SUPPORTING REPORT (2)

ANNEX 7 : STORM WATER DRAINAGE

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

FINAL REPORT

VOLUME IV : SUPPORTING REPORT (2)

ANNEX 7 : STORM WATER DRAINAGE

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CHAPTER 1 EXISTING STORM WATER DRAINAGE SYSTEMS

1.1 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 1.1.1. The extent of the drainage area is 55.5 km^2.

The highly urbanized areas expanding from Colombo MC spread over the northern part of the basin covered by Sri Jayawardenapura Kotte MC, Dehiwala-Mount Lavinia MC and Maharagama UC. The western part of the basin bordered by the Galle Road is also highly urbanized with residential and industrial areas in Dehiwala - Mount Lavinia MC and Moratuwa MC. The eastern part of the basin is mostly occupied with Kesbewa PS comprising urbanized areas in elevated lands and partly cultivated lowlands.

The Weras Ganga basin is drained by several tributaries and is broadly divided into the seven sub-basins.

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.

1.2 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 1.1.2. 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.

The upstream part of the sub-basin is covered with the densely urbanized area expanding to the downstream direction. Unused lowlands still remain along the principal drainage channels and branched urban drainage channels but are gradually filled with buildings and houses from the border. The most downstream of the sub-basin is covered by the Bellanwila-Attidiya Marsh.

1.3 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 1.1.3.

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.

The upper part of the northern sub-basin is occupied by the highly urbanized area expanding from Colombo MC. The lower reaches in the southern part of the sub-basin are mostly covered lowland with marsh area expanding from the Weras Ganga. On the right bank of the Bolgoda Canal, the Kawdana, Attidiya and Bellanwila areas to the west of the Attidiya Road were marsh areas in the past but have been developed with land filling for housing estates. The GCFC&EIP Phase III for urban drainage improvement is being implemented in these areas. Development with land filling is also ongoing on the right bank in and around the Police Academy compound being constructed.

The marsh area expanding over the downstream of the Attidiya Road is called the Bellanwila-Attidiya Marsh designated as a wetland for conservation by the government in 1990's. But the marsh is subject to encroachment by unauthorized land filling around its border in the right bank area. On the right bank vicinity of the Elawella Road, there is a garbage dumping site. A huge amount of garbage has been piled up and is giving off an offensive odor.

1.4 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 1.1.4, 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.

In the upstream end of the central lowland, there is a pond called the Boralesgamuwa Wewa for irrigation purpose. The Boralesgamuwa Wewa was constructed with a closing earth dike across the central lowland north to south. The length of the dike is 200 m and is 3 m in height. The water surface area of the Boralesgamuwa Wewa is around 6 ha, according to the 1:2000 scale topographic map.

The central lowland upstream of the Colombo-Piliyandala Road comprises part paddy field and the remainder unused land. Land filling is not significant in the central lowland at present. Meanwhile, houses are gradually encroaching on the lowland in the northern and eastern part of the sub-basin. The Bellanwila-Attidiya Marsh expands over the downstream of the Colombo-Piliyandala Road. The marsh area remains unused as a whole except to a limited extent of a temple and scattered small cultivations in the vicinity of the road.

1.5 Boralesgamuwa South Sub-basin

The Boralesgamuwa South sub-basin shown in Figure 1.1.5 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.

In this sub-basin, the urbanized area is expanding from the Maharagama-Dehiwala Road along the northern boundary of the sub-basin in the north. Paddy fields remain in the southern part of the sub-basin except the areas along the Colombo-Piliyandala Road and basin boundary. An elevated area in the south-west of the sub-basin is being developed with a housing estate.

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.

Clay for production of ceramics is exploited in the marsh area surrounding the Weras Ganga swamp. Clay exploitation was done in the area along the drainage channel. At present, the area of clay exploitation has shifted to the south. Clay pits after exploitation are left in the previous exploitation area which remains unused but is gradually encroached by houses.

1.6 Maha Ela Sub-basin

The location of the Maha Ela sub-basin is shown in Figure 1.1.6. 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.

It is observed that such fallow fields and marsh are subject to land filling. A part of the lowland along the Colombo-Piliyandala Road is reclaimed by some private firms. In the marsh on the right bank area of the Maha Ela, an island-wide reclaimed land is formed with some houses. Land fillings in the marsh are also found on the left bank around the end of the Duwawatta Road and Hamudawatta Road and are gradually expanding into the marsh. A garbage dumping site is located at the most downstream reaches on the left bank. An unpaved road across the marsh along the Weras Ganga left bank is also prone to garbage dumping in places.

1.7 Ratmalana-Moratuwa Sub-basin

The Ratmalana-Moratuwa sub-basin is located in the western part of the Weras Ganga basin as shown in Figure 1.1.7. 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 northern area is mostly covered by the Ratmalana Airport. The airport area is

drained by its own drainage system to the Weras Ganga. A small tributary of the Weras Ganga drains the Kandawala area to the south of the airport. The ground elevation varies from 7 m above MSL in the western boundary and 1 m or less along the Weras Ganga.

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.

The Telawala area is drained by another minor tributary of the Weras Ganga. The ground elevation varies from 7 m above MSL in the western boundary along the Galle Road and 1 m or less along the tributary to the Weras Ganga. The lowland with ground elevation less than 1 m above MSL lies along the tributary and is subject to land filling. Houses on land filling in the lowland areas are prone to the unsatisfactory drainage conditions.

The Katubedda area in the most southern part of the sub-basin is drained by a minor tributary. The ground elevation in the drainage area ranges from the highest of 20 m above MSL around the southern boundary of the sub-basin to less than 1 m in the marsh along the tributary. The Katubedda area is already densely urbanized except for the marsh area. Land filling is observed along the edge of the marsh in places and a garbage dumping site is located at the most downstream of the marsh.

1.8 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 1.1.8. 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.

1.9 Existing and Ongoing Projects

1.9.1 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 area of the GCFC&EIP Phase III is shown in Figure 1.1.9. 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.

1.9.2 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.

CHAPTER 2 FEATURES OF PRINCIPAL DRAINAGE CHANNELS

2.1 Weras Ganga

Figure 2.2.1 shows a general plan of the present condition of the Weras Ganga. The length of the Weras Ganga from the Kospalana bridge to the upstream end of the swamp is 4,500 m. The longitudinal profile of the Weras Ganga is shown in Figure 2.2.2. The salient features of the Weras Ganga by stretch are summarized below:

Features of Weras Ganga

Stretch	Length (m)	Channel Width (m)	Channel Depth (m)	Channel Bed Level (above MSL)	Bed Gradient
Weras Ganga swamp	1,000	100 to 500	1.0 to 1.5	-1.0	Almost Level
From downstream end of Weras Ganga swamp to Maha Ela confluence	1,200	60 to 160	1.0 to 1.5	-1.2 to -0.9	Almost Level
From Maha Ela confluence to Katubedda tributary confluence	1,400	160 to 600	1.5 to 2.0	-1.5 to -0.6	1/8,000
From Katubedda tributary confluence to Kospalana bridge	900	30 to 160	2.0	-1.5 to -1.3	1/8,000

A swamp expanding with a length of 1,000 m north to south and 500 m east to west is formed in the upstream end of the Weras Ganga. The bed elevation of the swamp is around 1.0 m below MSL.

The water surface width of the Weras Ganga becomes narrow downstream of the swamp. In the stretch from the downstream end of the swamp to the confluence of the Maha Ela, the channel width varies from 60 m to 160 m. The Borupana bridge on the Ratmalana-Moratuwa Road crosses the Weras Ganga around the middle of this stretch. The bed elevation is around 1 m below MSL.

After the confluence of the Maha Ela, the channel width becomes wider with 160 m to 600 m in the stretch down to the confluence of a tributary in Katubedda. Water depth also becomes deeper gradually to the downstream direction. The bed elevation is around 1.5 to 0.6 m below MSL.

In the most downstream stretch from the confluence of the Katubedda tributary to the Kospalana bridge, the channel flows down through relatively elevated lands with the highest elevation of 20 m above MSL or higher on both banks. The channel width is stable with a water surface width around 160 m. The bed elevation is around 1.5 m below MSL.

The flow capacity of the Weras Ganga by stretch is evaluated from the channel cross sections surveyed. A relationship between water level and runoff at a representative location in each stretch is derived from the hydraulic analysis discussed in ANNEX 3. The flow capacity at lowest bank level is smaller than the probable 2-year flood level in each stretch.

Flow Capacity of Weras Ganga

Stretch / Location	Lowest Bank Level (above MSL)	Flow Capacity (m^3/sec)	Corresponding Return Period
Weras Ganga swamp	0.4	2	Below 2-year
From downstream end of Weras Ganga swamp to Maha Ela confluence	0.5	4	Below 2-year
From Maha Ela confluence to Katubedda tributary confluence	0.5	28	Below 2-year
From Katubedda tributary confluence to Kospalana bridge	0.6	55	5-year

2.2 Nugegoda-Rattanapitiya Sub-basin

Figure 2.2.3 shows the principal drainage channels in the Nugegoda-Rattanapitiya sub-basin such as the Delkanda Ela, Nugedoda Ela and Rattanapitiya Ela.

The Delkanda Ela originates from the junction of the Old Kesbewa Road and Subhandrma Road and flows down along the Old Kesbewa Road to the confluence of the Nugegoda Ela. The total length of the channel is 2,400 m. The longitudinal profile of the Nugegoda Ela is shown in Figure 2.2.4. The salient features of the Delkanda Ela by stretch are summarized below:

Features of Delkanda Ela

Stretch	Length (m)	Channel Width (m)	Channel Depth (m)	Channel Bed Level (above MSL)	Bed Gradient
Upstream of High Level Road	880	1 to 10	0.5 to 2.5	+2.2 to +3.5	1/300
From High Level Road to Wela Road	590	2.5 to 11	0.5 to 2.0	+1.5 to +2.2	1/700
From Wela Road to confluence of Nugegoda Ela	880	2.5 to 10	1.0 to 2.0	+0.4 to 1.5	1/700

The Delkanda Ela runs along the Old Kesbewa Road down to the High Level Road. In the section upstream of the Edrishinghe Road, the channel width is around 3 m or

less and is restricted by buildings and houses constructed on the channel banks. The built-up part of the channel is hardly accessible and maintenance of the channel is not undertaken satisfactory for this stretch.

After the High Level Road, the channel flows down along the Old Kesbewa Road on the right bank and crosses the Wela Road. After crossing the Old Kesbewa Road, the channel joins with the Nugegoda Ela. The channel cross section is kept in general but the Old Kesbewa Road on the right bank and houses constructed close on the left bank result in a narrow channel width for a section.

There are 10 crossing bridges and culverts on public roads crossing the Delkanda Ela. Some of those restrict the channel cross section by small-sized opening. In addition, a number of foot bridges have been constructed privately.

The present flow capacity of each stretch is estimated by uniform flow calculation as follows:

Flow Capacity of Delkanda Ela

Stretch / Location	Min. Size of Cross Section	Flow Capacity (m^3/sec)	Corresponding Return Period
Upstream of High Level Road	Earth Open Channel Width 5 m, Depth 0.8 m	3	Below 2-year
From High Level Road to Wela Road	Culvert Width 2.5 m, Depth 2.1 m	11	Below 2-year
From Wela Road to confluence of Nugegoda Ela	Culvert Width 2.5 m, Depth 2.1 m	11	Below 2-year

The Nugegoda Ela originates around the Peters Place and flows down across the Church Street, Field Avenue and Pepiliyana Road, then joins with the Delkanda Ela. The total length of the channel is 2,800 m. The longitudinal profile of the Nugegoda Ela is shown in Figure 2.2.4.

Features of Nugegoda Ela

Stretch	Length (m)	Channel Width (m)	Channel Depth (m)	Channel Bed Level (above MSL)	Bed Gradient
Upstream of Church Street	300	3	1.0	+5.0 to +7.5	1/250
From Church Street to downstream end of concrete-lined channel section	350	3	1.0	+2.6 to +5.0	1/250
From downstream end of concrete-lined channel section to upstream end of inland marsh	450	3 to 5	0.5 to 1.0	+2.0 to +2.6	1/250
From upstream end of inland marsh to confluence of Rattanapitiya Ela	1,700	2.5 to 4	0.5 to 1.5	+0.5 to +2.0	1/1,200

The upper stretch is canalized with concrete-lining of 3 m width before crossing the Church Street and down to a distance of 400 m. The lower stretch to the confluence of the Delkanda Ela is 2,150 m in length and goes through the unused lowlands. The channel in the lower stretch remains unimproved with 2 to 3 m width except a locally improved part with 5 m width through a residential area. Compared with the Delkanda Ela, the Nugegoda Ela still keeps natural retention effects of the unused lowlands along the channel.

The present flow capacity of each stretch is estimated by uniform flow calculation as follows:

Flow Capacity of Nugegoda Ela

Stretch / Location	Min. Size of Cross Section	Flow Capacity (m3/sec)	Corresponding Return Period
Upstream of Church Street	Culvert Width 2 0 m, Depth 1.5 m	9	10-year
From Church Street to downstream end of concrete-lined channel section	Concrete Open Channel Width 3.0 m, Depth 1.0 m	9	2 to 5-year
From downstream end of concrete-lined channel section to upstream end of inland marsh	Earth Open Channel Width 4.0 m, Depth 0.8 m	3	Below 2-year
From upstream end of inland marsh to confluence of Rattanapitiya Ela	Earth Open Channel Width 2.0 m, Depth 0.6 m	0.4	Below 2-year

After the two channels join together, the channel is called the Rattanapitiya Ela down to the confluence of the Bolgoda Canal. The total length of the channel is 1,500 m. The longitudinal profile of the Rattanapitiya Ela is shown in Figure 2.2.4.

Features of Rattanapitiya Ela

Stretch	Length (m)	Channel Width (m)	Channel Depth (m)	Channel Bed Level (above MSL)	Bed Gradient
From confluence to Colombo-Piliyandala Road	300	5 to 9	1.0 to 2.5	-0.9 to +0.4	1/700
From Colombo-Piliyandala Road to confluence of Bolgoda Canal	1,200	8 to 13	1.0 to 2.5	-2.0 to -1.5	1/1,500

The channel passes alongside the Old Kesbewa Road on the left bank. The left bank between the channel and road is occupied by buildings but a flatland with scattered houses spreads on the right bank area. The channel enters into the Bellanwila-Attidiya Marsh 300 m downstream of the Colombo-Piliyandala Road. The channel in this stretch is hardly accessible for maintenance and has been neglected for a long period. As a result, the channel is completely filled up with water plants. The channel eventually joins with the Bolgoda Canal after crossing a bridge and water supply pipeline along the Dehiwala-Maharagama Road and an abandoned gate at the confluence. The present flow capacity of each stretch is estimated by uniform flow calculation as follows:

Flow Capacity of Rattanapitiya Ela

Stretch / Location	Min. Size of Cross Section	Flow Capacity (m^3/sec)	Corresponding Return Period
From confluence to Colombo-Piliyandala Road	Earth Open Channel Width 5.5 m Depth 1.0 m	4	Below 2-year
From Colombo-Piliyandala Road to confluence of Bolgoda Canal	Earth Open Channel Width 8.0 m Depth 1.0 m	6	Below 2-year

2.3 Bolgoda Canal

Figure 2.2.5 shows a general plan of the present condition of the Bolgoda Canal. The length of the Bolgoda Canal from the confluence of the Weras Ganga to the drainage area boundary near the Dehiwala Zoo is 4,900 m. The longitudinal profile of the Bolgoda Canal is shown in Figure 2.2.6. The salient features of the Bolgoda Canal by stretch are summarized below:

Features of Bolgoda Canal

Stretch	Length (m)	Channel Width (m)	Channel Depth (m)	Channel Bed Level (above MSL)	Bed Gradient
From Drainage Area Boundary to Hill Street	900	10 to 15	2.0 to 3.0	-0.5 to +0.5	1/1,300
Hill Street to Attidiya Road	1,300	12 to 26	1.5 to 3.0	+0.0 to -1.5	1/1,300
From Attidiya Road to Elawella Road	1,200	18 to 42	2.5 to 3.5	-3.0 to -1.5	Almost Level
From Elawella Road to Weras Ganga	1,700	14 to 22	2.0 to 2.5	-2.0 to -1.0	Almost Level

Around the drainage area boundary, the channel is deeply excavated with the lowest elevation of 0 m above MSL. The channel cross section is maintained in the stretch to the Hill Street but water plants growing in the channel are observed. Removed water plants and dredged material in the past were not disposed properly and were left along the bank of the channel. An inspection road is provided only for the right bank from the Hill Street to 250 m upstream. SLLRDC has initiated dredging of the channel upstream of the Hill Street.

