SUPPORTING REPORT (1)

ANNEX 3 : HYDROLOGY

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

FINAL REPORT

VOLUME III : SUPPORTING REPORT (1)

ANNEX 3 : HYDROLOGY

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CHAPTER 1 GENERAL

1.1 Objectives of the Hydrological Study

Hydrological analysis in this Study aims at clarifying the hydrological and hydraulic phenomena of the drainage systems in the study area with enough accuracy for assessing the effect of proposed structural measures and the influence of the change of land use conditions on the flood runoff and inundation characteristics. This analysis also provides the hydraulic conditions for the design of proposed structural measures.

The hydrological study includes the following.

1) Rainfall analysis
2) Setting up of hydrological and hydraulic models
3) Calculation of probable floods and generation of flood inundation maps

1.2 Objective Drainage Basins

Although the boundary line of the northern part of the study area crosses the middle reaches of the Dandugam Oya and the Ja Ela mainstreams as shown in Figure 1.2.1, it is appropriate that the basin upstream of those channels is also included in the objective area in this hydrological analysis.

In this hydrological analysis, therefore, the following are set as objective drainage basins.

Objective Drainage Basins for Hydrological Analysis

No.	Drainage Basin	Catchment Area
1.	Attanagalu Oya	860.6 km^2
2.	Kalu Oya	57.6 km^2
3.	Greater Colombo	98.5 km^2
4.	Bolgoda	394.0 km^2

The above four basins are shown in Figure 1.2.1.

(1) The Attanagalu Oya Basin

The Attanagalu Oya basin consists of the drainage basins of Attanagalu Oya, Mapalam Oya, Urwal Oya, Dandugam Oya, Ja Ela, Old Negombo canal and Hamilton canal. Among these rivers or canals, Old Negombo canal and Hamilton canal stretch from south to north along the coastline and small canals in the Muthurajawela marsh connect these. Other rivers are connecting with one another in the middle reaches, and finally flowing into Negombo Lagoon from two outfalls, i.e. Dandugam Oya and Ja Ela, from the north.

The catchment area of the total of Dandugam Oya and Ja Ela is around 800 km^2, and remaining 60 km^2 is the drainage area of Hamilton and Old Negombo canals.

(2) The Kalu Oya Basin

The downstream end of the Kalu Oya basin is set at the confluence between Kalu Oya and Old Negombo canal. The drainage area of the upstream basin from the end is 57.6 km^2.

The runoff from the Kalu Oya basin flows into Old Negombo canal. After flowing in the Old Negombo canal, the runoff flows south to join the Kelani Ganga. There is a closing bund with small culverts just north of the confluence of the Kalu Oya with the Old Negombo canal. This bund prevents the runoff from the Kalu Oya basin from flowing north at present. Since the flood runoff in the Kalu Oya basin can only flow into the Kelani Ganga through the Old Negombo canal, it is imagined that high water level lasts a long time when the stage water level of the Kelani Ganga is also high. This tendency is confirmed through the interview survey with the local residents in the basin.

(3) The Greater Colombo Basin

The drainage area of the Greater Colombo basin can be divided into two major basins, i.e. the Greater Colombo and Malabe basins. The catchment area of the former is 85.7 km^2 and that of the latter is 12.8 km^2. The Madiwela East diversion channel, constructed in 1997, connects these two basins and the runoff from the eastern part (about 5 km^2) of the Greater Colombo basin is diverted to the Malabe basin at present. There is a spillway at the boundary of these two basins and the excess flood runoff from the 5 km^2 catchment flows into the Greater Colombo basin through the spillway.

Considering the above condition, these two basins had better be handled as one basin. The Greater Colombo basin in this hydrological analysis, therefore, includes the Malabe basin.

The runoff from the Greater Colombo basin flows into the Kelani Ganga from Dematagoda Ela and the Madiwela East diversion channel. That also flows into the Indian Ocean from Welawatta and Dehiwala outfalls in the west.

(4) The Bolgoda Basin

The Bolgoda basin has four outfalls. The Panadura Ganga and Talpitiya Ela connect to the Indian Ocean. The Aluth Ela and Kepu Ela flow into the Kalu Ganga at the south end of the basin. Out of these four outfalls, the Talpitiya Ela outfall is clogged at present. Furthermore, the two rivers connecting to the Kalu Ganga, that is, the Aluth Ela and Kepu Ela, have gates before connecting to the Kalu Ganga. Although the gates were installed mainly for irrigation purposes, it is reported that those gates are closed when the stage water level of the Kalu Ganga is high in order to prevent the floodwater in the Kalu Ganga from flowing into the Bolgoda basin.

Considering the situation above, the only reliable outfall of the Bolgoda basin is the Panadure Ganga outfall.

The total catchment area of the Bolgoda basin is 394.0 km^2.

CHAPTER 2 OBSERVATION NETWORK IN THE OBJECTIVE DRAINAGE BASINS

2.1 Rainfall Records

A number of rainfall gauging stations are located in and around the drainage basins relevant to the study area. Of these, it was found that some stations are not operated properly or already closed. The daily rainfall records were therefore collected from the selected stations that are well maintained at present and have a sufficient period of records for the purpose of the study. The daily rainfall records were collected from the following 14 rainfall gauging stations:

Rainfall Gauging Stations

No.	Station	No.	Station
1.	Angoda	8.	Horana
2.	Bandaragama	9.	Kalutara
3.	Boralesgamuwa	10.	Katunayake
4.	Dehiwala	11.	Pasyala
5.	Halgahapitiya	12.	Ratmalana
6.	Hanwalla	13.	Vincit
7.	Henarathgoda	14.	Colombo

Locations of these stations are shown in Figure 2.1.1. The majority of these have more than 30 years of recent records with some intermittent. The period of daily rainfall records collected for each station is shown in Figure 2.1.2. As seen in the figure, the record of Bolaresgamuwa station (No.3) is available from September of 1990 continuously, and that of Hanwella station (No.6) is available from September of 1971. Although the daily rainfall records of other gauging stations are available from 1970, Bandaragama (No.2), Dehiwala (No.4), Horana (No.8) and Kalutara (No.9) have long intermittent period with durations of 1 year (Horana) to 12 years (Dahiwala) between 1970 and 2001. Regarding another stations, the daily rainfall records are generally available except for short duration intermittent periods.

Of the rainfall gauging stations above, pluviographs and short interval data at rainstorm events were also made available for the recording rainfall gauging stations of Katunayake (No.10), Ratmalana (No.12) and Colombo (No.14).

2.2 Water Level and Discharge Measurement Records

Figure 2.2.1 shows the location of existing water level and discharge measuring stations in the objective drainage basins. The period of water level records available is presented in Figure 2.2.2. The timing of installation of water level gauging stations is much later compared with that of rainfall gauging stations. All of the water level gauging stations were installed after 1995. Seven water level gauging stations were installed in the Greater Colombo basin in the middle of 1995 in the course of the Greater Colombo Flood Control and Environment Improvement Project (GCFC&EIP). The water level gauging stations were installed subsequently in the northern part of the Bolgoda basin from 1996 to 1998 also in the course of GCFC&EIP. The number of water level gauging stations was rapidly increased in the year of 2000 and 56 stations are functioning as of December 2001.

Water level is observed once or twice a day (morning and evening) at all those stations, even when in flood situation, by the gauge keepers living near the respective stations. Discharge measurements are also made a few times per month. Utilizing these observed water level and discharge measurement records, the relationship between water level and discharge (H-Q curves) is estimated for at least 9 stations, i.e. Station Nos. 19, 20, 22, 23, 26, 27, 28, 29 and 31. The existence of H-Q curves of other stations has not been confirmed.

Although the H-Q curves at 9 gauging stations are available, since the discharge measurement is seldom conducted during flood events, the discharges obtained by the H-Q curves are unreliable in high stage water levels.

2.3 Installation of New Rainfall and Water Level Gauging Stations

The problems in rainfall and water level gauging stations can be summarized as follows through the above discussions:

1) As for the rainfall gauging stations, the records of daily basis are relatively rich, while those of short-intervals such as 15-, 30- or 60-minute are insufficient.
2) Considering that the flood water level fluctuates rapidly according to the occurrence of storm rainfall, short-interval records of stage water level are also needed for studying the characteristics of the flood phenomenon in the study area. However no short-interval water level records are available so far.

In order to resolve the situation, it is very effective to install automatic rainfall and water level gauges for studying flood phenomena and formulating storm water drainage plans in the study area. Short-interval (less than 1 hour) rainfall and water level records are easily obtained by those automatic gauges in digital format.

Five automatic rainfall gauging stations and ten water level gauging stations were installed in the study area in April 2002 in the course of the study. The main purpose of the installation was for the calibration of hydrological and hydraulic models constructed in this study.

Locations of newly installed rainfall gauging stations (5 locations) and water level gauging stations (10 locations) are shown in Figure 2.3.1. The locations were decided taking into account locations of existing stations and the importance of the points for the flood analysis and drainage planning.

Figure 2.3.1 also shows the typical site photos of both rainfall and water level gauging stations.

Since no large storm rainfall occurred during the study period, the record of these automatic rainfall and water level gauging stations could not be utilized for the actual calibration work.

2.4 Elevation Data of Flood Plains

Collection of accurate information on the elevation in the study area, especially in flood plains, is one of the most important aspects for setting up flood inundation models and generating flood inundation maps.

That data were gathered from existing topographic maps mostly with the scale of 1 to 10,000. However, some part of flood plains are not covered by the 1:10,000 maps, and detailed information on the flood plain elevation is not included in these scaled topographic maps.

Determining the effect of the existing lowlands on the flood water level is one of the main points of this study. Considering that the volume of the flood plain controls the effect, lack of the elevation data of the lowland area is fatal for this kind of analysis.

The elevation in the flood plains was estimated from the result of channel cross section surveys and spot level surveys of marshy land boundaries carried out in this Study. The accuracy level adequate for the master planning is maintained by this operation. However, the detailed survey on the lowland area is needed in order to discuss the role of those areas more quantitatively and more accurately.

CHAPTER 3 RAINFALL ANALYSIS

3.1 Review of Rainfall Records Collected

Consistency of the rainfall records collected was tested using the Double Mass Curve method. Between two rainfall gauging stations, rainfall depth at each station is accumulated whenever records are available on corresponding days for both stations. The accumulated rainfall depth is plotted on a graph year by year as shown in Figure 3.1.1. Consistency of the records can be assessed from gradient of the plotted curves on the graph showing an almost linear gradient when records of two stations indicate consistency with each other.

This process was carried out for all the rainfall records of the 14 stations and no significant inconsistency was observed. It is therefore concluded that all the rainfall records have been recorded with acceptable accuracy.

3.2 Characteristics of Storm Rainfall

Heavy rainstorms in the study area located in the southwest quarter of the country occur mainly in the Southwest Monsoon period from May to September and occasionally in the two Inter-monsoon periods (Mach-April and October-November) as well. The rainstorms are caused by climatic features in the tropics, i.e. convection, convergence activity of Inter Tropical Convergence Zone (ITCZ), depressions, and cyclonic wind circulations.

Generally, heavy rainstorms brought by convergence, depressions, and cyclonic wind circulations are widespread phenomena while convection brings local thunderstorms with localized heavy rainfall.

The rainfall records at Colombo indicate that the annual maximum daily rainfall amounts to 130 mm in a normal year. It is observed that events of daily rainfall exceeding 250 mm occurred only twice in the last 30 years with 493 mm/day in July 1992 and 284 mm/day in April 1999.

According to the available short interval data at Colombo, most rainstorm events would have a duration of 3 hours or less and would show a distinct peak within a storm. On the other hand, exceptional rainstorm events are comprised of a series of storms. The rainstorm event in April 1999 indicates two separate main storms. In the historically extreme event in June 1992, four main storms occurred successively within 12 hours. Short interval data at Colombo for several rainstorm events are shown in Figure 3.2.1.

3.3 Probable Rainfall for Objective Drainage Basins

3.3.1 Data Interpolation

Missing data of the 14 rainfall gauging stations were interpolated using simple correlation. Correlation coefficients were computed and examined between each station and the others. Data interpolation could be made between two stations when the following criteria is satisfied:

$$r \geq 0.6 \quad \text{and} \quad r \geq |r| = \frac{10}{\alpha\sqrt{N-1}}$$

where,

r : Simple correlation coefficient
$|r|$: Standard of signification
α : Probability (%) that r will exceed $|r|$ (set at 0.25%)
N : Number of samples

The result of the correlation analysis is shown in Table 3.3.1. The linear interpolation was executed on the following stations.

Relationship between the Station of Defect and that of Complementation

Station of missing record	To be interpolated by the record of
Angoda	1. Colombo
Boralesgamuwa	1. Ratmalana 2. Colombo
Halgahapitiya	1. Vincit
Henarathgoda	1. Katunayake
Katunayake	1. Henarathgoda
Pasyala	1. Vincit
Rathmalana	1. Boralesgamuwa 2. Colombo
Vincit	1. Pasyala 2. Halgahapitiya
Colombo	1. Boralesgamuwa 2. Ratmalana 3. Angoda

For example, in order to interpolate the missing record of Colombo station, the record of Boralesgamuwa can be the most promising data for this operation. If the data of Boralesgamuwa is also missing, Colombo data can be filled utilizing Ratmalana data.

For the sake of maintenance of the reliability of interpolated data, a rule, "no missing record can be interpolated by interpolated data", is introduced. In other words, missing data can be filled only by the measured (recorded) rainfall data.

3.3.2 Estimation of Basin Average Rainfall

Basin average rainfall was prepared as an input of the rainfall-runoff simulation model for the objective drainage basins, employing the Thiessen Polygon method as below:

$$R_b = \sum(C_i \times R_i)$$

$$C_i = \frac{A_i}{A} \quad (\Sigma C_i = 1)$$

Where,

R_b : basin average rainfall
C_i : area weight of divided basin area for gauging station (i)
R_i : rainfall at gauging station (i)
A_i : basin area for gauging station (i), divided by Thiessen Polygon
A : entire area of drainage basin

A polygon system dividing the drainage basins was created by bisectors drawn perpendicularly to lines between each station and other neighboring stations as shown in Figure 3.3.1.

As mentioned in above item (1), since not all of missing daily rainfall data were interpolated by simple correlation, a part of rainfall data was still missing . The basin average rainfall computed from the Thiessen Polygon based on the 14 rainfall gauging stations could not cover the continuous period of 31 years. To obtain the basin average rainfall for the entire period, other different polygon systems were prepared depending on the data availability of the stations. The number of the polygon systems came to 16 in total. The area weights by drainage basin, based on each polygon system to compute the basin mean rainfall, are as shown in Table 3.3.2.

3.3.3 Extreme Value Analysis

The annual maximum series of basin average rainfall for each objective drainage basin were extracted as shown in Table 3.3.3. The extreme value analyses were carried out to examine the application of three different probability distributions, i.e. Iwai, Log Pearson Type III, and Gumbel.

The computed results were compared with the plotting positions of the annual maximum series by Weibull Plot as shown in Figure 3.3.2.

The figure shows that every calculation method has validity in all four drainage basins. Therefore, basin average daily rainfall for each return period has been estimated as a maximum value among these three methods. Table 3.3.4 shows the calculation result of probable 24-hour rainfall for the return periods of 2-, 5-, 10-, 25- and 50-years, and these are also summarized below:

Estimated Probable Basin Average 24-hour Rainfalls

Return Period (years)	Drainage Basin			
	Attanagalu Oya	Kalu Oya	Greater Colombo	Bolgoda
2	103 mm	130 mm	117 mm	103 mm
5	135 mm	184 mm	176 mm	137 mm
10	156 mm	220 mm	214 mm	160 mm
25	183 mm	266 mm	270 mm	188 mm
50	203 mm	230 mm	320 mm	210 mm

3.3.4 Temporal Distribution of Design Storm Rainfall

As the result of above extreme value analysis, the basin average rainfall for each return period is estimated on a daily basis. In order to generate basin average rainfall as an input for the flood runoff model, the operation that converts daily basis value to hourly or shorter basis should be made.

Following two methods are applicable for this conversion:

1) Generation of rainfall patterns of hypothetical distribution based on the rainfall intensity curves.
2) Generation of rainfall patterns by extending existing records of past events.

As mentioned above, one of the important characteristics of the rainstorm events over the study area is the occurrence of a series of storms with durations of around 3 hours. In short, one rainstorm event comprises several 3-hour duration storms in many cases. Taking this point into account, the extension of existing records can generate more suitable and more practical design rainfall patterns over the study area compared with the other generation method.

Since the drainage plan for the objective basins is carried out applying a relatively long return period such as 50 years, it is necessary to collect and analyze the rainfall records of around 50-year recurrence with short time sampling intervals. The record of automatic rainfall gauging machines, whose sampling interval is 1 hour or less, are available in Colombo, Katunayake and Rathmalana gauging stations in the objective drainage basins. However, the records of Katunayake and Rathmalana are fragmented and available for only a short period. Therefore only the records of the Colombo station are taken into account for generation of the time series distribution for the design rainstorm pattern. The derived pattern is to be applied to all of four drainage basins, i.e. the Attanagalu Oya, the Kalu Oya, the Greater Colombo and the Bolgoda.

Among the available records of rainstorm events at the Colombo automatic rainfall gauging station, the events that occurred on June 4th, 1992 (493mm of daily rainfall) and April 20th, 1999 (284mm of daily rainfall) seem to have a long recurrence period. On the other hand, the 493mm of the 1992-event is an extraordinary value compared with another annual maximum events. According to the extreme value analysis, whose samples comprise the annual maximum daily rainfalls at the Colombo station covering 31 years (1970-2000), the return period of 1992-event is around 250 years. However, if this extraordinary value is excluded from the plotting samples, the return period of this event jumps up to around 8,000 years. Therefore this 1992-event is not used in the design distribution pattern due to its abnormality. As a result, the time series distribution of the 1999-event is chosen as the design rainfall pattern. The value 284mm corresponds to a 50-year return period event according to the Gumbel probability distribution (excluding the 1992-event from the original samples).

The design storm pattern is calculated by the following manner:

$$R_b(t) = R_b \times \frac{R_c(t)}{R_c}$$

Where,

$R_b(t)$: Probable basin average rainfall at time t
R_b : 24-hour total amount of probable basin average rainfall
$R_c(t)$: Rainfall at time t at Colombo station
R_c : 24-hour accumulated rainfall at Colombo station

In estimating runoff from an objective basin, this design basin average rainfall is assumed to occur with aerial uniformity in this study. Therefore a careful consideration should be made when a time series distribution of a station, i.e. Colombo, is applied to an entire basin. Although it is impossible to verify this assumption based on the existing data and records, the study regards this as an acceptable supposition because the main causes of large scale rainstorm events in the study area are convergence, depressions, and cyclonic wind circulations, and these events have a relatively large coverage area.

Figure 3.3.3 shows the derived design storm rainfall pattern.

