CHAPTER 6 ENVIRONMENTAL CONSIDERATIONS

6.1 Initial Environmental Examination Study

6.1.1 Introduction

Through the Study, environmental considerations for the proposed plans have to be examined in each stage of the Study based on the JICA Guidelines on the Environment[1]. In the master plan stage of the Study, an Initial Environmental Examination (IEE) Study has been done by collecting data on present environmental conditions in the study area, conducting screening and scoping on the proposed plans, and reviewing environmental considerations in the past projects in Sri Lanka.

The term "IEE" used here in the Study means the environmental clearance activities prescribed under national legislation on the Environmental Impact Assessment (EIA) process in Sri Lanka, which is different from the IEE mentioned in the JICA Guidelines on the Environment. Accordingly, the term "IEE Study" is alternatively used in this Study to refer to the "IEE" described in the JICA Guidelines on the Environment.

6.1.2 Environmental Legislations in Sri Lanka

(1) Environmental Laws, Regulations and Standards

The National Environmental Act No.47 of 1980 (NEA) is the basic national charter for protection and management of the environment. Under this Act, the Central Environmental Agency (CEA) was formed as the agency charged with the responsibility of implementing the provisions of the NEA. The subsequent amendment to this Act empowers the CEA to implement a scheme for the control of pollution and to assess impacts on the environment from development activities. Environmental laws, regulations and standards, especially related to the Study, are shown in Table 6.1.

(2) EIA System

Only large-scale development projects likely to have significant impacts on the environment are listed as prescribed projects for the EIA process and given in the Gazettes No.772/22 of 24th June 1993 and No.859/14 of 23rd February 1995. The project-approving agency (PAA) will be the agency responsible for administering the EIA process. If the PAA is the project proponent, CEA will act as the appropriate PAA. CEA is charged with the responsibility of implementing the required provisions of the NEA, and will promptly advise PAA of any amendments to the relevant acts, orders and regulations. The EIA procedure is shown in Figure 6.1.

6.1.3 Environmental Screening and Scoping on the Proposed Storm Water Drainage Plans

Based on the JICA Guidelines on the Environment and information from the previous projects, collection of the data and information for the IEE Study was conducted by the subcontracted local consultant to determine current natural and social environmental conditions in the study area. Subsequently, environmental screening and scoping were done to preliminarily identify potential environmental impacts caused by the proposed measures. Potential environmental impacts caused by location and implementation of the proposed plans, by basin, were examined as follows.

Potential Environmental Impacts Caused by Implementation of the Proposed Plans

Potential Environmental Impacts	Preliminary Assessment
1) Ja Ela Basin Storm Water Drainage Plan	
- water level rise in Muthurajawela Marsh by increasing flow of storm water	- no impact to feeding grounds, but possible impacts to nesting sites for birds in breeding season, - lower contribution by the plan than that of the Kalu Oya Basin Storm Water Drainage Plan
- low quality water inflow into Muthurajawela Marsh due to urbanization along the Negombo road in the future	- low impact by improvement of urban sewerage drainage due to relative lower urbanization - no direct linkage with the proposed measures
- resettlement due to land acquisition and land use regulation	- expected to some extent
2) Kalu Oya Basin Storm Water Drainage Plan	
- water level rise in Muthurajawela Marsh by diversion of storm water	- no impact to feeding grounds, but possible impacts to nesting sites for birds in breeding season
- low quality water inflow into Muthurajawela Marsh	- possible impact due to urbanization in future
- resettlement due to land acquisition and land use regulation	- expected to some extent
3) Greater Colombo Basin Storm Water Drainage Plan	
- resettlement due to land acquisition and land use regulation	- expected to some extent., especially in project sites for restoration of Mutwal Tunnel and construction of New Tunnel
- coastal pollution due to leachate from the CMC dumping site along the canal	- expected to some extent, in case of no mitigation measures implemented for the dumping site
- resettlement due to Madiwela South Diversion Construction	- expected to some extent near the Parliament Lake - low impact in Weras Ganga and Bolgoda Lake due to some 10 cm water level rise at most
4) Bolgoda Basin Storm Water Drainage Plan	
- water level rise in Weras Ganga and Bolgoda Lake by urbanization upstream	- low impact due to some 10 cm water level rise at most
- negative impact to ecosystem in the Bellanwila-Attidiya Marsh by change of water regime in Weras Ganga	- expected to be minimal under present conditions already caused by several existing factors
- resettlement due to land acquisition and land use regulation	- expected to some extent

[1] JICA Guidelines for Environmental Considerations in the Development Study: "V. River & Soil Erosion Control" and "VII. Sewerage System" (unofficial translation from Japanese title)

Necessity of the IEE or EIA for each of the proposed projects was preliminarily checked based on the Gazettes No.772/22 of 24th June 1993 and No.859/14 of 23rd February 1995 on the prescribed projects for the IEE/EIA, though the IEE/EIA were not required in the previous GCFC&EIPs. A checklist on possibility of resettlement and IEE/EIA requirement for the proposed projects is shown in Table 6.2.

In general for all proposed plans, negative environmental impacts during construction stage might be caused by noise and vibration, dust, offensive odor from dredged canal sediment, storage and dumping of construction waste, and temporary traffic obstruction. Regarding the excavated materials from lowlands or other potential acid sulphate soils, disposal to sensitive ecosystems or productive agricultural lands should be avoided so as not to cause vegetation damage or low agricultural productivity in such lands. Environmental mitigation measures during construction stage should be undertaken for environmental impact items as stated above.

6.2 Environmental Issues Relevant to the Canal System

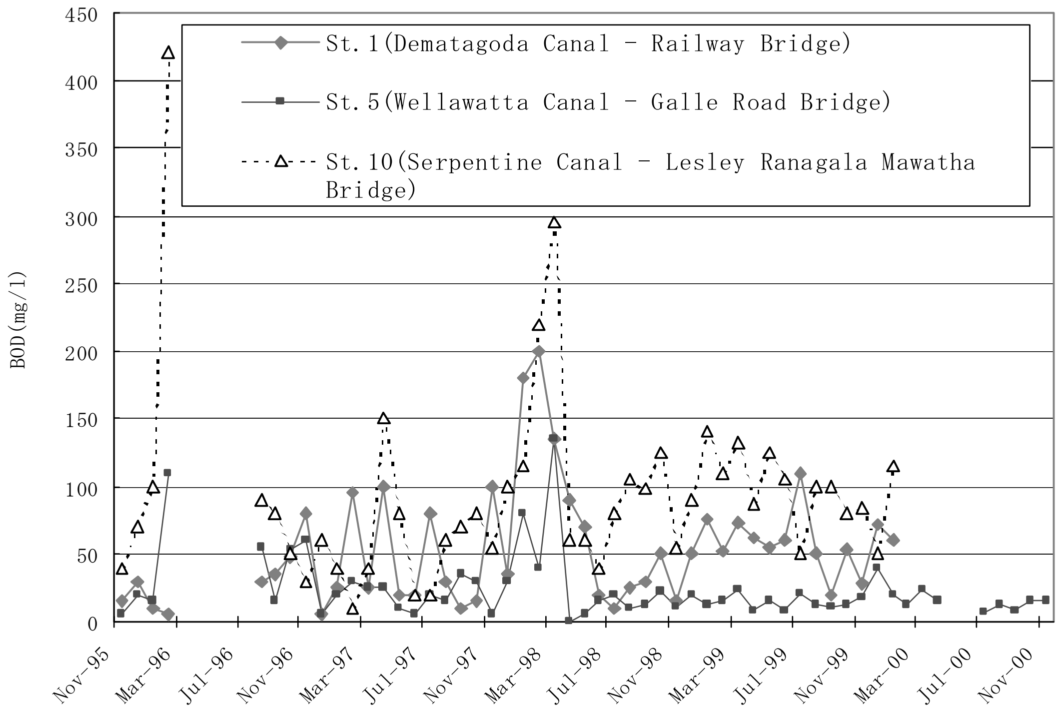
6.2.1 Waste Water Management

It can be observed that water quality in the canals of the study area, especially along the densely populated areas, is heavily deteriorated in many places. It is because inflow into the canals in the non-flooding period is almost only wastewater from domestic and industrial/commercial origins, sewers directly connecting to the canals, leachate from waste dumping sites and direct waste disposal into the canal, while the steady inflow of better quality water from outside of the canal system is negligible. In addition, stagnation of the pollutants in the canals accelerates the water quality deterioration process and causes high concentrations of the pollutants. Extraordinary growth of the aquatic weeds caused by the water quality deterioration in the canal blocks storm water passage in many places.

In the proposed storm water drainage plans, storm water retention areas are planned in the lowlands such as marshes and abandoned paddy fields. The retention area will temporarily receive some amount of polluted water from the canals during and after storm rainfall, though the polluted water from the canals are much diluted with storm water before entering the retention area. Therefore, the inflow of the polluted water might cause a negative impact, to some extent, to the ecological and/or sanitary conditions of the lowlands designated as retention areas, especially in the environmental protected areas such as Bellanwila-Attidiya Marsh and Muthurajawela Marsh. Improvement of water quality of the canals is to be considered in relation to storm water drainage improvement as well as hygienic conditions and urban landscape improvement in the study area.

In the GCFC&EIP Phase II, water quality monitoring and water level measurements in the canals has been conducted at 17 locations in the Greater Colombo area for the period from 1995 to 2000. Ten water quality parameters are monitored: ammonia, nitrate, temperature, phosphate, turbidity, pH, conductivity, DO, BOD, and COD. In addition to the water quality monitoring, a survey on discharge points of wastewater along the canals was conducted by type of pollution sources such as sewerage pipes and direct discharge of domestic and industrial wastewater. The water quality monitoring is continuing in the GCFC&EIP Phase III.

In general, values of some water quality parameters such as phosphate, DO, BOD and COD have not satisfied the environmental standards of Sri Lanka in the monitored canals. In almost all canals, improvement of the quality has not been seen for those parameters. Monitoring results of the BOD in three canals are shown below for example.



Water Quality in 3 Canals (BOD)

Source: Water Quality and Water Level Monitoring Program in the Greater Colombo Canal System (June 1995 - December 1999), GCFC&EIP Phase II, January 2000

The most efficient and essential resolution to improve water quality in the canal system is to thoroughly eliminate pollutants that undesirably flow into the canal system from pollution sources such as domestic/industrial wastewater and sewerage.

However, it is not realistic that all mitigation measures can be implemented in the whole area in a short period due to limited financial resources and other issues to be solved in advance.

It is proposed that the water quality improvement measures be implemented in phases in order to enhance public awareness on water quality improvement from public hygienic and urban landscape improvement viewpoints.

6.2.2 Solid Waste Management

Dumping of solid waste into the canals is observed as a common activity in many places of the CMR as well as illegal waste dumping in proximity to the canal due to lack of solid waste collection service and lack of public concern. This practice has caused blocking of the storm water passage in the canals as well as water quality deterioration.

Local Authorities (LAs) are responsible for the collection and disposal of solid waste arising from the following sources:

1) Residential and commercial wastes including market waste;
2) Hospital waste, clinical and non-clinical waste;
3) Industrial waste;
4) Slaughter house waste;
5) Drain cleaning and street sweepings.

The collection service provided by any LAs to the respective areas is one or a combination of door-to-door service, primary and secondary collection services.

In many areas, particularly in rural areas, a significant amount of the waste generated does not enter the waste stream and is not collected for final disposal. Over the last 3 years, a few LAs have privatized waste collection and disposal. This has shown a marked increase in street cleaning and door-to-door waste collection.

The most prevalent method of waste disposal is open dumping. The majority of such open dumping areas are in lowlands such as marshy lands and abandoned paddy fields. Due to various factors like urban sprawl development and severe public opposition, locating disposal sites in urban areas has become difficult. The present disposal sites of many MCs in urban areas have almost reached full capacity.

None of the open dumping sites are engineered to minimize or control pollutants released from decomposition of waste. There exist little or no basic operations such as leveling and covering of waste due to financial constraints. Soil cover is applied only at the final stage after using or due to public pressure. In addition to the dumping sites operated by the relevant authorities, haphazard dumping takes place along streets, marshes, abandoned paddy fields and stream banks by private parties without any control. Most of such sites border water bodies such as canals or rivers with waste spilling over and blocking the passage of water, in addition to discharge of leachate.

DMMC has disposed of its waste in the Bellanwila-Attidiya marsh and the dumping site is bordered by the Weras Ganga to the east and a canal flowing along the western and southern boundaries that falls into the Weras Ganga although the dumping site was closed due to a court order in response to opposition by residents nearby. As reported in the ERM study[2], the canal was blocked with waste. The Kolonnawa Ela forms the northern boundary of the Sri Jayawardenepura Kotte MC disposal site. The Moratuwa MC dumping site is bounded by the Depa Ela to the north, Maha Ela to the south and Weras Ganga to the east. With many other sites located adjacent to water bodies it is apparent that with no engineering controls in place, leachate generated will seep through to the water bodies and canals will be clogged with waste.

The fundamental problems and issues associated with waste disposal could be identified as:

1) Lack of coherent planning at national, provincial and local levels;
2) Lack of suitable waste treatment technologies and disposal facilities;
3) Shortage of suitable lands and public opposition to disposal facilities in their neighborhood;
4) Lack of resources in Local Authorities;
5) Insufficient public awareness on the health, social and environmental impacts of open dumping

[2] Review of Current Municipal Solid Waste Dump Sites in the Greater Colombo Area, Western Province, Sri Lanka, Colombo Environment Improvement Project and Presidential Task Force on Solid Waste Management, ERM, 2000

CHAPTER 7 SOCIAL DIMENSIONS

7.1 Governmental Poverty Reduction Program

Subsequent to the formulation of a framework for poverty reduction in 2000[1], a poverty reduction strategy (PRS) has been drafted by the Government in 2002. The Department of External Resources is a coordination agency for the working group of the PRS formed by relevant governmental agencies, NGOs, CBOs, and ad-hoc committees. The PRS will provide concrete targets, actions, and implementation schedules from 2002 to 2005 on poverty reduction for whole country.

In 1995, the Samurdhi Program replaced the Janasaviya Program (1989-1995), the first government program to adopt the new methodologies. The program consists of three components to protect and promote the poor[2]; i) income transfer program, ii) saving and credit programs, and iii) development of rural infrastructure through workfare programs. Together with the Samurdhi Program, the budget for education and health accounts for more than 50% of the total social welfare budget, while roughly 15% of the government total social welfare budget is spent on the Samurdhi Program. Total estimated expenditure in 1998 amounted to a little over Rs. 10 billion.

Nearly 40-50% of poor families in the study area are beneficiaries of the Samurdhi Program. According to GNs and DSs, the poor communities in the slums and shanties are mere recipients of monthly subsidies under the Program. The majority of the recipients are not involved in any income generation mini-projects even though the program expected to establish sustainable livelihood systems among the poor in the study area.

7.2 Current Housing Programs for Under-served Settlements

7.2.1 Sustainable Township Program

A Sustainable Township Program (STP) is being implemented by the newly created company, Real Estate Exchange Ltd. (REEL) established in 1999, to re-house 20,000 low-income families in Colombo City, during the next five years. According to a brochure of the STP, the STP will re-house all 66,000 households currently living in the slums and shanties in CMC in a fully developed, modern, and compact township without burdening the beneficiaries or the State. This process will liberate nearly 600 acres of encumbered prime land in the city. These lands will be sold by public

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1 Sri Lanka: A Framework for Poverty Reduction, Department of External Resources, November 2000
2 Monthly household income as poverty line for the Samurdhi Program is Rs. 1,500/month.

auction or redeveloped as a market-based and self-financed program after providing enough re-housing, environmental and public spaces.

The STP recognizes the rights of squatter households on the encroached lands to the places in the city where they have lived for decades. They will be offered a permanent home with title through the STP. At the end of the program, partners of REEL including SLLRDC receive payment for the encroached prime lands at market price, less cost of re-housing of households who are currently occupying them illegally.

7.2.2 Public Utilities Program

Treasury funds are used for the program that is implemented by the relevant Urban Council (UC) in which the settlement is situated. Under the program, the total cost of upgrading or providing additional infrastructure is shared equally by NHDA and UC.

The selection of the settlement and the activities to be implemented will be identified by the UC in consultation with the District offices of the NHDA. Special emphasis is given to water and sanitation requirements and the construction of community centers and pre-schools. The program is connected with the community development activities of the Japan Overseas Cooperation Volunteers (JOCV) Program in terms of community participation and mobilization (USIP, 2001[3]).

7.2.3 Community Contract System

The community contract system was introduced as a new approach under the Million Houses Program in 1980s[4]. Under the system, community infrastructure and amenities such as footpaths, the communities themselves, as contractors, under supervision of the relevant agency, construct drains, toilets and community centers. Under the system, only a community registered as a Community Development Council (CDC) can have a right for the contract. CDC is generally established through the CDC Formation Workshop, which is a part of the workshop modules in the Community Action Planning (CAP) dealing with specific aspects and needs of the communities[5].

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3 Sri Lanka: Proposed Urban Settlements Improvement Project (USIP), Project Implementation Plan, The Plan (Volume 2), EML/DHV Consultants with USIP Unit, 2000
4 Community Contracts System Guidelines, NHDA, 1988
5 Community Action Planning: Making Micro Plans for Community Improvement - CAP Workshop Module Guidelines Series, UNCHS/DANIDA, 1994 (The CAP method was established in NHDA under assistance of UNCHS and DANIDA in 1984 as a community-level participatory planning method.)

7.3 Legislation on Compensation and Resettlement Related to Land Acquisition for Public Projects

7.3.1 Land Acquisition

It is required to follow the rules and regulations of Land Acquisition Act No.60 in acquisition of lands under the Secretary of the Ministry of Lands. He has delegated his authority to the District Secretaries. Divisional Secretaries who work under the supervision of the District Secretaries have authority in land acquisition matters at DS division levels. In lower administrative levels, the director of the Town Development Authorities has powers to acquire land for town development activities.

Any project/program that would create benefits for the public can ask the government organizations that are vested with power to operate the Land Acquisition Act for land acquisition for implementation of the project or program. If the Government or Provincial Government Organization implements the project, the project can request the respective DS in the district to release the land for the project. If the land is government land, it is simple and DS can release it directly. If the land belongs to a private party, acquisition of such land would be a long process. In the first step, it should be published in the government gazette. A copy of the government gazette notice should be sent to the land owner/s. This can be done through publishing the gazette notice on the notice board in public places. If RDA or UDA implements the project, they also have a power, entrusted under the Land Acquisition Act, to acquire land from a private party.

The legal provision on payment for land acquisition is also provided under the Land Acquisition Act. The process of the payment involves several steps. In the first step, the organization that has a power to acquire land requests the Department of Valuation to value the land. The Department will send valuation officers to value the land. The value of the land is decided based on the market value of the land in the respective areas considering some conditions such as location, market value of the land, infrastructure facilities available in the area, and level of urbanization. Then, the Department of Valuation sends the valuation report to the organization that requested such a report. Finally, the payment is made to the respective parties based on the valuation report.

Once the land to be acquired is identified, the authorized organizations publish the decision in public and also inform the affected parties of the decision. The affected parties however have the right to go to the courts. The people who have encroached the government lands have no formal right to obtain compensation or to go to the courts, but in most cases they can also be compensated. The implementation of land acquisition and resettlement programs is in the hands of DS in the respective divisions.

7.3.2 Resettlement

The Divisional Secretary in each division carries out resettlement activities for the project. There is no legal requirement to be fulfilled once the compensation is paid, but different projects provide different assistances to the affected parties depending on their resources and also under the pressure of the affected parties.

Due to lack of a uniform system for the involuntary resettlement, different projects have followed different systems depending on the situations. In this process some communities and households have been negatively affected.

To address all prevailing problems, the Government under Asian Development Bank Technical Assistance (ADB-TA) in 1999 developed a policy on resettlement including guidelines for involuntary resettlement for smooth implementation of the proposed and future development projects. The second phase of ADB-TA is being implemented at present. The second phase includes the capacity building of CEA and the other government organizations to implement the suggested policy for the involuntary resettlement.

7.4 Review of Past Practices on Environmental Considerations in GCFC&EIP

7.4.1 Compensation and Resettlement

In the GCFC&EIP, either resettlement or an on-site infrastructure upgrading scheme was basically executed for the under-served settlements affected by the project. Assistance to the residents to be relocated was provided by the project and relevant government agencies as follows.

Assistance for Resettlement in GCFC&EIP

Items of Assistance
1) Land: compensation based on market value for land title holder, 2 perches (approx. 50 m^2, 30 years leasehold) in the resettlement site for non-land title holder
2) Community infrastructure in the resettlement site: water supply, latrines, drainage, garbage bins, community centers, streetlights, community roads, etc.
3) Housing loan: up to Rs. 20,000 by NHDA, grant at Rs. 8,000 for low-income residents
4) Ex gratia: Rs. 1,000/household
5) Transportation assistance for relocation activity
6) Preparation of foundation for housing in the resettlement site
7) Compensation for permanent buildings

Source: JBIC Ex-post Evaluation Report, JBIC, 2001

7.4.2 Community Development and Community Contract System

In the GCFC&EIP, the community contract system was applied for upgrading and newly constructing community infrastructure such as community drains in both resettlement sites and on-site upgrading. In some locations, community formulation and registration procedures were first completed with assistance of NGOs and JOCV staff in order that the community can have eligibility to the system.