The stretch from the Hill Street to Attidiya Road is fairly maintained except a limited part near the Attidiya Road. The channel width becomes narrow and growth of water plants is observed with sediment deposition near the Attidiya Road. Inspection roads are provided on both banks from the Hill Street to 300 m downstream and on left bank from the next section with a length of 300 m. But there is no inspection road for the rest of section to the Attidiya Road.

At the Attidiya Road, a bridge with an opening width of 15 m is being constructed under the GCFC&EIP Phase III. The stretch downstream of the Attidiya Road to Elawella Road has been neglected for a long period and is filled up completely by water plants. There is a path on the right bank from the Attidiya Road to confluence of the Rattanapitiya Ela but it is not possible to enter by vehicle for maintenance. Further downstream section is hardly accessible.

The stretch between the Elawella Road to confluence of the Weras Ganga indicates the same situation as above. The channel is filled up with water plants completely and is not accessible for maintenance.

At the Elawella Road across the Bolgoda Canal, the facilities consist of the gate, pumping station and causeway constructed by the Irrigation Department. These facilities were constructed for the purpose of protecting cultivation areas in and around the marsh from the Weras Ganga backwater during flood and salt water intrusion through the Weras Ganga. It is reported that these facilities are still

operational. However, it seems that the facilities have not functioned for the original purposes for a long period. Both downstream and upstream stretches of the channel are completely filled up with water plants. It is supposed that the present marsh area in the upstream of the facilities used to be cultivated but was abandoned and neglected a long time ago.

A relationship between water level and runoff at a representative location in each stretch is derived from the hydraulic analysis discussed in Annex 3. The present flow capacity at lowest bank level is estimated as follows:

Flow Capacity of Bolgoda Canal

Stretch / Location	Lowest Bank Level (above MSL)	Flow Capacity (m^3/sec)	Corresponding Return Period
From Drainage Area Boundary to Hill Street	2.0	12	10-year
Hill Street to Attidiya Road	1.2	22	5 to 10-year
From Attidiya Road to Elawella Road	0.9	15	Below 2-year
From Elawella Road to Weras Ganga	1.0	19	2-year

2.4 Boralesgamuwa North Sub-basin

Figure 2.2.7 shows a general plan of the present condition of the drainage system in the Boralesgamuwa North sub-basin. There is no principal drainage channel distinct from the central lowland to the Bolgoda Canal. Longitudinal profiles of irrigation creeks in the central lowland are shown in Figure 2.2.8.

Features of Channel in Boralesgamuwa North Sub-basin

Stretch	Length (m)	Channel Width (m)	Channel Depth (m)	Channel Bed Level (above MSL)	Bed Gradient
D2 Channel Downstream of Egodawatta Road	1,340	1 to 2	0.5 to 1.0	-0.5 to +1.8	1/1,000
D2 Channel Upstream of Egodawatta Road	530	2 to 4	0.5 to 1.0	+1.6 to +3.5	1/350
D1 Channel From Colombo-Piliyandala Road to Rattanapitiya Ela	370	2 to 4	1.0 to 1.5	+0.3 to +1.5	1/400
D3 Channel From Colombo-Piliyandala Road to Boralesgamuwa Wewa	1,620	1 to 2	0.5 to 1.0	+1.5 to +3.9	1/800

The irrigation creek is quite a small channel excavated to some 2 m width and 0.5 to 1.0 m depth. The irrigation creek relies on rainwater seeping from the ground and

trickles in the central lowland during dry weather. Water is also coming from the Bolaresgamuwa Wewa but seems not to be controlled intensively.

Besides the irrigation creeks, there are urban drainage channels along the borders between the urbanized areas in the northern and southern highlands and central lowland. These channels are also small sized and part excavated and part concrete/masonry. In the northern area, urban drainage channels are connected to the irrigation creek in the downstream where paddy fields are cultivated. The urban drainage channel along the southern edge of the urbanized highland is canalized by masonry work of some 1.5 m width and 0.5 m depth in the upstream section. The canalized section is fair in condition but the succeeding downstream section of earth open channel by excavation is poorly maintained and subject to growth of weeds. Urban drainage channels and irrigation creeks from the vicinity of the Colombo-Piliyandala Road to the downstream are in similar condition as a whole.

The Colombo-Piliyandala Road crossing the central lowland is prone to inundation during heavy rainstorm events due to the lack of proper drainage channel across the road. Inundation of the road is also attributed to the under-sized culverts crossing the road. The present flow capacity of each crossing culvert is estimated by uniform flow calculation as follows:

Flow Capacity of Culvert Crossing Colombo-Piliyandala Road

Stretch / Location	Min. Size of Cross Section	Flow Capacity (m3/sec)	Corresponding Return Period
D1 Channel, Near Northern End of Lowland	Culvert Width 2 m, Depth 1 m	4	Below 2-year
D2 Channel, Center of Lowland	Culvert Width 2 m, Depth 1 m	3	Below 2-year

2.5 Boralesgamuwa South Sub-basin

Figure 2.2.9 shows a general plan of the present condition of the drainage system in the Boralesgamuwa South sub-basin. An earth open channel to the Weras Ganga is identified in the downstream area of the Colombo-Piliyandala Road. Longitudinal profile of the channel is shown in Figure 2.2.10.

Features of Channel in Boralesgamuwa South Sub-basin

Stretch	Length (m)	Channel Width (m)	Channel Depth (m)	Channel Bed Level (above MSL)	Bed Gradient
Werahera Tributary From Colombo-Piliyandala Road to marsh surrounding Weras Ganga Swamp	500	4	1.0 to 1.5	+0.0 to +0.7	1/1,000

The urbanized northern drainage area is drained by an urban drainage channel, which connects with the drainage channel mentioned above in the marsh upstream of the Colombo-Piliyandala Road. The size of the urban drainage channel is 2 m width and 1 m depth, which is made of earth open channel with bank protection by gabion or concrete open channel by location. The length of the channel is around 500 m with a bed gradient of 1/250.

In the southern part of the sub-basin, drainage channel connecting to the above-mentioned channel to the Weras Ganga is not identified. It is supposed that the southern drainage area is drained by irrigation creeks in the paddy fields in the upstream and is discharged subsequently through a roadside drain crossing the Colombo-Piliyandala Road.

The present flow capacity of drainage channel is estimated by uniform flow calculation as follows:

Flow Capacity of Drainage Channel in Boralesgamuwa South

Stretch / Location	Min. Size of Cross Section	Flow Capacity (m^3/sec)	Corresponding Return Period
Werahera Tributary Colombo-Piliyandala Road Crossing Culvert	Earth Open Channel Width 4 m Depth 1 m	2	Below 2-year
Urban Drainage Channel in Northern Area	Earth Open Channel with Gabion Width 1.5 m Depth 0.5 m	1	2-year

2.6 Maha Ela

Figure 2.2.11 shows a general plan of the present condition of the Maha Ela and its tributary. The length of the Maha Ela from the Mahallarawa Road to confluence of the Weras Ganga is 7,250 m. The length of the tributary from the Colombo-Piliyandala Road to confluence of the Maha Ela is 1,660 m. The longitudinal profiles of the Maha Ela and tributary are shown in Figure 2.2.12. The salient features of the Maha Ela and tributary are summarized below:

Features of Maha Ela and Tributary

Stretch	Length (m)	Channel Width (m)	Channel Depth (m)	Channel Bed Level (above MSL)	Bed Gradient
Maha Ela From Mahallarawa Road to Pelanwatta Road	1,020	3 to 4	0.5 to 1.0	+5.6 to +8.8	1/300
Maha Ela From Pelanwatta Road to Maharagama-Piliyandara Road	1,430	3 to 4	0.5 to 1.0	+3.4 to +5.6	1/500
Maha Ela From Pelanwatta Road to Colombo-Piliyandala Road	2,930	3 to 5	0.5 to 1.0	+0.0 to +3.4	1/900
Maha Ela From Colombo-Piliyandala Road to Weras Ganga	1,870	7 to 16	1.0 to 2.9	-0.6 to +0.0	1/2000
Maha Ela Tributary From Colombo-Piliyandara Road to confluence	1,660	2 to 4	0.5	+0.0 to +2.0	1/900

The Maha Ela is mainly utilized as irrigation and drainage for paddy fields in the upper and middle reaches, together with irrigation creeks running in parallel. Around the Pelanwatta Road, the main stream is shifted to the northern boundary of the central lowland for collecting storm water runoff from the urbanized highland to the north. Except for this section, the main stream flows down through paddy fields in the central lowland around 1,000 m upstream of the Colombo-Piliyandala Road. From the downstream of the paddy cultivation area, the lowland used to be cultivated but becomes grassland or fallow field with scattered cultivation and livestock feeding in the vicinity of the Colombo-Piliyandala Road at present.

The Maha Ela is an earth open channel by excavation throughout the above mentioned stretches. There are five major road crossings along the stretches at the Mahallarawa Road, Pelanwatta Road, Alawwala-Piliyandala Road, Maharagama-Piliyandara Road and Colombo-Piliyandala Road.

A tributary of the Maha Ela coming from the Piliyandala area in the south joins the Maha Ela at 770 m downstream of the Colombo-Piliyandala Road. The drainage area of the tributary is 4.1 km^2. The tributary is used as an irrigation canal for the paddy fields located in the upstream but is also collecting storm water runoff from the urbanized catchment of Piliyandala area. A small extent of lowland is located north to south along the tributary in the downstream of the Piliyandala area. The lowland left unused is an abandoned paddy cultivation area and is subject to urbanization from the Piliyandala area. The channel is mostly like an irrigation creek and remains unimproved except the vicinities of road crossings.

The Maha Ela joins the tributary in the marsh spreading over the most downstream reaches. The marsh is drained to the Weras Ganga by the Maha Ela and branched small streams identified in the 1:2000 topographic map. The two gates are located at the Maha Ela and one of the branched streams crosses the unpaved road along the Weras Ganga. It is presumed that these gates were constructed for the purposes of preventing backwater and salt water intrusion from the Weras Ganga. The sizes of the gates are 1.5 m by 2 nos. at the Maha Ela and 1.0 m by 4 nos. at the branched stream. Both structures seem to be operational but would not be useful for the original purposes because the unused marsh expands over the upstream of the gates and the cultivated areas are located in further upstream reaches at present.

The present flow capacities of the Maha Ela and tributary are estimated by uniform flow calculation as follows:

Flow Capacities of Maha Ela and Tributary

Stretch / Location	Min. Size of Cross Section	Flow Capacity (m^3/sec)	Corresponding Return Period
Maha Ela From Maharagama-Piliyandala Road to Colombo-Piliyandala Road	Earth Open Channel Width 4 m Depth 1 m	3	Below 2-year
Maha Ela From Maharagama-Piliyandala Road to Colombo-Piliyandala Road	Culvert Width 2.6 m Depth 2.0 m	7	2-year
Maha Ela Colombo-Piliyandala Road crossing	Earth Open Channel Width 7 m Depth 1 m	3	Below 2-year
Maha Ela Tributary From Colombo-Piliyandara Road to Confluence	Earth Open Channel Width 2.0m Depth 0.5 m	0.3	Below 2-year

2.7 Ratmalana-Moratuwa Sub-basin

Figure 2.2.13 shows a general plan of the present condition of the minor tributaries of the Weras Ganga in the Ratmalana-Moratuwa sub-basin. All the tributaries flow down through lowland in the densely urbanized areas. The longitudinal profiles of the tributaries are shown in Figure 2.2.14. The salient features of the tributaries are summarized below:

Features of Minor Tributaries

Stretch	Length (m)	Channel Width (m)	Channel Depth (m)	Channel Bed Level (above MSL)	Bed Gradient
Tributary in Kandawala Area from a Pond near Defense Academy	1,400	2 to 20	0.5 to 1.0	-1.9 to +2.9	1/300
Tributary in Telawala Area from Telawala Road	800	4 to 12	1.0 to 1.5	-1.7 to +0.3	1/500
Tributary in Katubedda Area from Moratuwa-Piliyandala Road	1,370	2 to 4	0.5 to 2.0	-0.7 to +0.6	1/1800

A major part of the sub-basin is drained by these tributaries. As described in the previous sub-section, the densely urbanized areas in the sub-basin suffer from drainage problems caused by insufficiency of drainage system and topographic constraints.

The tributaries in Kandawala and Telawala are earth open channels which used to be natural streams and have becomes urban drainage channels in the process of urbanization. Lowlands along the channels are subject to land filling for construction of buildings, compounds of institutions or firms and private houses and dumping of industrial waste in places.

The Katubedda tributary was an irrigation canal for cultivation in the lowland, suggested by an abandoned gate located at 100 m upstream of the Weras Ganga confluence. Cultivation in the lowland would have been abandoned a long time before and the lowland is entirely covered with marsh at present. A plan for utilization of the lowland is envisaged providing new compounds for Moratuwa University.

The present flow capacities of the tributaries are estimated by uniform flow calculation as follows:

Flow Capacities of Tributary

Stretch / Location	Min. Size of Cross Section	Flow Capacity (m3/sec)	Corresponding Return Period
Tributary in Kandawala	Earth Open Channel Width 2 m Depth 1 m	2	2-year
Tributary in Telawala Area	Masonry Channel Width 4 m Depth 1 m	4	2 to 5-year
Tributary in Katubedda Area	Earth Open Channel Width 3 m Depth 1 m	1	Below 2-year

2.8 Thumbowila Sub-basin

The minor tributaries in the Thumbowila sub-basin shown in Figure 2.2.15 are not covered by the longitudinal profile and cross section survey because the tributaries are quite small and subject to local drainage issues only.

The Thumbowila sub-basin comprises the relatively undulating topography with ground elevation ranging from 1 to 20 m above MSL mostly as described before. Therefore, widespread affects by flooding of the Weras Ganga would not be anticipated. The minor tributaries are left unimproved at present and need proper channel improvement for local drainage.

