

The interest accruing on the construction fund invested during the construction period is calculated by the following formula.

$$I = 0.4 \gamma T$$

In the above,

I : Interest on construction fund invested
γ : Mean rate of interest 7.5%
T . Term of loan

Namely,

$$I = 0.03T$$

6-4-2 Depreciation Rate of Drainage Facilities

For the depreciation of drainage facilities, the fixed installment method is used with the reciprocal of durable years taken and the residual value of 10% allowed for. The principal drainage facilities include the pumping equipment, sluices, culverts, concrete revetment, bridges and others and the mean durable years of these facilities is 20 years. The depreciation rate is calculated as follows:

$$E = (1 - 0.10)/20 = 0.045$$

6-4-3 Estimate of Proper Amount and Efficiency of Investment

The proper amount of investment is "the amount of mean annual net revenues capitalized at the prescribed rate of interest, for the durable years of facilities" and is calculated by the following basic formula.

$$\text{Proper investment} = \frac{(\text{mean annual gross revenue}) - (\text{annual expenditure})}{(\text{interest rate} + \text{depreciation rate}) \times (1 + \text{interest on construction fund})}$$

The mean annual gross revenue is found by dividing the revenue from the sale of reclaimed land by the number of years which takes into account the period of construction as well as the period needed for land readjustment and sale of land.

Project	(A) Mean annual gross revenue	(B) Annual expenditure	(C) C = A - B	(D) D = (interest rate + depreciation rate) x (1 + interest on construction fund)	(E) E = C/D Proper investment	(F) Total construction cost	(G) G = E/F Investment efficiency
North Colombo	181,720,000 6.84 = 26,567,000	106,000	26,461,000	0.145	182,996,000	65,008,000	2.8
Gothatuwa	139,936,000 8.76 = 15,974,000	103,000	15,871,000	0.152	104,762,000	83,268,000	1.3
Heen Ela	98,176,000 6.83 = 14,374,000	89,000	14,285,000	0.145	98,859,000	64,928,000	1.5
Kotte	113,216,000 7.99 = 14,170,000	388,000	13,782,000	0.149	92,681,000	75,905,000	1.2

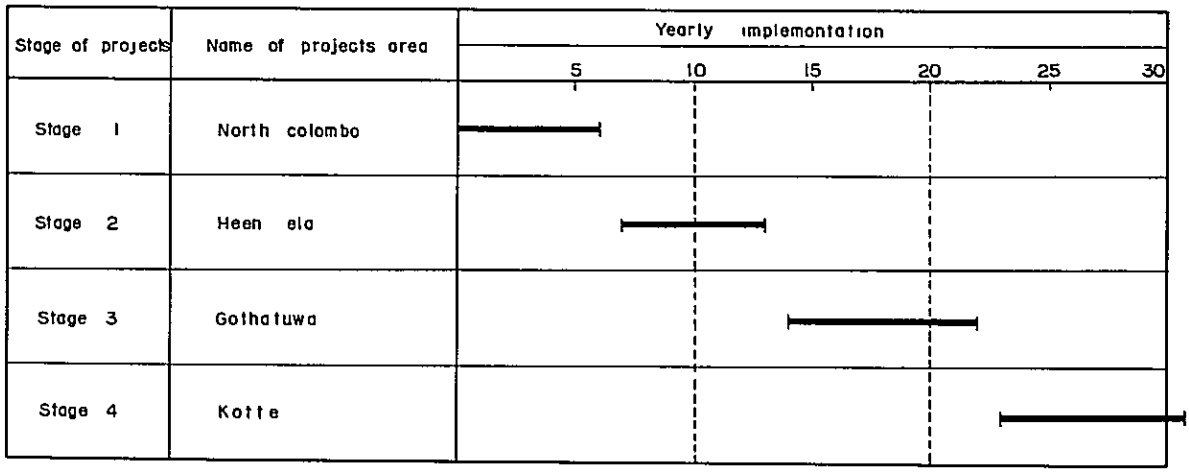
CHAPTER 7. IMPLEMENTATION OF PROJECTS

71- Staging of Projects

The present special Act of the Reclamation Board stipulates that the construction fund for land reclamation project shall be borrowed in the form of bank loan guaranteed by the government and be limited to Rs. 60,000,000 in its aggregate amount. Therefore, in view of their construction costs it is impossible to start the works for all projects simultaneously; and the projects are to be implemented as far as feasible within the limitation of borrowing so that the yields from the sale of reclaimed land after completion can be used to reimburse the loan.

The chart shown below is a staging for the implementation of the project prepared, taking into consideration the turn-round of construction fund, the priority of projects determined in the preceding paragraph and the construction period in which the prescribed efficiency of investment can be achieved.

In preparing the tentative staging of projects, the quantity of works per year was presumed to be Rs. 9,500,000.



7-2 Construction Plan and Phasing of Reclamation Works

7-2-1 North Colombo

According to the staging of works described in the preceding paragraph, the construction period for the North Colombo is six years. In the first year, the work on the Dematagota regulator which is needed to isolate North Colombo Area is to be constructed by the half-closing method of the river during the dry season. In this area, in view of the restricted borrowing of construction fund, the works in the Urugodawatta area where the higher efficiency of investment can be attained are to be completed first and a part of the gross revenue from the sale of reclaimed land is to be allotted to the construction fund for the remaining Mutwal Area. The works on the pumping station is started subsequent to the isolation of the area, and the dredging and the filling are carried out with the suction dredger disposing any flood in the area during construction period.

The works on the connecting culvert under the Prince of Wales Ave. and the sluice are to be started after the completion of works in the Urugodawatta. Further, the dredging and the filling in the Mutwal Area are to be undertaken after the Mutwal Tunnel has been restored and the disposing of flood during the construction period made possible.

7-2-2 Heen Ela

The limited construction period for this area is six years under the work staging. The works on the middle reach of High Level Canal should be started in the first year to isolate the project area.

After the area has been perfectly isolated, the pumping station and emergency sluice are to be built to dispose any flood and to regulate the water level in the area as desired during construction period, so that the dredging and the filling can be carried out with ease. As the total construction cost for this area exceeds slightly the borrowing limit imposed by the Reclamation Board, the insufficiency is to be met with a part of the net profit derived from the completion of works in the North Colombo. The dredging of drainage canals and the reclamation of marshes in the area are performed with the suction dredger, and the dredging of High Level Canal and the embankment work are carried out with a grab dredger.

7-2-3 Gothatuwa

For isolating the Project Area, the works on the isolation bunds and the upper reach of High Level Canal are practiced in Phase 1. Just before or after the completion of works in Phase 1, the works on the pumping station and the emergency sluice is to be started to complete them in a short period as possible. Thus the disposing of flood can be adequately carried out and the water level in the area regulated as desired during the construction period, so that a favorable condition can be provided to use the suction dredger for dredging and the filling in the area.

As the total construction cost exceeds the borrowing limit imposed by the Reclamation Board, a part of net profit to be expected from the project of the North Colombo is appropriated to those works and, on the other hand, it should be endevored to reduce the period of reclamation work and to sell the reclaimed land as soon as possible.

7-2-4 Kotte

In Phase 1, the works on tunnel and link canal included in the Madiwela Diversion Scheme to isolate the project area are implemented together with those on the regulator near the Battaramulla Bridge in the north end of Madiwela Catchment, to complete the isolation of the project area. Subsequently, the works on a series of drainage canals such as those on the Kirillapone Canal, Wellawatta and Dehiwela drainage canals, Dehiwela Jetties and regulator are practiced in Phase 2.

After the completion of works in Phase 2, a series of works on the pumping station, emergency sluice as well as dredging and filling are executed in Phase 3. The staging of projects described in the preceding paragraph, and the phasing of construction works are summarized in the following table.

Staging of works	Work planning	Name of work
Stage 1.	Phase 1.	1. Works on regulator and pumping station
North Colombo	Urugodawatta Area;	2. Dredging, filling and land surface dressing
	(land reclamation)	3. Work on revetment
		4. Land readjustment
		5. Other miscellaneous works
	Phase 2.	1. Connecting culvert and restoration of Mutuwal Tunnel
	Mutuwal Area;	2. Dredging, filling and land surface dressing
	(land reclamation)	3. Revetment
		4. Land readjustment
		5. Other miscellaneous works
Stage 2.	Phase 1.	1. Isolation bund
Heen Ela	High Level Canal; (middle reach) (From intersection with Kotte Road to confluence with Kirillapone waterway)	2. Dredging of canal
		3. Regulator
		4. Revetment
		5. Other miscellaneous works
	Phase 2.	1. Work on pumping station
	Heen Ela Area;	2. Dredging, filling, and land surface dressing
	(land reclamation)	3. Revetment
		4. Land readjustment
		5. Other miscellaneous works

Staging of works	Work planning	Name of work
Stage 3. Gothatuwa	Pahse 1. High Level Canal; (upper reach) (From Dematagoda regulating sluice to intersection with Kotte Road through Mahawatta Canal)	1. Isolation bunds 2. Dredging of canal 3. Works on bridge and sluiceway 4. Revetment 5. Other miscellaneous works
	Phase 2. Gothatuwa Area; (land reclamation)	1. Work on pumping station 2. Dredging, filling and land surface dressing 3. Revetment 4. Land readjustment 5. Other miscellaneous works
Stage 4. Kotte	Phase 1. Madiwela diversion	1. Tunnel excavation 2. Link canal
	Phase 2. High Level Canal; (lower reach) (From Kirillapone Canal to Wellawatta Canal and Dehiwela Canal)	1. Dredging of canal 2. Works on regulator and bridge 3. Revetment 4. Jetties and other works
	Phase 3. Kotte Area; land reclamation	1. Work on pumping station 2. Work on inverted siphon 3. Dredging, filling and land surface dressing 4. Revetment 5. Land readjustment 6. Other miscellaneous works

7-3 Construction Equipment

The principal works in this project are of course the excavation of flood detention lakes and drainage canals and the filling of marshes. It is most reasonable to use a suction dredger for these excavation and filling works, judging from the conditions in the project area. In view of the quantity of earthwork in each area it seems most economical to use a diesel pump dredger (suction dredger) of land transporting type with the dimension of 160 ps x ϕ200 mm or the like. The volume of work performed by such suction dredger is about 600 m^3/day, on the assumption that the ratio of mud content is 10%, that the standard distance of mut conveyance is 150 m, and that the net operating time of pump is 15 hours on the basis of 24 hours working in three shifts of 8 hours. Therefore, the annual volume of earth work as calculated on the basis of 180 days is 40,000 cube/year.

The required quantity of dredger of this type is 2 units which was evaluated from the construction schedule and the quantity of earthwork in respective areas. The leveling of filling earth and gravels is carried out with a 11 ton-class bulldozer. The excavation of foundation of pumping station and the embankment work require various earth-moving machines such as clamshell, back hoe, shovel, dump car and roller, etc.

As it is expected that the greater part of structures will be constructed on piling, a suitable pile driver is required. In excavating the foundation, because the ground-water level in the entire area is high, a special work method such as well-point-method should be used to lower it, together with temporary drainage pump. For concrete work, it is most economical to use ready-mixing concrete in view of the amount of placing or, if not available, a batcher plant is to be temporarily installed and be used successively by each project area. As it is believed that the estimated unit costs include the allowances for the rents of these machines, it will not be necessarily uneconomical to purchase them if the foreign currency is available, because these machines may be sold at residual prices with their rents reduced after the completion of works. Below is shown the list of construction equipment needed at the least for the works in the project area.

a) For earthwork:

   Pump dredger, clamshell, back hoe, shovel, bulldozer, dump car, roller, etc.

b) For concrete work:

   Batcher plant, vibrator, etc.

c) Others:

   Pile driver, compressor, jack hammer, winch, pump, generator, belt conveyor, etc.

CHAPTER 8. FUNDAMENTAL CONCEPTION OF MAINTENANCE AND SUPERVISION

As previously mentioned, although the principal object of project is to reclaimed land, the project has important bearings on the urban drainage and flood disposal in the Colombo Metropolitan Area. Therefore, the conception of maintenance and supervision for this purpose should be extended to include the maintenance and supervision of the drainage facilities in the above area. At present the principal drainage canals in the Colombo Area are supervised by the Irrigation Department; however, that the development of marshes has resulted in the decrease in their former ability to absorb the flood, that the drainage system has become more complicated due to the land reclamation project and, in addition, that any flood must be discharged only by the water surface gradient because of the flatness prevailing whole of the Colombo Area, all these factors are expected to increase the importance of operating and controlling of pumps and regulator. To give the instance of a similar project in our country, an integrated supervising office equipped with the computer has been established to conduct the rational operation of the whole facilities all over the area by remote control. Therefore, since the need for the each project area is to supervise and control the activities for disposing flood which causes disaster upon citizens, it is required in the near future to establish an integrated operating system for drainage by means of the above-mentioned remote control. The fundamental conception of such maintenance and supervision conceivable at the present point allowing for the social and economic conditions of Ceylon is as follows.

As the facilities for maintenance and supervision offices will be established in the North and South Colombo Areas on the basis of the proposed drainage systems. The Demadagoda regulator which constitutes the boundary between these areas will be supervised jointly by the south and north offices. These maintenance and supervision offices will have, for field operation, six offices, in total as their local agencies in their drainage area, and these offices and branch offices be administrated by an appropriate government agency as its subordinate organization. Some operators and watchmen will be employed by the government to assign them on the permanent basis to the pumping station and regulator, besides the staff of the branch operating offices. The annual expenditure of maintenance and supervision is as stated elswhere in this report.

TABLES AND FIGURES

Table II-1-1 Pump Capacity, Relaimed Land Area, Unit Area and Related Cost (Mutwal)

Pump cusec / n =	cusec 50	cusec 70	cusec 100	cusec 150	cusec 200	cusec 250	cusec 300
0.5	74.5	89.5	104.5	112.0	119.5		127.0
	101,609	76,418	59,128	54,423	53,680		57,602
1.0	68.0	86.0	98.0	110.0	116.0	112.0	
	105,462	75,087	62,215	53,425	54,356	55,893	
1.5	67.0	82.0	97.0	107.0	117 0	112.0	127.0
	100,728	76,467	60,448	53,908	54,068	55,835	57,491
2.0	64.0	82.0	100.0	106.0	112.0	118.0	124.0
	102,292	73,394	55,634	53,691	55,228	56,764	58,173
2.5	65.0	79.0	96.5	107.0	114.0	121.0	124.5
	96,586	75,218	57,031	53,127	54,658	56,012	58,030
3.0	62.0	78 0	98.0	106 0	114.0	118.0	126.0
	100,032	74,779	55,181	53,336	54,643	56,691	57,674

Notes : * Figures in the upper line are the area of reclaimed land ac.
* Figures at the bottom line represent the cost of reclamation per ac. in Rs.
* The value of n is the ratio of canal and marsh in area.

Table II-1-2 Pump Capacity, Reclaimed Land Area and Related Cost (Urugodawatta)

Pump n =	cusec 50	cusec 100	cusec 150	cusec 200	cusec 250	cusec 300	cusec 350	cusec 400
0 5	249.0	294.0	324.0	333.0	342.0	351.0	354.0	360.0
	63,335	45,961	37,418	35,899	34,451	33,077	33,293	33,853
1 0	240.0	288.0	318.0	330.0	338.0	350.0	354.0	358.0
	61,332	44,427	36,847	34,839	33,927	32,207	33,056	33,877
1.5	232.5	285.0	315.0	327.5	337.5	345.0	350.0	357.5
	60,607	42,540	36,156	34,278	33,076	32,475	33,167	33,874
2.0	228.0	282.0	312.0	327.0	336.0	345.0	351 0	357.0
	59,641	42,370	35,856	33,583	32,738	32,307	33,102	33,870
2.5	225.5	278.0	313.0	323 5	334.0	344.5	348.0	355.0
	58,527	42,312	34,889	33,734	32,657	32,306	33,188	33,929
3.0	222.0	278.0	310.0	322.0	334.0	346.0	350.0	354.0
	58,297	41,405	34,975	33,585	32,279	32,218	33,112	33,952

Notes: * Figures in the upper line are the area of reclaimed land ac
* Figures at the bottom line represent the cost of reclamation per ac. in Rs.
* The value of n is the ratio of canal and marsh in area

Table II-1-3 Pump Capacity, Reclaimed Land Area, Unit Area and Related Cost (Gothatuwa)

Pump / n =	cusec 50	cusec 100	cusec 150	cusec 200	cusec 250	cusec 300	cusec 350	cusec 400
0.5	486.0	542.0	587.0	609 5	624.5	632.0	639.5	647.0
	50,333	39,732	32,867	30,042	28,121	29,360	30,161	30,874
1.0	467.0	537.0	577.0	607 0	617.0	627.0	637.0	647.0
	49,274	37,344	32,044	28,688	28,839	29,617	30,365	31,151
1.5	457.0	519.5	569.5	594.5	619.5	632 0	632 0	644.5
	47,986	37,914	30,363	29,127	29,143	29,922	30,476	31,276
2.0	452 0	530.5	572.0	594.5	617 0	624.5	632.0	639.5
	46,625	35,979	30,286	28,337	29,265	29,950	30,618	31,325
2.5	444.5	514.5	567.0	593.3	610.8	619.5	628.3	637.0
	46,297	36,012	30,150	28,331	29,259	29,728	30,690	31,328
3.0	447.0	517.0	567.0	597.0	607.0	617.0	627.0	637.0
	44,534	34,844	29,598	28,543	29,277	30,041	30,731	31,396

Notes : * Figures in the upper line are the area of reclaimed land ac
* Figures at the bottom line represent the cost of reclamation per ac. in Rs.
* The value of n is the ratio of canal and marsh in area

Table II-1-4 Pump Capacity, Reclaimed Land Area, Unit Area and Related Cost (Kotte)

Pump / n =	cusec 50	cusec 100	cusec 150	cusec 200	cusec 250	cusec 300	cusec 350
0.5	386	432	469	499	521	530	530
	56,900	45,700	38,100	33,100	29,800	29,000	29,400
1.0	376	426	466	496	520	528	534
	55,500	44,200	37,100	32,700	29,700	28,700	29,400
1.5	361	411	461	499	521	531	534
	56,700	45,700	37,000	31,800	29,300	28,700	29,400
2.0	356	416	461	491	518	530	535
	56,000	43,400	36,300	32,600	29,600	28,800	29,400
2.5	344	414	449	484	515	529	535
	57,600	43,000	37,800	33,300	29,900	28,800	29,400
3.0	336	396	456	496	520	528	534
	58,400	45,600	36,200	31,400	29,200	28,900	29,400

Notes: * Figures in the upper line are the area of reclaimed land ac.
* Figures at the bottom line represent the cost of reclamation per ac. in Rs.
* The value of n is the ratio of canal and marsh in area.

Table II-1-5 Pump Capacity, Reclaimed Land Area, Unit Area and Related Cost (Heen Ela)

Pump / n =	cusec 70	cusec 100	cusec 150	cusec 200	cusec 250	cusec 300	cusec 350	cusec 400
1.0	329.0	359.0	395.0	413.0	425.0	431.0	437.0	443.0
	52,394	44,638	37,128	34,286	32,799	32,489	32,203	31,909
1.5	325.0	355.0	385.0	415.0	423.0	430.0	438.0	438.0
	50,973	43,767	38,062	33,177	32,662	32,205	31,730	35,529
2.0	319.0	349.0	385.0	409.0	421.0	427.0	433.0	439.0
	49,829	43,588	36,958	33,481	32,298	32,144	31,989	32,303
2.5	311.0	346.0	381.0	409.0	416.0	423.0	430.0	437.0
	50,312	42,383	36,288	32,332	32,047	31,788	31,525	31,868
3.0	309.0	341.0	381.0	405 0	413.0	421.0	429.0	437.0
	49,522	42,499	35,627	32,492	32,095	31,714	31,347	31,952

Notes : * Figures in the upper line are the area of reclaimed land ac
* Figures at the bottom line represent the cost of reclamation per ac. in Rs.
* The value of n is the ratio of canal and marsh in area.

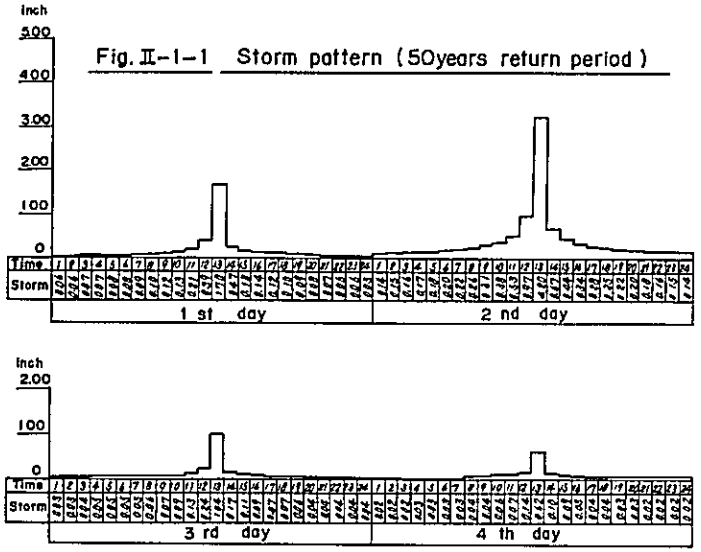


Fig. II-1-1 Storm pattern (50years return period)
Inch
5.00
4.00
3.00
2.00
1.00
0
Time
Storm
1 st day
2 nd day
Inch
2.00
1.00
0
3 rd day
4 th day

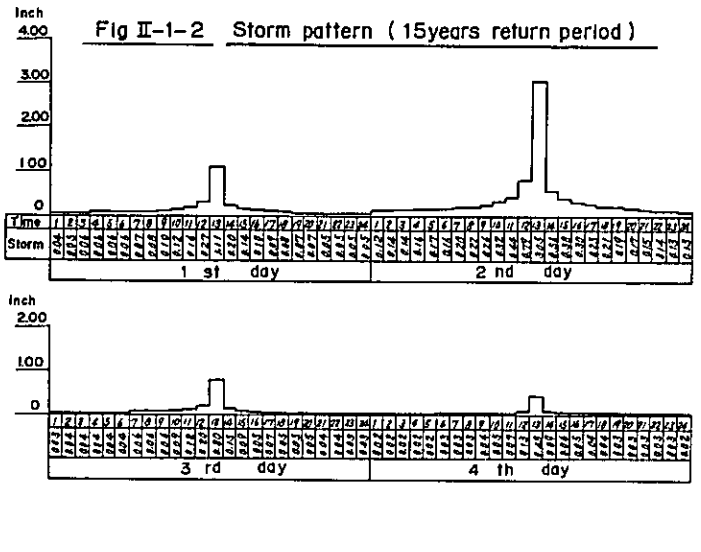


Fig II-1-2 Storm pattern (15years return period)
Inch
4.00
3.00
2.00
1.00
0
Time
Storm
1 st day
2 nd day
Inch
2.00
1.00
0
3 rd day
4 th day

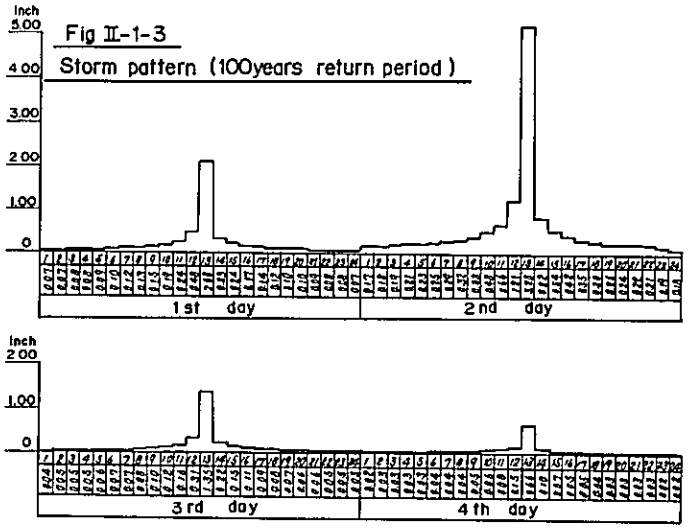


Fig II-1-3
Storm pattern (100years return period)
Inch
5.00
4.00
3.00
2.00
1.00
0
1st day
2nd day
Inch
2.00
1.00
0
3rd day
4th day

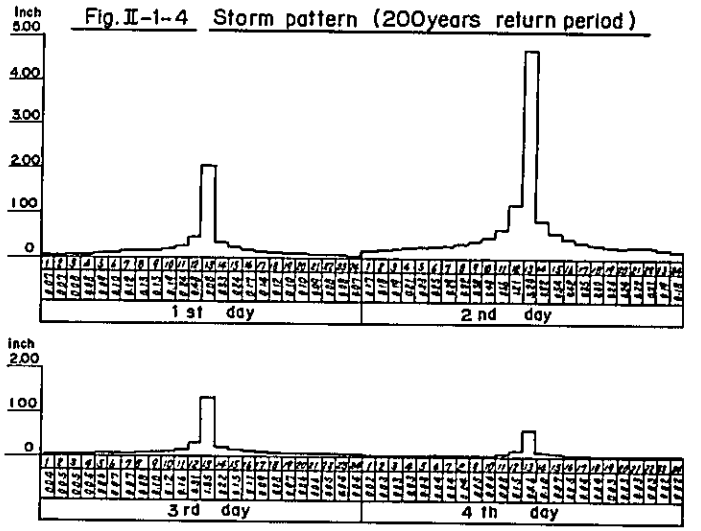


Fig. II-1-4 Storm pattern (200years return period)
Inch
5.00
4.00
3.00
2.00
1.00
0
1 st day
2 nd day
Inch
2.00
1.00
0
3rd day
4 th day

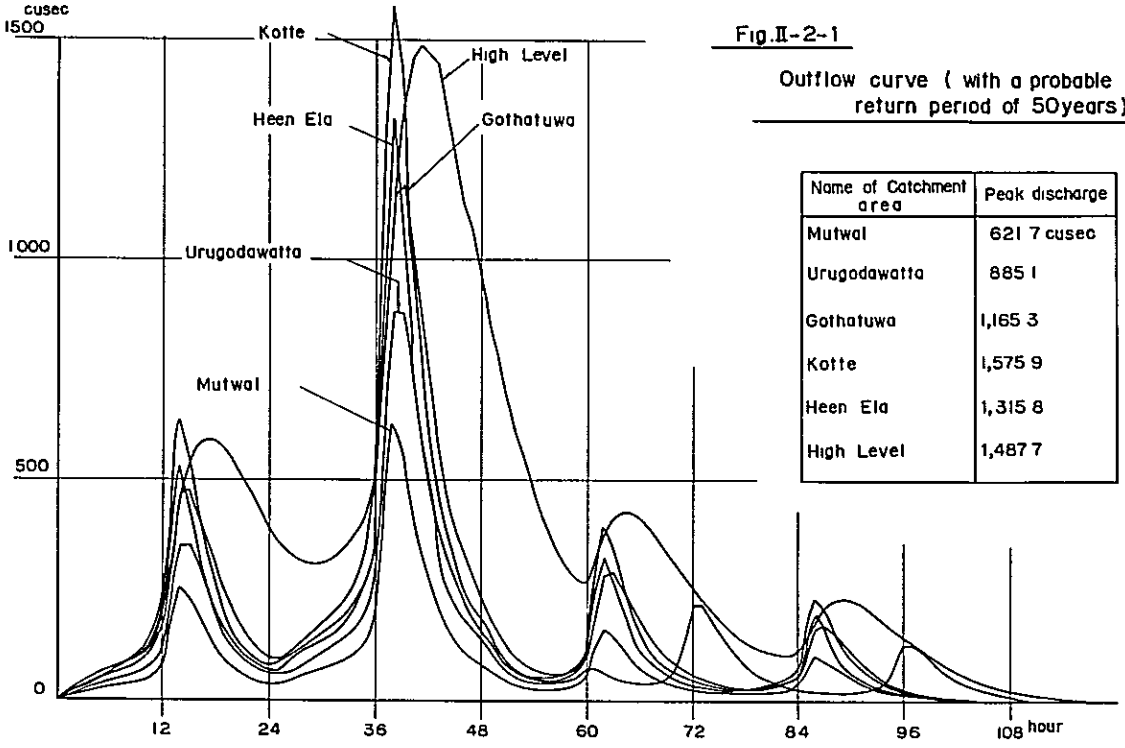


Fig.II-2-1

Outflow curve (with a probable return period of 50years)

Name of Catchment area	Peak discharge
Mutwal	621 7 cusec
Urugodawatta	885 1
Gothatuwa	1,165 3
Kotte	1,575 9
Heen Ela	1,315 8
High Level	1,487 7

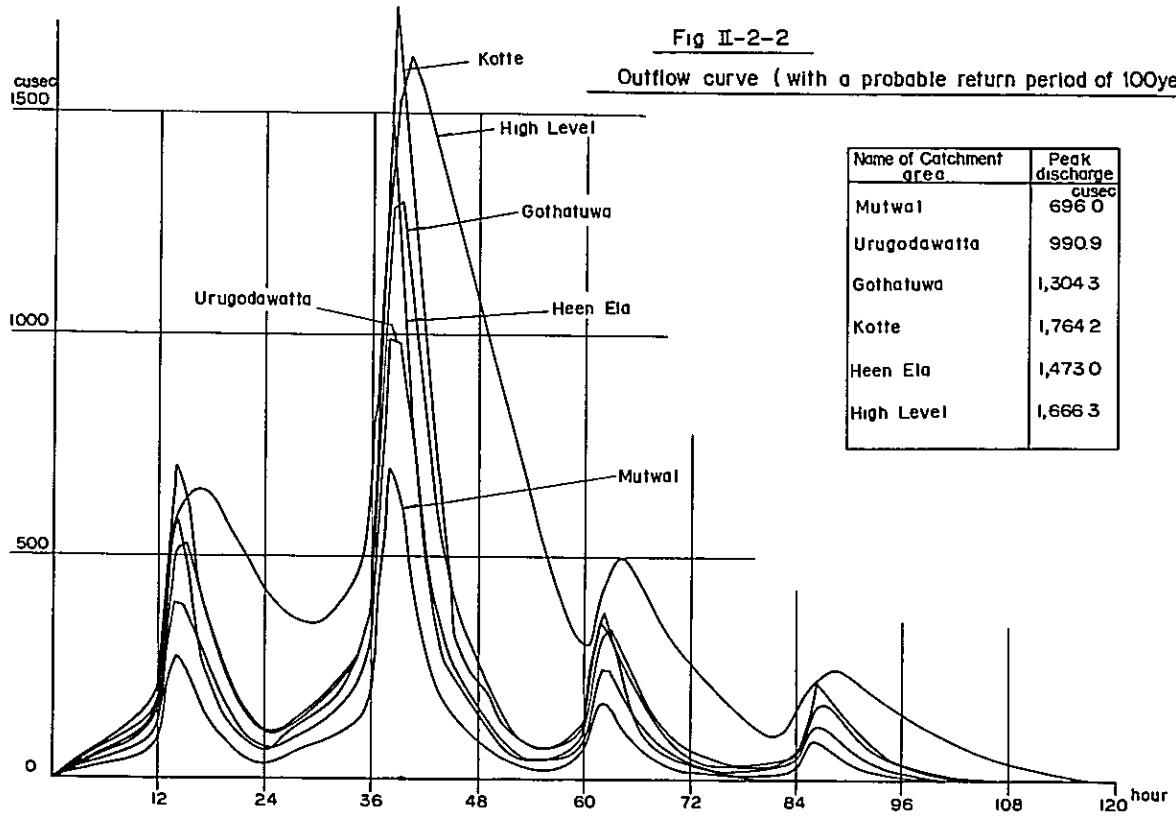


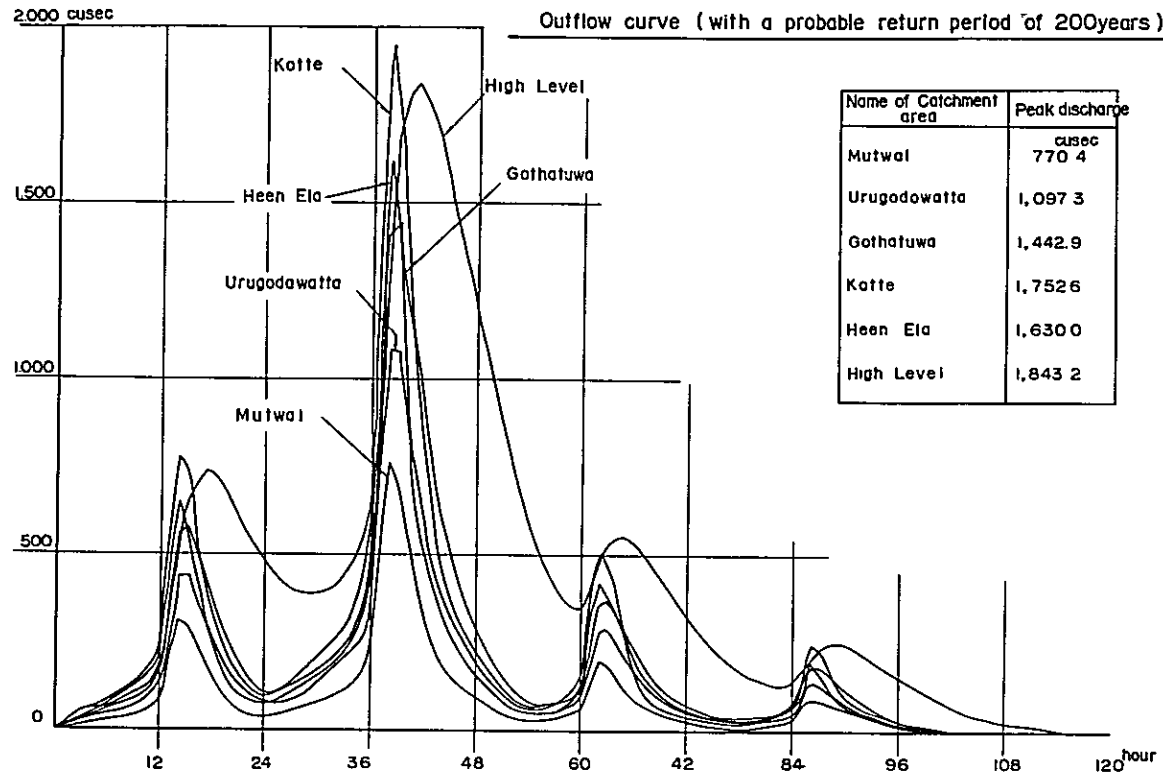
Fig II-2-2

Outflow curve (with a probable return period of 100years)

Name of Catchment area	Peak discharge cusec
Mutwal	696 0
Urugodawatta	990 9
Gothatuwa	1,304 3
Kotte	1,764 2
Heen Ela	1,473 0
High Level	1,666 3

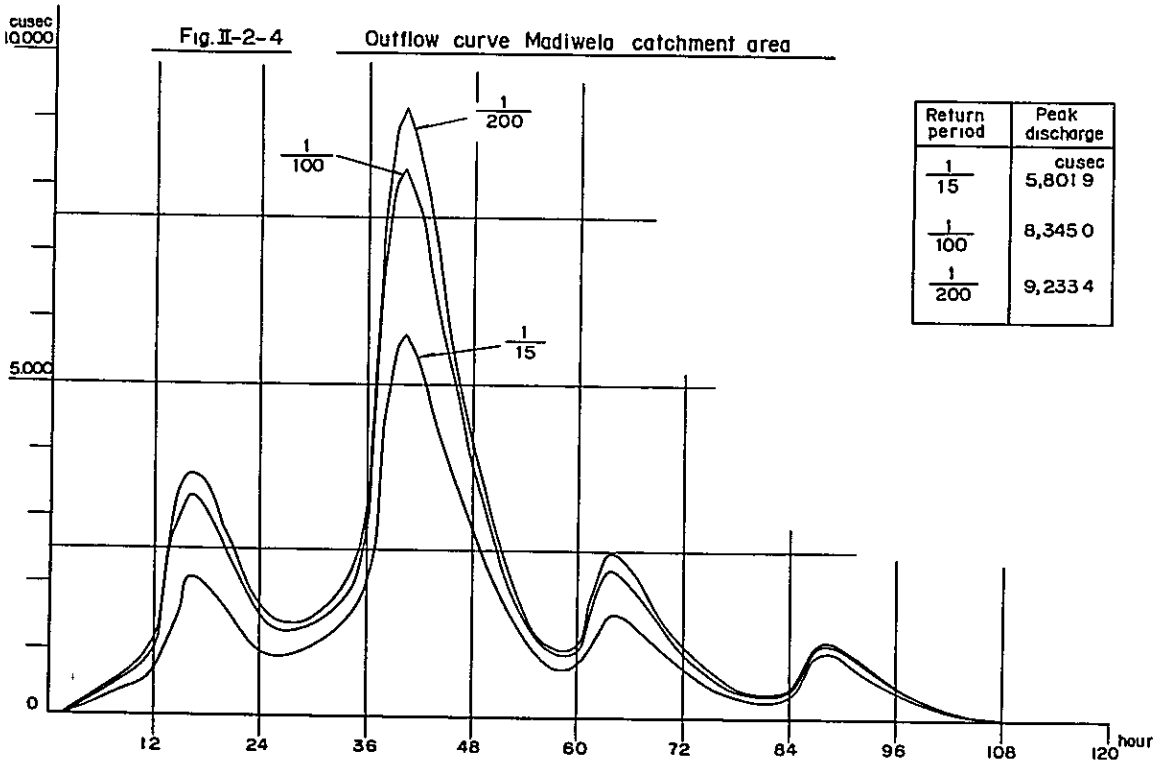
Fig.II-2-3

Outflow curve (with a probable return period of 200years)



Name of Catchment area	Peak discharge cusec
Mutwal	770 4
Urugodawatta	1,097 3
Gothatuwa	1,442.9
Katte	1,7526
Heen Ela	1,6300
High Level	1,843 2

