JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF HOUSING & PLANTATION INFRASTRUCTURE
SRI LANKA LAND RECLAMATION & DEVELOPMENT CORPORATION

THE STUDY

ON

STORM WATER DRAINAGE PLAN

FOR THE COLOMBO METROPOLITAN REGION

IN

THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

FINAL REPORT

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PREFACE

In response to a request from the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct a master plan and feasibility study on Storm Water Drainage Plan for the Colombo Metropolitan Region and entrusted the study to the Japan International Cooperation Agency (JICA).

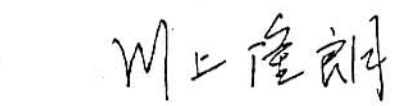
JICA selected and dispatched a study team headed by Mr. Hirofumi SADAMURA of NIPPON KOEI CO., LTD. to Sri Lanka three times between September 2001 and December 2002. In addition, JICA set up an advisory committee headed by Mr. Hideomi OI, Senior Advisor, Institute for International Cooperation, JICA between September 2001 and March 2003, which examined the study from specialist and technical point of view.

The team held discussions with the officials concerned of the Government of Sri Lanka and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Sri Lanka for their close cooperation extended to the team.

March 2003



Takao KAWAKAMI
President
Japan International Cooperation Agency

March 2003

Mr. Takao Kawakami
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir,

We are pleased to submit the final report entitled "The Study on Storm Water Drainage Plan in the Colombo Metropolitan Region in the Socialist Democratic Republic of Sri Lanka". This report compiles the results of the Study in accordance with the contracts signed on September 10, 2001 and June 14, 2002 between Japan International Cooperation Agency and Nippon Koei Co., Ltd.

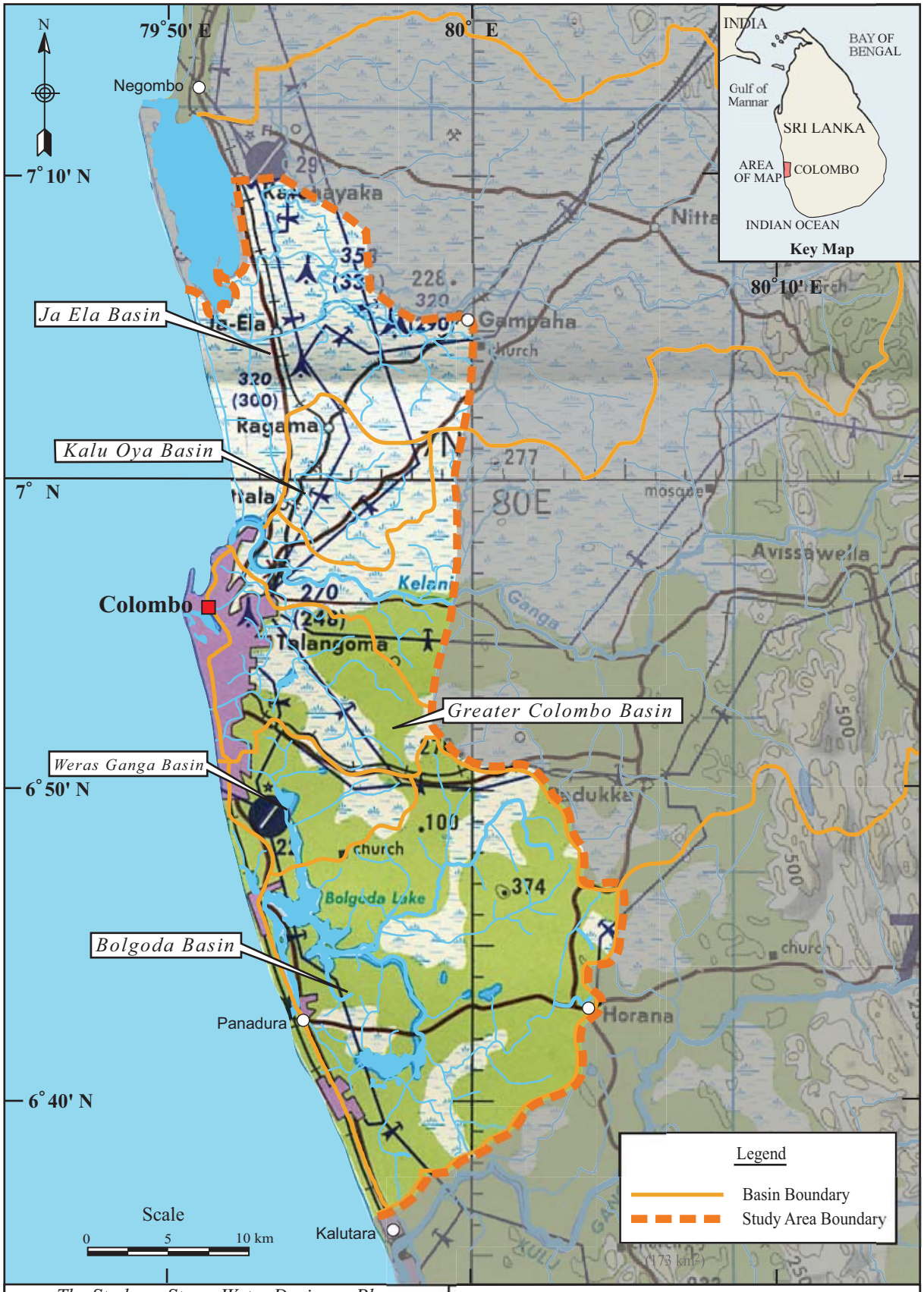
In the Study we present the Master Plan and Feasibility Study based on analyses of the existing conditions and problems on storm water drainage in the Colombo Metropolitan Region. The report consists of Executive Summary, Main Report, Supporting Report (1) and (2), and Data Book.

We wish to express our sincere appreciation to the personnel concerned of your Agency, Advisory Committee, and Embassy of Japan in Sri Lanka, and also to the officials concerned of the Government of Sri Lanka, Western Provincial Council, and Local Authorities in the Western Province for their cooperation extended to our team. We sincerely hopes that the results of the Study will be helpful for realization of the proposed projects for improvement of storm water drainage and will contribute to the promotion of socio-economic development in the Colombo Metropolitan Region.

Yours Faithfully,

定村寛文

Hirofumi Sadamura
Team Leader
The Study on Storm Water Drainage Plan
for the Colombo Metropolitan Region
in the Socialist Democratic Republic
of Sri Lanka



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka

JAPAN INTERNATIONAL COOPERATION AGENCY

Location Map

SUMMARY

PART I : INTRODUCTION

1. INTRODUCTION

Objectives of the Study and Study Area

1. The objectives of the Study are:

   1) To formulate a master plan for storm water drainage in the Colombo Metropolitan Region,
   2) To conduct a feasibility study on priority projects identified in the master plan, and
   3) To carry out technology transfer to counterpart personnel in the course of the Study.

2. The area for the master plan study is shown in Figure 2.1, which is a part of the Colombo Metropolitan Region. The study area is roughly divided into four drainage basins, Ja Ela basin, Kalu Oya basin, Greater Colombo basin and Bolgoda basin. The total catchment area comes to 830 km^2.

3. Based on the master plan study, the storm water drainage project for the Weras Ganga basin, a sub-catchment of the Bolgoda basin, was selected as a priority project for feasibility study. The Weras Ganga basin is shown in Figure 2.1. Its catchment area is 55.5 km^2.

PART II : MASTER PLAN

2. PRESENT CONDITIONS OF THE STUDY AREA

Drainage Basins

4. The study area is divided into the following drainage basins as shown in Figure 2.1. Among them, Ja Ela basin, Kalu Oya basin, Greater Colombo basin and Bolgoda basin are subject to the Study.

Basin	Basin Area (km^2)	Study Area (km^2)
Attanagalu Oya (Ja Ela)	860	173
Kalu Oya	58	58
Kelani Ganga	2,292	89
Greater Colombo	85	85
Bolgoda	394	394
Others	-	31
Total	-	830

Note: Ja Ela basin is a part of Attanagalu Oya basin.