3.4 Review of Existing DDF Curves

3.4.1 Purpose of the Review Work

The review of DDF curves proposed in the past studies was conducted for confirmation of their applicability to the planning of the storm water drainage facilities for the small and urbanized basins.

3.4.2 Rainfall Depth, Duration and Frequency

The equation for rainfall depth, duration and frequency applied in the GCFC&EIP Phase II and III projects is based on the analysis previously done by the Study of the

Canal and Drainage System in Colombo (the Canal Study, 1988), which refers to the following studies in the past.

H. Humphreys listed all the high intensity storm rainfall data for 15, 30, 45, 60, 75, and 90 minutes from 1921 through 1967. These data were read directly from the original daily charts of the automatic rainfall recorder at the Colombo observatory, and is one of the most comprehensive and reliable data set available. Based on these data, probable rainfalls were estimated for the given duration and frequencies.

V. R. Banghirathan and E. M. Shaw carried out depth-duration frequency (DDF) analysis of storm water rainfall at 19 stations over the country, of which Colombo is one, and tried to establish regional characteristics of the statistical parameters for storm rainfalls. For the Colombo station, rainfall data obtained from the automatic rainfall recorder for 21 years from 1950 to 1970 were used for estimating a DDF curve.

The Canal Study applied the results by H. Humpheys as 'short duration rainfall' (convective shower) and V. R. Banghirathan and E. M. Shaw as 'long duration rainfall' (cyclonical precipitation) as given below:

Short-duration Rainfall

Return Period (Years)	Rainfall Depth in mm and Duration		
	15 minutes	30 minutes	60 minutes
2	31.0	51.0	72.6
5	36.4	62.7	90.4
10	40.0	70.5	102.1

Source: The Study of the Canal and Drainage System in Colombo, 1988

Long-duration Rainfall

Return Period (Years)	Rainfall Depth in mm and Duration				
	3 hours	6 hours	12 hours	24 hours	48 hours
2	79.0	100.3	116.8	141.5	174.2
5	100.3	131.6	149.1	186.4	229.5
10	113.8	152.2	170.4	216.2	266.2

Source: The Study of the Canal and Drainage System in Colombo, 1988

3.4.3 Review of Depth, Duration and Frequency Curves (DDF Curves)

A review study of DDF curves was carried out in the Special Assistance for Project Formation for the Lunawa Lake Environment Improvement and Community Development Project by JBIC (SAPROF, 2001).

For the purpose of crosschecking with DDF curves above, the available recent records with 15 minute intervals were analyzed to estimate the probable rainfall depths with 15, 30, 60, 120, 180, 360 minutes and 24 hours. The estimated values were compared with the DDF curves in the Canal Study. The results show that the rainfall intensity for rainstorms with durations of 1 hour or less almost agrees with the equation applied by the GCFC&EIP Phase II. But the equation for the longer duration storms gives larger values than the DDF curves proposed by the Canal Study and is regarded inapplicable for the longer duration.

There is a discontinuous part around 1 to 3 hours duration in the DDF curves proposed by the Canal Study. The Canal Study explained that this is caused by the different characteristics between 'short duration rainfall' and 'long duration rainfall'. The Canal Study therefore proposed to use the different curves for 'short duration rainfall' and 'long duration rainfall'. A similar result was also obtained by SAPROF as a result of analyzing selected storm rainfall data at Colombo.

3.4.4 Application of DDF Curves

Following are the observations about DDF curves, which are based on the above discussions:

1) According to the past storm records, the duration of one rainstorm is about 3 hours. Therefore it is possible for DDF curves to reflect both the intensity and pattern of storm rainfall if the duration of design storm is 3 hours or shorter.
2) However, since the existing DDF curves indicate excessive value when they are applied to storms with durations of more than 1 hour, the applicable duration is 1 hour or shorter.
3) For storms with durations of 1 to 3 hours, the application of rainfall intensity curves proposed in the Canal Study seems to be difficult due to discontinuity between "short duration rainfall" and "long duration rainfall". On the other hand, the DDF curves proposed in the SAPROF are applicable for the storms of which duration is 3 hours or shorter although it cannot be said that those are derived based on adequate records.
4) DDF curves for the long duration rainfall (duration of more than 3 hours) work out average rainfall intensity of certain duration. However, the yielded rainfall pattern does not always show the actual pattern.

Considering the fact that runoff from a small basin in an urbanized area usually has a short flood concentration time of around 1 hour, DDF curves proposed in the Canal Study and GCFC&EIP Phase II are applicable for the estimation of peak discharges.

The estimation of flood runoff hydrographs is necessary for planning the storage facilities of pump stations. These design hydrographs can be estimated by inputting design storm patterns based on the existing DDF curves. Because relatively short return periods such as 5 or 10 years are usually applied for storm water drainage plans for small catchments in urbanized areas, the storm duration of 3 hours is sufficient for such scaled floods.

The storm patterns for the planning of some important facilities whose return period of design flood are relatively longer, is generated by extrapolating practical storm rainfall patterns in the same way as the estimation of flood runoff from the four objective basins, i.e. the Attanagalu Oya, the Kalu Oya, the Greater Colombo, and the Bolgoda.

CHAPTER 4 FLOOD RUNOFF AND INUNDATION ANALYSIS

4.1 Purpose and Approach of Flood Runoff and Inundation Analysis

The flood runoff and inundation analysis was carried out in order to;

1) Determine the present flood inundation condition,
2) Predict the change in the inundation state due to future land use development such as urbanization or reclamation of lowlands, and
3) Estimate the effect of proposed structural measures on the flood mitigation.

The general procedure for flood runoff and inundation model setup is shown in Figure 4.1.1. After the completion of modeling, simulation of flood runoff and inundation for each probable storm rainfall can be made.

4.2 Outline of Utilized Software

4.2.1 MIKE11

MIKE11, a one-dimensional (1D) and one-layer flow calculation software package developed by Danish Hydraulic Institute (DHI), comprises a lot of calculation modules such as hydrodynamic (HD), structural operation (SO), rainfall-runoff (RR) and so on. Following are the modules mainly used for this Study:

1) Hydrodynamic Module (HD)
   - The module for the computation of unsteady flow in channels
2) Structural Operation Module (SO)
   - The module for the computation of the effect of artificial structures such as weirs, culverts etc.
3) Rainfall Runoff Module (RR)
   - The module for the computation of runoff from drainage basins

4.2.2 MIKE11 GIS

MIKE11 GIS is also developed by DHI and this software enables the computation results of MIKE11 to be displayed on a 2-dimensional plane such as existing topographic maps or aerial photographs.

The water level of a defined grid in the flood plain is calculated by a distance-weighted average of calculated water levels at neighboring points by MIKE11 found in each quadrant.

The shape of the flood plain in the study area is also extracted using this MIKE11 GIS, and the data can, of course, be utilized as the input data for MIKE11.

4.3 Digital Elevation Model (DEM)

The DEM for the study area was assembled from spot levels and contours available on the topographic maps obtained from the Survey Department. Maps of a variety of scales were used and the data were either digitized from paper or sometimes extracted directly from digital data provided by the Survey Department.

The results of river cross section surveys and spot level surveys of marshy land boundaries conducted in this Study were also utilized for DEM generation.

These spot levels were converted to DEM using the DEM generation tool of MIKE11 GIS.

Generated DEMs for all four objective drainage basins are shown in Figure 4.3.1 (the Attanagalu Oya), Figure 4.3.2 (the Kalu Oya), Figure 4.3.3 (the Greater Colombo) and Figure 4.3.4 (the Bolgoda). A summary of elevation classifications for the four basins is presented in Table 4.3.1. The DEM grid size is 50m × 50 m for all basins, and the elevation value of a grid is the distance weighted average of spot level data around it. The DEMs under "Present Land Use Condition" were generated using original spot level data reflecting existing conditions, while those under "Future Land Use Condition" were generated considering reclamation of marshy and paddy areas according to the projection of future (2010) land use condition conducted in the Study.

Drastic change in elevation of the land within the flood plain is expected in the Kalu Oya and northwestern part of the Bolgoda basin. The area below 2 m elevation is to decrease from 740 ha to 440 ha in the Kalu Oya basin. In the Bolgoda basin, the area below 2m will change from 6,000 ha to 5,800 ha. In the southern part of the Bolgoda basin, vast lowlands (about 950 ha) below 0 m spread according to the generated DEM of the Bolgoda basin and these areas will remain unchanged in the year 2010.

4.4 Channel Network Hydrodynamic Model

4.4.1 Input Data and Parameters

Main input data for MIKE11 channel network model comprises:

1) Geographical information for the calculation points, i.e. the coordinates (longitude and latitude) of points where discharge (Q) or water level (h) is calculated,
2) Information regarding channel connections,

3) Information regarding structures (weirs, culverts, etc.) such as specifications or locations,
4) Channel cross section data, and
5) Lateral inflow (to be imported from the basin runoff model).

The channel network model for each objective basin comprises the mainstreams and major tributaries.

There are two kinds of parameter groups to be considered. One is the parameter group for description of flood phenomenon and the other is for stability of implicit finite difference equations converted from above mentioned two basic equations. A typical parameter for the former group is Manning's roughness coefficient (*n*), and for the latter, spatial or temporal steps (Δx or Δt).

4.4.2 Flood Cells

In order to include the behavior of the flood plain in the hydrodynamic model, "flood cells" are extracted from the generated DEMs and attached to the cross section database of the model. The flood cell is described by the relationship between elevation and inundation area (H-A curve).

The flood cells of both present and future land use conditions were extracted from the DEMs of each objective basin.

4.4.3 Preparation of Input Data

(1) The Attanagalu Oya Basin

The channel network system in the Attanagalu Oya basin is shown in Figure 4.4.1. Main channels in this basin are the Mapalam Oya, the Ja Ela and the Dandugam Oya. Surveyed cross-section data of these drainage channels are included in this hydrodynamic model.

Manning's roughness coefficient (n) is set at 0.04 for all channel stretches.

(2) The Kalu Oya Basin

Figure 4.4.2 shows the channel network system in the Kalu Oya basin. Main channels in this basin are the Kalu Oya mainstream, the Old Negombo Canal and four tributaries of the Kalu Oya. Surveyed cross-section data are included in this hydrodynamic model.

Manning's roughness coefficient (n) is set at 0.04.

(3) The Greater Colombo Basin

The drainage network system in the Greater Colombo basin is presented in Figure 4.4.3. The main channels in this basin are,

1) Main Drain,
2) St. Sebastian Canal,
3) Dematagoda Ela,
4) Kolonnawa Ela,
5) Heen Ela,
6) Torrington Canal,
7) Kotte Ela,
8) Kirillapone Canal,
9) Bolgoda Canal,
10) Dehiwara Canal,
11) Wellawatta, and
12) Madiwela East Diversion Canal

A large lake, Parliament Lake, is also included in the model.

Manning's roughness coefficient (n) is set at 0.04 for all channel systems and the "As Built Drawing of the Greater Colombo Flood Control and Environment Improvement Project (Phase I)" is utilized for construction of a cross-section database of this model.

(4) The Bolgoda Basin

Figure 4.4.4 shows the channel network system of the Bolgoda basin. Main channels of this basin are,

1) Bolgoda Canal,
2) Weras Ganga and its tributaries,
3) Maha Oya and its tributaries,
4) Bolgoda Ganga,
5) Thalpitiya Ela,
6) Aluth Ela,
7) Kepu Ela, and
8) Panape Ela.

Manning's roughness coefficient (n) is set at 0.04 for all channel systems and surveyed cross-section data are input in this model.

North and South Bolgoda lakes are also included in this model. Sounding survey results of these two lakes was taken into account.

4.4.4 Boundary Conditions

(1) Tidal Water Level

According to the Indian and British Tide Tables, tidal variations at Colombo harbor, related to MSL, are given below:

1) Lowest Astronomical Tide (L.A.T.) : 0.50 m below MSL
2) Mean Low Water Springs (M.L.W.S.) : 0.32 m below MSL
3) Mean Low Water Neaps (M.L.W.N.) : 0.08 m below MSL
4) Mean Sea Level (M.S.L.) : 0.00 m above MSL
5) Mean High Water Neaps (M.H.W.N.) : 0.10 m above MSL
6) Mean High Water Springs (M.H.W.S.) : 0.34 m above MSL
7) Highest Astronomical Tide (H.A.T.) : 0.50 m above MSL

However, according to the observed tidal level at Colombo harbor, the actual tidal levels are higher than the values above. The tidal records at Colombo harbor between April to June 2002 show the occurrence of tidal levels over +0.50 m as shown below:

Record of High Tidal Level at Colombo Harbor (April to June 2002)

Date (Time)	Tidal Level (above MSL)
Apr. 12, 2002 (15:00)	0.51 m
Apr. 13, 2002 (15:00)	0.53 m
Apr. 14, 2002 (15:00)	0.53 m
Apr. 26, 2002 (14:00)	0.54 m
Apr. 27, 2002 (15:00)	0.64 m
Apr. 28, 2002 (16:00)	0.66 m
Apr. 29, 2002 (16:00)	0.63 m
Apr. 30, 2002 (16:00)	0.52 m
Jun. 12, 2002 (15:00)	0.51 m
Jun. 13, 2002 (16:00)	0.54 m

Source: Sri Lanka Port Authority

Considering the situation above, the assumption that a high tidal level of over 0.50 m above MSL occurs during a flood event is reasonable. The lowest tidal level during the probable floods was set around M.H.W.N. from a conservative viewpoint. Finally, the tidal level data, which ranges between 0.13 and 0.61 m above MSL, was derived from the records at Colombo harbor and set as the downstream boundary condition at sea outfalls.

(2) Water Level at the Kelani Ganga

The 10-year probable flood water level data, which had been simulated by DHI, was set as the downstream boundary condition for the outfalls connecting to the Kelani Ganga. The 10-year probable maximum water level of the Kelani Ganga at Nagalam Street (10 km upstream from the Kelani Ganga outfall) had been calculated as 2.98 m above MSL by DHI. The high water level, with a water level of more than 2 m at Nagalam Street, continues for about 4 days according to the simulation result.

It is reported that the long duration of flood in the Kelani Ganga promotes severe local inundation especially in the Kalu Oya basin. In order to relieve the severe situation and stand on the conservative side, a 10-year flood in the Kelani Ganga was applied as the design boundary condition in this study.

4.5 Basin Runoff Model

4.5.1 Input Data and Parameters

NAM, originally developed by the Technical University of Denmark, is a lumped and conceptual basin runoff model, simulating the overland-, inter-, and base-flow components as a function of the moisture content in four storages, i.e. surface, lower or root zone, ground water, and snow. This has a concept similar to the Tank Model, commonly used for both low flow and flood runoff simulations in Japan. The concept of the NAM model is illustrated in Figure 4.5.1.

As shown in Figure 4.5.1, there are a lot of parameters to be set in the NAM model, and of them, the following 7 parameters are important for estimating flood runoff from the objective drainage basins. They are constituent elements of the surface and root zone parameter set:

1) Maximum water content in surface storage (U_{max})
2) Maximum water content in root zone storage (L_{max})
3) Overland flow runoff coefficient (CQOF)
4) Time constant for interflow (CKIF)
5) Time constant for routing interflow and overland flow (CK_{12})
6) Root zone threshold value for overland flow (TOF)
7) Root zone threshold value for interflow (TIF)

A function of auto-calibration of the above parameters is available in the MIKE11 RR module. However, since neither water level observations nor discharge measurement records on an hourly basis are available in the study area as mentioned in Chapter 2, those parameters are principally set by an empirical method based on the land surface or land use conditions. A detailed discussion is made in the following sub-sections.

4.5.2 Preparation of NAM Parameters

As mentioned above, it is almost impossible to adjust parameters for the basin runoff model using existing rainfall and runoff records. The parameter setting was therefore made introducing the following concepts referring to the past study carried out in 1995 as a part of the "Greater Colombo Flood Control and Environment Improvement Project (Phase I)", which also utilized MIKE11 and NAM.

Land use categories are classified in four types considering the hydrological characteristics as shown in the table below.

Classified Land Use Type for the Hydrological Analysis

Types	Type-1	Type-2	Type-3	Type-4
Land Use Category	Urbanized area	Semi-urbanized area	Rural area, Paddy	Marsh, Water

Note: Corresponding with the land use categories discussed in Annex 4 - Land Use

Following table shows the main NAM parameters for each typical basin.

NAM Parameters for each Typical Basin

	Land Use Type			
	Type-1	Type-2	Type-3	Type-4
Umax	5	7	18	1
Lmax	16	68	177	6.7
CQOF	0.83	0.72	0.54	0.90
CKIF	500	500	500	500
CK12	3.5	6	9	0.5
TOF	0.2	0.2	0.2	0.2
TIF	0	0	0	0

Note: Estimated based on the NAM parameters used for GCFC&EIP

Runoff characteristics of each land use type for three values of rainfall amounts (100, 200 and 300 mm) with the design storm rainfall pattern are presented in Figure 4.5.2.

The NAM parameters of sub-catchments are decided as the area-weighted average of above four types of land use condition utilizing GIS information of present and future land use conditions prepared in this Study.

4.5.3 Basin Division and Extracted Parameters

(1) The Attanagalu Oya Basin

The Attanagalu Oya basin is divided into 31 sub-catchments as seen in Figure 4.4.1. The ratio of each land use type (present and future) is listed in Table 4.5.1, and estimated basin runoff parameters of every sub-catchment for present and future land use conditions are listed in Table 4.5.2 and Table 4.5.3 respectively.

(2) The Kalu Oya Basin

The Kalu Oya basin is divided into 9 sub-catchments as shown in Figure 4.4.2. The ratio of each land use type and NAM parameters both under present and future land use conditions are listed in Tables 4.5.1, 4.5.2 and 4.5.3.

(3) The Greater Colombo Basin

The Greater Colombo basin is divided into 34 sub-catchments as in Figure 4.4.3. The ratio of each land use type and NAM parameters both under present and future land use conditions are listed in Table 4.5.1, 4.5.2 and 4.5.3.

(4) The Bolgoda Basin

26 sub-catchments are prepared for the Bolgoda basin as shown in Figure 4.4.4. The ratio of each land use type and NAM parameters under present and future land use conditions are listed in Table 4.5.1, 4.5.2 and 4.5.3.

4.5.4 Runoff from Sub-catchments

Flood runoff from the sub-catchments was simulated for five different probable rainfalls (2-, 5-, 10-, 25- and 50-year) with design storm rainfall patterns. Maximum flood discharges (m^3/sec) and specific discharges (m^3/sec/km^2) under present and future land use conditions are listed in Table 4.5.4. Large-scaled increase in flood peak and specific discharge is expected in the Kalu Oya, the Greater Colombo and the northwestern Bolgoda basins due to urbanization.

4.6 Model Calibration

The validity of hydrological-hydraulic models was examined in the Greater Colombo basin. The reasons why this basin was selected for model calibration are 1) hourly rainfall records are available from an automatic rainfall gauging station in this basin, 2) the basin scale is relatively small and the rainfall pattern of one rainfall station is judged to be applicable to the basin average rainfall pattern, 3) water level observation records are available for some storm rainfall events.