CHAPTER 3 FLOOD PRONE AREA AND FLOOD DAMAGE

3.1 Weras Ganga Basin

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. The flood prone areas identified by the surveys are listed in Table 3.1.1.

Flood prone areas in the Bolgoda Canal sub-basin and Ratmalana-Moratuwa sub-basin were covered by both flood damage surveys and some differences in locations and extent were identified. These are attributed to density of interview survey points and available topographic maps.

Both flood damage surveys were carried out by interviews at 1,000 points. The objective area of the 1995 survey covered the Colombo MC, Sri Jayawardenapura Kotte MC, Kolonnawa UC, Dehiwala-Mount Lavinia MC and Moratuwa MC with the total area of 104 km^2. On the other hand, the 2001 survey covered the total area of 830 km^2 including the lower Ja Ela basin, Kalu Oya basin, Greater Colombo basin and Bolgoda basin.

A part of the flood prone area identified in the lowland along the Weras Ganga right bank is not covered by the results of the 1995 survey. The 1995 survey used the topographic maps developed in 1983 with a scale of 1:2,000 and 1:5,000 for

identifying the flood prone areas. The present built-up lowland along the Weras Ganga right bank would be mostly covered with unused marsh when the previous maps were developed in 1983.

Although differences are found between the two surveys, the flood prone areas indicated by both surveys distribute a similar tendency implying the characteristics of storm water drainage problems in the Weras Ganga basin.

Some of the flood prone areas are located locally away from the Weras Ganga mainstream 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 Table 3.1.1 and Figure 3.1.1. 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 as shown in Table 3.1.2, 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)
Nugegoda-Rattanapitiya	4.4	0.8
Bolgoda Canal	6.1	1.0
Boralesgamuwa North	4.5	1.2
Boralesgamuwa 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	
Nugegoda-Rattanapitiya	99	118	128	142	150	30
Bolgoda Canal	114	140	147	159	162	85
Boralesgamuwa North	85	95	102	109	121	9
Boralesgamuwa 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

3.2 Nugegoda-Rattanapitiya Sub-basin

The flood damage survey carried out during the Master Plan study in 2001 identified 13 locations of flood prone areas in the Nugegoda-Rattanapitiya sub-basin as shown in Figure 3.2.1.

Storm water runoff from the urbanized drainage areas in the upper and middle reaches concentrates rapidly to the drainage channels. The flood prone areas in the upper and middle reaches are attributed to under-capacity of the drainage channels against the peak runoff. The Rubber Watta area along the Delkanda Ela is prone to inundation due to overflow from the channel restricted by houses. The channel capacity is estimated less than the probable 2-year flood runoff.

The Malwatta area along the Nugegoda Ela is inundated due to improper construction of the channel. The channel is constructed with concrete lining for collecting and discharging storm water runoff in the drainage area upstream of the

Church Street. However, the Nugegoda Ela does not drain the Malwatta area downstream of the Church Street located in the low ground elevation.

Inundation is reported at the area around the Rattanapitiya Junction in the downstream reaches. The channel gradient of the Rattanpitiya Ela is changing around this area from 1/700 in the upstream side to 1/1500 in the downstream side of the Bellanwila-Attidiya Marsh. The drainage condition is worsened by the downstream channel being totally filled with water plants thus obstructing storm water runoff. Storm water runoff becomes stagnant on the downstream stretch in the marsh and the channel in the upstream side overflows due to backwater from the downstream stretch.

The flood damage survey in 2001 showed a frequency of inundation 4.4 times a year with duration of 0.8-day on average. Estimated extent of inundation area is summarized below:

Estimated Extent of Flood Prone Area in the Nugegoda-Rattanapitiya Sub-basin

Return Period	2-year	5-year	10-year	25-year	50-year
Flood Prone Area (ha)	99	118	128	142	150

The annual flood damage in the Nugegoda-Rattanapitiya sub-basin is estimated at Rs. 30 million/year under the present condition.

3.3 Bolgoda Canal Sub-basin

The flood prone areas identified in the Bolgoda Canal sub-basin by the flood damage survey in 1995 were mainly concentrated in the Kawdana and Attidiya areas, which used to be a part of the Bellanwila-Attidiya Marsh and have been reclaimed for construction of housing estates since 1980's. These areas were prone to habitual inundation due to the absence of urban drainage system. The GCFC&EIP Phase III was therefore initiated in 1999.

It is expected that storm water drainage in these areas will be improved. Meanwhile, weakness of storm water drainage in the Bolgoda Canal sub-basin still remains on the Bolgoda Canal itself draining storm water runoff from the entire sub-basin. The stretch downstream of the Attidiya Road has been neglected for a long period. As a result, the channel is totally filled with water plants reducing flow capacity significantly. Influence by backwater together with obstruction of storm water runoff is anticipated to cause storm water drainage congestion in the upper drainage areas in the case of heavy rainstorm events.

The flood damage survey carried out during the Master Plan study in 2001 identified 11 locations of flood prone areas in the Bolgoda Canal sub-basin as shown in Figure 3.3.1. These are found in the lowland along the edge of the Bellanwila-Attidiya Marsh to the east of the Attidiya Road. 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.

According to the results of the flood damage survey in 2001, frequency of inundation is 6.1 times a year with duration of 1.0-day on average. Estimated extent of inundation area is summarized below:

Estimated Extent of Flood Prone Area in the Bolgoda Canal Sub-basin

Return Period	2-year	5-year	10-year	25-year	50-year
Flood Prone Area (ha)	114	140	147	159	162

The annual flood damage in the Bolgoda Canal sub-basin is estimated at Rs. 85 million/year under the present condition.

3.4 Boralesgamuwa North Sub-basin

The flood damage survey carried out during the Master Plan study in 2001 identified 4 locations of flood prone areas in the Boralesgamuwa North sub-basin as shown in Figure 3.4.1.

The Boralesgamuwa North Sub-basin is clearly divided into the urbanized highlands in the north and south and the central lowland. Inundation takes places mostly in the central lowland comprising paddy field, grassland and marsh with very little in the residential areas of the highlands. The Colombo-Piliyandala Road across the central lowland, which floods frequently, is the only substantial traffic route connecting Colombo with inland towns such as Piliyandala and Horana at present. Traffic volume is estimated around 8,000 vehicles a day between Colombo and Piliyandala and inundation of the road causes heavy traffic jams along this section in the Boralesgamuwa North sub-basin. Other than the Colombo-Piliyandala Road, flood prone areas are found locally in Pasel Mawattha and Janatha Road areas in the north.

According to the results of the flood damage survey in 2001, frequency of inundation is 4.5 times a year with duration of 1.2-day on average. Estimated extent of inundation area is summarized below:

Estimated Extent of Flood Prone Area in the Boralesgamuwa North Sub-basin

Return Period	2-year	5-year	10-year	25-year	50-year
Flood Prone Area (ha)	85	95	102	109	121

The annual flood damage in the Boralesgamuwa North sub-basin is estimated at Rs. 9 million/year under the present condition.

3.5 Boralesgamuwa South Sub-basin

The identified flood prone areas in the Boralesgamuwa South sub-basin and estimated inundation area by hydraulic simulation are shown in Figure 3.5.1. The flood prone areas are located around the lowland surrounding the Weras Ganga Swamp. Inundation is attributed to local drainage problems in the lowland reclaimed in the marsh area. Frequency of inundation is 2.8 times a year with duration of 1.6-day on average. Estimated extent of flood prone areas by inundation analysis is summarized below:

Estimated Extent of Flood Prone Area in the Boralesgamuwa South Sub-basin

Return Period	2-year	5-year	10-year	25-year	50-year
Flood Prone Area (ha)	60	76	81	87	91

The annual flood damage in the Boralesgamuwa South sub-basin is estimated at Rs. 5 million/year under the present condition.

3.6 Maha Ela Sub-basin

The Maha Ela sub-basin is characterized by the central lowland and highlands along the boundary of drainage area. Flood prone areas were not identified in the middle and upper reaches in the flood damage survey in 2001. As seen in Figure 3.6.1, estimation of inundation area by simulation indicates that a widespread inundation area appears entirely in the central lowland but would not affect residential areas seriously. As is the case for the Boralesgamuwa North Sub-basin, frequent inundation takes place along the Colombo-Piliyandala Road and results in heavy traffic congestion. The mainstream of the Maha Ela around the Colombo-Piliyandala Road remains unimproved with some 5 m width and 1 m depth. The flow capacity of the channel is lower than the probable 2-year flood. A bridge of the Colombo-Piliyandala Road crossing the Maha Ela is also under-sized with a similar size to the channel cross section. Along the Maha Ela, the lowland with ground elevation less than 1.0 m above MSL expands up to 500 m upstream of the Colombo-Piliyandala Road. The stretch crossing the road is therefore affected by backwater in the downstream marsh in the case of flood.

The flood prone areas found in Battiyawatta and Duwawatta are reclaimed lowlands affected directly by inundation in the marsh or suffering from drainage congestion due to unsatisfied storm water drainage for the lowlands. Frequency of inundation is 3.9 times a year with duration of 2.0-day on average. Estimated extent of inundation area is summarized below:

Estimated Extent of Flood Prone Area in the Maha Ela Sub-basin

Return Period	2-year	5-year	10-year	25-year	50-year
Flood Prone Area (ha)	272	331	367	405	431

The annual flood damage in the Maha Ela sub-basin is estimated at Rs. 26 million/year under the present condition.

3.7 Ratmalana-Moratuwa Sub-basin

Flood prone areas along the Weras Ganga are mainly identified on the right bank area from Kandawala to Telawala. The ground elevation in the right bank area varies from 7.0 m above MSL along the Galle Road to 1 m above MSL or less along the Weras Ganga. This area is one of the most densely urbanized areas in the Weras Ganga basin and consists of densely built-up residential areas and factory compounds.

Figure 3.7.1 shows the locations of flood prone areas identified by the flood damage surveys. These are found along the lowland with ground elevation lower than 1.0 m above MSL along the Weras Ganga mainstream and tributaries. This corresponds to almost all of the lowland. The estimated flood levels of the Weras Ganga are 0.6 m above MSL for 2-year return period and 0.9 m for 50-year return period, respectively suggesting that the lowland is directly affected by the Weras Ganga flooding. In addition, the lowland is also prone to congestion of storm water runoff drained from the higher ground in the upstream due to the topographic difficulty to drain storm water runoff to the Weras Ganga.

Flood prone areas are also located in the higher ground elevations. Inundation in such areas is caused by local drainage congestion due to insufficiency of urban drainage system in the densely urbanized area. Frequency of inundation is 7.0 times a year with duration of 1.0-day on average. Estimated extent of inundation area is summarized below:

Estimated Extent of Flood Prone Area in Ratmalana-Moratuwa Sub-basin

Return Period	2-year	5-year	10-year	25-year	50-year
Flood Prone Area (ha)	77	93	104	115	121

Based on the results of the inundation analysis and assessment of direct and indirect damages, the amount of annual damage was estimated at Rs. 95 million/year under the present condition.

3.8 Thumbowila Sub-basin

Outstanding flood prone areas were not identified in the Thumbowila sub-basin in the flood damage survey during the Master Plan Study. Minor problems on storm water drainage may exist locally. The characteristics of the sub-basin as described in the previous sub-sections suggest that problems with storm water drainage will not be serious if the existing minor tributaries are properly improved as urban drainage channels in the progress of urbanization expanding to the lowland. Estimated extent of inundation area is summarized below:

Estimated Extent of Flood Prone Area in Thumbowila Sub-basin

Return Period	2-year	5-year	10-year	25-year	50-year
Flood Prone Area (ha)	16	21	23	26	27

Based on the results of the inundation analysis and assessment of direct and indirect damages, the amount of annual damage was estimated at Rs. 2 million/year under the present condition.

3.9 Causes of Flooding

3.9.1 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.

3.9.2 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.

3.9.3 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.

3.9.4 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.

3.9.5 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 mainstream 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.

3.9.6 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 mainstream and surrounding marsh areas. Water plants grow remarkably, contributing to the reduction of flow capacity of the channels.

CHAPTER 4 FORMULATION OF STORM WATER DRAINAGE PLAN

4.1 Study on Storm Water Drainage Plan in Weras Ganga Basin

The basic principle for the storm water drainage plan is to undertake the necessary measures under a strategy of consistent implementation throughout a drainage basin. Based on a long term target of storm water drainage implementation in an entire drainage basin, a plan for the main stream is formulated first. Tributaries and smaller drainage channels are designed successively according to the conditions planned on the main stream. Consistent planning and implementation for storm water drainage throughout a drainage basin is determined by these approaches.

Within the present study, the Phase I - Master Plan study aimed at formulating the comprehensive basin-wide plans including the measures for storm water drainage of main stream and conservation of retention area in line with the long term target for storm water drainage works in the CMR. The storm water drainage plans for the four major basins, i.e. Ja Ela basin, Kalu Oya basin, Greater Colombo basin and Bolgoda basin were studied mainly for the storm water drainage plans of the main streams in the respective basins with a target of realization after 10 to 20 years. As a result of the Master Plan study, the storm water drainage plan for the Weras Ganga basin representing a part of the Bolgoda basin was selected as a candidate for a feasibility study as a priority project.

The Master Plan study analyzed the storm water drainage plans of the respective main streams together with conservation of the retention areas as the primary objective, based on the available topographic maps with the scale of 1:50,000 and 1:10,000.

The Phase II - feasibility study focused on storm water drainage schemes for early implementation. It was identified that the majority of existing problems were caused directly by the unsatisfactory conditions of principal and urban drainage channels to drain storm water runoff into the main stream. It is therefore necessary to conduct a series of in-depth studies on the characteristics of particular problems on storm water drainage in the entire Weras Ganga basin before proceeding with the feasibility study. Such studies require more accurate baseline data of topography, urbanization and drainage system, which are obtainable from the latest maps with a scale of 1:2,000 or more detail.

A series of in-depth studies were enabled with the latest 1:2,000 scale topographic maps produced by the Survey Department in 2001, which cover the entire Weras Ganga basin. As a result of the in-depth studies carried out in the early stage of the

Phase II - Feasibility Study, the storm water drainage plan for the Weras Ganga basin was formulated. The plan includes the storm water drainage of the Weras Ganga main stream and conservation of the retention areas as well as the component schemes of principal drainage channels and urban drainage channels.

Of the storm water drainage plan for the Weras Ganga basin, the feasibility study for a project composed of prioritized component schemes was undertaken subsequently.