Existing Problems on Storm Water Drainage

5. Based on the natural characteristics of the present drainage systems and the results of the flood damage survey, the major causes of flooding in the respective basins are classified into the following:

Basin	Causes of Flooding
Ja Ela Basin	• Overflow from main streams such as Attanagalu Oya, Urwal Oya, Dandugam Oya and Ja Ela • Natural drainage difficulty in lowland surrounding Muthurajawela Marsh • Lack of storm water drainage system for draining storm water runoff to the main streams or Muthurajawela Marsh
Kalu Oya Basin	• Natural drainage difficulty from Kalu Oya and Old Negombo Canal to Kelani Ganga • Lack of storm water drainage system for draining storm water runoff to the main streams such as Kalu Oya and Old Negombo Canal • Decrease of marsh and surrounding lowland functioning as storm water retention area due to land filling
Greater Colombo Basin	• Deterioration and under-capacity of existing urban drainage systems • Uncontrolled urbanization of unprotected area under the Kelani Ganga Flood Protection Scheme
Bolgoda Basin	• Lack of storm water drainage system for draining storm water runoff to the main streams • Natural drainage difficulty in lowland surrounding the downstream water system

Estimated Flood Damage

6. Based on the results of the inundation analysis and assessment of direct and indirect flood damages, the amount of annual flood damage under the present condition is estimated at Rs. 1,757 million/year for the entire study area as follows:

Sub-basin	Estimated Extent of Inundation Area by Return Period (ha)					Annual Flood Damage (million Rs.)
	2-year	5-year	10-year	25-year	50-year	
Ja Ela	1,113	1,609	1,938	2,755	3,390	509
Kalu Oya	283	384	449	496	558	329
Greater Colombo	153	288	408	581	774	549
Bolgoda	2,419	2,929	3,278	3,645	3,913	370
Study Area	3,968	5,210	6,073	7,477	8,635	1,757

3. HYDROLOGICAL ANALYSIS

Rainfall Analysis

7. Based on the daily rainfall data of 14 rainfall gauging stations in and around the study area, which are operated by the Department of Meteorology, the probable annual maximum daily rainfalls are estimated by basin and return period as follows:

Return Period (years)	Probable 1-Day Rainfall (mm)			
	Attanagalu Oya (800 km^2)	Kalu Oya (58 km^2)	Greater Colombo (85 km^2)	Bolgoda (394 km^2)
2	102.8	129.7	117.3	103.2
5	134.5	184.2	175.7	137.0
10	155.9	220.3	214.3	159.7
25	182.8	266.0	269.6	188.3
50	202.8	299.8	320.1	209.6

Flood Runoff and Inundation Analyses

8. The probable peak runoff discharges under present conditions are estimated at the most downstream base points of the respective basins as follows:

Return Period (years)	Probable Peak Runoff (m^3/sec)			
	Attanagalu Oya (800 km^2)	Kalu Oya (58 km^2)	Greater Colombo (85 km^2)	Bolgoda (394 km^2)
2	104.9	2.4	31.1	105.6
5	156.5	3.2	55.9	116.0
10	192.0	12.9	74.5	124.1
25	235.0	17.6	103.4	135.0
50	266.4	21.0	132.2	143.5

4. FORMULATION OF MASTER PLAN

4.1 Socio-economic Framework for Planning

9. The future socio-economic conditions in the study area have been projected in the Colombo Metropolitan Regional Structure Plan (CMRSP), targeting the year 2010. The socio-economic framework to be applied to the present storm water drainage master plan is set based on CMRSP, so that the target year for the present storm water drainage plan is also set at 2010. The population of the study area in 2010 is estimated at 4.18 million and the GRDP of the study area in 2010 is estimated at Rs. 612 billion.

4.2 Future Land Use

10. The future land use pattern is shown in Figure 4.1. It is forecasted by applying the driving forces of the land use change such as future development, urban sprawl, etc. Within the study area, the major land use categories relating to the Study are urban area, semi-urban area, paddy land, marsh area, water bodies and others such as forest and grassland. Their areas are 10,735 ha (13.3%), 16,950 ha (21.0%), 13,480 ha (16.7%), 1,937 ha (2.4%), 1,533 ha (1.9%) and 36,081 ha (44.7%), respectively.

4.3 Planning Scale and Comprehensive Storm Water Drainage Plan

11. A guideline for storm water drainage planning scale has not been prepared yet in Sri Lanka. The Study recommends applying a planning scale of a 50-year return period to main streams and major tributaries considering the importance of the study area in the Colombo Metropolitan Region. On the other hand, a planning scale of a 5 to 10-year return period is proposed for the urban drainage with small catchments. Besides 50-year return period, optional planning scales of 25-year and 10-year return periods are also studied.

12. The present Study intends to formulate a comprehensive storm water drainage plan and it includes the following components.

1) Structural measures
2) Non-structural measures
3) Institutional development plan
4) Operation and maintenance plan
5) Human resources development plan

4.4 Storm Water Drainage Plan for Ja Ela Basin

Basic Principle for Planning

13. The future land use projection for the study area indicates that the urbanization in the Ja Ela basin will proceed mainly along the Negombo Road and at a few inland locations such as Gampaha and Minuwangoda and most of the basin will remain unchanged. The significant increase of storm water runoff of the main streams will not be expected within the time scale ending in the target year 2010. The storm water drainage plan for the Ja-Ela basin therefore aims at protecting the future urbanized areas along the Negombo Road by means of improvement of the downstream reaches of Dandugam Oya and Ja Ela, conservation of the paddy lands in the middle reaches as a storm water retention area and conservation of the Muthurajawela Marsh as a flood plain.

Structural Measures

14. For the comparative study, the following alternative cases are set by combining the conceivable measures shown in Figure 4.6 for the planning scale of 50-year return period.

Case	Measures
J1	Channel Improvement of Ja Ela (B=45 m, L=7 km) + Channel Improvement of Dandugam Oya (B=55-65 m, L=9.9 km) + Retention Area
J2	Channel Improvement of Ja Ela (B=50 m, L=7 km) + Channel Improvement of Dandugam Oya (B=60-70 m, L=9.9 km) + Retention Area
J3	Channel Improvement of Ja Ela (B=55 m, L=7 km) + Channel Improvement of Dandugam Oya (B=65-75 m, L=9.9 km) + Retention Area
J4	Channel Improvement of Ja Ela (B=45 m, L=7 km) + Channel Improvement of Dandugam Oya (B=55-65 m, L=9.9 km) + Kotugoda-Seeduwa Diversion (B=20 m, L=3.1 km) + Retention Area
J5	Channel Improvement of Ja Ela (B=60 m, L=7 km) + Channel Improvement of Dandugam Oya (B=70-80 m, L=9.9 km) + Retention Area
J6	Channel Improvement of Ja Ela (B=80 m, L=7 km) + Channel Improvement of Dandugam Oya (B=90-100 m, L=9.9 km) + Retention Area

Note: B and L mean width and length, respectively.

Proposed Storm Water Drainage Plan

15. As a conclusion of the comparative study, Case J5 is selected for the Ja Ela basin. The proposed storm water drainage plan consists of the following measures and is shown in Figure 4.8.

Measures	Features
Channel Improvement of Ja Ela	Total length : 7.0 km, Width : 60 m
Channel Improvement of Dandugam Oya	Total length : 9.9 km Width : 80 m from Sta.3.5 to 7.5 km Width : 70 m from Sta.7.5 to13.5 km
Strom Water Retention Area	Lower area : 500 ha, Upper area : 376 ha

4.5 Storm Water Drainage Plan for Kalu Oya Basin

Basic Principle for Planning

16. The Kalu Oya basin has difficulty in natural drainage of storm water due to low-lying lands and the high water level of the Kelani Ganga during rainstorms. The Kalu Oya basin requires a solution for fundamental drainage problems and protection against future increase of storm water runoff due to the urbanization in the basin. The storm water drainage plan for the Kalu Oya basin should be formulated employing various measures such as channel improvement, diversion, pumping stations, securing of retention area, introduction of new storm water retention facilities.

Structural Measures

17. In order to select effective structural measures, the following measures shown in Figure 4.19 are first studied for the planning scale of a 50-year return period.