The storm event on April 20 and 21, 1999 is selected as a target event for model calibration because the land use condition in 1999 is similar to that at present. Furthermore, since Madiwela East diversion canal was completed in 1997, no modification of the channel network model is needed for this calibration work.

Instantaneous water level records from April 20 to 24 were collected at 5 points in the Greater Colombo drainage system as shown in Figure 4.7.1. The NAM parameters of 4 land use types and Manning's roughness coefficient (n) were adjusted by trial and error in order to make simulated water level coincide with those observed.

The result of the calibration work is illustrated in Figure 4.7.1. Although there are relatively large discrepancies between observed and simulated flood duration, the model shows adequate validity for the maximum water levels. Therefore it was judged that the model shows enough accuracy for the master planning purpose. The fixed parameters are presented in the preceding subsections.

Five automatic rainfall and ten automatic water level gauging stations were installed within the study area in this Study. However, since no large floods occurred during the study period, the observed data of those new gauging stations could not be utilized for the calibration work. Records of hourly or shorter intervals are still being acquired from those stations. The model parameters can be re-adjusted if the relevant scale of storm rainfall occurs in the future, and a review can be done even after the end of this Study as long as the gauges are maintained in good order.

4.7 Results of Analysis

The simulation of flood runoff and inundation under both present and future land use condition was carried out for five different probable storm rainfalls with return periods of 2-, 5-, 10-, 25- and 50-year for each objective drainage basin.

The results and findings are discussed below.

4.7.1 The Attanagalu Oya Basin

(1) Flood Runoff and Water Level

Twenty-seven (27) base points were set in the Attanagalu Oya channel system and examined simulated water levels and/or discharges at each point. The locations of those points are shown in Figure 4.8.1.

Figure 4.8.2 shows water level and discharge hydrographs of 4 base points, i.e. BP-2, 3, 19 and 20. No significant change in flood phenomena is observed from the figure since urbanization in this basin does not progress significantly according to the land use projection maps.

Maximum water levels and discharges at each base point are listed in Figure 4.8.3. The 50-year probable maximum discharges under future land use conditions at the cross-points of Negombo road and the Dandugam Oya (BP-19) and that of Negombo road and the Ja Ela (BP-20) were calculated at 197 m^3/sec and 70 m^3/sec, respectively.

(2) Flood Inundation Area

Figure 4.8.4 shows the simulated flood inundation area for 2-, 10- and 50-year probable floods both under present and future land use conditions.

Flood inundation maps under present land use conditions were generated as seen in Figure 4.8.5. The middle reaches of the Dandugam Oya inundates when the 5-year probable flood occurs. When in the 25-year probable flood stage, both the upstream and downstream reaches of the Dandugam Oya inundate.

Figure 4.8.6 shows flood inundation maps under future land use conditions. The characteristics of inundation are almost same as under present land use conditions.

Flood inundation area is summarized by each land use category in Table 4.8.1. There is no significant change in inundation area for any land use category.

4.7.2 The Kalu Oya Basin

(1) Flood Runoff and Water Level

Seventeen (17) base points were set in the Kalu Oya basin as presented in Figure 4.8.7. Water level and discharge hydrographs of the 50-year probable flood at 4 base points, i.e. BP-1, 2, 8 and 13, are illustrated in Figure 4.8.8. Both water level and discharge increase significantly as a result of basin-wide urbanization and large scaled reclamation. At the downstream base point BP-13, maximum flood water level increases more than 10 cm for every probable flood, and more than 30 cm increase is observed for the 2-year probable flood as seen in Figure 4.8.9. Maximum flood discharge also increases more than 40% in each probable flood.

(2) Flood Inundation Area

Figure 4.8.10 shows the simulated flood inundation area for 2-, 10- and 50-year probable floods both under present and future land use conditions.

Flood inundation maps under present and future land use conditions are generated and presented in Figures 4.8.11 and 4.8.12. A summary of inundation area by land use category is listed in Table 4.8.1. Total inundation area is to be reduced due to the land reclamation along the proposed Outer Circular Highway, however that of the urbanized area and semi-urbanized area increases due to the reclamation and urbanization.

4.7.3 The Greater Colombo Basin

(1) Flood Runoff and Water Level

Twenty-five (25) base points were set in the Greater Colombo basin as seen in Figure 4.8.13. Water level and discharge hydrographs of the 50-year probable flood for 4 base points, i.e. BP-22, 17, 18 and 19, are illustrated in Figure 4.8.14. The 50-year probable maximum flood discharge at Welawatta (BP-19) and Dehiwala (BP-20) outfalls are 54.7 m^3/sec and 31.1m^3/sec, respectively under future land use conditions, while they are 49.4 m^3/sec and 29.3 m^3/sec respectively under present land use conditions. Water level increases 7 to 14 cm as shown in Figure 4.8.15. The increase in water level and discharge is caused by urbanization.

(2) Flood Inundation Area

Figure 4.8.16 shows the simulated flood inundation area for 2-, 10- and 50-year probable floods both under present and future land use conditions.

Figures 4.8.17 and 4.8.18 show flood inundation maps under present and future land use conditions, respectively. Summarized inundation area by land use category is shown in Table 4.8.1. The inundation area of the built-up area and semi-urbanized area increase significantly.

4.7.4 The Bolgoda Basin

(1) Flood Runoff and Water Level

Thirty (30) base points were set in the Bolgoda basin as shown in Figure 4.8.19. Figure 4.8.20 shows the 50-year probable water level and discharge hydrographs at 4 base points, i.e. BP-9, 19, 20 and 30. Water level and discharge at Weras Ganga outfall (BP-9) increases significantly due to urbanization and land reclamation.

Simulated flood water level and discharge of every return period at each base point are listed in Figure 4.8.21. There are no significant changes in flood characteristics except for the Weras Ganga basin (northwestern part of Bolgoda basin).

(2) Flood Inundation Area

Figure 4.8.22 shows the simulated flood inundation area for 2-, 10- and 50-year probable floods both under present and future land use conditions.

Figures 4.8.23 and 4.8.24 show flood inundation maps under present and future land use conditions, respectively. Although the middle reaches of the Bolgoda Ganga between North and South Bolgoda Lakes are reported as a flood prone area, the flood inundation maps do not show that inundation will occur. This discrepancy seems to be caused by,

1) Insufficient accuracy of elevation data around the stretch, and/or
2) The characteristic of the simulation software that flood inundation phenomena is expressed only by the spill overtopping from the modeled channels.

Considering the fact that the area lies between two large water bodies (North and South Bolgoda Lake), it is inconceivable that the water level of the Bolgoda Ganga rises in greatly. Therefore, it is reasonable that flooding in this area is caused mainly by insufficient storm water drainage capacity of the area surrounding the Bolgoda Ganga. In other words, inundation in this area occurs not by the spill over topping the Bolgoda Ganga but by the water paths flowing into the Bolgoda Ganga. More water paths should be added to the model in order to express the inundation of those areas. However, this is very difficult considering the limited information on the elevations in the area.

Summarized inundation area by land use category is shown in Table 4.8.1. Although total inundation area is reduced due to the land reclamation in the Weras Ganga basin, the inundation area of built-up and semi-urbanized areas increases.

Tables

Table 3.3.1 Results of Simple Correlation Analysis among the Record of 14 Rainfall Gauging Stations

|r| \ r		Rainfall Gauging Station ID													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rainfall Gauging Station ID	1		0.428	0.610	0.486	0.407	0.467	0.514	0.461	0.430	0.488	0.383	0.566	0.407	**0.656**
	2	*0.473*		0.524	0.359	0.329	0.434	0.434	0.572	0.449	0.432	0.332	0.476	0.342	0.460
	3	*0.651*	*0.662*		0.596	0.375	0.547	0.549	0.499	0.637	0.574	0.381	**0.909**	0.417	**0.776**
	4	*0.525*	*0.618*	*0.685*		0.337	0.377	0.397	0.384	0.416	0.393	0.339	0.588	0.362	0.594
	5	*0.389*	*0.468*	*0.662*	*0.536*		0.446	0.532	0.415	0.312	0.514	0.576	0.370	**0.601**	0.405
	6	*0.411*	*0.522*	*0.662*	*0.555*	*0.415*		0.524	0.566	0.399	0.459	0.462	0.509	0.500	0.513
	7	*0.385*	*0.469*	*0.654*	*0.522*	*0.387*	*0.409*		0.504	0.377	**0.622**	0.555	0.464	0.556	0.519
	8	*0.402*	*0.490*	*0.722*	*0.573*	*0.404*	*0.429*	*0.400*		0.445	0.467	0.429	0.533	0.464	0.508
	9	*0.403*	*0.468*	*0.651*	*0.522*	*0.404*	*0.430*	*0.398*	*0.420*		0.397	0.302	0.532	0.330	0.502
	10	*0.381*	*0.464*	*0.651*	*0.523*	*0.384*	*0.406*	*0.380*	*0.396*	*0.397*		0.461	0.526	0.479	0.583
	11	*0.385*	*0.469*	*0.656*	*0.527*	*0.388*	*0.411*	*0.384*	*0.400*	*0.402*	*0.381*		0.352	**0.641**	0.378
	12	*0.381*	*0.464*	*0.651*	*0.522*	*0.383*	*0.406*	*0.380*	*0.396*	*0.397*	*0.376*	*0.381*		0.400	**0.760**
	13	*0.383*	*0.465*	*0.656*	*0.525*	*0.385*	*0.409*	*0.382*	*0.398*	*0.399*	*0.378*	*0.383*	*0.378*		0.424
	14	*0.381*	*0.464*	*0.651*	*0.522*	*0.383*	*0.406*	*0.380*	*0.396*	*0.396*	*0.376*	*0.381*	*0.376*	*0.378*	

Notes :
1) The numbers shown above the diagonal line are simple correlation coefficient (r) between the record of two rainfall gauging stations.
2) The numbers shown below the diagonal line, which are written by Italic character, are the standards of signification (| r |) at the 0.25% level.
3) The r-values written by bold character are the ones which satisfied the criteria for the interpolation.
4) The assignment of the rainfall gauging station ID is as follows:

1 : Angoda
2 : Bandaragama
3 : Boralesgamuwa
4 : Dehiwala
5 : Halgahapitiya
6 : Hanwella
7 : Henarathgoda
8 : Horana
9 : Kalutara
10 : Katunayake
11 : Pasyala
12 : Ratmalana
13 : Vincit
14 : Colombo

Table 3.3.2 Thiessen Weights of Each Rainfall Gauging Station

	Rainfall Gauging Station ID*													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Case-1														
1 Attanagalu Oya	0.094	0.000	0.000	0.000	0.111	0.000	0.280	0.000	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	0.000	0.000	0.000	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	0.000	0.249	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.276
4 Bolgoda	0.000	0.296	0.203	0.027	0.000	0.002	0.000	0.160	0.213	0.000	0.000	0.099	0.000	0.000
Case-2														
1 Attanagalu Oya	0.094	0.000	0.000	0.000	0.111	-	0.280	0.000	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	0.000	0.000	-	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	0.000	0.249	0.077	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.276
4 Bolgoda	0.000	0.296	0.204	0.027	0.000	-	0.000	0.162	0.213	0.000	0.000	0.099	0.000	0.000
Case-3														
1 Attanagalu Oya	0.094	0.000	0.000	0.000	0.111	-	0.280	-	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	0.000	0.000	-	0.164	-	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	0.000	0.249	0.077	0.000	-	0.000	-	0.000	0.000	0.000	0.000	0.000	0.276
4 Bolgoda	0.000	0.442	0.220	0.027	0.000	-	0.000	-	0.213	0.000	0.000	0.099	0.000	0.000
Case-4														
1 Attanagalu Oya	0.094	0.000	0.000	-	0.111	0.000	0.280	0.000	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	-	0.000	0.000	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	0.000	0.270	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.311
4 Bolgoda	0.000	0.296	0.213	-	0.000	0.002	0.000	0.160	0.213	0.000	0.000	0.116	0.000	0.000
Case-5														
1 Attanagalu Oya	0.094	0.000	0.000	-	0.111	0.000	0.280	0.000	-	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	-	0.000	0.000	0.164	0.000	-	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	0.000	0.270	-	0.000	0.000	0.000	0.000	-	0.000	0.000	0.021	0.000	0.311
4 Bolgoda	0.000	0.504	0.213	-	0.000	0.002	0.000	0.160	-	0.000	0.000	0.120	0.000	0.000
Case-6														
1 Attanagalu Oya	-	0.000	0.000	0.000	0.111	0.000	0.315	0.000	0.000	0.239	0.160	0.000	0.119	0.056
2 Kalu Oya	-	0.000	0.000	0.000	0.000	0.000	0.575	0.000	0.000	0.000	0.000	0.000	0.000	0.425
3 Greater Colombo	-	0.000	0.336	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.587
4 Bolgoda	-	0.296	0.203	0.027	0.000	0.002	0.000	0.160	0.213	0.000	0.000	0.099	0.000	0.000
Case-7														
1 Attanagalu Oya	0.094	-	0.000	-	0.111	-	0.280	0.000	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	-	0.000	-	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	-	0.270	-	0.000	-	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.311
4 Bolgoda	0.000	-	0.240	-	0.000	-	0.000	0.286	0.358	0.000	0.000	0.116	0.000	0.000
Case-8														
1 Attanagalu Oya	0.094	0.000	0.000	-	0.111	0.000	0.280	-	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	-	0.000	0.000	0.164	-	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	0.000	0.270	-	0.000	0.000	0.000	-	0.000	0.000	0.000	0.021	0.000	0.311
4 Bolgoda	0.000	0.427	0.219	-	0.000	0.025	0.000	-	0.213	0.000	0.000	0.116	0.000	0.000
Case-9														
1 Attanagalu Oya	0.094	0.000	0.000	-	0.111	-	0.280	0.000	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	-	0.000	-	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	0.000	0.270	-	0.000	-	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.311
4 Bolgoda	0.000	0.296	0.213	-	0.000	-	0.000	0.162	0.213	0.000	0.000	0.116	0.000	0.000
Case-10														
1 Attanagalu Oya	0.094	-	0.000	-	0.111	0.000	0.280	0.000	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	-	0.000	-	0.000	0.000	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	-	0.270	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.311
4 Bolgoda	0.000	-	0.241	-	0.000	0.002	0.000	0.283	0.358	0.000	0.000	0.116	0.000	0.000
Case-11														
1 Attanagalu Oya	0.094	0.000	0.000	-	0.111	-	0.280	0.000	-	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	-	0.000	-	0.164	0.000	-	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	0.000	0.270	-	0.000	-	0.000	0.000	-	0.000	0.000	0.021	0.000	0.311
4 Bolgoda	0.000	0.504	0.213	-	0.000	-	0.000	0.162	-	0.000	0.000	0.120	0.000	0.000
Case-12														
1 Attanagalu Oya	0.094	-	0.000	-	0.111	0.000	0.280	0.000	-	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	-	0.000	-	0.000	0.000	0.164	0.000	-	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	-	0.270	-	0.000	0.000	0.000	0.000	-	0.000	0.000	0.021	0.000	0.311
4 Bolgoda	0.000	-	0.256	-	0.000	0.002	0.000	0.526	-	0.000	0.000	0.215	0.000	0.000
Case-13														
1 Attanagalu Oya	0.094	-	0.000	0.000	0.111	0.000	0.280	0.000	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	-	0.000	0.000	0.000	0.000	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	-	0.249	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.276
4 Bolgoda	0.000	-	0.229	0.027	0.000	0.002	0.000	0.283	0.358	0.000	0.000	0.101	0.000	0.000
Case-14														
1 Attanagalu Oya	0.094	-	0.000	0.000	0.111	0.000	0.280	-	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	-	0.000	0.000	0.000	0.000	0.164	-	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	-	0.249	0.077	0.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.276
4 Bolgoda	0.000	-	0.303	0.027	0.000	0.063	0.000	-	0.506	0.000	0.000	0.101	0.000	0.000
Case-15														
1 Attanagalu Oya	0.094	0.000	0.000	0.000	0.111	0.000	0.280	-	0.000	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	0.000	0.000	0.000	0.164	-	0.000	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	0.000	0.249	0.077	0.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.276
4 Bolgoda	0.000	0.427	0.210	0.027	0.000	0.025	0.000	-	0.213	0.000	0.000	0.099	0.000	0.000
Case-16														
1 Attanagalu Oya	0.094	0.000	0.000	0.000	0.111	0.000	0.280	0.000	-	0.237	0.160	0.000	0.119	0.000
2 Kalu Oya	0.836	0.000	0.000	0.000	0.000	0.000	0.164	0.000	-	0.000	0.000	0.000	0.000	0.000
3 Greater Colombo	0.398	0.000	0.249	0.077	0.000	0.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.276
4 Bolgoda	0.000	0.504	0.203	0.027	0.000	0.002	0.000	0.160	-	0.000	0.000	0.103	0.000	0.000

Note : * Assignment of rainfall station ID is as follows:

1 : Angoda
2 : Bandaragama
3 : Boralesgamuwa
4 : Dehiwala
5 : Halgahapitiya
6 : Hanwella
7 : Henarathgoda
8 : Horana
9 : Kalutara
10 : Katunayake
11 : Pasyala
12 : Ratmalana
13 : Vincit
14 : Colombo

Table 3.3.3 Estimated Annual Maximum Basin Average Rainfall

(Unit : mm)