4.2 Objective Rivers and Drainage Channels

The storm water drainage plan in the Weras Ganga basin focuses on the entire drainage system in the basin as shown in Figure 4.2.1. The storm water drainage plan envisages providing measures against the problems directly related to the causes of inundation, comprising the improvement of existing drainage channels and the storm water retention areas. The existing problems and conceivable improvement of drainage channels are described below:

Existing Problems and Relevant Rivers and Drainage Channels

Problems	Rivers and Drainage Channels
Flooding in Weras Ganga	Weras Ganga
Obstruction of storm water drainage by reduction of flow capacity in downstream end of major tributary connecting to the Weras Ganga	Bolgoda Canal Rattanapitiya Ela Maha Ela
Overflow from major tributary due to less flow capacity of channel or under-sized crossing structure against storm water runoff	Nugegoda Ela Delkanda Ela Depawa Ela Maha Ela
Drainage difficulty due to absence of channel construction or improvement for storm water drainage	Nugegoda Ela Delkanda Ela Depawa Ela Maha Ela Tributary Werahera Tributary
Drainage difficulty in low-lying areas with ground elevation of 1.0 m above MSL or less	Minor Tributaries in Kandawala, Telawala, Katubedda and Urban Drainage Channels in Weras Ganga Right Bank

In view of the basin-wide plan for storm water drainage, the storm water retention in existing marsh areas is a key component of storm water drainage as concluded in the Master Plan. Therefore, the storm water drainage plan for the Weras Ganga basin incorporates an adequate amount of storm water retention area utilizing the marsh areas remaining in the future land use projection. The future land use projection

indicates that most of existing marsh will remain except the surroundings of the Police Academy compound being developed and an area for the proposed expansion of the Ratmalana Airport runway. The Boralesgamuwa Theme Park project is proposed in the previous clay exploitation site around Werahera to the northeast of the Weras Ganga swamp and it is intended that storm water retention areas in the surrounding marsh will remain.

In the past, several development plans were envisaged involving land reclamation in the marsh. These previous plans are now outdated since the issuance of the CRMSP, which restricts land reclamation in the existing marsh and allows only those land reclamation related to public purposes projects. There are no such projects on definitive basis in the Weras Ganga basin at this moment.

Based on the above considerations, the retention areas for the storm water drainage plan in the Weras Gang basin are selected as shown in Figure 4.2.2 and tabulated below:

Storm Water Retention Areas

Location	Extent (ha)
Upper Nugegoda Ela	7
Lower Nugegoda Ela	20
Delkanda Ela	9
Bellanwilla-Attidiya Marsh	108
Weras Ganga Swamp and Surrounding Marsh	65
Maha Ela Marsh and Lowland	132
Katubedda Tributary	23
Thumbowila Tributary	8
Total	372

4.3 Planning Scale

4.3.1 Classification of Rivers and Drainage Channels

The Master Plan study proposed the planning scale of 50-year return period for the main streams in the objective four major basins in the entire study areas of Ja Ela basin, Kalu Oya basin, Greater Colombo basin and Bolgoda basin on the basis of the following considerations:

1) Planning scale for storm water drainage suggested by CRMSP
2) Degree of importance of river in compliance with scale and socio-economic characteristics of drainage area
3) Consistency in planning scale among rivers and drainage channels with different sizes of drainage area

Scale of river or drainage channel is one of the key factors in selecting a planning scale of storm water drainage plan. In the Weras Ganga basin, the rivers and drainage channels comprising the drainage system are classified as follows in terms of their sizes of drainage areas:

Classification of Rivers and Drainage Channels in the Weras Ganga Basin

Classification	Name of River/Drainage Channel	Description
Main Stream	Weras Ganga	Largest stream in the basin, collecting storm water drained from the entire basin eventually.
Major Tributary	Bolgoda Canal Maha Ela Rattanapitiya Ela	Major tributaries of the Weras Ganga, collecting storm water drained from the respective sub-basins.
Minor Tributary	Delkanda Ela Nugegoda Ela Depawa Ela Maha Ela Tributary Werahera Tributary Katubedda Tributary	Minor tributaries, connecting to the Weras Ganga or major tributaries above.
Urban Drainage Channel	Kandawala Tributary Telawala Tributary	Artificially constructed or improved as main canals for urban drainage
Minor Drain		Secondary canals (branches of main canals) and tertiary drains (roadside drains and equivalent ones).
Irrigation Creek		Small creeks for irrigation and drainage for paddy fields.

Of the above, the storm water drainage plan for the Weras Ganga basin considers main stream, major/minor tributaries, and a part of urban drainage channels. As explained in the Master Plan study, different planning scales are generally adopted depending on degree of importance of river or drainage channel and consistency in planning scale among rivers and channels with different sizes of drainage area. In the Master Plan, the proposed planning scales in the Weras Ganga basin are 50-years return period for the main stream and 10-years return period for the selected tributaries. Accordingly, the planning scales by classification of rivers and drainage channels in the Weras Ganga basin are given as follows:

Planning Scale Proposed by Master Plan

Classification	Name of River /Drainage Channel	Drainage Area (km^2)	Planning Scale (Return Period)
Main Stream	Weras Ganga	55.5	50-year
Major Tributary	Bolgoda Canal	20.8	10-year
	Maha Ela	20.4	10-year *
	Rattanapitiya Ela	8.1	10-year
Minor Tributary	Delkanda Ela	3.3	10-year
	Nugegoda Ela	3.9	10-year
	Depawa Ela	4.9	10-year
	Maha Ela Tributary	4.1	(5 to10-year) **
	Werahera Tributary	2.6	(5 to 10-year) **
	Katubedda Tributary	2.4	(5 to 10-year) **
Urban Drainage Channel	Kandawala Tributary	1.3	(5 to 10-year) **
	Telawala Tributary	1.7	(5 to 10-year) **
Minor Drain			(5-year or Less) **

Note: * Planning scale of Maha Ela without Madiwela South Diversion
** Suggested planning scale for rivers and channels according to the Master Plan

4.3.2 Other Considerations regarding Planning Scale

(1) Existing and On-going Projects

The planning scale of the priority project should be determined in conformity with those of existing and on-going projects.

GCFC&EIP Phase I was the major storm water drainage project in the study area and has a similar scale (drainage area 86 km^2) to the objective area of the storm water drainage plan for the Weras Ganga basin. After the GCFC&EIP Phase I was completed, the safety level of 5 to 25-year return period was accomplished in the Greater Colombo basin. For further improvement of the safety level, the Master Plan gives the planning scale of 50-year return period as the long term target for the Greater Colombo basin.

GCFC&EIP Phase II and Phase III (drainage area of component schemes: 0.25 to 2.71 km^2) are the urban drainage projects designed on the basis of rainstorm with 2-year return period in consideration of minimizing the scale of drainage facilities to be constructed in the built-up areas.

After considering these on-going projects, it is suggested that the planning scale for the storm water drainage plan for the Weras Ganga basin would be in a range of 5 to 50-year return period for the main stream, major and minor tributaries, and the minimum of 2-year return period for the urban drainage channels and minor drains.

(2) Stage-wise Implementation

The planning scale of 50-year return period targeted is a long term objective to be accomplished for the Weras Ganga main stream after completion of all the proposed

schemes in the storm water drainage plan for the Weras Ganga basin (10 to 20 years). As the project cost for completion of the plan will be significant, and in view of financial schedule for public works, it is necessary to consider a stage-wise implementation of the proposed schemes. Prioritized schemes subject to the feasibility study are to be implemented in an earlier stage, followed by remaining schemes in latter stages until the target year of the plan.

(3) Urbanizing Conditions along Rivers and Drainage Channels

Urbanizing conditions along rivers and drainage channels are also taken into considerations for selecting the planning scale of each component scheme. In a highly urbanized area, construction works for storm water drainage scheme are constrained by built-up conditions and are subject to excessive costs for achieving a desirable planning scale. In these cases, a lower planning scale would be adopted as a practical solution for early implementation of storm water drainage project. GCFC&EIP Phase II and Phase III were designed on the basis of rainstorm with 2-year return period regarded as a minimum requirement for urban drainage for this reason.

When there are fewer constraints caused by urbanization, the improvement of storm water drainage should be carried out to the objective planning scale. At the same time, measures for preventing uncontrolled building activities near drainage channels in urbanized area should also be undertaken.

4.3.3 Proposed Planning Scale

The planning scales for the drainage channels comprising the storm water drainage plan for the Weras Ganga basin are proposed as shown in Figure 4.3.1 and tabulated below:

Proposed Planning Scale

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	20.8	10
	Maha Ela	20.4	10
	Rattanapitiya Ela	8.1	10
Minor Tributary	Delkanda Ela	3.3	10
	Nugegoda Ela	3.9	10
	Depawa Ela	4.9	10
	Maha Ela Tributary	4.1	10
	Werahera Tributary	2.6	5
	Katubedda Tributary	2.4	5
Urban Drainage Channel	Kandawala Tributary	1.3	2 or 5
	Telawala Tributary	1.7	2 or 5
Minor Drain			2

(1) Main Stream

The planning scale of 50-year return period is to be achieved by channel improvement in combination with conservation of storm water retention area. Retention area conservation is an important part of the storm water drainage plan in the Weras Ganga basin and should be undertaken urgently for controlling unauthorized land filling. Even though achievement of the 50-year return period is a long term objective, it is necessary to initiate the measures for the Weras Ganga main stream including conservation of storm water retention area at an early stage of the storm water drainage plan in the Weras Ganga basin.

(2) Major Tributary

The planning scale of 10-year return period is proposed for the major tributaries of the Weras Ganga such as Bolgoda Canal, Rattanapitiya Ela and Maha Ela. The proposed improvement of Maha Ela is regarded as the first stage of the Madiwela South Diversion and will be implemented in a the subsequent stage.

(3) Minor Tributary

The minor tributaries are connecting with the Weras Ganga or major tributaries mentioned above. The proposed planning scale for Delkanda Ela, Nugegoda Ela , Depawa Ela and Maha Ela tributary is 10-years return period because these are also regarded as principal drainage channels in the respective sub-basins. A planning scale of 5-year return period is proposed for the other two tributaries with the smaller drainage areas, which are the similar size to those of urban drainage channels.

(4) Urban Drainage Channel and Minor Drain

The planning scale of 5-year return period is desirable for urban drainage channels but application of 2-year return period is also considered in the case of built-up areas. The planning scale of 2-year return period is adopted for the minor drains such as branches of urban drainage channels and roadside drains.

4.4 Design Flood Runoff

4.4.1 Probable Runoff

Diagrams of flood runoff distribution in the Weras Ganga basin for probable 2, 5, 10, 25, 50, and 100-year rainstorm events under the present and future land use condition are shown in Figures 4.4.1 and 4.4.2. Probable flood runoffs and water levels at several locations along the Weras Ganga and major tributaries are tabulated below:

Estimated Probable Flood Runoff

(Unit: m^3/sec)

Location	Condition	Return Period (years)					
		2	5	10	25	50	100
Rattanapitiya Ela at Colombo-Piliyandala Road	Present	20	27	33	40	48	54
	Future	26	35	43	53	62	70
Bolgoda Canal at Attidiya Road	Present	15	21	25	31	36	43
	Future	16	23	27	35	39	46
Maha Ela at Colombo-Piliyandala Road	Present	13	21	27	37	44	54
	Future	29	44	57	71	83	96
Weras Ganga at Elawella Road	Present	18	25	32	39	45	51
	Future	24	34	41	52	61	70
Weras Ganga at Borupana Bridge	Present	24	32	39	49	56	64
	Future	31	42	51	63	71	81
Weras Ganga at Kospalana Bridge	Present	47	51	69	85	106	123
	Future	51	74	86	118	126	135

Note: Future condition assumes that the Bolgoda Canal is diverted to the Weras Ganga Swamp.

Estimated Probable Flood Level

(Unit: m above MSL)

Location	Condition	Return Period (years)					
		2	5	10	25	50	100
Rattanapitiya Ela at Colombo-Piliyandala Road	Present	1.84	1.96	2.03	2.11	2.17	2.22
	Future	1.94	2.06	2.13	2.21	2.27	2.31
Bolgoda Canal at Attidiya Road	Present	1.02	1.18	1.27	1.38	1.45	1.53
	Future	1.03	1.18	1.27	1.38	1.45	1.52
Maha Ela at Colombo-Piliyandala Road	Present	1.57	1.92	2.03	2.43	2.62	2.80
	Future	2.00	2.40	2.66	2.93	3.12	3.29
Weras Ganga at Elawella Road	Present	1.00	1.16	1.25	1.36	1.43	1.51
	Future	0.49	1.15	1.24	1.34	1.41	1.49
Weras Ganga at Borupana Bridge	Present	0.62	0.68	0.75	0.84	0.91	0.98
	Future	0.67	0.77	0.86	0.97	1.05	1.13
Weras Ganga at Kospalana Bridge	Present	0.53	0.54	0.55	0.56	0.62	0.66
	Future	0.53	0.56	0.58	0.65	0.66	0.69

Note: Future condition assumes that the Bolgoda Canal is diverted to the Weras Ganga Swamp.

4.4.2 Basic Flood Runoff

For planning purposes, the basic flood runoff is estimated on the basis that retention of runoff 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 are shown in Figure 4.4.3. Basic flood runoffs at several locations along the Weras Ganga and major tributaries are tabulated below:

Estimated Basic Flood Runoff

(Unit: m^3/sec)

Location	Condition	Return Period (years)					
		2	5	10	25	50	100
Rattanapitiya Ela at Colombo-Piliyandala Road	Future Basic Flood	43	61	71	84	92	100
Bolgoda Canal at Attidiya Road	Future Basic Flood	28	34	38	44	48	51
Maha Ela at Colombo-Piliyandala Road	Future Basic Flood	40	54	64	76	85	95
Weras Ganga at Elawella Road	Future Basic Flood	73	93	106	122	134	144
Weras Ganga at Borupana Bridge	Future Basic Flood	100	129	148	169	185	200
Weras Ganga at Kospalana Bridge	Future Basic Flood	159	206	238	280	312	346

Note: Future condition assumes that the Bolgoda Canal is diverted to the Weras Ganga Swamp.

4.4.3 Design Flood Runoff

Design flood runoff is determined in terms of discharging basic flood runoff safely through rivers and drainage channels in combination with storm water retention areas. Rivers and drainage channels are assumed to be widened with sufficient flow capacity (designated by planning scale) for discharging storm water runoff reduced from the basic flood runoff by the effect of storm water retention areas. Distribution diagrams of design flood runoff in the Weras Ganga basin are shown in Figure 4.4.4.

Design Flood Runoff

(Unit: m^3/sec)

Location	Condition	Return Period (years)					
		2	5	10	25	50	100
Rattanapitiya Ela at Colombo-Piliyandala Road	Future Design Flood	36	46	53	61	69	77
Bolgoda Canal at Attidiya Road	Future Design Flood	14	20	23	30	35	40
Maha Ela at Colombo-Piliyandala Road	Future Design Flood	27	42	53	69	80	95
Weras Ganga at Elawella Road	Future Design Flood	35	44	51	61	68	76
Weras Ganga at Borupana Bridge	Future Design Flood	43	55	63	73	79	89
Weras Ganga at Kospalana Bridge	Future Design Flood	79	104	123	146	164	181

Note: Future condition assumes that the Bolgoda Canal is diverted to the Weras Ganga Swamp.

4.5 Component Schemes of Structural Measures

The concept of the storm water drainage plan for the Weras Ganga basin is shown in Figure 4.5.1. The plan is composed of the component schemes for improvement of

storm water drainage of the Weras Ganga main stream and tributaries. The component schemes are broadly demarcated by sub-basin as follows:

1) Weras Ganga Scheme
2) Nugegoda-Rattanapitiya Scheme
3) Bolgoda Canal Scheme
4) Boralesgamuwa North Scheme
5) Boralesgamuwa South Scheme
6) Maha Ela Scheme
7) Ratmalana-Moratuwa Scheme

4.5.1 Weras Ganga Scheme

The highly urbanized area along the Weras Ganga right bank from Kandawala to Telawala is mostly located in the ground elevation less than 2.0 m above MSL. In this area, a number of houses are constructed on the ground elevation of 0.0 m to 1.0 m above MSL and are directly affected by the Weras Ganga flooding.