7.4.3 Lessons from the Previous Projects

In the urbanized areas of the CMR, there exist a lot of settlements in the flood-prone lowlands and in proximity to the canals and canal reservation areas, where the proposed storm water drainage project site would be. Under the circumstances, land acquisition and resettlement are anticipated to some extent by implementation of the proposed projects.

For the smooth implementation of the project, people affected by the project should be fairly compensated so as not to lower their living conditions. The compensation does not only mean cash compensation to damaged/lost property, but also assistance for upgrading the living environment and/or recovering livelihood. Especially for the under-served, low-income settlements, special assistance should be taken care of in terms of upgrading their basic living environment. In this sense, not only houses located within the boundary of the project sites in terms of storm water drainage improvement should be targeted, but also neighboring under-served settlements as well as low-income settlements should be focused on as project sites.

Previous works and experiences in the GCFC&EIP will be useful for assessing social considerations of the people affected by the proposed projects. Also, lessons and recommendations from the knowledge of relevant personnel and reports such as JBIC post evaluation report for the GCFC&EIP - Phase 1[6] will be reflected as shown below.

1) A participatory planning approach should be taken for selection of options by the project-affected people through planning and implementation processes in both resettlement and on-site upgrading cases;
2) Improvement of the living environment for residents should be well considered in the canal improvement scheme, especially for low-income residents;

6 Report of Ex-Post Evaluation by Third Party for the Greater Colombo Flood Control and Environmental Improvement Project (tentative fictitious title), JBIC Ex-Post Evaluation Report for ODA Loan Projects, M. Hosaka and T. Ogura, 2001

3) Assistance for community-based organizations, which contribute to community activity in the resettlement site, should be positively provided by the project itself and relevant government agencies;
4) Community-based activities such as community-contracted infrastructure construction should be planned and applied with a flexible schedule;
5) Coordination among relevant stakeholders should be reinforced to effectively use available resources for enhancement of the living environment for residents in the resettlement site.

According to the results of the Community Inventory Survey, some 60,000 households will potentially be affected and some 3,500 houses will potentially be relocated by implementation of the plan in connection with the land acquisition and proposed land use regulations, though those figures have to be confirmed by a detailed survey in the subsequent study.

To implement the proposed plan properly from social viewpoints, lessons and recommendations learned from previous experiences in the GCFC&EIP and similar public projects in Sri Lanka should be well reviewed and utilized by relevant agencies and parties not only to avoid or at least minimize negative impacts to project-affected peoples, but also to enhance the project benefits for stakeholders.

CHAPTER 8 PROJECT EVALUATION FOR MASTER PLAN

8.1 Economic Evaluation

8.1.1 Methodology

The economic viability of the projects is evaluated based on the estimated project cost and flood control benefit. The economic cost is obtained by deducting the transfer payment from the financial cost. The economic benefit is defined as the impact of flood control measures, which is composed of the flood damage reduction impact and the efficient land utilization permitted by the flood free condition. The economic evaluation is conducted by calculating the Economic Internal Rate of Return (EIRR) and cost benefit analysis (B/C and B-C) on the basis of the economic cost and the estimated flood control benefit.

8.1.2 Economic Cost

For the economic evaluation, the project cost of the proposed storm water drainage plan, which is estimated in financial cost, is converted to the economic cost. In order to derive the economic cost from the financial cost, transfer payments such as taxes and price escalation are deducted. In addition to subtracting the transfer payments, a conversion factor of 0.9 is applied to the local portion of cost to adjust the price.

8.1.3 Economic Benefit

Storm water drainage is considered as basic infrastructure for urban development and important for the economic development of CMR, which will not only reduce the flood damage and increase flood free area, but also promote economic activities by reducing the effect of flood such as poor living conditions, inconvenience to people's lives, unhygienic environment, and slow economic activities. Storm water drainage is particularly important in CMR because of on the going urbanization and reduction of low land area such as paddy and marsh. Project benefits are analyzed both qualitatively and quantitatively.

(1) Flood Damage Reduction Benefit

Flood damage reduction benefit is characterized as flood damage reduced by implementation of the storm water drainage plan, which includes damage to property, damage to infrastructure and disturbance to economic activities. The flood damage reduction benefit expected from the storm water drainage project is estimated by the following procedure.

1) Estimation of Unit Value of Assets

The expected flood damage is estimated by analyzing values of the assets by land use in the flood prone area. The values of the assets for the residential area are measured by the value of houses and household properties. The values for the commercial area are measured by the value of shops, offices (public buildings) and factories, and the values for the paddy area are measured by the productivity of paddy.

2) Estimation of Flood Damage by Inundation Depth

The relationship between inundation depth and damage rate prepared by the Ministry of Construction, Japan is utilized for estimation of the flood damage by inundation depth. The flood damage per hectare of inundation area for the respective land uses (Urban 1, Urban 2, Rural and Paddy) is calculated from the value of assets per hectare and the flood damage rate. The inundation area and depth by land use of Urban 1, Urban 2, Rural and Paddy are given by hydrological analysis.

3) Estimation of Probable Flood Damage

Damage to interruption to business operation and infrastructure is estimated based on the ratio set by the Ministry of Construction, Japan. The interruption to business operation is estimated at 6% of the property value, and the damage to infrastructure (roads, bridges) is estimated at 28% of the property value.

The probable flood damage, which includes direct damage (damage to property), interruption to business operations and damage to infrastructure, is calculated under the various magnitudes of flood events. The inundation area and the flood probabilities of 2, 5, 10, 25 and 50-year floods are set for calculating the probable flood damages.

Damage due to interruption to business operations and infrastructure is estimated based on the ratio set by the Ministry of Construction, Japan. The interruption to business operations is estimated at 6% of the property value, and the damage to infrastructure (roads, bridges) is estimated at 28% of the property value.

The estimated probable damages for four basins are shown in Table 8.1 and summarized below:

Probable Flood Damage

(Unit: million Rs.)

Return Period	Ja Ela	Kalu Oya	Greater Colombo	Bolgoda
2 years	224	527	684	176
5 years	906	697	1,286	410
10 years	1,634	833	1,816	552
25 years	2,686	1,074	2,831	773
50 years	3,536	1,277	3,949	951

Note: Estimated by JICA Study Team

4) Conversion of Probable Flood Damage to Annual Average Flood Damage

Based on the probable flood damage, the annual average flood damage is calculated by applying average occurrence probability to the corresponding probable flood damage as shown in Table 8.2. The table below shows the annual average flood damage for the four basins. The estimated annual average flood damage is considered as a base for the flood reduction benefits. The flood damage reduction benefit is derived from the annual average flood damage and the effect of the flood control measures measured by the reduced area of inundation.

Annual Average Flood Damage

(Unit: million Rs.)

Return Period	Ja Ela	Kalu Oya	Greater Colombo	Bolgoda
2 years	56	132	171	44
5 years	225	315	466	132
10 years	352	392	622	180
25 years	482	449	761	220
50 years	544	473	829	237

Note: Estimated by JICA Study Team

8.1.4 Land Enhancement Benefit

Land enhancement benefit is characterized as the value added and efficient utilization of the land generated from the flood free environment. The CMR plays an important role in the economy of Sri Lanka, and land shortage is one of the major constraints to development. Converting the flood prone area into a flood free area will accelerate utilization of the land. The land enhancement benefit is measured in terms of the increase of the land value.

The conditions for estimating the land enhancement benefit are set as follows.

1) The land enhancement benefit is produced by utilization of the areas presently not utilized for any economically productive activities.
2) The rent value is applied to measure the land enhancement benefits assuming that the rent represents the economic activities of the land based

on the fact that the value of the land is usually determined by the productivity or projected profit of the land.

3) The rent value of the land is divided into residential value and commercial value. The rent value is taken from past valuation record collected from the State Valuation Department.
4) Areas designated as marsh and water in the future land use are left untouched, that is, no utilization of those areas is expected.

Based on the estimated area to be utilized under the flood free condition and its rent price, the land enhancement benefit is calculated for each proposed measure by basin.

8.1.5 Intangible Benefit

In addition to the quantitative benefits discussed and estimated in the previous sections, it should be noted that the proposed storm water drainage project would produce a lot of intangible benefits that cannot be measured quantitatively. The following intangible benefits can be expected through the implementation of the storm water drainage projects.

(1) Promotion of Economic Development

The storm water drainage project creates flood free land and the flood free land can be utilized for industry, commercial and residential purposes. Consequently, the economic development of the region is promoted.

(2) Improvement of People's Living Conditions

A lot of people are living in the project area. Some of them including low-income or poor people are subject to relocation for project implementation. If the project pays attention to the living conditions of the people affected, the project will contribute much to the improvement of the people's living conditions and the reduction of poverty.

(3) Alleviation of Inconvenience to People's Life

The flooding usually affects the people's life and causes inconvenience. As the storm water drainage project aims at reducing flooding in space and time. The people's lives will become much more convenient due to the project.

(4) Hygienic Improvement of the Environment

The flooding causes health hazards such as breeding of mosquitoes, contaminating the water and the spread of intestinal diseases, which are identified as one of the major causes of death among children and elderly. The storm water drainage project will improve the hygienic environment in urban areas and improve the people's health. It eventually contributes to savings in health care cost.

(5) Elimination of the Menace of Flooding

The people living in the lowlands are exposed to the menace of flooding. The storm water drainage project will eliminate the menace of flooding by reducing flooding or protecting the people from flood.

(6) Improvement of the Water Environment

The storm water drainage project is to be implemented primarily aiming at improving the storm water drainage system, but it will also contribute to improvement of the water environment by clearing of river banks, cleaning of channels, provision of recreational facilities, improvement of landscape, etc.

8.1.6 Economic Evaluation for Proposed Storm Water Drainage Project

(1) Basic Condition

On the basis of the estimated construction cost, operation and maintenance cost (O&M cost) and estimated economic benefits, the Economic Internal Rate of Return (EIRR), B-C and B/C are calculated based on the following assumptions.

1) Project life of 40 years
2) Discount rate of 10%
3) Project cost is disbursed over five years as follows:
   - Year 1: 10% (detailed design)
   - Year 2: 10% (procurement)
   - Year 3: 30% (construction)
   - Year 4: 30% (construction)
   - Year 5: 20% (construction)
4) Annual O&M cost is assumed to be 1% of the direct cost and additional 1.5% for projects with pumping stations. The O&M cost is assumed to disbursed for the entire project lifetime from the year following completion of the project works.
5) Benefit is produced over the entire project life from the year following completion of the project works.
6) The benefit is expected to increase by 5% per annum based on the economic growth and change in life style.

(2) Economic Evaluation for Proposed Projects

The flood control benefit for the project is composed of the flood damage reduction benefit and the land enhancement benefit. This is calculated based on the annual average flood damage and the impact of the projects measured by the difference between the inundation area with and without the project. The impact of the projects is calculated by the size of reduction of the expected inundation area with the project.

(3) Result of Evaluation

The results of the evaluations for the proposed projects for each basin are expressed in B-C (Rs. million), B/C and EIRR (%). Economic feasibility line of the project is considered to be positive for B-C, one or above for B/C and 10% or higher for EIRR, which is based on the discount rate of 10%. The results of economic evaluation are shown in Table 8.3 and summarized below:

Economic Evaluation for Proposed Storm Water Drainage Plans

Proposed Storm Water Drainage Plan	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B-C (million Rs.)	B/C	EIRR (%)
Ja Ela Basin	3,349	440	741	1.34	12.9
Kalu Oya Basin	1,878	422	1,359	1.94	17.4
Greater Colombo Basin	3,334	886	3,154	2.23	19.5
Bolgoda Basin	4,026	1,023	3,767	2.22	19.2

8.1.7 Sensitivity Analysis

A sensitivity analysis was conducted to analyze the effect of delaying the macro socio-economic frame target originally set for 2010, which will decrease the project benefit for a certain period because of less development of the basin. The sensitivity analysis is conducted for following two cases.

Case 1: Macro frame is completed and full benefit is expected in 2015

Case 2: Macro frame is completed and full benefit is expected in 2020

The table below shows the result of the sensitivity analysis. The result of the sensitivity analysis shows the impact of delaying the macro frame target is about 2% in EIRR for case 1 and 4% for the case 2. There is almost no difference among the basins.

Sensitivity Analysis (Case 1)

Proposed Storm Water Drainage Plan	B-C (million Rs.)	B/C	EIRR (%)
Ja Ela Basin	277	1.13	11.1
Kalu Oya Basin	903	1.63	14.6
Greater Colombo Basin	2,101	1.77	15.6
Bolgoda Basin	2,633	1.86	16.0

Sensitivity Analysis (Case 2)

Proposed Storm Water Drainage Plan	B-C (million Rs.)	B/C	EIRR (%)
Ja Ela Basin	40	1.02	10.2
Kalu Oya Basin	239	1.13	11.0
Greater Colombo Basin	1,647	1.61	14.4
Bolgoda Basin	2,042	1.67	14.7

8.2 Technical Evaluation

The proposed storm water drainage projects include construction of dike, revetment, channel, bridge, tunnel and sluiceway. No constraint for implementation of the projects is found from the technical viewpoint such as design, construction and O&M since no special technology is needed for most of the construction works, which can be done by Sri Lanka Side in technical level. For the construction of the new Mutwal Tunnel and the crossing at High Level Road for Madiwela South Diversion Canal, participation of the international contractors will be advisable.

8.3 Environmental Evaluation

(1) Ja Ela Basin and Kalu Oya Basin

For the Ja Ela and Kalu Oya Basin Storm Water Drainage Plans, the storm water of the Ja Ela and Kalu Oya basins is planned to be discharged into the Negombo Lagoon through the Muthurajawela Marsh. As inundation by water level rise will be caused only for short time during and just after the storm rainfall, environmental impacts to habitats for fauna and flora in the Marsh barely occur, while nesting sites for some kinds of birds on the vegetation in the Marsh might be affected by the inundation in the case that breeding season falls on the storm period. The degree of environmental impact by the Ja Ela Basin Storm Water Drainage Plan will be lower than that of the Kalu Oya Basin Storm Water Drainage Plan since Ja Ela and Dandungam Oya are presently flowing into the Marsh, while the Kalu Oya Basin Storm Water Drainage Plan will newly divert the storm water into the Marsh.

Regarding the water quality flowing into the Muthurajawela Marsh and Negombo Lagoon from the Ja Ela and Kalu Oya basins, there is a possibility for the Kalu Oya Basin Storm Water Drainage Plan that a large volume of pollutants will flow into the Marsh through the Old Negombo Canal due to urbanization in the surrounding area of the proposed Kalu Oya retention area in the future and it might cause a negative environmental impact to the habitats for flora and fauna in the Marsh and the lagoon such as water pollution and vegetation loss. However, the potential environmental impact can be avoided or at least mitigated by implementing proper wastewater treatment along with the urbanization in the basin. While, in the Ja Ela basin, the potential environmental impact by pollutants is not directly caused by the proposed storm water drainage plan since the wastewater treatment should be handled by a different project.

By both Ja Ela and Kalu Oya Basin Storm Water Drainage Plans, land acquisition and resettlement will be expected in some extent for the proposed measures such as canal improvement and securing of storm water retention area.

(2) Greater Colombo Basin

For the Greater Colombo Basin Storm Water Drainage Plan, active conservation of marshes as storm water retention area by land use regulation in the Kolonnawa, Kotte and Heen Marshes will contribute to ecological and urban environment contexts as positive effects.

A solid waste dumping site of Colombo MC is located adjacent to the Main Canal at the northeast of the junction of the Port Access Road and Main Canal. The contaminated leachate from the dumping site has been seeping out and polluting the canal water. A preventive measure of the leachate from the dumping site into the canal should be conducted before the restoration of the existing Mutwal Tunnel and construction of new Mutwal Tunnel. Otherwise, the contaminated water will flow into the sea through the Mutwal Tunnels and coastal ecosystem near the outlet of the Mutwal Tunnels will be affected by the polluted water.

The proposed Madiwela South Diversion Channel mostly passes through abandoned paddy and vacant land. The diversion of storm water from the Parliament Lake basin into Weras Ganga will bring about water level rise in the Bolgoda Lake. Since the water level is estimated to raise a few cm, resettlement by expansion of the inundated area with water level rise will not be caused.

For implementation of the proposed plan, land acquisition and resettlement will be expected in some extent for the proposed measures such as canal improvement but no serious problem will be expected.

(3) Bolgoda Basin

In the Bolgoda basin, the water level of the Weras Ganga and Bolgoda Lake will be raised by increase of flood runoff due to urbanization in the upper basin of the Weras Ganga. The flood damage in the Weras Ganga sub-basin will be reduced by the proposed plan. As the water level rise is estimated at a few cm, resettlement by expansion of the inundation area will barely occur.

The environmental impacts to habitats for flora and fauna in the Bellanwila-Attidiya Marsh is barely expected by change of storm water flow regime of the Weras Ganga as the high water level will last only for short period.

Regarding the social environmental impact, land acquisition and resettlement will be expected in some extent for the proposed measures such as canal improvement, especially at the upstream area of the Weras Ganga sub-basin where has already been urbanized.

8.4 Social Evaluation

(1) Land Acquisition and Resettlement

As for the social aspect in implementation of the proposed storm water drainage plans, land acquisition and resettlement are important issues to be solved. According to the Community Inventory Survey carried out in the Study, the number of houses located in and around the proposed storm water drainage projects is roughly estimated at about 3,500 houses in total. They might be subject to relocation if the proposed projects are implemented. The distribution for each basin is 570 houses in Ja Ela basin, 730 houses in Kalu Oya basin, 1,060 houses in Greater Colombo basin, and 1,170 houses in Bolgoda basin.

The number of houses frequently inundated during rainy season is roughly estimated at about 8,800 houses. They might be a part of potential beneficiaries by the proposed storm water drainage projects. The distribution for each basin is 1,240 houses in Ja Ela basin, 3,010 houses in Kalu Oya basin, 2,530 houses in Greater Colombo basin and 2,030 houses in Bolgoda basin.

As stated above, the storm water drainage projects proposed in the Study are inevitably accompanied with land acquisition and resettlement. However, any critical location at the proposed project sites has not been identified so far from social aspect such as ethnic, religious, cultural and historical aspects in connection with land acquisition and resettlement activities.

(2) Poverty Reduction

In general, the land acquisition and resettlement tend to cause negative social impacts to the project-affected people such as livelihood and community linkage. Based on the experiences and knowledge from the previous projects such as GCFC&EIP, involvement of stakeholders, especially project-affected people, should be considered to mitigate the negative impact and enhance the project effects.

As mentioned before, about 19,000 households which may be affected by the proposed storm water drainage projects are under poverty line. The implementation of the proposed projects could contribute to improvement of their living conditions by incorporating it into the project scope and consequently contribute to poverty alleviation. The proposed projects can have positive social dimensions.

CHAPTER 9 PROJECT IMPLEMENTATION PLAN

9.1 Executing Agency

In line with the proposed rearrangement of responsibilities on storm water drainage works mentioned in the section 4.10, the executing agency for the storm water drainage projects proposed in the Study will be SLLRDC as the objective drainage basins are located within the Western Province.

9.2 Implementation Schedule

9.2.1 Basic Principles for Project Implementation Plan

The projects subject to implementation are those included in the Master Plan mentioned in the section 4.13. They are also shown in Figure 9.1.

The basic principles for the project implementation will consist of the following:

1) The proposed Comprehensive Storm Water Drainage Master Plan consists of structural storm water drainage plans, non-structural measures for storm water drainage, institutional development plan, operation and maintenance (O&M) plan and human resources development plan.
2) Priority is not considered among basins.
3) Multiple projects for structural measures are not implemented at the same time in any one basin in order to reduce the financial overburden as much as possible.
4) Typical implementation period of a structural storm water drainage project is to be four years (one year for detailed design and three years for construction), referring to recent similar projects.
5) Storm water retention facilities are to be constructed in conjunction with urban development.
6) Non-structural measures for storm water drainage, the institutional development plan, O&M plan and human resources development plan are to be implemented from the initial stage in parallel with structural measures in order to make the structural measures more effective and sustainable.
7) Annual disbursement costs are to be as even as possible.

Based on the above basic principles, an overall implementation schedule has been prepared as shown in Figure 9.1.

The implementation sequences of the respective projects and plans are briefly explained as follows.

9.2.2 Structural Measures

(1) Structural Projects of Ja Ela Basin

The proposed storm water drainage plan of the Ja Ela basin consists of the following structural measures;

1) Channel improvement of the Ja Ela
2) Channel improvement of the Dandungam Oya
3) Storm water retention areas (upper area and lower area)

The channel improvement of both rivers should be implemented before securing the retention area from the technical viewpoint since designation of the retention area cannot be made before the channel improvement. It will be preferable to implement the channel improvement of the Ja Ela before that of the Dandungam Oya because the project cost is less.

The securing of the storm water retention area should start in parallel with the channel improvement as the legal procedure to secure the retention area may take significant time.

(2) Structural Projects of Kalu Oya Basin

The proposed storm water drainage plan of the Kalu Oya basin is composed of the following structural measures;

1) Channel improvement of Kalu Oya main stream
2) Improvement of Old Negombo Canal
3) Storm water retention areas (upper area and lower area)
4) Construction of storm water retention facilities

Of these, the Old Negombo Canal should be improved first so as to receive the storm water from the Kalu Oya main stream and divert it to the Muthurajawela Marsh. The channel improvement of the Kalu Oya main stream should follow.

The securing of the storm water retention area should start in parallel with the channel improvement as the legal procedure to secure the retention area may take considerable time.