Year	Attanagalu Oya Basin		Kalu Oya Basin		Greater Colombo Basin		Bolgoda Basin	
	Date	1-day Rainfall	Date	1-day Rainfall	Date	1-day Rainfall	Date	1-day Rainfall
1970	Oct. 13	111	May 2	197	May 2	148	May 2	165
1971	Sep. 23	79	Oct. 26	139	Oct. 22	104	Sep.16	94
1972	May 12	79	Oct. 17	91	Jun. 17	86	Jun.17	108
1973	Oct. 19	84	Nov. 4	231	Nov. 4	175	May 6	113
1974	Apr. 26	102	May 22	145	Apr. 27	152	May 9	141
1975	May 23	114	Sep. 22	113	Sep. 22	74	Nov.17	59
1976	Aug. 23	68	Oct. 9	231	Oct. 9	233	Oct. 9	101
1977	Oct. 17	185	Oct. 16	201	May 13	199	Oct. 17	142
1978	Nov. 23	139	May 11	161	May 11	144	May 11	114
1979	Jun. 11	97	May 2	111	Nov. 30	84	Jun. 13	79
1980	Oct. 13	94	Oct. 13	121	Dec. 17	84	Oct. 13	73
1981	May 28	86	May 28	103	May 28	119	Nov. 9	112
1982	Aug. 5	96	Nov. 2	64	Mar. 21	104	Oct. 26	99
1983	May 16	49	Jul. 19	75	May 17	109	Sep. 6	104
1984	May 8	128	May 30	99	Sep. 25	81	Nov. 19	101
1985	Nov. 11	86	May 19	168	Sep. 24	93	Sep. 24	118
1986	Nov.4	75	May 1	76	Sep. 14	71	Feb. 25	80
1987	Sep. 23	84	Sep. 23	133	Sep. 23	139	May 31	95
1988	Jun. 25	96	Jun. 25	121	Jun. 25	116	Sep. 12	93
1989	Jul. 11	101	Jul. 11	81	Oct. 28	83	Oct. 28	91
1990	Nov. 2	75	Nov. 1	69	Apr. 17	75	May 15	64
1991	May 31	150	May 31	131	May 30	68	May 31	87
1992	Sep. 27	101	Jun. 4	253	Jun. 4	329	Nov. 12	155
1993	Sep. 28	91	Sep. 29	102	Oct. 24	125	Oct. 24	101
1994	May 27	125	May 27	116	Sep. 28	92	Sep. 28	110
1995	Nov. 5	161	Nov. 4	89	May 5	96	Nov. 5	101
1996	Sep. 9	124	Sep. 9	129	Sep. 9	113	Aug. 22	108
1997	Jul. 20	110	Oct. 19	155	Oct. 19	115	Sep. 15	61
1998	Jul. 18	179	Jul. 18	220	Jul. 18	131	Nov. 8	166
1999	Apr. 20	145	Apr. 20	238	Apr. 20	247	Apr. 20	221
2000	Jan. 8	111	May 3	111	Oct. 6	122	Nov. 7	90

Table 3.3.4 Calculated Probable Rainfall for Each Return Period

1. Attanagalu Oya Basin (Unit : mm)

Return Period	Probability	Calculation Method			Adopted
		IWAI	PEARSON III	GUMBEL	
2	0.5000	103	103	102	*103*
5	0.2000	133	132	135	*135*
10	0.1000	152	150	156	*156*
25	0.0400	175	172	183	*183*
50	0.0200	193	188	203	*203*

2. Kalu Oya Basin (Unit : mm)

Return Period	Probability	Calculation Method			Adopted
		IWAI	PEARSON III	GUMBEL	
2	0.5000	128	127	130	*130*
5	0.2000	178	178	184	*184*
10	0.1000	212	213	220	*220*
25	0.0400	255	259	266	*266*
50	0.0200	287	294	300	*300*

3. Greater Colombo Basin (Unit : mm)

Return Period	Probability	Calculation Method			Adopted
		IWAI	PEARSON III	GUMBEL	
2	0.5000	116	109	117	*117*
5	0.2000	168	157	176	*176*
10	0.1000	209	196	214	*214*
25	0.0400	270	256	263	*270*
50	0.0200	320	308	299	*320*

4. Bolgoda Basin (Unit : mm)

Return Period	Probability	Calculation Method			Adopted
		IWAI	PEARSON III	GUMBEL	
2	0.5000	103	101	103	*103*
5	0.2000	132	132	137	*137*
10	0.1000	151	153	160	*160*
25	0.0400	173	180	188	*188*
50	0.0200	189	201	210	*210*

Note : The probable rainfall for each return period was decided as the maximum value among three calculation methods, i.e., Iwai, Log Pearson Type III, and Gumbel, for all of four drainage basins.

Table 4.3.1 Area by Elevation in Four Objective Drainage Basins

Elevation (m)	Attanagalu Oya-Ja Ela		Kalu Oya		Greater Colombo		Bolgoda	
	Present Land Use (ha)	Future Land Use (ha)	Present Land Use (ha)	Future Land Use (ha)	Present Land Use (ha)	Future Land Use (ha)	Present Land Use (ha)	Future Land Use (ha)
Water Body	1	1	2	2	188	188	1,362	1,362
Below 0m	1,317	1,306	139	80	27	27	951	951
0 ~ 1m	1,751	1,676	366	171	501	500	2,824	2,664
1 ~ 2m	1,623	1,598	235	193	644	630	2,226	2,191
2 ~ 3m	1,227	1,225	151	135	709	685	1,985	1,970
3 ~ 4m	1,155	1,153	179	165	862	851	1,623	1,603
4 ~ 5m	1,510	1,623	727	958	1,218	1,216	1,980	2,208
5 ~ 10m	7,350	7,350	905	960	2,593	2,593	9,085	9,085
10 ~ 20m	21,765	21,765	3,057	3,097	3,104	3,154	13,345	13,345
Over 20m	5,848	5,848	0	0	6	6	3,418	3,418
No Data	42,516	42,516	0	0	0	0	603	603
Catchment Area	***86,060***		***5,760***		***9,850***		***39,400***	

Table 4.5.1 Ratio of Land Use Category of Each Sub-catchment (1/2)

1. Attanagalu Oya Basin

Code	Area (km^2)	Present Land Use Condition				Future Land Use Condition			
		Type-1	Type-2	Type-3	Type-4	Type-1	Type-2	Type-3	Type-4
A_1	107.0	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	0.0%
A_2	27.0	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	0.0%
A_3	54.0	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	0.0%
A_4	224.0	0.8%	0.1%	99.1%	0.0%	0.8%	0.5%	98.7%	0.0%
A_5	150.0	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	0.0%
A_6	34.8	0.4%	0.2%	99.4%	0.0%	0.8%	0.5%	98.8%	0.0%
A_7	40.2	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	0.0%
A_8	20.0	0.0%	0.0%	100.0%	0.0%	0.6%	0.0%	99.4%	0.0%
A_9	9.0	2.4%	0.0%	97.6%	0.0%	2.4%	0.6%	97.0%	0.0%
A_10	14.9	2.5%	0.0%	97.5%	0.0%	2.5%	0.8%	96.7%	0.0%
A_11	9.1	0.0%	0.0%	100.0%	0.0%	0.1%	0.0%	99.9%	0.0%
A_12	41.0	0.0%	0.1%	99.9%	0.0%	0.0%	0.0%	100.0%	0.0%
A_13	9.0	0.0%	1.4%	98.6%	0.0%	0.0%	0.7%	99.3%	0.0%
A_14	10.0	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	0.0%
A_15	22.0	4.7%	0.0%	95.3%	0.0%	4.7%	0.0%	95.3%	0.0%
A_16	5.7	17.5%	13.5%	69.1%	0.0%	17.5%	6.8%	75.7%	0.0%
A_17	3.3	9.8%	0.1%	90.2%	0.0%	18.7%	6.8%	74.6%	0.0%
A_18	15.0	1.6%	0.7%	97.5%	0.2%	1.6%	0.7%	97.5%	0.2%
A_19	4.0	13.4%	3.8%	82.8%	0.0%	23.5%	4.7%	71.8%	0.0%
A_20	1.4	6.1%	0.0%	93.9%	0.0%	14.5%	0.0%	85.5%	0.0%
A_21	6.0	0.0%	0.0%	56.9%	43.1%	0.0%	0.0%	56.9%	43.1%
A_22	2.8	0.0%	0.0%	94.6%	5.4%	0.0%	0.0%	94.6%	5.4%
A_23	2.8	9.3%	8.9%	81.8%	0.1%	37.3%	0.0%	62.6%	0.1%
A_24	3.3	12.9%	7.2%	79.9%	0.0%	39.8%	1.3%	58.9%	0.0%
A_25	2.3	10.7%	11.1%	78.2%	0.0%	39.2%	1.5%	59.3%	0.0%
A_26	1.7	4.3%	0.0%	95.7%	0.0%	68.5%	0.0%	31.5%	0.0%
A_27	3.7	11.0%	0.0%	89.0%	0.0%	47.3%	4.8%	47.9%	0.0%
A_28	1.6	19.3%	0.0%	78.3%	2.3%	60.5%	4.9%	32.2%	2.3%
A_29	3.0	0.0%	0.0%	60.5%	39.5%	0.0%	0.0%	60.5%	39.5%
A_30	12.0	7.2%	4.4%	83.5%	4.9%	7.6%	0.5%	87.0%	4.9%
A_31	20.0	10.0%	8.5%	45.4%	36.1%	18.4%	0.3%	45.2%	36.1%

2. Kalu Oya Basin

Code	Area (km^2)	Present Land Use Condition				Future Land Use Condition			
		Type-1	Type-2	Type-3	Type-4	Type-1	Type-2	Type-3	Type-4
K_1	2.8	11.1%	2.4%	86.6%	0.0%	17.1%	39.3%	43.6%	0.0%
K_2	8.5	7.0%	0.0%	83.1%	9.8%	18.4%	40.3%	36.2%	5.1%
K_3	13.4	1.9%	3.4%	93.5%	1.1%	13.4%	43.2%	42.6%	0.8%
K_4	12.8	0.1%	22.9%	77.0%	0.0%	16.1%	21.7%	62.2%	0.0%
K_5	3.1	0.0%	0.0%	100.0%	0.0%	4.2%	0.0%	95.8%	0.0%
K_6	7.3	4.1%	24.0%	71.9%	0.0%	7.1%	28.8%	64.1%	0.0%
K_7	4.2	24.8%	7.3%	58.3%	9.7%	36.1%	10.5%	47.4%	6.0%
K_8	3.8	24.7%	12.0%	63.4%	0.0%	61.1%	4.2%	34.7%	0.0%
K_9	1.7	11.9%	21.5%	66.6%	0.0%	45.3%	9.3%	45.4%	0.0%

Table 4.5.1 Ratio of Land Use Category of Each Sub-catchment (2/2)

3. Greater Colombo Basin

Code	Area	Present Land Use Condition				Future Land Use Condition			
	(km^2)	Type-1	Type-2	Type-3	Type-4	Type-1	Type-2	Type-3	Type-4
C_1	14.5	3.4%	18.1%	78.5%	0.0%	37.2%	9.9%	52.9%	0.0%
C_2	15.6	3.4%	15.7%	79.8%	1.1%	31.5%	9.8%	57.6%	1.1%
C_3	5.6	2.5%	17.4%	75.8%	4.3%	3.6%	33.3%	58.9%	4.2%
C_4	5.6	13.1%	20.0%	57.1%	9.8%	54.2%	3.0%	33.1%	9.8%
C_5	6.7	14.3%	15.8%	56.5%	13.3%	23.2%	17.8%	45.6%	13.3%
C_6	1.5	4.3%	27.8%	34.0%	33.8%	20.8%	12.7%	32.7%	33.8%
C_7	2.2	12.2%	15.4%	41.2%	31.2%	16.3%	13.5%	39.1%	31.2%
C_8	0.3	24.8%	29.0%	41.0%	5.2%	24.8%	24.3%	45.7%	5.2%
C_9	4.4	31.4%	10.2%	46.0%	12.5%	39.6%	5.9%	42.0%	12.5%
C_10	1.2	22.8%	8.9%	53.8%	14.6%	22.8%	7.1%	55.6%	14.6%
C_11	1.0	5.6%	5.4%	42.4%	46.6%	6.0%	5.3%	42.1%	46.6%
C_12	0.8	8.7%	8.9%	33.1%	49.4%	8.7%	8.9%	33.1%	49.4%
C_13	0.5	4.7%	27.1%	57.2%	11.0%	4.7%	25.2%	59.1%	11.0%
C_14	0.3	41.7%	3.1%	55.2%	0.0%	41.7%	0.5%	57.9%	0.0%
C_15	0.3	8.5%	27.9%	53.5%	10.0%	8.5%	40.1%	41.3%	10.0%
C_16	0.3	25.5%	0.0%	41.8%	32.7%	25.5%	0.0%	41.8%	32.7%
C_17	0.6	10.2%	4.5%	40.6%	44.7%	10.2%	17.4%	27.7%	44.7%
C_18	0.3	22.8%	11.7%	49.0%	16.5%	22.8%	12.2%	48.5%	16.5%
C_19	0.9	34.9%	7.9%	38.2%	19.0%	34.9%	14.1%	32.0%	19.0%
C_20	0.3	35.5%	4.8%	47.2%	12.5%	36.3%	4.8%	46.4%	12.5%
C_21	1.0	61.8%	3.7%	31.0%	3.5%	61.8%	3.7%	31.0%	3.5%
C_22	3.2	66.7%	0.0%	32.1%	1.2%	66.7%	0.7%	31.4%	1.2%
C_23	1.2	65.5%	0.0%	34.5%	0.0%	65.5%	0.0%	34.4%	0.0%
C_24	2.1	60.0%	0.0%	37.8%	2.2%	60.0%	0.0%	37.8%	2.2%
C_25	2.1	32.5%	31.0%	36.5%	0.0%	32.5%	31.1%	36.4%	0.0%
C_26	1.6	18.6%	21.7%	59.7%	0.0%	18.6%	44.9%	36.4%	0.0%
C_27	3.0	30.9%	15.1%	54.0%	0.0%	30.9%	14.4%	54.8%	0.0%
C_28	2.5	13.6%	8.0%	69.1%	9.3%	23.1%	13.3%	54.4%	9.3%
C_29	2.9	52.7%	4.0%	41.0%	2.3%	52.7%	7.8%	37.2%	2.3%
C_30	0.3	66.2%	4.3%	23.4%	6.1%	66.2%	0.0%	27.6%	6.1%
C_31	0.5	84.9%	1.4%	13.7%	0.0%	84.9%	0.0%	15.1%	0.0%
C_32	0.3	70.7%	0.5%	28.8%	0.1%	70.7%	0.0%	29.3%	0.1%
C_33	2.3	69.8%	1.7%	28.5%	0.0%	69.8%	1.6%	28.6%	0.0%
Malabe	12.8	0.5%	10.8%	88.7%	0.0%	46.5%	3.4%	50.1%	0.0%

4. Bolgoda Basin

Code	Area	Present Land Use Condition				Future Land Use Condition			
	(km^2)	Type-1	Type-2	Type-3	Type-4	Type-1	Type-2	Type-3	Type-4
B_1	5.7	63.4%	8.9%	27.7%	0.0%	63.4%	9.4%	27.2%	0.0%
B_2	11.6	24.2%	14.9%	59.9%	1.0%	57.4%	3.4%	38.3%	1.0%
B_3	3.6	0.0%	19.0%	70.2%	10.8%	67.7%	0.0%	23.4%	8.9%
B_4	4.7	21.2%	14.3%	64.5%	0.0%	35.0%	14.3%	50.7%	0.0%
B_5	2.0	27.6%	28.4%	41.5%	2.5%	27.7%	28.4%	41.4%	2.5%
B_6	21.4	0.4%	20.4%	78.1%	1.0%	48.9%	1.5%	48.5%	1.0%
B_7	1.5	43.3%	9.6%	31.7%	15.5%	43.3%	9.6%	31.7%	15.5%
B_8	2.6	33.5%	9.2%	49.1%	8.2%	42.4%	8.2%	41.2%	8.2%
B_9	20.1	2.4%	10.4%	67.6%	19.6%	8.7%	7.7%	64.0%	19.6%
B_10	13.5	0.0%	11.1%	88.7%	0.2%	23.0%	5.3%	71.6%	0.2%
B_11	23.0	0.0%	14.0%	86.0%	0.0%	10.8%	12.1%	77.1%	0.0%
B_12	37.9	0.0%	8.6%	91.4%	0.0%	0.1%	8.6%	91.3%	0.0%
B_13	7.4	0.0%	3.6%	96.4%	0.0%	1.3%	3.6%	95.1%	0.0%
B_14	11.4	0.0%	7.6%	90.0%	2.4%	0.0%	7.6%	90.0%	2.4%
B_15	19.8	1.3%	2.1%	83.1%	13.4%	7.2%	10.6%	68.7%	13.4%
B_16	38.4	0.0%	0.6%	99.4%	0.0%	0.2%	1.0%	98.8%	0.0%
B_17	19.4	0.0%	0.0%	96.5%	3.5%	6.3%	0.0%	90.2%	3.5%
B_18	10.3	0.0%	0.0%	96.4%	3.6%	0.0%	0.0%	96.4%	3.6%
B_19	3.6	0.0%	0.0%	95.3%	4.7%	0.0%	0.0%	95.3%	4.7%
B_20	9.3	0.1%	4.0%	90.3%	5.5%	7.2%	15.0%	72.2%	5.5%
B_21	4.4	0.0%	0.0%	81.9%	18.1%	0.0%	0.0%	81.9%	18.1%
B_22	70.6	0.0%	0.0%	99.6%	0.4%	0.4%	0.0%	99.2%	0.4%
B_23	9.5	0.0%	0.0%	73.8%	26.2%	0.0%	11.0%	62.8%	26.2%
B_24	15.9	0.0%	0.0%	96.0%	4.0%	0.0%	0.0%	96.0%	4.0%
B_25	8.6	0.0%	0.0%	98.3%	1.7%	0.0%	0.0%	98.3%	1.7%
B_26	17.6	0.0%	0.0%	98.7%	1.3%	0.0%	14.0%	84.8%	1.3%

Table 4.5.2 Rainfall-Runoff Model (NAM) Parameters for Present Land Use Condition (1/2)

1. Attanagalu Oya Basin

Code	Area (km^2)	Parameter									Initial Condition				
		Umax	Lmax	CQOF	CKIF	TOF	TIF	CK1,2	TG	CKBF	U	L	QOF	QIF	BF
A_01	107.0	18.0	177	0.540	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	4.28
A_02	27.0	18.0	177	0.540	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	1.08
A_03	54.0	18.0	177	0.540	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	2.16
A_04	224.0	17.9	176	0.542	500	0.2	0.0	17.9	0.5	2000	0.0	0.3	0.0	0.0	8.96
A_05	150.0	18.0	177	0.540	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	6.00
A_06	34.8	17.9	176	0.542	500	0.2	0.0	17.9	0.5	2000	0.0	0.3	0.0	0.0	1.39
A_07	40.2	18.0	177	0.540	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	1.61
A_08	20.0	18.0	177	0.540	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	0.80
A_09	9.0	17.7	173	0.547	500	0.2	0.0	8.9	0.5	2000	0.0	0.3	0.0	0.0	0.36
A_10	14.9	17.7	173	0.547	500	0.2	0.0	8.9	0.5	2000	0.0	0.3	0.0	0.0	0.60
A_11	9.1	18.0	177	0.540	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	0.36
A_12	41.0	18.0	177	0.540	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	1.64
A_13	9.0	17.8	175	0.543	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	0.36
A_14	10.0	18.0	177	0.540	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	0.40
A_15	22.0	17.4	169	0.554	500	0.2	0.0	8.7	0.5	2000	0.0	0.3	0.0	0.0	0.88
A_16	5.7	14.3	134	0.615	500	0.2	0.0	7.6	0.5	2000	0.0	0.3	0.0	0.0	0.23
A_17	3.3	16.7	161	0.568	500	0.2	0.0	8.5	0.5	2000	0.0	0.3	0.0	0.0	0.13
A_18	15.0	17.7	173	0.547	500	0.2	0.0	8.9	0.5	2000	0.0	0.3	0.0	0.0	0.60
A_19	4.0	15.8	151	0.586	500	0.2	0.0	8.2	0.5	2000	0.0	0.3	0.0	0.0	0.16
A_20	1.4	17.2	167	0.558	500	0.2	0.0	8.7	0.5	2000	0.0	0.3	0.0	0.0	0.06
A_21	6.0	10.7	104	0.695	500	0.2	0.0	5.3	0.5	2000	0.0	0.3	0.0	0.0	0.24
A_22	2.8	17.1	168	0.560	500	0.2	0.0	8.5	0.5	2000	0.0	0.3	0.0	0.0	0.11
A_23	2.8	15.8	152	0.583	500	0.2	0.0	8.2	0.5	2000	0.0	0.3	0.0	0.0	0.11
A_24	3.3	15.5	148	0.590	500	0.2	0.0	8.1	0.5	2000	0.0	0.3	0.0	0.0	0.13
A_25	2.3	15.4	148	0.591	500	0.2	0.0	8.1	0.5	2000	0.0	0.3	0.0	0.0	0.09
A_26	1.7	17.4	170	0.552	500	0.2	0.0	8.8	0.5	2000	0.0	0.3	0.0	0.0	0.07
A_27	3.7	16.6	159	0.572	500	0.2	0.0	8.4	0.5	2000	0.0	0.3	0.0	0.0	0.15
A_28	1.6	15.1	142	0.604	500	0.2	0.0	7.7	0.5	2000	0.0	0.3	0.0	0.0	0.06
A_29	3.0	11.3	110	0.682	500	0.2	0.0	5.6	0.5	2000	0.0	0.3	0.0	0.0	0.12
A_30	12.0	15.7	152	0.586	500	0.2	0.0	8.1	0.5	2000	0.0	0.3	0.0	0.0	0.48
A_31	20.0	9.6	90	0.714	500	0.2	0.0	5.1	0.5	2000	0.0	0.3	0.0	0.0	0.80