Fig.II-2-4 Outflow curve Madiwela catchment area



Return period	Peak discharge cusec
1/15	5,801 9
1/100	8,345 0
1/200	9,233 4

Fig II-3-1

Conperative Proposal 1-1

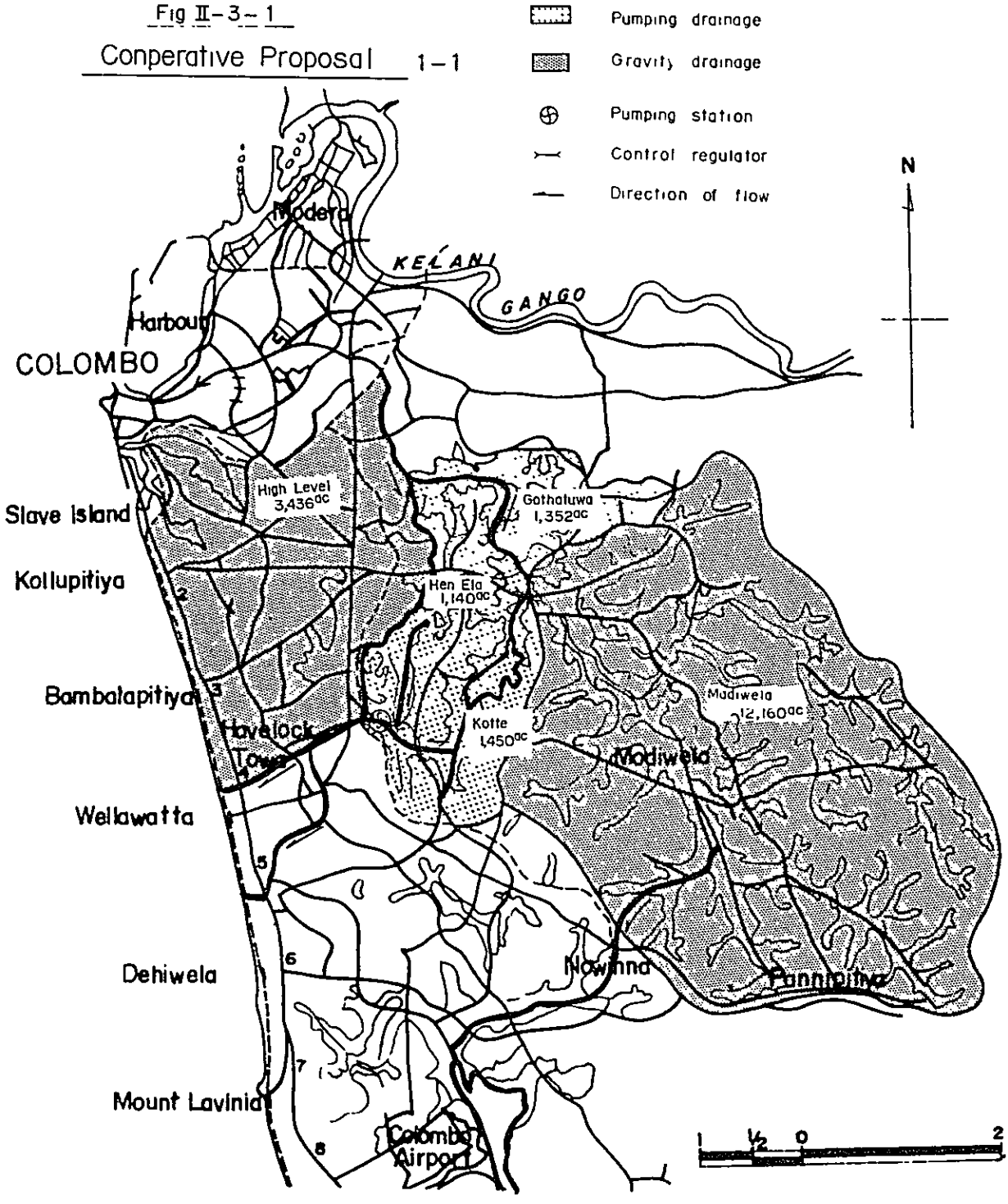


Fig II-3-2

Conperative Proposal 1-2

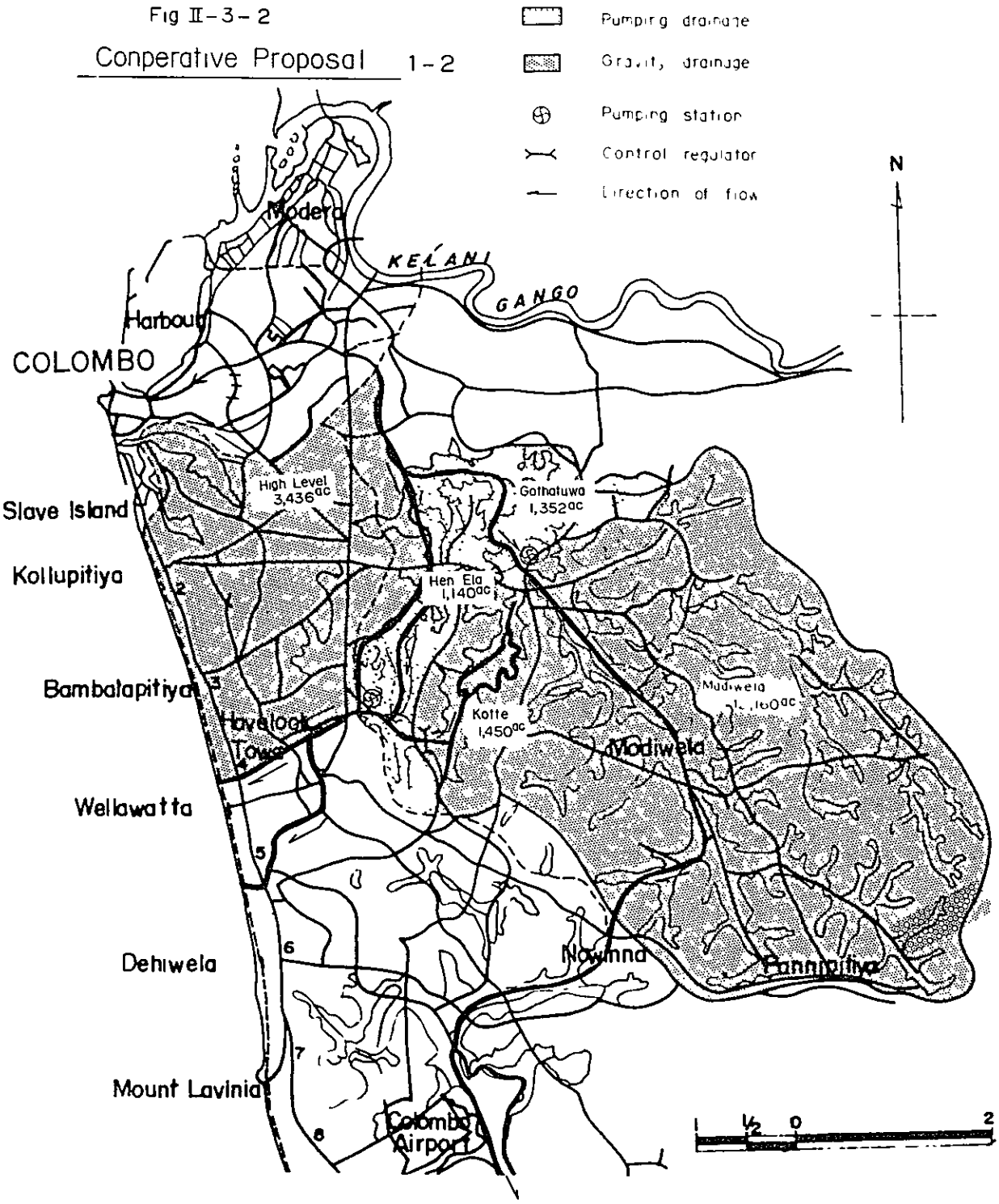


Fig II-3-3

Conperative Proposal 1-3

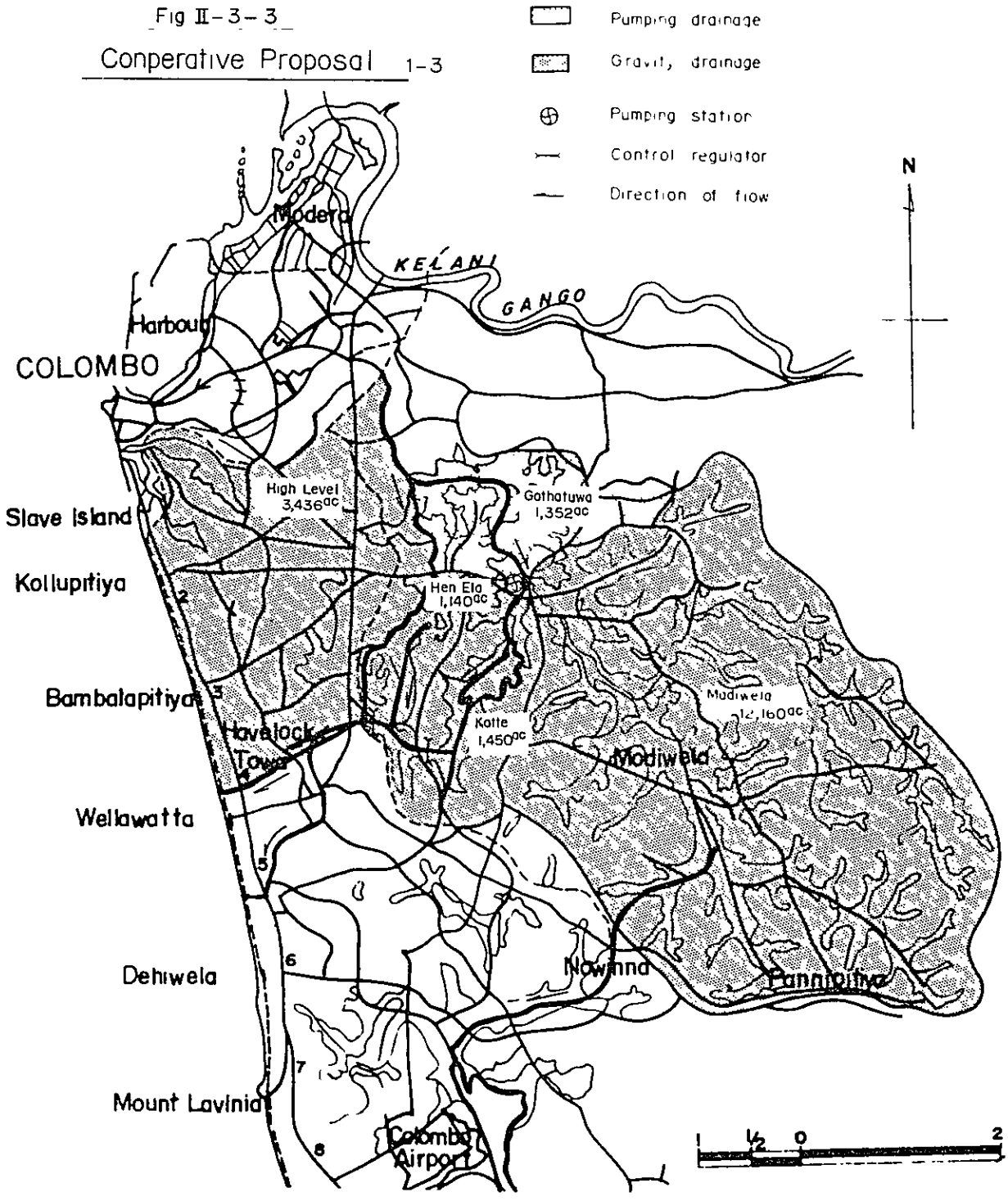


Fig II-3-4

Conperative Proposal 1-4

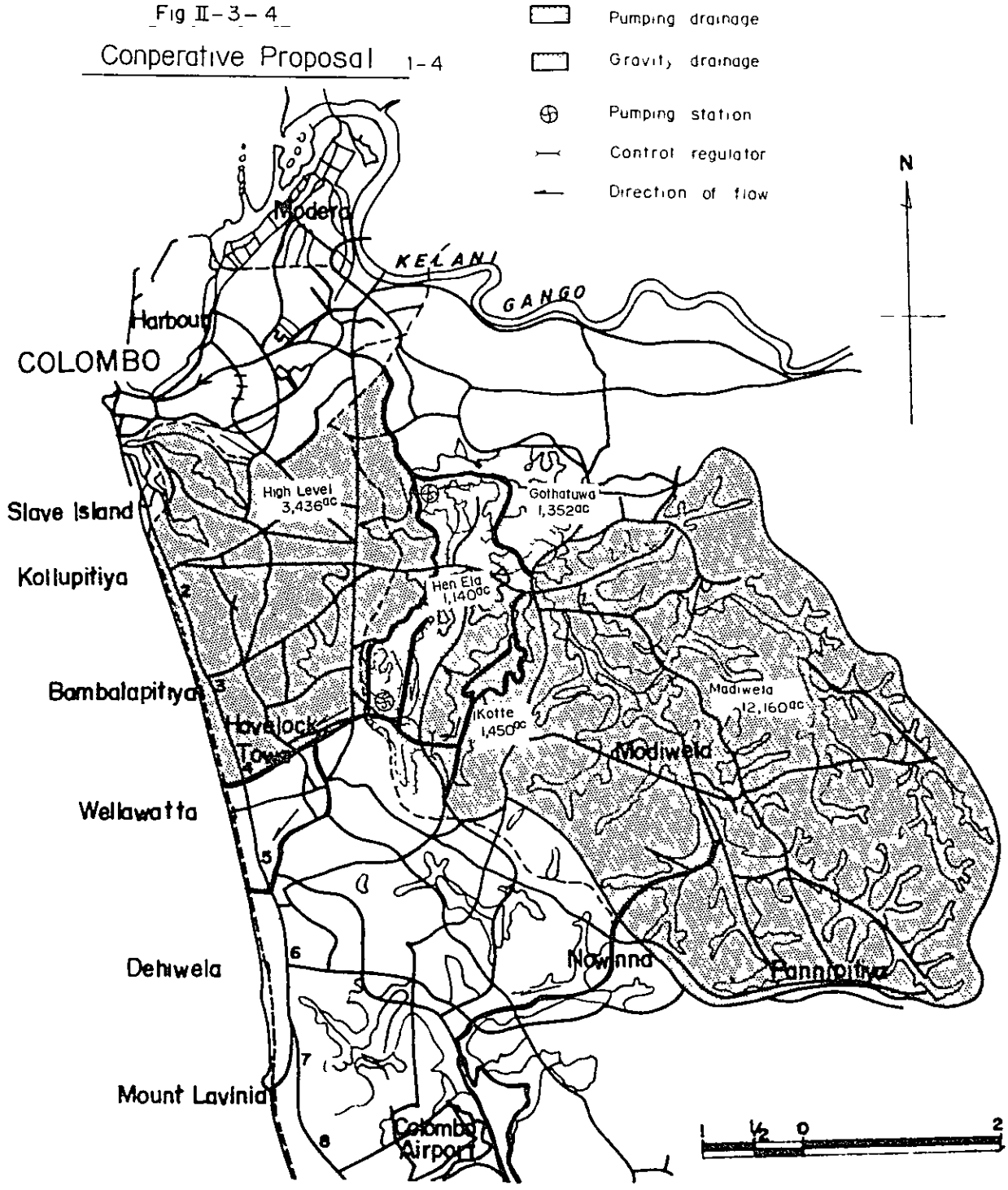


Fig II-3-5

Conperative Proposal 1-5

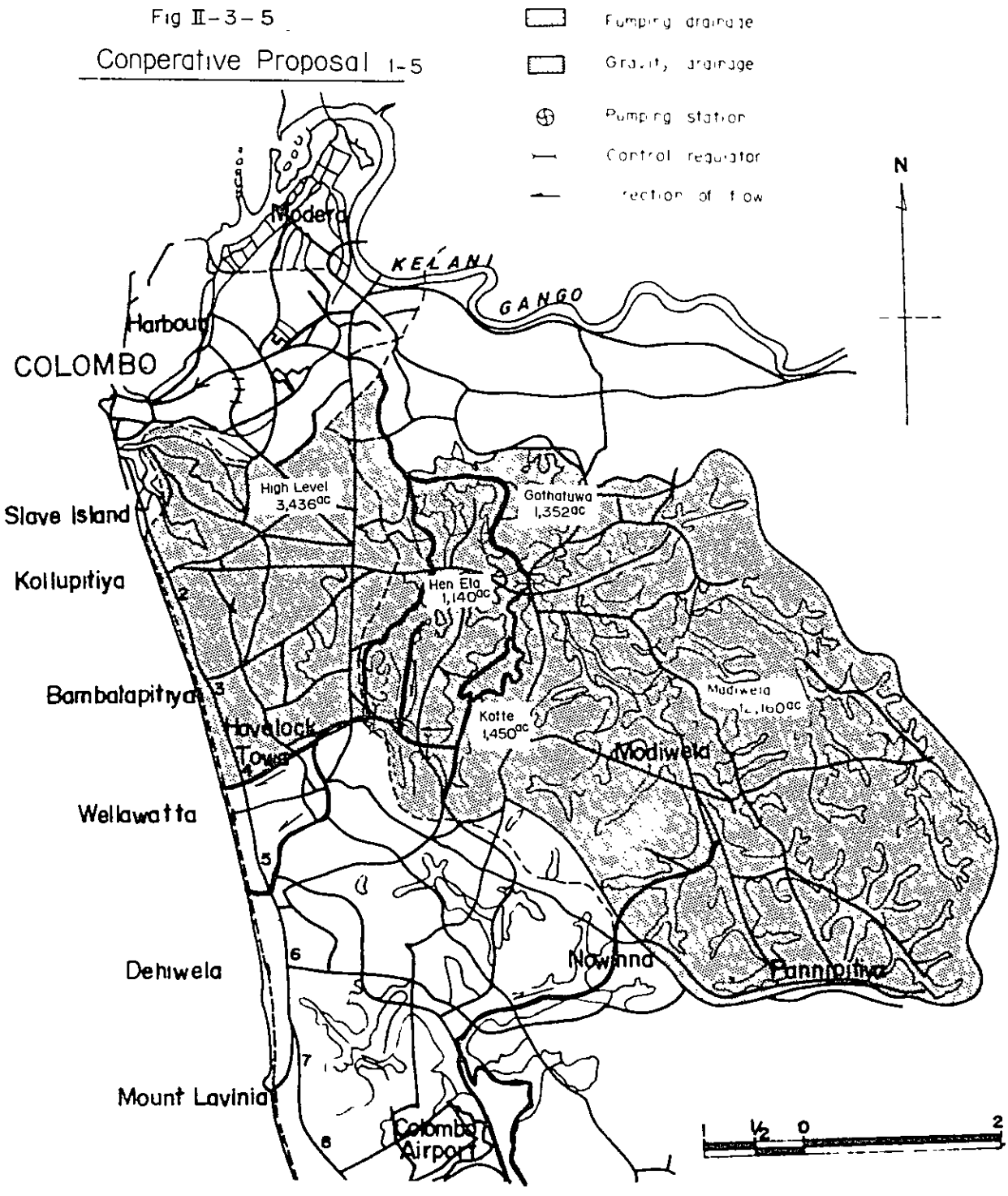


Fig II-3-6

Conperative Proposal 2-1

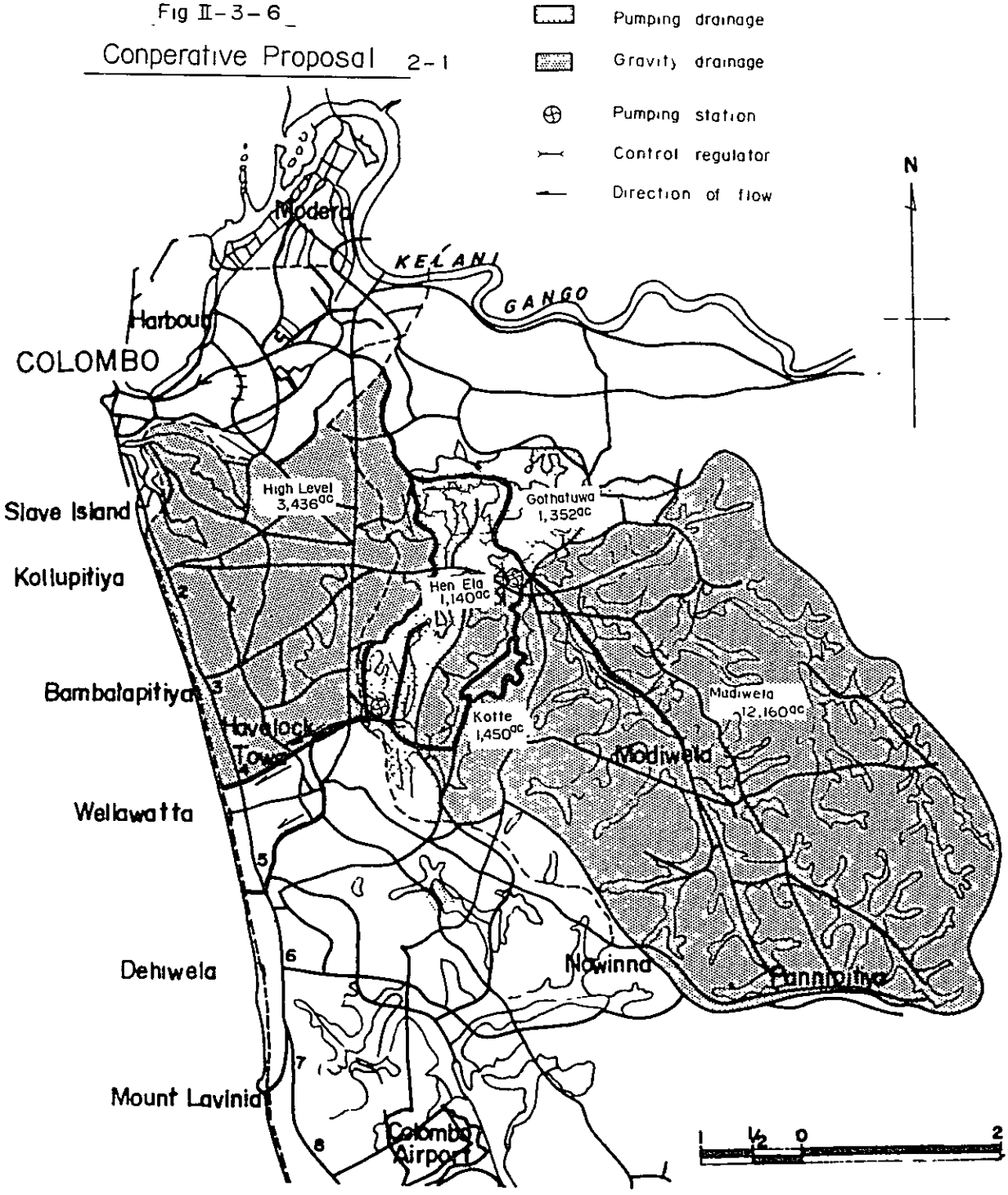


Fig II-3-7

Conperative Proposal 2-2

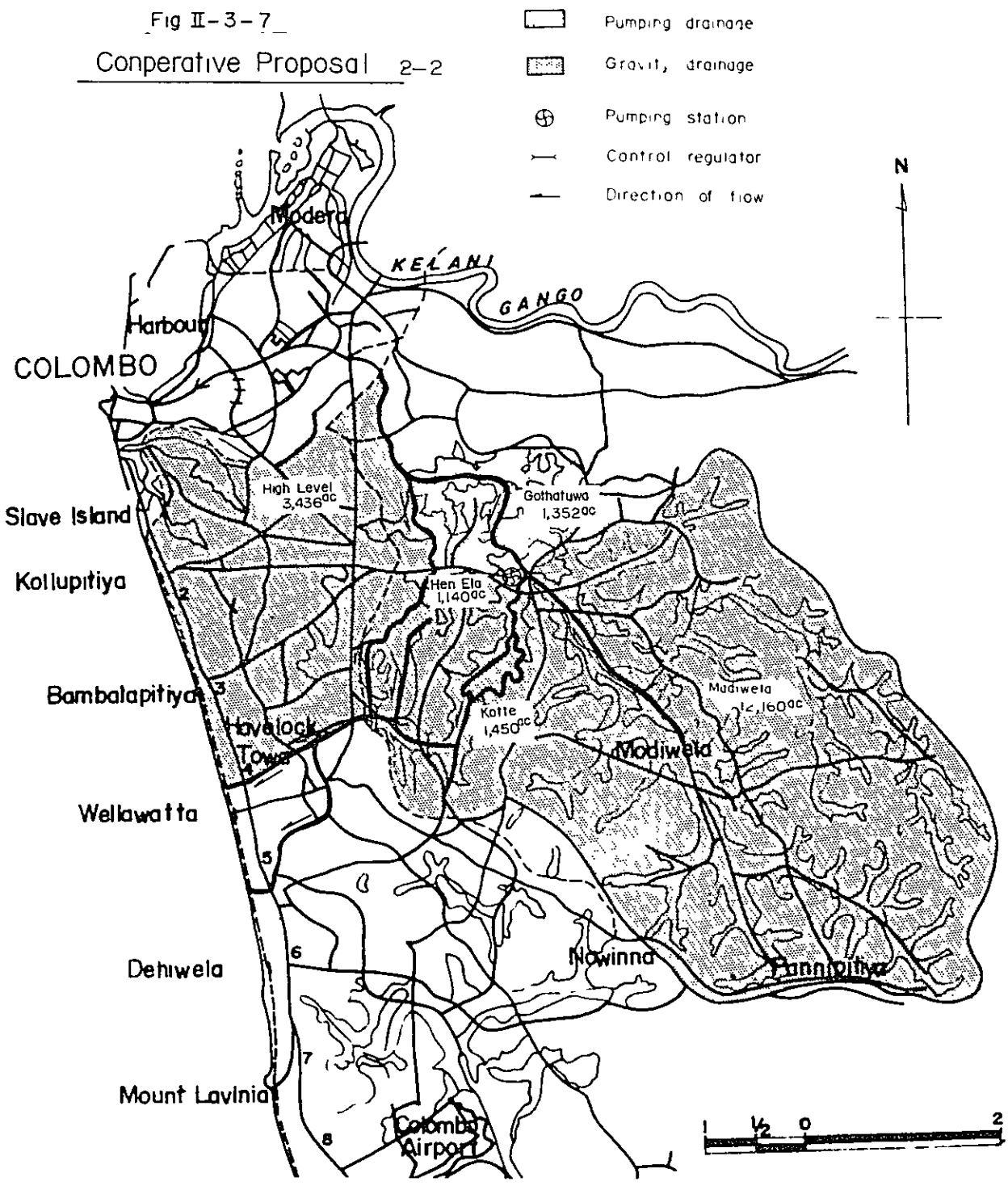


Fig II-3-8

Conperative Proposal 2-3

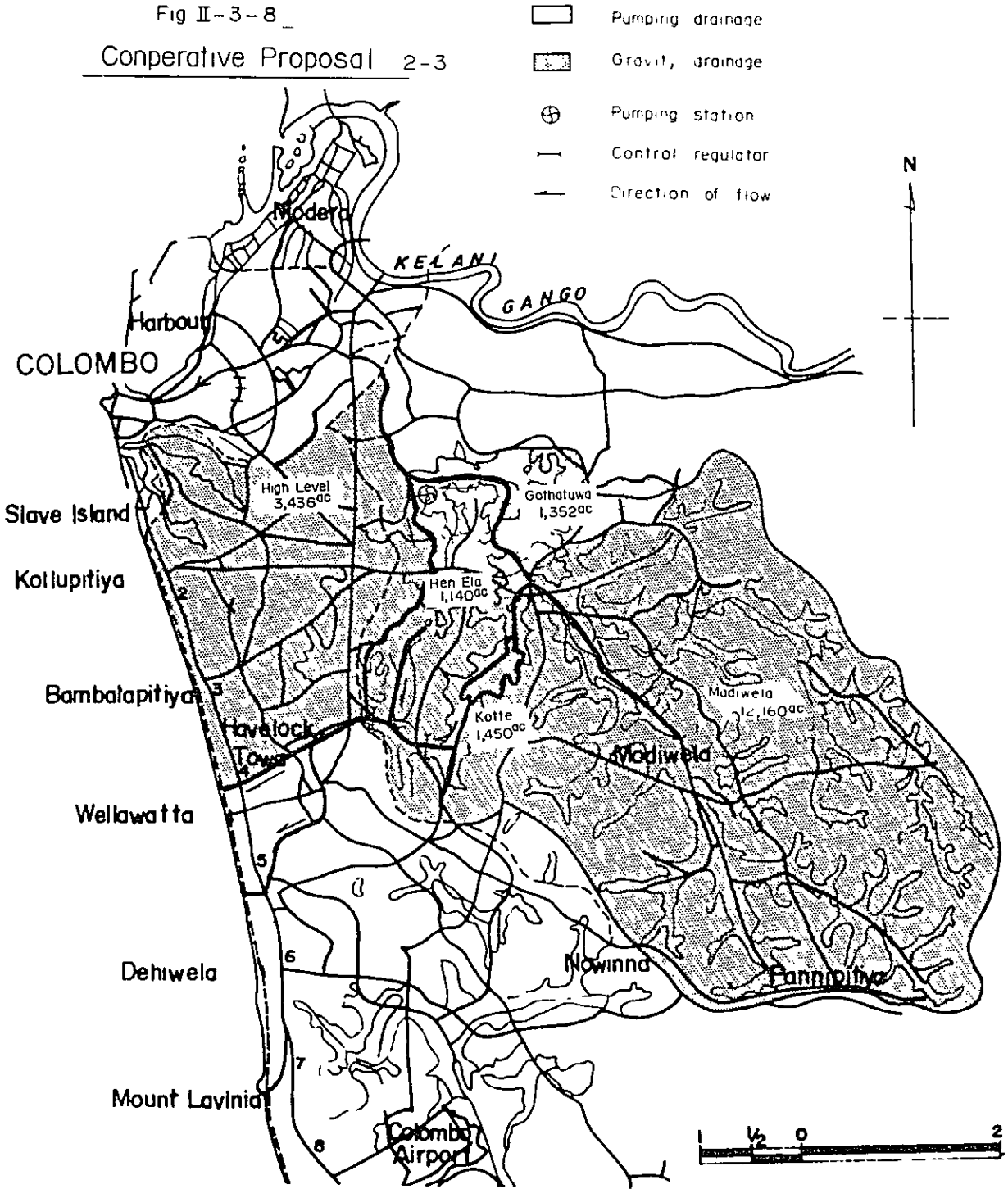


Fig II-3-9

Conperative Proposal 2-4

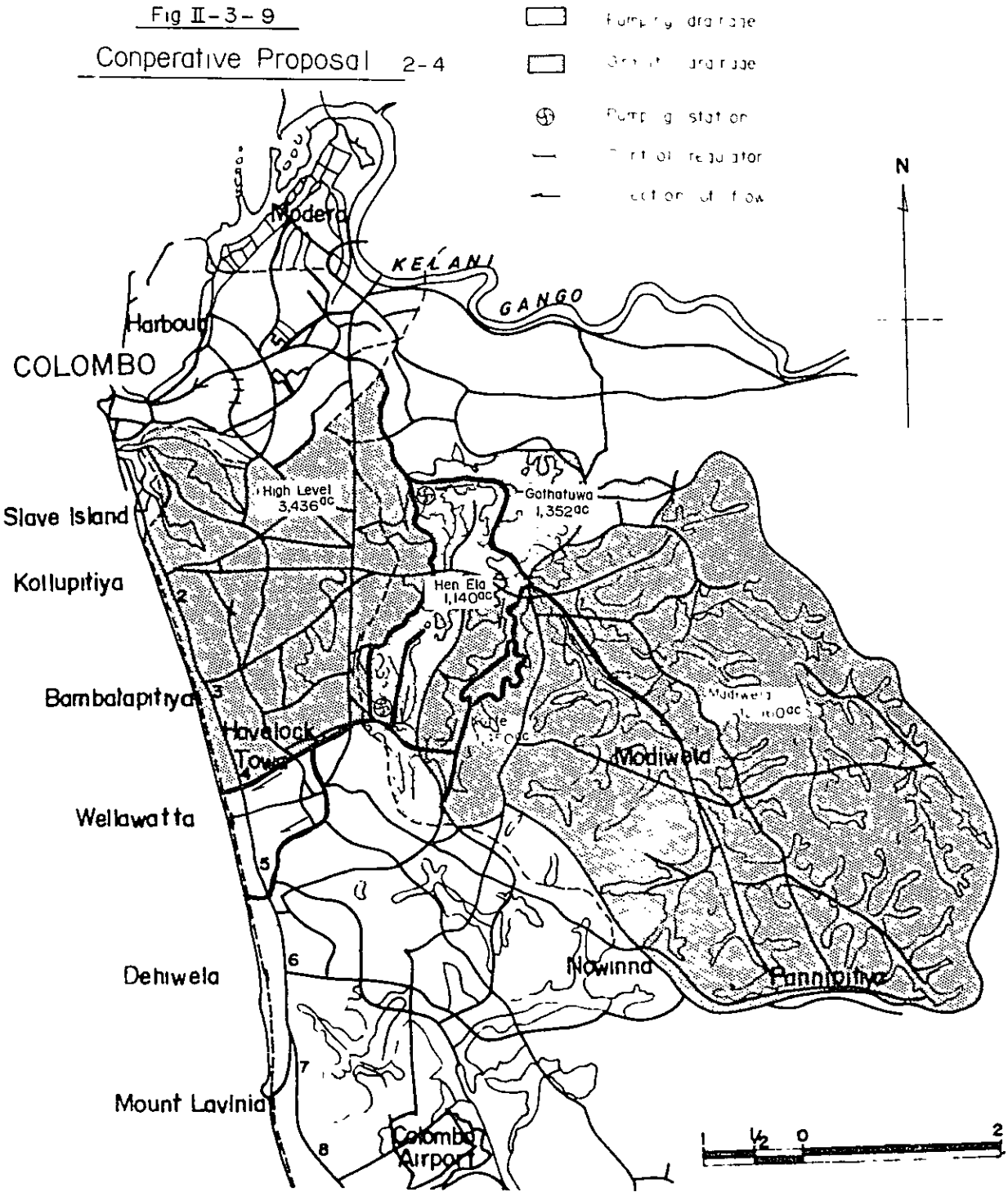


Fig II-3-10

Conperative Proposal 2-5

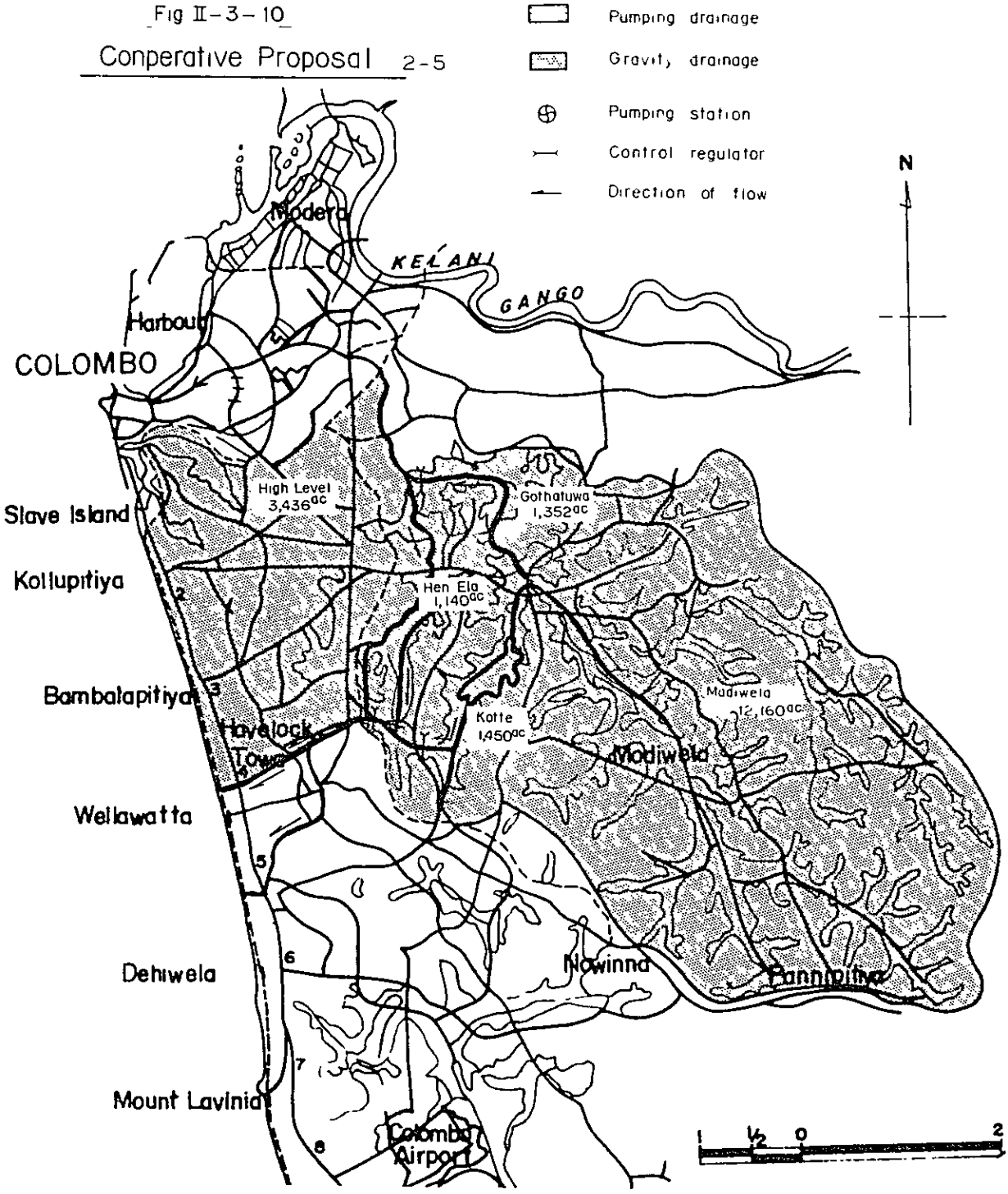


Fig II-3-11

Conperative Proposal 3-1

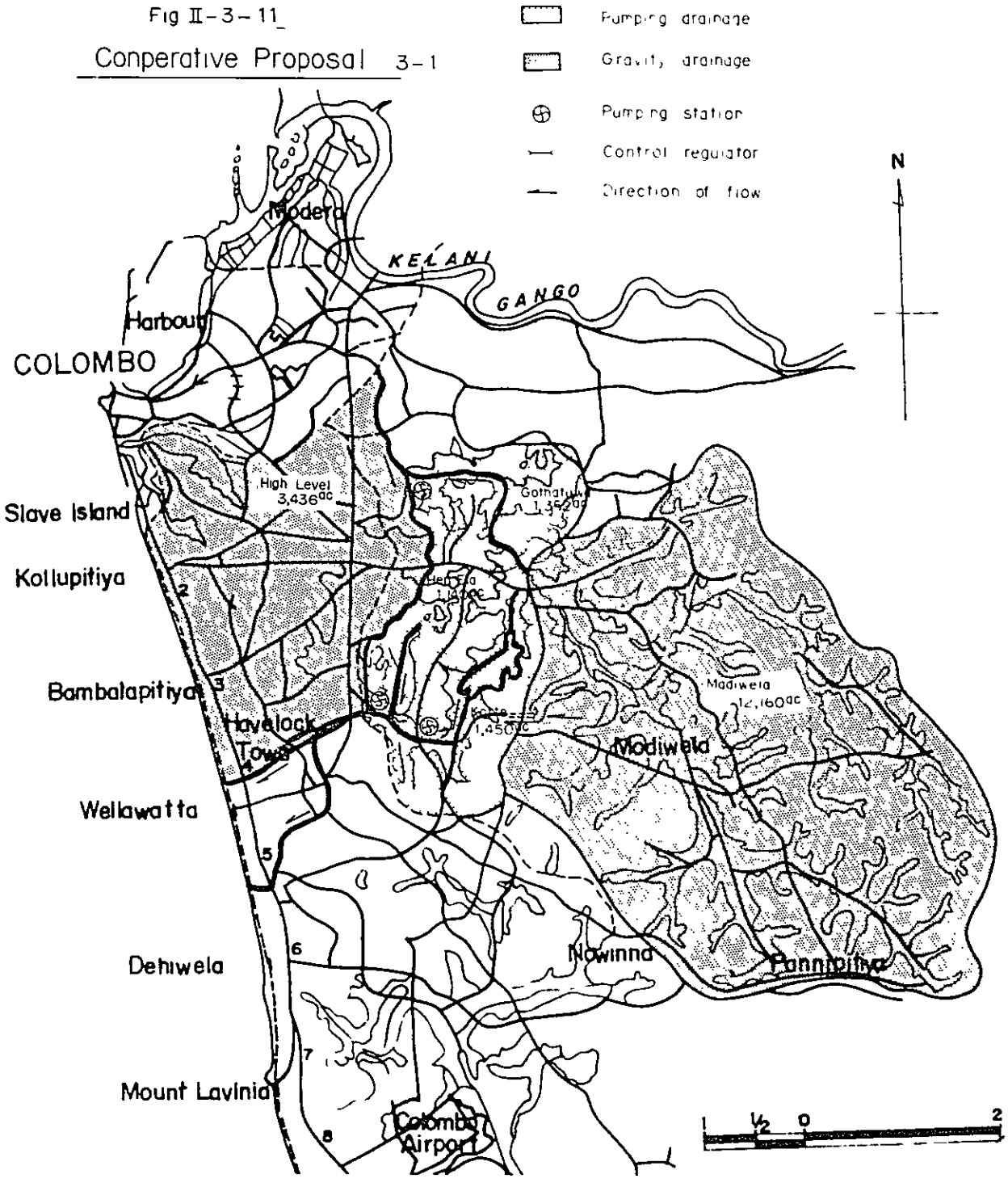


Fig II-3-12

Conperative Proposal 3-2

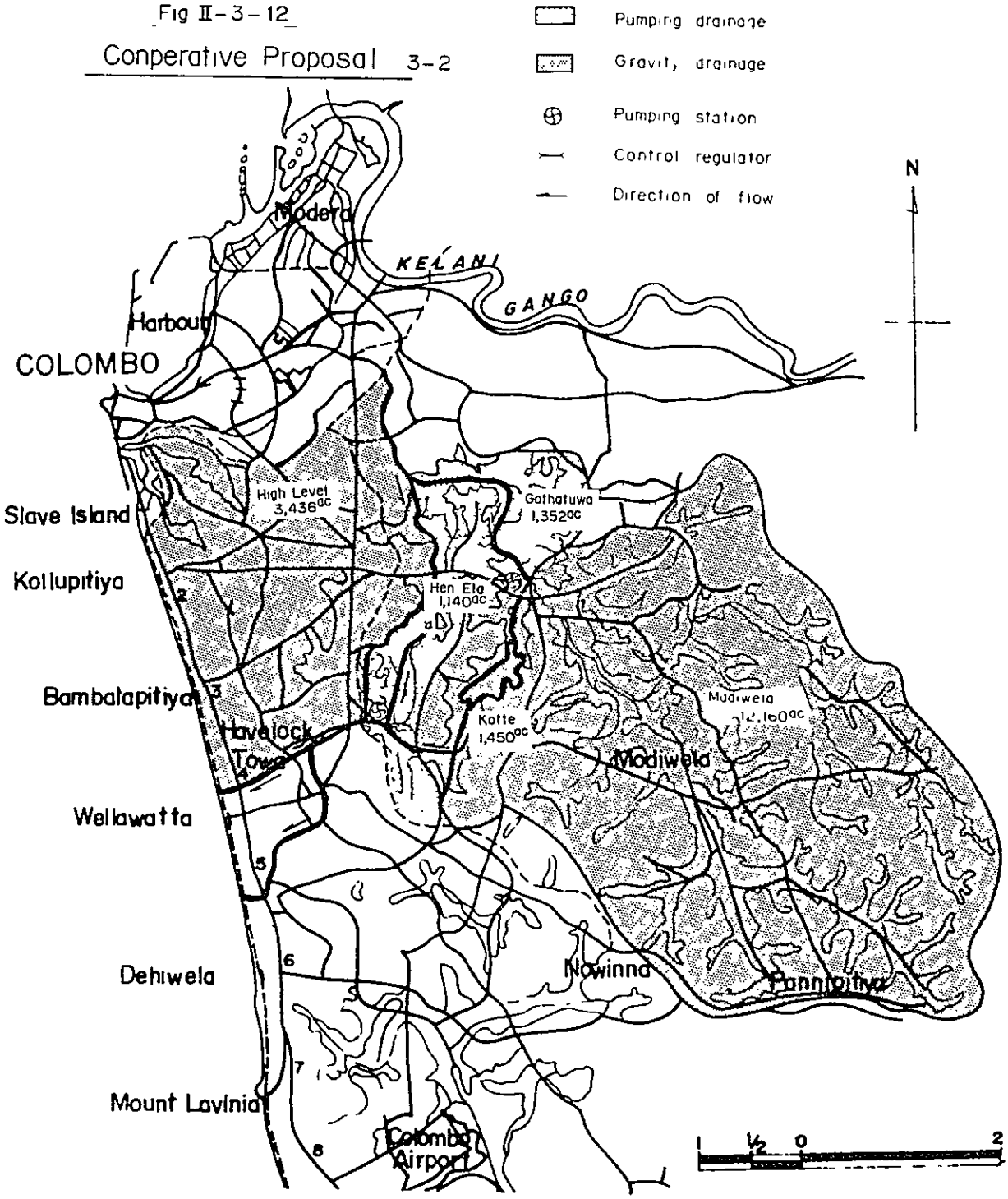


Fig II-3-13

Conperative Proposal 3-3

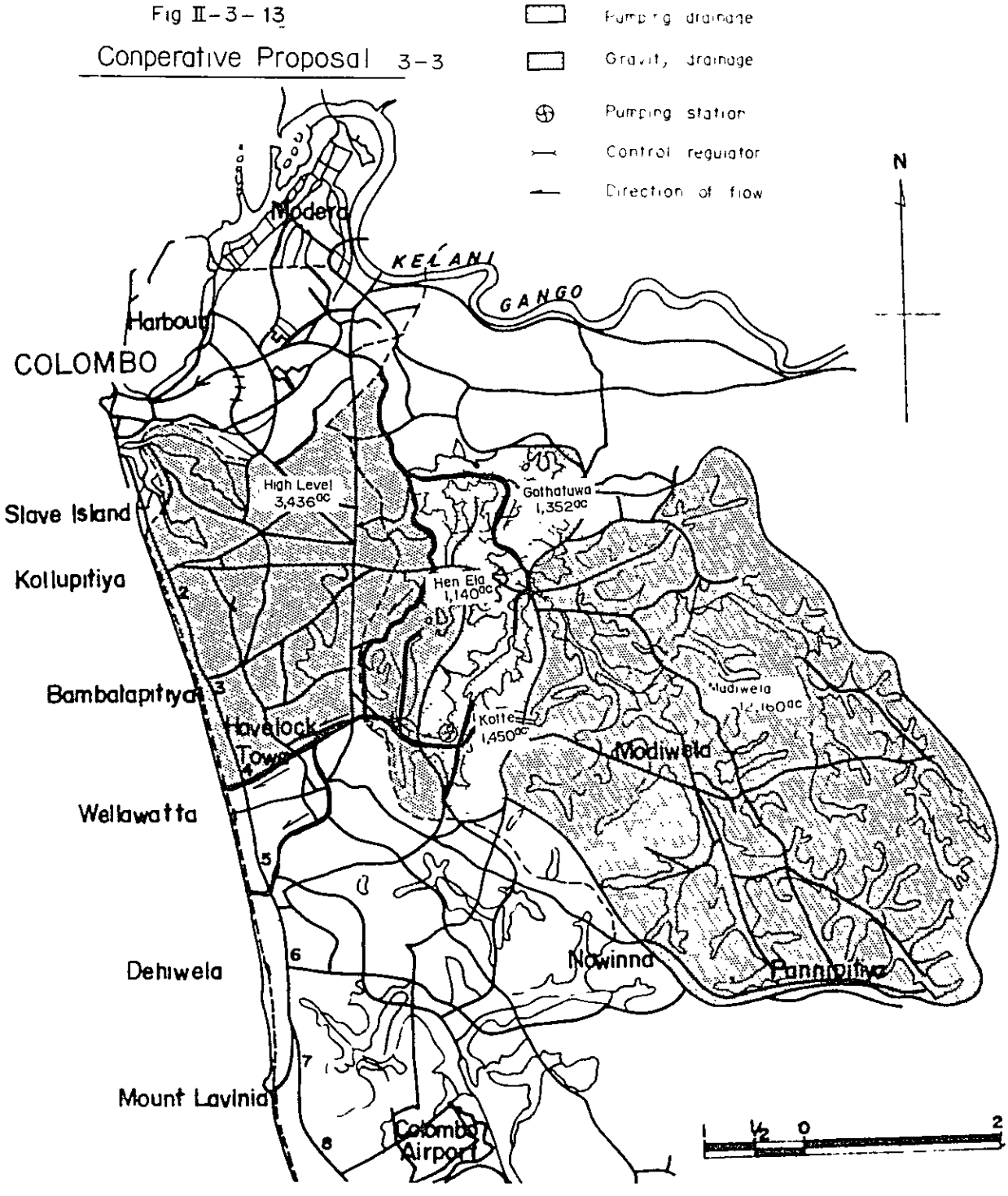


Fig II-3-14

Conperative Proposal 3-4

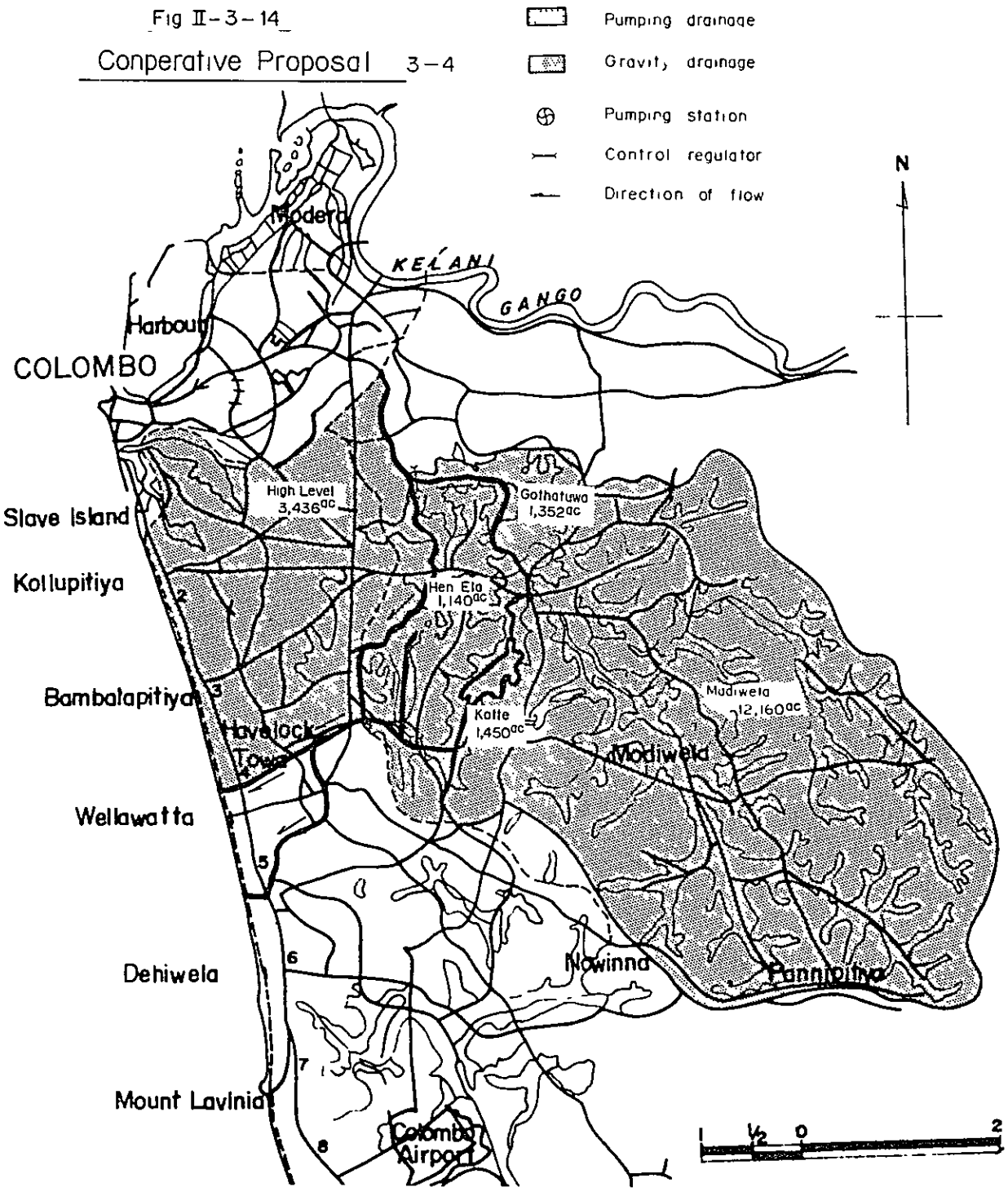


Fig II-4-1

Conperative Proposal 1-1 (Summary of water level and discharge)