The construction of storm water regulating ponds to reduce peak flood runoff should be undertaken in conjunction with the development of the basin by the developers. The first step for this is legal arrangement mentioned in the sub-section 9.2.2 (5) subsequently. The construction of storm water retention facilities is a continuous work.

(3) Greater Colombo Basin

In the Greater Colombo basin, the following measures are proposed.

1) Construction of Madiwela South Diversion Canal
2) Restoration of the existing Mutwal Tunnel
3) Construction of new Mutwal Tunnel
4) Storm water retention areas (Parliament Lake, Kolonnawa Marsh, Heen Marsh and Kotte Marsh)
5) Construction of storm water retention facilities

From the viewpoint of cost, the restoration of the existing Mutwal Tunnel should be implemented first. Construction of the Madiwela South Diversion should follow to avoid difficulty related to relocation and land acquisition in the future due to urbanization, even though the project cost of the Madiwela South Diversion is the largest among other measures. The construction of the new Mutwal Tunnel will come last.

The conservation activity of the existing retention areas such as Parliament Lake, Kolonnawa Marsh, Heen Marsh and Kotte Marsh should be started as early as possible to avoid reductions of the retention area due to unauthorized activities.

As mentioned before, the construction of storm water retention facilities to reduce peak flood runoff is to be carried out with development of the basin by the developers. This is to be a continuous work.

(4) Bolgoda Basin

The proposed storm water drainage plan for the Bolgoda basin consists of the following measures;

1) Channel Improvement of Weras Ganga and Tributaries
2) Storm water retention areas
3) Urban drainage improvement

Project implementation in the Weras Ganga basin should be considered urgent as significant urban development is expected in the future.

The securing of the retention areas should be started in parallel with the channel improvement as the legal procedure to secure the retention areas may require a long timeframe.

9.2.3 Non-structural Measures

The following non-structural measures for storm water drainage are proposed in the Study.

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

These measures are to conserve the proposed and natural retention areas and to reduce flood runoff peak by mandatory construction of storm water regulating ponds in the development area. The measures 1) and 3) are to be taken as early as possible even before implementation of the structural measures. The action 2) should be continued based on the existing relevant laws.

9.2.4 Institutional Development Plan

The institutional development plan consists of the following aspects:

1) Demarcation of responsibilities for storm water drainage works
2) Lowland management by SLLRDC

Demarcation of responsibilities and empowerment of SLLRDC are to be undertaken as early as possible because they are closely related to project implementation.

9.2.5 Operation and Maintenance Plan

The operation and maintenance plan (O&M) consists of the following items;

1) Strengthening of O&M organization of SLLRDC
2) Set-up of O&M organizations of local authorities

The SLLRDC will be an executing agency for the proposed projects and is also expected to train the staff of local authorities. Therefore, the strengthening of SLLRDC should commence before the setting-up of O&M organizations of local authorities. Both activities should be concluded before completion of the storm water drainage projects. Equipment planing and financial arrangements should be included with the O&M organization strengthening.

9.2.6 Human Resources Development Plan

The human resources development plan will include;

1) Training of O&M staff of SLLRDC and local authorities, and
2) Preparation and execution of comprehensive training programs on storm water drainage

The training of O&M staff of SLLRDC is a short term action and therefore should be started as early as possible in order to set up the O&M organization of local authorities. The execution of comprehensive training programs is a long term activity and may be started later, although it should be continuous.

9.3 Financial Arrangement

The disbursement schedule for the Master Plan is shown in Table 9.1. The maximum annual disbursement of the project cost is approximately Rs. 2.1 billion. This is less than the budget for construction of SLLRDC who will be the executing agency; i.e., Rs. 2.2 billion. This latter amount, which may include the disbursement for the Greater Colombo Flood Control and Environmental Improvement Project is funded by a JBIC loan.

In terms of annual disbursement, it may be possible to implement the projects proposed in the Master Plan by SLLRDC with the continuous financial arrangement by the central government.

The investment cost, Rs. 15.6 billion in total, should be procured from the international funding agencies taking into account the present severe financial condition of Sri Lanka Government.

CHAPTER 10 PRIORITY PROJECT

10.1 Criteria for Selection

In Chapter 4, a Storm Water Drainage Master Plan was formulated. The component projects are listed in the section 4.13.

For the subsequent feasibility study, a priority project has to be selected. The criteria for selection of the priority project are set out as follows taking into account the results of project evaluation in Chapter 8.

1) The project is to be economically, technically, environmentally and socially viable.
2) The project does not incur serious social problems in land acquisition and resettlement.
3) The project is expected to contribute to poverty alleviation.
4) The area is expected to be highly developed in the future.
5) The project having higher economic viability should have priority after meeting the above conditions.

The evaluation is made by the following evaluation items and marks. The classification "A" indicates the highest mark, and is followed by "B" and "C" in order.

Evaluation Items

Item	A (good)	B	C
Economic Feasibility			
B/C	> 1.5	1.5 – 1.0	< 1.0
IRR (%)	> 15	15 – 10	<10
Investment cost (million Rs.)	< 3,000	3,000 – 5,000	> 5,000
Technical Feasibility			
Construction	Easy	Moderate	Difficult
O&M	Easy	Moderate	Difficult
Environmental Impact	Low	Medium	High
Social Aspect			
Land Acquisition for Structure	< 10ha	10 – 20ha	> 20ha
Land Acquisition for Retention Area	< 500ha	500 – 1,000ha	> 1,000ha
Resettlement Household	< 250nos.	250 – 500nos.	> 500nos.
Poor Household Rate	> 30%	15% – 30%.	<15%
Future Land Use	Urbanized	Semi-urbanized	Non-urbanized

10.2 Selection of Priority Project

The evaluation results based on the criteria for selection of the priority project are presented in Table 10.1.

The results of are summarized as follows.

Overall Evaluation Results

Project	Overall Evaluation
Ja Ela Basin Storm Water Drainage Plan Ja Ela Channel Improvement Dandugam Oya Channel Improvement Storm Water Retention Area	C
Kalu Oya Basin Storm Water Drainage Plan Kalu Oya Channel Improvement Old Negombo Canal Improvement Storm Water Retention Area	B
Greater Colombo Basin Storm Water Drainage Plan Madiwela South Diversion Canal Restoration of Existing Mutwal Tunnel New Mutuwal Tunnel Storm Water Retention Area	B
Bolgoda Basin (Weras Ganga Sub-basin) Storm Water Drainage Plan Weras Ganga Channel Improvement Bolgoda Canal Improvement Major Tributaries Improvement Storm Water Retention Area	A

From the above overall evaluation, the Bolgoda Basin (Weras Ganga Sub-basin) Storm Water Drainage Plan is selected as a priority project. The estimated project cost is the largest among four objective basins as a result of the more detailed level of study it has received compared to other basins, but the proposed plan is economically viable. 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 four basins. The percentage of poor households, of which monthly income is less than Rs.

3,000, is as high as 35%, so that the proposed plan may contribute to poverty alleviation

In addition, the Sri Lanka Government has given priority to the Weras Ganga basin among four basins in the area of storm water drainage.

Consequently, the proposed storm water drainage project for the Weras Ganga sub-basin of the Bolgoda basin is selected as a priority project for feasibility study.

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

CHAPTER 11 CONCLUSION AND RECOMMENDATIONS ON MASTER PLAN STUDY

11.1 Conclusion

11.1.1 Project Evaluation

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

The proposed storm water drainage project is expected to yield various tangible and intangible benefits in addition to flood damage reduction, such as land enhancement, promotion of economic development, improvement of people's living conditions, alleviation of inconvenience of people's life, improvement of hygiene environment, elimination of menace of flooding, improvement of water environment and poverty reduction.

According to the community inventory survey carried out in the Study, the ratio 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 24% for the Bolgoda basin (22,000 households). The proposed storm water drainage projects could improve their living conditions and consequently contribute to the poverty reduction.

11.1.2 Priority Project for Feasibility Study

The storm water drainage project for the Weras Ganga sub-basin in the Bolgoda basin was selected as the priority project for a feasibility study, after considering economic feasibility, technical feasibility, environmental impact, social aspect and also prioritization by Sri Lanka Government.

The Weras Ganga basin is adjacent to the Greater Colombo area and most of the basin has been urbanized. It is also expected to become more highly developed in the future. The Weras Ganga basin presently suffers from flood damage and this is likely to increase in the future as development continues. The storm water drainage project for the Weras Ganga basin is therefore urgently needed and the undertaking of a feasibility study for the Weras Ganga basin storm water drainage project is seen as a appropriate project.

11.2 Recommendations

In further development of the proposed storm water drainage plans, it is recommended that the following issues be understood or settled as early as possible.

(1) Topographic Maps

In the master plan study, topographic maps of 1:50,000 and 1:10,000 only were available. The contour line intervals in those maps are 5 to 10 m and they are insufficient to accurately demarcate the storm water retention areas in the lowland areas (less than 2 m above MSL), an important measure in the proposed storm water drainage plan. The detailed topographic maps for the feasibility study should have contour lines of less than 1 m intervals in the lowland areas to be proposed as a storm water retention area.

(2) Planning Scale

No planning scale guideline for storm water drainage has been prepared in Sri Lanka. For the present Study, the guideline used in Japan was referred to. The planning scale is one of the fundamental subjects to determine a policy of flood control for the future and it should be decided by the government in accordance with various administrative issues in the country. The Study recommends applying the planning scale of 50-year return period considering the importance of the study area in the Colombo Metropolitan Region. Planning scales of 25-year and 10-year return periods were also studied. Based on the study result, the guideline for storm water drainage and flood control planning scales should be prepared as early as possible to allow for consistent storm water drainage and flood control works.

(3) Relation between Economic-framework and the Proposed Storm Water Drainage Plans

The socio-economic framework for the storm water drainage planning was set based on the Colombo Metropolitan Regional Structure Plan (CMRSP) prepared by UDA in May, 1998 with a target year of 2010. Although the proposed storm water drainage plans were prepared based on the above framework, all the proposed projects will not be implemented until after 2010 because of huge amount of project costs. Therefore, it should be understood that the proposed plans aim at coping with the realization of CMRSP but may not complete all proposed projects in this time frame.

(4) Storm Water Retention Area

In the Study, the minimum required retention areas for the proposed storm water drainage plan were proposed for each objective basin mostly in the lowlands. In addition, areas of lowlands extend outside of the proposed retention areas and also function as a natural storm water retention area. From the viewpoint of storm water drainage, the proposed retention areas have to be carefully conserved since it is closely related to scale of the proposed storm water drainage facilities such as river channels. The lowlands extending outside the proposed retention areas are not taken into account in the proposed storm water plan, but these lowlands should be kept as much as possible as they contribute to mitigation of flood damages.

(5) Non-structural Measures

From the viewpoint of a comprehensive storm water drainage plan, non-structural measures for the storm water drainage are proposed in addition to the structural measures. In order to achieve sustainability of the proposed storm water drainage projects, the institutional development plan, O&M plan and human resources development plans were proposed in the Study. It is recommended that these non-structural plans be considered important.

(6) Water Quality Improvement

The proposed storm water drainage plans include the storm water retention areas. The retention areas such as marshes and abandoned paddy lands will receive the wastewater from the densely populated areas during flood and the wastewater may cause a negative impact to the ecology of the lowlands designated as a storm water retention area. In addition, the stagnation of pollutants in the drainage canals during times of non-flood will accelerate the water quality deterioration process. This causes extraordinary growth of water plants such as water hyacinth, etc. and results in blocking of storm water passage in many places of the drainage canals. Treatment of the wastewater should be considered in relation to the storm water drainage project.

(7) Future Land Use Pattern

In the future land use pattern forecasted in the Study, the Ja Ela and Bolgoda basins (except Weras Ganga sub-basin) are assumed to remain almost unchanged because land use plans and development plan have not yet been prepared. The proposed storm water drainage plan should be reviewed when substantial land use changes are expected or concrete development plans are prepared, as the flood runoff conditions will change.

PART III : FEASIBILITY STUDY

CHAPTER 12 BACKGROUND OF PRIORITY PROJECT

12.1 Priority Project for Feasibility Study

As mentioned in the master plan study, the storm water drainage project for the Weras Ganga basin located in the northern part of the Bolgoda basin, (the Project) was selected as a priority project subject to feasibility study after comprehensively evaluating the storm water drainage plans for four objective basins from the viewpoints of economic viability, technical viability, environmental aspect, social aspect and also priority by Sri Lanka authorities.

The Weras Ganga basin is situated in the southeastern outskirts of Colombo City and adjacent to the city area. Urbanization in the basin is progressing with the sprawl of the city area. The population of the Weras Ganga basin is estimated at 382,000 in 2001 and expected to increase to 483,000 in 2010 while the GRDP of the Weras Ganga basin is estimated at Rs. 36 billion in 2001 and Rs. 86 billion in 2010.

The storm water drainage master plan for the Weras Ganga basin consists of seven schemes shown in Figure 4.52. The schemes to be subject to feasibility study are selected from these among these schemes based on economic viability and urgency of the Project through the feasibility study.

12.2 Implementation Policy of Storm Water Drainage Projects in Sri Lanka

The Colombo Metropolitan Region (CMR) is a center of socio-economy of Sri Lanka and therefore absolutely important for the national economy. The population of CMR is estimated at 5.4 million in 2001 or 28 % of Sri Lanka (19 million). GRDP of CMR is estimated at Rs. 378 billion or 43 % of the national GDP (Rs. 857 billion) in 2000. CMR administratively consists of three districts of Colombo, Gampaha and Kalutara. They are ranked from first to third by size of population and high population density in Sri Lanka in 2001. The Weras Ganga basin belongs to the Colombo District which has the largest population (2.2 million) and the highest population density (3,305 persons/km^2) among the districts in Sri Lanka.

It is planned to further develop CMR based on the Colombo Metropolitan Regional Structure Plan (CMRSP) prepared in 1998 by Urban Development Authority (UDA). According to CMRSP, the population and GRDP of CMR are expected to increase up to 6.5 million and Rs. 612 billion, respectively.

A national storm water drainage policy for Sri Lanka has not yet been established. Also, prioritization of storm water drainage project implementation by river and area has not been made yet. The storm water drainage projects have been implemented based on present needs. Considering the overwhelming importance of CMR in the national economy, the storm water drainage projects will be implemented focusing on CMR for the coming decade. The priority of storm water drainage improvement may be given to the Colombo District having the largest population and the highest population density in the country. It means that the proposed Weras Ganga basin storm water drainage project also may have priority in implementation.

12.3 Storm Water Drainage Projects in CMR

The first substantial storm water drainage project carried out in CMR is the Greater Colombo Flood Control and Environment Improvement Project (GCFC&EIP), started in 1992. Phases I and II were completed in 1998 and 2001, respectively, and Phase III is on-going from 2000. In Phase I, discharge capacities of the trunk drainage channels were increased by channel improvement and the environment along the drainage channels was also improved. Phase II aimed at solving major inundation problems in the Greater Colombo area. With these two projects, storm water drainage damages in the Greater Colombo were drastically decreased except those resulting from insufficient provision of road side drains.

Phase III is aiming at improving the urban drainage of Kawdana and Attidiya areas situated in the northwestern part of the Weras Ganga basin and outside the Greater Colombo area. It is scheduled to be completed in July 2004.

The Lunawa Lake Environment Improvement and Community Development Project (LLEI&CDP) is scheduled to commence shortly. The project consists of drainage improvement and community development and it primarily aims at the improvement of the drainage conditions of the entire Lunawa Lake basin.

The relation between objective basins and the above projects are summarized as follows:

1) Greater Colombo basin:
    - GCFC&EIP Phase I and II
2) Weras Ganga basin (Southeast of Greater Colombo):
    - GCFC&EIP Phase III
    - Weras Ganga Basin Storm Water Drainage Project proposed in the Study
3) Lunawa Lake basin (South of Greater Colombo):
    - LLEI&CDP

It should be noted that the storm water drainage project of the entire Weras Ganga basin has already been started by the GCFC&EIP Phase III and the proposed Project is therefore recognized as a second phase of the entire Weras Ganga Basin Storm Water Drainage Plan. It is recommended to carry out the proposed Project succeeding to the GCFC&EIP Phase III from the viewpoint of consistency of storm water drainage in the Weras Ganga basin.

12.4 Needs of Proposed Project

The needs of the proposed Weras Ganga Basin Storm Water Drainage Project are explained as follows:

(1) Protection of Loss of Storm Water retention Areas

The Weras Ganga basin is located in the center part of CMR and receives high pressure for development due to high development potential of CMR. The demand to develop the lowlands situating in the basin is particularly high with most of the lowlands in Attidiya area already fully developed. There is concern that disordered filling of the lowlands may happen unless strong legal regulations are made and enforced.

Against the disordered filling of the lowlands in CMR which function as a storm water retention area during flood, UDA proposed to prohibit development of the lowlands such as marsh area and paddy fields from the viewpoints of storm water drainage and environment in the Colombo Metropolitan Regional Structure Plan. However, as the proposal will exclude the public use of lowlands, the possibility of loss of lowlands as retention areas will still remain.

The storm water drainage system of the Weras Ganga basin also depends on the retarding effect of the lowlands in the basin. The decrease of retarding effect by the disordered filling of lowlands in the Weras Ganga basin will cause additional flood damage and also will influence the Bolgoda Lake and Panadura Ganga downstream.

(2) Flood Damage in Weras Ganga Basin

The present flood damages in the Weras Ganga (except quite local inundation damages) are observed in the following areas

1) Inundation damages in Nugegoda-Rattanapitiya area
2) Insufficient drainage in the downstream of Attidiya area
3) Inundation damages in Kandawala-Telawala area
4) Inundation damage in the lowlands along the right bank of the Weras Ganga

The causes of flood damages are insufficient capacities of drainage channels, insufficient opening of channel crossing structures and water level rise of the Weras Ganga.

The annual average flood damage amount is estimated at Rs. 253 million for the entire basin. The frequency of inundation is four to seven times/year and the duration of inundation is around one day.

(3) Needs of Proposed Project

The development of the Weras Ganga basin will progress not only in the lowlands but also in the entire basin. The urbanization of the basin will cause increase of flood runoff and the flood runoff increase will result in increase of the flood damage in the lower areas. The storm water drainage plan should be basin-wide plan taking into account the conditions of the entire basin. The present Study is expected to designate the required storm water retention area as well as formulation of the storm water drainage plan because issues concerning increased development are being discussed without any substantial engineering study on the required extent of retention area and influence of loss of retention area.

The proposed Weras Ganga basin storm water drainage project is formulated taking into account the above-mentioned background. It aims at not only flood damage reduction in the basin, but also conservation of the lowlands which function as a storm water retention area taking into account the future development of the basin. It is essential that the storm water drainage project should precede the basin development so as to minimize serious storm water drainage problem. The implementation of the storm water drainage project will assure the sound and easy development of the basin.

The proposed Project will include conservation of the storm water retention area. It will result in conservation of the lowland and bring positive impact to the environment. In addition, the proposed Project can contribute to poverty reduction through improvement of the living conditions of the people affected and benefited by the Project as they are mostly classified into the low-income group. The needs of the proposed Project can be confirmed based on the above consideration.

CHAPTER 13 PRESENT CONDITIONS OF WERAS GANGA BASIN

13.1 Natural Conditions

13.1.1 Geography

The Weras Ganga basin is situated in the south-eastern outskirts of Colombo and a sub-catchment of the Bolgoda basin as shown in Figure 2.1. The Weras Ganga basin extends approximately between lat. 6°47′N and lat. 6°53′N and between long. 79°52′E and long. 79°58′E. The catchment area of the Weras Ganga at Kospalana bridge near Moratuwa University is 55.5 km^2, which occupies 14.2 % of the Bolgoda basin with a catchment area of 394 km^2.

As seen in Figure 13.1, the Weras Ganga main stream extends from Boraresgamuwa South in the upstream to Kospalana bridge in the downstream and flows from north to south. Receiving several tributaries from the left and right bank sides, the Weras Ganga pours into the Bolgoda Lake North. Then, the lake water is discharged into the Indian Sea through Panadura Ganga. The channel width of the Weras Ganga mains tream is not constant and varies widely from about 100 to 500 m except local narrow points with 40 to 60 m wide. On the other hand, the depth of the Weras Ganga is as shallow as 1 to 1.5 m. The length of the Weras Ganga main stream is 4.2 km and its river bed slope is as gentle as about 1/4,000. The major tributaries are Bolgoda Canal, Rattanapitiya Ela, Depawa Ela and Maha Ela.

The Weras Ganga basin is generally flat and characterized by lowland extending along the Weras Ganga main stream and the downstream stretches of tributaries as shown in Figure 13.2. The lowland areas with a ground elevation less than 3 m above MSL are measures as shown in the table below. The lowland area below the elevation of 3 m above MSL occupies 25% of the Weras Ganga basin.

Ground Elevation in Weras Ganga Basin

Ground Elevation (m above MSL)	Area (km^2)	Ratio to Basin Area (%)
Less than 0	1.2	2.2%
0 - 1.0	4.2	7.6%
1.0 - 2.0	4.2	7.6%
2.0 - 3.0	4.3	7.8%
More than 3.0	41.7	75.0%
Total	55.5	100.0%

The lowland extending around Bellanwila and Attidiya including the abandoned paddies is called as " Bellanwilla-Attidiya Marsh".

On the other hand, the highest elevation is observed at the watershed boundary of Maha Ela sub-basin, which is 35 m above MSL. The elevations of highlands in other sub-basins range from 20 - 30 m above MSL.