2. Kalu Oya Basin

Code	Area (km^2)	Parameter									Initial Condition				
		Umax	Lmax	CQOF	CKIF	TOF	TIF	CK1,2	TG	CKBF	U	L	QOF	QIF	BF
K_01	2.8	16.3	157	0.576	500	0.2	0.0	8.3	0.5	2000	0.0	0.3	0.0	0.0	0.11
K_02	8.5	15.4	149	0.596	500	0.2	0.0	7.8	0.5	2000	0.0	0.3	0.0	0.0	0.34
K_03	13.4	17.2	168	0.556	500	0.2	0.0	8.7	0.5	2000	0.0	0.3	0.0	0.0	0.54
K_04	12.8	15.5	152	0.581	500	0.2	0.0	8.3	0.5	2000	0.0	0.3	0.0	0.0	0.51
K_05	3.1	18.0	177	0.540	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	0.13
K_06	7.3	14.8	144	0.595	500	0.2	0.0	8.1	0.5	2000	0.0	0.3	0.0	0.0	0.29
K_07	4.2	12.3	113	0.660	500	0.2	0.0	6.6	0.5	2000	0.0	0.3	0.0	0.0	0.17
K_08	3.8	13.5	124	0.633	500	0.2	0.0	7.3	0.5	2000	0.0	0.3	0.0	0.0	0.15
K_09	1.7	14.1	134	0.613	500	0.2	0.0	7.7	0.5	2000	0.0	0.3	0.0	0.0	0.07

Table 4.5.2 Rainfall-Runoff Model (NAM) Parameters for Present Land Use Condition (2/2)

3. Greater Colombo Basin

Code	Area	Parameter									Initial Condition				
	(km^2)	Umax	Lmax	CQOF	CKIF	TOF	TIF	CK1,2	TG	CKBF	U	L	QOF	QIF	BF
C_01	14.5	15.6	152	0.582	500	0.2	0.0	8.3	0.50	2000	0.00	0.30	0.00	0.00	0.58
C_02	15.6	15.6	153	0.582	500	0.2	0.0	8.2	0.50	2000	0.00	0.30	0.00	0.00	0.62
C_03	5.6	15.0	147	0.594	500	0.2	0.0	8.0	0.50	2000	0.00	0.30	0.00	0.00	0.22
C_04	5.6	12.4	117	0.649	500	0.2	0.0	6.8	0.50	2000	0.00	0.30	0.00	0.00	0.22
C_05	6.7	12.1	114	0.658	500	0.2	0.0	6.6	0.50	2000	0.00	0.30	0.00	0.00	0.27
C_06	1.5	8.6	82	0.724	500	0.2	0.0	5.1	0.50	2000	0.00	0.30	0.00	0.00	0.06
C_07	2.2	9.4	87	0.715	500	0.2	0.0	5.2	0.50	2000	0.00	0.30	0.00	0.00	0.09
C_08	0.3	10.7	97	0.683	500	0.2	0.0	6.3	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_09	4.4	10.7	94	0.694	500	0.2	0.0	5.9	0.50	2000	0.00	0.30	0.00	0.00	0.18
C_10	1.2	11.6	106	0.674	500	0.2	0.0	6.2	0.50	2000	0.00	0.30	0.00	0.00	0.05
C_11	1.0	8.8	83	0.734	500	0.2	0.0	4.6	0.50	2000	0.00	0.30	0.00	0.00	0.04
C_12	0.8	7.5	69	0.759	500	0.2	0.0	4.1	0.50	2000	0.00	0.30	0.00	0.00	0.03
C_13	0.5	12.5	121	0.642	500	0.2	0.0	7.0	0.50	2000	0.00	0.30	0.00	0.00	0.02
C_14	0.3	12.2	106	0.667	500	0.2	0.0	6.6	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_15	0.3	12.1	116	0.651	500	0.2	0.0	6.8	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_16	0.3	9.1	80	0.732	500	0.2	0.0	4.8	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_17	0.6	8.6	80	0.739	500	0.2	0.0	4.5	0.50	2000	0.00	0.30	0.00	0.00	0.02
C_18	0.3	10.9	99	0.686	500	0.2	0.0	6.0	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_19	0.9	9.4	80	0.724	500	0.2	0.0	5.2	0.50	2000	0.00	0.30	0.00	0.00	0.04
C_20	0.3	10.7	93	0.697	500	0.2	0.0	5.8	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_21	1.0	9.0	68	0.738	500	0.2	0.0	5.2	0.50	2000	0.00	0.30	0.00	0.00	0.04
C_22	3.2	9.1	68	0.738	500	0.2	0.0	5.2	0.50	2000	0.00	0.30	0.00	0.00	0.13
C_23	1.2	9.5	71	0.730	500	0.2	0.0	5.4	0.50	2000	0.00	0.30	0.00	0.00	0.05
C_24	2.1	9.8	77	0.722	500	0.2	0.0	5.5	0.50	2000	0.00	0.30	0.00	0.00	0.08
C_25	2.1	10.4	91	0.690	500	0.2	0.0	6.3	0.50	2000	0.00	0.30	0.00	0.00	0.08
C_26	1.6	13.2	123	0.633	500	0.2	0.0	7.3	0.50	2000	0.00	0.30	0.00	0.00	0.06
C_27	3.0	12.3	111	0.657	500	0.2	0.0	6.8	0.50	2000	0.00	0.30	0.00	0.00	0.12
C_28	2.5	13.8	131	0.627	500	0.2	0.0	7.2	0.50	2000	0.00	0.30	0.00	0.00	0.10
C_29	2.9	10.3	84	0.708	500	0.2	0.0	5.8	0.50	2000	0.00	0.30	0.00	0.00	0.12
C_30	0.3	7.9	55	0.762	500	0.2	0.0	4.7	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_31	0.5	6.8	39	0.789	500	0.2	0.0	4.3	0.50	2000	0.00	0.30	0.00	0.00	0.02
C_32	0.3	8.7	63	0.746	500	0.2	0.0	5.1	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_33	2.3	8.7	63	0.746	500	0.2	0.0	5.1	0.50	2000	0.00	0.30	0.00	0.00	0.09
Malabe	12.8	16.7	164	0.561	500	0.2	0.0	8.6	0.50	2000	0.00	0.30	0.00	0.00	0.51

4. Bolgoda Basin

Code	Area	Parameter									Initial Condition				
	(km^2)	Umax	Lmax	CQOF	CKIF	TOF	TIF	CK1,2	TG	CKBF	U	L	QOF	QIF	BF
B_01	5.7	8.8	65	0.740	500	0.2	0.0	5.2	0.5	2000	0.0	0.3	0.0	0.0	0.276
B_02	11.6	13.0	120	0.641	500	0.2	0.0	7.1	0.5	2000	0.0	0.3	0.0	0.0	0.348
B_03	3.6	14.1	138	0.613	500	0.2	0.0	7.5	0.5	2000	0.0	0.3	0.0	0.0	0.172
B_04	4.7	13.7	127	0.627	500	0.2	0.0	7.4	0.5	2000	0.0	0.3	0.0	0.0	0.204
B_05	2.0	10.9	97	0.680	500	0.2	0.0	6.4	0.5	2000	0.0	0.3	0.0	0.0	0.080
B_06	21.4	15.5	152	0.582	500	0.2	0.0	8.3	0.5	2000	0.0	0.3	0.0	0.0	0.844
B_07	1.5	8.7	71	0.738	500	0.2	0.0	5.0	0.5	2000	0.0	0.3	0.0	0.0	0.056
B_08	2.6	11.2	99	0.683	500	0.2	0.0	6.2	0.5	2000	0.0	0.3	0.0	0.0	0.100
B_09	20.1	13.2	128	0.636	500	0.2	0.0	6.9	0.5	2000	0.0	0.3	0.0	0.0	0.876
B_10	13.5	16.7	165	0.561	500	0.2	0.0	8.7	0.5	2000	0.0	0.3	0.0	0.0	0.564
B_11	23.0	16.5	162	0.565	500	0.2	0.0	8.6	0.5	2000	0.0	0.3	0.0	0.0	0.956
B_12	37.9	17.1	168	0.556	500	0.2	0.0	17.5	0.5	2000	0.0	0.3	0.0	0.0	1.704
B_13	7.4	17.6	173	0.546	500	0.2	0.0	8.9	0.5	2000	0.0	0.3	0.0	0.0	0.176
B_14	11.4	16.8	165	0.562	500	0.2	0.0	8.6	0.5	2000	0.0	0.3	0.0	0.0	1.172
B_15	19.8	15.3	150	0.596	500	0.2	0.0	7.7	0.5	2000	0.0	0.3	0.0	0.0	0.792
B_16	38.4	17.9	176	0.541	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	2.664
B_17	19.4	17.4	171	0.553	500	0.2	0.0	8.7	0.5	2000	0.0	0.3	0.0	0.0	0.836
B_18	10.3	17.4	171	0.553	500	0.2	0.0	8.7	0.5	2000	0.0	0.3	0.0	0.0	0.468
B_19	3.6	17.2	169	0.557	500	0.2	0.0	8.6	0.5	2000	0.0	0.3	0.0	0.0	0.128
B_20	9.3	16.6	163	0.567	500	0.2	0.0	8.4	0.5	2000	0.0	0.3	0.0	0.0	0.392
B_21	4.4	14.9	146	0.605	500	0.2	0.0	7.5	0.5	2000	0.0	0.3	0.0	0.0	0.184
B_22	70.6	17.9	176	0.542	500	0.2	0.0	17.9	0.5	2000	0.0	0.3	0.0	0.0	3.504
B_23	9.5	13.6	132	0.634	500	0.2	0.0	6.8	0.5	2000	0.0	0.3	0.0	0.0	0.448
B_24	15.9	17.3	170	0.554	500	0.2	0.0	8.7	0.5	2000	0.0	0.3	0.0	0.0	0.668
B_25	8.6	17.7	174	0.546	500	0.2	0.0	8.9	0.5	2000	0.0	0.3	0.0	0.0	0.292
B_26	17.6	17.8	175	0.545	500	0.2	0.0	8.9	0.5	2000	0.0	0.3	0.0	0.0	0.776

Table 4.5.3 Rainfall-Runoff Model (NAM) Parameters for Future Land Use Condition (1/2)

1. Attanagalu Oya Basin

Code	Area	Parameter									Initial Condition				
	(km^2)	Umax	Lmax	CQOF	CKIF	TOF	TIF	CK1,2	TG	CKBF	U	L	QOF	QIF	BF
A_01	107.0	18.0	177	0.540	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	4.28
A_02	27.0	18.0	177	0.540	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	1.08
A_03	54.0	18.0	177	0.540	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	2.16
A_04	224.0	17.8	175	0.543	500	0.2	0.0	17.9	0.5	2000	0.0	0.3	0.0	0.0	8.96
A_05	150.0	18.0	177	0.540	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	6.00
A_06	34.8	17.8	175	0.543	500	0.2	0.0	17.9	0.5	2000	0.0	0.3	0.0	0.0	1.39
A_07	40.2	18.0	177	0.540	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	1.61
A_08	20.0	17.9	176	0.542	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	0.80
A_09	9.0	17.6	173	0.548	500	0.2	0.0	8.9	0.5	2000	0.0	0.3	0.0	0.0	0.36
A_10	14.9	17.6	172	0.549	500	0.2	0.0	8.8	0.5	2000	0.0	0.3	0.0	0.0	0.60
A_11	9.1	18.0	177	0.540	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	0.36
A_12	41.0	18.0	177	0.540	500	0.2	0.0	18.0	0.5	2000	0.0	0.3	0.0	0.0	1.64
A_13	9.0	17.9	176	0.541	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	0.36
A_14	10.0	18.0	177	0.540	500	0.2	0.0	9.0	0.5	2000	0.0	0.3	0.0	0.0	0.40
A_15	22.0	17.4	169	0.554	500	0.2	0.0	8.7	0.5	2000	0.0	0.3	0.0	0.0	0.88
A_16	5.7	15.0	141	0.603	500	0.2	0.0	7.8	0.5	2000	0.0	0.3	0.0	0.0	0.23
A_17	3.3	14.8	140	0.606	500	0.2	0.0	7.8	0.5	2000	0.0	0.3	0.0	0.0	0.13
A_18	15.0	17.7	173	0.547	500	0.2	0.0	8.9	0.5	2000	0.0	0.3	0.0	0.0	0.60
A_19	4.0	14.4	134	0.617	500	0.2	0.0	7.6	0.5	2000	0.0	0.3	0.0	0.0	0.16
A_20	1.4	16.1	154	0.582	500	0.2	0.0	8.2	0.5	2000	0.0	0.3	0.0	0.0	0.06
A_21	6.0	10.7	104	0.695	500	0.2	0.0	5.3	0.5	2000	0.0	0.3	0.0	0.0	0.24
A_22	2.8	17.1	168	0.560	500	0.2	0.0	8.5	0.5	2000	0.0	0.3	0.0	0.0	0.11
A_23	2.8	13.1	117	0.649	500	0.2	0.0	6.9	0.5	2000	0.0	0.3	0.0	0.0	0.11
A_24	3.3	12.7	111	0.658	500	0.2	0.0	6.8	0.5	2000	0.0	0.3	0.0	0.0	0.13
A_25	2.3	12.7	112	0.656	500	0.2	0.0	6.8	0.5	2000	0.0	0.3	0.0	0.0	0.09
A_26	1.7	9.1	67	0.739	500	0.2	0.0	5.2	0.5	2000	0.0	0.3	0.0	0.0	0.07
A_27	3.7	11.3	96	0.686	500	0.2	0.0	6.3	0.5	2000	0.0	0.3	0.0	0.0	0.15
A_28	1.6	9.2	70	0.733	500	0.2	0.0	5.3	0.5	2000	0.0	0.3	0.0	0.0	0.06
A_29	3.0	11.3	110	0.682	500	0.2	0.0	5.6	0.5	2000	0.0	0.3	0.0	0.0	0.12
A_30	12.0	16.1	156	0.581	500	0.2	0.0	8.1	0.5	2000	0.0	0.3	0.0	0.0	0.48
A_31	20.0	9.4	85	0.724	500	0.2	0.0	4.9	0.5	2000	0.0	0.3	0.0	0.0	0.80

2. Kalu Oya Basin

Code	Area	Parameter									Initial Condition				
	(km^2)	Umax	Lmax	CQOF	CKIF	TOF	TIF	CK1,2	TG	CKBF	U	L	QOF	QIF	BF
K_01	2.8	11.4	107	0.660	500	0.2	0.0	6.9	0.5	2000	0.0	0.3	0.0	0.0	0.11
K_02	8.5	10.3	95	0.684	500	0.2	0.0	6.3	0.5	2000	0.0	0.3	0.0	0.0	0.34
K_03	13.4	11.4	107	0.660	500	0.2	0.0	6.9	0.5	2000	0.0	0.3	0.0	0.0	0.54
K_04	12.8	13.5	127	0.626	500	0.2	0.0	7.5	0.5	2000	0.0	0.3	0.0	0.0	0.51
K_05	3.1	17.4	170	0.552	500	0.2	0.0	8.8	0.5	2000	0.0	0.3	0.0	0.0	0.13
K_06	7.3	13.9	134	0.612	500	0.2	0.0	7.7	0.5	2000	0.0	0.3	0.0	0.0	0.29
K_07	4.2	11.1	97	0.685	500	0.2	0.0	6.2	0.5	2000	0.0	0.3	0.0	0.0	0.17
K_08	3.8	9.6	74	0.725	500	0.2	0.0	5.5	0.5	2000	0.0	0.3	0.0	0.0	0.15
K_09	1.7	11.1	94	0.688	500	0.2	0.0	6.2	0.5	2000	0.0	0.3	0.0	0.0	0.07

Table 4.5.3 Rainfall-Runoff Model (NAM) Parameters for Future Land Use Condition (2/2)