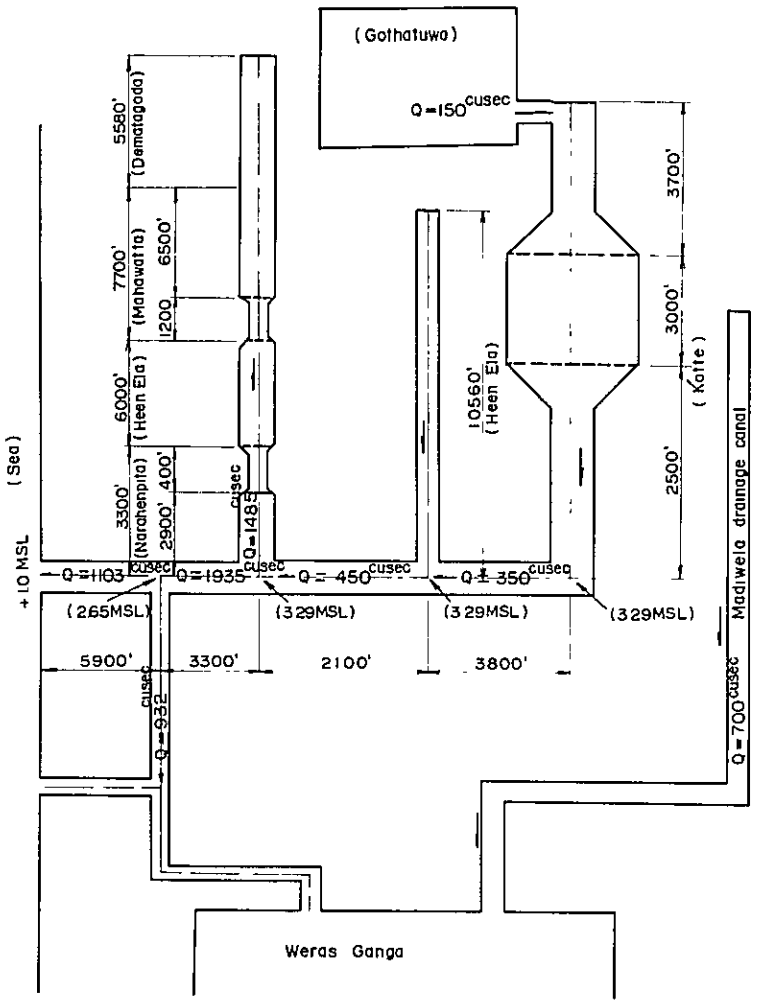


Fig II-4-2

Conperative Proposal 1-2 (Summary of water level and discharge)

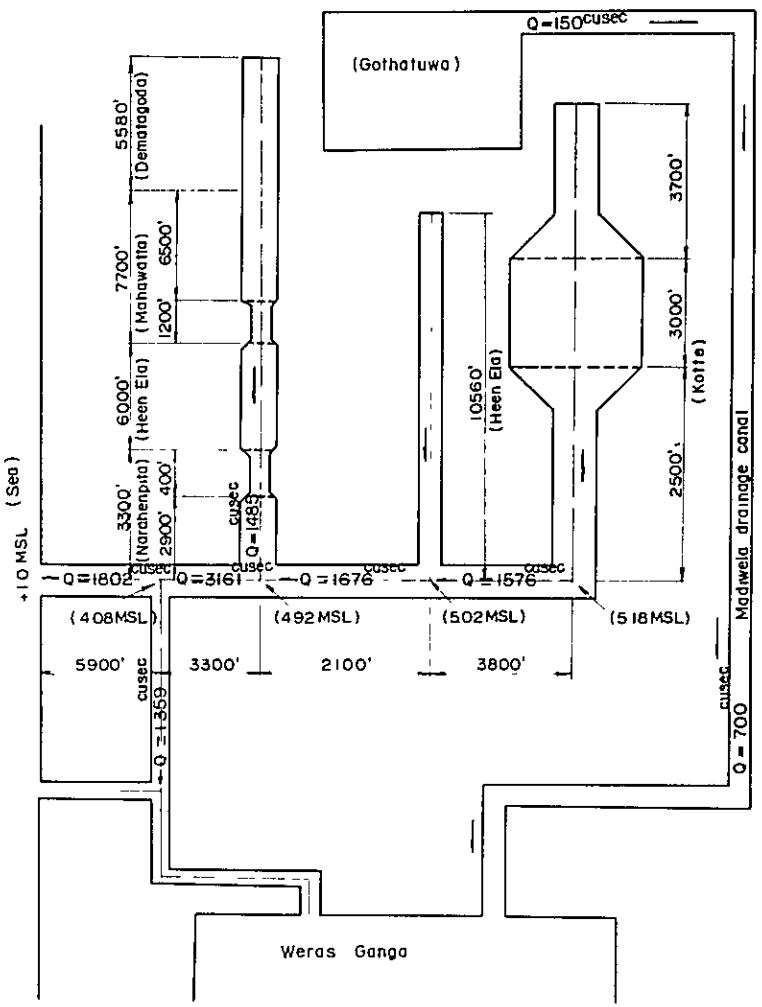


Fig. II-4-3

Conperative Proposal 1-3 (Summary of water level and discharge)

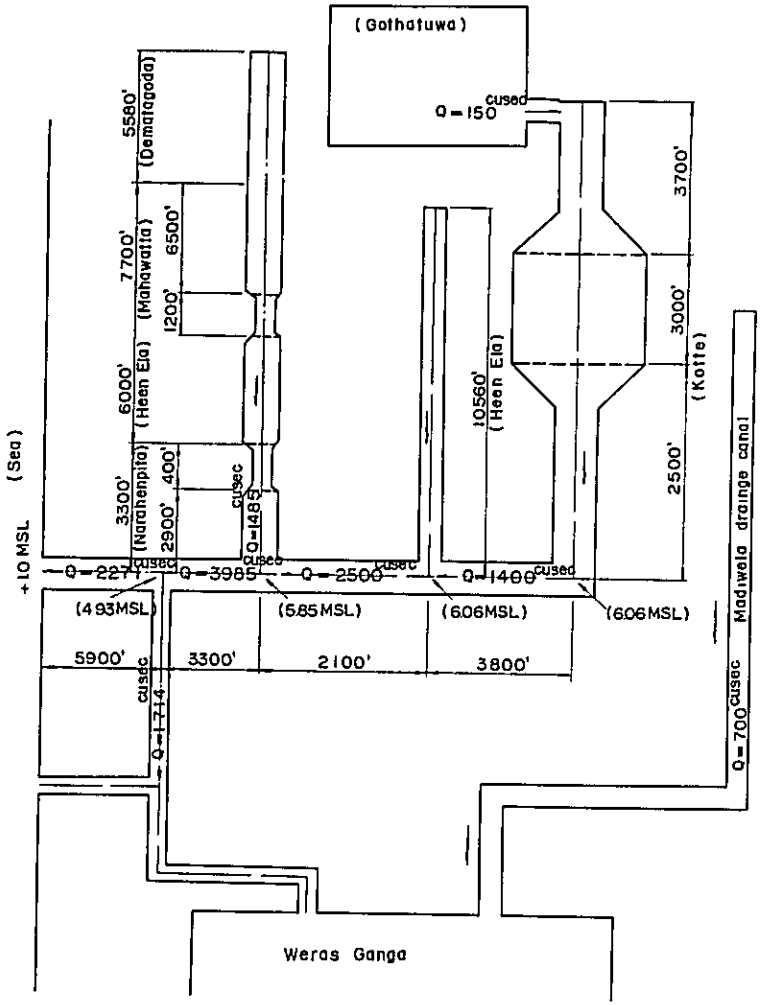


Fig. II-4-4

Conperative Proposal 1-4 (Summary of water level and discharge)

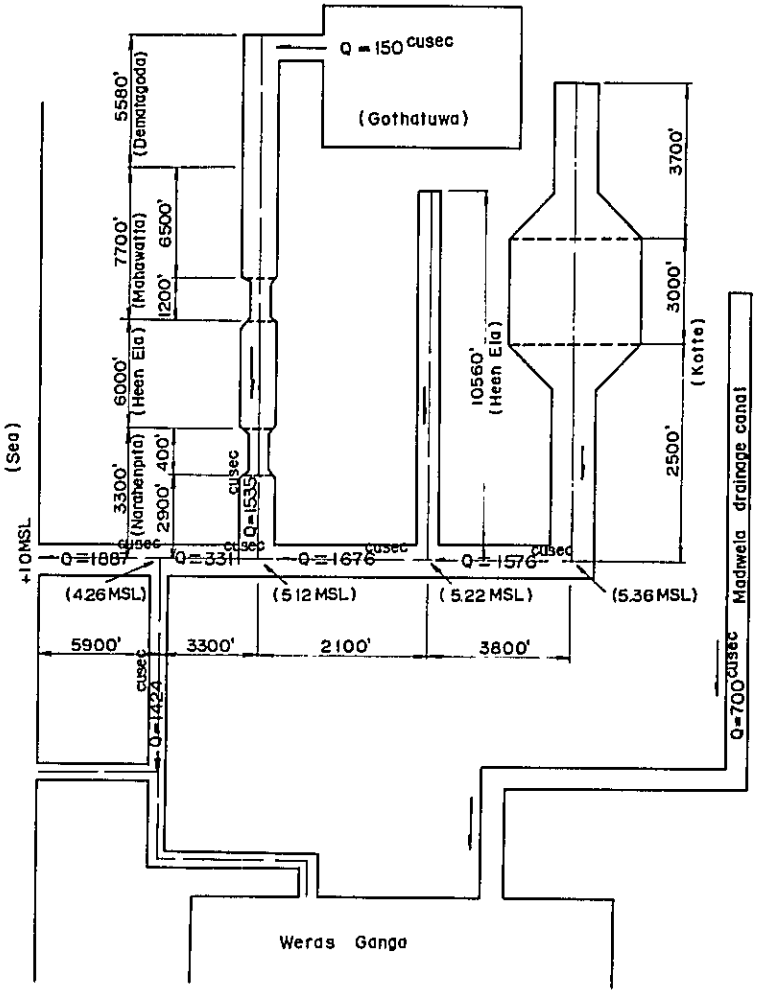


Fig II-4-5

Conperative Proposal 1-5 (Summary of water level and discharge)

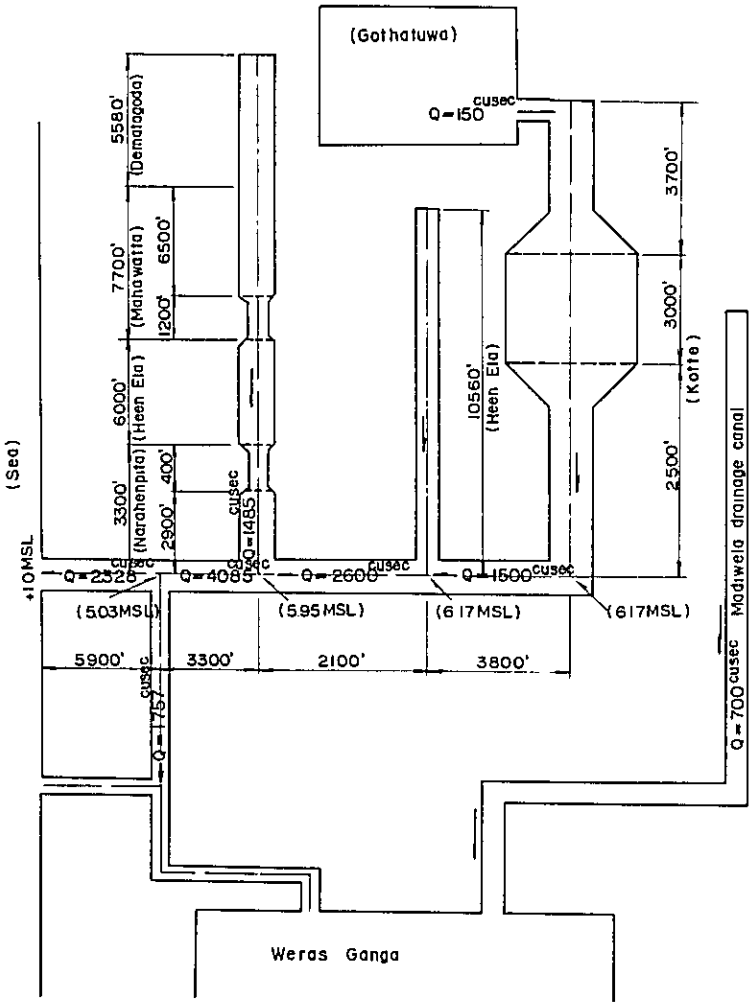


Fig II-4-6

Conperative Proposal 2-1 (Summary of water level and discharge)

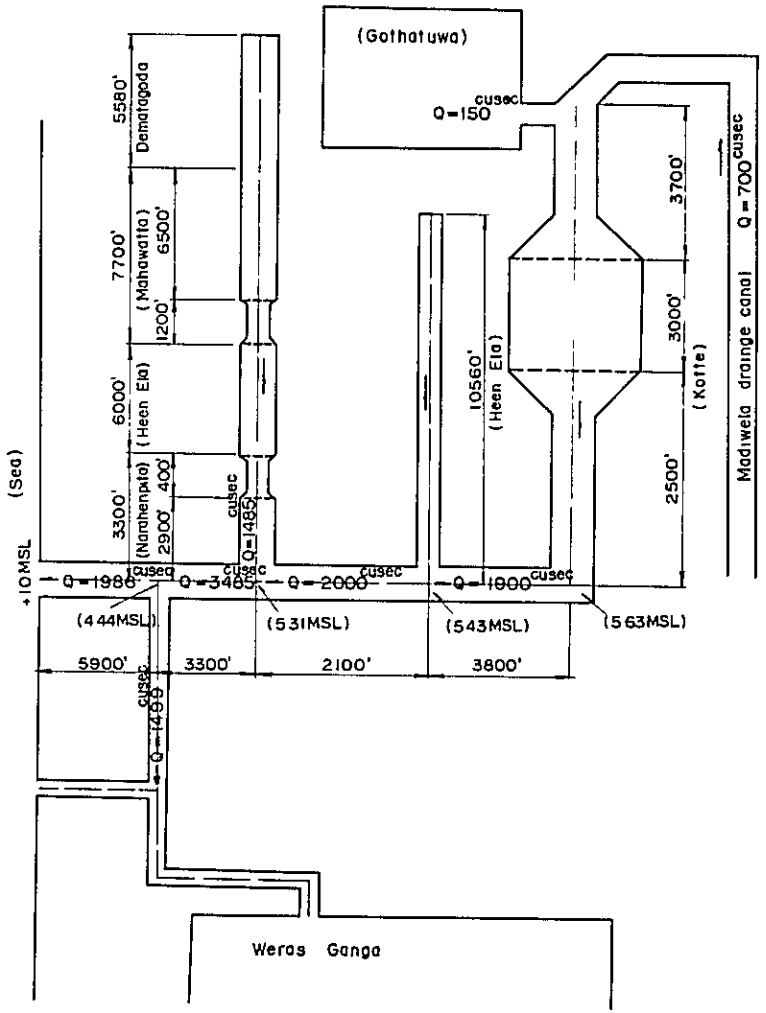


Fig.II-4-7

Conperative Proposal 2-2 (Summary of water level and discharge)

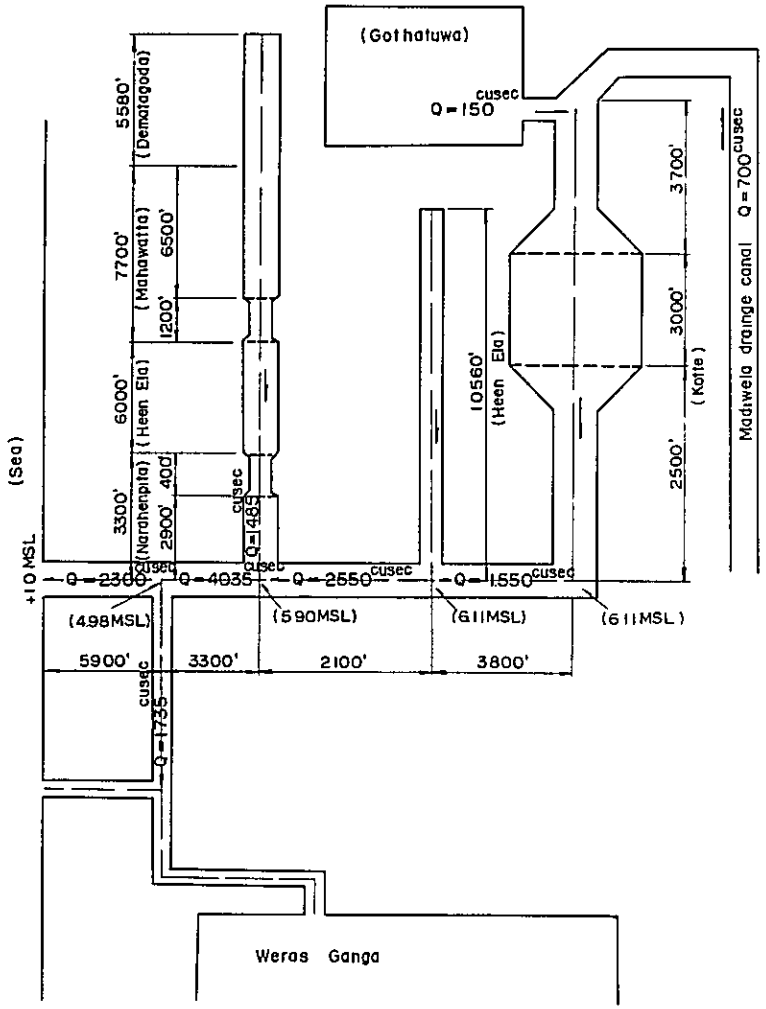


Fig II-4-8

Conperative Proposal 2-3 (Summary of water level and discharge)

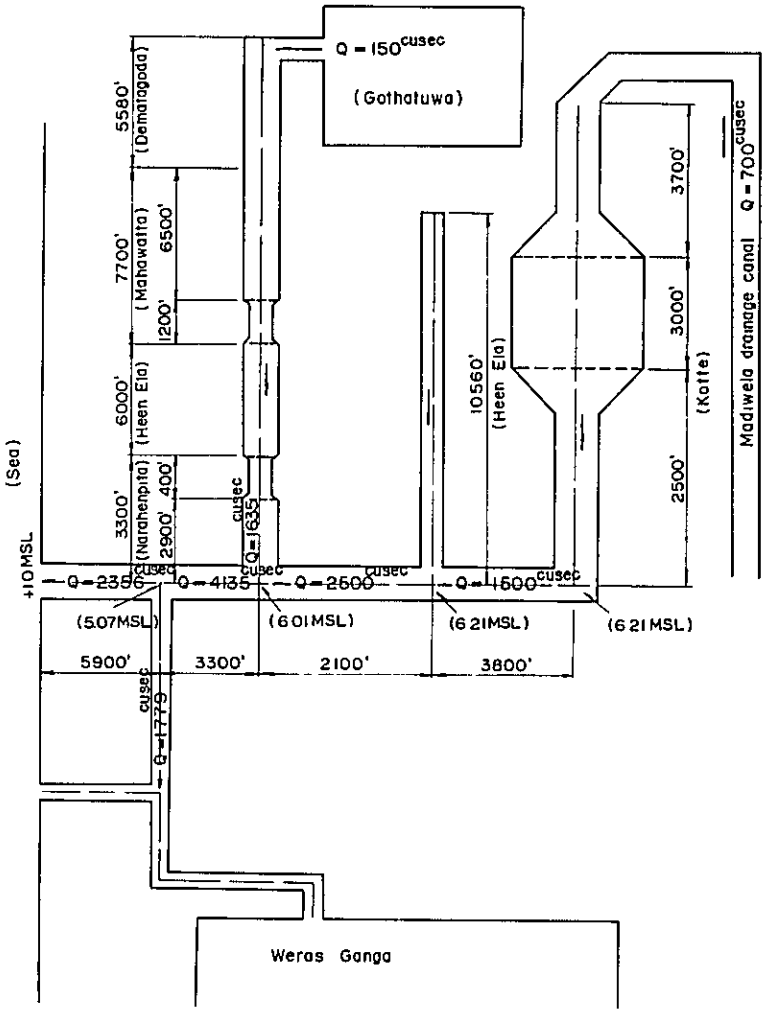


Fig II-4-9

Conperative Proposal 2-4 (Summary of water level and discharge)

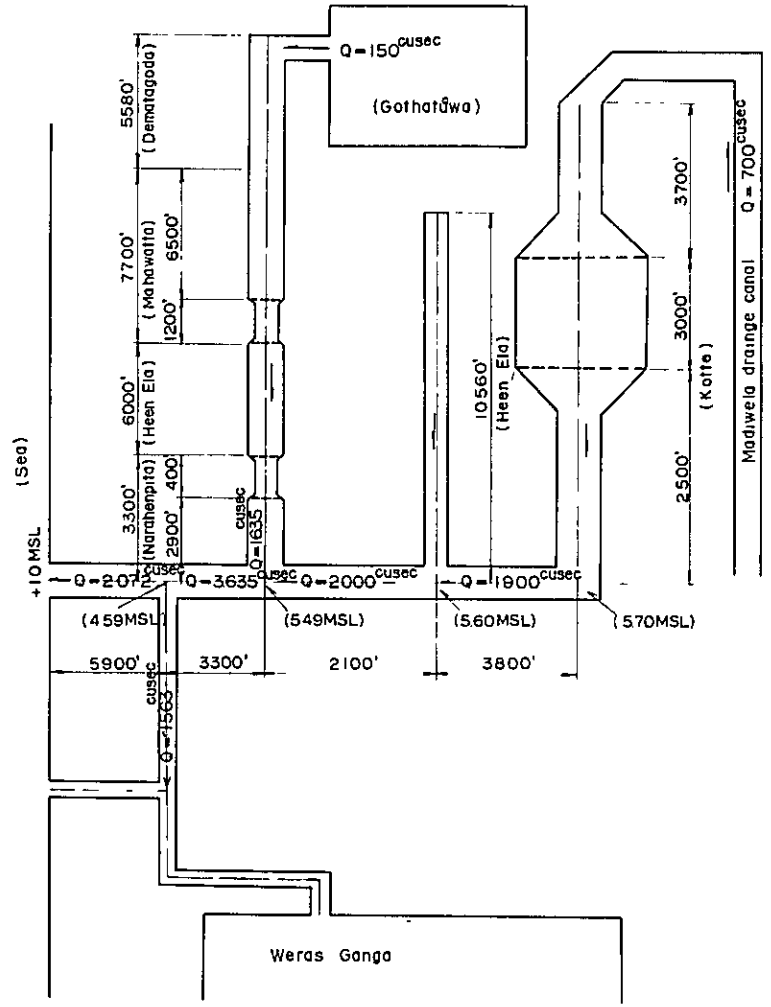


Fig II-4-10

Conperative Proposal 2-5 (Summary of water level and discharge)

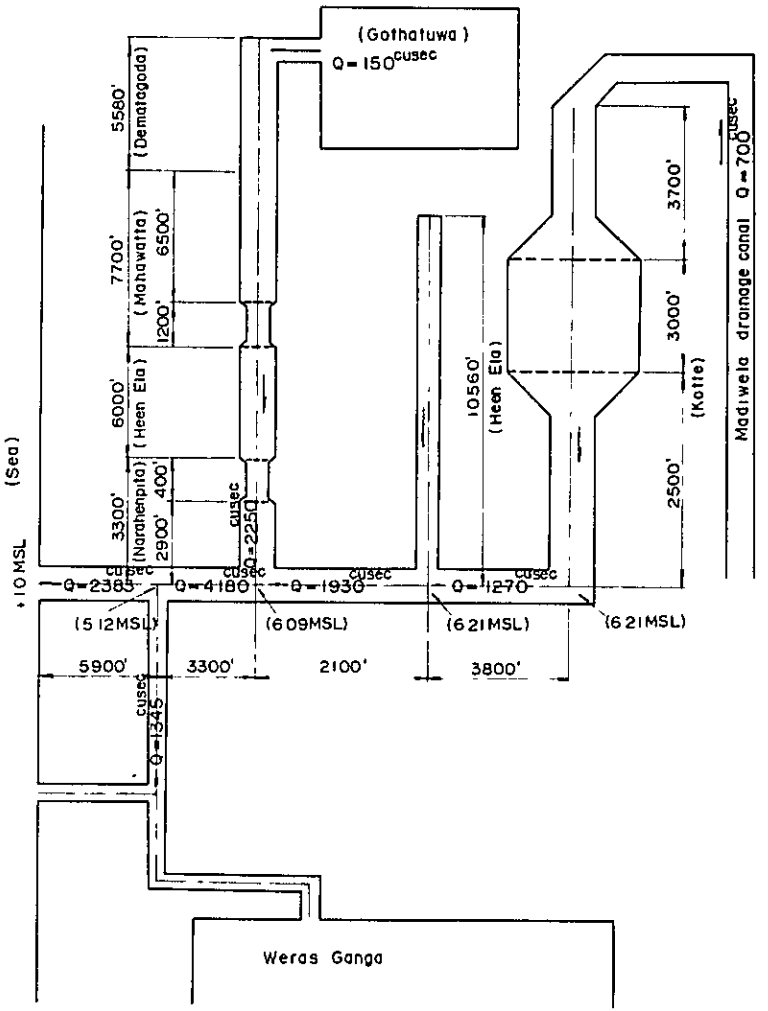


Fig. II-4-11

Conperative Proposal 3-1 (Summary of water level and discharge)

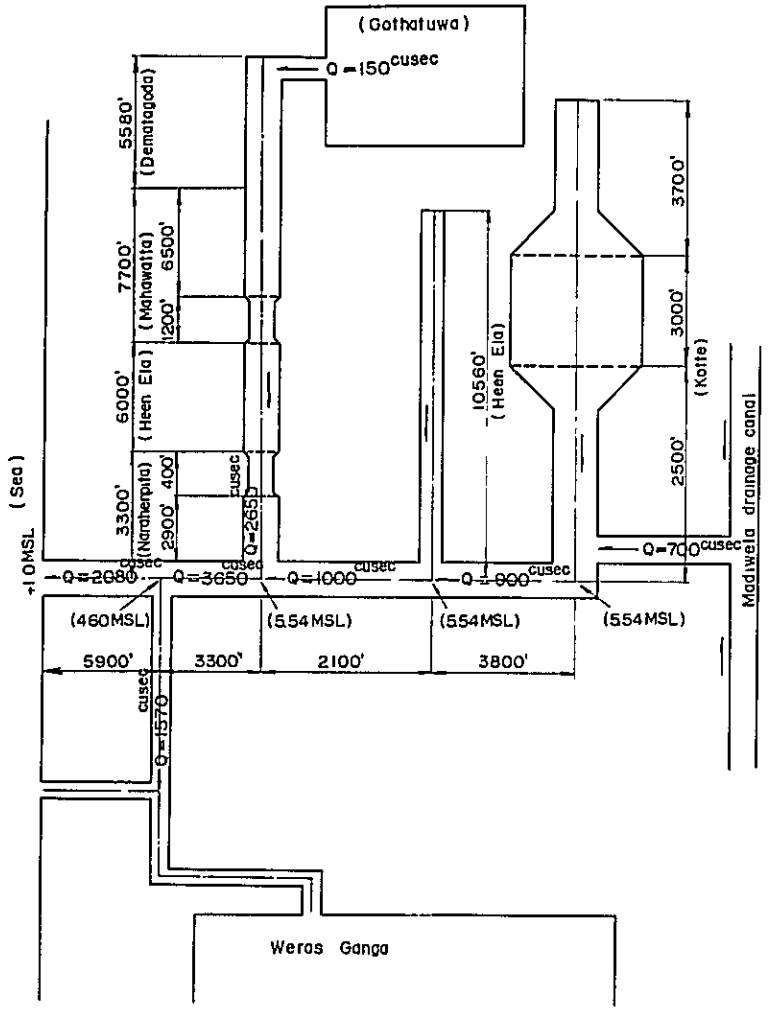


Fig II-4-12

Conperative Proposal 3-2 (Summary of water level and discharge)

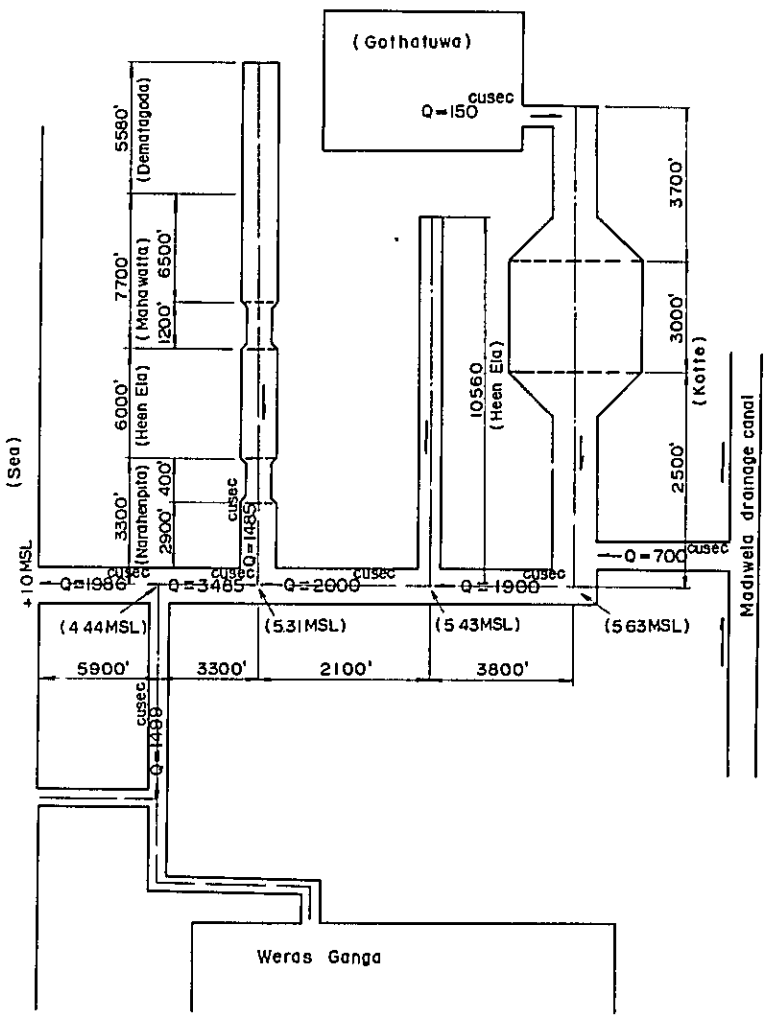


Fig II-4-13

Conperative Propgsal 3-3 (Summary of water level and discharge)

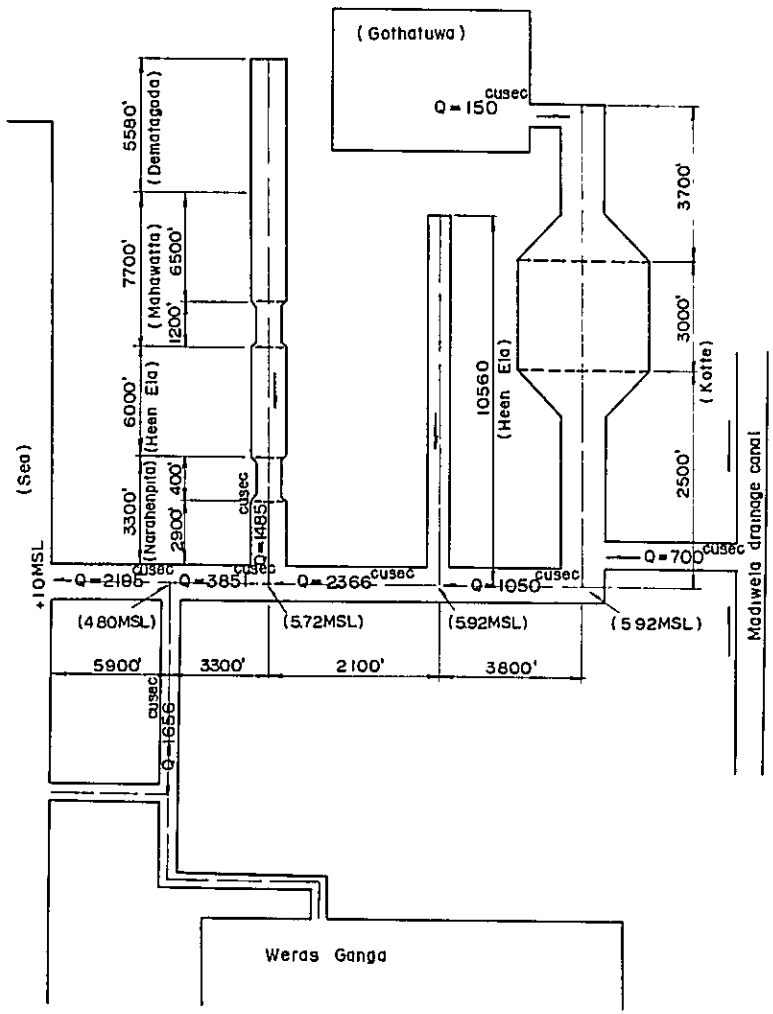


Fig II-4-14

Conperative Proposal 3-4 (Summary of water level and discharge)