The Weras Gaanga basin is largely divided into three large areas by drainage system, that is, northern, western and eastern areas.

The northern area (20.8 km^2) is an urbanized area and has three major drainage canals of Bolgoda Canal, Rattanapitiya Ela and Depawa Ela. The average canal bed slope of those canals are about 1/3,000, 1/800 and 1/1,000, respectively. The Rattanapitiya Ela and Depawa Ela join the Bolgoda Canal and the large wetland is formed along the downstream stretches and in the vicinities of their confluences. It functions as a storm water retention area during storm rains. The lowland area in the Bolgada Canal catchment has been urbanized and is suffering from inundation problem. In the upstream reaches of the Rattanapitiya Ela, several small scale lowland areas remain and are functioning as a storm water retention area.

The western area (8.1 km^2) is highly urbanized. The Ratmalana Airport is located in the area. The area slopes toward east, that is, to the Weras Ganga. The ground elevation around catchment boundary (upstream) is about 7 m MSL, while that along the Weras Ganga is about 0 to 0.5 m MSL. The average ground slope comes to about 1/300, but the lowland area along the Weras Ganga is affected by high water level of the Weras Ganga and is suffering from inundation during storm rains.

In the eastern area (26.6 km^2), the largest tributary in the basin, Maha Ela, exists. The Maha Ela has a catchment area of 20.4 km^2, which corresponds to 37 % of the basin, and a channel length of 7.6 km. The channel slope is 1/500 in the upstream and 1/3,500 in the downstream. Because of gentle slope of the downstream reaches of the Maha Ela, the area surrounding the Maha Ela downstream reaches is presently marshy area and functions as a storm water retention area during storm rains.

13.1.2 Geology, Geomorphology and Soils

In the Weras Ganga basin, the geology, geomorphology and soils of the Bellanwila-Attidiya Marsh was studied by the Wetland Conservation Project carried out by Central Environment Authority/Euroconsult from 1991 to 1993 and the results were compiled in the Wetland Site Report & Conservation Management Plan, Bellanwila-Attidiya Marsh, CEA, October 1993. Quoting from the above report although the report does not cover the whole basin, the general geology, geomorphology and soils of the basin are outlined as described hereinafter.

(1) Geology

The Weras Ganga basin is underlain by an ancient crystalline geology, consisting of gneisses (charnokitic, hornblende and biotite gneisses) and granites predominantly of the Vijayan Complex of Precambrian era (Cooray, 1984). Overlying this foundation of basement complex rocks, coastal deposits consisting of beach sands, and fluvio-tidal sediments to the island of this, form the geology of the coastal plain and the basin as shown in Figure 13.3.

The geological history of the area, as traced by Wilson (1992), outlines that a sea level rise during the Holocene period submerged a large part of the present coastal plain to the west and south of Mount Lavinia. As a consequence, a barrier sand bar was formed between the present Mount Lavinia and Payagala headlands which resulted in the formation of the large lagoon to its lowland side. Combined subsequently receding sea water level and siltation from the Panadura Ganga and surrounding catchment area, the lagoon gradually converted into the current complex of marshes and fresh water lakes. The Bolgoda Lake and Panadura Lake of today are considered to be remnants of the former lagoon.

(2) Geomorphology of Marsh Land Area

Geomorphology of the marsh land area itself has evolved through fluvial agents such as streams and floods, which were conveyed through Bolgoda Canal and Weras Ganga. The canal used to have an open connection with Bolgoda Lake in the south, and ultimately the sea, but since the bund and sluice were built on the south of Bellanwila-Attidiya Marsh, some 30 years ago, and this connection was interrupted. Classifying the landscape of the marsh and its surroundings into geomorphological units, identified through aerial photograph interpretation (1983 photographs) and field investigations, Wilson (1992) defines the following six land units within the Bellanwila-Attidiya Marsh.

1) Deep water marshland (ponds or heavily waterlogged areas, water depth 100 - 150 cm)
2) Shallow water marshland (water depth 35 - 100 cm deep)
3) Intervening swale marshland
4) Marginal marshland
5) Land-fills
6) Laterite caps (not belong to marshland, uplands adjacent to the marshland)

(3) Soils

Concerning the soils of the basin, the detailed reconnaissance soil map of the Attidiya drainage scheme prepared by Irrigation Department in 1976 may be the best available source of information on the soil of the Weras Ganga basin. Generally speaking, two categories of soils exist, that is, those of the low-lying areas, marshes and paddy fields and those of the surrounding uplands (which appear to be unsurveyed).

In low-lying areas organic clays prevail, forming a surface layer of 1 to 2 m thickness, underlaid by gray to yellowish-brown, medium to fine grained, silty sand (Jayawardena, 1987) and kaolin deposits (Cooray, 1984). Within these clays two soil groups, bog soils and half bog soils, have been distinguished in the basin by Irrigation Department (1976). The bog soils are black to dark grayish-brown in colour, have a pH from 5.5 to 7.5 and are characterized by high organic matter content (more than 30%). Half bog soils black to dark grayish, have a pH ranging from 5.5 to 6.5 and contain 15-30% organic matter.

The surrounding uplands are mainly composed of lateritic soils varying in colour from reddish-brown to chocolate-brown, and are the end product of in-situ weathering of the underlying gneisses and granites (Jayawardena, 1992). At its upper surface, the laterite is firm, but a gradual softening is evident with depth. In general, these laterites may be rated as highly porous, yet permeability vary greatly and depend largely on clay content and micro-structure.

13.1.3 Climate

The Weras Ganga basin is situated within the low country wet zone and has a tropical monsoonal climate.

Mean annual temperature is approximately 27°C, with mean maximum and minimum temperatures of 30°C and 24°C respectively showing little temperature variation throughout the year (2°C to 3°C only).

Rainfall data have been recorded by the Ratmalana meteorological station since 1935. Average annual rainfall for the basin is recorded as 2,500 mm. The monthly average rainfall ranges between about 70 mm and about 400 mm. The maximum amount is observed in May and October, while the minimum amount is observed in January.

The maximum daily rainfall is 365 mm recorded in June 1992 and it was observed within 12 hours. Under average conditions, however, the maximum daily rainfall amounts stay within 100 to 150 mm/day range. With respect to seasonal rainfall, three types of rainfall patterns can be distinguished in the basin, that is, monsoon rains, convectional rains and depressional rains.

Humidity varies from 70% during the day to 90-95% at night. In April, May and early June, when temperature is high, humidity remains high throughout the south-western coastal belt around Colombo.

13.2 Socio Economy

13.2.1 Overview

Weras Ganga Basin (feasibility study area), with the area of 55.5 km^2, is located in the southeast part of Colombo District which borders on Kalutara District on south, Galle Road on west, High Level Road on north, and covering northwest half of Kesbewa PS. It is characterized as one of fast growing areas in CMR (Colombo Metropolitan Region) and strategically important for the development of CMR. A northwest part of Weras Ganga Basin is designated as a Core Area in the CMRSP (Colombo Metropolitan Regional Structure Plan) prepared by UDA (Urban Development Authority) where population is highly concentrated and a large scale urban development is expected.

Weras Ganga Basin plays an important role as a center of the economic and social activity and provision of housing for the people of CMR. Dehiwala - Mount Lavinia, Ratmalana, and Moratuwa are centers of industrial and commercial activities where sawmill and garment factories are operating. Service activities are concentrated mainly along Galle Road. Maharagama and Kesbewa are characterized mainly as a residential area, and the potential for residential development is high due to urban sprawl phenomena from Colombo and migration from the other areas of Sri Lanka. The area surrounding Weras Ganga provides a waterfront environment and is a popular area for recreational activities as well as residential development.

13.2.2 Administrative Division

Weras Ganga Basin is composed of parts of six DS Divisions or six Local Authorities. Administrative units of DS Divisions and Local Authorities are shown in table below.

DS Division and Local Authorities

DS Divisions	Local Authorities
Dehiwala - Mount Lavinia	Dehiwala - Mount Lavinia MC
Ratmalana	Dehiwala - Mount Lavinia MC
Moratuwa	Moratuwa MC
Sri Jayawardenapura Kotte	Sri Jayawardenapura Kotte MC
Maharagama	Maharagama UC Homagama PS (a part of Kottawa South GN)
Kesbewa	Kesbewa PS

Since the Weras Ganga Basin boundary and administrative boundaries do not always match, the administrative units that have area both within and outside Weras Ganga Basin need to be separated based on GN Division boundary. There are 85 GN Divisions in Weras Ganga Basin. The coverage within Weras Ganga Basin is estimated as shown in the table below.

Number of GN Divisions

(Unit: Number)

Administrative Units (DS Divisions)	Total Number of GN Division	Number of GN Division in Weras Ganga Basin
Dehiwala - Mount Lavinia	14	6
Ratmalana	13	8
Moratuwa	42	9
Sri Jayawardenapura Kotte	20	5
Maharagama	41	12
Kesbewa	69	45
Total	183	85

13.2.3 Population

The population of Weras Ganga Basin, based on the GN division boundary, is estimated at 382,000 which accounts for 7.1% of the population of CMR (5.4 million) and 2% of the population of Sri Lanka (19 million, Central Bank estimates). Estimated population in Weras Ganga Basin by DS Division is shown in the table below. List of GN Divisions and population is summarized in Table 13.1.

Estimated Population in Weras Ganga Basin

Administrative Units (DS Divisions)	Population of DS Division	**Weras Ganga Basin Population**	Population Density (Persons/ha)
Dehiwala - Mount Lavinia	102,000	**48,000**	132
Ratmalana	108,000	**69,000**	87
Moratuwa	177,000	**48,000**	106
Sri Jayawardenapura Kotte	115,000	**30,000**	49
Maharagama	180,000	**54,000**	69
Kesbewa	207,000	**134,000**	52
Total	878,000	**382,000**	69

Source: Prepared by JICA Study Team based on 2001 Census and data from Local Authorities

Weras Ganga Basin is considered as one of the more densely populated areas in Colombo district and the population continues to increase. Average population density in Weras Ganga Basin is estimated to be 69 persons per ha, which is higher than the Colombo district average of 51 persons per ha. (Total Sri Lanka average is 3 persons/ha).

Weras Ganga Basin, which is the bed town of nearby urban centers and also a base of economic activity, is also located in one of high population growth areas in the CMR with the growth rate of 2.1%, which is higher than the average population growth rate for CMR (1.7% in 1990s). Moratuwa and Kesbewa shows high population increase rate of 2.9% and 2.3%, respectively.

13.2.4 Economic Conditions

Distribution of economic activities of Weras Ganga Basin can be characterized as high concentration of industrial activities in the west part of Weras Ganga Basin

(Dehiwala - Mount Lavinia, Moratuwa) and some agricultural activity and limited industrial activities in the east part of Weras Ganga Basin. Wood processing (Sawmill) factories and garment factories are located mainly in Ratmalana and Moratuwa.

GRDP for Weras Ganga Basin is estimated from GRDP for Western Province, employment for Colombo District, population allocation of Weras Ganga Basin, with some adjustments made based on the economic activities of the area. Estimated GRDP for Weras Ganga Basin is approximately Rs. 36.3 billion, which accounts for 7.5% of GRDP for CMR. Manufacturing sector has the highest share with 31.5% of GRDP followed by commercial/hotel & restaurant for 29.4%. Agriculture is limited to 1.1% of GRDP in the area. Per capita GRDP for Weras Ganga Basin is estimated to be Rs. 95,129 which is higher than the national average of Rs. 64,855.

Estimated GRDP for Weras Ganga Basin in 2000

Sector	GRDP (million Rs.)	Sector Share (%)
Agriculture, Forestry	410	1.1
Mining	61	0.2
Manufacturing	11,443	31.5
Electricity & Gas	1,079	3.0
Construction	1,777	4.9
Commercial/Hotel & Restaurant	10,673	29.4
Transport	3,977	10.9
Insurance & Banking Services	3,347	9.2
Government Services	2,368	6.5
Others	1,214	3.3
GRDP	36,349	100.0
Per Capita GRDP (Rs.)	95,129	64,855*

Source: Estimated by JICA Study team from GRDP data from Ministry of Planning and District Profile of Labor Force by Department of Census and Statistics
* Per Capita GDP for Sri Lanka 2000 estimated by Central Bank of Sri Lanka

13.2.5 Household Income in Weras Ganga Basin

Since the household income in DS Division level is not available, the income level of the Weras Ganga Basin is measured by the income of Colombo and by poverty condition by assessing the share of social welfare recipients such as Samurdhi, Food stamp, etc. Generally speaking, income in Weras Ganga Basin is expected to be high.

Monthly household income of Colombo District is the highest in Sri Lanka (Rs. 11,107), with the Western Province average at Rs. 9,230, also higher than the national average of Rs. 6,476. Since Weras Ganga belongs to Colombo District and economy is active, income level is expected to fall between Rs. 9,230 and Rs. 11,107.

For Samurdhi program, a subsidy is paid to the family with monthly family income of less than Rs. 1,500. The amount, which ranges from Rs. 140 to Rs. 1,000, is determined by the number and composition of family members. The incidence of poverty in Weras Ganga Basin is relatively low compared with the country as a whole, but worse than in Colombo District. The percentage of household receiving social welfare in Weras Ganga Basin is estimated to be 13.3% which is lower than the national average but higher than the Colombo District average.

Poverty Measures

Regions	Number of Household Receiving Welfare*	Percentage of Household Receiving Social Welfare (%)
Sri Lanka	1,243,390	39.1
West Province	248,315	26.0
Colombo	47,369	12.0
Weras Ganga Basin	**n.a.**	**13.3**

Source: Statistical Abstract 2000, Department of Census and Statistics, Local Authorities
*estimated from total household from Demographic Survey 1994

13.3 Land Use

13.3.1 Available Data on Present Land Use

New data sources for determining the current condition of land use were determined during the second field work in Sri Lanka. These data are (a) aerial photo with a ground resolution of 1:8,000 and (b) digitized map with a scale of 1: 2,000. Both of these data were prepared by Survey Department.

Within the feasibility study area, 138 additional photos, taken in 2000 and 2001, have been made available and have a ground resolution of 1:8,000.

In addition to the aerial photos, Survey Department, in March 2002, completed a more detailed map with a scale of 1:2,000 in a digital form, with technical and financial assistance from the Norway Government. The data contains 66 layers, each of which represents basic skeletons of the city, such as contours and elevation, drainage network, coastal lines, buildings, road, waterbody, and major land use.

13.3.2 Categories of Land Use

The first step to prepare the land use map is to define the categories of land use. It is essential that the classification scheme should depend on the objectives of the analysis that the land use map will be used for. In this feasibility study, the objectives of the analysis are two-fold:

1) To prepare a land use map that can be used as an information source for hydrological analysis

2) To provide information for damage estimation of flood inundation.

This study focuses on the objectively verifiable evidence that derives from the data collected. For these purposes, three proxy indicators are selected for the conduct of the study: (a) elevation, (b) building density and (c) the existence of tree cover. The elevation is used as an indicator for distinguishing high-land from lowland, which means the dryness or wetness of land. Building density, on the other hand, is regarded as a proxy indicator of a degree of urbanization. The existence of tree cover can be regarded as a proxy indicator for perviousness of land.

These indicators can be verifiable from the aerial photo, digital map, and other sources of information. Based on these criteria, thirteen categories were established: (a) shanty, (b) high density area, (c) homestead, (d) garden, (e) grassland, (f) airport, (g) factory, (h) vacant, (i) dumping site, (j) paddy, (k) marsh, (l) vegetation, and (m) water. The definition of each category is summarized below.

Definition of Each Category of Land Use

Category	Criteria
Very High Density Area	• Extremely high building density are observed • No tree cover can be observed
High Density Area	• Over 12.5 buildings per hectare • No tree cover can be observed
Homestead	• Over 7.5 buildings and less than 12.5 buildings per hectare are identified • Tree cover can be observed
Garden	• Under 7.5 buildings per four hectare • Dominant canopy cover can be identified
Grassland	• Under 7.5 buildings per four hectare • No canopy cover dominant
Airport	• Information from the field survey
Factory	• Lange scale lot & building can be identified • Other source of information and field survey
Vacant	• Bare soil on the land cover can be observed
Dumping Site	• Bare land cover can be observed • Other source of information and field survey
Paddy	• Elevation less than 5 meters • Compartment can be observed
Marsh	• Elevation less than 5 meters • Compartment cannot be observed
Vegetation	• Closed canopy cover observed • No buildings can be observed
Water	• Blackish texture can be identified • Information from the digital map

13.3.3 Overview of the Current Situation on Land Use Pattern

Figure 13.4 shows the current pattern of land use in the feasibility study area. The amounts of land and its share for respective categories are shown below.

Present Land Use Area and Share by Category

Categories	Area Extent (ha)	Percentage (%)
Urbanized Use	4,185	80.6
(a) Very High Density	22	0.4
(b) High Density Area	819	15.8
(c) Homestead	1,447	27.9
(d) Garden	1,310	25.3
(e) Grassland	229	4.4
(f) Airport	139	2.7
(g) Factory	136	2.6
(h) Vacant	75	1.4
(i) Dumping Site	8	0.2
Natural/Rural Use	1,002	19.3
Paddy	359	6.9
Marsh	302	5.8
Vegetation	219	4.2
Water	122	2.3
Total	5,187	100.0

Spatial pattern of land use in this area is characterized by its landform or elevation. For example, in the lowland under the elevation of 5 m, paddy, grassland, and marsh are dominant categories. Lands categorized as grassland are observed on the micro-relief, although this could be regarded as an abandoned paddy. In some upland areas, which are relatively free from flood inundation, residential areas are observed, some of which is now being developed with clearance of the coconut forest.

Another factor that determines the spatial pattern of land use is the east-west bank contrast of Weras Ganga. On the eastern side of Weras Ganga basin, important infrastructure/facilities for national economy are concentrated, such as industrial facilities and the airport, while on the eastern side only a few factories could be observed.

Localized characteristics of land use with respect to land-filling can be summarized as follows:

1) Urban sprawling and encroachment to marsh are observed in the Thumbowila area, a south-western part of the feasibility study area. Comparing the aerial photo taken in 1981, the situation in Thumbowila is quite similar to the situation around the area of Moratuwa University.
2) Several land-filling areas for waste dumping are observed in the lowland such as the Muthurajawela Marsh and Thumbowila.
3) Major factories are located in the western part of the basin, especially in the jurisdiction of the Dehiwala - Mount Lavinia Municipal Council. These factories are located at the midst of the lowland where the Horana roads cross the Maha Ela.

4) Artificial transformation of landform was also observed in the western part of the Attidiya Marsh area, which is also used as a residential area, under the favor of the improvement of drainage system.

13.4 Environment

13.4.1 Social Environment

(1) Inventory Survey on Households to be Resettled

The Inventory Survey on Households to be Resettled was conducted as part of the EIA Study for the feasibility study by subcontract to a local consultant. The objectives of the Inventory Survey on Households to be Resettled were to identify the land to be acquired and house/structure/movable properties to be relocated by the proposed schemes, to identify residential households to be resettled, and to collect their socio-economic data, opinions on improvement of their living environment, and intention and demand related to the resettlement.

The survey areas were selected on the basis of 1:2,000 scale topographic maps as follows, including lowlands along the Weras Ganga and tributaries subject to the structural measures envisaged:

1) Nugegoda-Rattanapitiya sub-basin: extent of 20 m from present edge of the canal/stream for both sides along the canals
2) Bolgoda Canal sub-basin: area lower than 1 m and below MSL
3) Weras Ganga and Ratmalana-Moratuwa sub-basin: area lower than 2 m and below MSL was surveyed.

The total number of households surveyed is 1,549. Details on resettlement issues are discussed in Chapter 20 of this report. The characteristics of households are summarized in Tables 13.2 and 13.3 and described hereunder.

(2) Property-Related Characteristic

People living in the survey area locating in the Ratmalana-Moratuwa area (Weras Ganga dredging and flood protection wall construction and Ratmalana-Moratuwa schemes) stay rather shorter period among the surveyed households, while people in the proposed Bellanwila-Attidiya retention area live for longer period. On the whole, households to be resettled tend to live at their present location for a shorter period compared to other surveyed households.

Households living in the proposed Bellanwila-Attidiya retention area and Maha Ela retention area have largest land area on average per household, 367 m^2 and 351 m^2 respectively. This is probably because landowners, who owned large lands when the area was used for agriculture, are included

On the other hand, households living in the Bolgoda Canal dredging and channel improvement section and Ratmalana-Moratuwa Scheme reside on smaller land areas, on average 113 m^2 and 129 m^2 per household, respectively. Many households living on small land areas less than 50 m^2 were found in the Weras Ganga flood protection wall construction section (44 households) and Nugegoda-Rattanapitiya Scheme (32 households).

Many of the surveyed households living in and around the Weras Ganga flood protection wall construction section are illegal occupants (253 households). In contrast, a large percentage of the surveyed households living in the proposed Bellanwila-Attidiya retention area own their lands (237 out of 287 households in total surveyed).

Most of land where surveyed households reside is privately-owned. It is highly probable that the households living in the public land such as State land and local authority's land are illegal occupants except for the households living in the permitted land.

(2) Socio-economic Characteristic

Average number in total surveyed households and households to be resettled are 4.2 and 4.4 persons/household respectively.

Major occupation among the surveyed households is labour, followed by unemployed. For the Maha Ela retention area section, unemployed status ranks first. These facts may show there is a potential employment opportunity in the area related to the proposed project.