3. Greater Colombo Basin

Code	Area	Parameter									Initial Condition				
	(km^2)	Umax	Lmax	CQOF	CKIF	TOF	TIF	CK1,2	TG	CKBF	U	L	QOF	QIF	BF
C_01	14.5	12.1	106	0.666	500	0.2	0.0	6.7	0.50	2000	0.00	0.30	0.00	0.00	0.58
C_02	15.6	12.6	114	0.653	500	0.2	0.0	6.9	0.50	2000	0.00	0.30	0.00	0.00	0.62
C_03	5.6	13.2	128	0.626	500	0.2	0.0	7.4	0.50	2000	0.00	0.30	0.00	0.00	0.22
C_04	5.6	9.0	70	0.738	500	0.2	0.0	5.1	0.50	2000	0.00	0.30	0.00	0.00	0.22
C_05	6.7	10.8	97	0.687	500	0.2	0.0	6.1	0.50	2000	0.00	0.30	0.00	0.00	0.27
C_06	1.5	8.1	72	0.745	500	0.2	0.0	4.6	0.50	2000	0.00	0.30	0.00	0.00	0.06
C_07	2.2	9.1	83	0.724	500	0.2	0.0	5.1	0.50	2000	0.00	0.30	0.00	0.00	0.09
C_08	0.3	11.2	102	0.674	500	0.2	0.0	6.5	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_09	4.4	10.1	86	0.710	500	0.2	0.0	5.6	0.50	2000	0.00	0.30	0.00	0.00	0.18
C_10	1.2	11.8	108	0.671	500	0.2	0.0	6.3	0.50	2000	0.00	0.30	0.00	0.00	0.05
C_11	1.0	8.7	82	0.735	500	0.2	0.0	4.5	0.50	2000	0.00	0.30	0.00	0.00	0.04
C_12	0.8	7.5	69	0.759	500	0.2	0.0	4.1	0.50	2000	0.00	0.30	0.00	0.00	0.03
C_13	0.5	12.8	123	0.639	500	0.2	0.0	7.1	0.50	2000	0.00	0.30	0.00	0.00	0.02
C_14	0.3	12.5	109	0.662	500	0.2	0.0	6.7	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_15	0.3	10.8	102	0.673	500	0.2	0.0	6.5	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_16	0.3	9.1	80	0.732	500	0.2	0.0	4.8	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_17	0.6	7.2	66	0.762	500	0.2	0.0	4.1	0.50	2000	0.00	0.30	0.00	0.00	0.02
C_18	0.3	10.9	99	0.687	500	0.2	0.0	6.0	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_19	0.9	8.7	73	0.735	500	0.2	0.0	5.0	0.50	2000	0.00	0.30	0.00	0.00	0.04
C_20	0.3	10.6	92	0.699	500	0.2	0.0	5.8	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_21	1.0	9.0	68	0.738	500	0.2	0.0	5.2	0.50	2000	0.00	0.30	0.00	0.00	0.04
C_22	3.2	9.0	67	0.739	500	0.2	0.0	5.2	0.50	2000	0.00	0.30	0.00	0.00	0.13
C_23	1.2	9.5	71	0.730	500	0.2	0.0	5.4	0.50	2000	0.00	0.30	0.00	0.00	0.05
C_24	2.1	9.8	77	0.722	500	0.2	0.0	5.5	0.50	2000	0.00	0.30	0.00	0.00	0.08
C_25	2.1	10.3	91	0.690	500	0.2	0.0	6.3	0.50	2000	0.00	0.30	0.00	0.00	0.08
C_26	1.6	10.6	98	0.675	500	0.2	0.0	6.6	0.50	2000	0.00	0.30	0.00	0.00	0.06
C_27	3.0	12.4	112	0.655	500	0.2	0.0	6.9	0.50	2000	0.00	0.30	0.00	0.00	0.12
C_28	2.5	12.0	110	0.664	500	0.2	0.0	6.5	0.50	2000	0.00	0.30	0.00	0.00	0.10
C_29	2.9	9.9	80	0.715	500	0.2	0.0	5.7	0.50	2000	0.00	0.30	0.00	0.00	0.12
C_30	0.3	8.3	60	0.754	500	0.2	0.0	4.8	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_31	0.5	7.0	40	0.786	500	0.2	0.0	4.3	0.50	2000	0.00	0.30	0.00	0.00	0.02
C_32	0.3	8.8	63	0.745	500	0.2	0.0	5.1	0.50	2000	0.00	0.30	0.00	0.00	0.01
C_33	2.3	8.8	63	0.745	500	0.2	0.0	5.1	0.50	2000	0.00	0.30	0.00	0.00	0.09
Malabe	12.8	11.6	98	0.681	500	0.2	0.0	6.3	0.50	2000	0.00	0.30	0.00	0.00	0.51

4. Bolgoda Basin

Code	Area	Parameter									Initial Condition				
	(km^2)	Umax	Lmax	CQOF	CKIF	TOF	TIF	CK1,2	TG	CKBF	U	L	QOF	QIF	BF
B_01	5.7	8.7	65	0.741	500	0.2	0.0	5.2	0.5	2000	0.0	0.3	0.0	0.0	0.276
B_02	11.6	10.0	79	0.716	500	0.2	0.0	5.7	0.5	2000	0.0	0.3	0.0	0.0	0.348
B_03	3.6	7.7	53	0.768	500	0.2	0.0	4.5	0.5	2000	0.0	0.3	0.0	0.0	0.172
B_04	4.7	11.9	105	0.667	500	0.2	0.0	6.6	0.5	2000	0.0	0.3	0.0	0.0	0.204
B_05	2.0	10.9	97	0.680	500	0.2	0.0	6.4	0.5	2000	0.0	0.3	0.0	0.0	0.080
B_06	21.4	11.3	95	0.688	500	0.2	0.0	6.2	0.5	2000	0.0	0.3	0.0	0.0	0.844
B_07	1.5	8.7	71	0.738	500	0.2	0.0	5.0	0.5	2000	0.0	0.3	0.0	0.0	0.056
B_08	2.6	10.2	86	0.707	500	0.2	0.0	5.7	0.5	2000	0.0	0.3	0.0	0.0	0.100
B_09	20.1	12.7	121	0.650	500	0.2	0.0	6.6	0.5	2000	0.0	0.3	0.0	0.0	0.876
B_10	13.5	14.4	134	0.617	500	0.2	0.0	7.6	0.5	2000	0.0	0.3	0.0	0.0	0.564
B_11	23.0	15.3	146	0.593	500	0.2	0.0	8.0	0.5	2000	0.0	0.3	0.0	0.0	0.956
B_12	37.9	17.0	168	0.556	500	0.2	0.0	17.5	0.5	2000	0.0	0.3	0.0	0.0	1.704
B_13	7.4	17.4	171	0.550	500	0.2	0.0	8.8	0.5	2000	0.0	0.3	0.0	0.0	0.176
B_14	11.4	16.8	165	0.562	500	0.2	0.0	8.6	0.5	2000	0.0	0.3	0.0	0.0	1.172
B_15	19.8	13.6	131	0.628	500	0.2	0.0	7.1	0.5	2000	0.0	0.3	0.0	0.0	0.792
B_16	38.4	17.9	176	0.542	500	0.2	0.0	17.9	0.5	2000	0.0	0.3	0.0	0.0	2.664
B_17	19.4	16.6	161	0.571	500	0.2	0.0	8.4	0.5	2000	0.0	0.3	0.0	0.0	0.836
B_18	10.3	17.4	171	0.553	500	0.2	0.0	8.7	0.5	2000	0.0	0.3	0.0	0.0	0.468
B_19	3.6	17.2	169	0.557	500	0.2	0.0	8.6	0.5	2000	0.0	0.3	0.0	0.0	0.128
B_20	9.3	14.5	140	0.608	500	0.2	0.0	7.7	0.5	2000	0.0	0.3	0.0	0.0	0.392
B_21	4.4	14.9	146	0.605	500	0.2	0.0	7.5	0.5	2000	0.0	0.3	0.0	0.0	0.184
B_22	70.6	17.9	176	0.543	500	0.2	0.0	17.9	0.5	2000	0.0	0.3	0.0	0.0	3.504
B_23	9.5	12.3	120	0.654	500	0.2	0.0	6.4	0.5	2000	0.0	0.3	0.0	0.0	0.448
B_24	15.9	17.3	170	0.554	500	0.2	0.0	8.7	0.5	2000	0.0	0.3	0.0	0.0	0.668
B_25	8.6	17.7	174	0.546	500	0.2	0.0	8.9	0.5	2000	0.0	0.3	0.0	0.0	0.292
B_26	17.6	16.2	160	0.570	500	0.2	0.0	8.5	0.5	2000	0.0	0.3	0.0	0.0	0.776

Table 4.5.4 Flood Runoff from Each Sub-catchment (1/2)

1. Attanagalu Oya Basin

Code	Area (km^2)	2-yr Probable Flood				5-yr Probable Flood				10-yr Probable Flood				25-yr Probable Flood				50-yr Probable Flood			
		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use	
		Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s
A_01	107.0	14.4	0.13	14.4	0.13	24.4	0.23	24.4	0.23	34.3	0.32	34.3	0.32	49.3	0.46	49.3	0.46	61.4	0.57	61.4	0.57
A_02	27.0	6.6	0.24	6.6	0.24	12.3	0.46	12.3	0.46	17.4	0.64	17.4	0.64	24.9	0.92	24.9	0.92	31.2	1.16	31.2	1.16
A_03	54.0	7.2	0.13	7.2	0.13	12.3	0.23	12.3	0.23	17.3	0.32	17.3	0.32	24.9	0.46	24.9	0.46	31.0	0.57	31.0	0.57
A_04	224.0	30.3	0.14	30.5	0.14	51.9	0.23	52.3	0.23	73.0	0.33	73.5	0.33	104.8	0.47	105.5	0.47	130.2	0.58	131.0	0.58
A_05	150.0	20.1	0.13	20.1	0.13	34.2	0.23	34.2	0.23	48.1	0.32	48.1	0.32	69.1	0.46	69.1	0.46	86.0	0.57	86.0	0.57
A_06	34.8	4.7	0.14	4.7	0.14	8.1	0.23	8.1	0.23	11.3	0.33	11.4	0.33	16.3	0.47	16.4	0.47	20.2	0.58	20.4	0.58
A_07	40.2	5.4	0.13	5.4	0.13	9.2	0.23	9.2	0.23	12.9	0.32	12.9	0.32	18.5	0.46	18.5	0.46	23.1	0.57	23.1	0.57
A_08	20.0	4.9	0.24	4.9	0.25	9.1	0.46	9.2	0.46	12.9	0.64	13.0	0.65	18.5	0.92	18.6	0.93	23.1	1.16	23.3	1.17
A_09	9.0	2.3	0.25	2.3	0.26	4.3	0.48	4.3	0.48	6.1	0.67	6.1	0.68	8.7	0.97	8.7	0.97	10.8	1.20	10.9	1.21
A_10	14.9	3.8	0.25	3.9	0.26	7.1	0.48	7.3	0.49	10.1	0.67	10.3	0.69	14.4	0.97	14.7	0.99	18.0	1.21	18.3	1.23
A_11	9.1	2.2	0.24	2.2	0.24	4.1	0.45	4.1	0.45	5.8	0.64	5.8	0.64	8.4	0.92	8.4	0.92	10.5	1.16	10.5	1.16
A_12	41.0	5.5	0.13	5.5	0.13	9.4	0.23	9.4	0.23	13.1	0.32	13.1	0.32	18.9	0.46	18.9	0.46	23.5	0.57	23.5	0.57
A_13	9.0	2.2	0.25	2.2	0.25	4.2	0.46	4.1	0.46	5.9	0.65	5.8	0.65	8.4	0.94	8.4	0.93	10.6	1.17	10.5	1.16
A_14	10.0	2.4	0.24	2.4	0.24	4.6	0.46	4.6	0.46	6.4	0.64	6.4	0.64	9.2	0.92	9.2	0.92	11.6	1.16	11.6	1.16
A_15	22.0	5.9	0.27	5.9	0.27	11.1	0.51	11.1	0.51	15.7	0.72	15.7	0.72	22.5	1.02	22.5	1.02	27.9	1.27	27.9	1.27
A_16	5.7	2.5	0.44	2.3	0.40	4.6	0.81	4.2	0.74	6.3	1.10	5.8	1.02	8.6	1.51	8.0	1.40	10.4	1.83	9.7	1.71
A_17	3.3	1.0	0.30	1.3	0.40	1.9	0.56	2.5	0.75	2.6	0.79	3.4	1.03	3.7	1.11	4.7	1.41	4.5	1.37	5.7	1.72
A_18	15.0	3.8	0.25	3.8	0.25	7.2	0.48	7.2	0.48	10.1	0.67	10.1	0.67	14.5	0.97	14.5	0.97	18.1	1.20	18.1	1.20
A_19	4.0	1.4	0.34	1.8	0.44	2.6	0.64	3.3	0.81	3.6	0.89	4.4	1.10	5.0	1.24	6.0	1.51	6.1	1.52	7.3	1.83
A_20	1.4	0.4	0.28	0.5	0.33	0.7	0.52	0.9	0.63	1.0	0.73	1.2	0.88	1.5	1.04	1.7	1.22	1.8	1.29	2.1	1.50
A_21	6.0	5.3	0.88	5.3	0.88	8.8	1.47	8.8	1.47	11.4	1.90	11.4	1.90	14.9	2.48	14.9	2.48	17.6	2.94	17.6	2.94
A_22	2.8	0.8	0.28	0.8	0.28	1.5	0.53	1.5	0.53	2.1	0.75	2.1	0.75	3.0	1.06	3.0	1.06	3.7	1.31	3.7	1.31
A_23	2.8	0.9	0.34	1.6	0.58	1.8	0.63	2.9	1.03	2.5	0.88	3.9	1.38	3.4	1.23	5.2	1.84	4.2	1.51	6.2	2.20
A_24	3.3	1.2	0.36	2.1	0.63	2.2	0.67	3.6	1.10	3.1	0.93	4.8	1.45	4.2	1.28	6.4	1.93	5.2	1.57	7.6	2.30
A_25	2.3	0.8	0.36	1.4	0.62	1.5	0.67	2.5	1.09	2.1	0.93	3.3	1.44	2.9	1.28	4.4	1.92	3.6	1.57	5.3	2.29
A_26	1.7	0.5	0.26	2.1	1.21	0.8	0.50	3.2	1.90	1.2	0.70	4.1	2.40	1.7	1.00	5.3	3.10	2.1	1.25	6.2	3.67
A_27	3.7	1.1	0.31	2.9	0.78	2.1	0.58	4.9	1.33	3.0	0.81	6.4	1.72	4.2	1.14	8.3	2.25	5.2	1.40	9.9	2.67
A_28	1.6	0.6	0.40	1.9	1.16	1.2	0.75	2.9	1.83	1.6	1.02	3.7	2.32	2.3	1.41	4.8	2.99	2.7	1.72	5.7	3.53
A_29	3.0	2.4	0.80	2.4	0.80	4.0	1.34	4.0	1.34	5.2	1.75	5.2	1.75	6.9	2.30	6.9	2.30	8.2	2.72	8.2	2.72
A_30	12.0	4.1	0.34	4.0	0.33	7.8	0.65	7.5	0.63	10.8	0.90	10.5	0.87	15.0	1.25	14.6	1.22	18.4	1.54	18.0	1.50
A_31	20.0	20.5	1.03	22.1	1.11	33.2	1.66	35.4	1.77	42.5	2.12	45.1	2.25	55.3	2.76	59.2	2.96	65.9	3.30	70.5	3.53

Note : Q_{max} : Maximum Flood Discharge (m^3/sec)
Q_s : Specific Discharge ($m^3/sec/km^2$)

2. Kalu Oya Basin

Code	Area (km^2)	2-yr Probable Flood				5-yr Probable Flood				10-yr Probable Flood				25-yr Probable Flood				50-yr Probable Flood			
		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use	
		Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s
K_01	2.8	1.5	0.55	2.9	1.04	3.3	1.19	5.6	1.99	4.8	1.70	7.5	2.67	6.7	2.39	10.0	3.58	8.2	2.94	11.9	4.24
K_02	8.5	5.5	0.64	10.7	1.25	11.5	1.36	19.5	2.29	16.2	1.91	25.9	3.04	22.6	2.65	34.4	4.05	27.5	3.23	41.6	4.89
K_03	13.4	6.3	0.47	14.0	1.04	14.1	1.05	26.6	1.99	20.2	1.50	35.8	2.67	28.9	2.15	48.0	3.58	35.7	2.66	56.9	4.24
K_04	12.8	7.4	0.58	10.4	0.81	15.8	1.23	20.8	1.63	22.4	1.75	28.6	2.23	31.4	2.46	39.0	3.05	38.4	3.00	45.7	3.57
K_05	3.1	1.3	0.42	1.4	0.46	2.9	0.94	3.2	1.02	4.3	1.37	4.6	1.47	6.1	1.98	6.5	2.11	7.6	2.46	7.8	2.52
K_06	7.3	4.7	0.64	5.4	0.74	9.8	1.34	11.0	1.51	13.8	1.89	15.3	2.09	19.1	2.62	21.0	2.87	23.3	3.19	24.5	3.36
K_07	4.2	4.4	1.04	5.2	1.25	8.4	1.99	9.6	2.30	11.3	2.69	12.8	3.06	15.2	3.62	17.1	4.08	18.2	4.34	20.7	4.94
K_08	3.8	3.2	0.85	6.2	1.63	6.4	1.70	10.9	2.86	8.8	2.32	14.5	3.81	12.0	3.16	19.5	5.12	14.5	3.81	23.4	6.16
K_09	1.7	1.3	0.74	2.2	1.28	2.6	1.51	4.0	2.33	3.6	2.09	5.3	3.10	4.9	2.88	7.0	4.14	5.9	3.48	8.5	5.00

Note : Q_{max} : Maximum Flood Discharge (m^3/sec)
Q_s : Specific Discharge ($m^3/sec/km^2$)

Table 4.5.4 Flood Runoff from Each Sub-catchment (2/2)