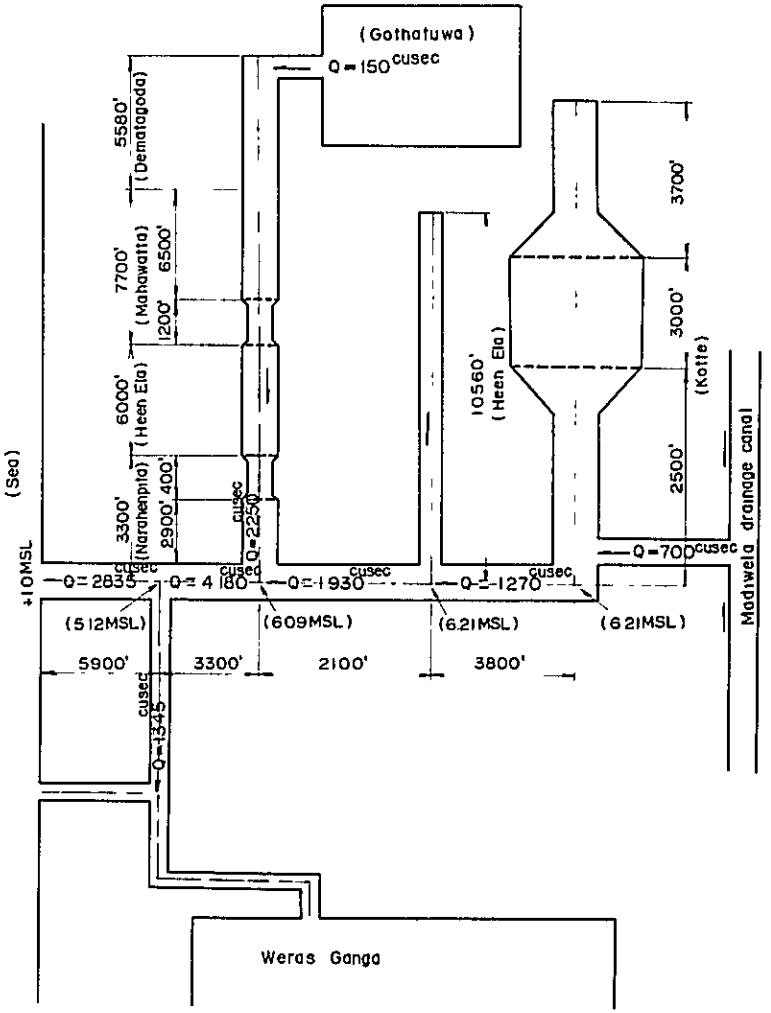


Fig. II-5 Proposed drainage system

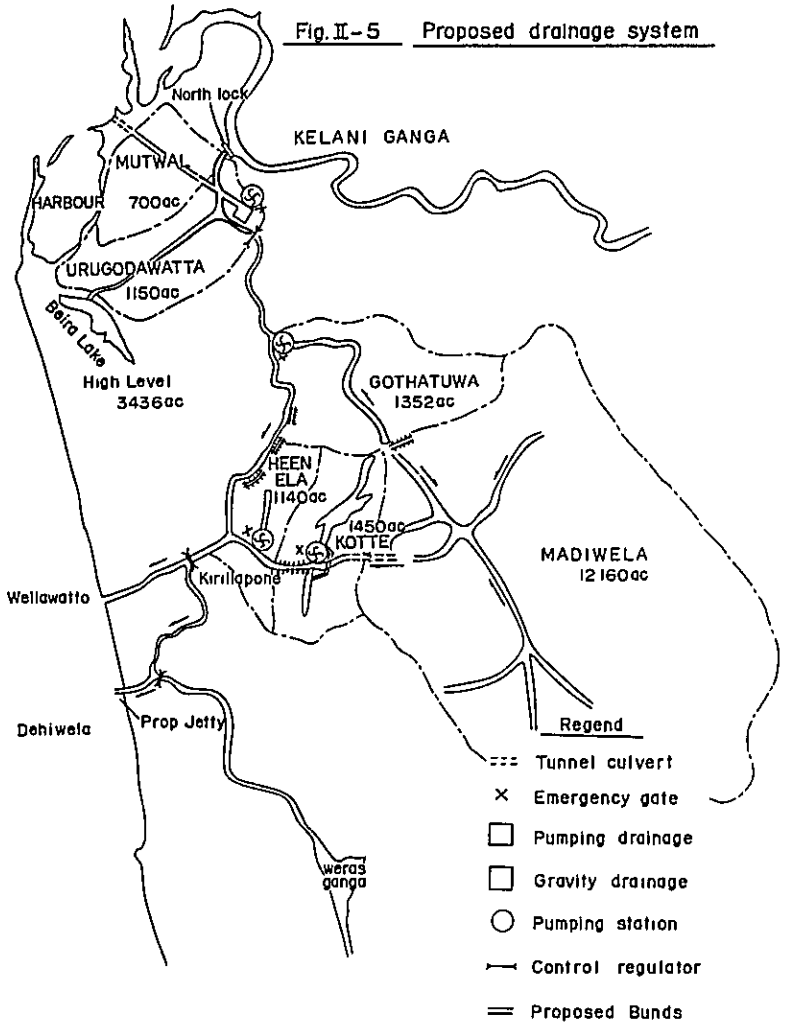


Fig II-6-1

Relation of pumping capacity and reclamation rate

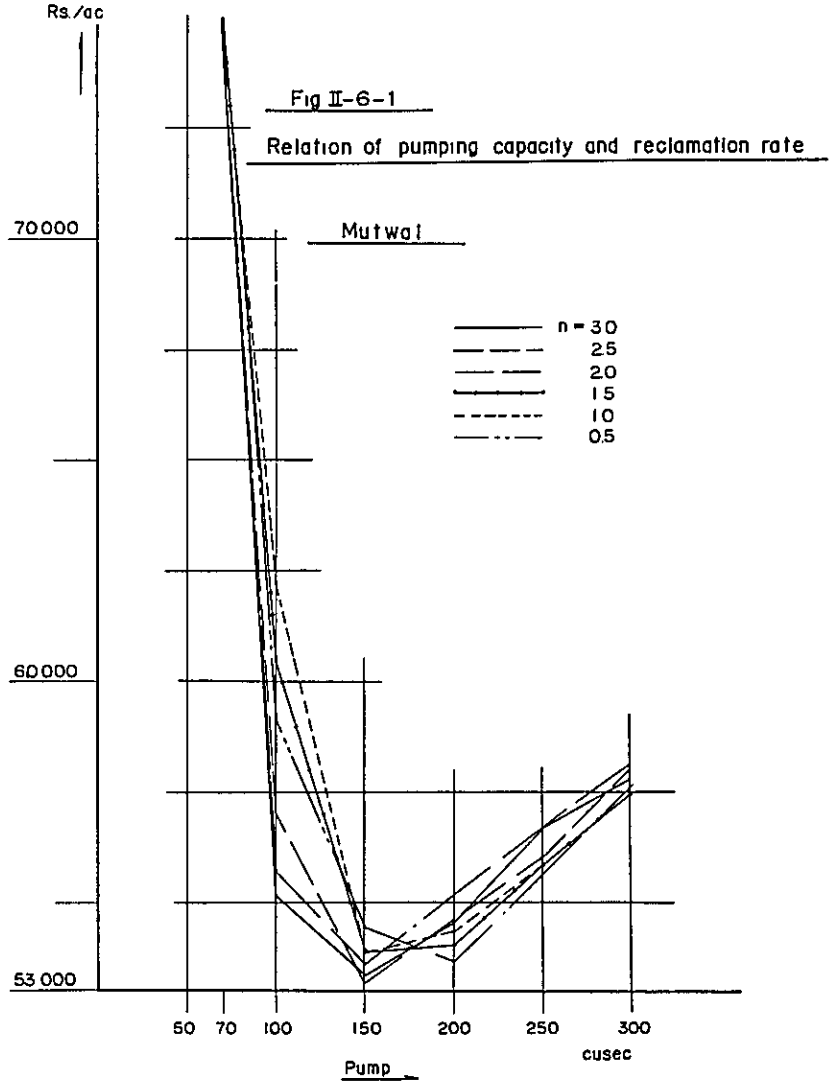


Fig II-6-2

Relation of pumping capacity and reclamation rate

Urugodawatta

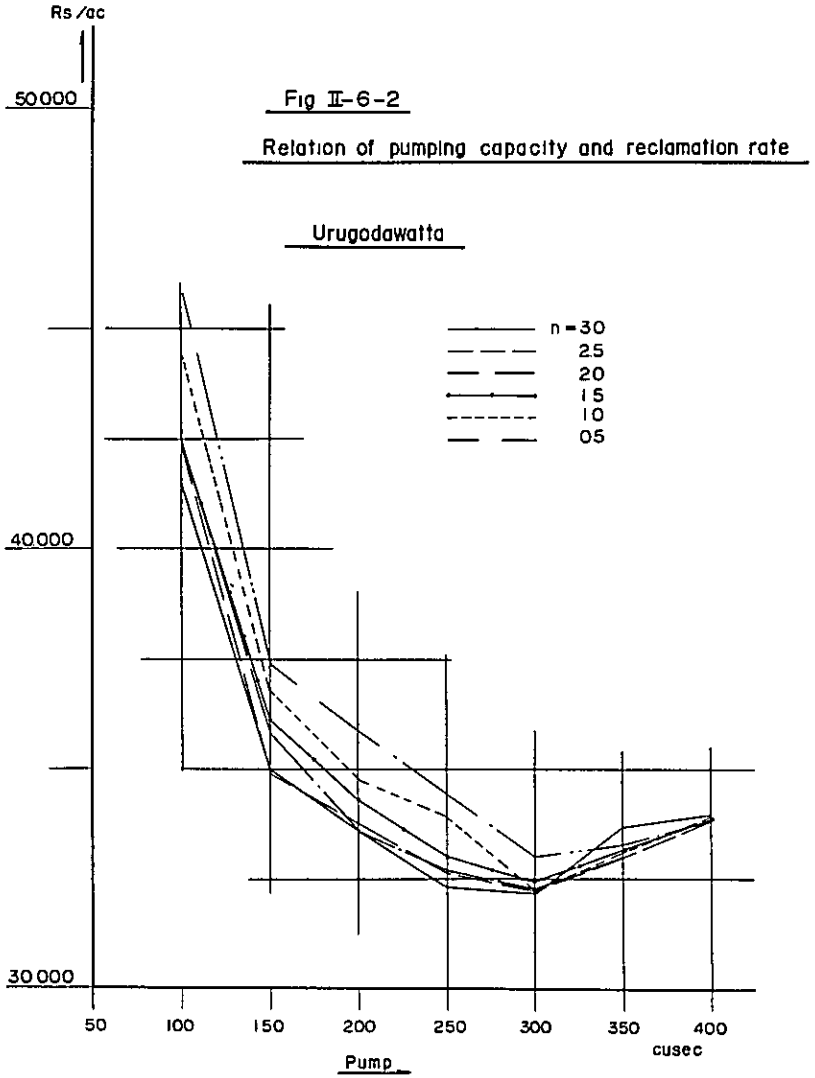


Fig II-6-3

Relation of pumping capacity and reclamation rate

Gothatuwa

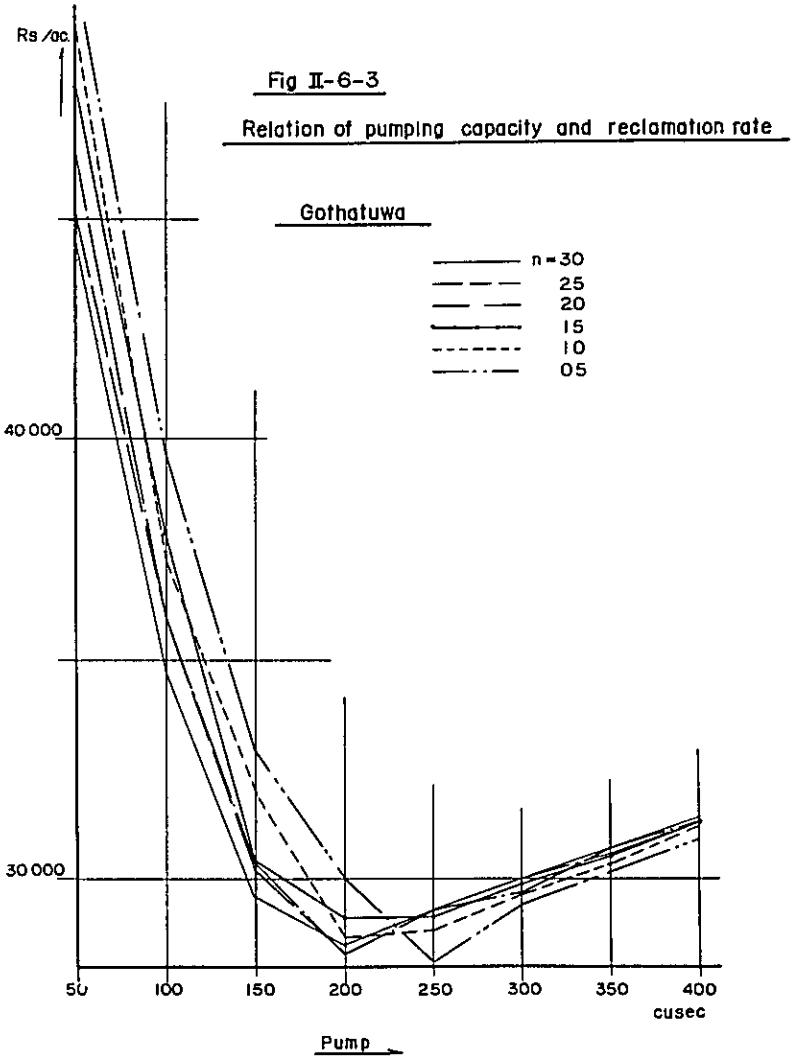


Fig.II-6-4

Relation of pumping capacity and reclamation rate

Kotte

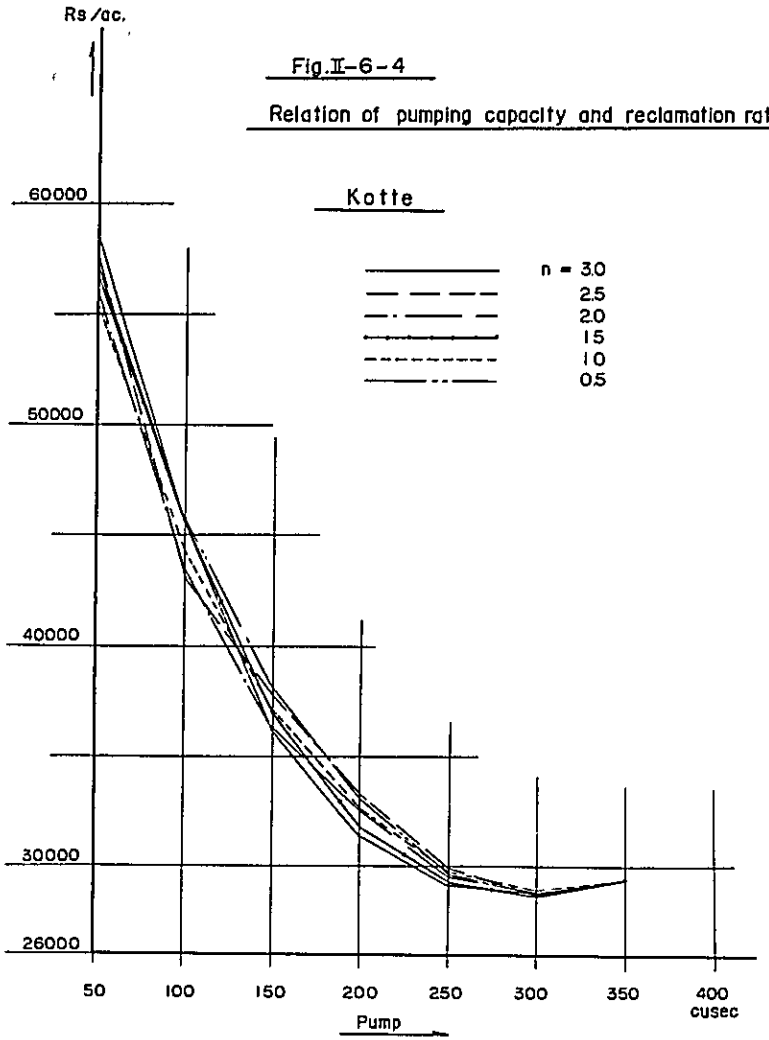
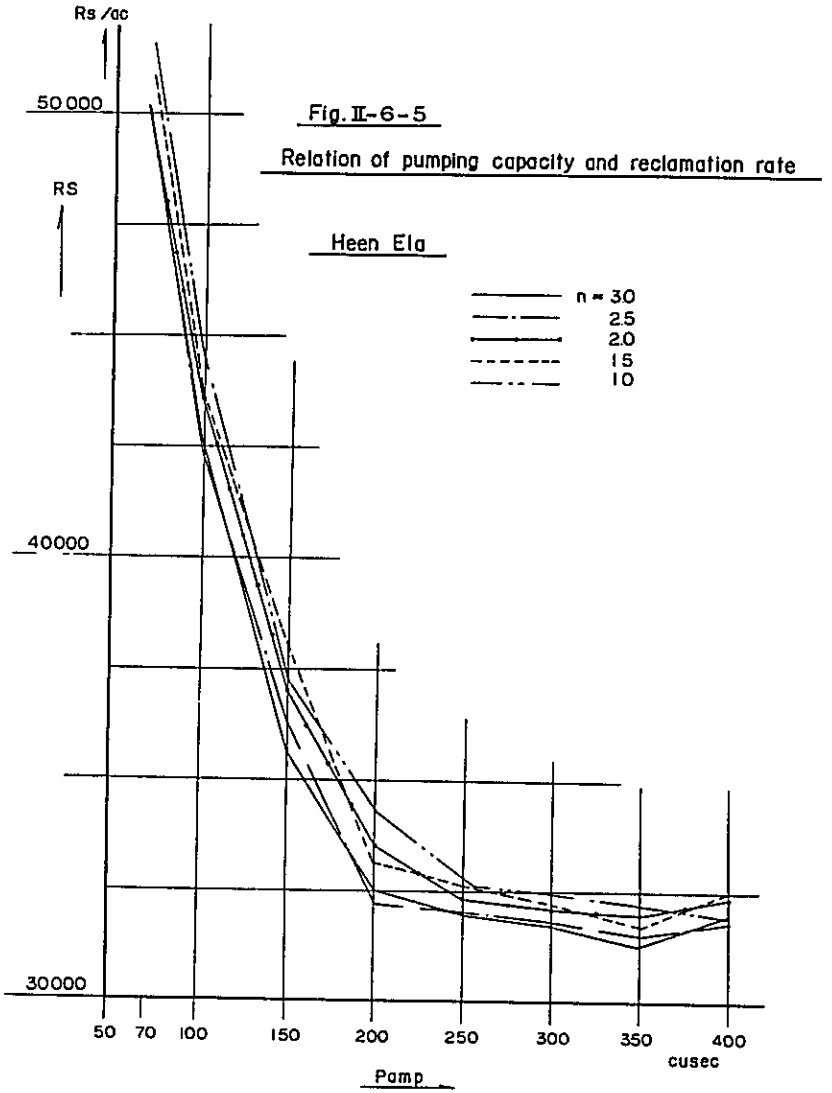


Fig.II-6-5

Relation of pumping capacity and reclamation rate

Heen Ela



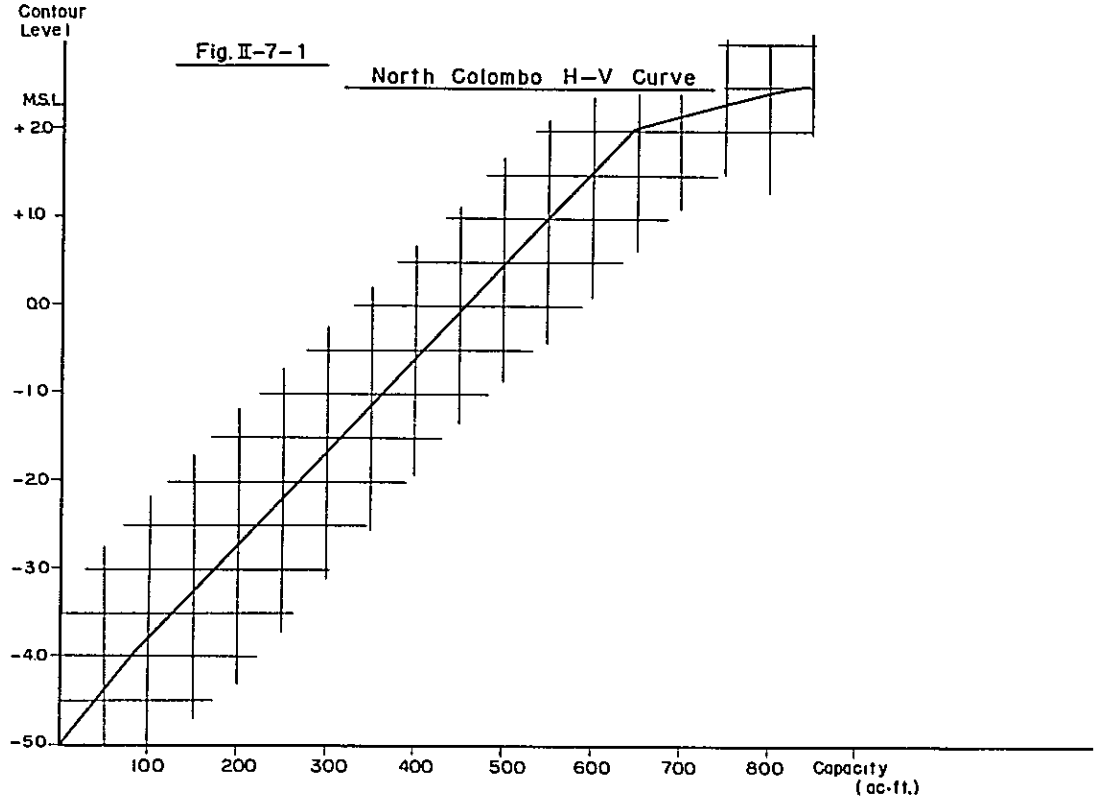


Fig. II-7-1 North Colombo H-V Curve

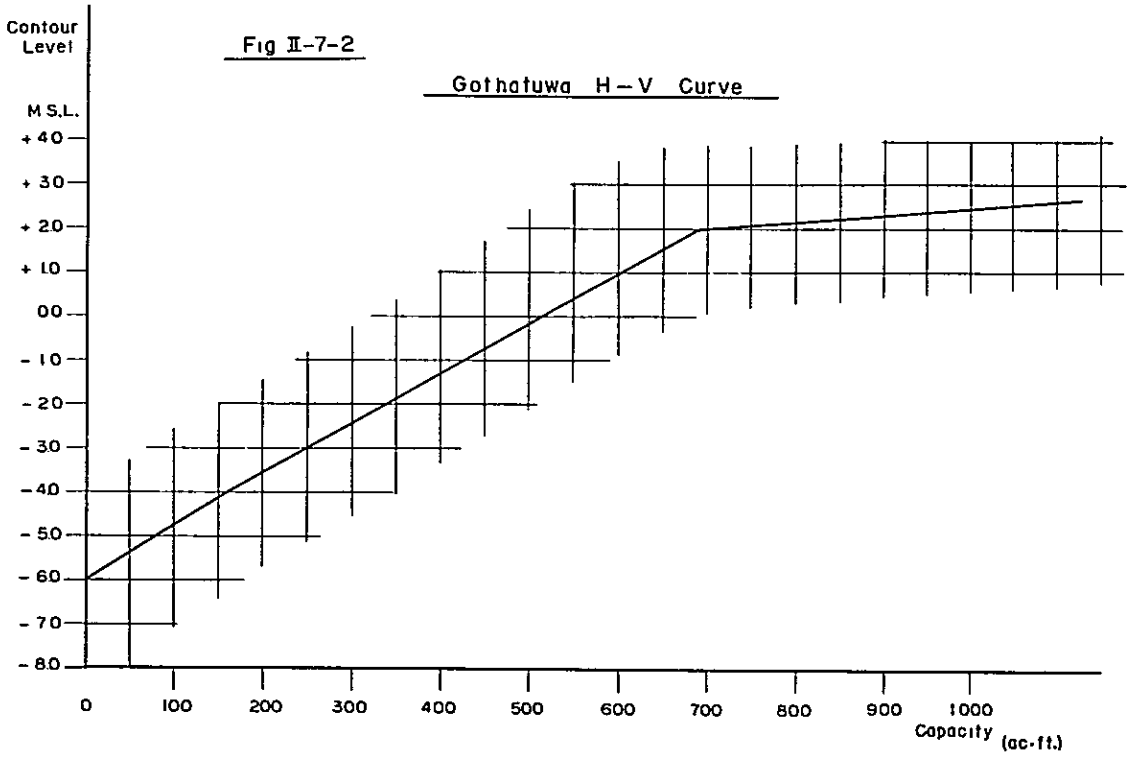


Fig II-7-2 Gothatuwa H-V Curve

Fig II-7-3

Kotte H-V Curve

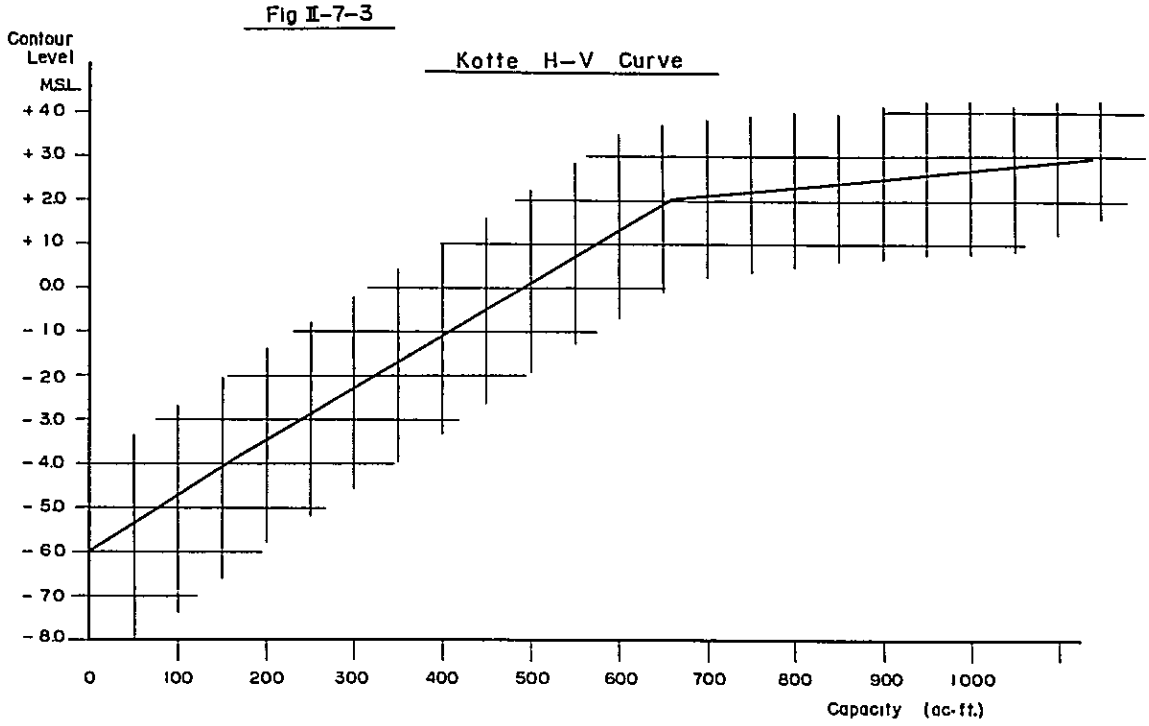
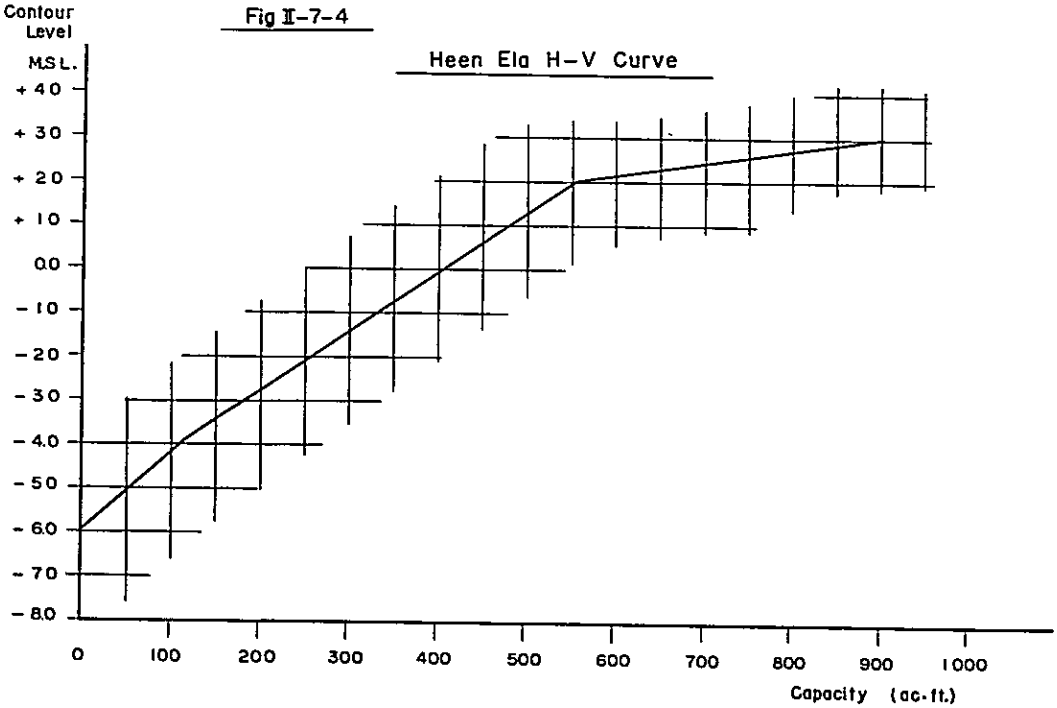


Fig II-7-4

Heen Ela H-V Curve



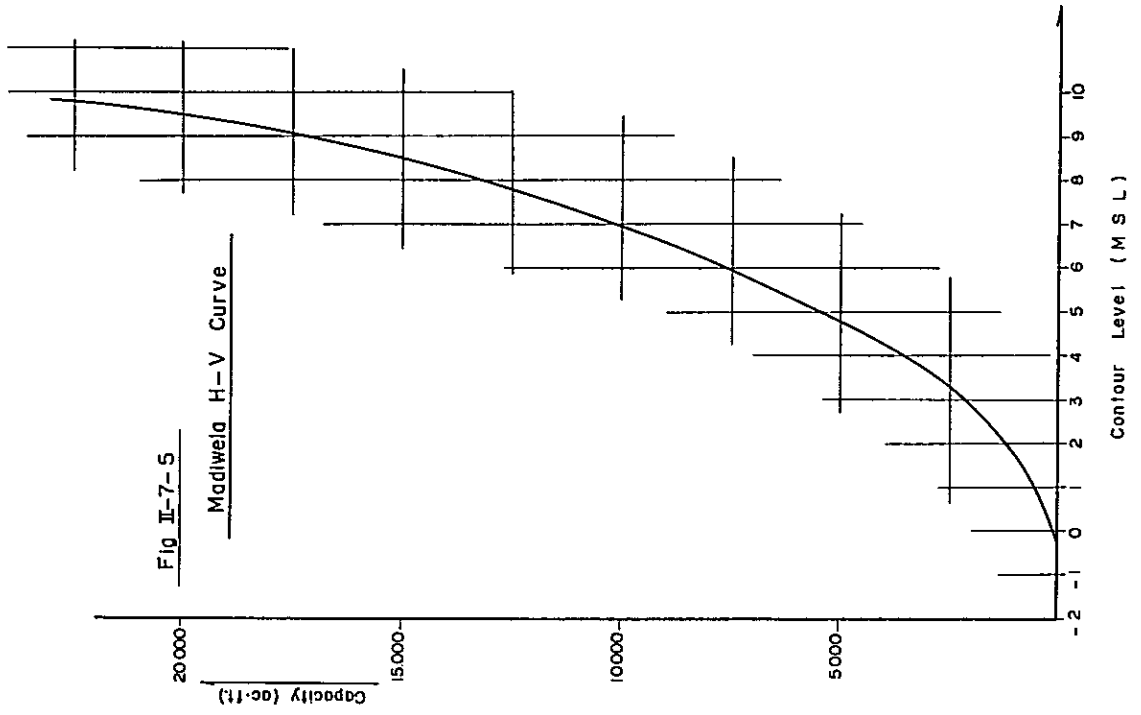


Fig II-7-5
Madiwela H-V Curve
Contour Level (M S L)
Capacity (Ac.ft.)
20000
15000
10000
5000
-2
-1
0
1
2
3
4
5
6
7
8
9
10

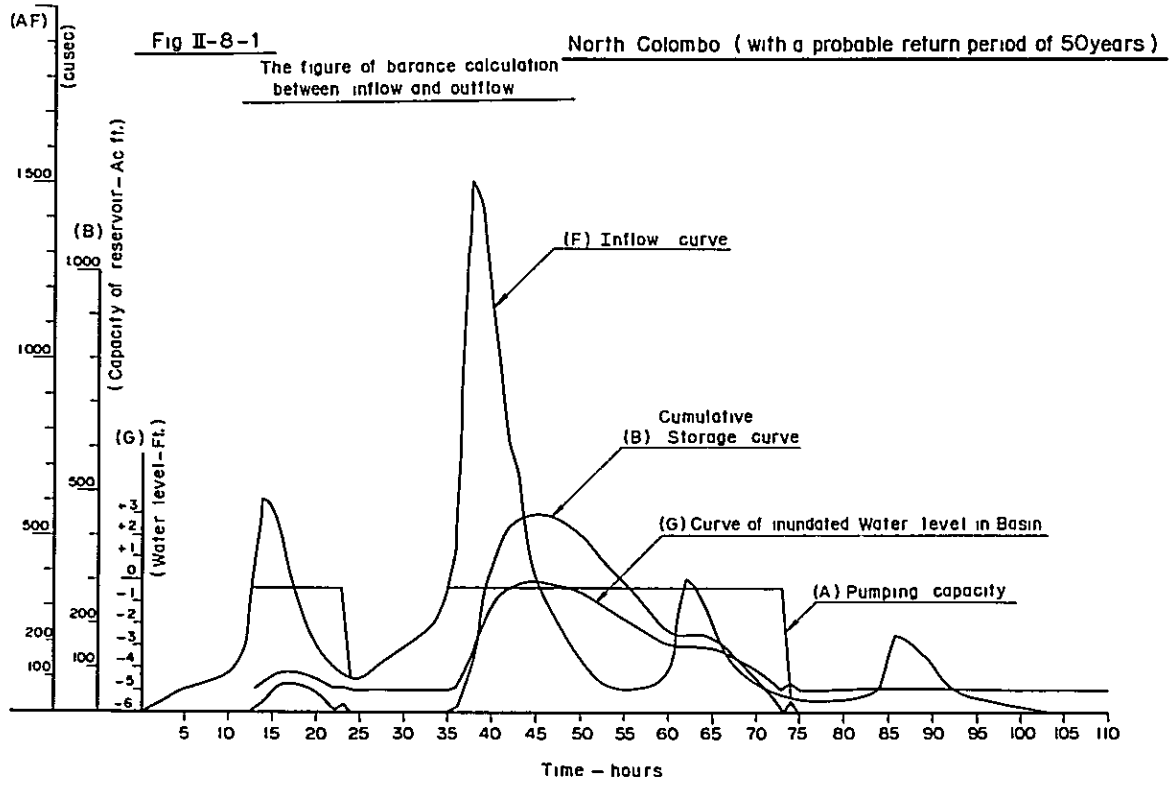


Fig II-8-1
North Colombo (with a probable return period of 50years)
The figure of barance calculation between inflow and outflow
(AF)
(cusec)
(Capacity of reservoir-Ac ft.)
(B)
(G)
(Water level-Ft.)
1500
1000
500
200
100
(F) Inflow curve
Cumulative
(B) Storage curve
(G) Curve of inundated Water level in Basin
(A) Pumping capacity
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110
Time - hours

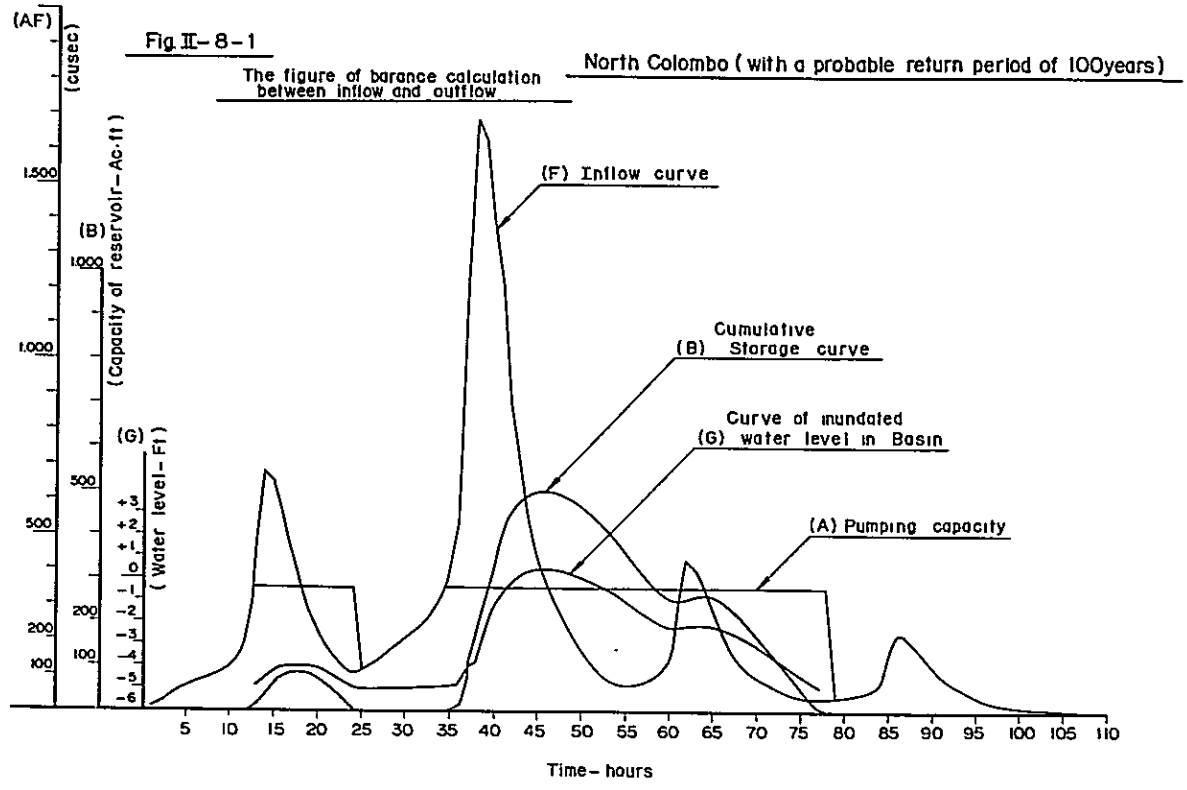


Fig II-8-1
The figure of barance calculation between inflow and outflow
North Colombo (with a probable return period of 100years)
(AF)
(cusec)
(B)
(Capacity of reservoir-Ac-ft)
(G)
(Water level-Ft)
(F) Inflow curve
Cumulative (B) Storage curve
Curve of inundated (G) water level in Basin
(A) Pumping capacity
Time-hours

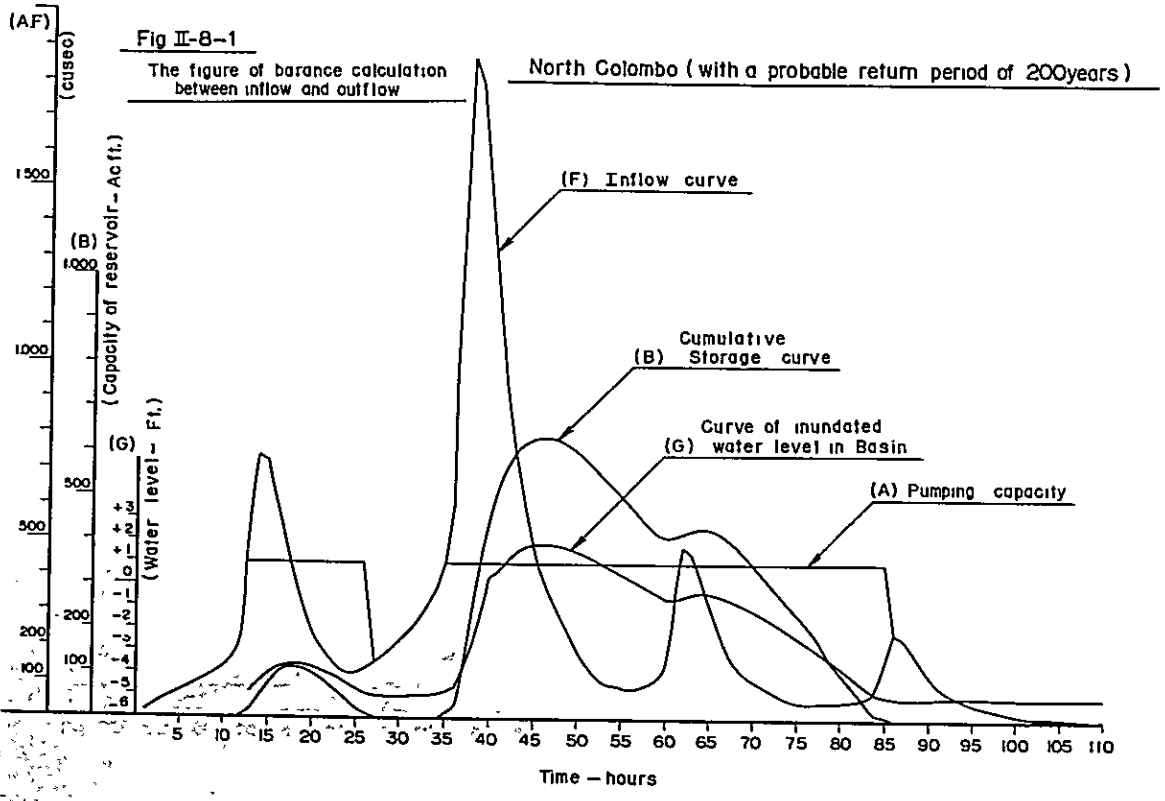


Fig II-8-1
The figure of barance calculation between inflow and outflow
North Colombo (with a probable return period of 200years)
(AF)
(cusec)
(B)
(Capacity of reservoir-Ac-ft.)
(G)
(Water level-Ft.)
(F) Inflow curve
Cumulative (B) Storage curve
Curve of inundated (G) water level in Basin
(A) Pumping capacity
Time-hours

Fig II-8-2

The figure of barance calculation between inflow and outflow

Gothatuwa (with a probable return period of 50years)

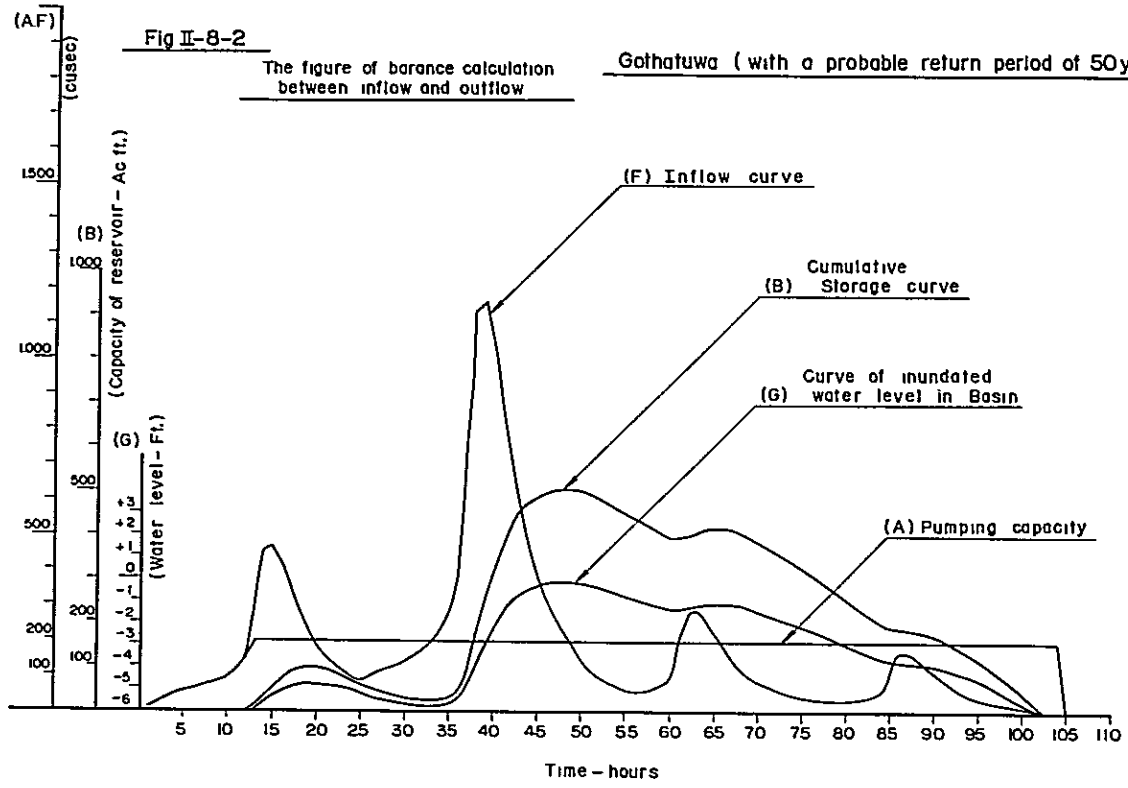


Fig II-8-2

The figure of barance calculation between inflow and outflow

Gothatuwa(with a probable return period of 100years)

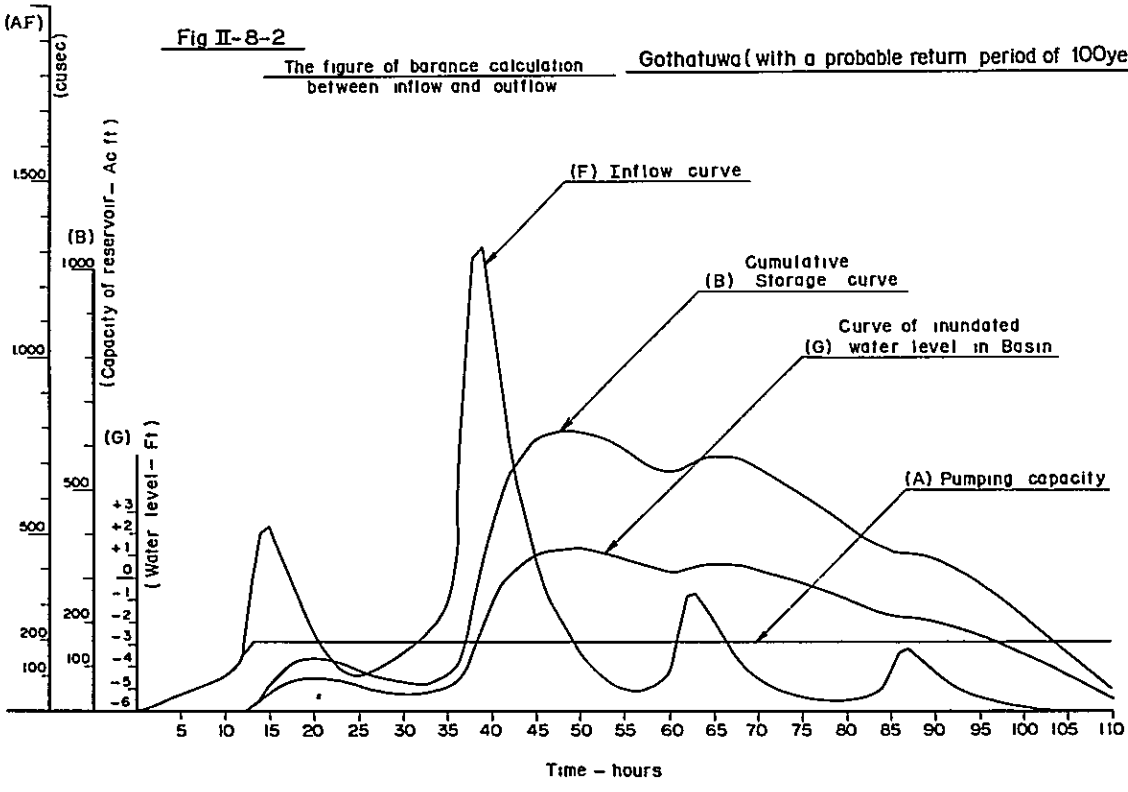


Fig II-8-2

The figure of barance calculation between inflow and outflow

Gothatuwa (with a probable return period of 200years)