For alleviating the situations above, the conceivable structure measures for storm water drainage improvement are illustrated in Figure 4.5.2.

(1) Construction of Flood Protection Dike along Right Bank

For protection of the residential area in the low-lying area along the Weras Ganga, construction of a masonry wall dike along the right bank is proposed. The masonry wall dike extends with a length of 2,300 m from the tributary confluence near the Defense Academy in Kandawala to the Sri Rahula Mawatha in Telawala. The top elevation of the wall is 1.1 m to 1.4 m above MSL to cope with the design flood level at 50-year return period.

(2) Dredging of Weras Ganga Riverbed

The Weras Ganga is quite shallow with a normal water depth of 1.0 m from the upstream swamp to the entrance of the North Bolgoda Lake. The lowest riverbed level ranges from 1.5 m to 0.5 m below MSL. The riverbed profile of the Weras Ganga indicates that deposition of riverbed material is significant between the Borupana bridge and Katubedda tributary. Deposition of riverbed material would be caused over a long period by stagnant water flow worsened by growth of the water plants obstructing the channel. Therefore, dredging of the Weras Ganga riverbed down to the entrance of the North Bolgoda Lake is effective for draining storm water runoff smoothly to the North Bolgoda Lake. The length of the stretch to be dredged is 5,500 m from the Weras Ganga Swamp to 1,200 m downstream of the Kospalana

bridge. The riverbed level is designed at 1.5 m below MSL corresponding to the bed level of the entrance of the North Bolgoda Lake as shown in Figure 4.5.3.

Design Features of Weras Ganga Scheme

Components	Design Features
Flood Protection Wall	• Length: 2,300m • Type: gravity wall by masonry, width 0.35 m • Crest Elevation of Wall: +1.1 m to +1.4 m • Design Flood Level (50-year return period): +1.0 m • Flap gate for Urban Drainage System in Kandawala to Telawala areas: 2 nos.
Dredging Stretch WG1 from North Bolgoda Lake to Maha Ela confluence	• Length: 3,400 m • Width of Dredging: 40 m • Channel Bed Gradient: level • Channel Bed Level: -1.5 m • Design Runoff (50-year return period): 164 m^3/sec at Kospalana bridge
Dredging of Weras Ganga Stretch WG2 from Maha Ela Confluence to Weras Ganga Swamp	• Length: 2,100 m • Width of Dredging: 19 to 40 m • Channel Bed Gradient: level • Channel Bed Level: -1.5 m • Design Runoff (50-year return period): 79 m^3/sec at Borupana bridge

(3) Retention Areas

1) Weras Ganga Swamp Retention Area

A swamp with surrounding marsh area, estimated at 105 ha, is located in the most upstream end of the Weras Ganga.

To the west of the Weras Ganga Swamp, the expansion plan of the Ratmalana Airport runway is under consideration. A land filling area, estimated at 40 ha, for expansion of embankment for the airport runway covers the existing marsh area on the right bank of the Weras Ganga Swamp.

Although implementation of the airport expansion is not yet committed, the storm water drainage plan in the Weras Ganga basin assumes that it will be implemented in the future. The storm water drainage plan for the Weras Ganga basin therefore proposes that the remaining 65 ha of the swamp and surrounding marsh area be designated a retention area to be conserved.

2) Maha Ela Marsh and Lowland Retention Area

A widespread lowland is located along the downstream stretch of the Maha Ela from the confluence of the Weras Ganga and the vicinity of the Colombo-Piliyandara Road. The extent of lowland is estimated at 132 ha consisting of mostly marsh area downstream of the Colombo-Piliyandala Road and the rest

of the abandoned cultivation area in the vicinity of the road. This lowland needs to be maintained as a retention area for the probable 50-year flood on the condition that the series of structural measures described in this sub-section as well as the Madiwela South Diversion Scheme proposed in the Master Plan are incorporated.

4.5.2 Nugegoda-Rattanapitiya Scheme

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 in the lower reaches of Rattanapitiya Ela, but also at Nugegoda Ela and Delkanda Ela in the middle and upper reaches.

The Rattanapitiya Ela flows into the Bellanwila-Attidiya Marsh and joins eventually the Weras Ganga. The channel in the urbanized area is affected by backwater from the downstream reaches in the Bellanwila-Attidiya Marsh, where storm water runoff becomes stagnant due to obstruction by riverbed deposit and water plants. The Rattanapitiya Ela is obstructed by growth of water plants in the stretch through the Bellanwila-Attidiya Marsh. In combination with these causes, the channel overflows around the junction of the Colombo-Piliyandala Road and Old Kesbewa Road.

The Delkanda Ela flows down along the Old Kesbewa Road in the middle and upper basin. A part of the stretch downstream of the High Level Road bridge becomes narrow due to restriction by houses. The stretch upstream of the High Level Road is highly restricted as well and remains unimproved as a whole. The majority of the houses in the most upstream stretch are impoverished families living in an unsatisfactory environment.

The Nugegoda Ela is canalized with a concrete-lined channel from upstream of Church Street. The existing canalized stretch with a length of 400 m has a sufficient flow capacity for storm water runoff from the upstream catchment. However, the canalized stretch is not effective for storm water drainage in the right bank area downstream of the Church Street. The lowland on the right bank area is not drained by the existing concrete-lined canal nearby and is prone to inundation. The stretch flowing down through lowland remains unimproved with less flow capacity than the upstream stretch except for a limited part through a residential area. Storm water runoff becomes stagnant in the lowland, obstructed by under-sized crossing culverts and water plants growing in the channel.

For alleviating these situations, the conceivable structure measures for storm water drainage improvement are illustrated in Figures 4.5.4 and 4.5.5.

(1) Rattanapitiya Ela Channel Improvement

Channel improvement of the Rattanapitiya Ela from the confluence of the Delkanda Ela and Nugegoda Ela to Bolgoda Canal is required for discharging storm water runoff concentrated from the sub-basin.

For the stretch within Bellanwila-Attidiya Mash, water plants filling up the channel will be removed and the abandoned gate at the confluence of the Bolgoda Canal be demolished. The channel requires dredging to the bed elevation of 1.5 m below MSL from the confluence of the Bolgoda Canal to Kalaluvwa-Dehiwala Road. The bed elevation varies from 1.5 to 1.1 m below MSL with a gradient of 1:1,200 from Kalaluvwa-Dehiwala Road to boundary of the Bellanwila Attidiya Marsh. The channel bed will be widened to 19 m width which is the same as the bed width designed for the upstream stretch.

As the channel flows down into the retention area, the channel bank level remains as at present, allowing the channel to overflow its left bank against excessive runoff. A maintenance road with 4 m width is provided on the right bank. Surface elevation of embankment for the maintenance road is designed at 1.8 m above MSL to cope with the 50-year design flood level in the retention area. The necessary number of crossing drains are provided in the embankment of the maintenance road for the purpose of draining storm water flowing into the retention area from the right bank into the channel.

For the stretch upstream of Bellanwila-Attidiya Marsh, the existing channel is widened to cope with the design runoff of 53 m^3/sec at 10-year return period. The channel bed gradient is designed at 1/800. A designed channel cross section is rectangular-shaped with 19 m width, protected by gabion on both banks. A maintenance road with 4 m width is provided on the right bank of the channel. This stretch is extended along the present Nugegoda Ela up to 600 m upstream of the present confluence of the Delkanda Ela and Nugegoda Ela.

Design Features of Nugegoda-Rattanapitiya Scheme
(1) Rattanapitiya Ela Channel Improvement

Components	Design Features
Channel Improvement Stretch RE1 from Confluence of Bolgoda Canal to Edge of Bellanwila-Attidiya Marsh	• Length: 890 m • Channel Bed Gradient: level to 1/1,200 • Channel Bed Level: -1.5 m to -1.1 m • Design Runoff (10-year Return Period): 25 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 19 m bed width • Maintenance Road: right bank, width 4 m, surface elevation +1.8 m, earth embankment with cross drains • Bridge: 1 no.
Channel Improvement Stretch RE2 from Edge of Bellanwila-Attidiya Marsh to Nugegoda Ela / Delkanda Ela Confluence	• Length: 1,240 m • Channel Bed Gradient: 1/800 • Channel Bed Level: -1.1 m to +0.5 m • Design Runoff (10-year Return Period): 53 m^3/sec • Channel Cross Section: earth open channel with protection by gabion on both banks, rectangular section, 19 m width • Maintenance Road: right bank, width 4 m • Bridge: 4 nos.

(2) Delkanda Ela Channel Improvement

The flow capacity of the stretch downstream of the Pengiriwatta Road needs to be augmented. The design runoff at 10-year return period is estimated at 22 m^3/sec. The channel bed gradient is designed at 1/700. In this stretch, the channel branches 600 m upstream of the present confluence with the Nugegoda Ela for reducing runoff to the built-up section in the downstream. The branched channel crosses the Old Kesbewa Road by constructing a crossing culvert and is connected to the Nugegoda Ela .

A designed channel cross section between the Pengiriwatta Road to a new culvert across the Old Kesbewa Road is rectangular-shaped with 13.5 m width, protected by gabion on both banks. The branch channel is composed of earth open channel with trapezoidal cross section with the bed width of 13.5 m together with a 4 m wide maintenance road on the left bank. For the branch channel running into the retention area, the channel bank level remains at its present level so as to allow the channel to overflow its right bank against excessive runoff.

The upstream stretch of the Delkanda Ela is designed for the peak runoff of 14m^3/sec at 10-year return period. A concrete-lined channel of 3 m width is provided in this section. Improvement of this stretch is subject to the relocation of houses and compensation for families along the existing channel.

Design Features of Nugegoda-Rattanapitiya Scheme
(2) Delkanda Ela Channel Improvement

Components	Design Features
Construction of Branch Stretch D1	• Length: 280 m • Channel Bed Gradient: 1/700 • Channel Bed Level: +0.5 to +0.9 m • Design Runoff (10-year Return Period): 29 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 13.5 m bed width • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains • Bridge: 1 no.
Channel Improvement Stretch D2 from Old Kesbewa Road to Pengiriwatta Road	• Length: 790 m • Channel Bed Gradient: 1/700 • Channel Bed Level: +0.9 m to +2.1 m • Design Runoff (10-year Return Period): 22 m^3/sec • Channel Cross Section: earth open channel with protection by gabion on both banks, rectangular section, 13.5 m width • Bridge: 5 nos.
Channel Improvement Stretch D3 upstream of Pengiriwatta Road	• Length: 690 m • Channel Bed Gradient: 1/300 • Channel Bed Level: +2.1 m to +4.2 m • Design Runoff (2-year Return Period): 14 m^3/sec • Channel Cross Section: earth open channel with wet masonry revetment, trapezoidal section, 3 m width • Culvert 2 nos.

(3) Nugegoda Ela Channel Improvement

A diversion channel is constructed replacing the downstream half of the existing concrete-lined stretch for the purpose of improving drainage congestion in the right bank area. The stretch including this diversion channel and the downstream channel (total length of 640 m) is composed of earth open channel with bank protection by gabion. The channel bed gradient of this stretch is designed at 1/450. The channel cross section is rectangular-shaped with 5 to 13 m width based on the peak runoff of 10 to 22 m^3/sec at 10-year return period. A maintenance road with 4 m width is provided on the right bank of the channel.

The rest of downstream stretch (940 m length) runs through the lowland functioning as a retention area. For this stretch, the channel bed is widened to 13 m by excavation/dredging and removal of water plants. Within the retention area, the channel bank level remains at present level for allowing the channel to overflow its left bank against excessive runoff. A maintenance road with 4 m width is provided on the right bank and the necessary number of crossing drains are provided through the embankment of the maintenance road.

Design Features of Nugegoda-Rattanapitiya Scheme
(3) Nugegoda Ela Channel Improvement

Components	Design Features
Channel Improvement Stretch NE1	• Length: 940 m • Channel Bed Gradient: 1/700 • Channel Bed Level: +0.5 to +1.9 m • Design Runoff (10-year Return Period): 24 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 13 m bed width • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains • Bridge: 1 no.
Channel Improvement Stretch NE2	• Length: 280 m • Channel Bed Gradient: 1/700 • Channel Bed Level: +1.9 m to +2.3 m • Design Runoff (10-year Return Period): 22 m^3/sec • Channel Cross Section: earth open channel with protection by gabion on both banks, rectangular section, 13 m width • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains • Bridge: 1 no.
Channel Improvement Stretch NE3	• Length: 360 m • Channel Bed Gradient: 1/450 • Channel Bed Level: +2.3 m to 3.0 m • Design Runoff (10-year Return Period): 10 m^3/sec • Channel Cross Section: earth open channel with protection by gabion on both banks, rectangular section, 5 m width • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains • Bridge: 1 no.

(4) Retention Areas in Urbanized Area

The lowlands remaining in the middle and upper reaches in the Nugegoda-Rattanapitiya sub-basin are naturally functioning as storm water retention area. These lowlands with the total extent of 36 ha are kept as storm water retention area to the future.

4.5.3 Bolgoda Canal Scheme

The stretch of Bolgoda Canal from the Hill Street bridge to the Attidiya Road bridge is in fair condition. However, the downstream stretch to the Weras Ganga is completely filled up with water plants and does not function as drainage channel at all. For augmentation of storm water drainage in the Bolgoda Canal sub-basin as well as the Nugegoda-Rattanapitiya and Boralesgamuwa North sub-basins, the downstream stretch of Bolgoda Canal should be restored. The conceivable structure measures of the Bolgoda Canal Scheme are illustrated in Figures 4.5.6 and 4.5.7.

(1) Channel Improvement of Bolgoda Canal

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 no significant difference is expected in hydraulic conditions between use of the existing channel and the diversion channel.

It is assumed that the existing flood gate and pumping station under the management of the Irrigation Department would be demolished together with improvement of the Bolgoda Canal. The flood gate and pumping station were constructed for the purpose of preventing salt water intrusion through the Weras Ganga, protection of the Weras Ganga backwater and a pumping drainage for upstream side when the flood gate is closed.

It appears that these facilities have not been in operation for the original purposes for some time. The Bellanwila-Attidiya Marsh upstream of the flood gate used to be cultivated and was supposed to be affected by salt water intrusion and the Weras Ganga backwater. At present, there is no cultivation in the Bellanwila-Attidiya Marsh upstream of the flood gate except in limited areas with ground elevation of 1.0 m above MSL or higher.

The channel improvement comprises removal of water plants, excavation/dredging, and provision of a maintenance road. The stretch downstream of the Attidiya Road is completely filled with water plants at present. Water plants are removed and the channel bed is dredged to the bed elevation of 1.5 m below MSL. As the channel flows down into the retention area, the channel bank level remains at present level for allowing the channel to overflow its right bank against excessive runoff.