Case	Measures
K1	Channel Improvement of Kalu Oya (B=40 m, L=5 km) + Retention Area
K2	Channel Improvement of Kalu Oya (B=45 m, L=5 km) + Retention Area
K3	Channel Improvement of Kalu Oya (B=50 m, L=5 km) + Retention Area
K4	Wattala Pumping Station (Q=10 m^3/sec) + Retention Area
K5	Wattala Pumping Station (Q=20 m^3/sec) + Retention Area
K6	Wattala Pumping Station (Q=30 m^3/sec) + Retention Area
K7	Diversion Channel to Muthurajawela Marsh (B=30 m, L=2.4 km) + Retention Area
K8	Improvement of Old Negombo Canal (B=30 m, L=4.2 km) + Retention Area
K9	Improvement of Old Negombo Canal (B=35 m, L=4.2 km) + Retention Area
K10	Improvement of Old Negombo Canal (B=40 m, L=4.2 km) + Retention Area

Note: B, L and Q mean width, length and capacity, respectively.

18. Considering the effectiveness of the alternative measures, the following alternative cases are prepared for the comparative study on the condition that the water level in the lower retention area does not exceed the allowable water level.

Case	Measures
K11	K1+K8+Retention Area
K12	K2+K9+Retention Area
K13	K3+K10+ Retention Area
K14	K1+K7+K8+Retention Area
K15	K1+K6+K8+Retention Area
K16	K1+K7+Retention Area
K17	K1+K9+Retention Area
K18	K1+K10+Retention Area
K19	K3+K7+K10+Retention Area
K20	K3+K6+K7+K10+Retention Area

Proposed Storm Water Drainage Plan

19. Resulting from the comparative study, Case K13 has the highest economic viability and therefore it is proposed to select Case K13 for the Kalu Oya basin. The proposed storm water drainage plan for the Kalu Oya basin consists of the following measures and is shown in Figure 4.21.

Measures	Features
Channel Improvement of Kalu Oya	Total length : 5.0 km, Width : 50 m (Sta. 0.0 to 3.8 km) Width : 25 m (Sta. 3.8 to 5.0 km)
Improvement of Old Negombo Canal	Total length : 4.5 km, Width : 40 m
Strom Water Retention Area	Lower area : 360 ha, Upper area : 89 ha

4.6 Storm Water Drainage Plan for Greater Colombo Basin

Basic Principle for Planning

20. The Greater Colombo basin is expected to be continuously urbanized toward the suburbs. This will result in an increase of the storm water runoff and worsen the

storm water drainage condition unless further measures are provided. Due to limitation of available land for canal widening, it is essential to conserve the presently functioning storm water retention areas and also preserve other lowlands available for the purpose of storm water retention as much as possible. Based on that, structural measures such as channel improvement, diversion, pumping stations, tunnels, etc. should be taken to augment the capacities of the existing storm water drainage systems and increase the flood safety level.

Structural Measures

21. In order to select effective measures, the following measures shown in Figure 4.31 are first studied for the planning scale of 50-year return period.

Case	Measures
G1	Mararadua Pumping Station (Q=5m^3/s) and Improvement of Galle Face Outfall Gates + Retention Area
G2	Mararadua Pumping Station (Q=10 m^3/s) and Improvement of Galle Face Outfall Gates + Retention Area
G3	North Lock Pumping Station (Q=10 m^3/s) + Retention Area
G4	North Lock Pumping Station (Q=15 m^3/s) + Retention Area
G5	Gotatuwa Pumping Station (Q=30 m^3/s) + Retention Area
G6	Gotatuwa Pumping Station (Q=40 m^3/s) + Retention Area
G7	Madiwela South Diversion Canal (B=40 m, L=8.8 km) + Retention Area
G8	Restoration of Existing Mutwal Tunnel (D=1.8m, L=554 m) + Retention Area
G9	New Mutwal Tunnel (D=3m, L=740 m) + Retention Area
G10	New Mutwal Tunnel (D=4m, L=740 m) + Retention Area
G11	Improvement of Wellawatta (B=30m, L=1,900 m) and Kirillapone Canals (B=25m, L=1,200 m) + Retention Area

Note: B, L and Q mean width, length and capacity, respectively.

22. The following alternative cases are prepared for the comparative study.

Case	Measures
G12	G7+G8+Retention Area
G13	G7+G9+Retention Area
G14	G7+G10+Retention Area
G15	G8+G9+Retention Area
G16	G8+G10+Retention Area
G17	G7+G11+Retention Area
G18	G7+G8+G9+Retention Area
G19	G7+G8+G10+Retention Area
G20	G7+G8+G11+Retention Area
G21	G7+G9+G11+Retention Area
G22	G7+G10+G11+Retention Area
G23	G7+G8+G10+G11+Retention Area
G24	G4+G7+ G8+G10+G11+Retention Area

Proposed Storm Water Drainage Plan

23. Based on the results of the comparative study, Case 19 is selected as the storm water drainage plan for the Greater Colombo basin. The proposed storm water drainage plan for the Greater Colombo basin consists of the following measures and is shown in Figure 4.33.

Measures	Features
Madiwela South Diversion Channel	Total length : 8.8 km, Width : 32 m
Restoration of Existing Mutwal Tunnel	Total length : 554 m, Diameter : 1.8 m
New Mutwal Tunnel	Total length : 740 m, Diameter : 4.0 m
Storm Water Retention Area	380 ha

4.7 Storm Water Drainage Plan for Bolgoda Basin

Basic Principle for Planning

24. The Bolgoda basin is characterized by the drainage system in the downstream lowland consisting of the two major lakes and waterways interconnecting with each other. According to the future land use projection, extensive urbanization in the basin is not expected except in the Weras Ganga basin in the northern part of the Bolgoda basin. It is essential to conserve the existing water surface areas and surrounding lowlands from the viewpoints of storm water retention as well as environmental protection in the entire Bolgoda basin.

25. On the other hand, the Weras Ganga basin requires channel improvement of the main stream and major tributaries to cope with runoff increase due to urbanization and mitigation of the flood damage in the basin. Therefore, the storm water drainage plan for the Bolgoda basin is formulated focusing on the storm water drainage plan for the Weras Ganga basin.

Structural Measures and Proposed Storm Water Drainage Plan

26. The conceivable measures for the Bolgoda basin are shown in Figure 4.46. Further, the conceivable structural measures for the Weras Ganga and tributaries are shown in Figure 4.47 and grouped into the component schemes broadly demarcated by sub-basin. Through the studies on these measures, the following structural measures are proposed as the storm water drainage plan for the Bolgoda basin.

1) Weras Ganga Sub-basin

Component Scheme	Measures
(1) Weras Ganga	• Weras Ganga Dredging (L=5.5 km, B=19-40 m) • Flood Protection Dike on Right Bank (L=2.3 km) • Weras Ganga Swamp Retention Area (65 ha) • Maha Ela Marsh and Lowland Retention Area (106 ha)
(2) Nugegoda-Rattanapitiya Scheme	• Channel Improvement of Nugegoda-Ela (L=1.58 km, B=5-13 m) • Channel Improvement of Delkanda Ela (L=1.76 km, B=3-13.5 m) • Channel Improvement of Rattanapitiya Ela (L=2.13 km, B=19 m) • Retention Areas(36 ha in total)
(3) Bolgoda Canal Scheme	• Channel Improvement of Bolgoda Canal (L=2.4 km, B=17-19 m) • Bellanwila-Attidiya Marsh Retention Area (88 ha)
(4) Boralesgamuwa North Scheme	• Channel Improvement of Depawa Ela (L=3.09km, B=6 m)
(5) Boralesgamuwa South Scheme	• Channel Improvement of Werahara Tributary (L=0.98 km, B=15m)
(6) Maha Ela Scheme	• Channel Improvement of Maha Ela (L=2.7 km, B=32 m) • Channel Improvement of Maha Ela Tributary (L=1.76 km, B=15 m)
(7) Ratmalana-Moratuwa Scheme	• Urban Drainage Improvement (L=11.12 km, B=0.8-6 m) • Kandawala Retention Pond (3 ha) • Telewala Retention Pond (10 ha) • Channel Improvement of Katubedda Tributary (L=1.25 km, B=8 m)

Note: L and B mean length and width, respectively.

2) Entire Bolgoda Basin

- Conservation of lowlands in the entire Bolgoda basin as a storm water retention area (4,739 ha)

4.8 Non-structural Measures for Storm Water Drainage

27. An effective storm water drainage plan should be formulated as a combination of structural and non-structural plans. In the study area, the following non-structural measures will support the structural measures taking into account the basin conditions.