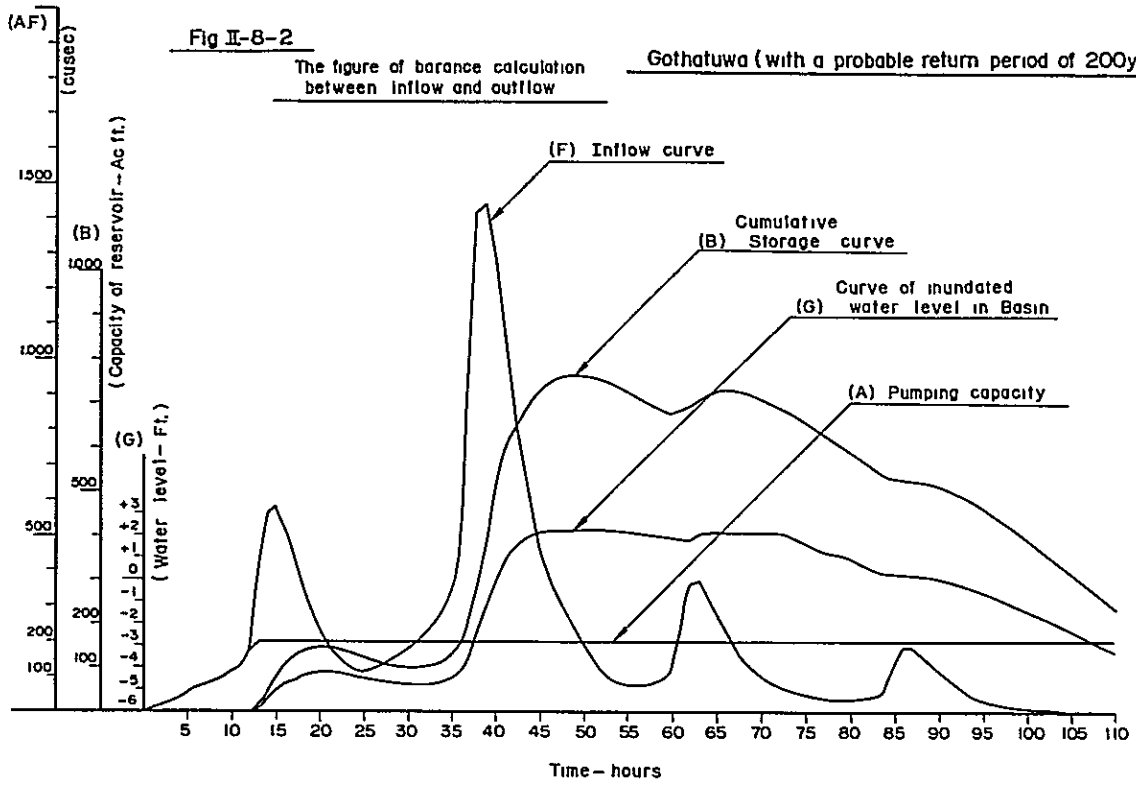
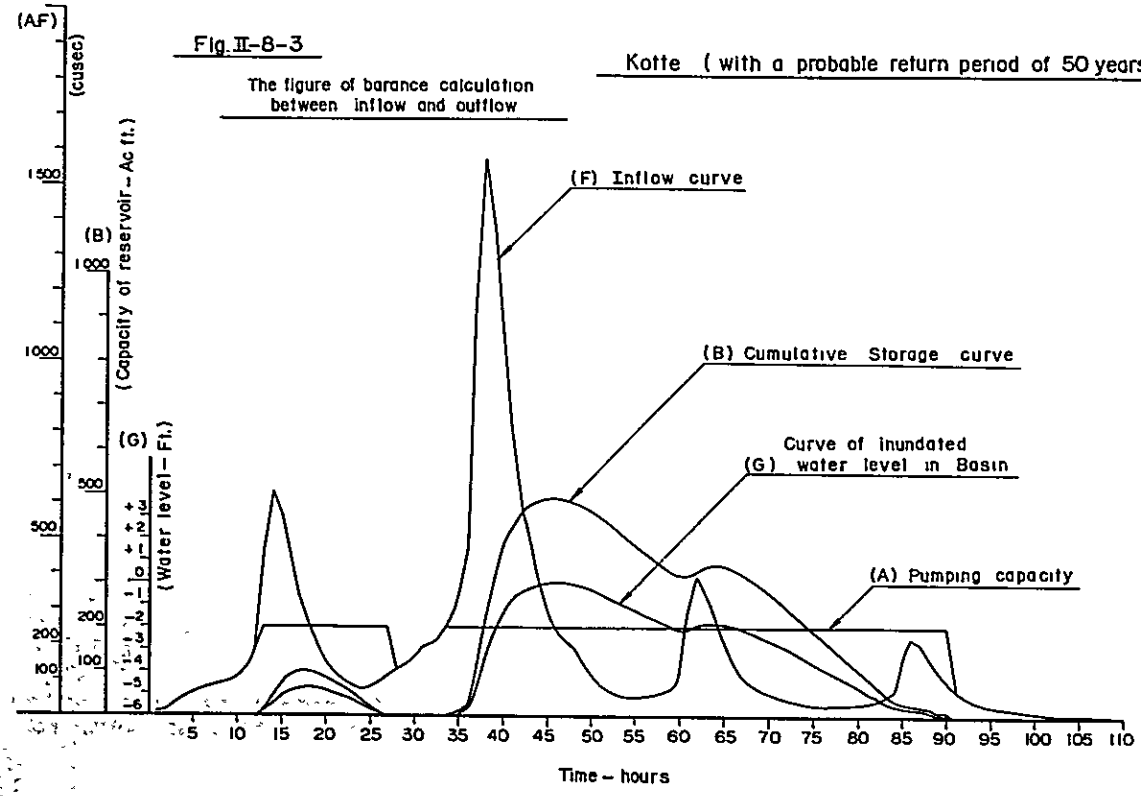


Fig.II-8-3

The figure of barance calculation between inflow and outflow

Kotte (with a probable return period of 50 years)



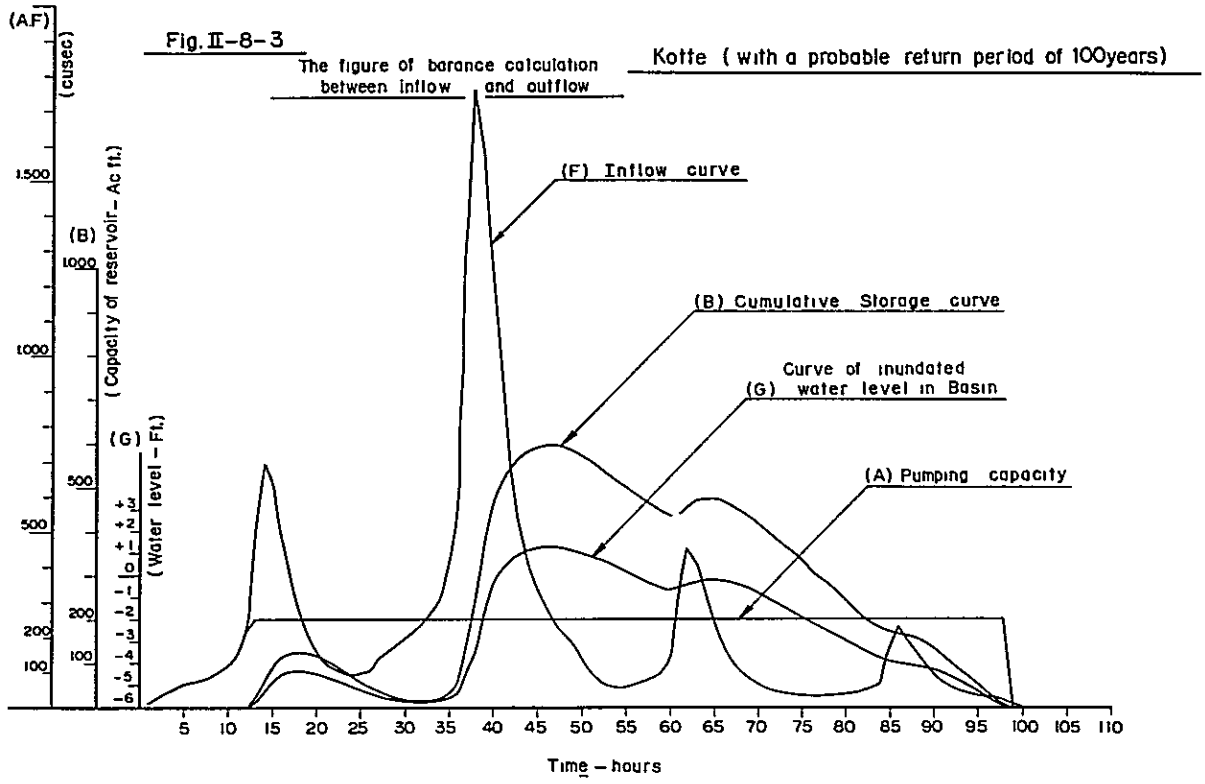


Fig. II-8-3
Kotte (with a probable return period of 100years)
The figure of barance calculation between inflow and outflow
(F) Inflow curve
(B) Cumulative Storage curve
Curve of inundated (G) water level in Basin
(A) Pumping capacity
(AF)
(cusec)
(B)
(Capacity of reservoir - Ac ft.)
(G)
(Water level - Ft.)
Time - hours

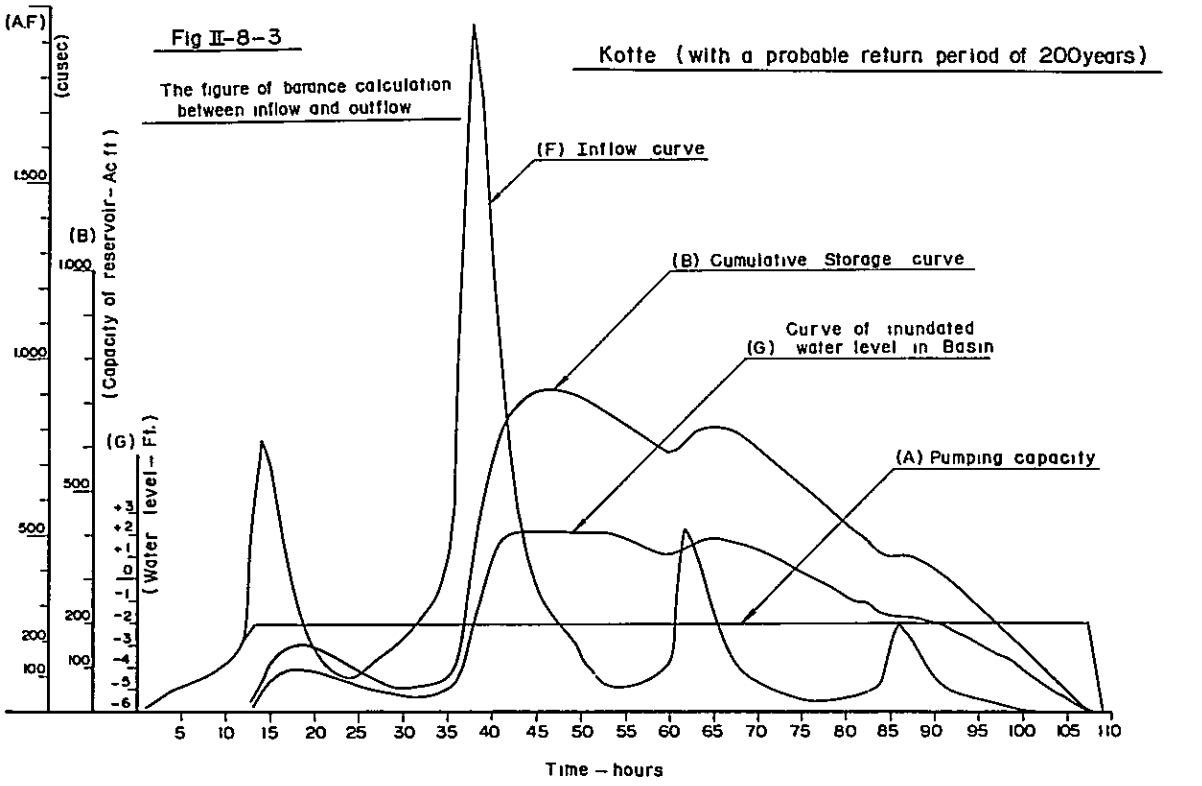


Fig II-8-3
Kotte (with a probable return period of 200years)
The figure of barance calculation between inflow and outflow
(F) Inflow curve
(B) Cumulative Storage curve
Curve of inundated (G) water level in Basin
(A) Pumping capacity
(AF)
(cusec)
(B)
(Capacity of reservoir - Ac ft)
(G)
(Water level - Ft.)
Time - hours

Fig II-8-4

The figure of barance calculation between inflow and outflow

Heen Ela (with a probable return period of 50years)

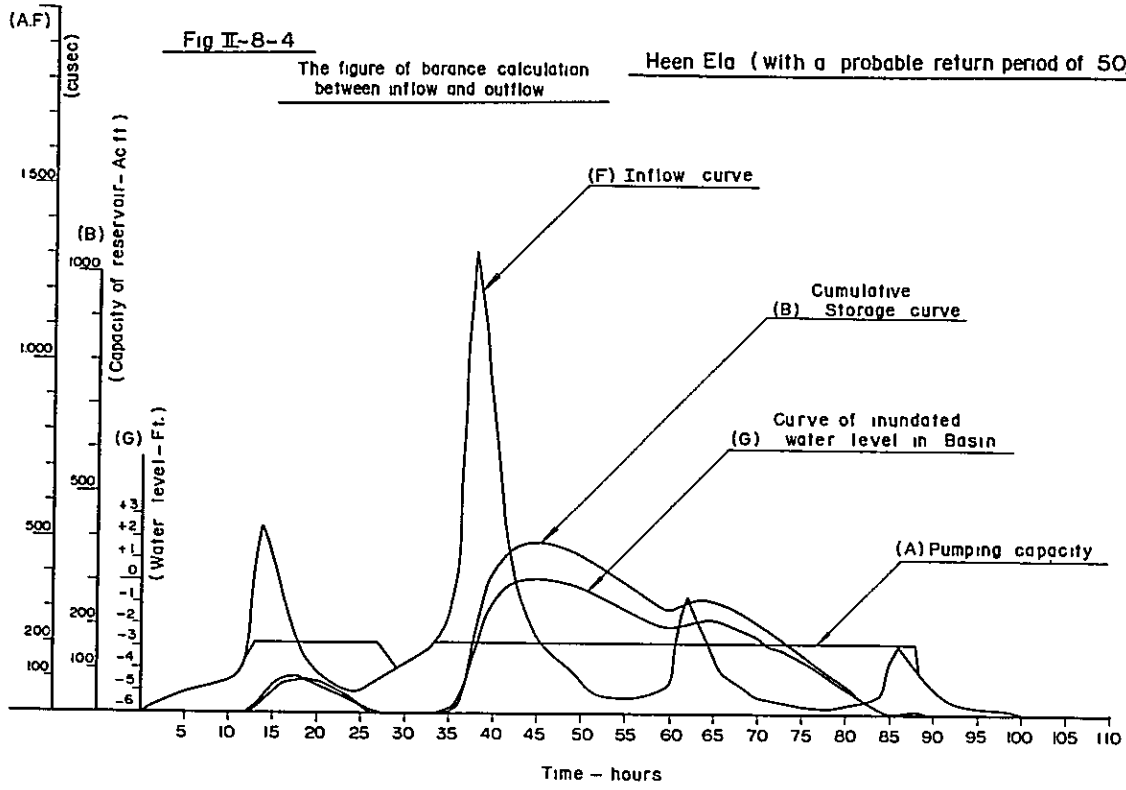


Fig II-8-4

The figure of barance calculation between inflow and outflow

Heen Ela (with a probable return period of 100years)

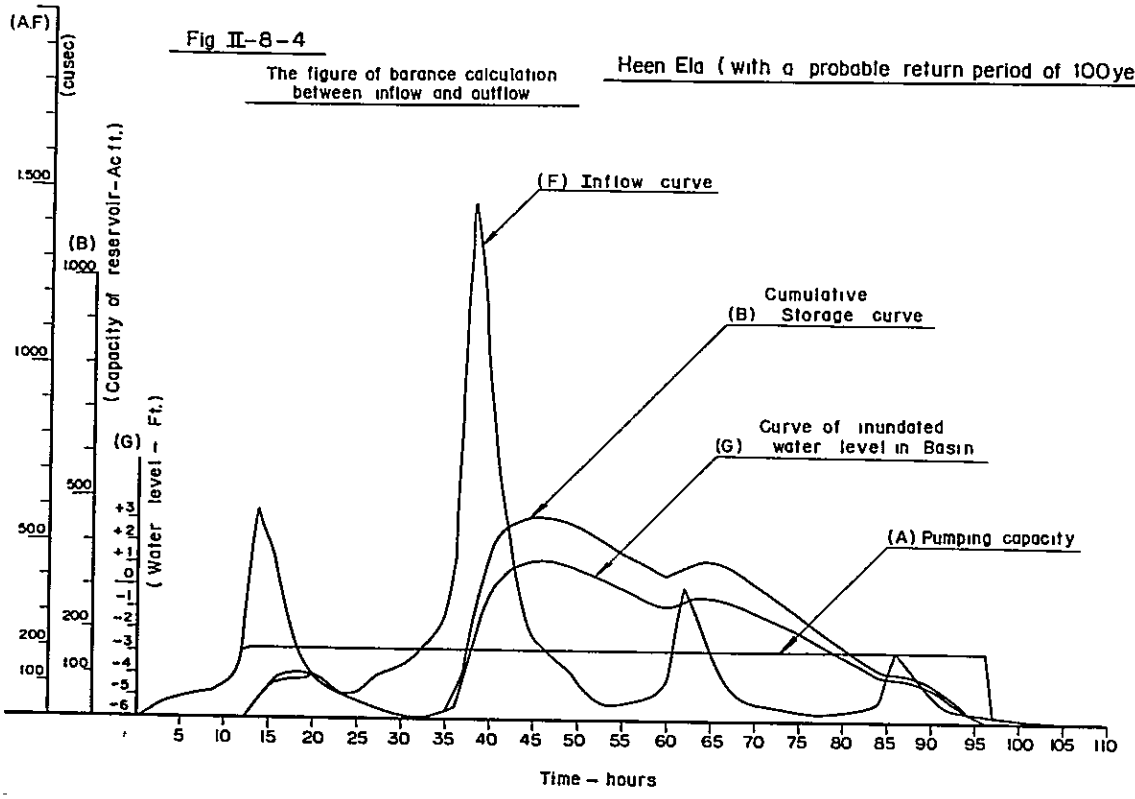


Fig II-8-4

Heen Ela (with a probable return period of 200years)

The figure of barance calculation between inflow and outflow

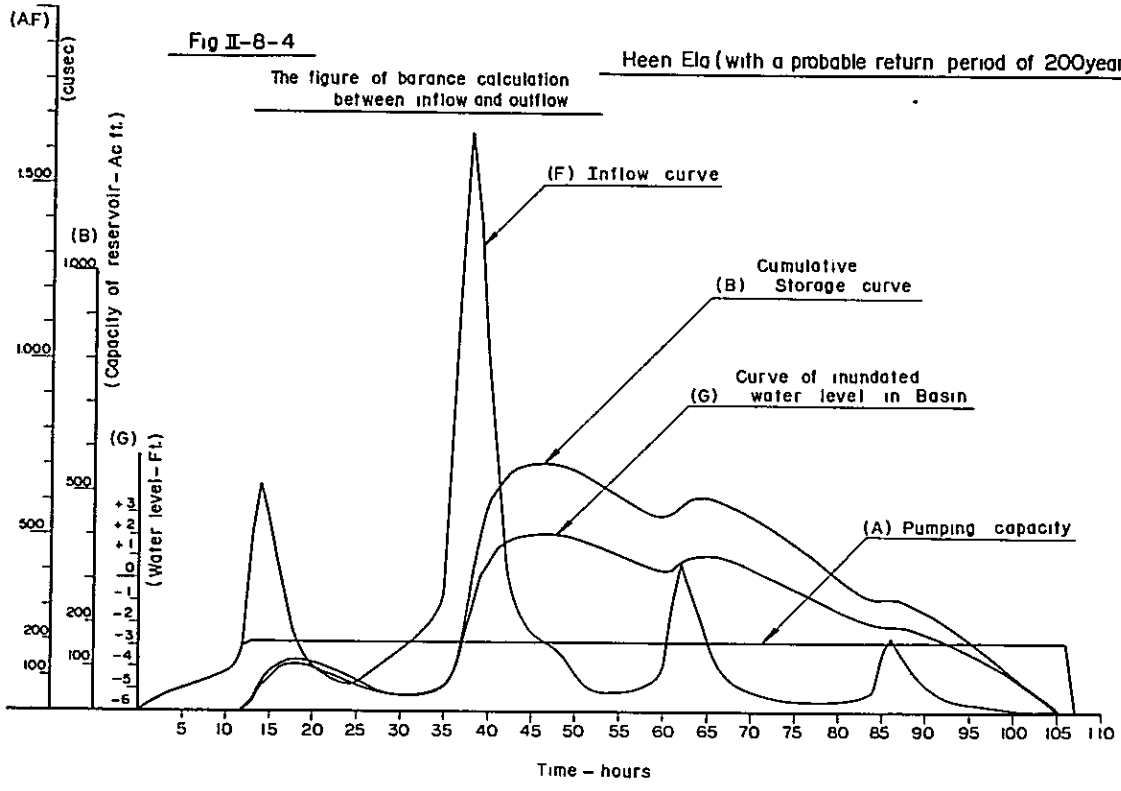


Fig II-8-5

Madiwela (with a probable return period of 15years)

The figure of barance calculation between inflow and outflow

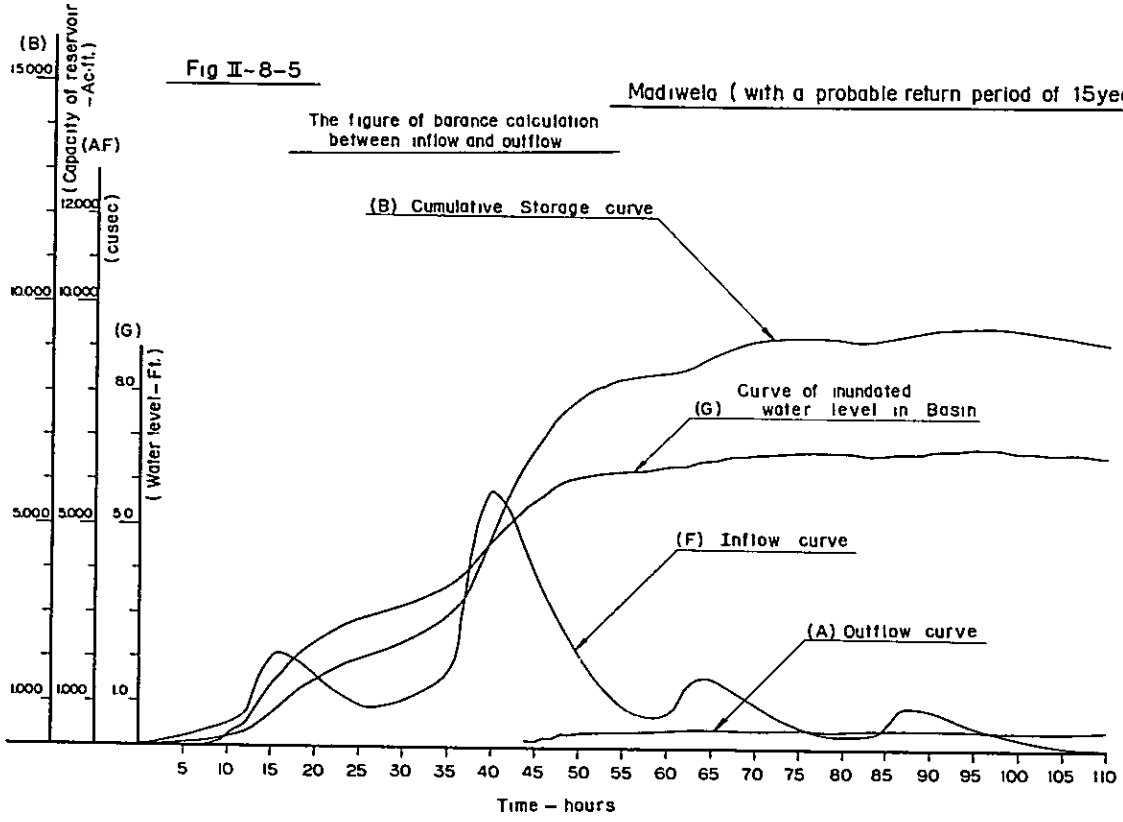


Fig II-8-5

The figure of barance calculation between inflow and outflow

Madiwela (with a probable return period of 100years)

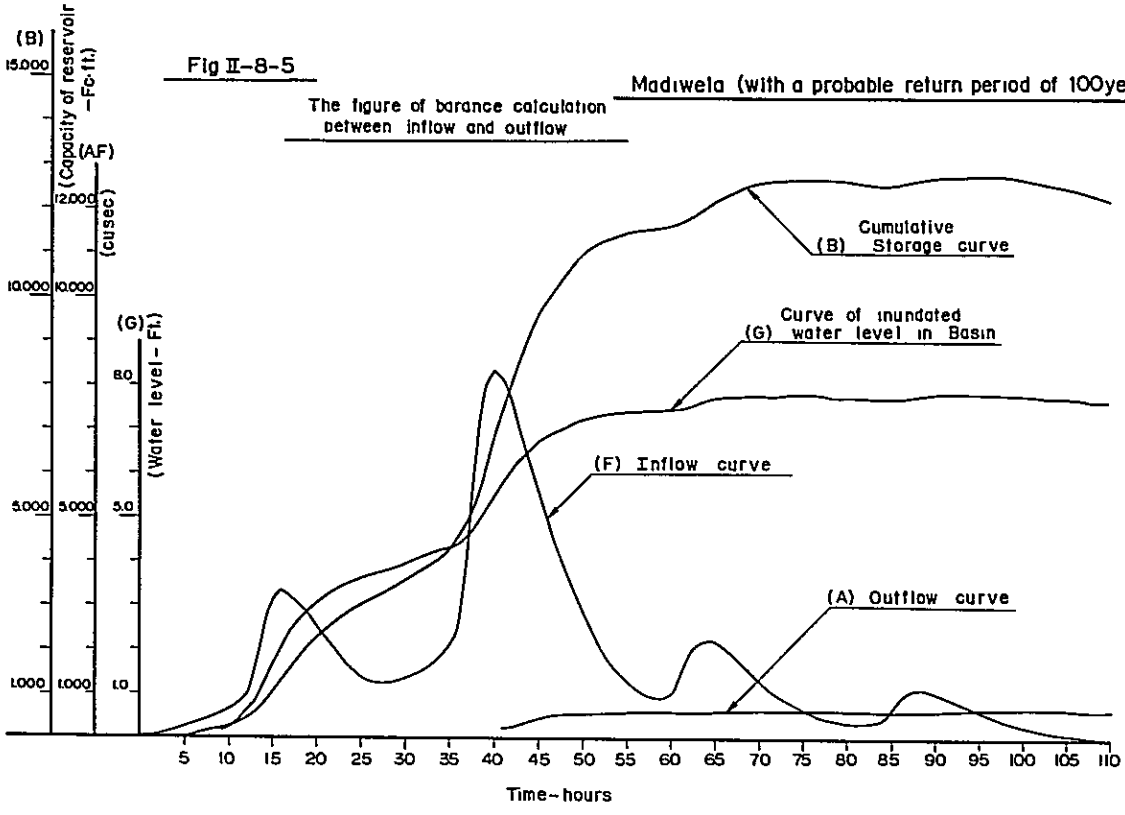


Fig II-8-5

The figure of barance calculation between inflow and outflow

Madiwela (with a probable return period of 200years)

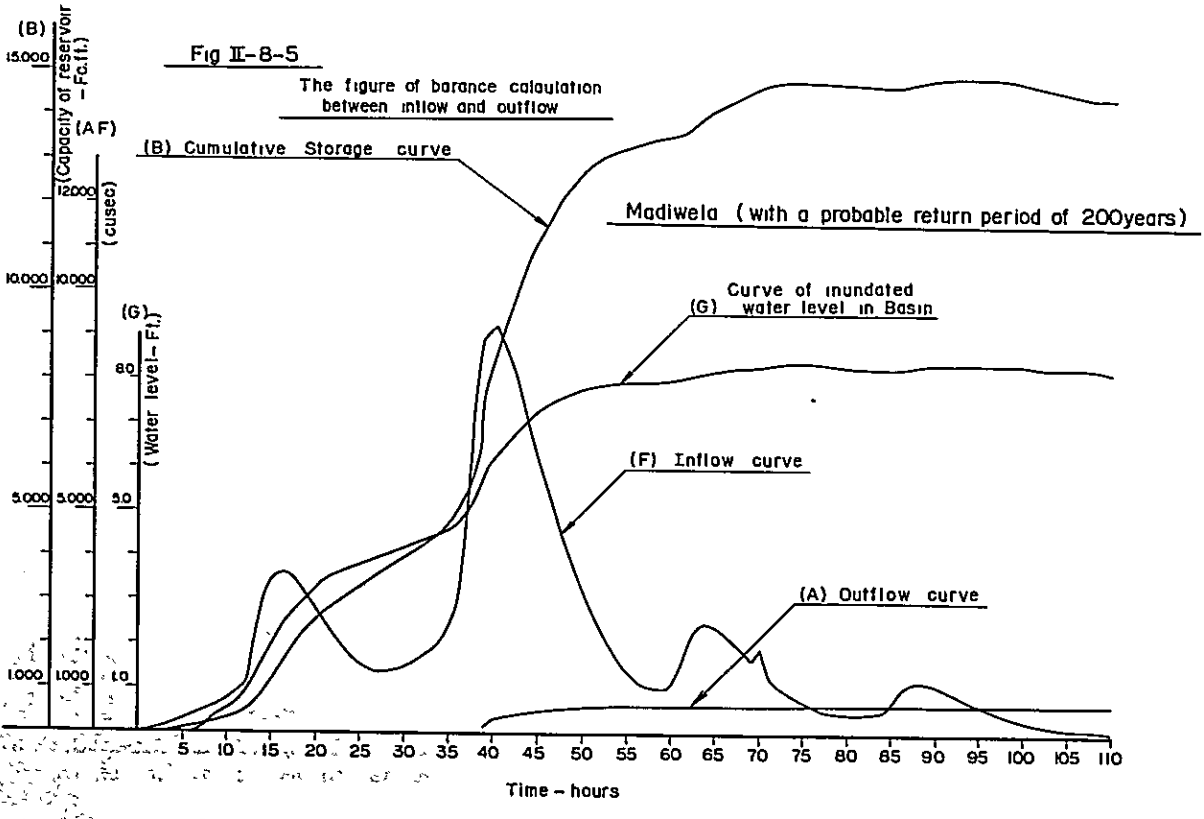


Fig. II-9

Plan of High level canal and others

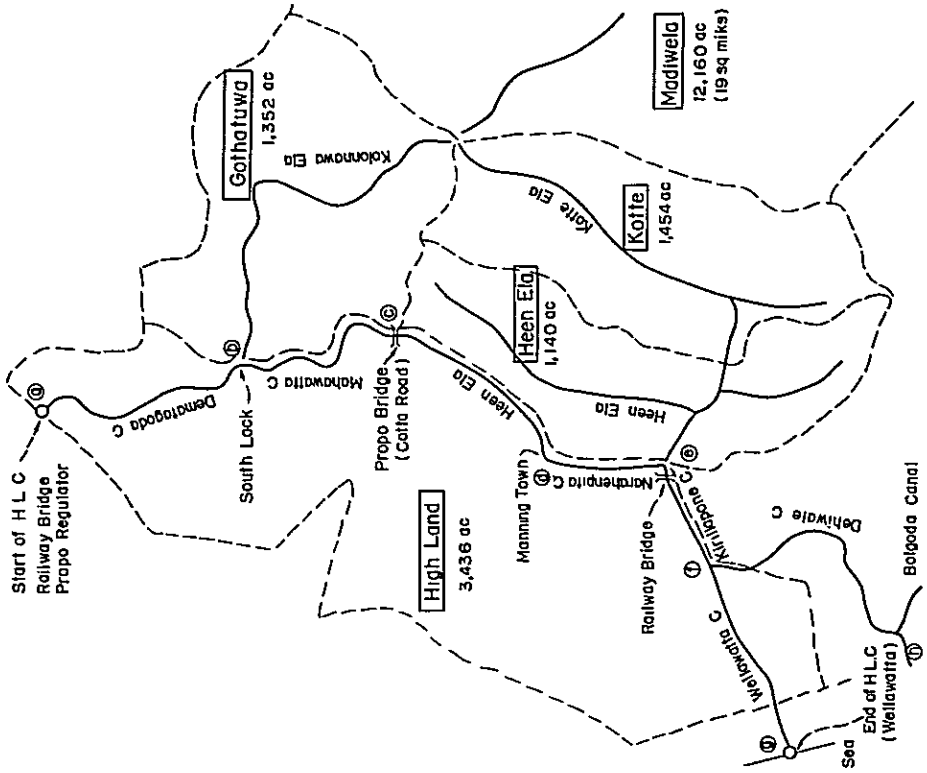


Fig II-10

Madiwela Tunnel Discharge Curve

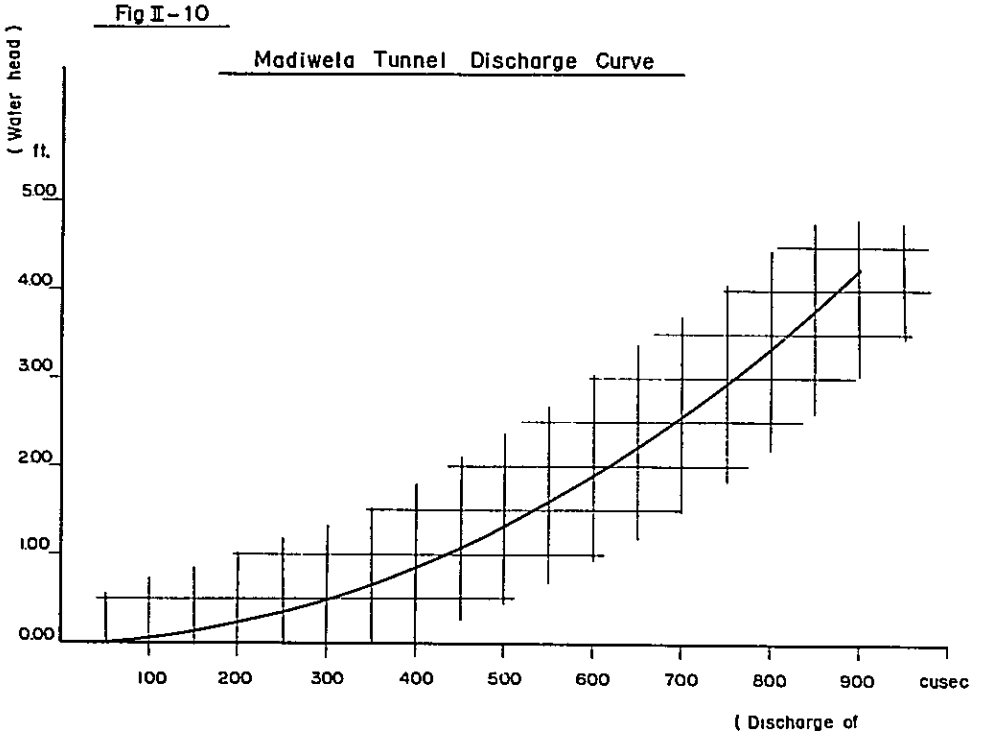


Fig. II-11

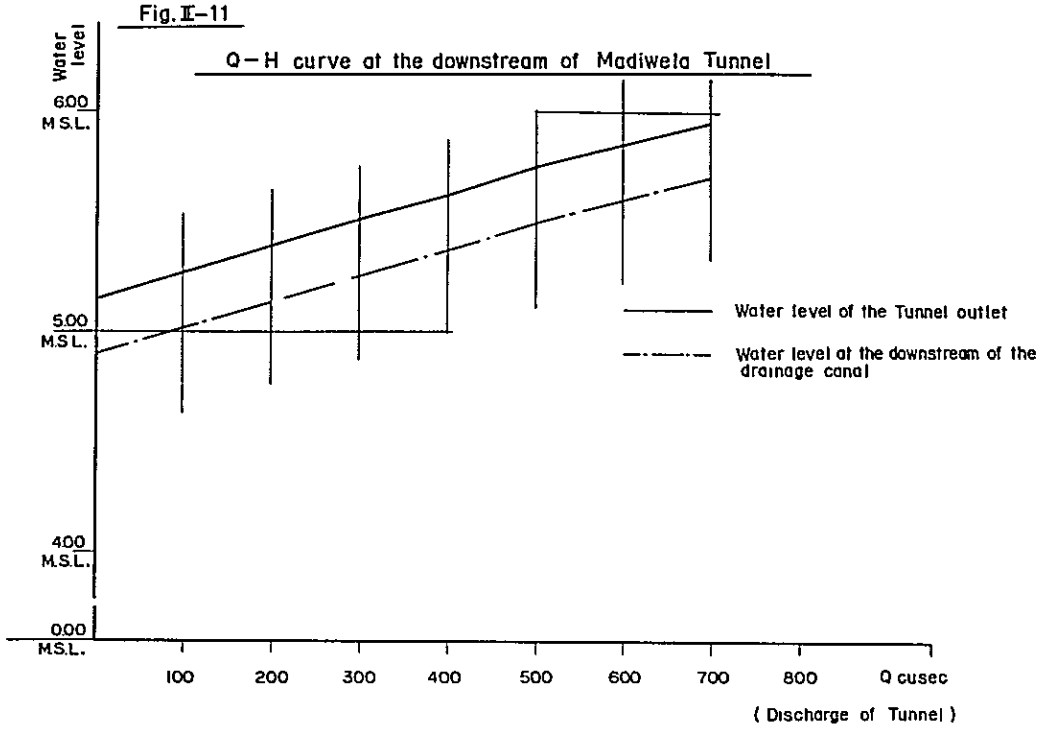
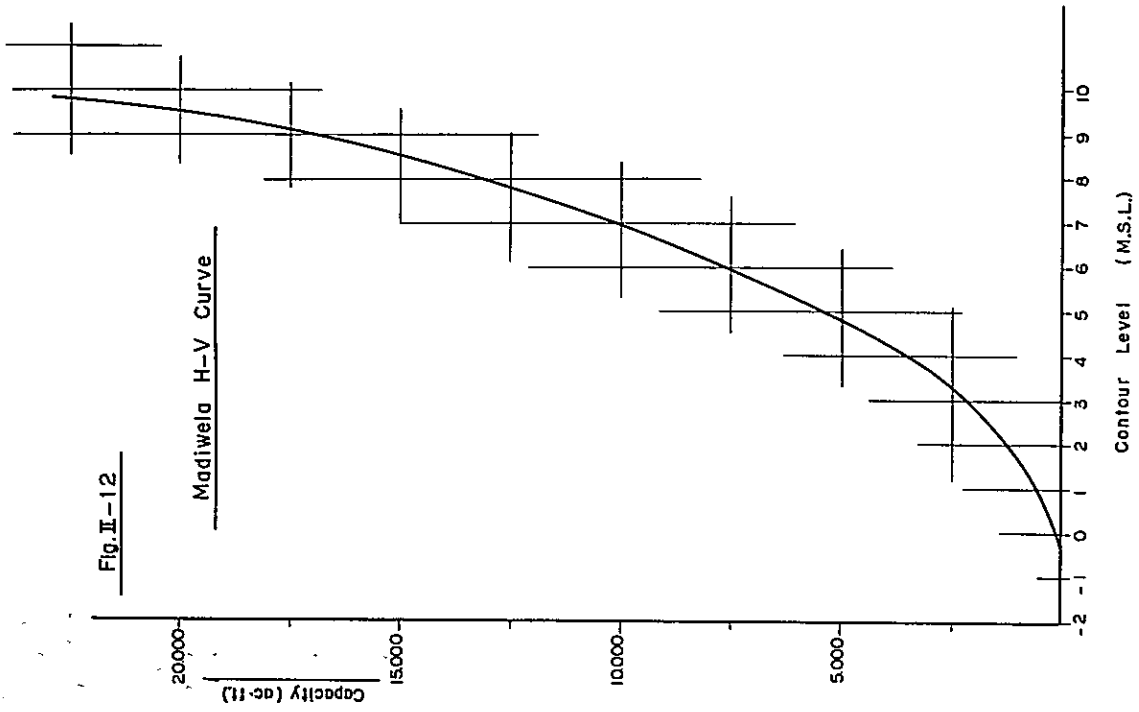


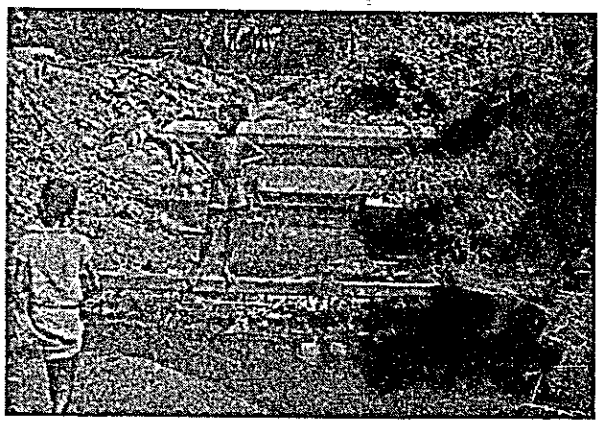
Fig. II-12



Mutwal Marsh

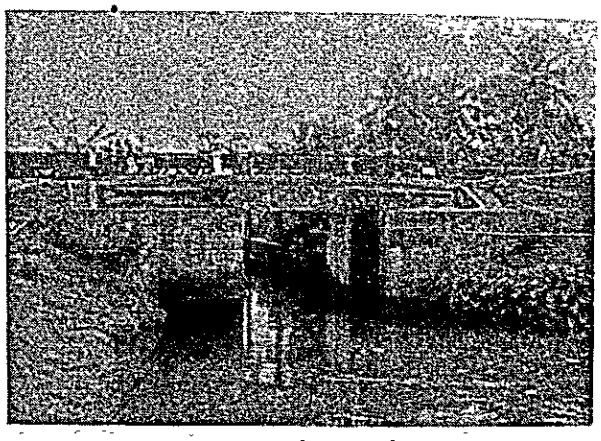
Main Drain in Mutwal

Inlet of Mutwal Tunnel

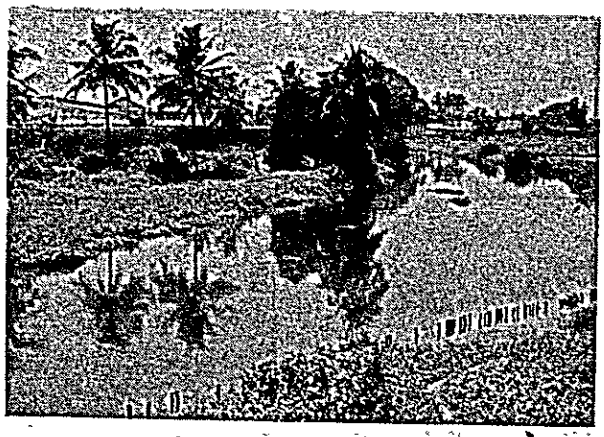


Inlet of Mutwal Tunnel

St. Sebastian Canal
North

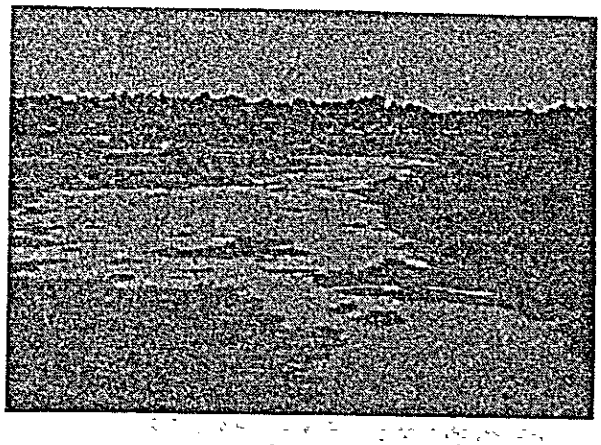


North Lock

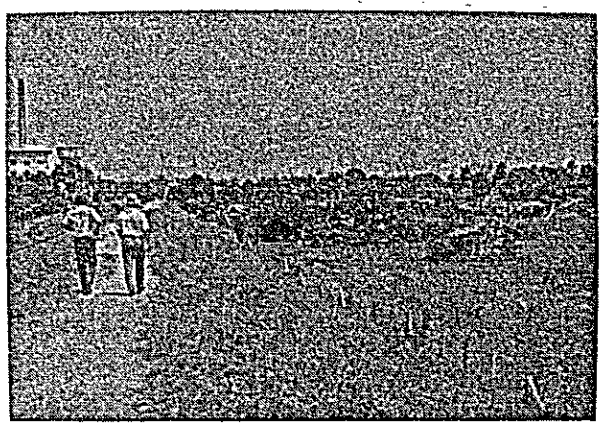


Urugodawatta Canal

Culvert under
Prince of Wales Ave.