At present, the downstream stretch is inaccessible. A maintenance road with 4 m width is therefore provided on the right bank. Surface elevation of embankment for the maintenance road is designed at 1.8 m above MSL to cope with the design flood level in the retention area. The necessary number of crossing drains are provided in the embankment of the maintenance road for the purpose to drain storm water flowing into the retention area on the right bank into the channel.

Design Features of Bolgoda Canal Scheme

Components	Design Features
Channel Improvement and Dredging of Bolgoda Canal Stretch BC1 from Weras Ganga Confluence to Elawella Road	• Length: 1,000 m • Channel Bed Gradient: level • Channel Bed Level: -1.5 m • Design Runoff (10-year return): 51 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 19 m bed width • Maintenance Road: right bank, width 4 m, earth embankment with crossing drains • Bridge: 1 no.
Channel Improvement and Dredging of Bolgoda Canal Stretch BC2 from Elawella Road to Confluence of Rattanapitiya Ela	• Length: 400 m • Channel Bed Gradient: level • Channel Bed Level: -1.5 m • Design Runoff (10-year return period): 37 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 19 m bed width • Maintenance Road: right bank, width 4 m, earth embankment with crossing drains
Channel Improvement and Dredging of Bolgoda Canal Stretch BC3 from Confluence of Rattanapitiya Ela to Attidiya Pond	• Length: 1,000 m • Channel Bed Gradient: level • Channel Bed Level: -1.5 m • Design Runoff (10-year return period): 23 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 15 m bed width • Maintenance Road: left bank, width 4 m

(2) Bellanwila-Attidiya Marsh Retention Area

The Bellanwila-Attidiya Mash is conserved as a retention area for the storm water drainage plan in the Weras Ganga basin. The retention area is based on the marsh area remaining in the future land use projection. The extent of retention area is estimated at 108 ha under the projected future land use condition.

4.5.4 Boralesgamuwa North Scheme

There is no principal drainage channel in the Boralesgamuwa North sub-basin although one of the small drains and creeks crossing the Colombo-Piliyandala Road is named Depawa Ela. Due to the absence of principal drainage channels, storm water runoff becomes stagnant in the central lowland located west to east. The Colombo-Piliyandala Road crossing the central lowland north to south is inundated and heavy traffic jams occur with every occasion of the inundation. It is also reported that the growing urban area in the north-eastern part of the sub-basin faces inundation due to the lack of proper storm water drainage.

Required improvement of storm water drainage in this sub-basin involves the provision of a principal drainage channel for discharging storm water runoff from the entire sub-basin to the Bolgoda Canal. A conceivable route of principal drainage channel is shown in Figure 4.5.8.

The existing storm water drainage channels are running along the borders between the central lowland and highlands in the north and south. In the central lowland, there are small irrigation creeks for paddy cultivation only. The existing storm water drainage channels collect storm water runoff as well as wastewater. Paddy cultivation remains in the middle and upper part of the lowland. The route of the principal drainage channel to be proposed is therefore selected so as to minimize affects on the paddy cultivation.

The paddy cultivation in the central lowland is mainly undertaken in the upper area of the Egodawatta Road and to a limited extent in the lower area of the Egodawatta Road. It appears that cultivation in the vicinity of the Colombo-Piliyandala Road and the northern part downstream of the Egodawatta Road has been abandoned for some time. It is thought that cultivation will not be resumed and urbanization will expand from the present urban area to these areas in the future.

The route of principal drainage channel is selected to run along the northern part of the central lowland up to the Egodawatta Road and to go down to the existing culvert crossing of the Colombo-Piliyandala Road around the center of the lowland. The channel bed gradient of this stretch is designed at 1/700. The channel cross section is rectangular-shaped of 6 m width based on the peak runoff of 23 m^3/sec at 10-year return period. A maintenance road with 4 m width is provided on the right bank of the channel.

The rest of downstream stretch runs through the Bellanwila-Attidiya Marsh functioning as a retention area. It is difficult to identify any trace of a channel running down to the Bolgoda Canal in the marsh. The route of the new channel is therefore selected to go down from the culvert crossing of the Colombo-Piliyandala Road and to pass the existing culvert of the Maharagama-Dehiwela Road, then to join the Bolgoda Canal near the Elawella Road crossing. As the channel flows down into the retention area, the channel bank remains at present level for allowing the channel to overflow its right bank against excessive runoff. A maintenance road with 4 m width is provided on the right bank and the necessary number of crossing drains are provided for embankment of the maintenance road.

Design Features of Boralesgamuwa North Scheme

Components	Design Features
Channel Improvement Stretch DE1	• Length: 1,350m • Channel Bed Gradient: 1/1,000 • Channel Bed Level: -1.5 to -0.2 m • Design Runoff (10-year return period): 18 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 6 m bed width • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains • Bridge: 2 no.
Channel Improvement Stretch DE2	• Length: 1,520 m • Channel Bed Gradient: 1/700 m • Channel Bed Level: -0.2 m to +2.2 m • Design Runoff (10-year Return Period): 23 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 6 m bed width • Maintenance Road: right bank, width 4 m, earth embankment with crossing drains • Bridge: 2 nos.
Channel Improvement Stretch DE3	• Length: 220 m • Channel Bed Gradient: 1/700 m • Channel Bed Level: +2.3 m to +2.9 m • Design Runoff (10-year Return Period): 14 m^3/sec • Channel Cross Section: earth open channel with protection by gabion on both banks, rectangular section, 6 m width • Maintenance Road: right bank, width 4 m, earth embankment with crossing drains • Culvert: 1 no.

4.5.5 Boralesgamuwa South Scheme

The Boralesgamuwa South sub-basin is a relatively small catchment between the Boralesgamuwa North and Maha Ela sub-basins. The principal drainage channel runs down through a lowland in the center of the sub-basin but is totally deteriorated and has not been maintained or improved for a long time. The Colombo-Piliyandala Road across the lowland becomes flooded with heavy traffic congestion on each occasion of inundation. The situation of inundation is anticipated to worsen as the upstream section of the Colombo-Piliyandala Road is developed with housing schemes, resulting in an an increase of storm water runoff peak in the downstream stretch.

Required improvement of storm water drainage in this sub-basin is to restore a principal drainage channel for discharging storm water runoff from the entire sub-basin to the Weras Ganga swamp. A conceivable route of principal drainage channel is shown in Figure 4.5.9.

The existing channel to the Weras Ganga swamp is restored together with reconstruction of the existing crossing culvert at the Colombo-Piliyandala Road to

cope with the design runoff at 5-year return period. The channel bed gradient is designed at 1/1,000. A designed channel cross section is trapezoidal-shaped with 15 m bed width. A maintenance road with 4 m width is provided on the right bank of the channel.

Design Features of Boralesgamuwa South Scheme

Components	Design Features
Channel Improvement Stretch	• Length: 980m • Channel Bed Gradient: 1/1,000 • Channel Bed Level: -0.4 to +0.6 m • Design Runoff (5-year return period): 28 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 15 m bed width • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains • Bridge: 1 no.

4.5.6 Maha Ela Scheme

The Maha Ela is the largest tributary of the Weras Ganga. The lowland in the middle and upper reaches of the Maha Ela are paddy cultivation areas. The Maha Ela functions as an irrigation canal for the paddy cultivation together with small creeks running in parallel. Storm water runoff in the Maha Ela sub-basin gathers and retards into the lowlands and is drained by the Maha Ela and irrigation creeks. In the downstream reaches, the paddy cultivation was abandoned in the vicinity of the Colombo-Piliyandala Road. A widespread marsh area is located in the most downstream reaches to the Weras Ganga.

The problems on inundation are mainly reported around the vicinity of the Colombo-Piliyandala Road. In the downstream reaches, the channel is affected by backwater from the Weras Ganga in the marsh area, where storm water runoff becomes stagnant in the unimproved and neglected channel inaccessible for improvement or maintenance. In combination with these causes, the channel overflows in the vicinity of the Colombo-Piliyandala Road. Houses in the vicinity are prone to inundation and heavy traffic jams occur on every occasion of inundation.

A tributary joins the Maha Ela at 770 m downstream of the Colombo-Piliyandala Road. This tributary is a small creek which was used for irrigation. At present, the lowland along the tributary is abandoned paddy field likely to be urbanized in the future. It is also expected that the presently urbanized area along the Colombo-Piliyandala Road including Piliyandala town area will be expanding to the lowland. It is therefore desirable to improve this tributary as a principal drainage channel.

Based on the considerations above, the conceivable structure measures of the Maha Ela Scheme are illustrated in Figure 4.5.10.

(1) Maha Ela Channel Improvement

For the stretch 830 m upstream from the Colombo-Piliyandala Road, the existing channel is improved to cope with the design runoff at 10-year return period. The channel bed gradient is designed at 1/950. A designed channel cross section is trapezoidal-shaped with 32 m bed width. A maintenance road with 4 m width is provided on the right bank of the channel.

For the downstream stretch of the Colombo-Piliyandala Road, the channel is dredged to discharge storm water runoff smoothly to the Weras Ganga. The lowest channel bed level is 1.5 m below MSL at the confluence of the Weras Ganga and the channel bed gradient is designed at 1/950 to 1/4,600. As the channel flows down in the retention area, the channel is allowed to overflow its left bank against excessive runoff. A maintenance road with 4 m width is provided on the right bank. Surface elevation of embankment for the maintenance road is designed at 1.2 to 1.7 m above MSL to cope with the design flood level in the retention area. The necessary number of crossing drains are provided for embankment of the maintenance road for the purpose to drain storm water flowing into the retention area on the right bank into the channel.

Design Features of Maha Ela Scheme
(1) Maha Ela Channel Improvement

Components	Design Features
Channel Improvement Stretch ME1	• Length: 1,100 m • Channel Bed Gradient: 1/4,600 • Channel Bed Level: -0.6 m to -0.4 m • Design Runoff (10-year return period): 47 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 32 m bed width and 2.0 m depth • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains • Bridge: 1 no.
Channel Improvement Stretch ME2	• Length: 770 m • Channel Bed Gradient: 1/950 • Channel Bed Level: -0.4 m to -0.2 m • Design Runoff (10-year return period): 51 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 32 m bed width • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains • Bridge: 1 no.

Components	Design Features
Channel Improvement Stretch ME3	• Length: 830 m • Channel Bed Gradient: 1/950 m • Channel Bed Level: -0.2 m to +0.7 m • Design Runoff (10-year Return Period): 61 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 32 m bed width • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains

(2) Maha Ela Tributary Channel Improvement

The existing channel upstream of Thumbowila Road crossing culvert is improved to cope with the design runoff of 10 m^3/sec at 10-year return period. The channel bed gradient is designed at 1/850. A designed channel cross section is trapezoidal-shaped with 15 m bed width. For the rest of the stretch flowing down in the retention area, the channel bank remains at present level to allow the channel to overflow its left bank against excessive runoff. A maintenance road with 4 m width is provided on the right bank. The necessary number of crossing drains are provided for embankment of the maintenance road in the retention area.

Design Features of Maha Ela Scheme
(2) Maha Tributary Ela Channel Improvement

Components	Design Features
Channel Improvement Stretch MET1	• Length: 780 m • Channel Bed Gradient: 1/2,000 • Channel Bed Level: -0.4 m to -0.4 m • Design Runoff (10-year return period): 28 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 15 m bed width • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains • Bridge: 1 no.
Channel Improvement Stretch MET2	• Length: 980 m • Channel Bed Gradient: 1/850 • Channel Bed Level: 0.4 m to 1.2 m • Design Runoff (10-year return period): 28 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 15 m bed width • Maintenance Road: left bank, width 4 m, earth embankment with crossing drains • Bridge: 1 no.

(7) Ratmalana-Moratuwa Scheme

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 drainage congestion because of the low-lying topography. The conceivable structure measures of the Ratmalana-Moratuwa Scheme are illustrated in Figure 4.5.11.

It is expected that the highly urbanized area along the Weras Ganga right bank will be protected from the Weras Ganga flooding by constructing the masonry wall dike. However, the drainage problem will still remain in the lowland with ground elevation of 1.0 m or less along the Weras Ganga. Although this problem originates from the topographic constraints making it difficult to drain storm water runoff from its own catchment, it is necessary to provide alleviation measures by improving the existing urban drainage system in this area.

Improvement of the existing urban drainage system to be incorporated with the storm water drainage plan for the Weras Ganga basin comprises construction of drains including urban drainage channels and retention ponds at the downstream ends of existing minor tributaries of the Weras Ganga. The design discharge of 2-year return period is applied for the urban drainage improvement. 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 on the right bank of the Weras Ganga.

A minor tributary of the Weras Ganga in Katubedda is also improved for alleviating drainage congestion along the border of the marsh area. The channel bed gradient is designed at 1/750. For the rest of the stretch flowing down in the retention area, the channel bank remains present level for allowing the channel to overflow its left bank against excessive runoff. A maintenance road with 4 m width is provided on the right bank. The necessary number of crossing drains are provided for embankment of the maintenance road in the retention area.

Design Features of Ratmalana-Moratuwa Scheme

Component	Design Features
Urban Drainage	• Total Length: 11,120 m • Design Runoff (2-year return period) • Concrete Flume with Cover: length 6,390 m • Open Channel with Masonry Revetment: length 2,800 m • Improvement of Existing Channel: length 1,920 m
Retention Pond Kandawala	• Water Surface Area: 3 ha • Bottom Level of Pond: -1.0 m • Storage at Normal Water Level of +0.4 m: 42,000 m^3 • Storage at High Water Level of +0.6 m: 48,000 m^3
Retention Pond Telawala	• Water Surface Area: 10 ha • Bottom Level of Pond: -1.0 m • Storage at Normal Water Level of +0.4 m:140,000m^3 • Storage at High Water Level of +0.6 m: 160,000 m^3

Component	Design Features
Channel Improvement Minor Tributary of Weras Ganga	• Length: 1,250 m • Channel Bed Gradient: 1/1,600 • Channel Bed Level: -0.9 m to -0.1 m • Design Runoff (5-year return period): 11 m^3/sec • Channel Cross Section: earth open channel, trapezoidal section, 6 m bed width • Maintenance Road: right bank, width 4 m, earth embankment with crossing drains • Culvert: 2 nos.

4.6 Required Extent of Retention Area

The conceivable storm water drainage plans discussed in the section are based on the premise that the lowlands categorized as 'marsh' in the future land use projection discussed in Annex 4 of this report will be conserved as storm water retention areas.

However, encroachment into the marsh is occurring throughout the Weras Ganga basin although efforts of restriction by the government in accordance with the CRMSP are being undertaken. Loss of the existing marsh by land filling affects adversely the storm water drainage plan for the Weras Gang basin. Therefore, the present study envisages highlighting the need for conserving the existing marsh as storm water retention area.

At first, increase of storm water runoff by loss of retention area is analyzed for sub-basin. The retention areas located in the highly urbanized areas directly affect the downstream channel as tabulated below:

Increase of Storm Water Runoff by Loss of Retention Area

Drainage Channel in Sub-basin	Planning Scale (Return Period)	Design Runoff (m^3/sec)	
		With R/A	Without R/A
Rattanapitiya Ela	10-year	53	64
Katubedda Tributary	5-year	11	13
Thumbowila Tributary	5-year	3	4

The retention areas in the Nugegoda-Rattanapitiya Ela sub-basin are located upstream of the Rattanapitiya Ela. Storm water runoff in the Rattanapitiya Ela increases by 11 m^3/sec without the existing retention areas. The Rattanapitiya Ela is being subject to urbanization that is anticipated to restrict further widening of the channel after the loss of the retention areas. Therefore, the upstream retention areas of 36 ha should be kept essentially for the storm water drainage plan in the sub-basin even though the loss of the retention areas would not have much affect on the Weras Ganga.