1) Storm water retention area management
2) Development control in urban development areas
3) Land use regulation in lowland areas
4) Dissemination of flood information to the public
5) Flood-proofing of buildings in flood-prone areas
6) Flood fighting

4.9 Institutional Development Plan

28. Institutional and legislative issues on the storm water drainage works are 1) unclear responsibilities among government agencies for storm water drainage works, 2) lack of an authorized land use plan, 3) malfunction of the regulation system for low land development and 4) shortage of resources for the storm water drainage works. The following measures are proposed as an institutional development plan.

(1) Demarcation of responsibility for the storm water drainage works among the related organizations, that is, SLLRDC, local authorities (LA), Road Development Authority (RDA) and Irrigation Department (IRD)
(2) Lowland management by SLLRDC for proper and effective storm drainage works

4.10 Operation and Maintenance Plan

29. For the sustainable O&M works, the following measures are proposed as an O&M plan.

1) Organization strengthening of SLLRDC and organization set-up of local authorities including staff arrangement
2) Procurement of O&M Equipment
3) Financial arrangement for O&M works

4.11 Human Resources Development Plan

30. Human resources development for management of the entire storm water drainage works as well as the O&M works will be a key issue for implementation agencies, that is, SLLRDC and the local authorities. The following measures are proposed as a human resources development plan.

1) O&M staff training for SLLRDC and local authorities as a short term objective
2) Overall training for human resources development for the storm water drainage sector as a long term objective

5. CONSTRUCTION PLAN AND COST ESTIMATE

Construction Plan

31. The major construction works will be executed by contractors selected through international competitive bidding (ICB) complying with the regulations of the Government of Sri Lanka and the guideline of the international financing organizations. The construction period of each component of the proposed storm water drainage plan is estimated at 3 to 4 years taking into account work volumes of

the proposed projects and also construction periods of past similar projects. The overall construction schedule is shown in Figure 9.1.

32. The estimated project costs of the proposed storm water drainage plans are as follows:

Basin	Project Cost (million Rs.)
Storm Water Drainage Plan for Ja Ela Basin	3,679
Storm Water Drainage Plan for Kalu Oya Basin	2,463
Storm Water Drainage Plan for Greater Colombo Basin	4,389
Storm Water Drainage Plan for Bolgoda Basin	5,102

All costs are estimated at August 2002 price level. The exchange rate is set at US$1.0 = Rs 96.26 = Yen 118.94.

33. Annual O&M costs of the channel and other civil structures are assumed at 1% of the construction cost. While, the annual O&M costs for pumping stations and gates are estimated at 2.5% of the construction cost.

6. ENVIRONMENTAL CONSIDERATIONS

34. *Ja Ela basin:* A rise of water level in the Muthurajawela Marsh is expected to be caused by the proposed Ja Ela and Dandugam Oya channel improvement during rainstorms. The breeding sites for some kinds of birds in the marsh might be affected by the water level rise. The environmental impact to feeding grounds for fauna will be minimal since the fauna such as birds can temporarily evacuate to a safe place during rainstorms. Any negative environmental impact to flora is not expected to occur due to the short time of inundation.

35. *Kalu Oya basin:* The storm water will be mostly discharged into the conservation zone of the Muthurajawela Marsh by the proposed Kalu Oya channel and Old Negombo Canal improvement. Since the higher water level will last only for a short time, the environmental impact to the Muthurajawela Marsh will be the same as that mentioned for the Ja Ela basin above. There is a possibility that a large volume of pollutants from the urbanized area will flow into the Muthurajawela Marsh through the improved Old Negombo Canal and the polluted water might cause an environmental impact to the habitats for flora and fauna unless the wastewater is properly treated within the urban area.

36. *Greater Colombo basin:* Active conservation of the existing marshes, such as Kolonnawa, Kotte and Heen Marshes, as a retention area with proper management will bring about positive effects for both ecological and urban environments in the basin. The proposed restoration of the existing Mutwal Tunnel and construction of

the new Mutwal Tunnel will not cause any serious environmental impact by themselves. By construction of the proposed Madiwela south diversion, the storm water diverted from the Parliament Lake basin to the Weras Ganga may cause a water level rise of the Weras Ganga and the Bolgoda Lake North. However, no harmful impact will occur since the water level rise is estimated at 10 cm for the Weras Ganga and 3 cm for the Bolgoda Lake North.

37. Bolgoda basin : The proposed channel improvement will reduce the flood water level in the sub-basin, while the water level of the Bolgoda Lake North will raise a few cm. Since the water level rise is small, no harmful impact will occur. There exists the Bellanwila-Attidiya Marsh in the Weras Ganga sub-basin. The water level in the Marsh area will not rise due to the proposed channel improvement. The proposed storm water drainage plan will not cause an environmental impact to habitats for flora and fauna in the Marsh.

7. SOCIAL CONSIDERATIONS

38. In the urbanized portion of the study area, there exist many settlements in the flood-prone lowland areas and along the drainage canals, where the proposed storm water drainage projects would be located. Under this circumstance, land acquisition and resettlement are inevitably anticipated for implementation of the proposed projects. For smooth resettlement, people affected by the proposed projects should be fairly compensated so as not to lower their life conditions, especially for the under-served settlements and low income households, but also to upgrade their living environment through project implementation.

39. Previous works and experiences in the GCFC&EIP are useful for projecting social impacts on the people affected by the proposed storm water drainage projects. The key points for successful implementation of the projects will be as follows:

1) Participatory planning approach,
2) Improvement of living environment of residents,
3) Assistance for community-based organization for successful resettlement,
4) Introduction of community-based activities such as community contracts and
5) Coordination among stakeholders.

8. PROJECT EVALUATION

40. It is concluded that the storm water drainage plans proposed for the four objective basins of Ja Ela, Kalu Oya, Greater Colombo and Bolgoda basins are economically, technically, environmentally and socially viable for the planning scale of a 50-year return period. Also, it should be noted that implementation of the proposed storm

water drainage projects will contribute to poverty reduction through reduction of flood damage, development of the study area, improvement of living conditions of the low-income group, etc.

41. The results of economic evaluation for the proposed storm water drainage projects are summarized below.

Subject Basin	Project Cost (million Rs.)	Annual Benefit (million Rs./year)	B/C	EIRR (%)
Ja Ela Basin	3,679	388	1.34	12.9
Kalu Oya Basin	2,463	422	1.94	19.5
Greater Colombo Basin	4,389	886	2.23	19.8
Bolgoda Basin	5,102	1,022	2.22	19.2

42. In addition to the above quantitative benefits, many intangible benefits are expected from the implementation of the proposed storm water drainage projects. They are:

1) Promotion of economic development
2) Improvement of people's living conditions
3) Reduction of inconvenience in people's life
4) Improvement of the hygienic environment
5) Elimination of the menace of flooding
6) Improvement of the water environment
7) Contribution to poverty reduction

9. PROJECT IMPLEMENTATION PLAN

43. The overall implementation schedule is prepared as shown in Figure 9.1. The maximum annual disbursement of the project costs comes to around Rs. 2.1 billion in total, which is less than the current budget for construction of SLLRDC, which is Rs. 2.2 billion. In terms of annual disbursement, it may be possible for SLLRDC to implement the project as proposed in the master plan with the continuous financial coverage by the central government. On the other hand, investment cost of Rs. 15.6 billion in total should be procured from an international funding agencies taking into account the present severe financial condition of the Sri Lanka Government.

10. PRIORITY PROJECT

44. For the subsequent feasibility study, priority project has to be selected based on the criteria as given in Table 10.1. The overall evaluation result is given below.

Project	Overall Evaluation
Ja Ela Basin Storm Water Drainage Project	C
Kalu Oya Basin Storm Water Drainage Project	B
Greater Colombo Basin Storm Water Drainage Project	B
Bolgoda Basin (Weras Ganga Sub-basin) Storm Water Drainage Project	A

45. Based on the above result and priorities set by the Sri Lanka government, the Bolgoda Basin (Weras Ganga Sub-basin) Storm Water Drainage Project is selected as a priority project for the feasibility study. The number of resettlement households (158) is much smaller than other basins (more than 500) and also the land acquisition area is the smallest among the four basins. The rate of poor households, of which monthly income is less than Rs. 3,000, is as high as 35%, so that the proposed plan could improve the people's living conditions and consequently contribute to poverty reduction. It is judged that selection of the Weras Ganga sub-basin will be reasonable.