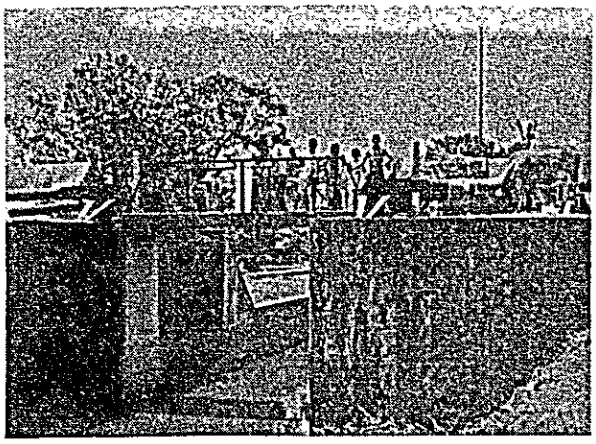
Gothatuwa Marsh



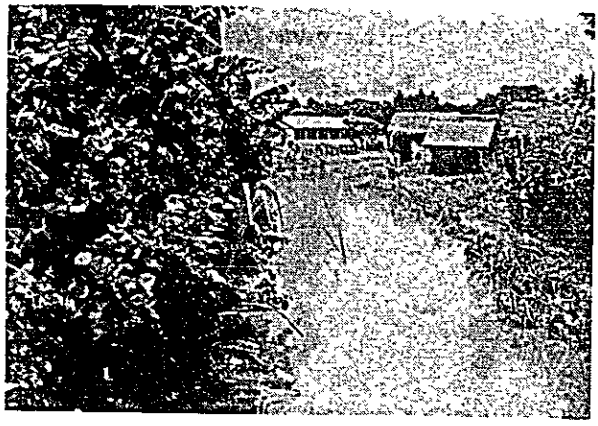
Gothatuwa Flood
Protection Bund

Kotte Lake

Heen Elą

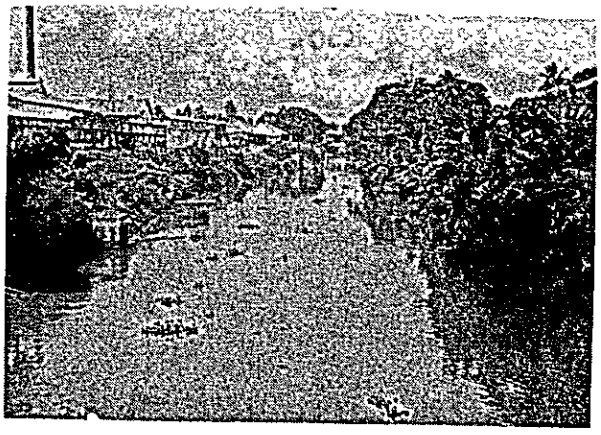


South Lock

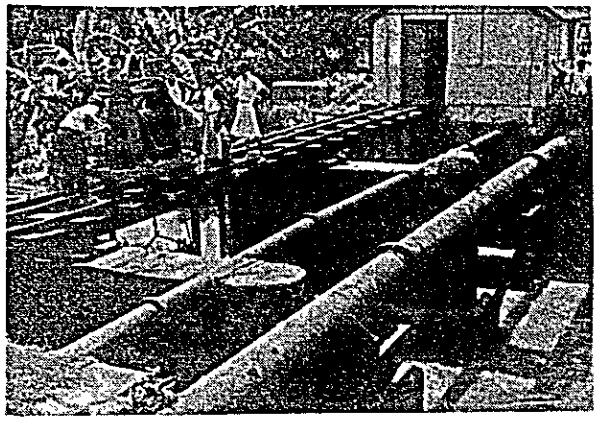


Mahawatta Ela

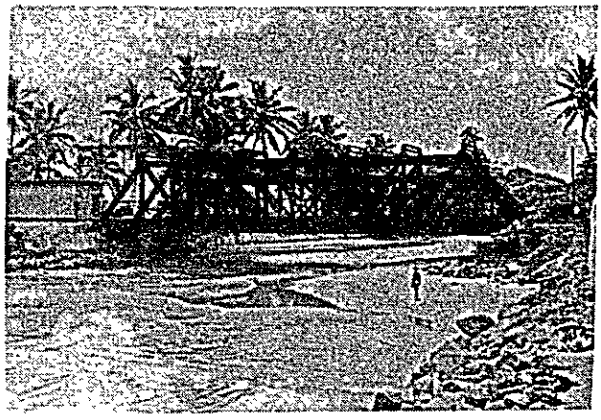
Kirillapone Canal



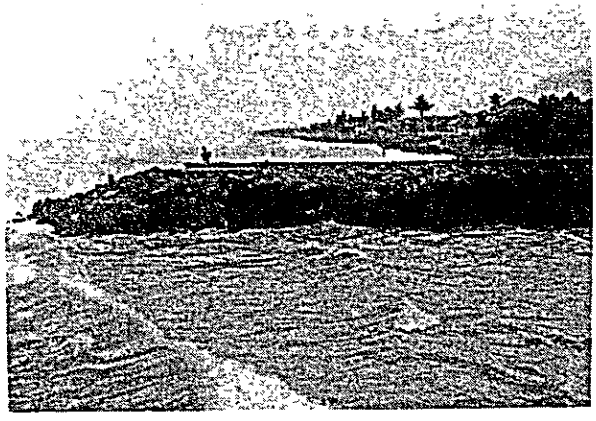
Wellawatta Canal



Havelock Town Regulator



Wellawatta Canal

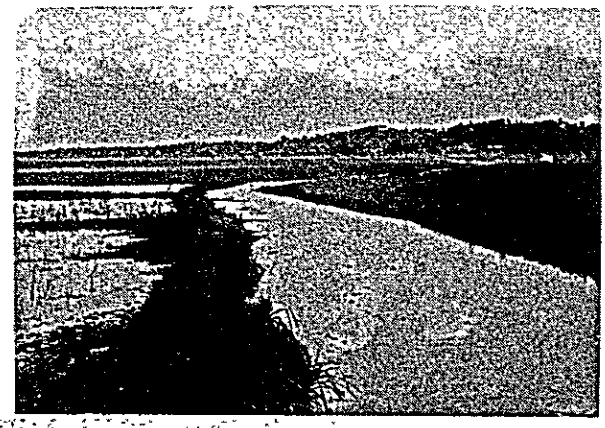


Wellawatta Jetty

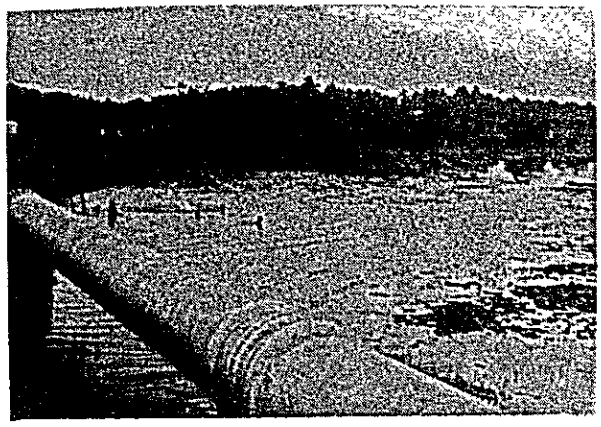
Dehiwela Canal

Dehiwela Outlet

Weras Ganga

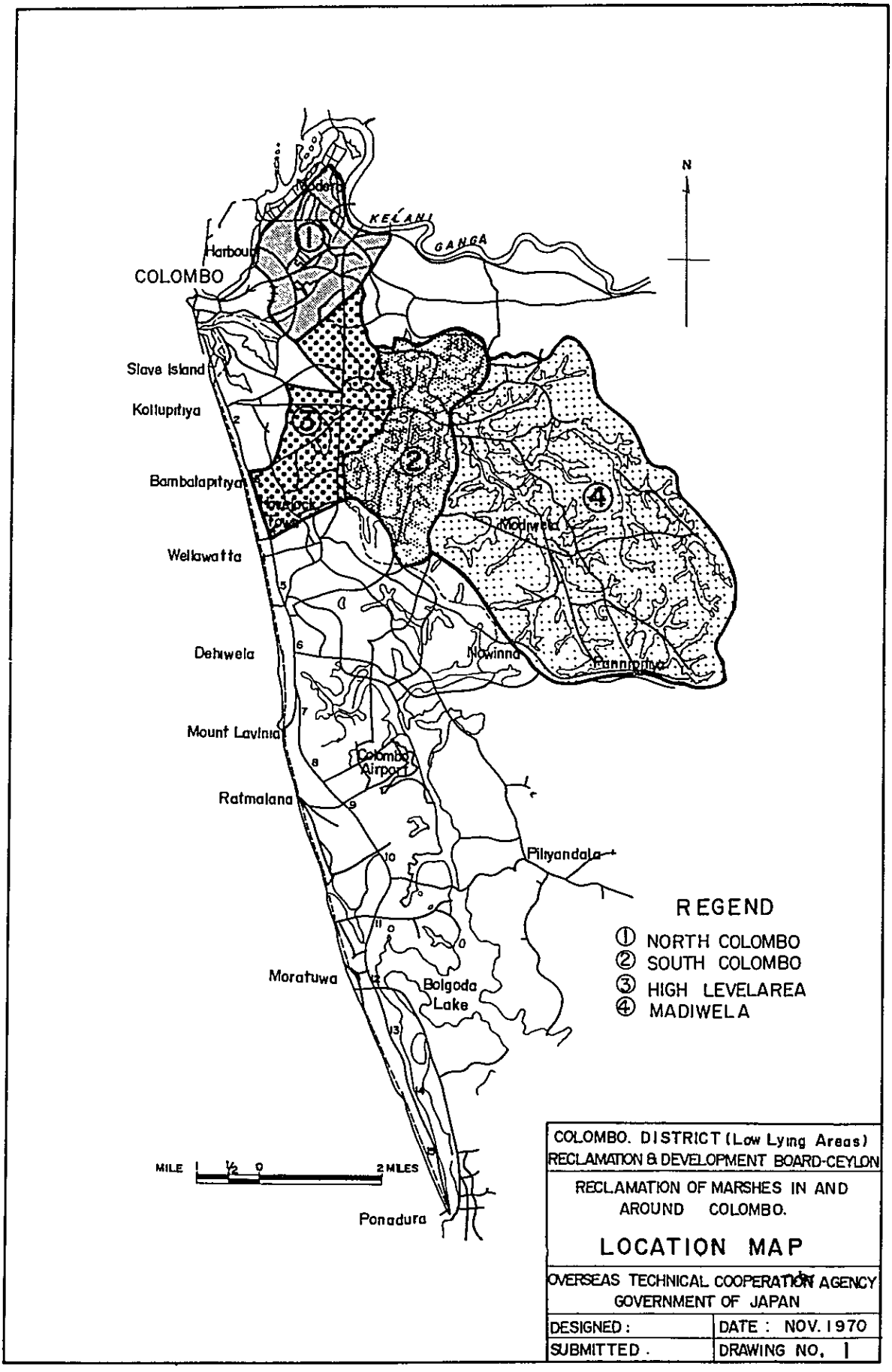


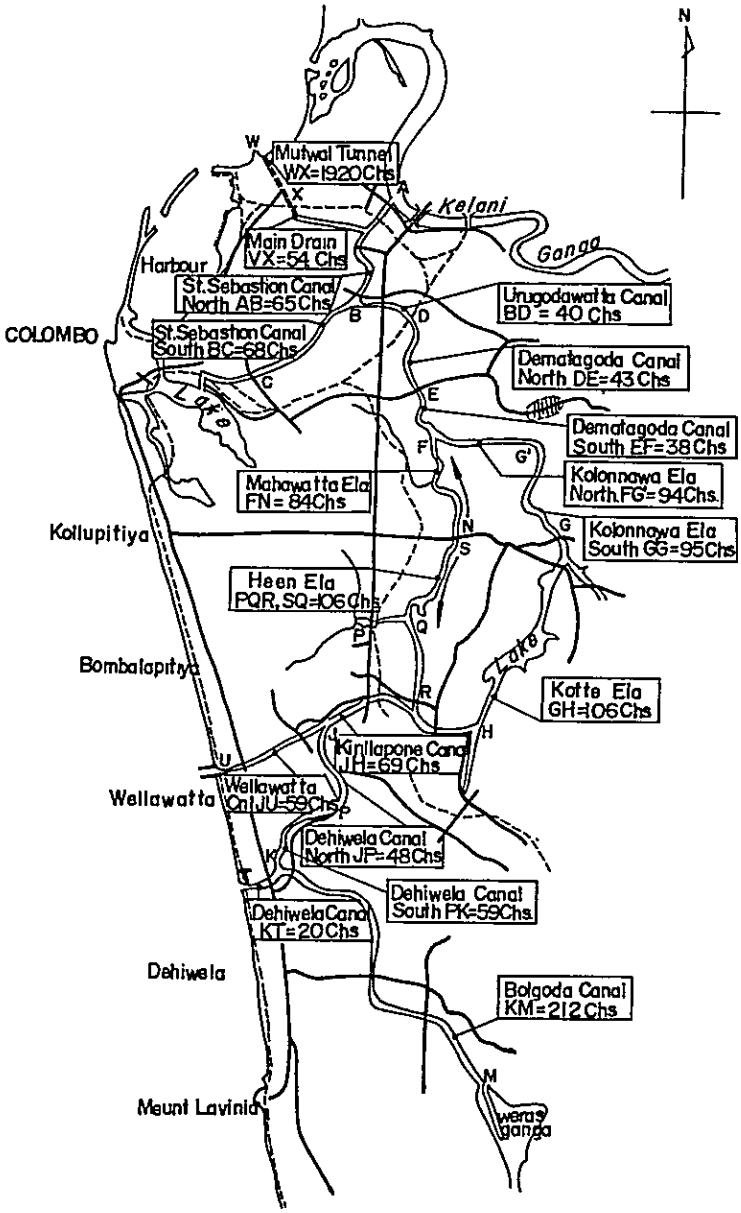
Canal in Madiwela Catch.



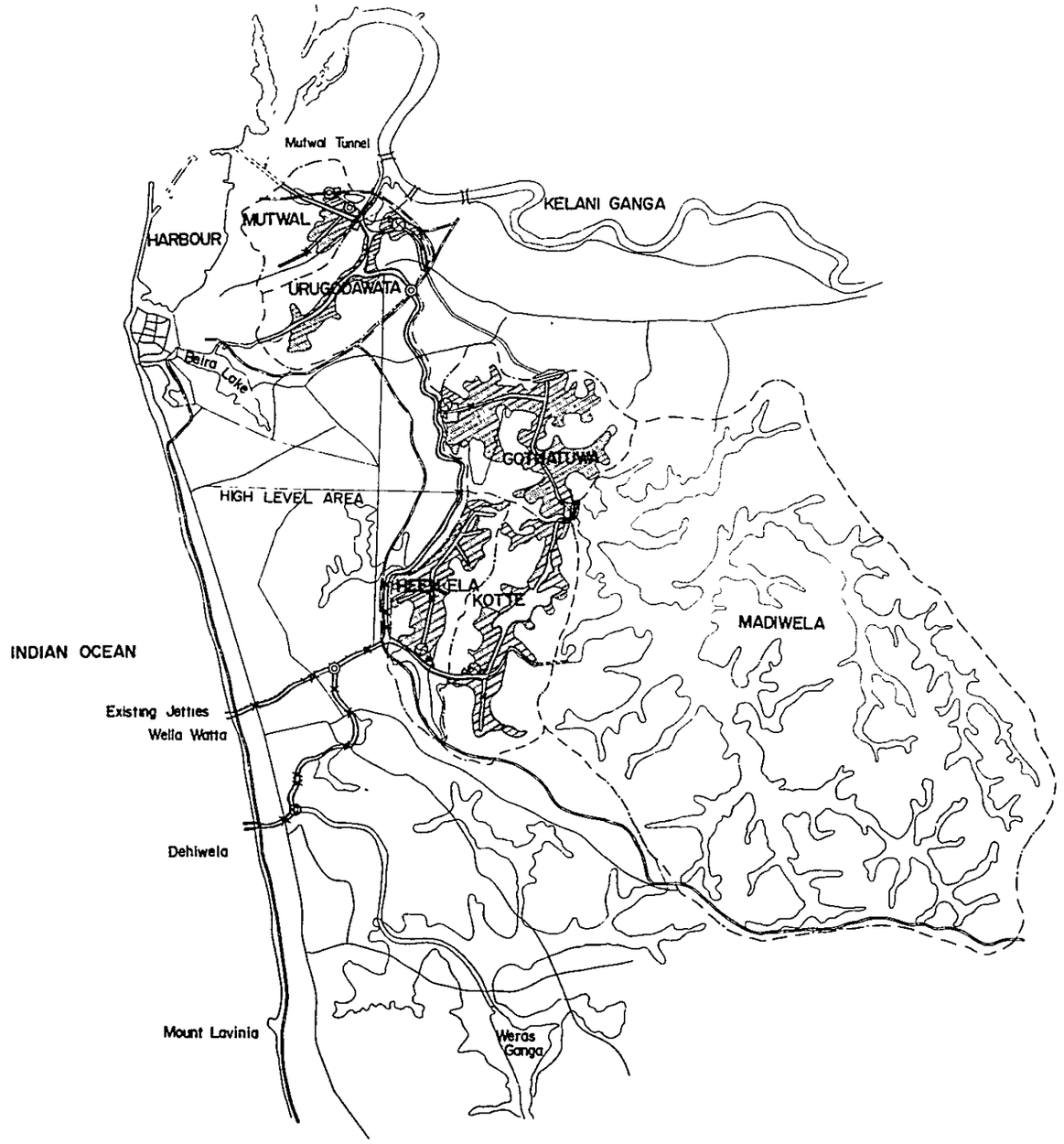
Battaramura Bridge

DRAWINGS


N
KELANI
GANGA
Harbour
COLOMBO
Slave Island
Kollupitiya
Bambalapitiya
Wellawatta
Dehiwela
Mount Lavinia
Ratmalana
Moratuwa
Bolgoda Lake
Ponadura
Pilyandala
Nawinna
Madiwela
Colombo Airport
MILE
2 MILES
REGEND
① NORTH COLOMBO
② SOUTH COLOMBO
③ HIGH LEVELAREA
④ MADIWELA
COLOMBO. DISTRICT (Low Lying Areas)
RECLAMATION & DEVELOPMENT BOARD-CEYLON
RECLAMATION OF MARSHES IN AND AROUND COLOMBO.
LOCATION MAP
OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
DESIGNED :
DATE : NOV. 1970
SUBMITTED .
DRAWING NO. 1



COLOMBO. DISTRICT (Low Lying Areas) RECLAMATION & DEVELOPMENT BOARD-CEYLON	
RECLAMATION OF MARSHES IN AND AROUND COLOMBO.	
EXISTING CANAL	
OVERSEAS TECHNICAL COOPERATION AGENCY GOVERNMENT OF JAPAN	
DESIGNED :	DATE : NOV 1970
SUBMITTED :	DRAWING NO. 2



Item / Catchment	Pumping station	Regulator	Emergency gate	Main Bridge	Concrete revetment	Culvert	The others
North Colombo	1 (nos)	3 (nos)	1 (nos)	1 (nos)	59,600 (ft)	2 (nos)	—
Gothatuwa	1	—	1	2	25,000	—	—
Heen Ela	1	—	1	1	45,400	—	—
Kotte	1	—	1	—	37,800	—	Siphon 1
Madiwela	—	—	—	—	—	—	Tunnel 1
High Level	—	2	—	13	87,000	—	—
Total	4	5	4	17	254,800	2	2

LEGEND

- Catchment boundary
- Proposed pumping station
- Proposed control regulator
- Proposed emergency gate
- Existing protection bund
- Proposed bund
- Proposed culvert
- Drainage canal & lake
- Existing bridge
- Proposed bridge
- Existing road
- Reclaimed land
- Proposed tunnel
- Railway
- Existing jetties
- Proposed jetties

1/2 0 1 mile

SCALE OF MILE

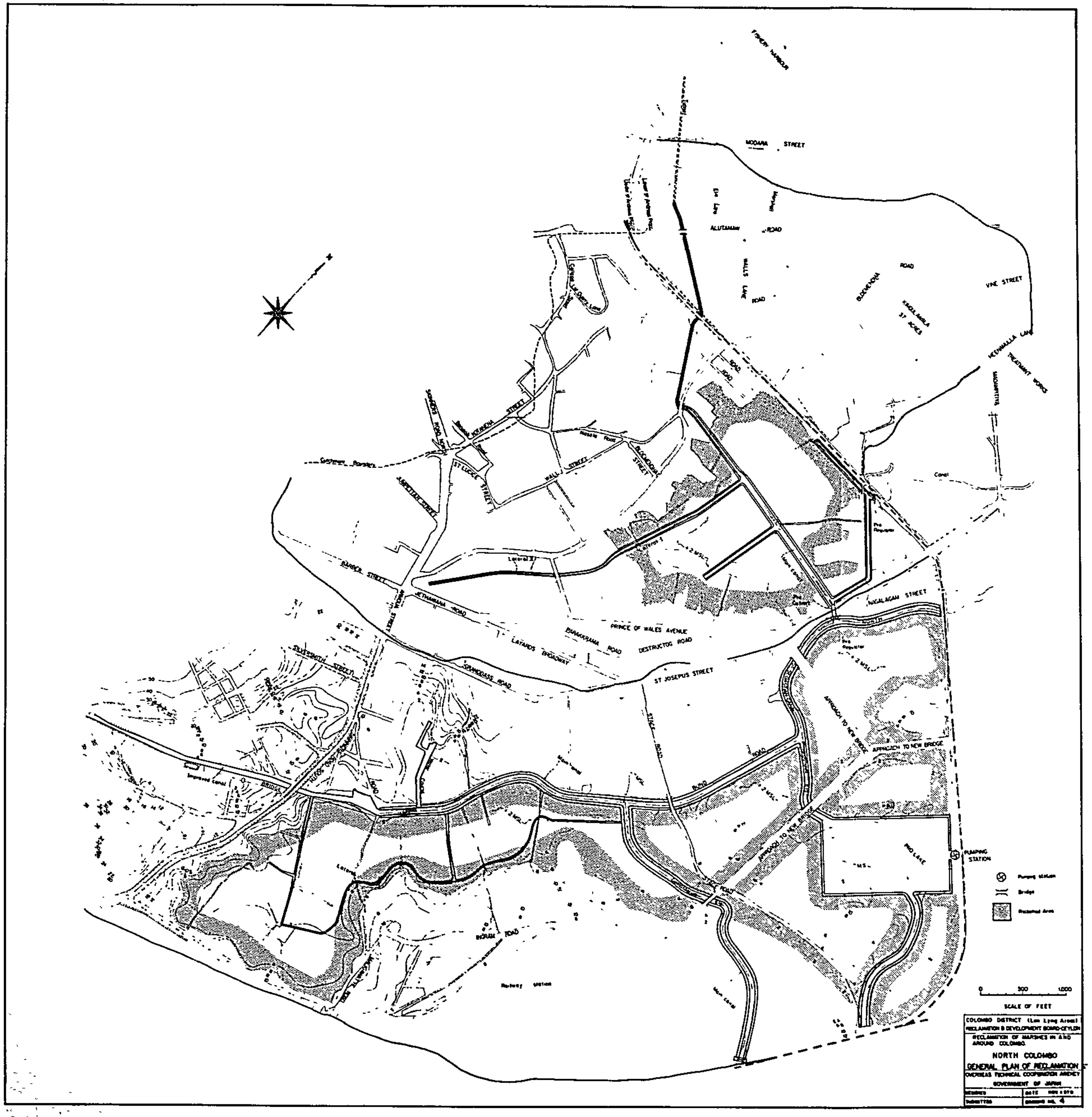
COLOMBO DISTRICT (Low Lying Areas)
RECLAMATION & DEVELOPMENT BOARD-CEYLON

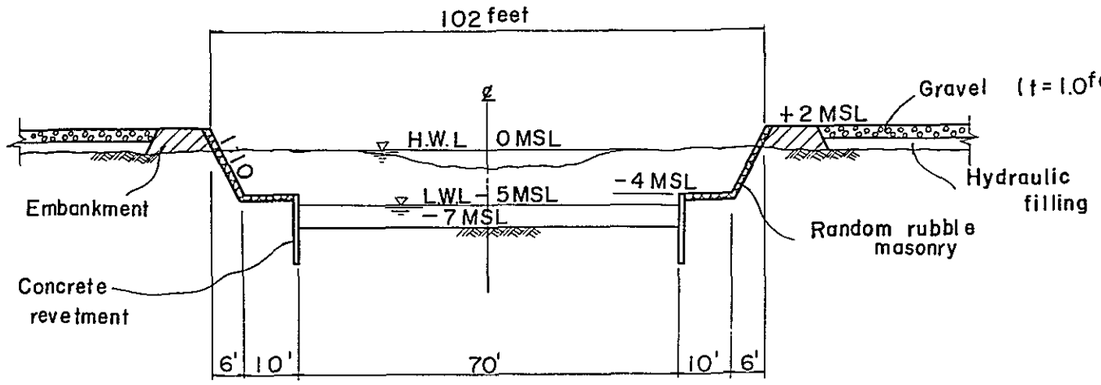
RECLAMATION OF MARSHES IN AND AROUND COLOMBO.

GENERAL PLAN

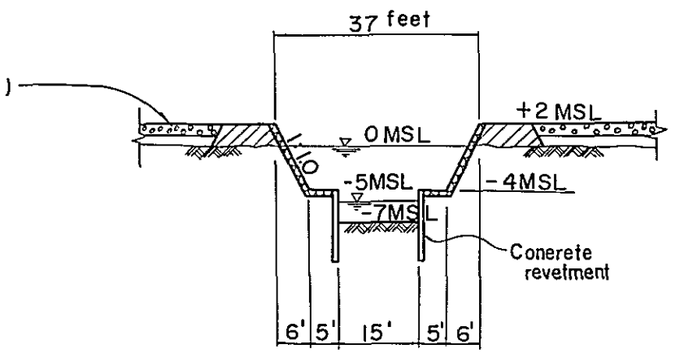
OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

DESIGNED	DATE : NOV. 1970
SUBMITTED :	DRAWING NO. 3

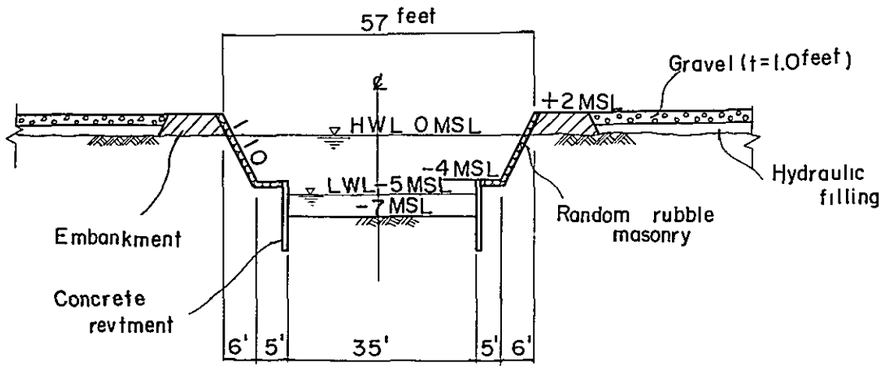

MODARA STREET
NAGALAGAM STREET
PRINCE OF WALES AVENUE
ST JOSEPHS STREET
APPROACH TO NEW BRIDGE
PUMPING STATION
0 300 1,000
SCALE OF FEET
COLOMBO DISTRICT (Low Lying Areas)
RECLAMATION & DEVELOPMENT BOARD-CEYLON
RECLAMATION OF MARSHES IN AND AROUND COLOMBO
NORTH COLOMBO
GENERAL PLAN OF RECLAMATION
OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN



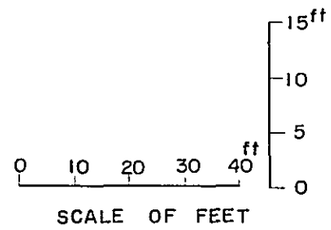
TYPICAL CROSS SECTION OF MAIN CANAL



TYPICAL CROSS SECTION OF LATERAL

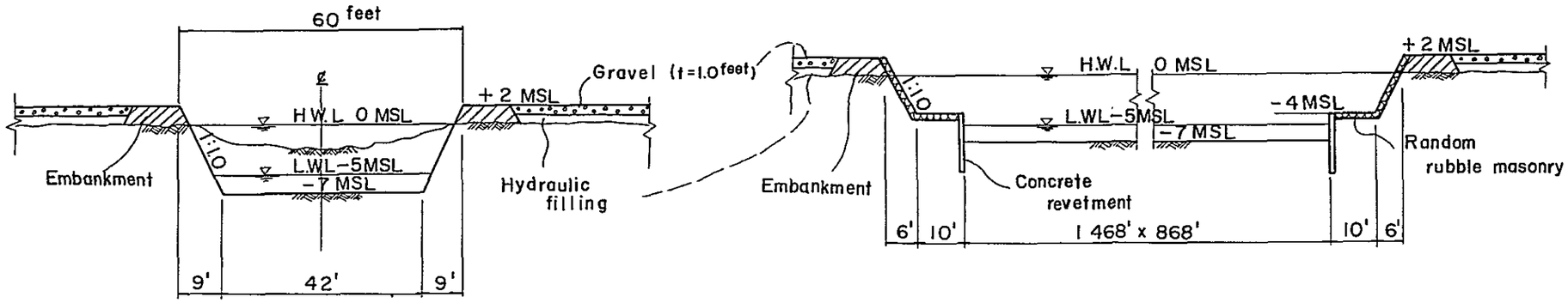


TYPICAL CROSS SECTION OF LATERAL I



SCALE OF FEET

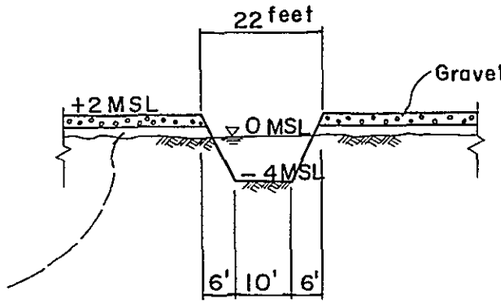
COLOMBO. DISTRICT (Low Lying Areas) RECLAMATION & DEVELOPMENT BOARD-CEYLON	
RECLAMATION OF MARSHES IN AND AROUND COLOMBO. **NORTH COLOMBO (MUTWAL)**	
OVERSEAS TECHNICAL COOPERATION AGENCY GOVERNMENT OF JAPAN	
DESIGNED.	DATE: NOV. 1970
SUBMITTED	DRAWING NO. 5



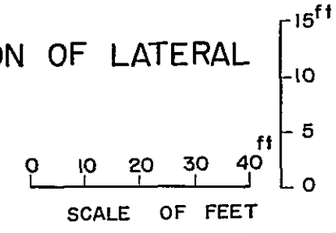
IMPROVED CROSS SECTION OF SAN SEBASTIAN CANAL

TYPICAL CROSS SECTION OF LAKE

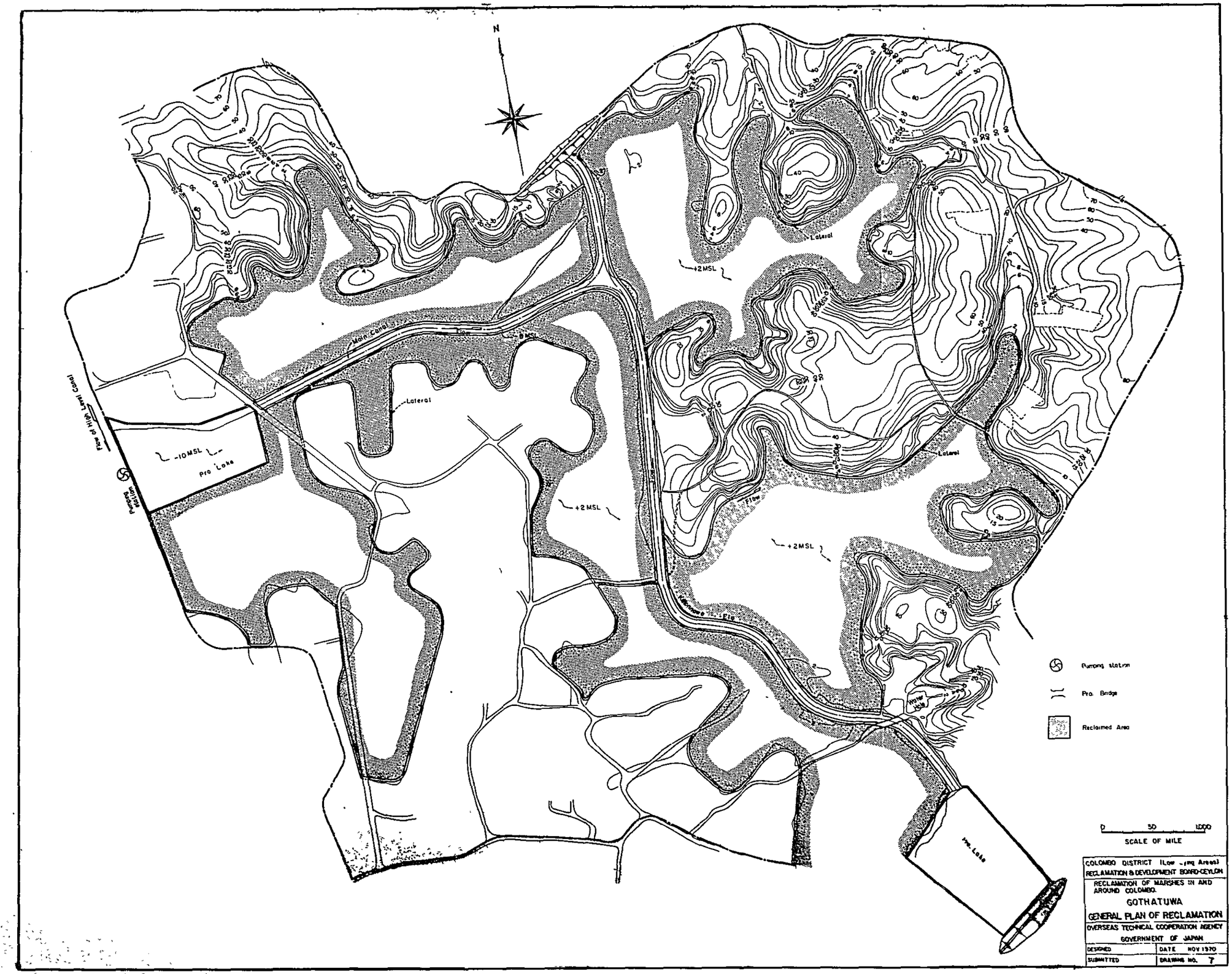
TYPICAL CROSS SECTION OF MAIN CANAL

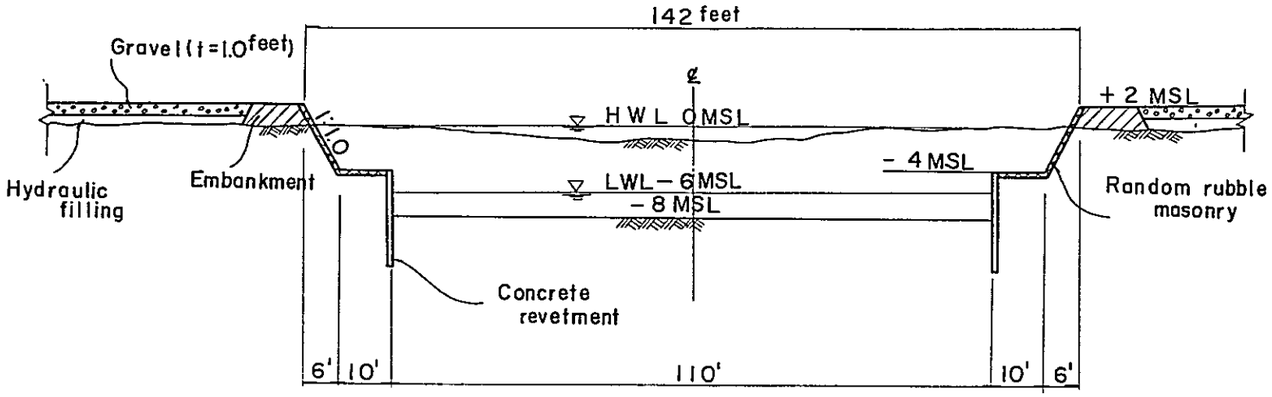


TYPICAL CROSS SECTION OF LATERAL

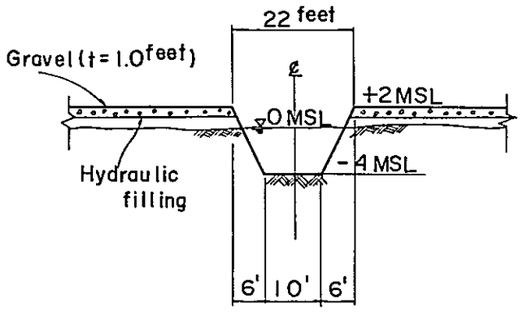


COLOMBO. DISTRICT (Low Lying Areas) RECLAMATION & DEVELOPMENT BOARD-CEYLON	
RECLAMATION OF MARSHES IN AND AROUND COLOMBO. **NORTH COLOMBO (URUGODAWATTA)**	
OVERSEAS TECHNICAL COOPERATION AGENCY GOVERNMENT OF JAPAN	
DESIGNED:	DATE: NOV. 1970
SUBMITTED:	DRAWING NO. 6

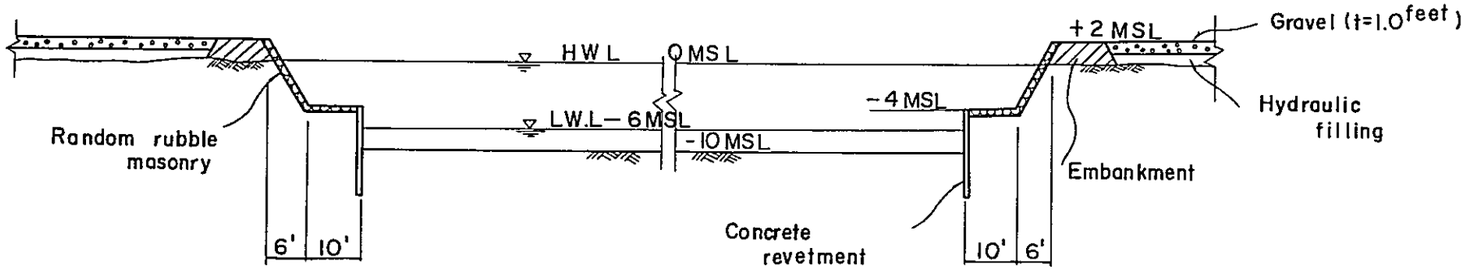

N
Main Canal
Lateral
+2MSL
-10MSL
Pro Lake
Flow of High Level Canal
Pumping station
Flow
Pro. Bridge
Reclaimed Area
0
50
1000
SCALE OF MILE
COLOMBO DISTRICT (Low - lying Areas)
RECLAMATION & DEVELOPMENT BOARD-CEYLON
RECLAMATION OF MARSHES IN AND AROUND COLOMBO.
GOTHATUWA
GENERAL PLAN OF RECLAMATION
OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
DESIGNED
DATE NOV 1970
SUBMITTED
DRAWING NO. 7



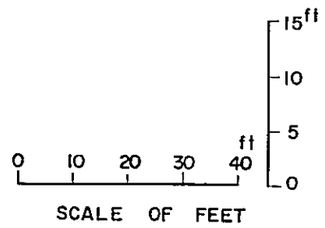
TYPICAL CROSS SECTION OF MAIN CANAL



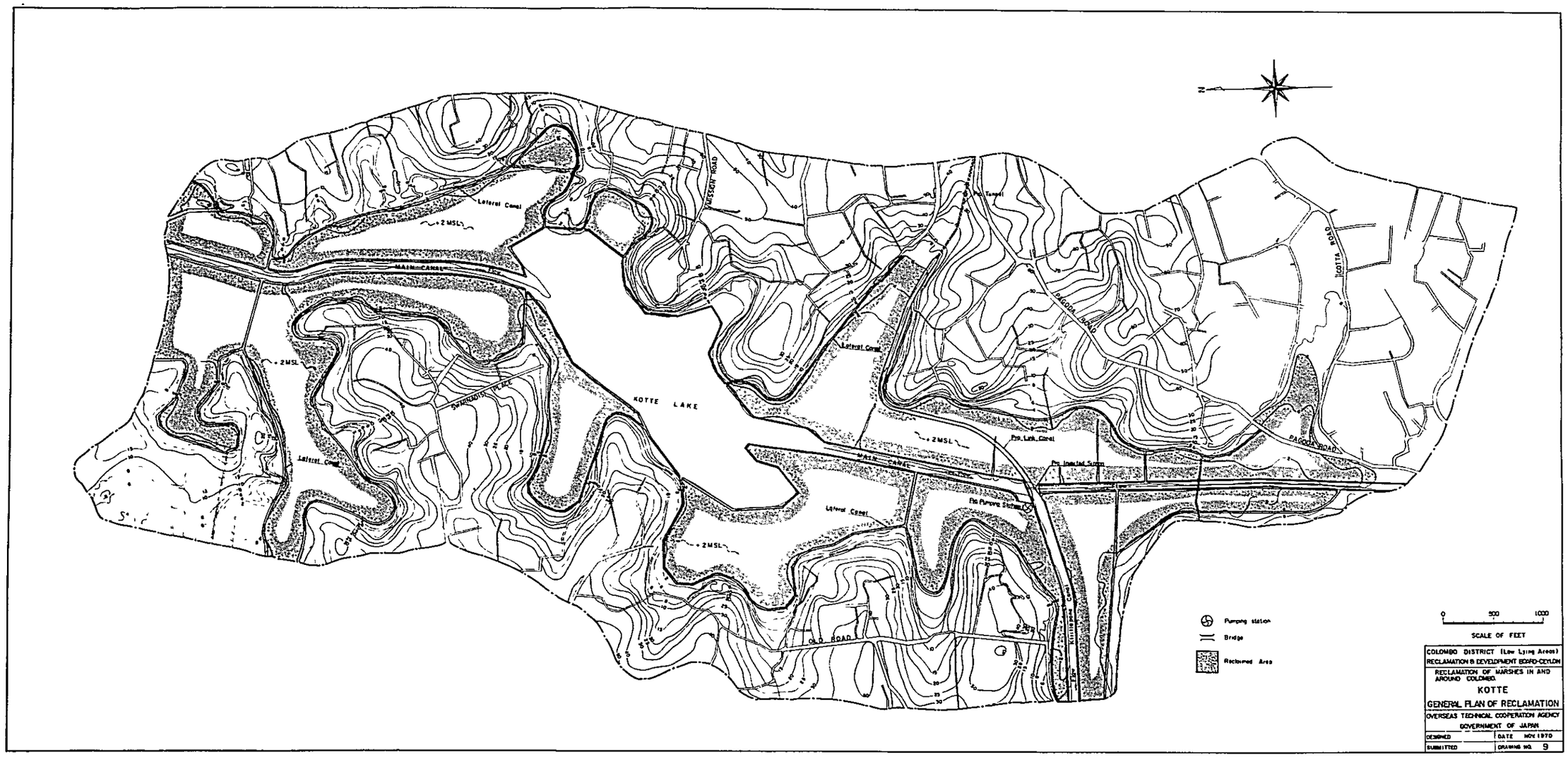
TYPICAL CROSS SECTION OF LATERAL

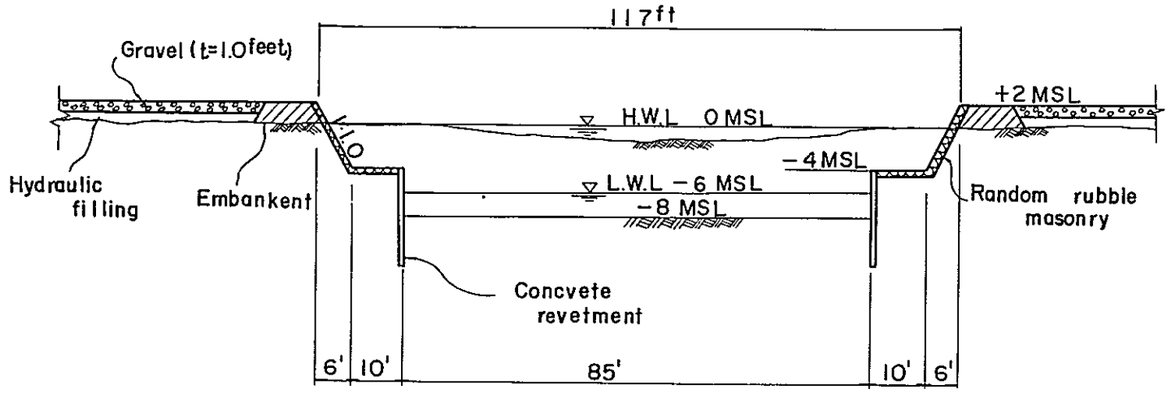


TYPICAL CROSS SECTION OF LAKE

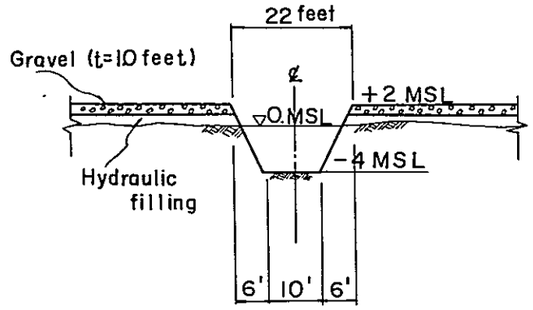


COLOMBO. DISTRICT (Low Lying Areas) RECLAMATION & DEVELOPMENT BOARD-CEYLON	
RECLAMATION OF MARSHES IN AND AROUND COLOMBO. GOTHATUWA	
OVERSEAS TECHNICAL COOPERATION AGENCY GOVERNMENT OF JAPAN	
DESIGNED :	DATE : NOV. 1970
SUBMITTED :	DRAWING NO. 8