For the subsequent analysis of required extent of storm water retention area in the Weras Ganga basin, loss of storm water retention area beyond the future land use projection is assumed on the basis of the followings:

1) Locations of outstanding land filling identified, which tend to be expanding.
2) Influence on marsh near future urbanized area, suggested by the detail land use zonings for Dehiwela-Mount Lavinia MC, Moratuwa MC and Kesbewa PS prepared by UDA as of October 1998.

Locations of these are shown in Figure 4.6.1 and loss of retention area for the analysis is assumed as follows:

1) Marsh areas with small extent surrounded by highly urbanized area, such as Katubedda Tributary and Thumbowila Tributary, total extent of 31 ha
2) Bellanwila-Attidiya Marsh, north, east and southeast, 40 ha
3) Maha Ela Marsh and Lowland upstream of Colombo-Piliyandala Road, 26 ha

The retention areas subject to the assumed loss are shown in Figure 4.6.2. The analyses are undertaken on the following assumptions:

Case-1: Storm water retention area remains as of the extent of marsh in the future land use projection.

Case-2: The total 31 ha of retention areas with small extent in highly urbanized area are lost.

Case-3: In addition to Case-2, loss of retention area of 40 ha occurs in Bellanwila-Attidiya Marsh.

Case-4: In addition to Case-3, loss of retention area of 26 ha occurs in Maha Ela Marsh and Lowland upstream of Colombo-Piliyandala Road

The cases above are analyzed by the simulation model for inundation. The results are summarized as lost extent of retention area and water level at base point.

Summary of Simulation Analysis on Loss of Retention Area

Case	1	2	3	4
Retention Area (ha)	372	341	301	275
Water Level at Base Points (m above MSL)				
• Confluence of Bolgoda Canal and Rattanapiliya Ela	1.45	1.46	1.58	1.58
• Weras Ganga, Downstream End of Swamp	1.07	1.07	1.12	1.14
• Weras Ganga, Confluence of Katubedda Tributary	0.80	0.81	0.82	0.84
Average Water Level (m above MSL)	1.10	1.11	1.17	1.19

Influence by loss of retention area to water level of the Weras Ganga is different for each retention area. For analyzing this influence, the extent of retention area is related with water level of the Weras Ganga. Figure 4.6.3 indicates the estimated water surface profiles of the Weras Ganga for the respective cases. The cases 2 to 4 for loss of retention area shows a tendency that the increment of water level is larger in the upstream and is gradually reducing to the downstream. Water level in the Weras Gagna would rise with a similar tendency by loss of retention area because of the existence of the widespread water area of the North Bolgoda Lake in the downstream. The influence by loss of each retention area is therefore evaluated with a relationship between an extent of retention area and average water levels at several representative points in the Weras Ganga.

Figure 4.6.4 indicates the relationships between the extent of retention area and average water level of the Weras Ganga. A 'Line-A' represents a change of the average water level as loss of retention area is increasing with occurrence of Case-2, 3 and 4 successively. Under this assumption, the average water level reaches the equivalent in the case of 'without' project at a reduced extent of retention area of 312 ha in total. When further increase of the average water level is not allowed, a required extent of retention area is 312 ha in total.

Line-B or C for different process would also be possible. A required retention area is different by process, i.e. 340 ha for Line-B and 295 ha for Line-C. The result is that the slope of the line represents the grade of influence by corresponding loss of retention area. The Bellanwila-Attidia Mash retention area represents the highest influence by its reduction, followed by the Maha Ela Marsh and Lowland retention area and the small retention areas in the urbanized areas.

Required extent of retention area resulting from the analyses above is shown by individual retention areas as follows, together with the retention areas based on the future land use projection:

Retention Areas for Storm Water Drainage Plan in Weras Ganga Basin

Retention Area	Based on Future Land Use Projection (ha)	Required Extent of Retention Area (ha)
Upper Nugegoda Ela	7	7
Lower Nugegoda Ela	20	20
Delkanda Ela	9	9
Bellanwila-Attidiya Marsh	108	88
Weras Ganga Swamp and Surrounding Marsh	65	65
Maha Ela Marsh and Lowland	132	106
Katubedda Tributary	23	0
Thumbowila Tributary	8	0
Total	372	295

4.7 Conclusions of Storm Water Drainage Plan

As a conclusion of the studies discussed in this section, the proposed storm water drainage plan comprise 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

Tables

Table 3.1.1 List of Flood Prone Areas Identified by Flood Damage Survey in 2001

Location No.	Sub-basin	Name of Area
1	Nugegoda-Rattanapitiya	Nugegoda Behind St. Joseph's Convention
2	Nugegoda-Rattanapitiya	Kattiya Junction Off Gangodavila North
3	Nugegoda-Rattanapitiya	Gangodavila South, Pepiliyana Road
4	Nugegoda-Rattanapitiya	Walawwatta Road
5	Nugegoda-Rattanapitiya	Rubber Watta Close to Imbugahawatta Area Off Old Kesbewa Road
6	Nugegoda-Rattanapitiya	Nugegoda - Perera Mw, Dutugemunu Street Kohuwala
7	Nugegoda-Rattanapitiya	Peters Place, Reymond Road, Travence Gardens
8	Nugegoda-Rattanapitiya	Nugegoda Nalandarama Road
9	Nugegoda-Rattanapitiya	Nugegoda - Meldor Place, Tissa Avenue Area
10	Nugegoda-Rattanapitiya	Kalubowila - Woodland Avenue Part
11	Nugegoda-Rattanapitiya	Sunethradevi Road near Dhatumaluwa Temple
12	Nugegoda-Rattanapitiya	Sri Mala Vihara Road
13	Nugegoda-Rattanapitiya	Rattanapitiya Area near to Rattanapitiya Junction
14	Bolgoda Canal	Vijayaraja Avanue, Vijitha Road
15	Bolgoda Canal	Attidiya - End of Upananda Mawatha Area Around
16	Bolgoda Canal	Attidiya - Manthrimulla Road, Indigahadeniya
17	Bolgoda Canal	Mt. Lavinia Peiris Road, Abeysekera Road Area
18	Bolgoda Canal	Mt. Lavinia Peiris Road,
19	Bolgoda Canal	Uldagoda Mw
20	Bolgoda Canal	Athula Mawatha
21	Bolgoda Canal	Ratmalana Sri Dhammadara Mw from Maliban Factory
22	Bolgoda Canal	Yasorapura
23	Bolgoda Canal	Ratmalana, Lower End of First Lane
24	Bolgoda Canal	Ratmalana - Second Lane, Third Lane, Fourth Lane
25	Boraleagamuwa North	Welayaya Road between Nawinna Junction and Wijerama Junction, Welyaya Road up to Pasal Mw
26	Boraleagamuwa North	Janatha Road (Access from Nawinna Junction)
27	Boraleagamuwa North	Rattanapitiya Colombo-Horana Road near Bridge and Lowland area
28	Boraleagamuwa North	Bellanwila Dehiwala Road near Lowland Area, Bellanwila Gramasewaka Office
29	Boraleagamuwa South	Borelasgamuwa Pirivena Road
30	Boraleagamuwa South	Borelasgamuwa Pubudu Mawatha
31	Maha Ela	Bokundara Colombo-Horana Road near ICC
32	Maha Ela	Battiyawatta, Duwawatta Road, Pattiyawatta Road
33	Maha Ela	Karadiyana Werahera Karadiyana Area
34	Ratmalana-Moratuwa	Ratmalana - Kandawala
35	Ratmalana-Moratuwa	Ratmalana - Borupana Road, Borupana Dharmarama Mw, Borupana 1st Cross Street
36	Ratmalana-Moratuwa	Borupana
37	Ratmalana-Moratuwa	Telawala
38	Ratmalana-Moratuwa	Katubedda
39	Ratmalana-Moratuwa	Rawatawatta

Table 3.1.2 Results of Interview Survey for Frequencey and Duraion of Inundation (1/3)

Location No.	Sub-basin	Name of Area	Frequency of Inundation (times/year)		Duration of Inundation (days)	
			Inunation Outside House/Building	Inundation Inside House/Building	Average Inundation	Maximum Inundation
1	Nugegoda-Rattanapitiya	Nugegoda Behind St. Joseph's Convention	5	4	0	1
			3	2	0	1
			6	6	1	3
2	Nugegoda-Rattanapitiya	Kattiya Junction Off Gangodavila North	1	-	1	2
			-	3	2	1
3	Nugegoda-Rattanapitiya	Gangodavila South, Pepiliyana Road	10	10	3	3
			3	3	2	5
4	Nugegoda-Rattanapitiya	Walawwatta Road	10	10	1	14
			3	3	2	3
			4	4	1	2
5	Nugegoda-Rattanapitiya	Rubber Watta Close to Imbugahawatta Area Off Old Kesbewa Road	1	0	1	1
			2	2	1	2
			5	1	1	2
6	Nugegoda-Rattanapitiya	Nugegoda - Perera Mw, Dutugemunu Street Kohuwala	1	-	0	-
			6	0	0	0
			0	0	1	1
7	Nugegoda-Rattanapitiya	Peters Place, Reymond Road, Travence Gardens	10	5	1	2
			4	4	0	1
			3	2	1	5
8	Nugegoda-Rattanapitiya	Nugegoda Nalandarama Road	2	5	1	2
			6	6	0	2
			20	20	0	1
9	Nugegoda-Rattanapitiya	Nugegoda - Meldor Place, Tissa Avenue Area	6	2	-	-
			6	3	0	30
			3	0	0	1
10	Nugegoda-Rattanapitiya	Kalubowila - Woodland Avenue Part	3	5	0	1
			3	2	1	4
			4	1	0	1
11	Nugegoda-Rattanapitiya	Sunethradevi Road near Dhatumaluwa Temple	3	3	0	0
			3	3	0	0
			7	7	0	1
12	Nugegoda-Rattanapitiya	Sri Mala Vihara Road	5	0	2	3
			3	0	1	1
			5	6	1	1
13	Nugegoda-Rattanapitiya	Rattanapitiya Area near to Rattanapitiya Junction	2	1	1	3
			4	2	1	1
			3	3	1	7

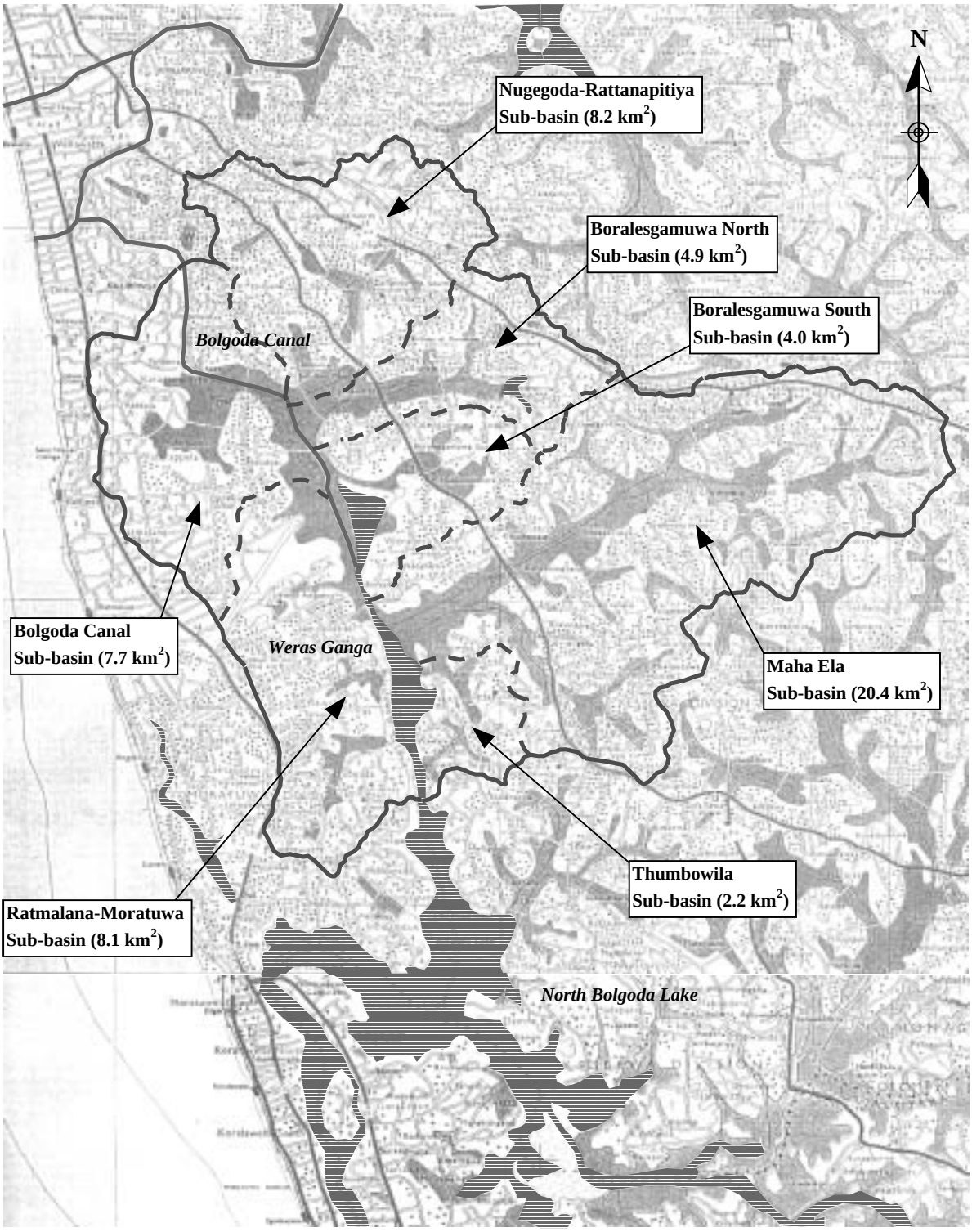
Table 3.1.2 Results of Interview Survey for Frequencey and Duraion of Inundation (2/3)