46. The priority project is named the Weras Ganga Basin Storm Water Drainage Project and component schemes of the priority project will be selected from seven schemes proposed in the master plan through further study in the feasibility study.

11. Conclusion and Recommendations for Master Plan

Conclusion

47. It is concluded that the storm water drainage plans proposed for the four basins, Ja Ela, Kalu Oya, Greater Colombo and Bolgoda are economically and technically viable for the planning scale of a 50-year return period. Also, no serious environmental or social issues, which could hamper the implementation of the proposed storm water drainage plans, are expected.

48. The proposed storm water drainage projects are expected to yield various benefits not only flood damage reduction but also other tangible and intangible benefits mentioned before. According to the community inventory survey carried out in the Study, the ratios of poor households to total households of GN divisions having flood damages are estimated at 37% for the Ja Ela (6,000 households) and Kalu Oya basins (7,000 households), 24% for the Greater Colombo basin (27,000 households) and 35% for the Bolgoda basin (22,000 households). Many of them will be beneficiaries of the proposed storm water drainage plans. The proposed storm water drainage projects could improve their living conditions and consequently contribute to the reduction of poverty.

49. Regarding the priority project subject to a feasibility study, the storm water drainage project for the Weras Ganga sub-basin in the Bolgoda basin was selected based on

consideration from the viewpoints of economic feasibility, technical feasibility, environmental impact, social aspects and also prioritization by Sri Lanka side.

50. The Weras Ganga basin is adjacent to the Greater Colombo area and most of the basin has been urbanized. It is also expected to be highly developed in the future. The Weras Ganga basin presently has flood damage to be mitigated and will have a large flood damage potential in the future. There is an urgent need for the storm water drainage project for the Weras Ganga Basin. It is reasonable to carry out the feasibility study for the Weras Ganga storm water drainage project.

Recommendations

51. The recommendations on the master plan study are as follows:

1) Needs of detailed topographic maps for further detailed study
2) Earlier preparation of guideline for storm water drainage and flood control planning scales
3) Understanding of relation between CMRSP and proposed storm water drainage plan.
4) Understanding of importance of proposed storm water retention areas and function of lowlands.
5) Steady execution of proposed non-structural measures, institutional development plan, O&M plan and human development plan
6) Treatment of wastewater for water quality improvement of drainage canals
7) Necessity of review of the proposed storm water drainage plan according to future land use change

PART III : FEASIBILITY STUDY

12. BACKGROUND OF PRIORITY PROJECT

Priority Project for Feasibility Study

52. The storm water drainage project for the Weras Ganga basin (the Project) located in the northern part of the Bolgoda basin was selected as a priority project subject to a feasibility study after totally evaluating the storm water drainage plans for the four objective basins from the viewpoints of economic viability, technical viability, environmental aspects, social aspects and also prioritization by Sri Lanka side.

Needs of Proposed Project

53. Needs of the proposed Weras Ganga basin storm water drainage project are explained as follows:

1) Mitigation of flood damage
2) Assurance of sound and easy development of the basin
3) Improvement of people's living conditions, consequently contribution to poverty alleviation
4) Identification and conservation of required storm water retention areas
5) Promotion of economic development

13. PRESENT CONDITIONS OF THE WERAS GANGA BASIN

13.5 Existing Storm Water Drainage Systems

Drainage Systems

54. The Weras Ganga basin selected for feasibility study is defined as a drainage area upstream of the Kospalana bridge on the Moratuwa-Piliyandala Road across, which crosses the Weras Ganga from west to east as shown in Figure 13.1. The extent of the drainage area is 55.5 km^2. The Weras Ganga basin is broadly divided into the following seven sub-basins.

Sub-basin	Area (km^2)
Nugegoda-Rattanapiya	8.2
Bolgoda Canal	7.7
Boralesgamuwa North	4.9
Boralesgamuwa South	4.0
Maha Ela	20.4
Ratmalana-Moratuwa	8.1
Thumbowila	2.2
Total	55.5

Flood Prone Areas and Flood Damage

55. The flood damage survey under the GCFC&EIP Phase II in 1995 identified 75 locations of flood prone areas in Dehiwala-Mount Lavinia MC and Moratuwa MC. Of those, 30 locations were located within the Weras Ganga basin. The other survey carried out in 2001 during the Study identified 39 locations of flood prone areas in the Weras Ganga basin. Locations of the flood prone areas mentioned above are shown in Figure 13.13.

56. According to the results of interviews in the flood prone areas under the 2001 flood damage survey, frequency of inundation is 5.2 times a year with duration of 1.1-day on average as shown below. It is suggested that flooding in the Weras Ganga basin is characterized by frequent occurrences even in the case of normal rainstorm event.

Sub-basin	Frequency (times/year)	Duration (days)
Nugetoda-Rattanapitiya	4.4	0.8
Bolgoda Canal	6.1	1.0
Boralesgamuwa North	4.5	1.2
Boralesgamewa South	2.8	1.6
Maha Ela	3.9	2.0
Ratmalana-Moratuwa	7.0	1.0
Thumbowila	(N/A)	(N/A)
Weras Ganga Basin	5.2	1.1

57. Based on the results of the inundation analysis and assessment of direct and indirect damages, the amount of annual damage under the present condition is estimated at Rs. 253 million/year for the entire Weras Ganga basin as shown below. On the other hand, the flood damage survey in 1995 estimated an annual flood damage of Rs. 118 million/year in total for Dehiwala - Mount Lavinia MC and Moratuwa MC areas.

Sub-basin	Estimated Extent of Inundation Area by Return Period (ha)					Annual Damage (million Rs.)
	2-year	5-year	10-year	25-year	50-year	
Nugetoda-Rattanapitiya	99	118	128	142	150	31
Bolgoda Canal	114	140	147	159	162	85
Boralesgamuwa North	85	95	102	109	121	9
Boralesgamewa South	60	76	81	87	91	5
Maha Ela	272	331	367	405	431	26
Ratmalana-Moratuwa	77	93	104	115	121	95
Thumbowila	16	21	23	26	27	2
Weras Ganga Basin	721	873	952	1,042	1,101	253

Causes of Flooding

58. The outstanding problems attributed to the present storm water drainage system of the Weras Ganga basin are broadly classified as follows.

Problems	Affected Areas
Flooding of Weras Ganga	Low-lying areas along the Weras Ganga right bank from Kandawala to Telewala in the Ratmalana-Moratuwa sub-basin
Obstruction of storm water drainage by reduction of flow capacity in the downstream end of the major tributary connecting to the Weras Ganga	Downstream reaches of Bolgoda Canal, Rattanapitiya Ela, Depawa Ela and Maha Ela,
Overflow from major tributary due to insufficient flow capacity of channel or crossing structure for storm water runoff	Middle and upstream reaches of Nugegoda, Ela, Delkanda Ela, Depawa Ela, Maha Ela
Drainage difficulty due to absence of channel construction or improvement for storm water drainage	Middle and upstream reaches of Nugegoda, Ela, Delkanda Ela, Depawa Ela, Boralesgamuwa South
Drainage difficulty in low-lying areas with ground elevation of 1.0 m above MSL or less, backed up by Weras Ganga water level	Low-lying areas along the Weras Ganga right bank from Kandawala to Telewala in Ratmalana-Moratuwa sub-basin

59. The causes of the above problems are uncontrolled urbanization, encroachment of low-lying areas of Weras Ganga, runoff increase resulting from urbanization, uncoordinated construction and improvement of drainage facilities and lack of maintenance of drainage facilities.

14. HYDROLOGICAL ANALYSIS

Rainfall Analysis

60. Based on the daily rainfall data of 3 rainfall gauging stations in the Weras Ganga basin, which are operated by the Department of Meteorology, the probable basin maximum 24 hr rainfall for return periods from 2 to 50 years is analyzed. Also, the probable 60-minute rainfall is analyzed based on the short duration rainfall record of the Colombo rainfall gauging station. The results are as follows:

Return Period (years)	Probable Maximum 24 hr Rainfall (mm)	Probable Maximum 60-minute Rainfall (mm)
2	137	66
5	175	80
10	201	89
25	234	101
50	258	109

Flood Runoff Analysis

61. The probable peak runoff discharges calculated under present and future conditions at 1) Bolgoda canal at Elewalla road, 2) Maha Ela outfall and 3) Weras Ganga outfall are summarized in the table below.