3. Greater Colombo Basin

Code	Area (km²)	2-yr Probable Flood				5-yr Probable Flood				10-yr Probable Flood				25-yr Probable Flood				50-yr Probable Flood			
		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use	
		Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s
C_01	14.5	6.6	0.46	12.8	0.88	16.3	1.13	27.5	1.90	24.2	1.67	38.3	2.64	36.7	2.53	54.8	3.79	48.7	3.37	70.7	4.89
C_02	15.6	7.2	0.46	12.5	0.80	17.7	1.14	27.4	1.76	26.2	1.68	38.5	2.47	39.6	2.55	55.6	3.57	52.7	3.39	72.0	4.63
C_03	5.6	2.8	0.50	3.7	0.66	6.8	1.22	8.4	1.51	10.0	1.80	12.0	2.16	15.0	2.69	17.6	3.16	19.9	3.56	23.0	4.12
C_04	5.6	4.5	0.80	8.5	1.52	9.8	1.75	16.3	2.92	13.8	2.46	22.5	4.03	19.9	3.55	32.3	5.78	25.8	4.61	41.8	7.48
C_05	6.7	5.7	0.85	7.1	1.06	12.3	1.84	14.5	2.17	17.2	2.57	20.0	2.99	24.7	3.70	28.4	4.25	32.0	4.79	37.3	5.58
C_06	1.5	2.1	1.40	2.4	1.63	4.0	2.72	4.7	3.20	5.6	3.79	6.5	4.43	8.1	5.48	9.3	6.33	10.5	7.14	12.1	8.18
C_07	2.2	2.9	1.33	3.0	1.39	5.7	2.60	5.9	2.71	7.9	3.61	8.2	3.77	11.4	5.24	11.9	5.46	14.9	6.85	15.5	7.12
C_08	0.3	0.3	1.02	0.3	0.95	0.6	2.11	0.6	1.99	0.9	2.91	0.8	2.76	1.2	4.12	1.2	3.94	1.6	5.39	1.5	5.11
C_09	4.4	5.0	1.12	5.6	1.25	10.1	2.27	11.0	2.47	13.8	3.11	15.0	3.37	19.8	4.46	21.7	4.89	26.0	5.85	28.4	6.39
C_10	1.2	1.2	0.97	1.1	0.94	2.5	2.03	2.4	1.98	3.4	2.82	3.4	2.76	4.9	4.02	4.8	3.94	6.4	5.28	6.3	5.16
C_11	1.0	1.5	1.51	1.5	1.54	2.9	3.00	3.0	3.08	4.1	4.19	4.2	4.29	5.9	6.05	6.0	6.19	7.6	7.86	7.8	8.02
C_12	0.8	1.5	1.83	1.5	1.83	3.1	3.65	3.1	3.65	4.2	5.02	4.2	5.02	6.0	7.12	6.0	7.12	7.7	9.11	7.7	9.11
C_13	0.5	0.3	0.76	0.3	0.73	0.8	1.67	0.8	1.63	1.1	2.36	1.1	2.31	1.6	3.42	1.5	3.36	2.1	4.45	2.0	4.37
C_14	0.3	0.3	0.89	0.2	0.85	0.5	1.91	0.5	1.86	0.8	2.67	0.7	2.60	1.1	3.82	1.1	3.73	1.4	4.94	1.4	4.82
C_15	0.3	0.3	0.80	0.3	0.95	0.6	1.76	0.6	1.99	0.8	2.47	0.9	2.76	1.1	3.57	1.3	3.94	1.5	4.63	1.6	5.10
C_16	0.3	0.5	1.48	0.5	1.48	1.0	2.91	1.0	2.91	1.4	4.05	1.4	4.05	2.0	5.86	2.0	5.86	2.6	7.61	2.6	7.61
C_17	0.6	0.9	1.56	1.1	1.87	1.8	3.12	2.2	3.72	2.5	4.34	3.0	5.10	3.7	6.25	4.2	7.20	4.7	8.10	5.4	9.20
C_18	0.3	0.3	1.05	0.3	1.05	0.7	2.16	0.7	2.17	1.0	2.98	1.0	2.99	1.4	4.27	1.4	4.27	1.9	5.62	1.9	5.62
C_19	0.9	1.3	1.40	1.4	1.52	2.5	2.70	2.7	2.92	3.5	3.75	3.7	4.05	5.0	5.42	5.4	5.81	6.5	7.06	7.0	7.53
C_20	0.3	0.3	1.14	0.3	1.15	0.6	2.31	0.6	2.32	0.8	3.16	0.9	3.18	1.2	4.55	1.2	4.58	1.6	5.97	1.6	6.01
C_21	1.0	1.5	1.52	1.5	1.52	2.9	2.90	2.9	2.90	4.0	3.99	4.0	3.99	5.7	5.71	5.7	5.71	7.4	7.39	7.4	7.39
C_22	3.2	4.8	1.52	4.9	1.53	9.2	2.90	9.2	2.91	12.7	3.99	12.7	4.01	18.1	5.71	18.2	5.74	23.4	7.39	23.5	7.42
C_23	1.2	1.7	1.44	1.7	1.44	3.3	2.76	3.3	2.76	4.5	3.78	4.5	3.78	6.4	5.42	6.4	5.42	8.3	7.03	8.3	7.03
C_24	2.1	2.8	1.35	2.8	1.35	5.5	2.63	5.5	2.63	7.5	3.59	7.5	3.59	10.8	5.18	10.8	5.18	14.1	6.74	14.1	6.74
C_25	2.1	2.2	1.08	2.2	1.08	4.5	2.19	4.5	2.19	6.2	3.00	6.2	3.00	8.7	4.23	8.7	4.23	11.4	5.53	11.4	5.53
C_26	1.6	1.1	0.70	1.6	0.97	2.5	1.57	3.2	2.02	3.6	2.24	4.5	2.78	5.2	3.26	6.3	3.96	6.8	4.25	8.2	5.11
C_27	3.0	2.5	0.84	2.4	0.82	5.4	1.82	5.3	1.78	7.6	2.54	7.5	2.50	10.9	3.66	10.8	3.60	14.1	4.73	13.9	4.66
C_28	2.5	1.7	0.67	2.2	0.89	3.8	1.52	4.7	1.90	5.4	2.18	6.6	2.65	7.9	3.19	9.5	3.81	10.4	4.17	12.3	4.94
C_29	2.9	3.6	1.23	3.8	1.29	7.1	2.43	7.4	2.52	9.6	3.31	10.0	3.42	13.8	4.75	14.4	4.93	18.1	6.21	18.7	6.43
C_30	0.3	0.6	1.80	0.5	1.71	1.1	3.45	1.0	3.28	1.5	4.72	1.4	4.50	2.1	6.66	2.0	6.38	2.6	8.52	2.5	8.21
C_31	0.5	1.1	2.22	1.1	2.20	2.0	4.16	2.0	4.13	2.7	5.58	2.7	5.54	3.7	7.71	3.7	7.66	4.7	9.72	4.7	9.66
C_32	0.3	0.6	1.59	0.5	1.59	1.0	3.03	1.0	3.03	1.4	4.17	1.4	4.17	2.1	5.94	2.0	5.94	2.6	7.67	2.6	7.66
C_33	2.3	3.7	1.60	3.7	1.60	7.0	3.04	7.0	3.04	9.6	4.18	9.6	4.17	13.7	5.96	13.7	5.95	17.7	7.68	17.6	7.67
Malabe	12.8	5.0	0.39	12.8	1.01	12.6	0.99	26.7	2.09	18.9	1.48	36.8	2.89	29.2	2.29	52.3	4.10	39.2	3.07	68.4	5.36

Note : Q_{max} : Maximum Flood Discharge (m^3/sec)
Q_s : Specific Discharge ($m^3/sec/km^2$)

4. Bolgoda Basin

Code	Area (km²)	2-yr Probable Flood				5-yr Probable Flood				10-yr Probable Flood				25-yr Probable Flood				50-yr Probable Flood			
		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use		Present Land Use		Future Land Use	
		Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s	Q_{max}	Q_s
B_01	5.7	7.2	1.26	7.2	1.26	11.4	2.00	11.4	2.00	14.4	2.54	14.4	2.53	18.8	3.31	18.8	3.31	22.3	3.92	22.3	3.93
B_02	11.6	6.3	0.55	11.7	1.01	11.7	1.01	19.4	1.68	15.9	1.37	25.0	2.15	21.5	1.85	32.5	2.80	25.9	2.23	38.3	3.30
B_03	3.6	1.6	0.45	5.6	1.54	3.1	0.84	8.8	2.43	4.2	1.15	11.3	3.11	5.7	1.58	14.7	4.04	7.0	1.92	17.3	4.77
B_04	4.7	2.3	0.50	3.3	0.70	4.3	0.93	5.8	1.24	5.9	1.26	7.6	1.63	8.1	1.72	10.2	2.18	9.8	2.09	12.1	2.59
B_05	2.0	1.5	0.77	1.5	0.77	2.7	1.34	2.7	1.34	3.5	1.76	3.5	1.76	4.6	2.32	4.6	2.32	5.5	2.76	5.5	2.76
B_06	21.4	7.2	0.34	17.4	0.81	14.0	0.65	30.0	1.40	19.8	0.92	39.2	1.83	27.7	1.29	51.7	2.41	34.2	1.60	61.3	2.86
B_07	1.5	1.8	1.20	1.8	1.20	3.0	1.93	3.0	1.93	3.8	2.46	3.8	2.46	5.0	3.23	5.0	3.23	5.9	3.85	5.9	3.85
B_08	2.6	2.0	0.79	2.5	0.97	3.6	1.37	4.2	1.62	4.7	1.80	5.4	2.08	6.1	2.37	7.0	2.72	7.3	2.82	8.3	3.21
B_09	20.1	11.0	0.55	12.3	0.61	20.0	1.00	22.2	1.10	27.2	1.35	29.6	1.48	36.9	1.83	39.9	1.99	44.4	2.21	47.9	2.39
B_10	13.5	3.9	0.29	6.0	0.45	7.5	0.55	11.5	0.85	10.6	0.79	15.6	1.16	15.3	1.13	21.7	1.60	18.9	1.40	26.4	1.95
B_11	23.0	6.8	0.30	8.6	0.37	13.3	0.58	16.6	0.72	18.8	0.82	23.1	1.00	26.8	1.16	32.2	1.40	33.1	1.44	39.6	1.72
B_12	37.9	5.7	0.15	5.7	0.15	10.3	0.27	10.3	0.27	14.6	0.39	14.6	0.39	20.8	0.55	20.8	0.55	25.8	0.68	25.8	0.68
B_13	7.4	1.8	0.24	1.8	0.25	3.6	0.48	3.7	0.50	5.2	0.70	5.3	0.72	7.5	1.01	7.7	1.04	9.4	1.27	9.7	1.31
B_14	11.4	4.0	0.35	4.0	0.35	7.1	0.62	7.1	0.62	9.8	0.86	9.8	0.86	13.7	1.20	13.7	1.20	16.8	1.47	16.8	1.47
B_15	19.8	7.5	0.38	10.0	0.51	14.6	0.74	18.6	0.94	20.3	1.03	25.3	1.28	28.3	1.43	34.6	1.75	34.8	1.76	41.8	2.12
B_16	38.4	6.3	0.16	6.3	0.17	10.3	0.27	10.4	0.27	14.2	0.37	14.3	0.37	20.1	0.52	20.3	0.53	24.8	0.65	25.0	0.65
B_17	19.4	5.3	0.27	6.0	0.31	10.2	0.53	11.7	0.60	14.6	0.75	16.5	0.85	21.0	1.08	23.4	1.21	26.1	1.35	29.0	1.50
B_18	10.3	2.8	0.27	2.8	0.27	5.5	0.53	5.5	0.53	7.8	0.75	7.8	0.75	11.2	1.08	11.2	1.08	13.9	1.34	13.9	1.34
B_19	3.6	1.0	0.27	1.0	0.27	1.9	0.53	1.9	0.53	2.8	0.76	2.8	0.76	4.0	1.09	4.0	1.09	4.9	1.36	4.9	1.36
B_20	9.3	2.8	0.30	3.9	0.42	5.5	0.59	7.5	0.80	7.8	0.84	10.2	1.10	11.1	1.19	14.2	1.53	13.7	1.47	17.4	1.87
B_21	4.4	1.8	0.41	1.8	0.41	3.5	0.79	3.5	0.79	4.8	1.08	4.8	1.08	6.7	1.50	6.7	1.50	8.1	1.84	8.1	1.84
B_22	70.6	10.3	0.15	10.3	0.15	17.7	0.25	17.8	0.25	25.0	0.35	25.0	0.35	35.9	0.51	35.9	0.51	44.6	0.63	44.7	0.63
B_23	9.5	5.1	0.54	6.1	0.65	9.4	0.99	10.9	1.15	12.7	1.34	14.6	1.53	17.3	1.82	19.5	2.05	20.9	2.20	23.4	2.46
B_24	15.9	4.3	0.27	4.3	0.27	8.4	0.53	8.4	0.53	12.0	0.75	12.0	0.75	17.3	1.09	17.3	1.09	21.5	1.35	21.5	1.35
B_25	8.6	2.1	0.25	2.1	0.25	4.2	0.49	4.2	0.49	6.0	0.70	6.0	0.70	8.8	1.02	8.8	1.02	11.0	1.27	11.0	1.27
B_26	17.6	4.5	0.26	5.5	0.31	8.7	0.49	10.6	0.60	12.5	0.71	14.9	0.85	18.0	1.02	21.2	1.20	22.5	1.28	26.2	1.49

Note : Q_{max} : Maximum Flood Discharge (m^3/sec)
Q_s : Specific Discharge ($m^3/sec/km^2$)

Table 4.8.1 Flood Inundation Area by Land Use Category

1. Attanagalu Oya Basin (Unit : ha)

Return Period	Land Use Condition	Land Use Category					Total
		Urbanized	Semi-urbanized	Rural	Paddy	Marsh/Water	
2-year	Present	4	0	340	769	1,205	**2,317**
	Future	0	0	324	681	1,205	**2,210**
5-year	Present	14	1	514	1,080	1,205	**2,814**
	Future	14	1	500	993	1,205	**2,712**
10-year	Present	15	1	656	1,266	1,213	**3,150**
	Future	14	1	637	1,177	1,213	**3,041**
25-year	Present	15	2	892	1,846	1,213	**3,968**
	Future	15	3	876	1,750	1,213	**3,856**
50-year	Present	21	3	1,095	2,271	1,213	**4,602**
	Future	21	3	1,070	2,150	1,213	**4,456**

2. Kalu Oya Basin (Unit : ha)

Return Period	Land Use Condition	Land Use Category					Total
		Urbanized	Semi-urbanized	Rural	Paddy	Marsh/Water	
2-year	Present	8	4	61	210	137	**419**
	Future	29	16	64	176	73	**357**
5-year	Present	26	9	88	261	137	**522**
	Future	31	18	74	208	73	**404**
10-year	Present	26	15	106	302	137	**585**
	Future	38	20	84	233	73	**448**
25-year	Present	26	15	116	339	137	**634**
	Future	55	25	97	278	73	**528**
50-year	Present	28	18	133	379	137	**694**
	Future	55	28	115	306	73	**577**

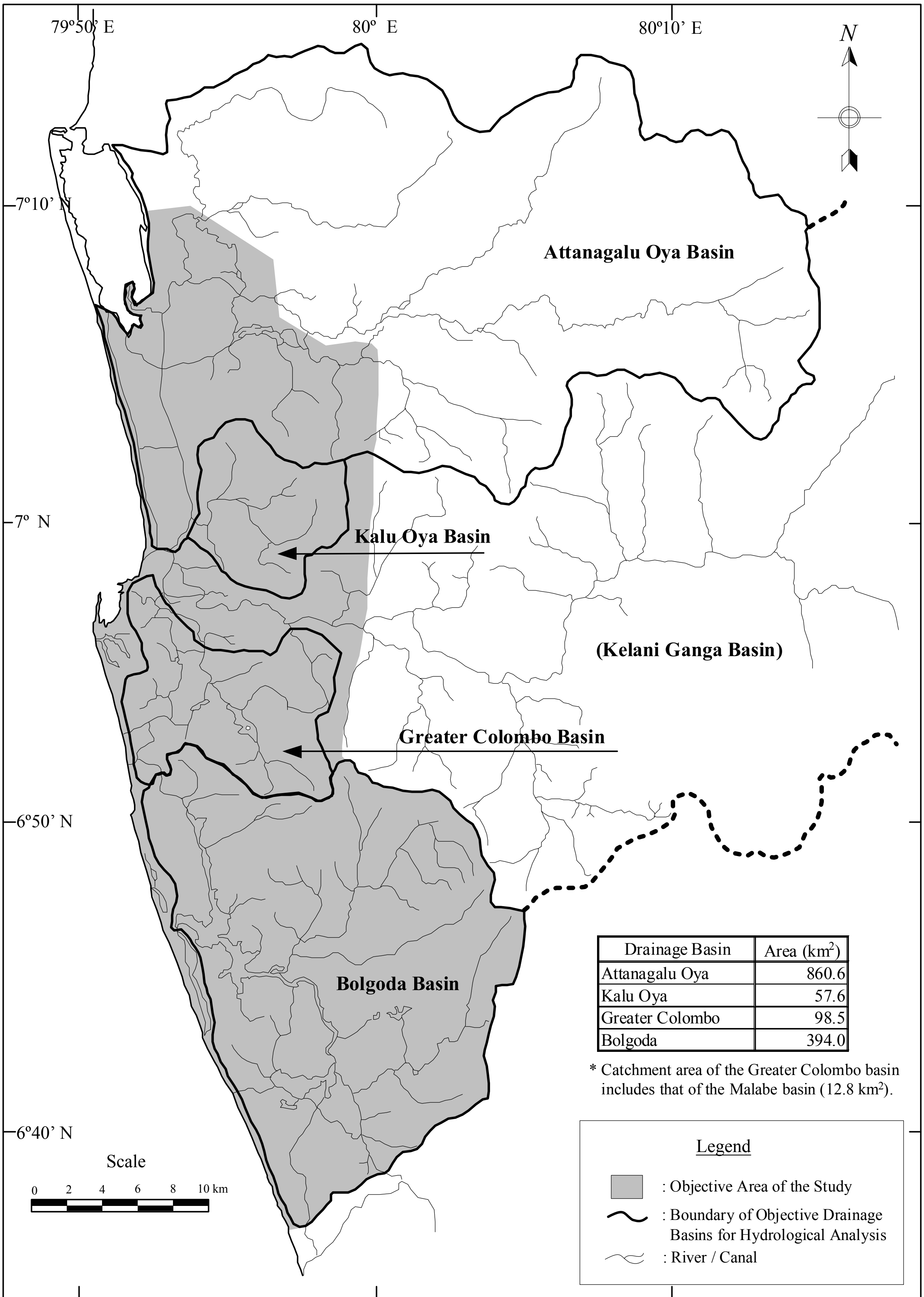
3. Greater Colombo Basin (Unit : ha)

Return Period	Land Use Condition	Land Use Category					Total
		Urbanized	Semi-urbanized	Rural	Paddy	Marsh/Water	
2-year	Present	14	10	93	36	278	**430**
	Future	15	32	90	40	292	**469**
5-year	Present	22	20	158	88	343	**631**
	Future	43	45	156	122	373	**739**
10-year	Present	34	27	215	132	407	**814**
	Future	68	54	225	150	436	**932**
25-year	Present	67	38	302	174	470	**1,050**
	Future	103	66	307	196	510	**1,181**
50-year	Present	110	54	401	209	528	**1,302**
	Future	150	83	405	231	542	**1,411**

4. Bolgoda Basin (Unit : ha)

Return Period	Land Use Condition	Land Use Category					Total
		Urbanized	Semi-urbanized	Rural	Paddy	Marsh/Water	
2-year	Present	0	4	527	1,888	1,302	**3,720**
	Future	6	11	555	1,897	1,301	**3,769**
5-year	Present	0	5	629	2,295	1,311	**4,240**
	Future	17	19	698	2,270	1,309	**4,314**
10-year	Present	6	9	698	2,565	1,317	**4,595**
	Future	20	24	782	2,503	1,318	**4,647**
25-year	Present	7	16	787	2,835	1,321	**4,965**
	Future	24	31	876	2,712	1,325	**4,966**
50-year	Present	7	20	867	3,019	1,328	**5,241**
	Future	27	34	948	2,882	1,334	**5,224**

Figures



Drainage Basin	Area (km²)
Attanagalu Oya	860.6
Kalu Oya	57.6
Greater Colombo	98.5
Bolgoda	394.0

* Catchment area of the Greater Colombo basin includes that of the Malabe basin (12.8 km²).