The majority are Buddhist with other religions represented by much smaller numbers. This characteristic is similar for the households to be resettled. In the resettlement, the religious characteristic, especially for Hindu, Christians and Muslims in small number groups, should be carefully considered and selection of the resettlement sites should be based on their preferences.

Approximately half the total households (722 households out of total 1,478 households) are counted as low income households (less than Rs. 5,000/month). Further, 303 households fall into a category under the poverty line (Rs. 3,000/month).

Among the surveyed households, the Weras Ganga flood protection wall construction area and Ratmalana-Moratuwa Scheme area show higher rate of lower income households. The surveyed households in the proposed Bellanwila-Attidiya retention area and Nugegoda-Rattanapitiya Scheme have a high rate of highest income group (over Rs. 10,000/month).

13.4.2 Natural Environment

(1) Bellanwila-Attidiya Wildlife Sanctuary

The Bellanwila-Attidiya marsh area was widely cultivated for rice until the end of the 1970's. However, due to increasing severity of drainage problems with seasonal flooding caused by land-filling and housing construction in the catchment area, siltation of drainage lines and rampant growth of aquatic weeds, the paddy cultivation was abandoned. Since then, intensive use of the marsh has not been undertaken. Consequently, the marsh has been re-colonized by diverse vegetation that provides habitat for a great variety of wildlife[1]. After several researches by NGOs on the ecological condition of the marsh, the marsh area, whose total land area is 372 ha, was declared a Sanctuary under the Flora and Fauna Protection Ordinance (FFPO) in 1990.

However, effective management of the marsh has not been conducted by the Department of Wildlife Conservation (DWLC) who has direct management, responsibility due to the following reasons.

1) While all wildlife is fully protected within any area of the Sanctuary, plants and habitats are legally protected only on State lands under the FFPO, not private land.
2) The greater part of the marshlands are privately owned.
3) All who owned land within the Bellanwila-Attidiya marsh prior to its declaration as a Sanctuary, can continue to enjoy the rights and privileges as they did before under the FFPO.

Thus, the legal restriction to the Sanctuary status is too weak to conserve the marsh area appropriately.

Under the condition for the conservation of the Sanctuary, urban pressure from the upper basin and surrounding area of the marsh such as wastewater inflow and solid waste dumping has gradually deteriorated natural environment of the marsh. As a result, it is reported that the precious rich biodiversity in the marsh does not remain anymore. There is no definite management plan at present. Stakeholders related to the marsh have different views as shown below.

[1] Wetland Site Report & Conservation Management Plan: Bellanwila-Attidiya Marsh, CEA/Euroconsult. 1993

Stakeholders and their Concerns to Bellanwila-Attidiya Wildlife Sanctuary

Stakeholders	Concerns on Bellanwila-Attidiya Wildlife Sanctuary
DWLC	Low priority to be conserved compared to other protected areas in the country such as national park.
UDA	Fully conserved by pro-nature use such as water park. The land of the sanctuary to be conserved is acquired.
Local authority	Almost no intention.
Private land owners	Willing to sell by filling land due to high demand of the land under urbanization in the area
Local environmental NGOs, Part of local residents and supporters	Active conservation of the Sanctuary

(2) Weras Ganga

In addition to the water flow from the upper stream of the canals connecting to the Weras Ganga, the Weras Ganga receives runoff from its boundary areas. Based on the water quality data, salinity level is low in the upstream reaches of the Weras Ganga since tidal flow is prevented by fresh water flow from upstream of the canals. According to a local NGO, the fish catch has been virtually depleted in the last decade due to industrial pollution although a wide variety of fish species living in the Weras Ganga is reported.

(3) Wastewater Management

Surface water pollution in the canals and marshes is a most serious problem in the feasibility study area as well as that in other area of the CMR. The main causes of surface water pollution are[2]:

1) Discharge of urban drainage water mixed with industrial and domestic origin to natural streams including runoff from open markets and garbage dumps,
2) Direct discharge of industrial wastewater into rivers, canals and lowlands,
3) Uncontrolled and illegal dumping of industrial and domestic waste in waterways, embankments and lowlands,
4) Discharge of sewerage directly into canal/surface water bodies mainly by shanty settlements along canals,
5) Insufficient maintenance and cleaning of watercourses and embankments resulting in siltation, blockage and aquatic weed growth.

Regarding the domestic wastewater, only some part of Dehiwala - Mount Lavinia MC area is served by a piped sewerage system established in early 1900s. The feasibility study area is not covering the sewerage service. Most of the population have no or inadequate facilities in the feasibility study area.

[2] IEE Study on Storm Water Drainage Plan for CMR, LHI, 2002

The Ratmalana-Moratuwa industrial area comprises more than 190 industries mainly textile and garments, pharmaceutical, metal finishing, food industry and paint industry. This industrial area does not have a central treatment facility and industrial wastewater is discharged into surface drains, while domestic wastewater is discharged via septic tank into soakage pits. Due to the high water table and sandy soil in the area, the partially treated wastewater from septic tanks enters the ground water[3].

(4) Solid Waste Management

Waste disposal is one of main environmental issues and it is closely related to the canal system and storm water drainage in the feasibility study area as well as other built-up area in the CMR.

The waste disposal is undertaken by mainly open dumping method under responsibility of the relevant local authorities in the feasibility study area. Most dumping sites are located in lowlands such as marshy and abandoned paddy fields creating water pollution problem by polluted leachate from dumping site to water bodies including canal system. In general, privately-owned lands are targeted for the dumping sites since those lands are available as a mean of land reclamation.

The waste disposal sites mainly operated by local authorities in the study area are shown below and in Figure 13.5. Information about the waste disposal by contracted private companies is not available.

Solid Waste Disposal Sites by Local Authorities

DS Division	Solid Waste Disposal Sites	Remarks
Dehiwala - Mount Lavinia	Attidiya South	-
Ratmalana	Attidiya South	-
Moratuwa	Dendeniyawatta-Katubedda	About 40 tractor loads per day
Kotte	Athul Kotte	-
Maharagama	Navinna	Adjacent to High Level road
Kesbewa	Mabahatha	About 4 tractor loads per day

Source: IEE Study on Storm Water Drainage Plan for CMR, LHI, 2002

The Dehiwala – Mount Lavinia MC (DMMC) has disposed of its waste in the Bellanwila-Attidiya marsh on a site bordered by the Weras Ganga to the east and a canal flowing along the western and southern boundaries that falls into the Weras Ganga. However, the dumping site was closed recently because of court order due to opposition by residents to the dumping activity.

3 University of Moratuwa, 2001, Feasibility Study Report on the Establishment of a Central Waste Water Treatment Plant (CWWTP) for Ratmalana-Moratuwa Industrial and Residential Areas

The Maharagama PS has initiated a source segregation scheme among 2,300 households and it has been effective in reducing the total quantity of waste collected[4].

13.5 Existing Storm Water Drainage Systems

13.5.1 Drainage Systems in Weras Ganga Basin

(1) Weras Ganga

The objective area of the feasibility study covers the Weras Ganga basin, which is defined as a drainage area upstream of the Kospalana bridge on the Moratuwa-Piliyandala Road across 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 drained by several tributaries and is broadly divided into the seven sub-basis. The characteristics of each sub-basin are described hereunder.

Sub-basins of Weras Ganga Basin

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
Tumbowila	2.2
Total	55.5

The ground elevation of the Weras Ganga basin ranges from the highest of 35 m above MSL around the northeastern boundary of the basin to nearly 0 m along the Weras Ganga and surrounding lowland.

The Weras Ganga is regarded as a part of the water system of the Bolgoda basin consisting of the two major lakes, North Bolgoda Lake and South Bolgoda Lake, and surrounding wetlands. The total extent of the water surface and surrounding wetlands is around 4,000 ha, including the water surface areas of the North Bolgoda Lake (760 ha) and the South Bolgoda Lake (340 ha). The length of the Weras Ganga from the Kospalana bridge to upstream end of the swamp is 4,500 m. The Weras Ganga also has a large water surface including the swamp area at its upstream end and rather wide channel with its width varying from 60 m to 600 m connecting with the North Bolgoda Lake to the south.

4 State of the Environment Report, Sri Lanka- First Draft, Ministry of Environment/NORAD/UNEP/SACEP 2000

(2) Nugegoda - Rattanapitiya Sub-basin

The Nugegoda-Rattanapitiya sub-basin is located in the most northern part of the Weras Ganga basin as shown in Figure 13.6. The drainage area of the sub-basin is 8.2 km^2. The majority of the drainage area is occupied by the densely urbanized area expanding from Colombo MC to the south.

The ground elevations in the Nugegoda-Rattanapitiya sub-basin are 25 m above MSL around the northern boundary, 1 to 6 m in the urbanized stretches along the principal drainage channels and 1 m or less in the Bellanwila-Attidiya Marsh.

The existing principal drainage channels are the Nugegoda Ela and Delkanda Ela in the upper basin. These two channels join together and become to the Rattanapitiya Ela in the downstream. It is supposed that these channels were natural streams originally and became drainage channels in the process of the urbanization.

(3) Bolgoda Canal Sub-basin

The Bolgoda Canal provides a drainage area upstream of the confluence of the Rattanapitiya Ela, the Nugegoda-Rattanapitiya sub-basin, the Boralesgamuwa North sub-basin and the residual drainage area downstream to the Weras Ganga. The total drainage area at the confluence of the Weras Ganga is 20.8 km^2. Of the total drainage area, the Bolgoda Canal sub-basin covers 7.7 km^2 including the drainage area upstream of the confluence of the Rattanapitiya Ela and residual drainage area downstream to the Weras Ganga as shown in Figure 13.7.

The ground elevations in the Bolgoda Canal sub-basin are 30 m above MSL around the northwestern boundary, 1 to 5 m in the urbanized stretches along the Bolgoda Canal and 1 m or less in the Bellanwila-Attidiya Marsh.

The Bolgoda Canal connects the Dehiwala Canal in the neighboring Greater Colombo basin to the north with the Weras Ganga. The total length of the channel is 5,600 m. Across the drainage area boundary around the Dehiwala Zoo, storm water runoff is drained to both north and south ends respectively during normal flow condition. Improvement of the Bolgoda Canal was undertaken by the GCFC&EIP Phase I for the stretch from the Dehiwala Canal with the length of 2,700 m.

(4) Boralesgamuwa North Sub-basin

The Boralesgamuwa North sub-basin with a drainage area of 4.9 km^2 is located to the north of the Nugegoda-Rattanapitiya sub-basin. As seen in Figure 13.8, this sub-basin is characterized with relatively high grounds in the north and south and the lowland consisting of paddy field and marsh in the center of the sub-basin.

The ground elevations in the Boralesgamuwa North sub-basin are 20 m above MSL around the northern boundary, 1 to 4 m in the central lowland and 1 m or less in the Bellanwila-Attidiya Marsh.

A stream in the central lowland spreading east to west is called the Depawa Ela but there is no principal drainage channel in this sub-basin. Small irrigation creeks go down in the central lowland and urban drainage channels collecting storm water runoff from the highlands in the north and south run along the respective borders of the central lowland. Storm water runoff flowing down from the sub-basin retards in the central lowland and is drained gradually to the Bolgoda Canal through the Bellanwila-Attidiya Marsh.

(5) Boralesgamuwa South Sub-basin

The Boralesgamuwa South sub-basin shown in Figure 13.9 is located to the east of the Weras Ganga Swamp between the Boralesgamuwa North sub-basin to the north and the Maha Ela sub-basin to the south. The drainage area of 4.0 km^2 is largely occupied by the marsh area surrounding the Weras Ganga swamp in the downstream.

The ground elevations in the Boralesgamuwa South sub-basin are 20 m above MSL around the eastern boundary, 2 to 4 m in the central lowland and 1 m or less in the Weras Ganga swamp.

A drainage channel across the Colombo-Piliyandala Road goes down to the Weras Ganga swamp through the lowland in the center of the sub-basin. It seems that the channel has been neglected for a long period. The channel is hardly accessible in the lowland covered with bush and grass in the upstream side of the Colombo-Piliyandala Road. The channel in the downstream side is filled with water plants. The lowland is badly deteriorated by garbage dumped and left along the Colombo-Piliyandala Road.

(6) Maha Ela Sub-basin

The location of the Maha Ela sub-basin is shown in Figure 13.10. The Maha Ela sub-basin has the largest extent of the drainage area in the Weras Ganga basin. The extent of the drainage area is 20.4 km^2. The upstream end of the sub-basin is around Pannipitiya in Manaragama UC along the High Level Road. The lowland runs in the center of the sub-basin from northeast to southwest. The Maha Ela flows down through the lowland and pours into the Weras Ganga. Compared with the northern and western sub-basins in the Weras Ganga, the elevated lands surrounding the central lowland are urbanized moderately in the Maha Ela sub-basin. Highly urbanized areas are located in limited areas along the High Level Road and Colombo-Piliyandala Road.

The ground elevations in the Maha Ela sub-basin are 35 m above MSL around the eastern boundary, 1 to 7 m in the central lowland and 1 m or less in the most downstream lowland.

The upper half of the central lowland is paddy cultivation area irrigated by the Maha Ela with 3 to 5 m width and some irrigation creeks running in parallel with the Maha Ela. Rainwater retards in the lowland and is discharged gradually through the Maha Ela and irrigation creeks. The downstream half of the lowland consists of fallow fields and marsh. The fallow fields down to the vicinity of the Colombo-Piliyandala Road are utilized for livestock feeding and scattered crop cultivation. Further downstream to the Weras Ganga is covered with the marsh as a whole.

(7) Ratmalana-Moratuwa Sub-basin

The Ratmalana-Moratuwa sub-basin is located in the western part of the Weras Ganga basin as shown in Figure 13.11. The extent of the sub-basin is 8.1 km^2. The Ratmalana-Moratuwa sub-basin is broadly bounded by the Ratmalana Airport in the north, the Galle Road in the west and hilly areas in the south.

The central area between Kandawala and Telawala is occupied by densely populated residential areas and industrial compounds. The ground elevation varies from 8 m above MSL in the western boundary along the Galle Road and 1 m or less along the Weras Ganga. There is no principal drainage channel collecting and draining storm water runoff to the Weras Ganga. Roadside drains are found along the Ratmalana-Borupana Road and some principal roads. But such drains cover a limited part of the drainage area and do not lead the storm water runoff properly to the Weras Ganga. This drainage area covers the lowland with ground elevation of 1 m above MSL or less along the right bank of the Weras Ganga. The lowland used to be a marsh and has since been reclaimed for housing. At present, the lowland is densely occupied by houses forming under-served settlements. Drainage condition in the lowland is unsatisfactory because of the absence of drainage system and topographic constraints.

(8) Thumbowila Sub-basin

The Thumbowila sub-basin is a small catchment of 2.2 km^2 located on the left bank of the Weras Ganga in the southern end as shown in Figure 13.12. The sub-basin is drained by minor tributaries of the Weras Ganga. The sub-basin is bordered by the highlands with ground elevation around 15 m above MSL along the Moratuwa-Piliyandala Road in the south and the compound of a ceramics production company in the east. The northern boundary is located in the relatively lowland continuing from the marsh in the neighboring Maha Ela downstream reaches. The ground elevation of the northern lowland is 1 m above MSL or more. A marsh area exists along the small tributary flowing down southeast to northwest in the sub-basin. Areas with an elevation of 1 m or less, which are likely to be affected by the Weras Ganga flood, are found in the most downstream of the northern lowland and marsh area to a limited extent. Urbanized areas are observed mainly along the above-mentioned highlands and surrounding slopes. Meanwhile, the northern lowland is subject to land filling from the border.

13.5.2 Existing and Ongoing Projects

(1) Greater Colombo Flood Control and Environment Improvement Project Phase III

In the Bolgoda Canal sub-basin, the right bank of the Bolgoda Canal upstream of the Attidiya Road used to be a part of the Bellanwila-Attidiya Marsh. Development by land reclamation in the right bank area commenced in the 1980's and a large part of the previous marsh has been reclaimed for construction of residential estates. In the process of development, the residential areas in Kawdana and Attidiya areas came to be prone to problems on storm water drainage due to the low-lying topography originally in the marsh and insufficient considerations for storm water drainage system in the development areas.

An extensive study on storm water drainage in the Greater Colombo areas was carried out in 1996 under the GCFC&EIP Phase II. The Kawdana and Attidiya areas were investigated under the study. Areas prone to frequent inundation in the Kawdana and Attidiya areas were identified totaling 128 ha. It was reported that inundation occurs 6 times a year on average and results in the amount of annual direct damage of Rs. 76 million/year which accounts for 64% of the annual direct damage in the Dehiwela - Mount Lavinia MC.

The storm water drainage plans for the Kawdana and Attidiya areas were therefore formulated for alleviating frequent inundation. Early implementation of the Kawdana and Attidiya schemes was envisaged succeeding the storm water drainage improvement by the GCFC&EIP Phase I and II. The Kawdana and Attidiya schemes were initiated as the GCFC&EIP Phase III in 1999 with the project loan by JBIC extending financial assistance for the GCFC&EIP since 1990.

The project consists of the Kawdana and Attidiya schemes with the drainage areas of 1.6 and 2.2 km^2, respectively. Improvement of the urban drainage systems in the two schemes is composed of main and secondary drainage canals and conduits as well as tertiary drains of 53 km length in total. The total project cost was estimated at Rs. 4,072 million. The project is being implemented and will be completed in

2004.

(2) Bolgoda Canal Improvement

SLLRDC envisages improving the Bolgoda Canal connecting the Dehiwala Canal with Weras Ganga for augmentation of storm water drainage in the Bolgoda Canal sub-basin including the GCFC&EIP Phase III project area.

As described before, the Bolgoda Canal is totally deteriorated to the downstream of the Attidiya Road. Deterioration of the downstream stretch is a fundamental problem on storm water drainage in the Bolgoda Canal sub-basin for draining storm water runoff from the entire sub-basin to the Weras Ganga. A proposal for improvement is to clean and dredge the deteriorated stretch downstream of the Attidiya Road in combination with diversion to the Bolgoda Canal to Weras Ganga Swamp.

Downstream of the Elawella Road, the present channel goes between the Weras Ganga Swamp and Ratmalana Airport and joins the Weras Ganga just downstream of the swamp. This section is hardly accessible for maintenance at present. In addition, this section is subject to the proposed reclamation by expansion of the airport runway. The expansion plan of the airport runway also envisages the diversion of the Bolgoda Canal.

Another improvement is also under consideration for the stretch from the Hill Street to Dehiwala Canal. It aims at discharging storm water runoff in the Bolgoda Canal sub-basin to the sea through the Dehiwala Canal whose sea outfall is close to the confluence of the Bolgoda Canal. The present channel bed is sloping for both sides across the drainage area boundary around the Dehiwala Zoo. To enable channel flow to the Dehiwala Canal, dredging of channel bed is envisaged for the entire stretch by 0 m MSL.

13.5.3 Flood Prone Areas and Flood Damage

The assessment of flood prone areas and damage in the Weras Ganga basin is carried out in the feasibility study on the priority project, based on the following studies:

1) Flood damage survey in Dehiwala - Mount Lavinia and Moratuwa areas under the Review of F/S of the GCFC&EIP Phase II in 1995
2) Flood damage survey during the Master Plan Study in 2001
3) Flood inundation analysis by MIKE11 based on the latest 1:2,000 topographic maps.

Locations of flood prone areas and situations of flooding are assessed from the results of the flood damage surveys above. Estimation of flood inundation area and flood damage is based on the flood inundation analysis by MIKE11, together with assessment of direct and indirect damage.

The flood damage survey undertaken during 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. Based on the 1995 survey, urban drainage improvement schemes in Kawdana and Attidiya areas were selected as the urgent schemes to be implemented under the GCFC&EIP Phase III commenced in 1999. The other survey carried out during the Master Plan study in 2001 identified 39 locations of flood prone areas in the Weras Ganga basin.

Some of the flood prone areas are located locally away from the Weras Ganga main stream or major tributaries. These areas suffer from local drainage problems on existing urban drainage systems. The flood prone areas directly affected by the Weras Ganga or major tributaries are also found mainly in the following locations:

1) Weras Ganga right bank from Kandalawa to Telawala
2) Delkanda Ela along Old Kesbewa Road
3) Nugegoda Ela around Church Street
4) Rattanapitiya Ela along Old Kesbewa Road and Rattanapitiya Junction
5) Depawa Ela along Colombo-Piliyandala Road
6) Maha Ela along Colombo-Piliyandala Road

It is also pointed out that lowlands along the edge of marsh surrounding the Bolgoda Canal and Weras Ganga are prone to inundation. Houses constructed with land filling are affected directly by inundation in the marsh or suffer from drainage congestion due to improper storm water drainage in the lowland. Affected areas are mainly identified as follows:

1) Weras Ganga right bank from Kandalawa to Telawala
2) Attidiya along Bellanwila-Attidiya Marsh
3) Werahera to the north of Weras Ganga Swamp
4) Battiyawatta and Duwawatta to the south of Maha Ela Marsh

Locations of the flood prone areas above are shown in Figure 13.13. According to the results of the 2002 survey, frequency of inundation is 5.2 times a year with duration of 1.1-day on average, suggesting that flooding in the Weras Ganga basin is characterized as a “frequent occurrence” even in the case of normal rainstorm events.