Return Period (years)	Bolgoda canal at Elewalla Road (20.8 km^2)		Maha Ela outfall (20.4 km^2)		Weras Ganga outfall (55.5 km^2)	
	Present (m^3/sec)	Future (m^3/sec)	Present (m^3/sec)	Future (m^3/sec)	Present (m^3/sec)	Future (m^3/sec)
2	19.5	25.5	7.9	11.0	48.3	52.0
5	26.9	35.2	10.6	14.7	60.6	69.9
10	33.0	42.7	12.6	17.2	69.8	82.4
25	40.4	53.8	15.3	20.3	83.6	99.0
50	46.0	62.7	17.3	22.4	94.0	112.9

15. FORMULATION OF PRIORITY PROJECT

15.1 Socio-economic Framework for Planning

62. Population framework is set based on the development strategy in the CMR Structure Plan (CMRSP). The total population of the Weras Ganga basin in 2010 is estimated at 483,000, which is 1.26 times larger than the 2001 level. GRDP of the Weras Ganga basin is estimated at Rs. 85.8 billion, which is 2.37 times larger than the 2001 level.

15.2 Future Land Use Pattern

63. Figure 15.2 shows the future land use pattern of the Weras Ganga basin. The share of urbanized area is estimated at 83%, which does not change significantly compared with present land use. This is because the natural/rural use areas such as paddy, marsh, vegetation and water are limited and no area change is expected. However, a large change is forecast in the urbanized use. The share of homesteads will grow from 28% to 50%, while that of gardens will decrease from 25% to 9%.

15.3 Selection of Component Schemes of Priority Project

64. Considering the economic evaluation result and the urgent necessity of the scheme based on the present flood damage situation, the following four schemes shown in Figure 15.3 were selected to be combined as a priority scheme. The proposed Weras Ganga Basin Storm Water Drainage Project consists of those four schemes.

1) Weras Ganga Scheme
2) Nugegoda-Rattanapitiya Scheme
3) Bolgoda Canal Scheme
4) Ratmalana-Moratuwa Scheme (Urban Drainage Improvement in Kandawala and Telawala areas)

15.4 Structural Measures

65. The proposed Weras Ganga Basin Storm Water Drainage Project consists of the following structural measures and is shown in Figures 15.9 to 15.12.

Component Scheme	Measures
(1) Weras Ganga	• Weras Ganga Dredging (L=5.5 km, B=19-40 m) • Flood Protection Dike on Right Bank (L=2.3 km) • Weras Ganga Swamp Retention Area (65 ha) • Maha Ela Marsh and Lowland Retention Area (106 ha)
(2) Nugegoda-Rattanapitiya Scheme	• Channel Improvement of Nugegoda-Ela (L=1.58 km, B=5-13 m) • Channel Improvement of Delkanda Ela (L=1.76 km, B=3-13.5 m) • Channel Improvement of Rattanapitiya Ela (L=2.13 km, B=19 m) • Retention Areas(36 ha in total)
(3) Bolgoda Canal Scheme	• Channel Improvement of Bolgoda Canal (L=2.4 km, B=15-19 m) • Bellanwila-Attidiya Marsh Retention Area (88 ha)
(4) Ratmalana-Moratuwa Scheme	• Concrete Flume (L=6.39 km, B=0.8-2 m) • Wet Masonry Channel along Dike (L=1.15 km, B=1-1.5 m) • Open Channel with Wet Masonry Revetment (L=1.65 km, B=1-3 m) • Open Channel with Gabion Revetment (L=0.79 km, B=3-6 m) • Earth Channel (L=1.14 km, B=2-6 m) • Kandawala Retention Pond (3 ha) • Telewala Retention Pond (10 ha)

Note: L and B mean length and width, respectively.

15.5 Non-structural Measures

66. In order to supplement the structural measures or make them sustainable, non-structural measures are proposed. The non-structural measures proposed for the Weras Ganga basin are as follows:

1) Storm water retention area management
2) Development control in urban development areas
3) Land use regulation in lowland areas
4) Dissemination of flood information to the public
5) Flood-proofing of buildings in flood-prone areas

These measures are the same as those proposed in the master plan.

16. PRELIMINARY DESIGN

Design Criteria

67. The preliminary design was carried out for the structures proposed for each scheme such as river channels, dikes, revetments, bridges, sluiceways, culverts, retention ponds and peripheral canals for the retention areas. The criteria for the preliminary design were established referring to the Manual for River Works in Japan, Government Ordinance on Structural Standards for River Management Facilities, etc. of Japan, Geometric Design of Roads of Sri Lanka and the Bridge Design Manual of Sri Lanka.

Major Design Features

68. The major design features of the proposed schemes are listed below and the preliminary design drawings are compiled in the end of this report.

1) Weras Ganga Scheme

Channel	Length	Design Discharge	Longitudinal Profile	Channel Shape	Bed Width
Weras Ganga	5.5 km	79 - 164 m^3/s	-1.5 m MSL (Level)	Trapezoidal	19 - 40 m

Location	Size (BxH)	Number
Kandawala	2.0 m x 1.9 m	2 nos.
Telawala North	2.5 m x 1.9 m	2 nos.
Telawala North	2.5 m x 1.9 m	2 nos.

2) Nugegoda-Rattanapitiya Scheme

Channel	Length	Design Discharge	Longitudinal Profile	Channel Shape	Bed Width
Rattanapitiya	2.13 km	25 - 53 m^3/s	1/1,200 - 1/800	Rectangular, Trapezoidal	19 m
Delkanda	1.76 km	14 - 29 m^3/s	1/300 - 1/700	Rectangular, Trapezoidal	3 - 13.5 m
Nugegoda	1.58 km	10 - 24 m^3/s	1/450 - 1/700	Rectangular, Trapezoidal	5 - 13 m

3) Bolgoda Canal Scheme

Channel	Length	Design Discharge	Longitudinal Profile	Channel Shape	Bottom Width
Bolgoda Canal	2.4 km	23 - 51 m^3/s	-1.5 m MSL (Level)	Trapezoidal	15 - 19 m

4) Ratmalana-Moratuwa Scheme

Channel	Length/Area	Channel Size (BxH)
Main Drain (Concrete Flume)	6,390 m	0.8 m x 0.8 m to 2.0 m x 1.5 m
Main Drain (Open Channel)	3,580 m	1.0 m x 1.0 m to 6.0 m x 1.5 m
Drainage Channel along Dike	1,150 m	1.0 m x 1.0 m to 1.5 m x 1.0 m
Retention Pond at Kandawara	3 ha	1 pond
Retention Ponds at Telawala	10 ha	3 ponds

17. INSTITUTIONAL ARRANGEMENT

Institutional Arrangement for project Implementation

69. As shown in Figure 17.1, SLLRDC will be appointed as an executing agency for the proposed Project under supervision of the Ministry of Housing & Plantation Infrastructure (MHPI). In addition, the Inter-Agency Steering Committee (IASC), Utility Diversion Committee (UDC) and HCDC Coordination Committee (HCC) are organized in order to make the project implementation smooth.

Institutional Arrangement of Relevant Local Authorities

70. The project area belongs to the administrative areas of five local authorities, that is, Dehiwala - Mount Lavinia MC (DMMC), Moratuwa MC (MMC), Kotte MC (KMC), Mahalagama UC (MUC) and Kesbewa PS (KPS). Among them, DMMC, MMC and MUC have already established an HCDC, which is chaired by the Mayor or Chairman with coordination from the Community Development Officer (CDO).

71. Kesbewa PS has not established an HCDC yet. One CDO was dispatched by the Commission of Local Government, Western Provincial Council and is working for community related works with some staff. It is recommended to establish HCDC by initiative of CDO and start the activities before commencement of the Project.

18. OPERATION AND MAINTENANCE PLAN

Organization for O&M

72. The organizations responsible for O&M of the drainage facilities to be constructed by the Project are SLLRDC, Dehiwala - Mount Lavinia MC, Moratuwa MC, Kotte MC, Maharagama UC and Kesbewa PS. However, it is proposed that SLLRDC should be responsible for O&M of the major parts of the Project taking into account the O&M work capacities of the relevant local authorities and their relationship with lowland management. Meanwhile, the local authorities should be responsible for O&M of the urban drainage systems in the respective administrative areas.