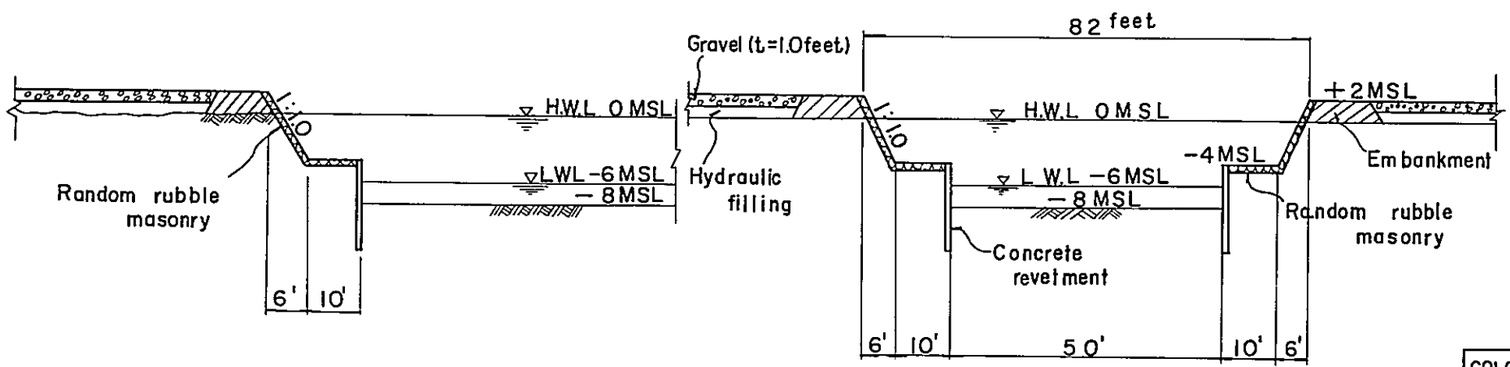

N
Lateral Canal
+2 MSL
MAIN CANAL
MISSION ROAD
KOTTE LAKE
SWARNADIPA PLACE
PAGODA ROAD
KOTTA ROAD
Pipe Link Canal
Pipe Inverted Syphon
Flap Pumping Station
OLD ROAD
Pumping station
Bridge
Reclaimed Area
0 500 1000
SCALE OF FEET
COLOMBO DISTRICT (Low Lying Areas)
RECLAMATION & DEVELOPMENT BOARD-CEYLON
RECLAMATION OF MARSHES IN AND AROUND COLOMBO.
KOTTE
GENERAL PLAN OF RECLAMATION
OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
DESIGNED
DATE NOV. 1970
SUBMITTED
DRAWING NO. 9



TYPICAL CROSS SECTION OF MAIN CANAL

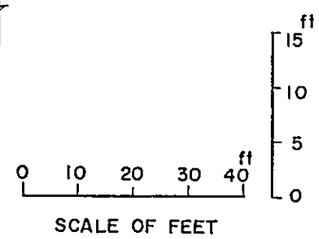


TYPICAL CROSS SECTION OF LATERAL II



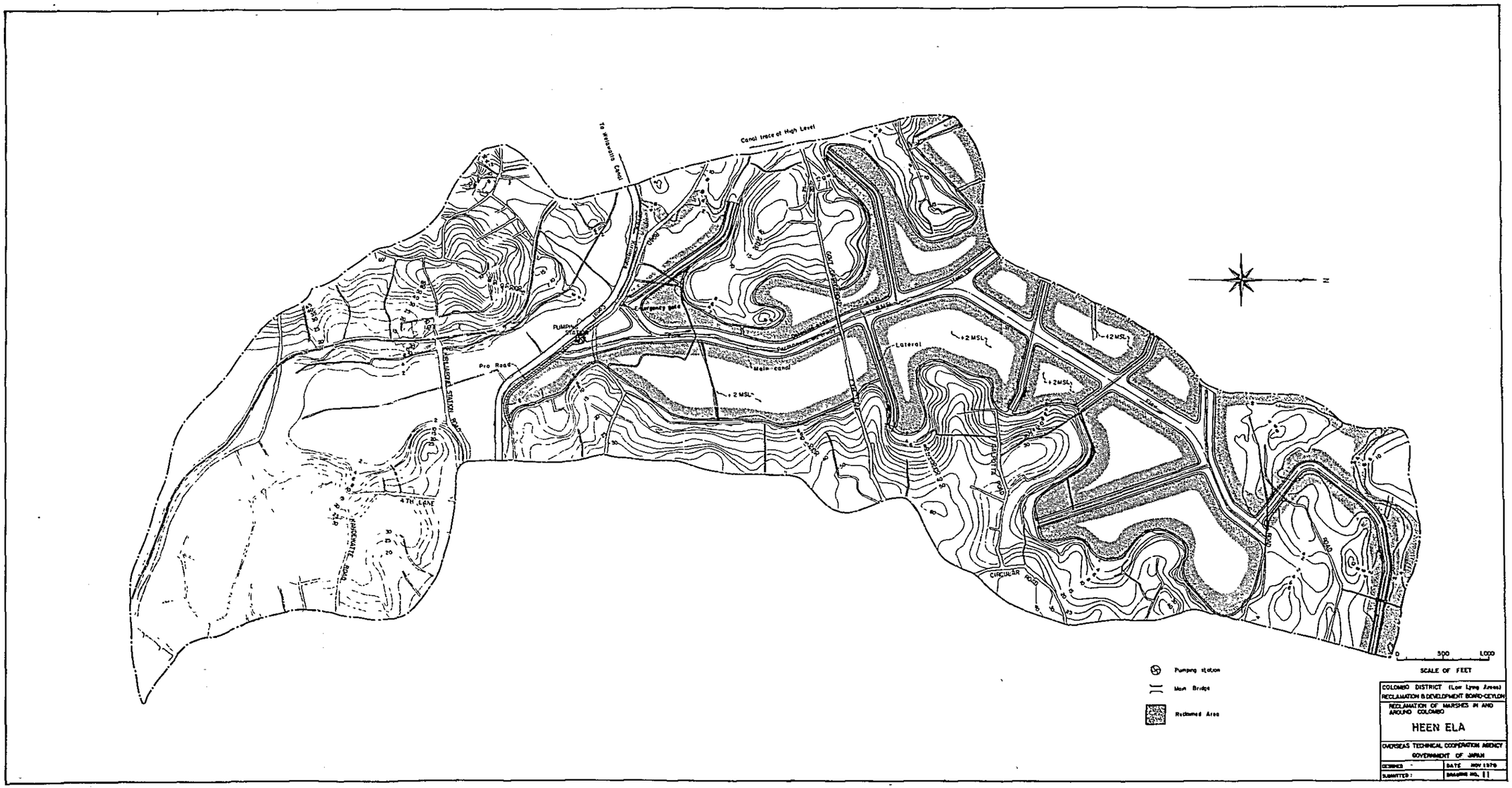
TYPICAL CROSS SECTION OF LAKE

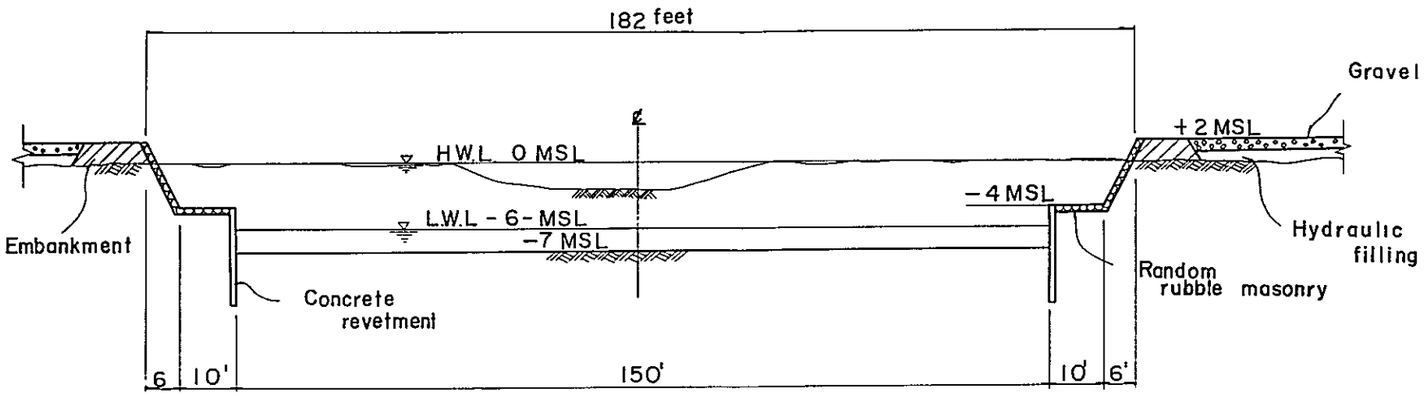
TYPICL CROSS SECTION OF LATERAL I



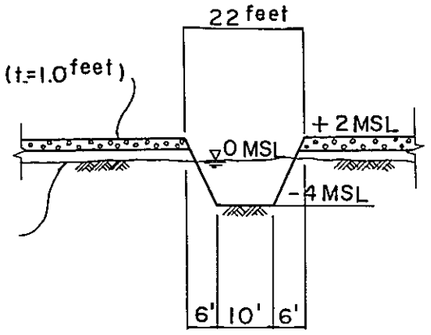
SCALE OF FEET

COLOMBO. DISTRICT (Low Lying Areas) RECLAMATION & DEVELOPMENT BOARD-CEYLON	
RECLAMATION OF MARSHES IN AND AROUND COLOMBO. KOTTE	
OVERSEAS TECHNICAL COOPERATION AGENCY GOVERNMENT OF JAPAN	
DESIGNED.	DATE : NOV. 1970
SUBMITTED :	DRAWING NO. 10

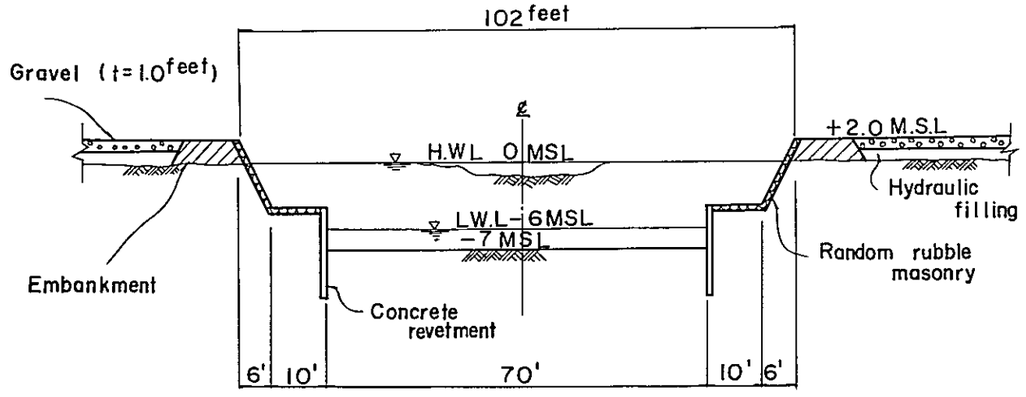

To Wellawatta Canal
Canal Trace at High Level
PUMPING STATION
Pro Road
Lateral
Main canal
+2 MSL
+2MSL
+2MSL
+2MSL
4TH LANE
CIRCULAR ROAD
ROAD
0
500
1000
SCALE OF FEET
Pumping station
Main Bridge
Reclaimed Area
COLOMBO DISTRICT (Low Lying Areas)
RECLAMATION & DEVELOPMENT BOARD-CEYLON
RECLAMATION OF MARSHES IN AND AROUND COLOMBO
HEEN ELA
OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
DESIGNED :
DATE NOV 1978
SUBMITTED :
DRAWING NO. 11



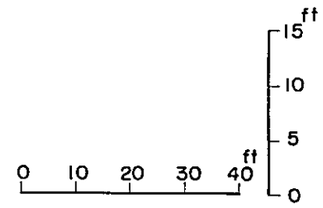
TYPICAL CROSS SECTION OF MAIN CANAL



TYPICAL CROSS SECTION OF LATERAL II

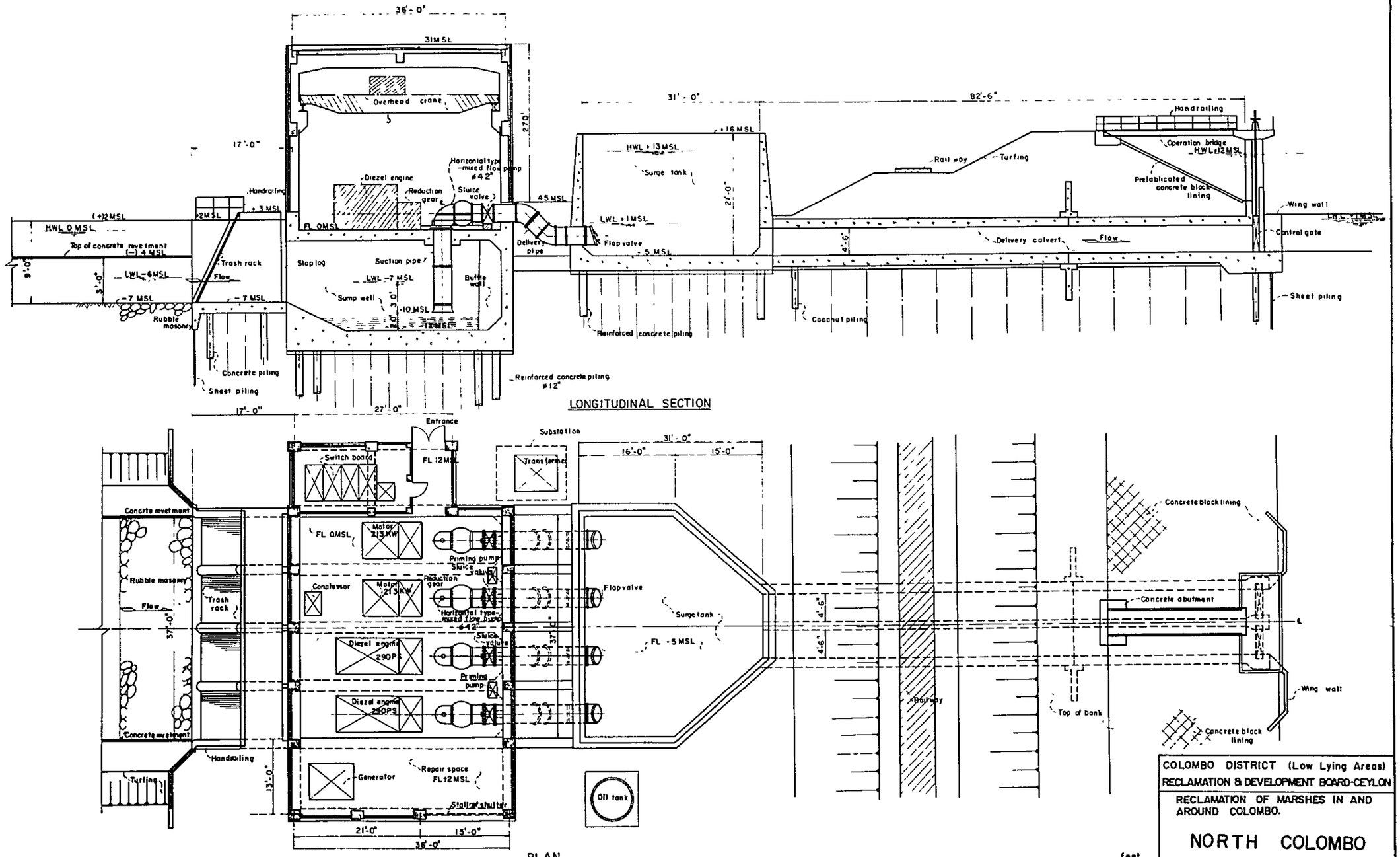


TYPICAL CROSS SECTION OF LATERAL I



SCALE OF FEET

COLOMBO. DISTRICT (Low Lying Areas) RECLAMATION & DEVELOPMENT BOARD-CEYLON	
RECLAMATION OF MARSHES IN AND AROUND COLOMBO. HEEN ELA	
OVERSEAS TECHNICAL COOPERATION AGENCY GOVERNMENT OF JAPAN	
DESIGNED :	DATE : NOV. 1970
SUBMITTED :	DRAWING NO. 12



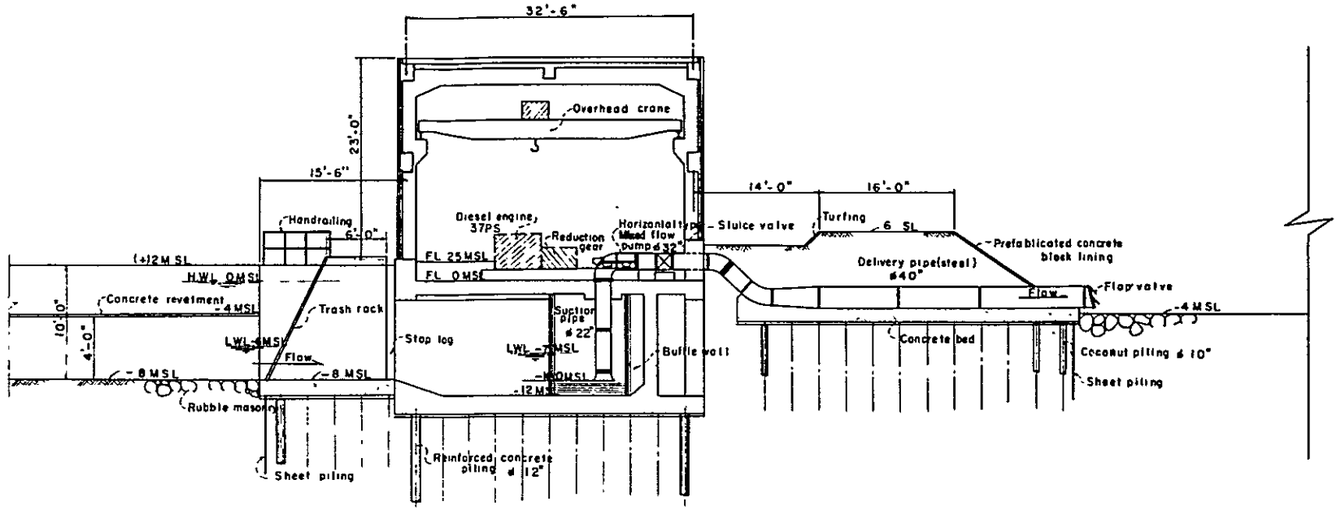
COLOMBO DISTRICT (Low Lying Areas)
RECLAMATION & DEVELOPMENT BOARD-CEYLON

RECLAMATION OF MARSHES IN AND AROUND COLOMBO.

NORTH COLOMBO

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

DESIGNED	DATE NOV. 1970
SUBMITTED	DRAWING NO. 13



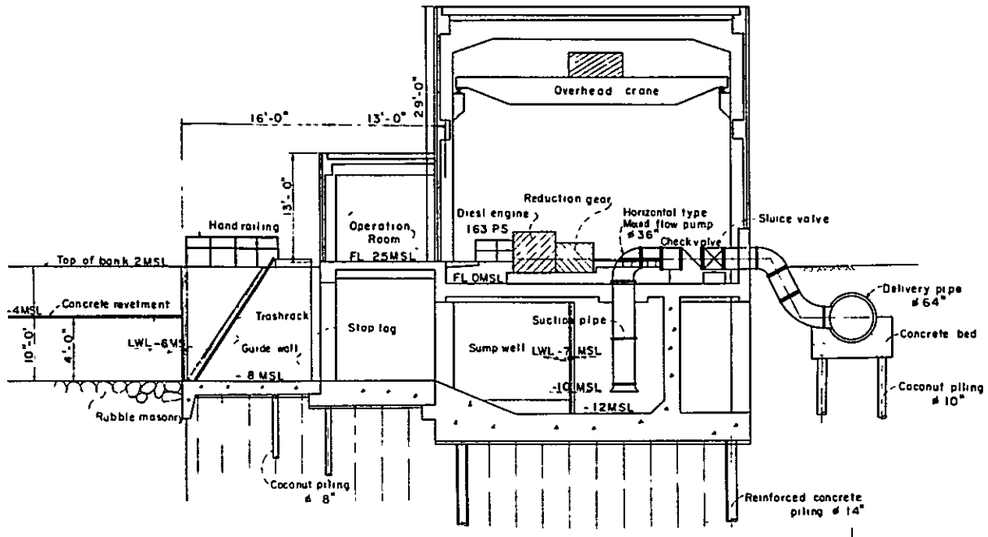
COLOMBO DISTRICT (Low Lying Areas)
RECLAMATION & DEVELOPMENT BOARD-CEYLON

RECLAMATION OF MARSHES IN AND AROUND COLOMBO.

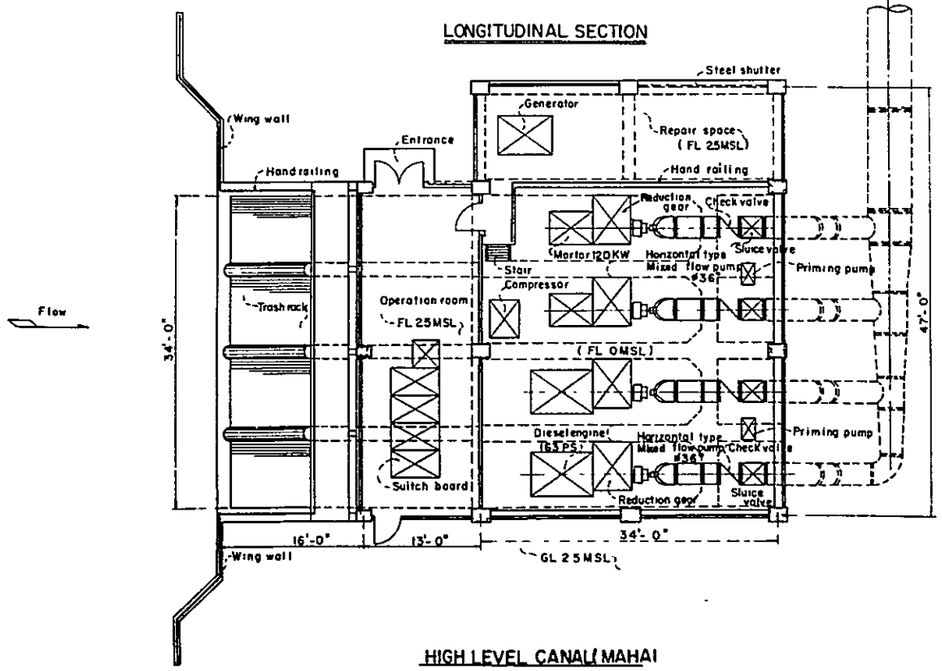
GOTHATUWA
HEENELA

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

DESIGNED :	DATE : NOV. 1970
SUBMITTED :	DRAWING NO. 14



LONGITUDINAL SECTION



HIGH LEVEL CANAL(MAHAI

PLAN

0 10 20 30 feet

SCALE OF FEET

COLOMBO DISTRICT (Low Lying Areas) RECLAMATION & DEVELOPMENT BOARD-CEYLON	
RECLAMATION OF MARSHES IN AND AROUND COLOMBO. KOTTE	
OVERSEAS TECHNICAL COOPERATION AGENCY GOVERNMENT OF JAPAN	
DESIGNED :	DATE NOV. 1970
SUBMITTED :	DRAWING NO. 15

COLLECTED DATA

1. HIGHEST INTENSITIES OF RAINFALL RECORD AT COLOMBO

(1935 to 1938 and 1945 to 1960)

Time (minutes)	3	6	8	10	13	17	23	28	32	39	52	60	85	103	115	194	215
Rainfall (inches)	0.4	0.8	1.0	1.2	1.6	2.0	2.4	2.8	3.0	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0

Time (hours)	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0
Rainfall (inches)	2.8	4.0	4.5	5.2	5.4	5.5	5.7	7.4	8.6	9.4	10.0	10.8	11.7	12.3

Note : The highest amounts are from the heavy shower of 18-5-1936

(On the night of 1964, October 8-9 from 11.20 to 12.20, intensity was 5.2 inches in 60 minutes. Total 7.70")

2. RAINFALL AVERAGE (INCHES) FOR 30 YEAR PERIOD 1931 - 1960.

STATION	January Rain fall	Days	February Rain fall	Days	March Rain fall	Days	April Rain fall	Days	May Rain fall	Days	June Rain fall	Days	July Rain fall	Days	August Rain fall	Days	September Rain fall	Days	October Rain fall	Days	November Rain fall	Days	December Rain fall	Days	Year Rain fall	Days
Apura	4.85	12	2.11	6	3.89	7	7.36	13	3.92	8	0.53	4	1.25	3	1.84	5	2.74	5	9.17	16	9.78	19	9.54	17	56.98	115
Baculla	9.02	17	4.75	10	4.33	11	7.74	17	4.50	11	0.95	6	1.94	7	3.78	9	3.65	9	8.51	17	10.52	20	10.82	20	70.51	154
Batticaloa	10.99	16	7.02	10	3.34	8	2.85	7	1.23	5	0.73	3	1.49	4	2.43	6	1.88	5	7.01	14	11.23	18	16.92	20	67.12	116
Colombo	3.46	8	3.78	7	4.63	11	10.23	18	13.88	23	8.33	22	5.50	15	4.87	15	6.04	17	13.94	21	12.77	19	6.88	12	94.31	188
Diyatalawa	6.00	17	3.37	10	4.78	12	8.27	18	5.63	14	1.82	8	2.31	9	3.52	10	3.72	11	9.77	19	10.94	22	8.01	20	68.14	170
Galle	4.45	11	4.56	9	4.59	11	9.94	16	11.90	21	8.67	22	6.72	19	7.04	19	7.06	19	14.02	21	12.69	19	7.31	14	98.95	201
Hambantota	3.97	9	2.30	5	2.61	7	4.29	10	4.76	12	2.17	12	1.70	7	1.66	8	1.79	8	4.95	13	7.38	15	4.76	12	42.34	118
Jaffna	3.80	8	1.45	3	1.18	3	2.76	7	2.47	4	0.64	1	0.65	2	1.24	4	1.87	3	9.59	13	16.19	18	10.50	14	52.34	118
Kandy	4.66	8	3.27	5	4.73	8	7.41	12	7.48	11	7.27	18	6.08	16	5.59	14	4.81	12	10.18	17	9.83	17	8.29	13	79.60	151
KKS	3.21	6	1.34	2	0.97	2	2.13	4	1.86	4	0.56	1	0.73	2	1.46	3	1.98	4	8.73	11	16.08	16	10.25	13	49.30	68
Kurnnegala	3.86	9	2.35	6	6.70	10	10.36	16	7.74	16	6.43	21	4.40	17	4.53	16	4.30	14	12.99	20	11.08	19	6.95	14	81.69	178
Mannar	3.44	8	1.32	3	1.75	4	3.48	8	1.94	4	0.19	1	0.28	1	0.63	2	0.93	2	6.60	11	9.56	17	7.97	13	38.09	74
Nuwara Eliya	5.71	13	2.99	9	3.80	11	6.05	16	9.32	17	10.28	24	8.76	22	7.07	22	6.50	20	8.75	21	8.21	21	7.48	17	85.15	213
Puttalam	2.88	9	1.80	5	2.99	7	5.42	10	3.89	10	0.91	6	0.67	3	0.84	4	1.39	4	6.84	13	10.04	18	6.04	13	43.71	102
Ratnapura	5.96	13	7.11	12	9.59	18	13.41	21	19.46	24	18.21	26	12.07	24	12.90	24	12.40	22	19.62	23	13.92	21	8.41	16	153.06	244
Trincomalee	8.29	13	3.75	6	1.90	5	3.02	7	2.67	6	0.73	2	2.13	4	4.05	7	3.50	6	9.24	16	13.98	19	14.72	18	67.98	109
Vavuniya (P.W.D)	5.45	10	2.11	4	2.46	5	5.64	11	4.37	7	0.47	1	1.06	3	2.69	6	3.11	6	8.78	15	11.55	18	10.92	16	58.63	102
Vatawala	4.39	10	4.29	9	7.74	13	11.66	19	27.64	23	35.85	28	28.06	27	25.82	27	21.09	23	25.43	24	14.33	20	8.56	14	214.86	237
Ginigathena (Kenilworth)	4.52	9	4.27	8	8.30	13	13.14	20	29.98	25	37.03	28	27.69	27	26.61	27	22.42	23	27.11	24	15.65	20	7.63	13	224.45	237

3. RAINFALL DATA — MONTHLY TOTALS

Location : Colombo Observatory

MONTH	YEAR OF OBSERVATION											
	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
January	6.15	2.18	0.94	5.83	1.11	8.34	0.19	1.49	0.31	4.34	4.25	4.33
February	2.03	0.80	0.78	0.75	2.25	2.26	1.56	5.42	0.07	5.57	0.10	0.34
March	5.53	5.26	0.40	0.32	1.47	8.07	3.80	5.07	4.47	10.03	1.85	3.36
April	17.70	2.87	5.81	0.73	10.60	12.19	3.81	4.74	11.17	4.78	4.53	5.96
May	12.55	10.74	3.72	9.98	19.28	7.30	14.32	11.00	30.99	5.59	12.14	20.01
June	5.20	4.08	8.43	5.76	19.01	4.96	10.27	7.96	7.97	5.41	5.04	3.59
July	2.94	13.28	3.69	2.76	4.59	7.11	3.76	12.63	13.54	1.71	3.11	4.26
August	1.19	11.81	0.76	1.35	1.82	0.64	1.49	0.57	4.91	2.28	2.09	4.47
September	4.36	1.60	2.29	4.84	5.08	2.82	4.15	7.18	3.82	12.74	1.06	16.74
October	16.36	19.21	20.97	14.94	17.23	6.46	16.02	14.12	3.25	4.24	14.76	12.47
November	2.21	10.55	7.05	14.77	12.98	11.50	11.97	25.14	8.04	11.04	5.10	8.89
December	1.63	0.83	4.83	7.33	5.72	11.77	2.92	1.49	2.03	4.30	4.45	9.28

MONTH	YEAR OF OBSERVATION											
	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
January	0.83	7.55	2.12	6.96	2.56	3.53	2.51	5.66	6.27	6.61	5.75	4.25
February	3.36	0.19	2.12	0.01	2.66	1.02	0.14	3.67	2.78	1.78	1.97	3.48
March	5.95	4.90	1.63	3.25	11.29	7.33	5.74	5.91	3.65	6.69	2.67	1.86
April	14.77	8.97	8.30	7.48	8.92	15.95	2.53	11.00	8.99	18.66	13.52	9.40
May	8.68	5.09	22.66	4.48	21.74	8.02	25.95	22.65	7.92	15.46	26.24	11.81
June	17.44	1.50	9.86	7.96	6.98	12.09	13.25	8.64	8.92	9.62	13.34	10.60
July	2.54	5.12	2.71	12.44	13.76	5.75	11.86	2.87	5.65	2.00	1.12	12.12
August	0.94	3.44	1.11	8.18	4.53	4.80	5.31	0.52	2.12	0.31	1.93	9.11
September	2.04	0.94	1.36	13.61	15.01	12.21	9.43	9.18	4.14	10.02	6.59	5.54
October	15.27	8.44	10.92	13.29	14.50	13.73	12.42	10.12	24.70	4.74	33.38	7.03
November	14.49	3.46	21.47	8.75	9.61	25.21	10.23	7.43	17.59	9.32	9.72	15.74
December	4.42	3.96	3.56	9.02	10.83	8.32	5.61	3.63	8.78	5.01	0.27	15.44

RAINFALL DATA — MONTHLY TOTALS

Location : Colombo Observatory

MONTH	YEAR OF OBSERVATION											
	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943
January	0.0	6.57	12.22	0.69	2.52	3.43	1.74	6.61	0.61	1.22	2.65	4.48
February	3.59	2.60	2.81	2.78	4.07	7.09	5.97	0.05	1.42	3.06	1.75	4.16
March	2.60	2.40	7.57	3.76	5.29	6.48	8.14	3.39	0.95	0.77	3.75	4.69
April	11.27	3.25	17.04	3.69	2.86	10.64	15.57	10.67	10.10	7.93	10.72	7.16
May	29.38	20.89	8.61	14.18	33.81	18.63	3.48	13.03	11.30	13.50	17.90	16.63
June	1.68	10.12	18.22	11.39	5.97	6.17	1.94	6.25	7.93	8.42	7.67	8.46
July	1.56	6.58	0.85	2.81	1.88	3.98	4.10	8.62	3.05	3.72	2.99	2.71
August	15.99	14.64	1.46	7.87	1.15	2.12	4.77	6.76	4.23	6.03	5.74	3.38
September	7.16	4.13	2.23	3.80	8.09	14.97	5.74	4.97	8.35	9.46	1 85	2.17
October	30.74	8.43	21.10	23.65	10.69	9.67	4.86	12.83	17.40	15.20	6.86	13.67
November	14.60	8.72	20.61	11.93	15.89	18 00	3.82	19.71	17.05	14.23	4.67	13.60
December	5.73	1.16	2.05	9.93	7.94	2.63	4.63	4.22	1.86	6.60	15.01	8.90

MONTH	YEAR OF OBSERVATION											
	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955
January	2.17	0.01	0.36	3.13	4.52	1.50	0.82	5.41	8.09	3.79	7.33	7.05
February	7.88	0.43	1.90	1.66	0.17	0.14	10.60	1.00	4.58	7.20	5.54	6.63
March	4.93	8.31	5.11	6.45	2.63	6.08	7.64	6.21	0.26	9.46	9.73	5.54
April	6.05	5.09	12.82	4.83	11.39	22.98	4.61	6.48	8.30	25.87	20.49	6.94
May	9.50	8.97	6.63	18.02	6.60	12.62	10.19	22.00	12.05	0.79	13.78	12.61
June	6.70	15.24	6.33	10.55	11.55	12.46	6.29	9.36	8.54	9.88	1.81	5.75
July	3.29	6.24	4.49	7.07	2.70	6.53	6.99	10.97	0.28	20.82	3.33	3.68
August	7.43	1.25	4.45	9.23	6.60	4.82	3.65	0.13	0.42	1.84	5.74	1.11
September	7.83	2.06	5.87	7.31	2.18	3.04	4.72	12.97	8.40	3.51	4.05	15.84
October	14.90	23.79	13.25	11.41	8.97	13.04	16.28	7.73	11.01	25.62	12.96	16.11
November	16.63	7.37	15.67	5.72	12.32	9.70	2.83	23.22	12.48	15.08	4.73	12.33
December	1.81	4.11	18.95	5.31	5.22	3.35	4.27	5.88	6.57	4.69	13.91	2.52

RAINFALL DATA — MONTHLY TOTALS

Location : Colombo Observatory

MONTH	YEAR OF OBSERVATION								
	1956	1957	1958	1959	1960	1961	1962	1963	1964
January	4.27	2.48	2.88	1.75	1.84	1.19	3.11	2.95	1.68
February	2.25	4.03	6.94	2.68	6.82	1.92	1.52	8.73	6.82
March	6.32	0.17	5.13	0.51	2.73	10.58	3.86	4.75	4.80
April	11.66	5.36	7.88	18.37	7.81	18.42	11.09	12.94	6.16
May	4.61	19.99	18.81	12.05	14.05	20.10	19.44	21.52	19.96
June	4.90	9.86	8.63	12.31	4.96	8.77	5.15	7.23	5.38
July	0.43	5.88	1.47	7.34	18.38	8.84	4.31	15.49	6.76
August	3.45	0.87	3.06	7.08	1.65	9.06	17.13	3.15	2.57
September	8.66	0.70	1.88	9.12	4.55	16.79	7.87	20.98	5.09
October	14.21	9.08	13.96	9.88	13.89	19.07	16.41	27.84	18.25
November	11.22	17.35	10.62	10.58	16.75	19.84	8.67	17.15	7.83
December	7.15	21.54	6.43	6.61	2.10	10.25	3.34	12.08	2.86

4. ANNUAL MAXIMUM RAINFALL OF DAY, 2 DAYS, 3 DAYS, AND 4 DAYS CONSECUTIVES AT COLOMBO.

Year	Daily Rainfall	2 Day-Consecutive Rainfall	3 Day Consecutive Rainfall	4 Day Consecutive Rainfall
1901	5.68	6.97	8.03	8.50
02	6.09	6.21	7.34	8.95
03	2.74	3.14	3.28	4.82
04	6.86	6.96	6.98	7.14
05	3.00	4.11	5.55	5.99
06	4.01	4.38	5.45	5.53
07	6.33	6.61	6.68	6.72
08	4.56	7.10	7.28	7.63
09	3.55	4.96	5.68	6.32
10	4.77	7.50	8.00	8.46
11	3.52	4.13	5.14	7.14
12	3.94	5.84	5.96	6.43
13	3.33	5.72	6.83	7.57
14	3.74	3.81	3.88	3.96
15	7.35	7.42	9.72	11.56
16	7.25	10.59	14.39	14.42
17	3.11	5.90	7.31	7.89
18	3.53	4.45	4.48	4.96
19	5.28	5.57	6.01	6.37
20	5.55	6.81	7.52	7.78
21	2.66	3.65	4.18	4.29
22	4.17	8.99	11.26	13.26
23	2.98	3.95	4.40	5.55
24	4.85	6.91	7.20	10.36
25	7.11	11.40	11.82	11.99
26	9.12	13.68	16.03	16.88
27	4.18	7.27	7.96	8.33
28	3.40	5.40	6.55	6.57
29	3.13	4.88	6.19	6.28

Year	Daily Rainfall	2 Day-Consecutive Rainfall	3 Day Consecutive Rainfall	4 Day Consecutive Rainfall
1930	10.09	15.39	16.42	16.81
31	4.24	4.36	4.43	4.71
32	10.43	12.62	14.57	14.65
33	5.13	5.76	6.35	6.87
34	7.18	10.93	13.02	16.79
35	3.79	5.67	6.98	7.76
36	11.40	15.25	19.30	20.30
37	3.42	9.38	10.21	10.83
38	3.23	3.74	4.02	5.07
39	6.42	10.11	10.68	11.02
40	3.62	5.26	5.66	6.57
41	5.90	6.48	6.61	7.16
42	4.63	6.06	6.87	7.00
43	4.20	4.29	5.18	6.00
44	3.09	4.54	5.54	6.29
45	5.51	10.32	13.97	16.38
46	5.79	7.37	8.46	10.59
47	7.06	7.07	8.45	8.57
48	3.46	5.37	5.71	6.23
49	8.27	10.65	11.45	13.35
50	3.77	4.52	4.52	6.59
51	6.35	7.64	8.35	9.40
52	2.82	5.28	5.55	5.55
53	6.61	8.68	2.29	9.41
54	7.35	10.11	10.50	12.81
55	4.00	4.74	6.77	8.25
56	4.63	5.46	6.98	7.96
57	4.14	7.10	10.00	10.43
58	5.34	8.08	9.40	10.49
59	3.57	4.16	4.42	6.52
60	7.53	8.78	10.83	12.03
61	5.30	6.26	7.04	8.61
62	9.39	10.00	10.97	11.37
63	7.61	9.36	12.05	14.58
64	5.15	8.58	11.57	13.05