As seen in the inundation map resulting from the inundation analysis, the marsh and lowlands along the Weras Ganga and major tributaries are widely inundated by the probable 2-year flood. Because of the characteristics of the Weras Ganga basin having a large extent of marsh and lowland along the streams, the increment of inundation area by scale of flood is relatively small even though duration and depth of inundation increases with scale of flood.

Frequency and Duration of Inundation in the Weras Ganga Basin

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

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. The flood damage survey in 1995 estimated the flood damage at Rs. 118 million/year in total for Dehiwala - Mount Lavinia MC and Moratuwa MC.

Estimated Extent of Inundation in the Weras Ganga Basin

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

13.5.4 Causes of Flooding

(1) Problems on Storm Water Drainage System

Based on assessment of present drainage systems and flood prone areas in the Weras Ganga basin, outstanding problems attributed to the present storm water drainage system of the Weras Ganga basin are broadly classified as follows:

Outstanding Problems on Storm Water Drainage System

Problems	Affected Areas
Flooding of Weras Ganga	Low-lying areas along the Weras Ganga right bank from Kandawala to Telawala in Ratmalana-Moratuwa sub-basin
Obstruction of storm water drainage by reduction of flow capacity in downstream end of 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 less flow capacity of channel or crossing structure against 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, affected by Weras Ganga water level	Low-lying areas along the Weras Ganga right bank from Kandawala to Telawala in Ratmalana-Moratuwa sub-basin

The problems above are directly related to the causes of inundation due to the difficulty of natural drainage in the low-lying areas and shortcomings of existing storm water drainage system in the Weras Ganga basin.

The problems above have also been created and worsened by indirect causes such as urbanization and related issues as described in the subsequent paragraphs.

(2) Influence by Uncontrolled Urbanization

The storm water drainage system in the Weras Ganga basin has been affected by uncontrolled urbanization.

Buildings and houses constructed closely to drainage channels are observed in the urbanized areas, obstructing channel improvement or maintenance. Wastewater is directly discharged into drainage channels resulting in a worsening living environment caused by drainage congestion and pollution. Such problems are seen in places along Bolgoda Canal, Nugegoda Ela, Delkanda Ela, Rattanapitiya Ela and commonly observed along urban drainage channels.

The low-lying areas of the Weras Ganga are subject to encroachment by unauthorized land fillings which have not been controlled effectively and are expanding gradually. Buildings and houses constructed on land filling are prone to inundation because such land fillings and constructions have been done without proper technical considerations for storm water drainage. These problems are seen in the border of existing marsh areas, i.e., Bellanwila-Attidiya Marsh, Weras Ganga Swamp, Maha Ela Marsh and Lowland, and lowlands in the Ratmalana-Moratuwa sub-basin.

(3) Reduction of Retention Area

Land fillings are still in a limited extent at present compared with the scale of existing marsh areas but are a potential future threat due to storm water drainage ability and reduction of natural retention capacity of the basin.

As the upper drainage areas have been highly urbanized in the northern part of the Weras Ganga basin, storm water runoff concentrating into the Rattanapitiya Ela has increased, overburdened the existing channel. There are some extensive lowlands functioning as storm water retention areas in the upper basin, but these are subject to land filling. Loss of the existing lowlands will result in a further burden to the Rattanapitiya Ela. As areas along the channel continue to be urbanized, attempts at channel improvement will become more difficult and expensive both for construction as well as relocation and compensation after loss of the existing lowlands as storm water retention areas.

These problems will also expand over the entire lowlands along the Weras Ganga without prevention of unauthorized land filling from the existing major retention areas, i.e., the Bellanwila-Attidiya Marsh, Weras Ganga Swamp and Maha Ela Marsh.

(4) Inconsistent Facility Construction

The drainage channels and road crossing structures have been constructed or improved gradually on an ad-hoc basis with different ownership, i.e., government organizations, local authorities, and private sectors. The ad-hoc construction or improvement has resulted in inconsistency of drainage facilities in terms of flow capacity and service level. For example, sections of drainage channel or road crossing culverts in upstream reaches have been improved with sufficient flow capacity but other sections in downstream reaches remain unimproved with less flow capacity and are therefore prone to inundation. Such a situation is found in the upstream reaches of Nugegoda Ela and other examples are commonly observed in urban drainage channels.

There are several old facilities constructed in relation to storm water drainage which are now outdated. The gate located at the Elawella Road is now an obstacle to channel flow in the Bolgoda Canal. The Elawella Road is elevated with its surface elevation 2 m above MSL, sufficient for flood level. The gate consists of six openings of 1.8 m width on the elevated embankment. A pumping station with a capacity of 20 m^3/sec is installed beside the gate but doe not seem to have been operated for some time. A causeway for emergency release of storm water runoff is provided with a lower surface level of 0.5 m above MSL but it has not been maintained and both downstream and upstream are covered with dense grasses and bushes. The facilities do not perform the original purposes and are regarded as out-of-date for storm water drainage of the Bolgoda Canal.

Similar facilities are observed at the downstream ends of the drainage channels joining the Weras Ganga such as the Rattanapitiya Ela, Maha Ela and Katubedda tributary.

(5) Insufficient Maintenance for Storm Water Drainage Facilities

Little maintenance has been carried out in Bolgoda Canal and Rattanapitiya Ela downstream reaches. Drainage channels are inaccessible for maintenance and are filled up with water plants reducing flow capacity of these channels.

Improvements and maintenance have not been undertaken at the main stream of the Weras Ganga. The present bed level of the Weras Ganga is almost flat around 1 m below MSL and slightly higher from the upstream swamp to the confluence of the Telawala tributary. This stretch, where normal water depth becomes 1 m or less, is prone to deposition of silt and withered water plants, suggested by the bed level deepening down to 2 to 1.5 m below MSL in the North Bolgoda Lake.

(6) Other Problems

There is no sewerage system in the Weras Ganga basin and wastewater is directly discharged into drainage channels. Therefore, water and bed materials in the drainage channel are contaminated together with offensive odor in places. Contamination is accumulating in the downstream ends of the major tributaries, the Weras Ganga main stream and surrounding marsh areas. Water plants grow remarkably, contributing to the reduction of flow capacity of the channels.

CHAPTER 14 HYDROLOGICAL ANALYSIS

14.1 Objective Basin and Drainage System

14.1.1 Basin Division

Utilizing the 1:2,000 topographic map, the Weras Ganga basin (upstream drainage basin from Kospalana bridge) was extracted with enough accuracy as shown in Figure 14.1. The total drainage area of the Weras Ganga basin is 55.5 km^2. The major river channels in the Weras Ganga basin are Bolgoda canal (20.8 km^2), Rattanapitiya Ela (8.2 km^2), Maha Ela (20.4 km^2) and Weras Ganga main stream (55.5 km^2).

For the present hydrological analysis, the Weras Ganga basin was further divided into 187 sub-catchments.

14.1.2 Hydrological Observation in the Weras Ganga Basin

There are three rainfall gauging stations and eight water level gauging stations in or around the Weras Ganga basin. Rainfall gauging stations are maintained by Meteorological Department and water level gauging stations are maintained by SLLRDC, Irrigation Department or Lanka Hydraulic Institute (LHI).

The location of existing rainfall and water level gauging stations are shown in Figure 14.2. Dehiwala and Ratmalana rainfall gauging stations were installed before 1970, while Bolaresgamuwa rainfall station was installed late 1990. However, observations at Dehiwala station suffer from many interruptions and very few records are available from 1972 to 1985. Continuous observation is conducted at other two stations, Bolaresgamuwa and Ratmalana. Short duration rainfall records such as 15- or 60-minute are available at Ratmalana station, while other two stations have only daily basis data.

Water levels are recorded by gauge keepers living beside the stations. They are recorded twice a day (morning and evening) in principle. All of stations were installed after mid-90s, and water level observation at 5 stations of 8 started in the middle of the year 2000.

Discharge measurements are conducted at two water level gauging stations, i.e., Attidiya-Bolgoda Canal (No.1) and Badowita (No.2), once a month by SLLRDC. Those records are assembled in their respective season, i.e., wet and dry, and the relationship between stage water levels and measured discharges (H-Q curve) are estimated.

However, due to the insufficiency of discharge measurement and water level observation record during flood evens, flood runoff discharges estimated from the H-Q curves do not have enough reliability.

14.2 Rainfall Analysis

14.2.1 Characteristics of Storm Rainfall

Figure 14.3 shows the hourly hyetographs of major storm rainfalls observed at Ratmalana rainfall gauging station. It can be clearly seen that every large-scaled storm rainfall has multiple prominent peaks within the duration of a series of storm event. In other word, storm rainfalls that bring about severe damage are comprised of several independent short-term storm rainfalls with duration of 3 to 4 hours.

Isohyetal maps for four large-scaled storm rainfall events occurred in the last decade are illustrated in Figure 14.4. These maps were generated using daily rainfall records of 3 stations in the Weras Ganga basin and those of surrounding stations, i.e., Colombo, Bandaragama, Horana and Kalutara.

As to the event of June 1992, there is a trough along the line connecting Dehiwala and Boralesgamuwa stations. The rainfall amount at Dehiwala station is only 52% of that of Ratmalana station and 38% of Colombo station. The aerial skew of this storm event is relatively large. Another three events shown in the figure have large amount of rainfalls occurring with aerial uniformity on a daily basis.

After the examination of collected daily rainfall record at three gauging stations in the basin and short-term rainfall record at Ratmalana station, the following tendencies were found:

1) There is a large aerial skew in the small-scaled storm events with daily rainfall of less than 30 mm.
2) For the large-scaled storm rainfall with daily rainfall of more than 100 mm, the aerial skew in daily basis is smaller than that of small-scaled ones.

Considering above tendencies and the fact that the probable basin average daily rainfalls with return period of more than 2 years, which are estimated by Thiessen polygon method, are over 100 mm as shown in succeeding subsection, the aerial uniformity of design storm rainfall over the entire Weras Ganga basin is a reasonable basis for the planning purpose.

14.2.2 Probable Rainfall Amount and Design Storm Rainfall Pattern

(1) Extreme Value Analysis

Basin average rainfall was calculated for the entire Weras Ganga basin, employing the Thiessen Polygon method.

Structural measures proposed in the Study are not only for the Weras Ganga main stream but also for small canals in the upstream basins. Information relating to storms with shorter duration is necessary for the planning of small-scaled basin storm water drainage scheme of less than 10 km^2. This is because rainfall within the flood concentration time controls the peak flood discharge which will determine the conditions for the channel design.

Since no station in the Weras Ganga basin records such a short-duration rainfall except for Ratmalana station, estimation of basin average rainfall in hourly basis is quite difficult. Moreover, the short-term rainfall record in Ratmalana is fragmented and available only for a few (8) samples. The extreme value analysis for probable hourly rainfall was therefore carried out using the short-duration storm record of Colombo automatic rainfall gauging station whose location is about 6 km north from Dehiwala rainfall gauging station.

Calculated Probable Basin Average Daily Rainfalls

(Unit : mm)

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

(2) Temporal Distribution of Design Storm Rainfall

Normally, design storm rainfall is prepared after comparative examination among a lot of past records and artificial patterns. It is natural that each scheme has its own design storm rainfall pattern in proportion to the flood traveling time from its drainage basin. However, only one design storm rainfall pattern, which has applicability both for the small basin and the entire Weras Ganga basin, is used in the Study for the following reasons:

1) Both peak runoff discharge and flood water level in the lower reaches with a large drainage area such as the Weras Ganga main stream seem to be controlled mainly by the total rainfall amount and not sensitive to the shape of hyetograph, because of the retarding effect of widely spread lowlands.

2) Considering the flood traveling time of small catchments, flood discharges in the upstream basin are controlled not by temporal distribution of rainfall but by the maximum hourly rainfall amount.

The hourly rainfall pattern at Colombo automatic rainfall gauging station on April 20, 1999 is selected as a prototype of design rainfall pattern in the Study. This pattern was also selected as a design rainfall pattern in the Master Plan Study.

The design storm rainfall pattern is generated by the following manner:

1) Convert the maximum hourly rainfall value of the prototype to the probable 60-minute rainfall value calculated above.
2) Reduce the rainfall amount of remaining portion of prototype proportionally to the original share in order to retain the total rainfall amount.

The derived design storm rainfall pattern is illustrated in Figure 14.5.

14.3 Flood Runoff and Inundation Analysis

14.3.1 Flood Runoff Modeling

(1) Digital Elevation Model

Flood runoff analysis for the Weras Ganga basin was conducted utilizing MIKE11, a hydrological and hydraulic modeling software. A DEM (Digital Elevation Model) of the entire Weras Ganga basin was generated with the size of 10 m × 10 m (0.01 ha) utilizing 1:2,000 topographic maps provided by Survey Department. This DEM is useful not only for generation of flood inundation map but also for extraction of flood plain characteristics to be reflected in the hydraulic model.

(2) Branch Network Model

Flood inundation phenomena is expressed only by overtopping from modeled channel in MIKE11. Therefore, small water paths should be included in the network model in addition to the major river channels and canals in order to revive the inundation situation at places apart from the main channels and canals. Major river channel and canals in the Weras Ganga basin are listed below:

1) Main Bolgoda Canal (upper part of Branch 001)
2) Weras Ganga (lower part of Branch 001)
3) Maha Ela (Branch 002)
4) Nugegoda Ela (Branch 005)
5) Delkanda Ela (Branch 006)
6) Rattanapitiya Ela (lower part of Branch 005)
7) Depawa Ela (Branch 004)

Major structures crossing channels such as bridges, culverts and gates are also included in the network model utilizing the output of inventory survey conducted in this Study.

According to the result of future land use projection, the branch network condition remains unchanged except for the lowest reaches of Bolgoda Canal. If the proposed runway extension of Ratmalana Airport is realized, Bolgoda canal flows into Weras Ganga swamp directly. As a future branch network condition, the runway extension was taken into account as seen in Figure 14.6.

(3) Basin Runoff Model

The Weras Ganga basin is divided into 187 sub-catchments with area of less than 1 km^2 (100 ha) in the light of the branch network model described above. NAM, lumped and conceptual basin runoff model, is utilized. Parametering concept of this NAM basin runoff model is same as the Master Plan Study, that is, four land use/surface categories are set for fixing NAM parameters referring to the present and future land use maps drawn up in the Study.

14.3.2 Results of Flood Runoff and Inundation Analysis

Simulated peak flood water level and runoff under present and future conditions at these 6 points for 5 return periods, i.e., 2-, 5-, 10-, 25- and 50-yr, is presented in Table 14.1.

The 50-year probable flood water level and runoff hydrographs under present and future conditions at six selected points are presented in Figure 14.7. Due to urbanization especially in the eastern area of the basin, peak flood runoffs at all points increases. At Weras Ganga outfall, 50-year probable flood runoff discharge is assumed to increase from 94 m^3/sec to 113 m^3/sec (increase rate: 20%).

Figure 14.8 shows simulated flood inundation area with return periods of 2-, 10-, and 50-year. The rate of increase in the total inundation area due to the urbanization and low-land filling is not so large as seen in the figure. Total inundation area is assumed to increase from 721 ha to 778 ha (+8%) in 2-year probable flood and from 1,101 ha to 1,180 ha (+7%) in 50-year probable flood. Inundation depth is large at Bellanwila-Attidiya marsh and at the middle reaches of Maha Ela. The ground elevation of those area is relatively low and back water effect caused by the bridge and culvert is very remarkable at Maha Ela middle reaches.

Tables 14.2 and 14.3 show estimated flood inundation area by land use category under present and future land use conditions respectively.

CHAPTER 15 FORMULATION OF PRIORITY PROJECT

15.1 Socio-economic Framework

15.1.1 Population Framework

Population framework is formulated based on the development strategy in the CMRSP and detailed strategy for specific areas set by UDA after publication of the CMRSP. The urban population growth rate estimated in the CMRSP is 2.4% which is higher than the CMR average of 1.4%.

In the CMRSP, the target for the future population density is proposed. Proposed population density for the Core Area is 120 persons per ha, and for high density areas, the population density allowed is set as high as 300 persons per ha. Based on the strategy specified in CMRSP, UDA is currently preparing development plans for Local Authorities, which include proposed population density.

Based on the basic assumption and projected population density of Weras Ganga Basin, population for 2010 is estimated. Total population of Weras Ganga Basin is estimated to be 483,000, which is 1.26 times larger than 2001 level. The population density will be 87 persons/ha.

Estimated Population of the Project Area in 2010

DS Divisions	Population (2001)	Projected Population (2010)	Estimated Annual Increase Rate (%)
Dehiwala - Mount Lavinia	48,000	57,000	1.88
Ratmalana	69,000	83,000	1.88
Moratuwa	48,000	60,000	2.38
Sri Jayawardenapura Kotte	30,000	39,000	2.68
Maharagama	54,000	71,000	2.68
Kesbewa	134,000	173,000	2.87
Weras Ganga Basin	382,000	483,000	2.37

Note: Prepared by JICA Study Team based on CMRSP

Projected Population Density

(Unit: Persons/ha)

DS Divisions	Population Density (2001)	Projected Population Density (2010)
Dehiwala - Mount Lavinia	132	159
Ratmalana	87	105
Moratuwa	106	135
Sri Jayawardenapura Kotte	49	64
Maharagama	69	89
Kesbewa	52	68
Weras Ganga Basin	69	87

Note: Estimated by JICA Study Team

15.1.2 Economic Framework

According to "Vision 2010 Sri Lanka", Sri Lanka's GDP growth rate is targeted between 7% and 8% during the decade up to 2010. The leading growth sectors will be manufacturing and services-related activities such as information technology, electronics, communications, transshipment and financial and business services. The emphasis of a macro perspective will be on increasing value addition, together with the efficient utilization and processing of domestic resources. The following table shows macro economic indicators set in the Vision 2010.

Macro Economic Indicators, 2000-2010

Item	2000	2003	2006	2008	2010
GDP Growth Rate (%)	6.0	6.3	7.4	7.6	8.2
Unemployment Rate (%)	7.4	6.3	5.1	3.8	3.0
Inflation (%)	6.2	5.9	3.9	3.5	3.5
Per Capita Income (US$)	897	1,100	1,380	1,945	2,490

Sources: Vision 2010 Sri Lanka, National Planning Department, Ministry of Finance and Planning

The economic framework set for the Master Plan is used as the base for setting the economic framework for Weras Ganga Basin. Additional information concerning the economic activities of the area is also used to analyze the trend of economic activities.

The expected trends of economic activities in Weras Ganga Basin are summarized below.

1) Agricultural activity will decrease due to decrease in agricultural area and decrease in the number of farmers.
2) Manufacturing will still be one of major economic activities, but because of the restriction of industrial activities proposed in the CMRSP, manufacturing is limited in designated industrial estate such as Ratmalana. Only small scale factories and environmentally friendly factories are allowed outside the estate.
3) Commercial activities will be developed to accommodate increased population and to replace some industrial activities to be relocated to outside Weras Ganga Basin.
4) Housing development will be accelerated to supply housing for increased population from Colombo and from other areas of Sri Lanka.
5) Tourism will be developed and contribute to the economy of the area. The Government is trying to provide recreational facilities similar to Galle Face in Colombo. UDA is planning recreational development along Weras Ganga, and other recreational activities will emerge after the flood is controlled. Facilities like parks and restaurants are expected to be

constructed.

Economic Framework of Weras Ganga Basin

Sector	Growth Rate (2001-05) (%)	Growth Rate (2006-10) (%)	GRDP (Rs. million)	Sector Share (%)
Agriculture	1.6	1.6	481	0.6
Industry	6.3	7.0	27,335	31.8
Service	9.9	10.9	58,034	67.6
Weras Ganga Basin	8.4	9.5	*85,851	100.0

Note: Estimated by JICA Study Team
* The figure may not match the target in "Vision 2010" because of different source and different method of calculation.

15.1.3 Future Properties

(1) Land Value

Land value is determined by the location and the condition of land such as primary area, secondary area, and tertiary area. Average land value is calculated from the information provided by Local Authorities. The land value of highly urbanized area such as Dehiwala - Mount Lavinia is high, which is close to three times higher than land values in not so urbanized areas such as Kesbewa. The condition of the land also is an important factor of determination of the land value. The difference between high value area and low value area is as large as three times.

In the past 10 years, the rate of land value increase was high in the early 1990s and low in late 1990s. The average increase rate for the period of 1990 to 1995 was 5% and the rate for the period of 1996 to 2001 was 4%.

The Government intends to stimulate land transaction by changing laws to promote of housing development as one of the measures for the economic reform plan and active land transaction is expected. In addition, the demand for housing in Weras Ganga Basin is expected to be high due to migration from other areas of Sri Lanka.

Based on the condition mentioned above, the land value in Weras Ganga Basin continues to be high even though the Government has tried to lower the inflation rate to 3.5%. The annual increase rate for the land value is set as 4%. The table below shows the expected land value in 2010.

Average Land Value by Land Use in 2010

(Unit: Rs./m^2)

DS Division	Land Use (Land Condition)		
	High Area	Medium Area	Low Area
Dehiwala - Mount Lavinia	12,639	8,252	4,226
Ratmalana	8,617	6,838	5,443
Moratuwa	8,558	4,979	3,628
Sri Jayawardenapura Kotte	9,936	7,196	3,731
Maharagama	7,233	6,140	n.a.

Kesbewa	4,310	3,007	2,208

Note: Estimated by JICA Study Team

(2) Building Value

Building value is summarized from the registered value to the Local Authority. Building value also shows the same trend as land value. Weras Ganga west tends to show high value compared with the value in Weras Ganga east. The values in 2010 are estimated based on economic growth for which 8.4% is applied.