Location No.	Sub-basin	Name of Area	Frequency of Inundation (times/year)		Duration of Inundation (days)	
			Inunation Outside House/Building	Inundation Inside House/Building	Average Inundation	Maximum Inundation
14	Bolgoda Canal	Vijayaraja Avanue, Vijitha Road	5	5	2	4
			3	3	1	2
			5	5	1	7
15	Bolgoda Canal	Attidiya - End of Upananda Mawatha Area Around	10	8	2	4
			12	8	2	3
			8	2	1	3
16	Bolgoda Canal	Attidiya - Manthrimulla Road, Indigahadeniya	3	0	2	5
			5	3	4	3
			5	3	4	12
17	Bolgoda Canal	Mt. Lavinia Peiris Road, Abeysekera Road Area	4	0	0	0
			4	0	0	0
18	Bolgoda Canal	Mt. Lavinia Peiris Road,	4	4	0	0
19	Bolgoda Canal	Uldagoda Mw	3	2	3	5
			7	6	0	1
20	Bolgoda Canal	Athula Mawatha	3	2	1	4
21	Bolgoda Canal	Ratmalana Sri Dhammadara Mw from Maliban Factory	6	0	0	0
			6	0	0	0
			5	3	0	0
22	Bolgoda Canal	Yasorapura	8	7	1	1
			8	1	1	2
			10	0	1	2
23	Bolgoda Canal	Ratmalana, Lower End of First Lane	10	0	0	2
			5	0	1	2
			10	10	1	2
24	Bolgoda Canal	Ratmalana - Second Lane, Third Lane, Fourth Lane	6	6	0	1
			0	3	0	1
			10	2	0	1
25	Boralesgamuwa North	Welayaya Road between Nawinna Junction and Wijerama Junction	6	0	1	1
		, Welyaya Road upto Pasal Mw	2	2	1	1
26	Boralesgamuwa North	Janatha Road (Access from Nawinna Junction)	4	3	1	3
			4	4	1	14
27	Boralesgamuwa North	Rattanapitiya Colombo-Horana Road near Bridge and Lowland area	5	5	1	7
			4	2	1	1
			5	5	2	4
28	Boralesgamuwa North	Bellanwila Dehiwala Road near Lowland Area, Bellanwila Gramasewaka Office	6	10	1	1
			3	3	2	5
			6	0	1	1

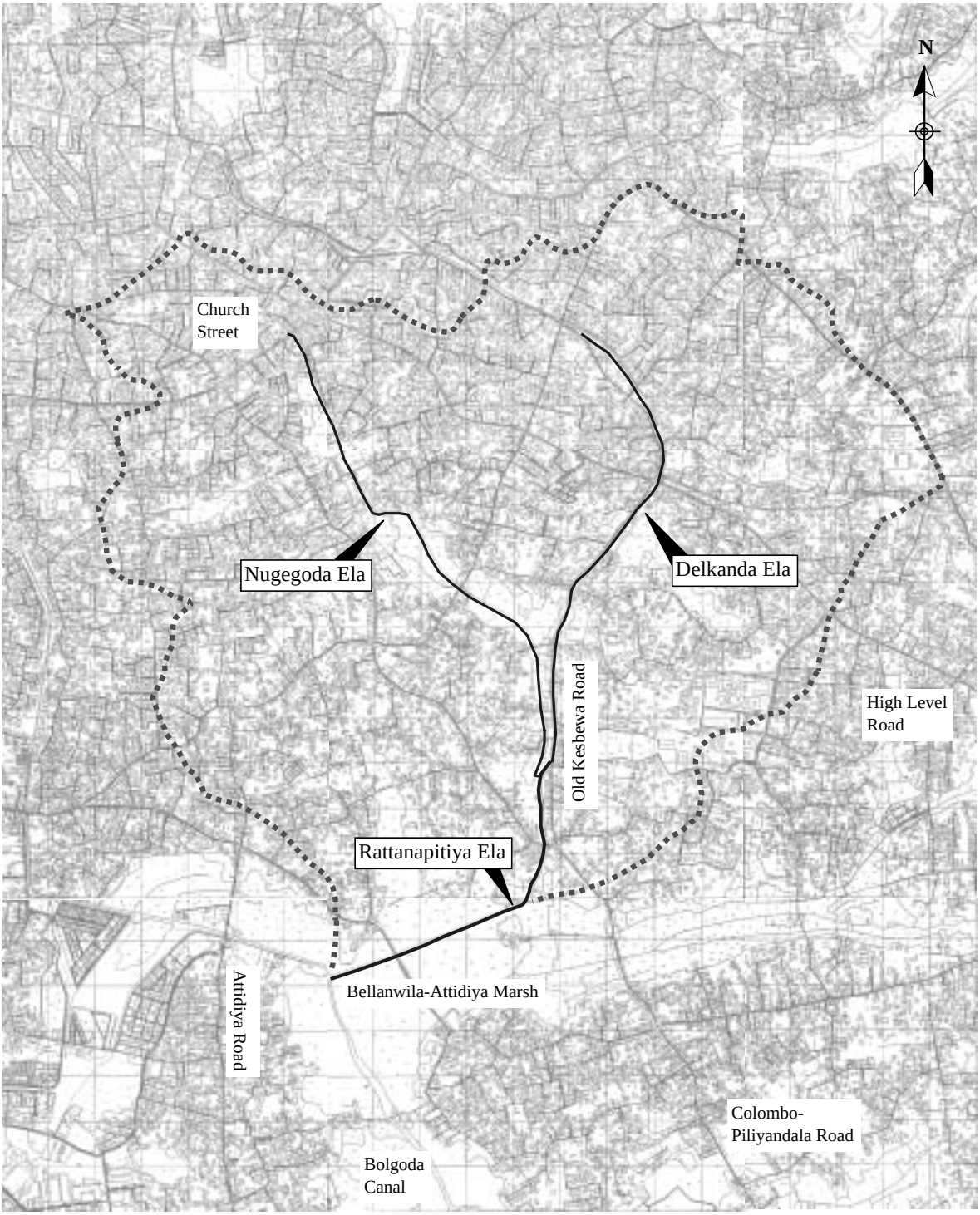
Table 3.1.2 Results of Interview Survey for Frequencey and Duraion of Inundation (3/3)

Location No.	Sub-basin	Name of Area	Frequency of Inundation (times/year)		Duration of Inundation (days)	
			Inunation Outside House/Building	Inundation Inside House/Building	Average Inundation	Maximum Inundation
29	Boralesgamuwa South	Borelasgamuwa Pirivena Road	2	2	1	1
			4	3	2	2
			3	0	1	2
30	Boralesgamuwa South	Borelasgamuwa Pubudu Mawatha	2	0	3	10
			3	3	1	2
31	Maha Ela	Bokundara Colombo-Horana Road near ICC	6	3	2	2
			3	3	3	4
			6	4	2	2
			2	2	2	-
32	Maha Ela	Battiyawatta, Duwawatta Road, Pattiyawatta Road	2	1	1	7
			6	6	5	14
			5	1	1	1
			5	0	1	15
33	Maha Ela	Karadiyana Werahera Karadiyana Area	5	0	2	2
			3	-	1	1
			0	0	2	1
34	Ratmalana-Moratuwa	Ratmalana - Kandawala	4	2	0	1
			3	2	1	2
			4	2	1	2
35	Ratmalana-Moratuwa	Ratmalana - Borupana Road, Borupana Dharmarama Mw, Borupana 1st Cross Street	10	4	0	0
			6	2	0	3
			6	-	1	2
36	Ratmalana-Moratuwa	Ratmalana-Borupana Road	3	4	1	2
			10	10	1	1
			8	2	2	14
37	Ratmalana-Moratuwa	Telawala	4	4	1	2
			3	5	1	1
			5	0	1	1
38	Ratmalana-Moratuwa	Katubedda	10	10	1	2
			10	-	1	2
			9	5	1	2
39	Ratmalana-Moratuwa	Rawatawatta	10	6	1	1
			15	10	1	1
			6	-	3	-
Average			5.2	3.3	1.1	3.1

Figures



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 1.1.1 Weras Ganga Basin
JAPAN INTERNATIONAL COOPERATION AGENCY	



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

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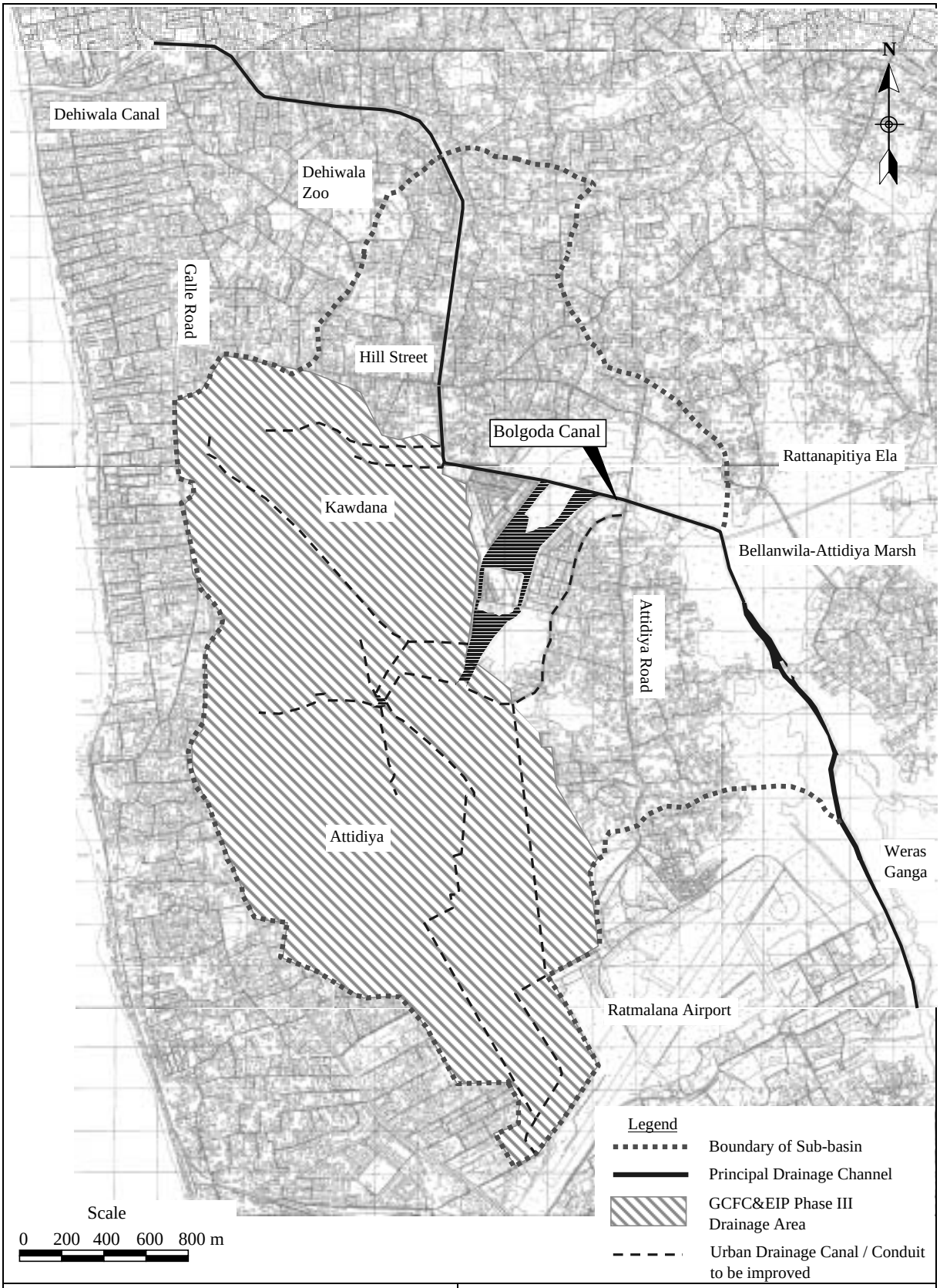
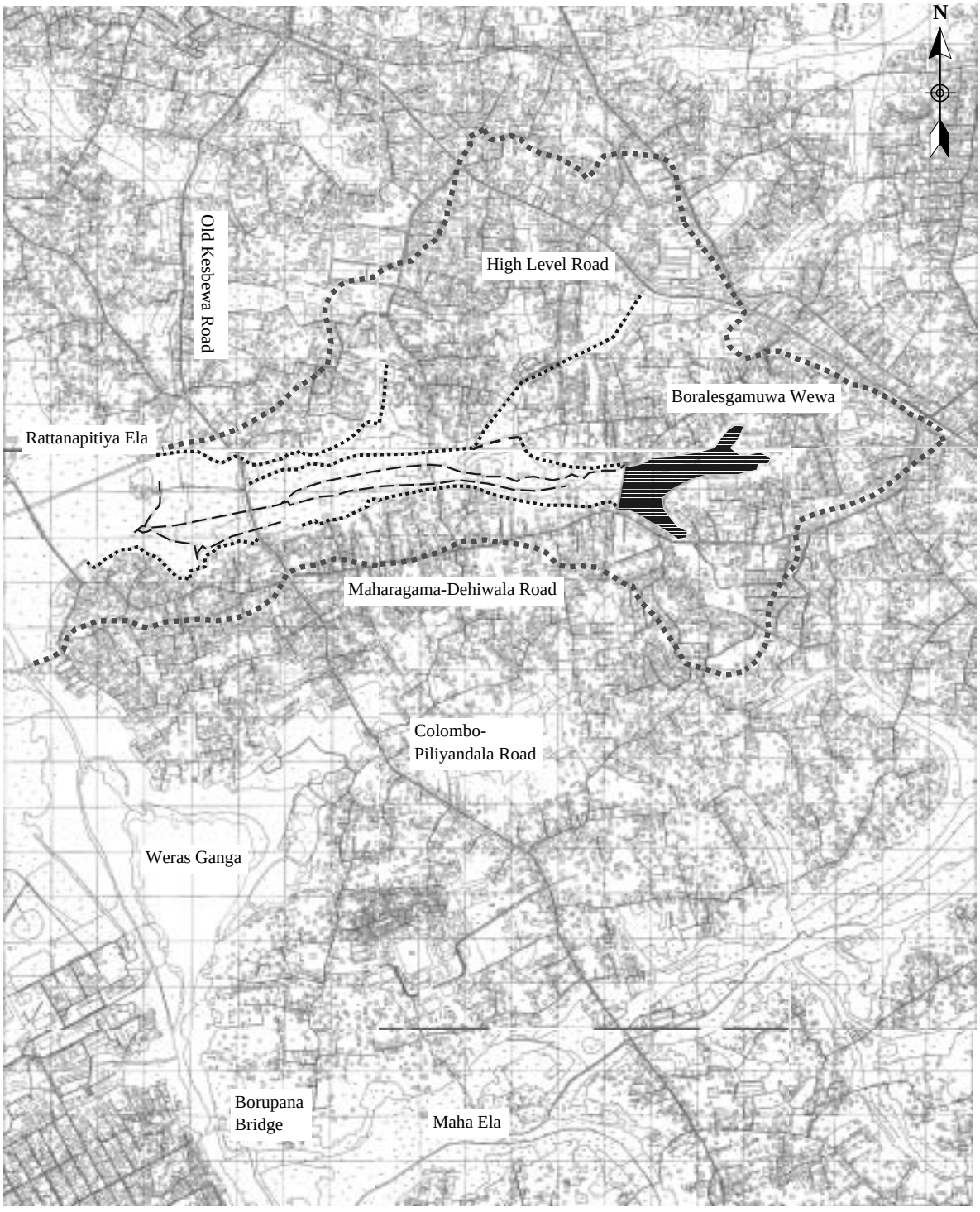
Figure 1.1.2
Nugegoda-Rattanapitiya Sub-basin



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 1.1.3 Bolgoda Canal Sub-basin
JAPAN INTERNATIONAL COOPERATION AGENCY	



Scale
0 200 400 600 800 m

Legend
Boundary of Sub-basin
Urban Drainage Channel
Irrigation Creek

The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 1.1.4 Boralesgamuwa North Sub-basin
JAPAN INTERNATIONAL COOPERATION AGENCY	