5. DAILY RAINFALL
1965 AT COLOMBO OBSERVATORY

	Jan:	Feb:	Mar:	Apr:	May:	June:	July:	Aug:	Sep:	Oct:	Nov:	Dec:
1	1.10	0	-	0.03	2.00	-	-	0.24	-	0.05	0.09	-
2	0.20	0.13	-	-	0.41	-	-	0.16	-	0.08	0.31	0.19
3	0	0.43	0.11	-	0.14	-	0.16	0.05	0.04	-	0.64	0.02
4	0	0	0.09	-	1.26	-	-	0.02	0.02	-	1.01	0.04
5	0	0.33	0.02	-	2.58	0.18	-	-	-	-	0.09	0.02
6	0.15	1.94	-	-	6.61	0.12	-	-	-	-	0.70	0.25
7	-	-	-	-	7.50	-	-	-	-	-	0.14	1.14
8	-	-	-	0.44	0.03	-	0.01	-	-	-	-	1.03
9	-	-	-	0.15	0.16	1.11	-	0.10	0.07	-	0.01	0.23
10	-	-	-	-	-	0.33	0.09	2.30	0.06	0.09	1.65	-
11	-	-	0.39	-	-	0.03	-	0.21	0.45	-	-	-
12	-	0.25	0.02	-	-	0.07	-	0.26	0.08	0.61	-	-
13	-	0.21	1.23	2.62	-	0.01	-	0.72	0.33	0.42	0.12	-
14	0.06	-	-	1.18	-	0.16	0.04	0.17	-	0.32	-	-
15	0.13	0.02	-	-	-	-	0.04	0.05	0.06	0.01	1.80	-
16	-	0.09	-	0.3	0.42	-	0.06	0.06	0.19	2.03	0.50	-
17	-	-	-	0.9	-	0.21	0.18	-	0.22	0.14	0.87	3.80
18	-	-	-	-	-	0.28	-	0.04	0.14	0.33	-	-
19	-	-	-	-	0.13	0.03	-	-	0.06	3.62	-	0.74
20	-	-	-	1.07	0.76	-	-	-	-	1.46	0.01	0.40
21	-	0.58	-	-	0.15	-	-	0.01	-	0.70	-	0.25
22	-	0.17	-	0.17	-	0.04	0.02	-	0.18	2.67	0.44	0.15
23	-	-	-	1.67	-	-	0.46	0.04	0.14	1.61	0.27	-
24	-	-	-	0.28	0.55	-	0.27	0.16	0.49	1.59	0.31	0.02
25	-	-	-	0.05	1.02	-	0.10	0.06	1.18	0.43	0.01	-
26	-	-	-	4.58	0.18	0.01	-	0.02	1.60	3.54	0.13	0.42
27	-	-	-	1.21	-	-	-	-	2.47	0.21	-	0.07
28	-	-	-	-	0.02	-	0.02	0.21	0.12	-	-	0.16
29	-	-	-	0.35	-	0.31	0.02	0.24	0.36	-	-	-
30	-	-	-	0.05	-	-	0.60	0.05	0.69	-	-	-
31	0.03	-	0.06	-	-	0.04	0.08	-	-	0.05	-	-
	1.67	4.15	1.92	13.97	24.00	2.93	2.15	5.17	8.96	19.96	6.65	8.94

1966

	Jan:	Feb:	Mar:	Apr:	May:	June:	July:	Aug:	Sep:	Oct:	Nov:	Dec:
1	-	-	1.45	-	0.25	-	0.29	-	1.54	0.56	0	0.09
2	-	-	0.41	0.04	-	0.08	-	-	-	1.24	1.41	0.02
3	-	-	-	-	-	-	-	-	-	0.02	0.26	0.90
4	-	-	-	0.03	-	-	-	-	-	0.02	0.11	0.06
5	-	-	0.14	-	0.02	0.04	0.01	0.13	-	0.90	-	0.42
6	-	-	0.31	-	0.45	0.12	0.12	0.03	-	-	0.12	0.05
7	-	-	-	-	-	-	-	0.08	0.14	1.40	0.57	0.61
8	-	-	-	0.24	-	-	-	-	-	1.42	0.15	0.73
9	0.54	-	-	0.18	-	0.82	0.40	-	-	0.47	1.01	-
10	0.52	0.01	-	-	-	0.25	1.84	-	0.07	0.03	-	-
11	3.50	-	0.55	-	-	-	0.02	-	0.02	-	-	-
12	-	-	0.57	-	-	-	-	-	0.08	-	0.08	-
13	0.03	-	0.11	0.06	-	0.25	-	0.03	-	0.21	0.02	-
14	0.08	0.04	0.03	0.19	-	-	0.10	-	-	0.04	0.03	-
15	-	0.12	-	0.02	-	-	-	-	-	0.09	0.67	-
16	0.08	0.08	-	0.06	-	0.02	-	-	-	0.09	-	-
17	0.03	-	-	0.02	-	0.95	-	-	-	1.69	0.34	-
18	-	-	-	-	1.64	0.77	0.07	0.02	-	0.41	1.89	-
19	-	-	-	0.09	-	0.71	0.82	-	-	0.04	1.66	-
20	-	-	-	0.33	0.02	0.15	0.17	-	1.49	-	-	0.01
21	-	-	-	2.57	-	0.49	-	-	1.94	-	0.02	0.26
22	-	-	-	0.02	-	0.01	-	-	1.22	4.30	-	0.03
23	1.15	-	-	3.45	0.03	-	-	-	0.67	0.40	-	-
24	0.17	-	-	-	0.36	0.10	-	0.35	1.34	-	-	-
25	-	-	4.98	-	1.73	-	-	-	1.54	0.53	-	-
26	-	0.29	0.10	0.67	0.70	0.06	-	-	0.10	0.04	-	0.02
27	-	-	-	-	-	0.19	-	0.09	2.90	-	0.24	-
28	-	0.47	0.14	3.36	0.37	-	-	-	2.66	0.17	-	-
29	0.18	-	-	1.24	-	0.18	0.18	-	5.85	0.25	-	0.10
30	0.25	-	-	0.59	0.21	0.15	-	0.21	0.14	0.22	0	0.10
31	-	-	-	-	0.02	-	-	0.19	-	0.72	-	0.03
	6.54	1.01	8.97	13.17	5.80	5.34	4.02	1.13	21.70	15.27	8.58	3.43

1967

	Jan:	Feb:	Mar:	Apr:	May:	June:	July:	Aug:	Sep:	Oct:	Nov:	Dec:
1	-	-	-	-	0.97	0.22	-	0.77	-	-	0.43	0.13
2	-	-	-	-	0.27	0.31	0.02	0.48	0.09	-	0.82	2.44
3	-	0.06	-	-	4.79	0.04	-	1.09	-	0.19	0.28	-
4	-	1.22	0.14	-	3.11	0.02	1.58	0.61	-	0.01	0.06	-
5	-	-	-	-	3.50	-	0.02	0.03	-	-	2.48	0.76
6	-	-	-	-	-	0.12	0.05	-	-	-	1.16	0.87
7	-	-	-	-	3.50	0.34	-	-	-	-	0.05	0.24
8	-	-	-	-	2.75	0.56	0.20	-	0.02	-	0.21	-
9	-	-	0.38	-	0.23	0.70	-	-	-	1.48	0.34	-
10	-	-	0.33	0.07	0.11	0.02	-	0.01	-	0.80	0.07	1.75
11	-	-	-	-	0.18	-	-	-	0.02	0.74	0.10	-
12	-	-	0.34	1.36	0.18	-	-	0.05	0.48	1.13	-	0.85
13	0.02	-	0.02	-	0.27	0.07	-	0.15	-	5.65	-	0.04
14	0.33	-	0.69	0.39	0.02	0.24	0.22	0.11	0.25	-	0.14	0.60
15	0.27	-	0.69	-	0.23	0.08	0.11	0.08	0.02	0.90	0.88	-
16	-	-	0.05	0.52	0.02	-	-	-	0.80	0.37	0.10	-
17	-	-	-	-	1.21	-	-	0.64	0.02	0.43	-	0.46
18	-	-	0.46	-	0.39	0.17	-	0.12	0.80	3.19	-	3.27
19	-	-	0.01	-	-	-	0.06	0.83	1.82	7.19	0.09	-
20	-	0.16	0.01	-	-	0.02	-	0.22	2.74	1.04	2.47	-
21	-	0.74	-	0.45	0.31	0.20	-	-	1.20	1.29	0.10	-
22	-	0.02	-	-	-	1.30	0.34	0.29	0.11	-	0.08	-
23	-	-	-	0.89	0.09	0.38	1.30	0.23	0.46	-	0.25	-
24	-	0.77	-	-	0.09	0.34	2.15	0.01	0.01	-	-	-
25	-	-	-	0.59	-	0.15	-	0.07	1.02	-	-	-
26	-	-	1.21	-	-	-	0.38	-	0.05	-	0.16	0.66
27	-	-	-	-	-	-	2.39	-	0.05	-	0.64	1.60
28	-	-	0.19	-	0.01	0.31	0.54	0.18	-	0.58	0.20	-
29	-	-	-	-	0.02	0.84	0.05	-	0.04	-	1.43	-
30	-	-	-	-	0.17	-	-	-	0.10	-	0.04	-
31	-	-	-	-	0.94	-	-	-	-	-	-	-
	0.62	2.97	4.52	4.27	23.36	6.16	9.41	5.97	10.10	24.39	12.58	13.69

1968

	Jan:	Feb:	Mar:	Apr:	May:	June:	July:	Aug:	Sep:	Oct:	Nov:	Dec:
1	-	-	-	-	-	0.08	1.45	-	-	0.30	0.40	0.76
2	-	-	-	-	-	0.11	1.39	-	-	0.20	-	0.09
3	-	-	-	0.39	-	-	0.74	-	-	0.26	0.38	0.01
4	-	-	-	-	0.20	0.05	3.48	-	0.02	0.01	-	0.06
5	-	-	0.10	-	0.48	0.58	0.10	0.08	0.07	-	0.17	-
6	-	-	0.65	0.08	-	0.08	-	0.11	-	-	0.95	-
7	-	-	0.12	0.13	-	0.62	-	-	0.01	-	-	-
8	-	-	-	0.08	-	1.14	0.05	0.16	0.74	-	0.14	-
9	-	-	-	0.23	-	0.69	-	0.01	0.99	0.05	1.58	-
10	-	-	-	0.60	-	1.56	-	-	0.53	-	-	-
11	0.75	-	-	-	-	0.02	-	-	0.47	-	-	-
12	-	-	-	0.77	-	0.01	-	-	0.03	0.24	-	-
13	-	-	0.37	-	1.04	-	0.21	1.19	0.14	0.10	-	-
14	2.89	-	0.04	0.11	-	-	0.28	0.20	-	0.10	0.07	-
15	-	-	0.74	0.40	-	0.07	0.30	-	0.19	0.22	0.79	-
16	-	-	-	0.47	-	-	0.17	-	-	1.38	2.53	-
17	-	-	0.49	-	0.04	-	0.05	-	-	0.49	-	0.02
18	-	-	-	-	-	0.04	0.75	0.07	-	0.59	0.59	-
19	-	-	-	0.49	-	-	0.70	-	0.05	0.13	0.02	1.01
20	-	-	-	2.17	-	2.38	0.52	-	0.17	0.54	1.92	0.09
21	-	-	-	-	-	0.57	-	-	0.77	0.09	-	0.11
22	0.04	0.03	-	1.40	0.08	0.19	-	-	0.11	0.87	1.58	0.12
23	-	0.44	0.03	0.85	-	0.73	-	-	0.02	0.22	-	0.18
24	-	0.04	0.51	0.02	-	0.15	-	0.04	0.04	0.10	-	1.30
25	-	-	-	0.07	1.15	-	-	-	0.45	0.30	-	-
26	-	-	0.29	0.17	0.65	0.07	0.07	-	0.02	0.07	-	0.05
27	-	-	0.06	0.32	-	0.42	0.42	-	0.82	-	-	0.87
28	-	-	-	0.10	0.12	0.11	-	-	0.08	0.20	-	0.07
29	-	0.02	-	0.09	-	0.07	-	-	0.23	0.71	0.02	-
30	-	-	-	-	0.03	0.92	-	-	-	0.80	0.08	-
31	-	-	-	-	0.06	-	-	-	-	0.51	-	-
	3.68	0.53	3.40	8.85	3.85	10.66	10.68	1.86	5.95	7.89	11.22	4.74

1969

	Jan:	Feb:	Mar:	Apr:	May:	June:	July:	Aug:	Sep:	Oct:	Nov:	Dec:
1	-	-	-	-	-	0.03	-	0.65	0.10	0.04	-	1.92
2	-	-	0.04	-	-	0.02	-	0.82	0.04	0.01	-	-
3	-	-	-	0.22	3.00	0.32	0.06	-	0.02	-	-	-
4	-	-	-	0.04	0.30	0.34	0.24	-	0.23	-	-	0.42
5	0.01	-	-	0.84	2.93	-	-	0.05	-	0.21	-	0.84
6	-	0.70	-	1.44	1.18	0.01	-	0.06	-	0.30	-	-
7	0.27	0.05	-	0.14	-	0.18	-	0.42	-	0.14	0.17	-
8	-	-	-	0.23	0.54	0.01	-	0.14	-	0	-	-
9	-	-	-	1.67	-	0.11	-	0.22	0.20	0.04	-	-
10	0.01	0.03	-	0.68	0.11	-	-	-	-	0.29	-	-
11	-	-	-	-	0.04	-	-	-	0.92	0.04	-	-
12	0.33	-	-	-	1.68	0.15	-	-	-	7.83	0.80	-
13	4.91	-	-	0.27	0.05	0.51	-	-	-	2.41	1.89	-
14	0.12	-	1.45	0.61	3.31	-	-	0.06	-	0.74	0.11	-
15	0.23	-	-	-	0.47	-	0.11	0.08	-	1.19	0.27	0.18
16	-	-	-	-	0.14	0.02	-	0.79	0.17	1.76	1.58	0.92
17	-	1.34	-	0.61	0.19	-	-	0.33	-	0.64	0.73	0.07
18	-	0.64	-	-	0.17	-	-	0.08	0.07	0.28	0.22	-
19	-	-	-	0.63	-	-	-	0.25	-	2.75	0.09	-
20	0.16	-	-	0.35	0.78	-	-	1.15	-	0.72	0.76	0.25
21	0.01	-	-	0.09	-	0.11	0.04	0.07	-	0.20	1.40	0.12
22	-	-	-	1.38	3.66	0.06	0.55	-	0.01	0.01	-	-
23	-	-	-	-	0.94	0.05	0.03	-	0.01	0.07	-	-
24	-	-	0.81	0.02	0.43	0.47	-	-	-	1.03	-	-
25	-	-	-	0.08	1.01	0.58	-	0.35	0.36	-	-	0.36
26	-	-	-	0.83	0.30	0.34	-	0.60	0.02	-	0.14	-
27	-	0.18	-	0.02	0.11	0.06	-	0.14	-	0.02	0.04	4.64
28	-	0.11	-	-	0.56	-	-	0.08	-	0.29	-	0.27
29	-	-	-	-	0.09	-	-	0.63	0.03	-	1.06	2.45
30	-	-	-	1.12	0.13	-	-	1.02	0.01	1.00	0.80	4.13
31	-	-	-	-	-	-	-	0.37	-	-	-	0.24
	6.05	3.05	2.30	11.27	22.13	3.37	1.03	8.36	2.19	22.01	110.06	16.81

6. ANNUAL MAXIMUM FLOOD LEVELS AT NAGALAGAM STREET GAUGING STATION

Year	Maximum flood leve - ft.	adove	above	M. S. L.		
1940	11.00	21 st	May	at	7.30	a.m.
1941	3.92	16 th	Aug	at	"	"
1942	8.17	20 th	July	at	"	"
1943	6.58	20 th	May	at	"	"
1944	6.00	27 th	May	at	"	"
1945	5.17	20 th	Oct	at	"	"
1946	5.17	20 th	Oct	at	"	"
1947	12.50	17 th	Aug	at	"	"
1948	6.00	26 th	Oct	at	"	"
1949	4.92	30 th	Aug	at	"	"
1950	4.50	15 th	Sept	at	3.00	p.m.
1951	4.33	2 nd	June	at	"	
1952	8.25	27 th	May	at	"	
1953	6.00	27 th	Oct	at	7.30	a.m.
1954	4.25	4 th	May	at	3.00	p.m.
1955	5.25	25 th	Oct	at	"	"
1956	8.00	23 rd	Oct	at	"	"
1957	5.42	5 th	June	at	7.00	a.m.
1958	6.25	30 th	Dec	at	3.00	p.m.
1959	5.33	24 th	June	at	6.00	p.m.
1960	4.67	21 st	July	at	2.00	p.m.
1961	3.75	3 rd	Nov	at	"	"
1962	5.50	21 st	May	at	3.00	p.m.
1963	4.25	25 th	May	at	4.00	p.m.
1964	6.42	26 th	Oct	at	11.00	a.m.
1965	5.08	10 th	May	at	9.00	a.m.
1966	8.67	30 th	Sept	at	4.00	p.m.
1967	9.00	1 st	Oct	at	6.00	p.m.
1968	9.17	23 rd	Oct	at	12.00	a.m.

7. DATA OF DISCHARGE MEASUREMENTS

Gaugeing Station	Date	Time	Flow area.	Velocity	Discharge	Remark.
			Sq. ft.	ft. /sec	cusec	
Havelock Rood	12th, May,'67	9.40 am	232.75	1.79	417.05	
	22th, Oct,'67	-	314.25	2.68	841.36	
	21th, Oct,'67	1.50 pm	316.00	2.64	833.81	
Dehiwela-Galle Bridge	13th, May,'67	11.30 am	77.95	0.55	42.67	No Gauge.
Atlidiya	13th, May,'67	8.00 am	72.02	0.29	20.99	No Gauge.
	21th, Oct,'67	9.15 am	104.30	0.72	75.90	
	22th, Oct,'67	9.15 am	104.30	0.72	75.90	
Kotte Bridge	11th, May,'67	12.00 am	528.75	0.65	345.38	No Gauge.
	23th, May,'67	10.50 am	655.70	1.10	721.52	
	22th, Oct,'67	2.10 pm	667.60	1.03	688.31	
	21th, Oct,'67	12.15 am	668.60	1.06	707.28	
	20th, Oct,'67	9.30 am	664.45	1.11	739.86	
Batlara-mulla	11th, May,'67	10.30 am	546.75	0.61	335.05	
	10th, May,'67	3.30 pm	573.25	0.67	388.66	
	19th, Oct,'67	4.15 pm	633.65	1.16	738.17	
	20th, Oct,'67	11.30 am	740.75	1.76	1,305.71	
	21st, Oct,'67	9.30 am	733.10	1.20	948.84	

Cont'

Gauging station	Date	Time	Flow area.	Velocity	Discharge	Remark
Batta ramulla	22nd Oct. '67	4.00 pm	731.60	1.37	1,003.05	
	23rd Oct. '67	11.45 am	686.75	0.70	482.55	
Hill Street	13th May '67	9.40 am	–	–	–	
	21st Oct. '67	3.00 pm	62.10	0.40	–	
	22nd Oct. '67	10.30 am	58.20	0.38	21.90	
Bofeju Rd.	13th May '67	1.40 pm	290.0	0.34	9.73	
Kalapalu wawa	11th May '67	2.00 pm	121.75	0.49	59.60	
	20th Oct. '67	10.00 am	206.65	–	260.62	
	21th Oct. '67	11.40 am	217.70	0.62	134.35	
	22nd Oct. '67	–	–	0.36	75.54	
	23rd Oct. '67	0.32 am	202.95	0.32	65.08	
Kirillapne	12th May '67	11.00 am	89.00	0.65	57.56	
	23rd May '67	9.00 am	100.00	1.36	136.70	

8. RECORD OF TIDE LEVEL ON OCTOBER

	1-10-69	2-10-69	3-10-69	4-10-69	5-10-69	6-10-69	7-10-69	8-10-69	9-10-69	10-10-69	11-10-69
8	1'- 3"	1'- 3.5"	1'- 3.5"	1'- 3"	1'- 4.5"	1'- 4.5"	1'- 4.5"	1'- 3"	1'- 0"	1'- 0"	1'- 10"
9	0 - 10.5	1 - 1.5	1 - 0.5	1 - 2	1 - 4	1 - 6	1 - 6.5	1 - 5	1 - 4	1 - 2	1 - 1
10	0 - 8	0 - 11	0 - 9"	1 - 1	1 - 4.5	1 - 7.5	1 - 9	1 - 9	1 - 9	1 - 8	1 - 4
11	0 - 8.5	0 - 10.5	0 - 9.5	1 - 0.5	1 - 6	1 - 8	2 - 0.5	2 - 1	2 - 2	2 - 0	1 - 9
12	0 - 11.5	0 - 11	0 - 10	1 - 0.5	1 - 5	1 - 9	2 - 2	2 - 3	2 - 5	2 - 5	2 - 2
1	1 - 2.5	1 - 0.5	1 - 0.5	1 - 1	1 - 4.5	1 - 8	2 - 1	2 - 4	2 - 7	2 - 7	2 - 6
2	1 - 6.5	1 - 3.5	1 - 2.5	1 - 2.5	1 - 4	1 - 7	2 - 0	2 - 3	2 - 8	2 - 8	2 - 8
3	1 - 9.5	1 - 5.5	1 - 3.5	1 - 1.5	1 - 3	1 - 5	1 - 9	2 - 0	2 - 6	2 - 5	2 - 7
4	1 - 9.5	1 - 6	1 - 4.5	1 - 1.5	1 - 1.5	1 - 3	1 - 5	1 - 7.5	2 - 2	1 - 11	2 - 4
5	1 - 8.5	1 - 4	1 - 3.5	1 - 2.5	1 - 2	1 - 1.5	1 - 2	1 - 2.5	1 - 8	1 - 5	1 - 9
6	1 - 6	1 - 2.5	1 - 2.5	1 - 1.5	1 - 0	1 - 0.5	1 - 0.5	0 - 11	1 - 3	1 - 1	1 - 2
7	1 - 2.5	1 - 0	1 - 1	1 - 0	0 - 10.5	1 - 0	1 - 0	0 - 11	0 - 11	0 - 10	0 - 9
8	0 - 11	0 - 9.5	0 - 4.5	0 - 10.5	1 - 0.5	1 - 1	1 - 0.5	0 - 11.5	0 - 11	0 - 10	0 - 8
9	0 - 6	0 - 8.5	0 - 6.5	1 - 0	1 - 1	1 - 3.5	1 - 4.5	1 - 2.5	1 - 3	1 - 10	0 - 10
10	0 - 4.5	0 - 8	0 - 5	0 - 7	1 - 2	1 - 6.5	1 - 8.5	1 - 7	1 - 7	1 - 6	1 - 1
11	0 - 6.5	0 - 7.5	0 - 5.5	0 - 11	1 - 2	1 - 7.5	1 - 11.5	1 - 16.5	2 - 0	2 - 0	1 - 7
12	0 - 10	0 - 9	0 - 8	1 - 0	1 - 3	1 - 9.5	2 - 1.5	2 - 3.5	2 - 6	2 - 6	2 - 4
1	1 - 2	0 - 11.5	0 - 11	1 - 1	1 - 4	1 - 9.5	2 - 1.5	2 - 5.5	2 - 11	2 - 9	2 - 10
2	1 - 6	1 - 3	1 - 1	1 - 3	1 - 4.5	1 - 8.5	1 - 11.5	2 - 5	3 - 0	2 - 9	3 - 0
3	1 - 9.5	1 - 5	1 - 3	1 - 4	1 - 4	1 - 8	1 - 10.5	2 - 1.5	2 - 10	2 - 6	3 - 0
4	2 - 0.5	1 - 7	1 - 4.5	1 - 3.5	1 - 2.5	1 - 6	1 - 8	2 - 10	2 - 5	2 - 3	2 - 8
5	2 - 0.5	1 - 7.5	1 - 5	1 - 3.5	1 - 1.5	1 - 4.5	1 - 4.5	1 - 5	2 - 0	1 - 9	2 - 2
6	1 - 10	1 - 7.5	1 - 4.5	1 - 4	1 - 3	1 - 2.5	1 - 3	1 - 2	1 - 6	1 - 4	1 - 8
7	1 - 7.5	1 - 5.5	1 - 4	1 - 5	1 - 3.5	1 - 3	1 - 2	1 - 0	1 - 0	1 - 1	1 - 3

	12-10-69	13-10-69	14-10-69	15-10-69	16-10-69	17-10-69	18-10-69	19-10-69	20-10-69	21-10-69	22-10-69
8	0'- 10"	1'- 0"	1'- 2"	1'- 4"	1'- 5"	1'- 11"	2'- 2"	1'- 11"	1'- 10"	1'- 9"	1'- 7"
9	0 - 11	0 - 10	0 - 10	1 - 0	1 - 2	1 - 7	1 - 10	1 - 11	1 - 11	2 - 0	1 - 11
10	1 - 1	1 - 0	0 - 11	0 - 11	1 - 1	1 - 6	1 - 8	1 - 10	2 - 0	2 - 1	2 - 2
11	1 - 5	1 - 4	1 - 2	1 - 1	1 - 1	1 - 5	1 - 6	1 - 9	2 - 0	2 - 4	2 - 5
12	1 - 11	1 - 8	1 - 5	1 - 3	1 - 2	1 - 5	1 - 6	1 - 7	1 - 10	2 - 4	2 - 5
1	2 - 4	2 - 1	1 - 10	1 - 6	1 - 5	1 - 7	1 - 7	1 - 7	1 - 8	2 - 1	2 - 5
2	2 - 7	2 - 5	2 - 2	1 - 10	1 - 9	1 - 0	1 - 8	1 - 7	1 - 7	2 - 0	2 - 3
3	2 - 6	2 - 8	2 - 4	2 - 2	2 - 0	1 - 11	1 - 9	1 - 6	1 - 6	1 - 10	1 - 11
4	2 - 3	2 - 5	2 - 3	2 - 2	2 - 1	2 - 1	1 - 10	1 - 6	1 - 5	1 - 8	1 - 7
5	1 - 9	2 - 0	2 - 0	2 - 0	2 - 0	2 - 1	1 - 10	1 - 6	1 - 4	1 - 5	1 - 4
6	1 - 4	1 - 6	1 - 8	1 - 7	1 - 8	1 - 9	1 - 10	1 - 8	1 - 3	1 - 4	1 - 1
7	0 - 10	1 - 0	1 - 0	1 - 2	1 - 6	1 - 6	1 - 9	1 - 8	1 - 4	1 - 5	1 - 1
8	0 - 7	0 - 8	0 - 8	0 - 10	1 - 2	1 - 3	1 - 7	1 - 8	1 - 6	1 - 7	1 - 3
9	0 - 6	0 - 6	0 - 6	0 - 7	0 - 11	1 - 1	1 - 5	1 - 8	1 - 9	1 - 0	1 - 7
10	0 - 4	0 - 9	0 - 8	0 - 6	0 - 9	1 - 0	1 - 3	1 - 9	1 - 11	2 - 2	2 - 0
11	1 - 6	1 - 3	0 - 10	0 - 7	0 - 11	1 - 2	1 - 3	1 - 8	2 - 0	2 - 6	2 - 5
12	2 - 0	1 - 10	1 - 5	1 - 0	1 - 2	1 - 6	1 - 4	1 - 9	2 - 0	2 - 7	2 - 9
1	2 - 8	2 - 5	2 - 0	1 - 5	1 - 6	1 - 6	1 - 6	1 - 6	2 - 0	2 - 7	2 - 11
2	3 - 1	2 - 10	2 - 6	2 - 0	2 - 0	1 - 10	1 - 10	1 - 8	1 - 11	2 - 4	2 - 9
3	3 - 0	3 - 1	2 - 10	2 - 4	2 - 3	2 - 0	2 - 0	1 - 8	1 - 9	2 - 1	2 - 6
4	3 - 0	3 - 0	2 - 11	2 - 7	2 - 6	2 - 4	2 - 4	1 - 8	1 - 7	1 - 10	2 - 1
5	2 - 7	2 - 9	2 - 9	2 - 7	2 - 7	2 - 6	2 - 6	1 - 8	1 - 6	1 - 7	1 - 8
6	2 - 0	2 - 3	2 - 5	2 - 5	2 - 6	2 - 5	2 - 5	1 - 9	1 - 5	1 - 5	1 - 5
7	1 - 7	1 - 8	1 - 11	2 - 0	2 - 3	2 - 4	2 - 4	1 - 10	1 - 6	1 - 5	1 - 3

	23-10-69	24-10-69	25-10-69	26-10-69	27-10-69	28-10-69	29-10-69	30-10-69	31-10-69
8	1'- 3"	0'- 11"	0'- 8"	0'- 7"	0'- 9"	1'- 2"	1'- 4"	1'- 6"	1'- 8"
9	1 - 7	1 - 1	0 - 9	0 - 8	0 - 8	1 - 0	1 - 1	1 - 3	1 - 4
10	2 - 0	1 - 6	1 - 0	0 - 11	0 - 10	1 - 1	1 - 1	1 - 1	1 - 2
11	2 - 2	1 - 11	1 - 5	1 - 4	1 - 1	1 - 4	1 - 2	1 - 1	1 - 2
12	2 - 6	2 - 2	1 -11	1 - 9	1 - 6	1 - 7	1 - 5	1 - 4	1 - 4
1	2 - 7	2 - 5	2 - 3	2 - 1	1 - 11	2 - 0	1 - 8	1 - 7	1 - 5
2	2 - 4	2 - 5	2 - 3	2 - 3	2 - 2	2 - 4	2 - 0	1 - 9	1 - 7
3	2 - 0	2 - 1	2 - 1	2 - 2	2 - 3	2 - 5	2 - 2	1 - 11	1 - 9
4	1 - 7	1 - 8	2 - 9	1 - 10	2 - 0	2 - 4	2 - 1	2 - 1	1 - 10
5	1 - 2	1 - 2	1 - 4	1 - 6	1 - 9	2 - 0	1 - 10	2 - 0	1 - 10
6	0 - 11	0 - 10	0 - 9	1 - 0	1 - 3	1 - 8	1 - 9	1 - 9	1 - 10
7	0 - 10	0 - 7	0 - 5	0 - 7	0 - 9	1 - 4	1 - 4	1 - 5	1 - 9
8	1 - 0	0 - 7	0 - 4	0 - 4	0 - 6	0 - 9	1 - 0	1 - 3	1 - 7
9	1 - 3	0 - 10	0 - 7	0 - 6	0 - 7	0 - 10	0 - 10	1 - 0	1 - 6
10	1 - 10	1 - 3	1 - 0	0 - 10	0 - 10	1 - 0	0 - 11	0 - 10	1 - 6
11	2 - 4	1 - 9	1 - 5	1 - 5	1 - 3	1 - 3	1 - 1	1 - 0	1 - 5
12	2 - 9	2 - 4	2 - 0	1 - 11	1 - 10	1 - 9	1 - 6	1 - 2	1 - 6
1	2 - 11	2 - 9	2 - 6	2 - 5	2 - 4	2 - 2	1 - 11	1 - 7	1 - 8
2	2 - 10	2 - 10	2 - 3	2 - 9	2 - 8	2 - 5	2 - 3	2 - 0	1 - 10
3	2 - 7	2 - 8	2 - 2	2 - 11	2 - 11	2 - 9	2 - 7	2 - 3	2 - 0
4	2 - 1	2 - 4	2 - 5	2 - 8	2 - 10	2 - 10	2 - 9	2 - 5	2 - 2
5	1 - 7	1 - 9	2 - 0	2 - 3	2 - 6	2 - 8	2 - 1	2 - 6	2 - 3
6	1 - 2	1 - 2	1 - 5	1 - 8	2 - 0	2 - 3	2 - 4	2 - 4	2 - 3
7	0 - 11	0 - 10	1 - 0	1 - 2	1 - 6	1 - 9	2 - 0	2 - 1	2 - 2

RECORD OF TIDE LEVEL ON NOVEMBER

	1-11-69	2-11-69	3-11-69	4-11-69	5-11-69	6-11-69	7-11-69	8-11-69	9-11-69	10-11-69	11-11-69
8	1'- 11"	2'- 0"	2'- 0"	1'- 11"	1'- 8"	1'- 6"	1'- 3"	1'- 2"	0'- 10"	0'- 8"	1'- 0"
9	1 - 9	1 - 11	1 - 11	1 - 11	1 - 10	1 - 9	1 - 7	1 - 5	0 - 10	0 - 10	0 - 11
10	1 - 6	1 - 9	1 - 10	2 - 0	1 - 11	2 - 0	2 - 0	1 - 9	1 - 1	1 - 2	1 - 1
11	1 - 5	1 - 8	1 - 10	1 - 11	2 - 1	2 - 2	2 - 3	2 - 1	1 - 5	1 - 6	1 - 4
12	1 - 5	1 - 7	1 - 8	1 - 10	2 - 0	2 - 3	2 - 3	2 - 5	1 - 10	1 - 11	1 - 8
1	1 - 6	1 - 7	1 - 8	1 - 9	1 - 11	2 - 2	2 - 4	2 - 7	2 - 1	2 - 2	2 - 1
2	1 - 8	1 - 7	1 - 8	1 - 8	1 - 9	2 - 0	2 - 3	2 - 5	2 - 2	2 - 4	2 - 5
3	1 - 10	1 - 7	1 - 7	1 - 6	1 - 6	1 - 8	2 - 0	2 - 1	1 - 11	2 - 3	2 - 5
4	1 - 10	1 - 9	1 - 7	1 - 6	1 - 5	1 - 4	1 - 7	1 - 8	1 - 7	2 - 0	2 - 2
5	1 - 10	1 - 10	1 - 8	1 - 6	1 - 3	1 - 1	1 - 2	1 - 2	1 - 2	1 - 5	1 - 11
6	1 - 8	1 - 9	1 - 8	1 - 5	1 - 2	1 - 0	0 - 11	0 - 11	0 - 8	1 - 11	1 - 6
7	1 - 5	1 - 9	1 - 8	1 - 6	1 - 4	1 - 1	1 - 0	0 - 6	0 - 5	0 - 9	1 - 0
8	1 - 3	1 - 9	1 - 8	1 - 7	1 - 6	1 - 3	1 - 4	0 - 7	0 - 5	0 - 11	0 - 8
9	1 - 2	1 - 8	1 - 9	1 - 9	1 - 10	1 - 8	1 - 8	0 - 9	0 - 9	1 - 4	0 - 8
10	1 - 1	1 - 9	1 - 10	2 - 0	2 - 1	2 - 1	2 - 1	1 - 3	1 - 1	1 - 9	1 - 1
11	1 - 2	1 - 7	1 - 10	2 - 1	2 - 5	2 - 5	2 - 6	1 - 10	1 - 8	2 - 3	1 - 7
12	1 - 4	1 - 7	1 - 9	2 - 0	2 - 4	2 - 8	2 - 11	2 - 6	2 - 4	2 - 9	2 - 2
1	1 - 7	1 - 8	1 - 9	2 - 0	2 - 4	2 - 8	3 - 1	3 - 0	2 - 11	3 - 0	2 - 8
2	1 - 10	1 - 8	1 - 8	1 - 10	2 - 2	2 - 6	2 - 11	3 - 1	2 - 11	3 - 3	3 - 2
3	2 - 2	1 - 9	1 - 9	1 - 10	1 - 10	2 - 2	2 - 7	2 - 10	2 - 7	3 - 3	3 - 5
4	2 - 3	1 -11	1 - 8	1 - 7	1 - 8	1 - 11	2 - 3	2 - 6	2 - 2	3 - 0	3 - 4
5	2 - 4	2 - 0	1 - 9	1 - 6	1 - 5	1 - 7	1 - 9	2 - 0	1 - 7	2 - 6	2 - 11
6	2 - 3	2 - 0	1 - 9	1 - 6	1 - 4	1 - 3	1 - 5	1 - 4	1 - 2	1 - 11	2 - 6
7	2 - 2	2 - 1	1 - 10	1 - 7	1 - 4	1 - 2	1 - 3	1 - 0	0 - 10	1 - 4	1 - 11

	12-11-69	13-11-69	14-11-69	15-11-69	16-11-69	17-11-69	18-11-69	19-11-69	20-11-69	21-11-69	22-11-69
8	1'- 5"	1'- 9"	1'- 11"	2'- 0"	2'- 1"	2'- 3"	2'- 4"	2'- 1"	1'- 10"	1'- 7"	1'- 4"
9	1 - 2	1 - 6	1 - 8	1 - 9	1 - 10	2 - 1	2 - 3	2 - 2	2 - 0	1 - 9	1 - 6
10	1 - 3	1 - 6	1 - 5	1 - 7	1 - 8	1 - 11	2 - 1	2 - 2	2 - 2	2 - 0	1 - 8
11	1 - 5	1 - 6	1 - 5	1 - 5	1 - 6	1 - 9	1 - 11	2 - 1	2 - 4	2 - 1	2 - 1
12	1 - 8	1 - 9	1 - 6	1 - 6	1 - 6	1 - 7	1 - 9	2 - 0	2 - 2	2 - 3	2 - 3
1	2 - 1	2 - 0	1 - 9	1 - 6	1 - 8	1 - 7	1 - 8	1 - 10	1 - 11	2 - 2	2 - 4
2	2 - 5	2 - 4	2 - 0	1 - 8	2 - 0	1 - 7	1 - 7	1 - 7	1 - 8	2 - 0	2 - 2
3	2 - 6	2 - 6	2 - 2	1 - 10	2 - 1	1 - 8	1 - 7	1 - 5	1 - 6	1 - 8	1 - 11
4	2 - 4	2 - 6	2 - 3	1 - 11	2 - 3	1 - 9	1 - 7	1 - 4	1 - 4	1 - 4	1 - 6
5	2 - 0	2 - 4	2 - 2	1 - 11	2 - 2	1 - 9	1 - 8	1 - 3	1 - 0	1 - 1	1 - 3
6	1 - 8	2 - 1	2 - 0	1 - 11	2 - 2	1 - 10	1 - 10	1 - 4	1 - 0	0 - 10	0 - 11
7	1 - 4	1 - 8	1 - 9	2 - 0	2 - 1	2 - 0	2 - 0	1 - 6	1 - 4	1 - 0	0 - 10
8	0 - 11	1 - 5	1 - 5	1 - 11	2 - 0	2 - 2	2 - 2	1 - 10	1 - 9	1 - 2	1 - 0
9	0 - 10	1 - 2	1 - 3	1 - 8	1 - 10	2 - 3	2 - 5	2 - 3	2 - 0	1 - 7	1 - 6
10	1 - 0	1 - 2	1 - 1	1 - 6	1 - 9	2 - 3	2 - 7	2 - 6	2 - 5	2 - 2	2 - 0
11	1 - 6	1 - 5	1 - 2	1 - 6	1 - 8	2 - 2	2 - 7	2 - 8	2 - 9	2 - 9	2 - 5
12	2 - 0	1 - 9	1 - 6	1 - 7	1 - 7	2 - 0	2 - 6	2 - 8	2 - 11	3 - 0	2 - 9
1	2 - 7	2 - 2	1 - 10	1 - 10	1 - 9	2 - 0	2 - 4	2 - 7	2 - 10	3 - 1	3 - 1
2	3 - 0	2 - 7	2 - 3	2 - 0	1 - 10	1 - 11	2 - 2	2 - 4	2 - 8	2 - 11	3 - 1
3	3 - 4	3 - 0	2 - 6	2 - 3	2 - 1	1 - 11	1 - 11	2 - 1	2 - 2	2 - 7	2 - 10
4	3 - 5	3 - 1	2 - 10	2 - 6	2 - 2	1 - 11	1 - 10	1 - 10	1 - 9	2 - 2	2 - 5
5	3 - 2	3 - 0	2 - 11	2 - 8	2 - 3	2 - 0	1 - 9	1 - 7	1 - 7	1 - 9	1 - 9
6	2 - 9	2 - 9	2 - 9	2 - 7	2 - 5	2 - 2	1 - 10	1 - 7	1 - 5	1 - 5	1 - 4
7	2 - 3	2 - 5	2 - 6	2 - 5	2 - 5	2 - 4	1 - 11	1 - 8	1 - 5	1 - 4	1 - 1

	23-11-69	24-11-69	25-11-69	26-11-69	27-11-69	28-11-69	29-11-69	30-11-69
8	1'- 0"	0'- 9"	1'- 0"	1'- 1"	1'- 6"	1'- 7"	1'- 8"	1'- 11"
9	1 - 0	0 - 10	1 - 0	1 - 0	1 - 4	1 - 3	1 - 4	1 - 7
10	1 - 4	1 - 0	1 - 1	1 - 2	1 - 3	1 - 1	1 - 1	1 - 5
11	1 - 8	1 - 5	1 - 4	1 - 5	1 - 5	1 - 2	1 - 0	1 - 4
12	1 - 11	1 - 9	1 - 8	1 - 8	1 - 8	1 - 4	1 - 2	1 - 3
1	2 - 2	2 - 1	2 - 0	2 - 0	1 - 11	1 - 7	1 - 5	1 - 5
2	2 - 1	2 - 3	2 - 3	2 - 3	2 - 2	1 - 11	1 - 8	1 - 8
3	1 - 10	2 - 1	2 - 3	2 - 5	2 - 5	2 - 2	1 - 9	1 - 11
4	1 - 7	1 - 9	2 - 1	2 - 4	2 - 4	2 - 3	1 - 11	2 - 1
5	1 - 2	1 - 4	1 - 10	2 - 1	2 - 2	2 - 2	1 - 11	2 - 2
6	0 - 10	0 - 11	1 - 5	1 - 9	1 - 11	1 - 10	1 - 10	2 - 1
7	0 - 8	0 - 8	1 - 1	1 - 3	1 - 6	1 - 7	1 - 8	2 - 0
8	0 - 7	0 - 8	0 - 10	1 - 1	1 - 4	1 - 4	1 - 5	1 - 10
9	0 - 11	0 - 11	0 - 10	1 - 2	1 - 2	1 - 2	1 - 3	1 - 8
10	1 - 5	1 - 4	1 - 2	1 - 4	1 - 4	1 - 1	1 - 1	1 - 6
11	2 - 0	1 - 9	1 - 7	1 - 8	1 - 6	1 - 2	1 - 1	1 - 5
12	2 - 5	2 - 4	2 - 1	2 - 0	1 - 10	1 - 6	1 - 4	1 - 6
1	2 - 10	2 - 10	2 - 6	2 - 6	2 - 3	1 - 10	1 - 8	1 - 9
2	2 - 11	3 - 1	2 - 10	2 - 10	2 - 8	2 - 2	2 - 0	1 - 11
3	2 - 9	2 - 11	3 0 -	3 - 1	2 - 10	2 - 6	2 - 4	2 - 2
4	2 - 4	2 - 8	2 - 11	3 - 1	2 - 11	2 - 8	2 - 6	2 - 5
5	1 - 11	2 - 3	2 - 7	2 - 10	2 - 10	2 - 8	2 - 7	2 - 6
6	1 - 4	-	2 - 1	2 - 6	2 - 6	2 - 5	2 - 6	2 - 6
7	1 - 0	1 - 3	1 - 7	2 - 0	2 - 0	2 - 1	2 - 3	2 - 4

9. RATES OF CONSTRUCTION MATERIALS, EQUIPMENT ETC.

a) Electricity:

Meter charge Rs. 1501 = per month; Rate per K.W.H. 10 ctc.

b) Fuel:

Cost of one gal. of disoline		Rs. 1/66
Cost of one gal. of	(Ruper)	Rs. 3/56
Cost of one gal. of	(regular)	Rs. 3/26

c) Prices of Reclaimed land

1. Buller's Road	Rs. 6,000/-, Per purch (16 o purches = 1 Acre.)	
2. Crow Island	Rs. 2,500/-,	"
3. Mutwal	Rs. 3,500/-,	"
4. Urugodawatta	Rs. 3,500/-,	"
5. Kotte, Heen Ela	Rs. 2,000/-,	"

d) Filling

Cost of hydraulic filling by suction dredger
Rs. 22/. per cube (Buller's Rd.)

Cost of earth fill
Rs. 22/. per cube (Buller's Rd.)
Rs. 25/. per cube (Crou Island)

e) Jetty

Carry of 5 miles

(a)	large boulder 4 5^t.	Rs. 200/- per cube
(b)	small boulder 6" 9"	Rs. 150/- per cube

Carry of 20 miles

(a)	Large boulder 4 5^t	Rs. 300/- per cube
(b)	Small boulder 6" 9"	Rs. 110/- per cube

f) Revetments

i)	Coconut Log Revetment per L.ft.	Rs. 101/-
ii)	Bamboo revetment per L.ft.	Rs. 6/-
iii)	Concrete revetment per cube	Rs. 325/-