Average Building Value by Utilization in 2010

(Unit: Rs./m^2)

DS Division	Property Utilization			
	Residential	(unit value)	Commercial	Factory
Dehiwala - Mount Lavinia	18,873	(3,623,616)	31,723	20,666
Ratmalana	12,309	(2,363,328)	23,452	20,261
Moratuwa	12,309	(2,363,328)	23,452	20,261
Sri Jayawardenapura Kotte	14,147	(2,716,224)	21,771	19,451
Maharagama	9,422	(1,809,024)	11,819	18,236
Kesbewa	6,258	(1,201,536)	6,258	6,630

Note: Estimated by JICA Study Team
Unit value is calculated based on the average size of building of the area, 192 m^2

15.2 Future Land Use

15.2.1 Spatial Trends in the Feasibility Study Area

In order to characterize the change of land use and its spatial trends, changes of land use patterns in the study area are examined, including examining historical materials and with a visual comparison of aerial photos between 1981 and 2000.

Following major changes are observed:

1) Paddy compartment disappears in the lowland, because cultivation has been abandoned. Paddy was converted into marsh or grassland.
2) Artificial transformation of land (i.e., large-scale land filling) was also observed at the western part of the Attidiya Marsh. These transformations were carried out by the NHDA/SLLRDC housing scheme or private companies such as CEILINCO in order to develop the residential area.

3) Encroachment to lowland is also observed at Thumbowila in the east bank of the Weras Ganga. Several low-quality settlements characterized by the high building density can be identified at several points of the riverine area of Weras Ganga, which was formed because of the land filling of lowland.
4) Trends in urbanization along the road can be observed, especially at the upper area of Weras Ganga, such as Nugegoda and Maharagama. Some are established as commercial centers.
5) Conversion of vegetative area into residential area can be identified in the area of Sadamulla area, a southern part of the study area.

15.2.2 Proposal/Development Plan for the Feasibility Study Area

(1) Zoning Plan by UDA

General zoning plan along the Weras Ganga was drafted by UDA in 1991. The proposal is comprised of following zones, such as:

1) Core Area of the marsh to preserve
2) Proposed Green belt/open spaces in the area outside of the core area
3) Industrial Estate along the eastern side of the Horana road
4) Lake extension to the eastward direction
5) Potential area for tourism in the center of the area as a strip along the west bank of Weras Ganga.
6) Middle-class housing scheme at the north-eastern part of the Core Area of the Welawatta-Attidiya Marsh.
7) Middle-class housing scheme at the west bank of Weras Ganga, and
8) Housing scheme at the northern part of the Depawa Ela near Werahera

(2) Master Plan for Lowland by UDA

In 1996, Environmental and Landscape Planning Division of UDA proposed a master plan for lowland. Although this plan mainly focuses on the lowland in the Core Area in the CMR Structure plan, especially around the Parliament Lake in Sri Jayawardenapura Kotte Municipal Council, the north-eastern part of catchment area of Weras Ganga is also included in the map extent. The lowlands are divided into three categories; (a) nature park, (b) parks and play ground, (c) nature park/special recreational project (golf)/agricultural/tree crop, etc.

(3) Bellanwila-Attidiya Wildlife Sanctuary

Conservation on the Bellanwila-Attidiya Wildlife Sanctuary has been debated for a decade. Historically, this marsh was declared as a sanctuary under the Flora and Fauna Protection Ordinance by gazette notification in July 25, 1990. CEA Wetland conservation report in 1994 summarizes its history, characteristics of ecosystem, and threat to the marsh, and recommends a conservation plan in the area. Although the area still has a legal status on the sanctuary, the quality of the marsh as a habitat has already been degraded, compared to the last 10 years when the report was prepared.

15.2.3 Development Projects

The following projects are anticipated to trigger large-scale change of land use. Locations of the projects are shown in Figure 15.1.

(1) Ratmalana Airport Expansion Project

Runway expansion project at Ratmalana Airport, which was initiated by the Ratmalana Airport Authorities, was emerging at the beginning of 1990's. The purpose of the project is to expand the runway, which enables large-scale aircraft or small jet to land or take off. The proposal comprises a 2,000 feet (610 m) expansion of runway to the direction of marsh and 28 ha of land-filling. For security reasons, a buffer zone around the runway edge is also planned. In order to keep the retention area, some private land is to be acquired by the Airport Authority for the purpose of establishing a retention area in the area of south-eastern part of Boralesgamuwa. The plan contains a shift of the existing channel to the eastern side and directly connecting to the lake at downstream, thus there might be some impact to the drainage of Weras Ganga.

(2) Police Academy Project

Police Academy Project is a project that aims to construct a training center for police officers as well as housing at the Badowita tract, located at the west part of the Bellanwila-Attidiya marsh. The project is initiated by the Police Department and filling-up the land is conducted by SLLRDC. In addition to the academy for police officers, the proposal includes some residential use for people working in the area. Part of the proposed site has already been reclaimed by SLLRDC. Some ten acres of the backyard of the proposed site is planned to be reserved as a retention area.

(3) Bolaresgamuwa Theme Park Project

Bolaresgamuwa Theme Park Project is a project initiated by Sri Lanka Ceramic Corporation, a private company with technical assistance from UDA. The project site is located in the area marked (b) in an abandoned kaolin refinery site owned by a private company along the swamp of Weras Ganga. Layout plan for several facilities is designed to maximize the use of existing conditions of the riverine environment, and several facilities are designed to be submerged when high water level arises. It appears that this project will not affect the flow regime of the Weras Ganga, although a precise study will be carried out at the drainage plan section of this report. The project will be operated by the company and construction is expected to start in 2003.

(4) Baseline Road Extension Project

There is also a plan, by RDA, to extend the Baseline Road to the Ratmalana Airport. The land for the development road has already been acquired by RDA, which was reclaimed by SLLRDC.

15.2.4 Driving Forces of the Land Use Change in the Feasibility Study Area

The major phenomena that can be identified in this area are the processes of urban sprawl in the high land and land-filling in lowland. As mentioned in the Master Plan study, urban sprawl, which means the expansion of built-up area, could be conditioned by four factors, such as population density factors, transportation factors, planning factors and limiting factors. The factors and their criteria, and the rules of change are summarized below:

Factors and Rule of Changes

Factors	Rule of Change
Density Factor	**Rule #1**: Areas with a building density of 5 buildings per hectares building per hectare are to be upgraded to 10-20 buildings per hectares. Due to this change, the area that falls into the categories in garden will be turned into the categories of homestead. **Rule #2** : Area that comprise few buildings in large lot, such as universities, institute, large-scale private companies, will not be affected by rule #1.
Transportation Factor	**Rule #3** Major road buffer within 500 meters are changed. **Rule #4** Two kilometers from the town centers, such as Maharagama and Piliyandara is to be urbanized to the categories of homestead, and one kilometers form the town centers are converted into the categories of high-density.
Planning Factor	**Rule #5** Police Academy Project and the Ratmalana Airport Expansion project is to be implemented
Limiting Factor	**Rule #6** Paddy, represented as a category of grassland, is to be converted into homestead use. **Rule #7** Paddy land still cultivated still remains as a paddy land.

15.2.5 Future Patterns of Land Use in the Feasibility Study Area

Figure 15.2 shows the future pattern of land use in the study area, and the Table 15.1 shows the transition matrix between categories. Transition matrix is a matrix that can explicitly represent the causal change between categories. For each category of land use, the amounts to be converted and its use could be identified diagonal elements represent the amount of land that cannot affect the change. The matrix indicates that 851 ha of garden land is likely to be converted to homestead category.

The results of change between present situation and future (forecast) situation show that, although the share of urbanized use does not change significantly, compositional change between categories occurs, especially between garden categories and homestead categories. The share of homestead area grows rapidly, increasing to 50.3%. In terms of natural use, the share of paddy lands remains even, while marsh and vegetation categories are on the decline, triggered by the expansion of airport runway. This result does not include the implementation of the housing scheme. However, if these schemes are to be implemented, an additional 3.6 ha will be converted from marsh category to high-density categories.

Comparison between Present and Future Land Use

Categories	Present		Future	
	Area Extent (ha)	Percentage	Area Extent (ha)	Percentage
Urbanized Use	4,183	80.6	4,285	82.6
(a) Very High Density	22	0.4	30	0.5
(b) High Density Area	818	15.8	883	17.0
(c) Homestead	1,447	27.9	2,612	50.3
(d) Garden	1,310	25.3	458	8.8
(e) Grassland	229	4.4	0	0
(f) Airport	139	2.7	166	3.2
(g) Factory	136	2.6	136	0.2
(h) Vacant	75	1.4	0	0
(i) Dumping Site	8	0.2	0	0
Natural/Rural Use	1,001	19.3	899	17.3
Paddy	359	6.9	359	6.9
Marsh	302	5.8	293	5.6
Vegetation	219	4.2	126	2.4
Water	121	2.3	121	2.3
Total	5,184	100.0	5,184	100.0

15.3 Selection Component Schemes of Priority Project

15.3.1 Weras Ganga Basin Storm Water Drainage Plan

As concluded in the Master Plan, the proposed Weras Ganga Basin Storm Water Drainage Plan comprises the seven component schemes as summarized below:

1) Weras Ganga Scheme
   - Weras Ganga Dredging: length 5,500 m
   - Flood Protection Wall on Right Bank: length: 2,300 m
   - 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: length 1,580 m

- Channel Improvement of Delkanda Ela: length 1,760 m
- Channel Improvement of Rattanapitiya Ela: length 2,130 m
- Retention Areas: total extent 36 ha

3) Bolgoda Canal Scheme

- Channel Improvement of Bolgoda Canal: length 2,400 m
- Bellanwila-Attidiya Marsh Retention Area: 88 ha

4) Boralesgamuwa North Scheme

- Channel Improvement of Depawa Ela: length 3,090 m

5) Boralesgamuwa South Scheme

- Channel Improvement of Werahara Tributary: length 980 m

6) Maha Ela Scheme

- Channel Improvement of Maha Ela: length 2,700 m
- Channel Improvement of Maha Ela Tributary: length 1,760 m

7) Ratmalana-Moratuwa Scheme

- Urban Drainage Improvement: 11,120 m
- Kandawala Retention Pond: 3 ha
- Telawala Retention Pond: 10 ha
- Channel Improvement of Katubedda Tributary: length 1,250 m

The priority project subject to the feasibility study is composed of the component schemes which need to be implemented in the early stage of the Master Plan.

15.3.2 Evaluation and Selection of Component Schemes

(1) Economic Evaluation

The result of evaluation for the proposed projects for each basin is expressed in B-C (Rs. million), B/C and EIRR (%). Economic feasibility line of the project is considered to be positive figure for B-C, one or above for B/C and 10% or higher for EIRR, which is based on the discount rate of 10%. The results of evaluation for sub-basin are summarized below.

Economic Evaluation for Weras Ganga Basin Storm Water Drainage Plan

Scheme	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B-C (million Rs.)	B/C	EIRR (%)
(1) Nugegoda-Rattanapitiya	1,316	204	576	1.75	16.1
(2) Bolgoda Canal	458	87	760	2.08	17.9
(3) Boralesgamuwa North	279	44	122	1.74	16.1
(4) Boralesgamuwa South	137	17	37	1.45	13.8
(5) Maha Ela	626	121	442	2.16	18.7
(6) Ratmalana-Moratuwa	1,299	213	308	1.95	16.9
(7) Weras Ganga Scheme	986	98	128	1.21	10.9

The results of economic evaluation reflect the different urbanized conditions and distribution of flood prone areas by sub-basin. The schemes located in the northern and western part of the Wears Ganga basin indicate relatively higher economic viability.

(2) Selection of Component Schemes

The Weras Ganga Scheme shows relatively lower economic viability. However, the Weras Ganga Scheme envisages alleviating direct flood damage in the densely urbanized lowland on the right bank as well as improving the principal drainage channels such as Bolgoda Cana and Rattanapitiya Ela connecting to the Weras Ganga by increasing its flow capacity. Therefore, it is desirable to proceed with the Weras Ganga Scheme from the early stage of the storm water drainage plan for the Weras Ganga basin for ensuring the improvement of the Bolgoda Canal sub-basin and Nugegoda-Rattanapitiya sub-basin.

It is also essential to initiate conservation of the proposed storm water retention areas by restricting unauthorized land filling of existing marsh designated as retention area. The Schemes including the proposed storm water retention areas, i.e., Weras Ganga Scheme, Nugogoda Rattanapitiya Scheme and Bolgoda Canal Scheme need to be implemented earlier.

The Ratmalana-Moratuwa Scheme consists of the two sub-components such as the urban drainage improvement in Kandawala and Telawala areas on the right bank of the Weras Ganga and channel improvement of the Katubedda Tributary. The urban drainage improvement in Kandawala and Telawala areas is an urgent need in the light of the flooding situations as indicated by the flood damage surveys 1995 and 2001. The channel improvement of the Katubedda Tributary will be required in consideration of a future development envisaged around the surrounding lowland. However, the channel improvement of the Katubedda Tributary is not prioritized as the envisaged development is still conceptual basis at present.

As a conclusion of the considerations above, the following component schemes are selected for the proposed priority project subject to the subsequent feasibility study:

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

Locations of the selected schemes are shown in Figure 15.3.

15.4 Structural Measures

15.4.1 Planning Scale and Design Flood Runoff

(1) Planning Scale

The planning scales for the component schemes of the priority project follow those as proposed for the Master Plan. The planning scale of 50-year return period is a long term target for the storm water drainage plan in the Weras Ganga basin by the proposed improvement of the main stream combined with the retention areas. The Weras Ganga main stream and retention areas are fundamental elements for improvement of storm water drainage in the Weras Ganga basin. In particular, conservation of the proposed retention areas is urgently required for restricting unauthorized land filling in progress at present. From these view points, the channel improvement of the Weras Ganga and conservation of the retention areas need to be initiated under the priority project for attaining the long term target in the future.

Planning Scale for Priority Project

Classification	Name of River /Drainage Channel	Drainage Area (km^2)	Planning Scale (Return Period: Years)
Main Stream	• Weras Ganga	55.5	50
Major Tributary	• Bolgoda Canal • Rattanapitiya Ela	20.8 8.1	10 10
Minor Tributary	• Delkanda Ela • Nugegoda Ela	3.3 3.9	10 10
Urban Drainage Channel	• Kandawala Triburary • Telawala Tributary • Connecting Drains	1.3 1.7	2 2 2

(2) Design Flood Runoff

Resulting from the hydrological analysis discussed in Chapter 14, diagrams of flood runoff distribution in the Weras Ganga basin for the probable 10- and 50-year rainstorm event under the future land use condition are shown in Figures 15.4 and 15.5.

For planning purposes, the basic flood runoff is estimated on the condition that runoff retention effect in the basin except the Weras Ganga swamp is not considered and storm water runoff is therefore confined within river channels. Distribution diagrams of basic flood runoff in the Weras Ganga basin for the probable 10- and 50-year rainstorm event under the future land use condition are shown in Figures 15.6 and 15.7.

Design flood runoff is estimated subsequently for discharging basic flood runoff safely through rivers and drainage channels in combination with storm water retention areas. Basic flood runoff is distributed to river, drainage channel and storm water retention area, respectively. River and drainage channels are assumed to be widened with sufficient flow capacity designated by planning scale for discharging corresponding storm water runoff reduced from basic flood runoff by effect of storm water retention area. Distribution diagrams of design flood runoff in the Weras Ganga basin for the probable 10- and 50-year rainstorm event under the future land use condition are shown in Figures 15.8 and 15.9.

Estimated Flood Runoff for Weras Ganga (50-year Return Period)

Location	Probable Flood (m^3/sec)	Basic Flood (m^3/sec)	Design Flood (m^3/sec)
Weras Ganga at Borupana Bridge	71	185	79
Weras Ganga at Maha Ela Confluence	107	291	156
Weras Ganga at Kospalana Bridge	126	312	164

Estimated Flood Runoff for Priority Project (10-year Return Period)

Location	Probable Flood (m^3/sec)	Basic Flood (m^3/sec)	Design Flood (m^3/sec)
Nugegoda Ela at Pepiliyana Road	17	34	24
Delkanda Ela at Wela Road	26	37	29
Rattanapitiya Ela at Colombo-Piliyandala Road	43	71	53
Bolgoda Canal at Rattanapitiya Ela Confluence	29	82	37
Bolgoda Canal at Elewalla Road	41	106	51

15.4.2 Component Schemes of Priority Project

(1) Weras Ganga Scheme

A general layout plan of the Weras Ganga Scheme is shown in Figure 15.10. The Weras Ganga Scheme envisages alleviating direct flood damage in the densely urbanized lowland on the right bank as well as improving the principal drainage channels such as Bolgoda Canal and Rattanapitiya Ela connecting to the Weras Ganga by increasing its flow capacity. The structure measures for storm water drainage improvement are proposed as follows:

1) Conservation of two major storm water retention areas, i.e., Weras Ganga Swamp Retention Area (65 ha) and Maha Ela Marsh Retention Area (106 ha)
2) Dredging of riverbed (length 5,500 m and width 19 m to 40 m)
3) Flood protection for the densely urbanized lowland in Kandawala-Telawala area on the right bank (length 2,300 m)

(2) Nugegoda-Rattanapitiya Scheme

A general layout plan of the Weras Ganga Scheme is shown in Figure 15.11. The Nugegoda-Rattanapitiya sub-basin is located in the northern part of the Weras Ganga basin and is already highly urbanized. Inundation takes place not only the Rattanapitiya Ela in the lower reaches but also the Nugegoda Ela and Delkanda Ela in the middle and upper reaches.

The Rattanapilitya Ela in the urbanized area is affected by backwater from the downstream reaches in the Bellanwila-Attidia Marsh, where storm water runoff becomes stagnant due to obstruction by riverbed deposit and water plants. The stretch of the Delkanda Ela downstream of the High Level Road becomes narrow due to restriction by houses. The Nugegoda Ela faces the inconsistency of the channel alignment in upper stretch as well as the less flow capacity and obstruction by under-sized crossing in the unimproved lower stretch. The proposed structure measures for alleviating the problems above are listed below:

1) Channel improvement of Rattanapitiya Ela (length 2,130 m)
2) Channel improvement of Delkanda Ela (length 1,760 m)
3) Channel improvement of Nugegoda Ela (1,580 m)
4) Conservation of retention areas in the middle reaches, i.e., Upper Nugegoda Ela Retention Area, Lower Nugegoda Ela Retention Area and Delkanda Ela Retention Area (total extent 36 ha)

(3) Bolgoda Canal Scheme

A general layout plan of the Weras Ganga Scheme is shown in Figure 15.12. The downstream stretch of the Bolgoda Canal to the Weras Ganga is completely filled up with water plants and does not function as a drainage channel at all. For augmentation of storm water drainage in the Bolgoda Canal sub-basin as well as the Nugegoda-Rattanapitiya sub-basin, the downstream stretch of Bolgoda Canal should be restored. The proposed structure measures for the Bolgoda Canal sub-basin are listed below:

1) Channel improvement of Bolgoda Canal lower reaches (length 2,400 m)
2) Conservation of Bellanwila-Attidiya Marsh Retention Area (88 ha)

(4) Ratmalana-Moratuwa Scheme (Urban Drainage Improvement of Kandawala and Telawala Areas)

A general layout plan of the Weras Ganga Scheme is shown in Figure 15.13. Besides the direct affect by the Weras Ganga flooding, the highly urbanized area along the Weras Ganga right bank from Kandawala to Telawala is prone to storm water drainage congestion because of the low-lying topography. The urban drainage improvement in Kandawala and Telawala areas covers the drainage area between the Galle Road and Weras Ganga with an extent of 3.3 km^2.

1) Construction or improvement of urban drainage channels (total length 11,120 m)
2) Construction of storm water retention ponds such as Kandawala Pond (3 ha) and Telawala Pond (10 ha)

15.4.3 Studies on Component Schemes

Preliminary features of the component schemes have been studied as discussed in Annex 7 of Volume IV: Supporting Report (2). In this section, several supplementary technical issues are discussed for preparing definitive features of the priority project.

(1) Weras Ganga Scheme

1) Dredging Width

The total length of the proposed dredging is 5,500 m. The design bed for dredging is level at 1.5 m below MSL in consideration of the bed level of the North Bolgoda Lake. Dredging width is designed on the basis of the present opening width at the Kospalana Bridge. The Kospalana bridge is constructed with 12 m × 3-span. The total width of opening is 40 m including the spans and piers. This width is the minimum in the Weras Ganga and is regarded as a normal flow width maintained by water flow created by difference of water level between upstream and downstream. Therefore, the dredging width 40 m corresponding to the opening at the Kospalana bridge is proposed.

2) Channel Width

It is difficult to define the channel width of the Weras Ganga as it comprises a quite shallow depth at the normal flow condition and associated marsh. From the confluence of the Bolgoda Canal to Kospalana bridge, water depth of the Weras Ganga is less than 1 m with the surface width varying from 60 to 600 m. Water surface width becomes larger as water level rising during flood. The water surface width under the probable 50-year flood is estimated in a range of 100 to 700 m in the Weras Ganga.