O&M Work Demarcation

73. It is proposed that the substantial O&M works for the Weras Ganga, Nugegoda-Rattanapitiya and Bolgoda Canal Schemes are undertaken by SLLRDC, while the O&M works for the Ratmalana-Motrtauwa Scheme are undertaken by Dehiwala - Mount Lavinia MC (DMMC) and Moratuwa MC (MMC). Other local authorities are requested to assist SLLRDC's O&M activity by periodical inspection of the drainage facilities located in the respective administrative areas..

Operation and Maintenance Work Plan

74. In SLLRDC, the Canal Maintenance Section of the Canal Development & Maintenance Division (CDM) is the section responsible for the O&M works. The actual works are proposed to be handled by the existing Attidiya Regional Office from the view point of easy access to the work sites and the existing task allocation.

75. DMMC and MMC should establish a separate section in the Municipal Engineers Department so as to undertake the O&M related activities by themselves after taking over the drainage facilities constructed by the Project. On the other hand, Kotte MC and Kesbewa PS may keep the existing organizational structure for the time being as only periodical inspection of the drainage facilities is requested.

76. The responsible organizations should procure the equipment required for the O&M works over a long term. Also, it is proposed to carry out the stock control of the spare parts and tools under the management of a responsible section to meet the demand at any time.

Staff Training Program for SLLRDC and Local Authorities

77. For sustainable O&M works, it is proposed to prepare and execute training programs for the staff of SLLRDC and local authorities in charge of O&M works. One is an O&M Management Program. It aims at developing the management capability of managerial and engineering staff. The main subjects are overview of management principles and planning and programming know-how for O&M works. The other is an O&M Equipment Operation Program. It aims at training technical staff, work supervisors and machine operators. The main subjects are understanding of the mechanism of O&M equipment and how to achieve the operational knowledge and experience.

19. ENVIRONMENTAL IMPACT ASSESSMENT

78. *Social Environment*: The important social environment to be considered is land acquisition and resettlement. No critical social constraints which hamper the proposed Project are expected so far. The number of households to be resettled for the proposed Project is estimated at 158.

79. *Bellanwila-Attidiya Wildlife Sanctuary*: The dredging of the Weras Ganga and demolition of the saline water intrusion protection gates on the Bolgoda Canal would cause a certain rise in salinity level of the channels in the Sanctuary during non-flood periods. However, most of the vegetation in the Sanctuary would not be affected drastically because most of the sanctuary area is not submerged during non-flood periods.

80. *Dredged Materials*: The dredged materials contain organic matter. The dredging volume is estimated at around 140,000 m^3. In addition, some of the materials excavated for channel improvement also contain organic matter. An offensive odor is expected if the dredged materials are disposed of by open dumping without any measures. Therefore, the dredged materials should be immediately transported to the designated temporary dumping site or final disposal site keeping a certain distance from residential areas.

81. Aquatic Weeds: Many places of the Weras Ganga and canals in the lowlands are covered by floating, submerged and bottom-rooted vegetation. Extraordinary growth of these aquatic weeds caused by the water quality deterioration in the canal blocks storm water passage. To reduce the volume to be disposed and avoid public complaint on the disposal of the aquatic weeds, it is recommended to consider utilization of the removed aquatic weeds for biogas generation and composting by digestion facilities.

20. RESETTLEMENT PLAN

Basic Information

82. The number of households to be resettled is estimated at 158. Most of the houses are located in the Weras Ganga scheme area (36 houses) and Nugegoda-Rattanapitiya scheme area (98 houses). The land area to be acquired for the proposed Project is estimated at 31 ha in total not counting the storm water retention area of 295 ha. Almost half (49%) of the households to be benefited by the Project (158 households) are classified into the low-income group of which monthly income is less than Rs. 5,000 and 42% of them are under poverty line with a monthly income of Rs. 3,000 or less.

Responsible Organizations

83. The organizations responsible for resettlement for the proposed Project are SLLRDC (Executing Agency), relevant five local authorities and National Housing Development Agency (NHDA). SLLRDC is in charge of the land acquisition and resettlement with assistance of NHDA. SLLRDC is responsible for preparation and implementation of the Resettlement Action Plan under the Sri Lanka National Involuntary Resettlement Policy (NIRP). For the resettlement, the relevant local authorities undertake official procedures and activities related to the resettlement by direct communication with the households to be resettled.

Assistance for Resettlement

84. Based on the Sri Lanka National Involuntary Resettlement Policy (NIRP), a comprehensive Resettlement Action Plan (RAP) has to be prepared for the proposed Project. The households to be resettled need to recover their livelihood after the resettlement. The households to be resettled are generally scattered except those of the Delkanda Ela area. The resettlement sites will be selected near the present residence based on consultations with each household under assistance of HCDC, NHDA and SLLRDC.

85. On the other hand, it may be difficult to acquire resettlement sites near the present residences in the Delkanda Ela area where the building density is high and the number of households to be resettled is relatively large (60 households). Therefore, a resettlement site with an area of about one ha should be prepared for the people of the Delkanda Ela area.

Public Involvement

86. *Public Explanation*: A public explanation meeting on the proposed Project and the induced resettlement should be held for the households affected as early as possible. In addition, consultation with the households to be resettled should be conducted by the relevant organizations such as local authorities, NHDA and SLLRDC.

87. *Community Contract*: It is recommended to apply the community contract system for a small part of the project construction works to involve the relevant communities in the Project, allocate a part of project profit to the community and also enhance the public awareness of the necessity of the proposed storm water drainage project.

88. *Employment in Construction Works:* The community contract is one of the measures for public involvement in the Project. In addition to the community contract, it is proposed to establish a system to employ the people affected by the Project as laborers as much as possible, taking into account the low-income level of the households affected by the Project.

21. CONSTRUCTION PLAN AND COST ESTIMATE

Construction Period

89. The construction period of each scheme is estimated below. The overall construction period of the proposed Weras Ganga Storm Water Drainage Project comes to 36 months. The overall construction schedule is shown in Figure 23.1.

1) Weras Ganga Scheme : 21 months
2) Bolgoda Canal Scheme : 19 months
3) Nugegoda-Rattanapitiya Scheme : 32 months

4) Ratmalana-Moratuwa Scheme : 31 months

Mode of Construction

90. It is proposed to divide the proposed project works into two packages of main civil works and procurement of O&M equipment taking into account the sort of work. The selection of the contractors for both packages will be made through international competitive bidding. The contractors to be selected should have an adequate capability to successfully execute the scheduled works and extensive experience in international business.

Cost Estimate

91. The costs are estimated based on the preliminary design. The estimated project cost is given below.

Cost Item	Amount (million Rs.)
1) Construction cost	1,907
2) Land acquisition and compensation cost	841
3) Procurement of O&M equipment	113
4) Engineering services cost	381
5) Administration cost	63
7) Price escalation	88
8) Physical contingency	303
9) Tax	693
Total	4,389

92. The cost of annual O&M for the channel, other civil structures and storm water retention areas is estimated at Rs. 40 million. This corresponds to about 2% of the construction cost.

22. PROJECT EVALUATION

93. It is concluded that there is sufficient need for the proposed Weras Ganga Basin Storm Water Drainage Project to justify its implementation and that it is economically, technically, environmentally and socially viable. The proposed project primarily aims at reducing the flood damages in the Weras Ganga basin, but it will produce various tangible and intangible benefits. Also, the proposed project will improve the people's living conditions and consequently contribute to poverty reduction.

94. The economic evaluation of the Project is as shown below.

(Unit : million Rs.)

Extent of Retention Area	Project Cost	Annual Flood Reduction Benefit	Annual Land Enhancement Benefit	B-C	B/C	EIRR (%)
295 ha	4,389	147	875	3,043	2.09	18.8

95. In addition to the quantitative benefit, the proposed storm water drainage project is expected to yield the following qualitative benefits.