In the most downstream stretch from Kospalana bridge to confluence of the Katubedda triburary, the channel width of the Weras Ganga is relatively stable with a water surface width varying from 130 to 170 m in the normal flow condition. The water surface width is estimated in a rage of 140 to 190 m under the probable 50-year flood. The highest water level by the probable 50-year flood varies from 0.7 to 0.9 m above MSL. In this stretch, lowland with the ground elevation less than 1 m is limited only along the channel. Therefore, problems by the Weras Ganga flooding do not expand largely when the existing channel width is maintained. The Kospalana bridge limits the channel width to its opening of 40 m. Although such a bottle-neck is not preferable against flood, influence by this bottle-neck would not be significant because the water level around the bridge is mainly subject to the water level in the North Bolgoda Lake.

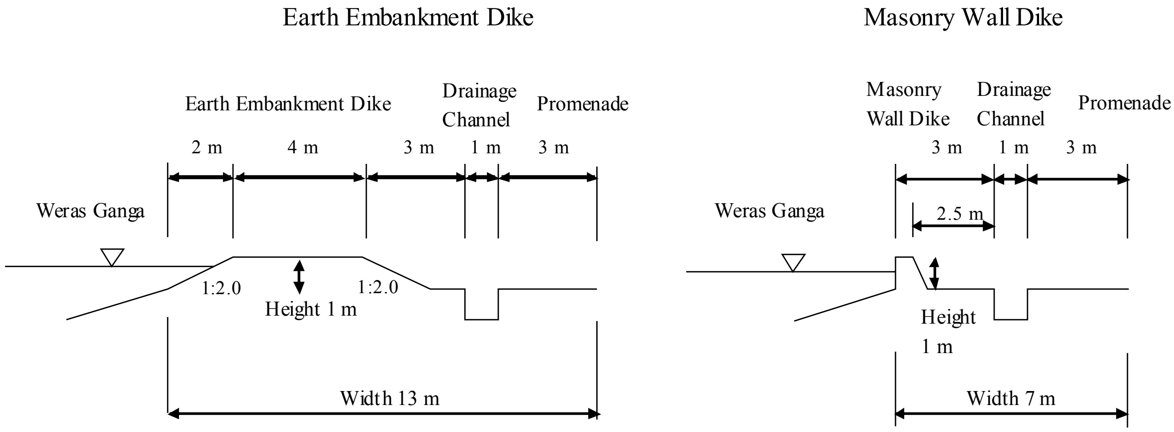
The stretch from the Katubedda tributary to Telawala Tributary indicates a quite large water surface with 220 to 620 m width under normal flow condition. In the subsequent stretch to 150 m downstream of the Borupana bridge, the masonry wall dike is proposed on the right bank. The left bank is occupied by the retention area of the Maha Ela Marsh.

The rest of the stretch to the downstream end of the Weras Ganga is subject to water level rising with the increase of storm water runoff after improvement of the Bolgoda Canal and the Weras Ganga dredging. A required channel width in this stretch is therefore studied. Figure 15.14 shows the estimated water surface profiles of the Weras Ganga. As seen in the profiles, the channel width of 100 m lowers the water level in the upstream of the Borupana bridge but increases the water level in the downstream due to the increase of storm water runoff in line with the flow capacity enlarged by the channel improvement. Meanwhile, the channel width around 70 to 80 m lowers the water level in the upstream of the Borupana bridge and minimizes the water level rising in the downstream. Consequently, the required channel width is in a range of 70 to 80 m for this stretch.

3) Flood Protection on Right Bank

The Weras Ganga right bank from Kandawala to Telawala is elevated with a dike (flood bund) to prevent the densely populated lowland from the Weras Ganga flood. The required crest level of the dike is 1.3 m above MSL, which comprises the probable 50-year flood level of 1.0 m above MSL plus 0.3 m freeboard. The height of the dike is therefore 1.3 m or less from the ground.

For constructing this low-height dike, a masonry wall is proposed instead of earth embankment. The masonry wall dike also minimizes the required width of land for construction in consideration of the present built-up condition along the right bank. The proposed dike is made of masonry wall with promenade and drainage canal. The required width for construction is 7 m, which is 6 m less than required for the earth embankment.



Comparison of Dike

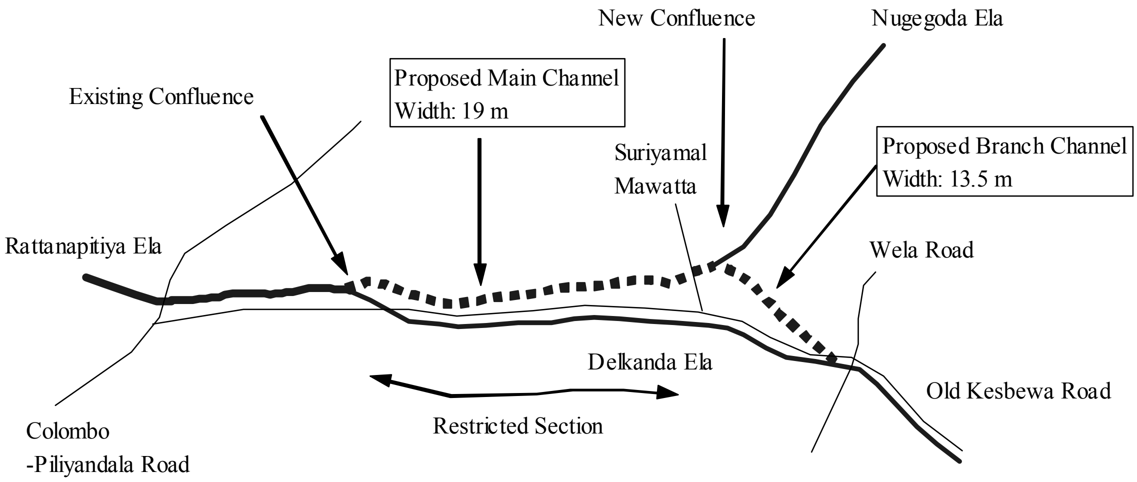
(2) Nugegoda-Rattanapitiya Scheme

In the Nugegoda-Rattanapitiya sub-basin, the Delkanda Ela becomes narrow between the existing confluence of the Nugegoda Ela and Suriyamal Mawatta with a length of 600 m. This stretch has a flow capacity less than 2-year return period due to the narrow width as well as under-sized crossing culverts. Overflow of this stretch is a major cause of inundation in the Delkanda Ela downstream reaches of the Wela Road.

The Delkanda Ela needs to be widened largely with 13.5 m to cope with the design runoff of 22 m^3/sec for 10-year return period. The existing width is 7 m on average. The right bank of the stretch is mostly occupied by the shoulder of the Old Kesbewa Road. The left bank is also restricted by middle-class houses in places. Therefore, the widening of this stretch is rather difficult in compliance with relocation and compensation issues.

In the upstream area, there is some extent of lowland in the other side of the Old Kesbewa Road. This lowland extends along the Nugegoda Ela to the existing confluence of the Delkanda Ela. An alternative channel alignment is therefore conceivable to divert and connect the Delkanda Ela with Nugegoda Ela just upstream of the Suriyamal Mawatta in the lowland. A new confluence is located around 600 m upstream from the existing confluence.

The design runoff in the stretch downstream of the new confluence is 53 m^3/sec for 10-year return period. The channel width is designed with 19 m between the Suriyamal Mawatta and the existing confluence, which is the same width as for the channel improvement of the Rattanapitiya Ela.



Proposed Channel Alignment of Nugegoda-Rattanapitiya Scheme

(3) Bolgoda Canal Scheme

1) Diversion of Bolgoda Canal to Weras Ganga Swamp

In the vicinity of the Bolgoda Canal, the expansion plan of the Ratmalana Airport runway is under consideration. According to the expansion plan, a land filling area for expansion of embankment for the airport runway covers the existing channel downstream of the existing flood gate under management of the Irrigation Department. Together with the land filling for expansion of the airport runway, construction of a diversion channel is envisaged along the edge of the land filling area for connecting the Bolgoda Canal with the swamp of the Weras Ganga. This diversion is incorporated with the Scheme because any remarkable difference is not expected in hydraulic conditions between use of the existing channel and the diversion channel.

The channel improvement comprises removal of water plants, excavation/dredging, and provision of maintenance road. The stretch downstream of the Attidiya Road is completely filled up with water plants at present. Water plants will be removed and the channel bed dredged to the bed elevation of 1.5 m below MSL.

2) Envisaged Dredging from Hill Street to Dehiwala Canal

An improvement plan of the Bolgoda Canal from Hill Street to Dehiwala Canal is under consideration by SLLRDC. This improvement plan envisages discharging storm water runoff from the Bolgoda Canal sub-basin to Dehiwala Canal by dredging the channel bed level down to 0 m above MSL throughout the stretch.

This improvement will contribute to reduction of storm water runoff to the Weras Ganga in the case of heavy rainstorm in the Bolgoda Canal sub-basin. Storm water runoff would come reversely from the Dehiwala Canal to Weras Ganga in case of a heavy rainstorm in the Greater Colombo basin.

There are some technical issues to be considered on the dredging of existing bed of the Bolgoda Canal. The channel is already excavated deeply around the drainage area boundary. Depth from the top of bank to the bottom of the channel is 5 m or more with a rather steep slope. For dredging the stretch around the drainage area boundary, measures for preventing the channel bank from sliding would be required. In addition, the stretch from the Pratibimbarama Road to Dehiwala Canal was improved with gabion and masonry wall under the GCFC&EIP Phase I. Treatment measures are required for the foundation of gabion and masonry wall when the channel bed is dredged in this stretch.

Dredging of the Bolgoda Canal has already been initiated from the Hill Street. However, dredging beyond the drainage area boundary still includes uncertainty on its realization from the considerations above. Therefore, the feasibility study focuses on improvement of the Bolgoda Canal for discharging storm water runoff from the Bogoda Canal sub-basin to the Weras Ganga. The channel improvement of the Bolgoda Canal is designed on the condition that all of storm water runoff from the Bolgoda Canal sub-basin is discharged into the Weras Ganga.

(4) Ratmalana-Moratuwa Scheme

The urban drainage improvement aims at alleviating drainage congestion in the lowland with the ground elevation of 1 m above MSL or less along the Weras Ganga and local drainage problems taking place frequently at higher locations. The total length of the proposed urban drainage improvement is 11,120 m, together with the two storm water retention ponds in Kandawala and Telawala.

1) Main canals discharging storm water runoff into the Weras Ganga
2) Secondary canals leading storm water runoff into the main canals or retention ponds
3) Storm water retention ponds at the downstream ends of the main canals for alleviating influence to the lowland by the Weras Ganga flood level

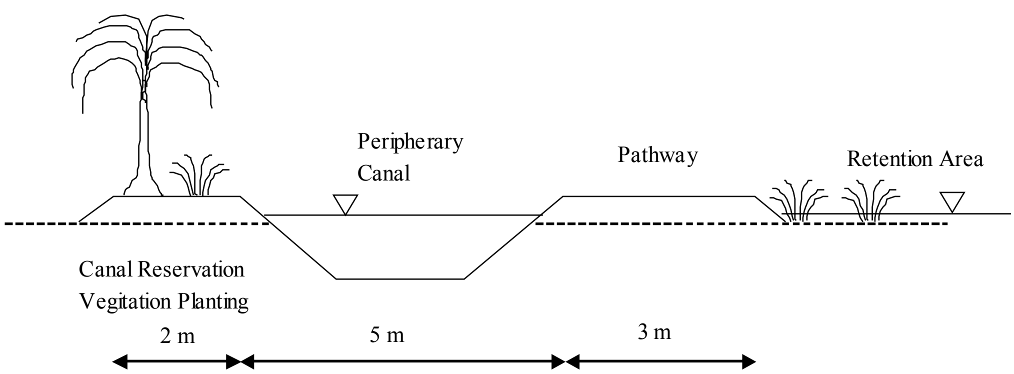
Design discharge is estimated by the same approach to the GCFC&EIP Phase III, based on the rainfall intensity in short duration with 2-year return period. The concept of the urban drainage improvement is to intercept and discharge storm water runoff to the retention ponds as much as possible for the purpose of alleviating concentration of storm water runoff to the lowland in the right bank of the Weras Ganga.

(5) Physical Measures for Conservation of Retention Area

The following proposed storm water retention areas need to be conserved by legislative restriction for land use control.

1) Upper Nugegoda Ela Retention Area, Lower Nugegoda Ela Retention Area and Delkanda Ela Retention Area (total extent 36 ha)
2) Weras Ganga Swamp Retention Area (65 ha) and Maha Ela Marsh Retention Area (106 ha)
3) Bellanwila-Attidiya Marsh Retention Area (88 ha)

Physical measures are also required for making the land use control effective by means of clear delimitation of the boundary of retention area. Such an idea is given in the conservation plan for the Bellanwila-Attidiya Marsh by UDA as shown below:



An Idea of Periphery Canal

A peripheral canal is provided along the boundary of retention area, together with promenade and vegetation. The total length of the required peripheral canal is 20,490 m as tabulated below:

Peripheral Canal for Retention Area

Retention Area	Extent (ha)	Length of Peripheral Canal (m)
Upper Nugegoda Ela	7	1,780
Lower Nugegoda Ela	20	2,110
Delkanda Ela	9	1,800
Bellanwila-Attidiya Marsh	88	4,400
Weras Ganga Swamp	65	4,400
Maha Ela Marsh	106	6,000
Total	295	20,490

15.4.4 Proposed Structural Measures

As a conclusion of the studies discussed in this section, the proposed structural measures of the priority project consists of the following:

(1) Weras Ganga Scheme

1) Weras Ganga Dredging

- Length: 5,500 m
- Dredging Width: 19 to 40m
- Dredging Volume: 150,000 m^3

2) Flood Protection Wall on Right Bank

- Type: Masonry Wall with Promenade and Drainage Canal
- Length: 2,300 m
- Total Width: 7 m

3) Weras Ganga Swamp Retention Area

- Extent: 106 ha
- Length of Periphery Canal with Promenade and Vegetation Planting: 4,400 m

4) Maha Ela Marsh Retention Area

- Extent: 106 ha
- Length of Periphery Canal with Promenade and Vegetation Planting: 6,000 m

(2) Nugegoda-Rattanapitiya Scheme

1) Channel Improvement of Nugegoda-Ela

- Length: 1,580 m
- Channel Bed Width: 5 to13 m
- Bridge: 3 locations

2) Channel Improvement of Delkanta Ela

- Length: 1,760 m
- Channel Bed Width: 3.0 to 13.5 m
- Bridge: 5 locations
- Culvert: 2 location

3) Channel Improvement of Rattanapitiya Ela

- Length: 2,130 m
- Channel Bed Width: 19 m
- Bridge: 5 locations

4) Retention Areas

- Total Extent: 106 ha
- Length of Periphery Canal with Promenade and Vegetation Planting: 5,690 m

(3) Bolgoda Canal Scheme

1) Channel Improvement of Bolgoda Canal

- Length: 2,400 m
- Channel Bed Width: 15 to 19 m
- Bridge: 1 location

2) Bellanwila-Attidiya Marsh Retention Area

- Extent: 88 ha
- Length of Periphery Canal with Promenade and Vegetation Planting: 4,400 m

(4) Ratmalana-Moratuwa Scheme (Urban Drainage Improvement in Kandawala and Telawala Area)

1) Urban Drainage Improvement

- Length: 11,120 m
- Size: 0.8m (B)×0.8m (H) to 6.0m (B) ×1.5m (H)

2) Kandawala Retention Pond: 3 ha

3) Telawala Retention Pond: 10 ha

15.5 Non-structural Measures

15.5.1 Conceivable Measures

From the viewpoint of flood damage mitigation, the measures are classified into structural and non-structural ones. The structural measures are as proposed in the previous Section 15.4.4. In this section, the non-structural measures are proposed, which will play an important role for the storm water drainage in the Weras Ganga basin.

In the study area, the following non-structural measures will be conceivable, 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

They are explained in the subsequent sub-sections.

15.5.2 Storm Water Retention Area Management

This is a sort of floodplain management. As mentioned in the proposed storm water drainage plan, a role of the storm water retention area is very important from the technical and economic viewpoints. If the storm water retention area is not provided, it is quite difficult to confine the storm water in the river channel and the solution is very expensive. Therefore, it is proposed to keep the storm water retention areas. The following retention areas to be conserved are proposed in the study. They are shown in Figure 15.15.

Proposed Storm Water Retention Areas in Weras Ganga Basin

Proposed Retention Area	Area (ha)	Sub-basin Related
Upper Nugegoda Ela	7	Nugegoda-Rattanapitiya Ela
Lower Nugegoda Ela	20	Nugegoda-Rattanapitiya Ela
Delkanda Ela	9	Nugegoda-Rattanapitiya Ela
Bellanwila-Attidiya Marsh	88	Bolgoda Canal and Nugegoda-Rattanapitiya
Weras Ganga Swamp	65	Weras Ganga and Boralesgamuwa South
Maha Ela	106	Maha Ela
Katubedda Tributaries	-	Ratmalana-Moratuwa
Thumbowila Tributaries	-	Thumbowila
Total Area	295	-

In order to properly keep those storm water retention areas, the following measures are required.

(1) Legal Designation of Storm Water Retention Area

The proposed storm water retention areas are presently functioning as a natural retention area, however no legal designation as a retention area has been made due to lack of an authorized land use map including the storm water retention areas.

In order to conserve and manage the proposed retention areas, it is necessary to clearly demarcate the retention areas. The authorized land use plan of the entire Weras Ganga basin should be prepared as early as possible before implementation of the proposed Weras Ganga basin storm water drainage project and also the proposed retention areas should be legally designated as an authorized storm water retention area based on the authorized land use map.

In addition, the designated retention area should be notified to the government agencies concerned and the public for their understandings to stop and control the illegal or unauthorized filling and uncontrolled development in the designated retention area.

It should be noted that the Bellanwila-Attidiya Marsh retention area and Weras Ganga Swamp retention area belong to the Bellanwila-Attidiya Marsh Sanctuary and also most of the retention areas are private lands. For the conservation of the retention areas, it is preferred that the Government acquire the whole storm water retention areas.

(2) Regulation of Land Use in Storm Water Retention Area

The proposed storm water retention areas are extensive open space. There may be demand to utilize the retention area for other purposes such as play ground, park, cultivation, etc. Utilization of the retention areas for the purpose other than storm water retention can be allowed under the condition that the storm water retention effect is not decreased, but it should be properly regulated by the agency concerned such as SLLRDC.

(3) Strict Legal Action for Illegal Activities

In the Weras Ganga basin, unauthorized dumping of garbage to the marsh and also unauthorized filling of the lowland have been observed at several sites in the basin. These illegal activities result in decrease of the storm water retention capacity in the basin and increase of flood damages. The illegal activities should be strictly controlled by the local authorities concerned and UDA who have powers to stop them.

15.5.3 Development Control in Urban Development Areas

The Weras Ganga basin is expected to be highly urbanized in the future because of its location adjacent to the city of Colombo. Urbanization of the basin causes increase of flood runoff. There is a limit to the increase in the discharge capacity of rivers and drainage canals with increase of flood runoff. Therefore, the urban development should be properly controlled taking into account the capacities of storm water drainage system of the basin.

It may be inevitable that development projects will be implemented in the future. To cope with this, it is proposed to compulsorily have all developers including the government agencies in charge of urban development construct flood retarding ponds, rainwater storage facilities and seepage facilities to reduce the flood runoff from the development areas.

To ensure the construction of the storm water retention facilities, legislation for mandatory construction is proposed. The main points of the legislation will be as follows referring to the Japanese Guideline on the provision of flood retarding pond.

1) The storm water retarding ponds should be constructed for all large scale development with a development area of more than 10 ha.
2) The peak runoff from the objective development area should not exceed the peak runoff under the conditions before development.
3) SLLRDC should be a responsible agency for evaluation, approval and monitoring of the development plan from storm water drainage aspect, and for providing technical guidance on plan/design of the storm water retention facilities.
4) SLLRDC should be empowered to take a legal action in contravention.

15.5.4 Land Use Regulation in Lowlands

As often seen in the Colombo Metropolitan Region, the houses affected by storm water inundation are mostly located in the lowlands which are were originally flood-prone areas. This situation is also observed in the lowlands of the Weras Ganga basin. The people living in the lowlands along the Weras Ganga are affected by high water level of the Weras Ganga.

To prevent recurrence of the same situation, it is proposed to regulate the land use in the lowland areas so as to stop dwelling in the flood-prone lowland.

15.5.5 Flood-proofing of Buildings in Flood-prone Areas

In principle, it is better to relocate the houses in the flood-prone areas such as marsh and natural flood retention areas to mitigate the flood damages. However, if it is inevitable to dwell in the flood-prone areas because of certain circumstances, flood-proofing of the buildings (houses) should be introduced. There are several types of flood-proofing such as raising of foundation ground, piloti type building, wall-fencing around house and waterproof building.

15.5.6 Dissemination of Flood Information

In the previous section 14.4, importance of conservation of the storm water retention areas is stresses. To properly conserve the retention areas, the various information such as related regulations, prohibited activities, boundaries of the retention areas, etc. should be disseminated to the public to get their understandings and awareness for the flood control.

It also will be effective to mitigate the flood damage by disseminating information on flooding condition of the residential areas and lowlands to the public. The information useful will be flooding area, flood magnitude, flood duration, flood frequency, evacuation route, etc. For this purpose, a flood hazard map is commonly prepared although it needs detailed topographic maps to accurately forecast the inundation area and depth.

Based on the information disseminated, the people may avoid dwelling in the areas with flooding risk such as lowlands and also learn how to cope with flood.