1) Recreational development
2) Housing development
3) Promotion of economic development
4) Improvement of people's living conditions
5) Reduction of inconvenience in people's lives
6) Improvement of the hygienic environment
7) Elimination of the menace of flooding
8) Improvement of the water environment
9) Contribution to poverty reduction

96. According to the inventory survey on households affected by the proposed project conducted in the Study, the number of the households with monthly incomes of less than Rs. 5,000 comes to about 750 households or 49% of the households surveyed (1,539 households) and the share of households with monthly incomes under the poverty line (less than Rs. 3,000/month) is 21%. These people are recognized as beneficiaries of the proposed project. The improvement of their living conditions by the Project will consequently contribute to poverty reduction.

23. PROJECT IMPLEMENTATION PLAN

97. The proposed organization for implementation of the Weras Ganga Basin Storm Water Drainage Project (the Project) is shown in Figure 17.1. The Sri Lanka Land Reclamation & Development Corporation (SLLRDC) is assigned as the executing agency for the Project. The Ministry of Housing and Plantation Infrastructure (MHPI) will supervise SLLRDC through the Inter-Agency Steering Committee.

98. The Project is planned to be implemented over 6 years as shown in Figure 23.1. The implementation period is largely divided into the detailed design stage, pre-construction stage and construction stage. The detailed design stage including investigation and tender document preparation will be implemented over 22 months, the pre-construction stage for procurement of contractors for 12 months and the construction stage for 38 months.

99. The project cost is estimated at Rs. 4,389 million. Considering the present severe financial condition of Sri Lanka Government, it is proposed to procure a soft loan for the Project from the international funding agencies. The loan amount will come to Rs. 2,792 million excluding land acquisition and compensation cost, administration cost and tax which will be not eligible for a loan. The Sri Lanka Government has to bear the remaining cost of Rs. 1,597 million.

24. CONCLUSION AND RECOMMENDATIONS ON FEASIBILITY STUDY

Conclusion

100. The proposed Weras Ganga Basin Storm Water Drainage Project is economically and technically viable and there are no serious environmental or social problems that hamper implementation of the proposed project. It is concluded that the proposed project should be implemented.

101. The proposed project will contribute to poverty reduction through improvement of the people's living conditions. According to the household inventory survey carried out in the Study, half (49%) of the households to be benefited by the Project are classified into the low-income group of which monthly income is less than Rs. 5,000/month. 42% of them are under the poverty line with a monthly income of Rs. 3,000 or less. The proposed Project could improve their living conditions and consequently contribute to poverty reduction. Further, the Project may promote economic development in the project area and poverty will be indirectly alleviated by upgrading of the people's living standard through economic development.

Recommendations

102. The recommendations on the feasibility study are as follows:

1) Establishment of conservation policy of Bellanwila-Attidiya Wildlife Sanctuary
2) Method and measures for conservation of proposed storm water retention areas
3) Study on removal of saline water intrusion protection gates
4) Explanation on the Project to the people affected by the Project
5) Demarcation of responsibilities for the storm water drainage works
6) Construction of sewerage treatment system for water quality improvement of drainage canals canal

THE STUDY ON STORM WATER DRAINAGE PLAN
FOR THE COLOMBO METROPOLITAN REGION
IN
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

FINAL REPORT

VOLUME II : MAIN REPORT

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ABBREVIATIONS

ADB	Asian Development Bank
ADD	Agrarian Development Department
BOD	Biochemical Oxygen Demand
CAP	Community Action Plan
CBO	Community Based Organization
CCD	Coastal Conservation Department
CDC	Community Development Council
CD&M	Canal Development and Maintenance Division
CEA	Central Environment Authority
CEB	Ceylon Electricity Board
CEPOM	Committee on Environmental Policy and Management
CHPB	Center for Housing Planning and Building
CKE	Colombo-Katunayake Expressway
CMC	Colombo Municipal Council
CMR	Colombo Metropolitan Region
CMRSP	Colombo Metropolitan Regional Structure Plan
COD	Chemical Oxygen Demand
CSP	Clean Settlements Project
DAC	Development Assistance Committee
DEM	Digital Elevation Model
DHI	Danish Hydraulic Institute
DMMC	Dehiwala/Mt. Lavinia Municipal Council
DO	Dissolved Oxygen
DS	Divisional Secretariats
DWLC	Department of Wildlife Conservation
EIA	Environmental Impact Assessment
EMS	Environmental Management Strategy
FC	Foreign Currency
FEPO	Fauna and Flora and Protection Ordinance
GCFC&EIP	Greater Colombo Flood Control and Environment Improvement Project
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
GN	Grama Niladhari
GOJ	Government of Japan
GOSL	Government of Sri Lanka
HAT	Highest Astronomical Tide
HCC	HCDC Coordination Committee
HCDC	Housing and Community Development Committee
IASC	Inter-Agency Steering Committee
ICB	International Competitive Bidding
ICTAD	Institute for Construction Training and Development
IDA	International Development Agency
IEE	Initial Environmental Examination
IRD	Irrigation Department
ITCZ	Inter Tropical Convergence Zone
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JOCV	Japan Overseas Cooperation Volunteers
KMC	Kotte Municipal Council
KPS	Keabewa Pradeshiya Sabha
KUC	Kolonnawa Urban Council
LA	Local Authority
LAA	Land Acquisition Act

LAT	Lowest Astronomical Tide
LC	Local Currency
LRD	Land Registration Department
LUPPD	Land Use Policy Planning Division
MC	Municipal Council
MFP	Ministry of Finance and Planning
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MMC	Moratuwa Municipal Council
MOL	Ministry of Land
MHAPCLG	Ministry of Home Affairs, Provincial Councils and Local Government
MHPI	Ministry of Housing and Plantation Infrastructure
MSL	Mean Sea Level
MUC	Maharagama Urban Council
NEA	National Environmental Act
NERD	National Engineering Research Development Center
NGO	Non-governmental Organization
NHDA	National Housing Development Authority
NIBM	National Institute of Business Management
NIRP	National Involuntary Resettlement Policy
NWSDB	National Water Supply and Drainage Board
ODA	Overseas Development Assistance
O&M	Operation and Maintenance
PAA	Project-approving Agency
P&E	Plant and Equipment Division
PIRD	Provincial Irrigation Department
PRS	Poverty Reduction Strategy
PS	Pradeshiya Sabha
PTU/WP	Provincial Training Unit in Western Provincial Council
RAP	Resettlement Action Plan
RDA	Road Development Authority
RDD	Research and Design Division
REEL	Real Estate Exchange Ltd.
SAPROF	Special Assistance for Project Formation
SLIDA	Sri Lanka Institute of Development and Administration
SLILG	Sri Lanka Institute of Local Government
SLLRDC	Sri Lanka Land Reclamation and Development Corporation
SLR	Sri Lanka Railway
SLTL	Sri Lanka Telecom
STP	Sustainable Township Program
TA	Technical Assistance
UC	Urban Council
UHD	Urban Housing Division
UDA	Urban Development Authority
UDC	Utility Diversion Committee
UNDP	United Nations Development Program
USIP	Urban Settlement Improvement Project Unit
USS	Under-served Settlements
WPC	Western Provincial Council

MEASUREMENT UNITS

Area

cm^2	=	Square Centimeters
m^2	=	Square Meters
km^2	=	Square Kilometers
ha	=	Hectares (10,000 m^2)

Length

mm	=	Millimeters
cm	=	Centimeters
m	=	Meters
km	=	Kilometers

Currency

US$	=	United State Dollars
¥	=	Japanese Yen
Rs.	=	Sri Lanka Rupee

Energy

kVA	=	Kilovolt Ampere
kW	=	Kilowatt

Economy

EIRR	=	Economic Internal Rate of Return
NPV	=	Net Present Value
B/C	=	Benefit Cost Ratio

Volume

cm^3	=	Cubic Centimeters
m^3	=	Cubic Meters
m^3/day	=	Cubic Meters per Day
m^3/sec	=	Cubic Meters per Second
l or lit	=	Liter (1,000 cm^3)
lpcd	=	Liter per capita per day
MCM	=	Million Cubic Meter

Weight

g	=	Grams
mg	=	Milligrams (1/1,000 g)
mg/l	=	Milligrams per liter
kg	=	Kilograms (1,000 g)
kg/cm^2	=	Kilograms per square centimeter
t	=	Metric ton (1,000 kg)

Time

sec	=	Seconds
min.	=	Minutes
hr	=	Hours

Others

per/km^2	=	Persons per Square Kilometer
MSL	=	Mean Sea Level