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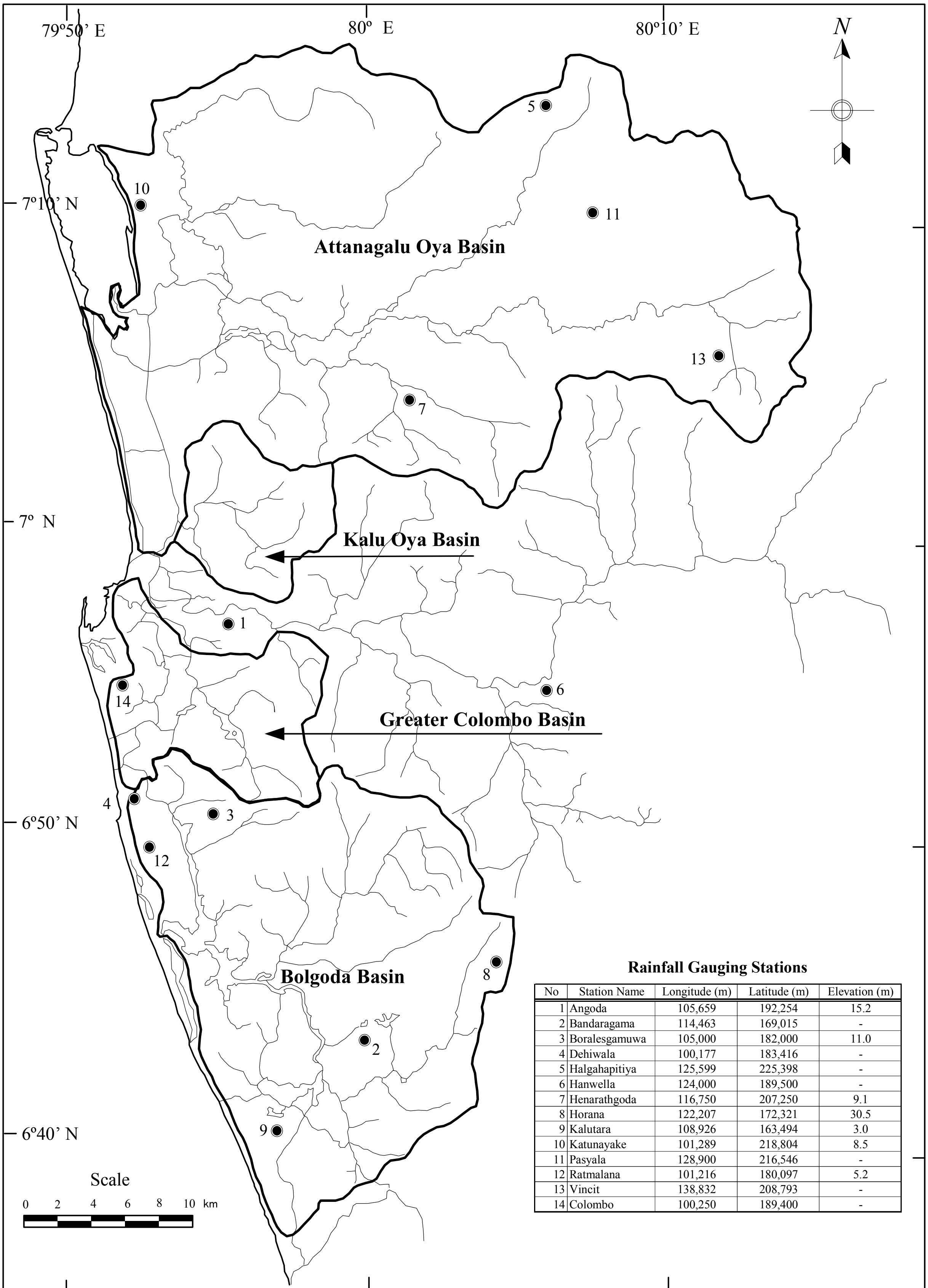
Figure 1.2.1
Objective Drainage Basins for Hydrological and Hydraulic Study



Rainfall Gauging Stations

No	Station Name	Longitude (m)	Latitude (m)	Elevation (m)
1	Angoda	105,659	192,254	15.2
2	Bandaragama	114,463	169,015	-
3	Boralesgamuwa	105,000	182,000	11.0
4	Dehiwala	100,177	183,416	-
5	Halgahapitiya	125,599	225,398	-
6	Hanwella	124,000	189,500	-
7	Henarathgoda	116,750	207,250	9.1
8	Horana	122,207	172,321	30.5
9	Kalutara	108,926	163,494	3.0
10	Katunayake	101,289	218,804	8.5
11	Pasyala	128,900	216,546	-
12	Ratmalana	101,216	180,097	5.2
13	Vincit	138,832	208,793	-
14	Colombo	100,250	189,400	-

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Figure 2.1.1
Location of Rainfall Gauging Stations in and around the Objective Drainage Basins

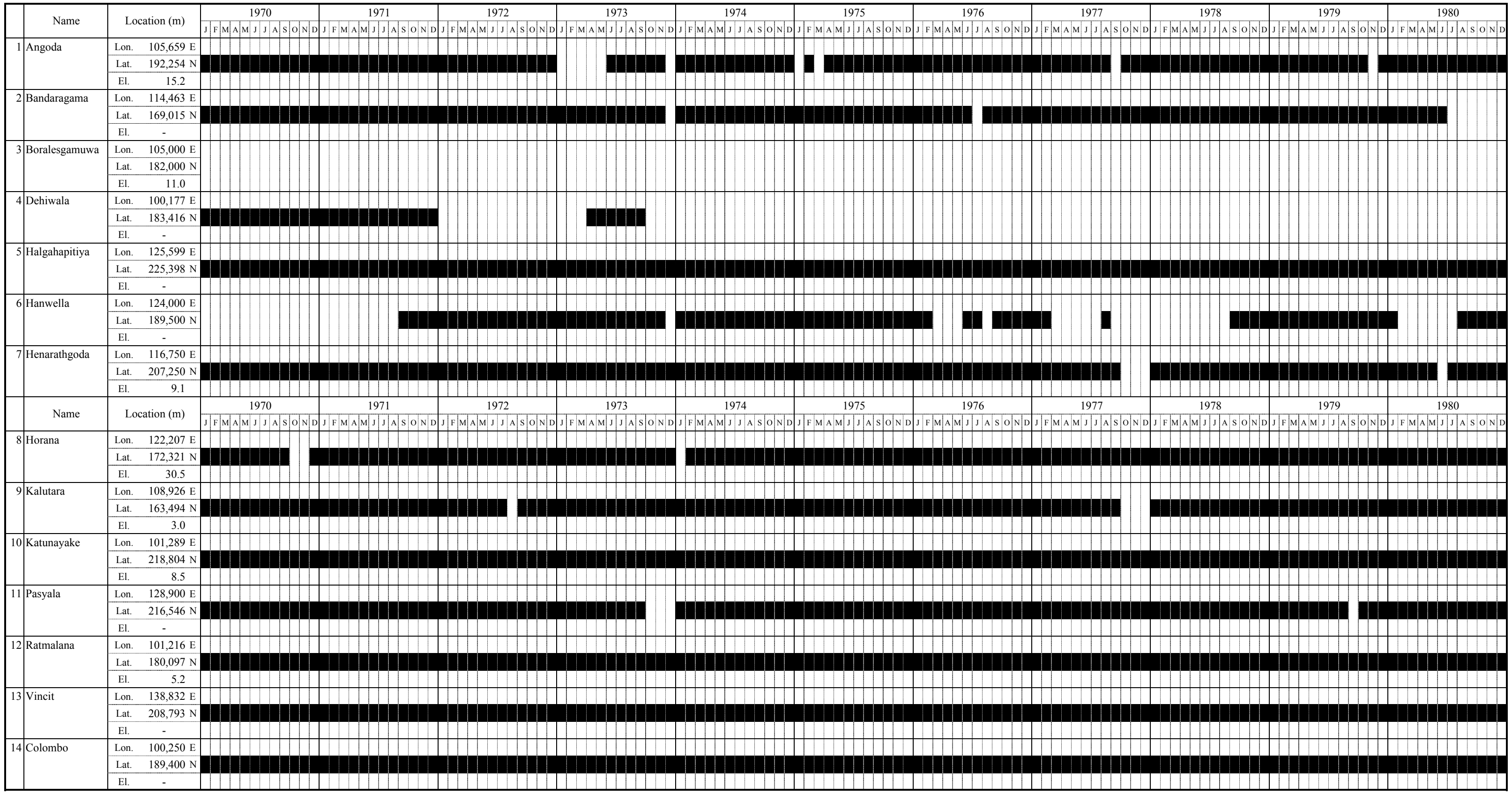

Figure 2.1.2
Rainfall Gauging Stations and Available Daily
Rainfall Data in and around the Study Area (1/3)

No.	Name	Location (m)	
1	Angoda	Lon.	105,659 E
		Lat.	192,254 N
		El.	15.2
2	Bandaragama	Lon.	114,463 E
		Lat.	169,015 N
		El.	-
3	Boralesgamuwa	Lon.	105,000 E
		Lat.	182,000 N
		El.	11.0
4	Dehiwala	Lon.	100,177 E
		Lat.	183,416 N
		El.	-
5	Halgahapitiya	Lon.	125,599 E
		Lat.	225,398 N
		El.	-
6	Hanwella	Lon.	124,000 E
		Lat.	189,500 N
		El.	-
7	Henarathgoda	Lon.	116,750 E
		Lat.	207,250 N
		El.	9.1
8	Horana	Lon.	122,207 E
		Lat.	172,321 N
		El.	30.5
9	Kalutara	Lon.	108,926 E
		Lat.	163,494 N
		El.	3.0
10	Katunayake	Lon.	101,289 E
		Lat.	218,804 N
		El.	8.5
11	Pasyala	Lon.	128,900 E
		Lat.	216,546 N
		El.	-
12	Ratmalana	Lon.	101,216 E
		Lat.	180,097 N
		El.	5.2
13	Vincit	Lon.	138,832 E
		Lat.	208,793 N
		El.	-
14	Colombo	Lon.	100,250 E
		Lat.	189,400 N
		El.	-

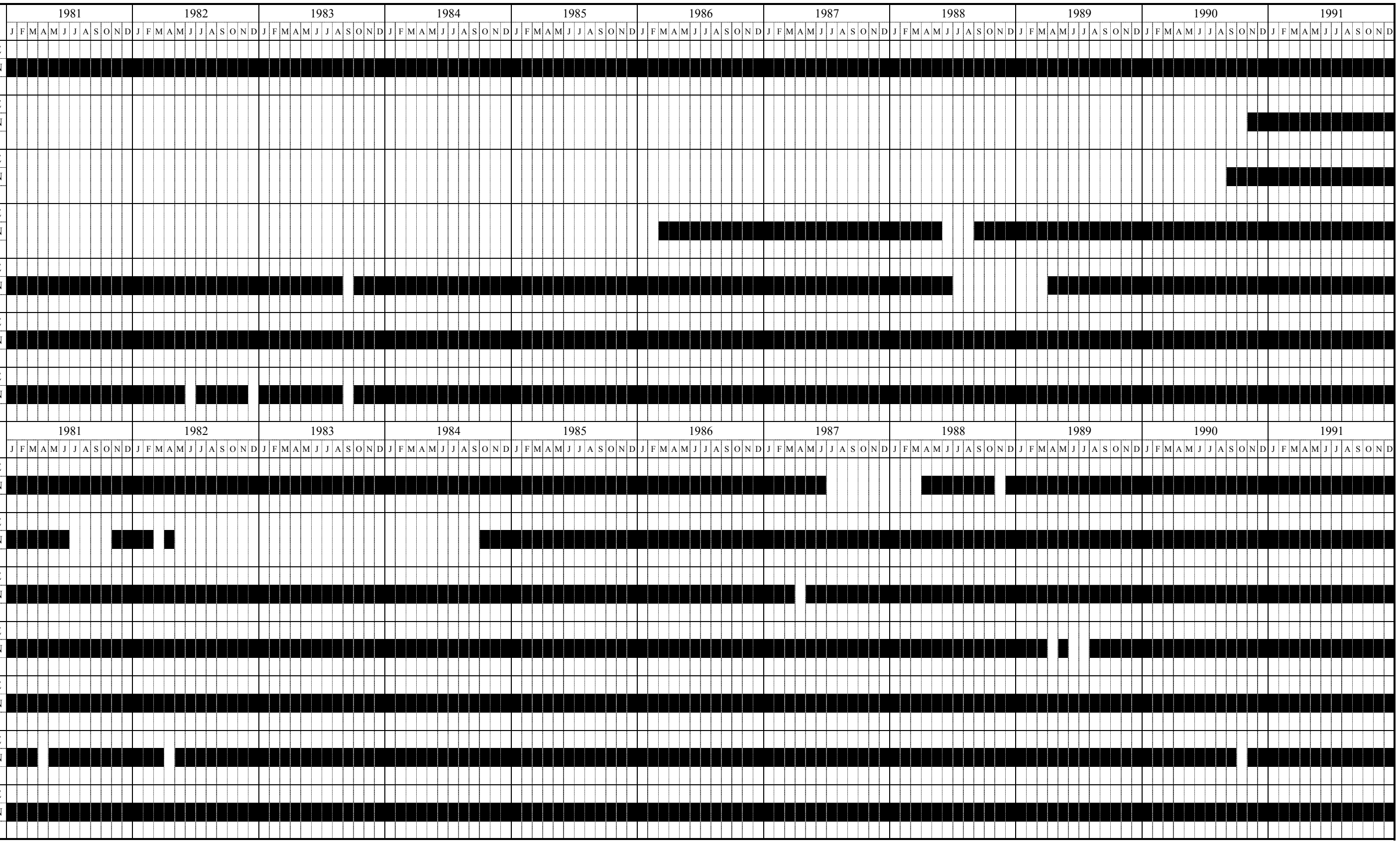

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Figure 2.1.2
Rainfall Gauging Stations and Available Daily Rainfall Data in and around the Study Area (2/3)

No.	Name	Location (m)	
1	Angoda	Lon.	105,659 E
		Lat.	192,254 N
		El.	15.2
2	Bandaragama	Lon.	114,463 E
		Lat.	169,015 N
		El.	-
3	Boralesgamuwa	Lon.	105,000 E
		Lat.	182,000 N
		El.	11.0
4	Dehiwala	Lon.	100,177 E
		Lat.	183,416 N
		El.	-
5	Halgahapitiya	Lon.	125,599 E
		Lat.	225,398 N
		El.	-
6	Hanwella	Lon.	124,000 E
		Lat.	189,500 N
		El.	-
7	Henarathgoda	Lon.	116,750 E
		Lat.	207,250 N
		El.	9.1
8	Horana	Lon.	122,207 E
		Lat.	172,321 N
		El.	30.5
9	Kalutara	Lon.	108,926 E
		Lat.	163,494 N
		El.	3.0
10	Katunayake	Lon.	101,289 E
		Lat.	218,804 N
		El.	8.5
11	Pasyala	Lon.	128,900 E
		Lat.	216,546 N
		El.	-
12	Ratmalana	Lon.	101,216 E
		Lat.	180,097 N
		El.	5.2
13	Vincit	Lon.	138,832 E
		Lat.	208,793 N
		El.	-
14	Colombo	Lon.	100,250 E
		Lat.	189,400 N
		El.	-

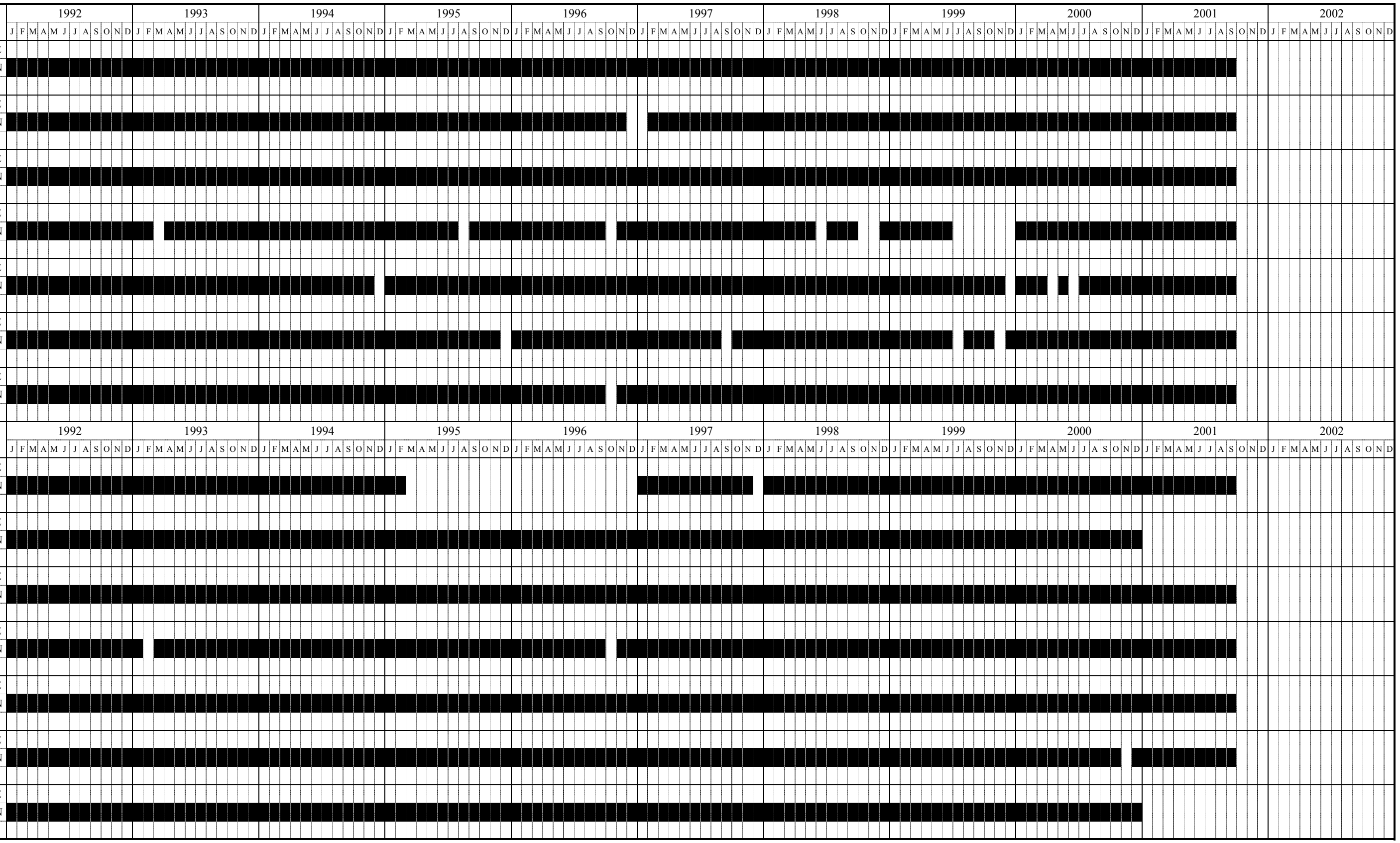

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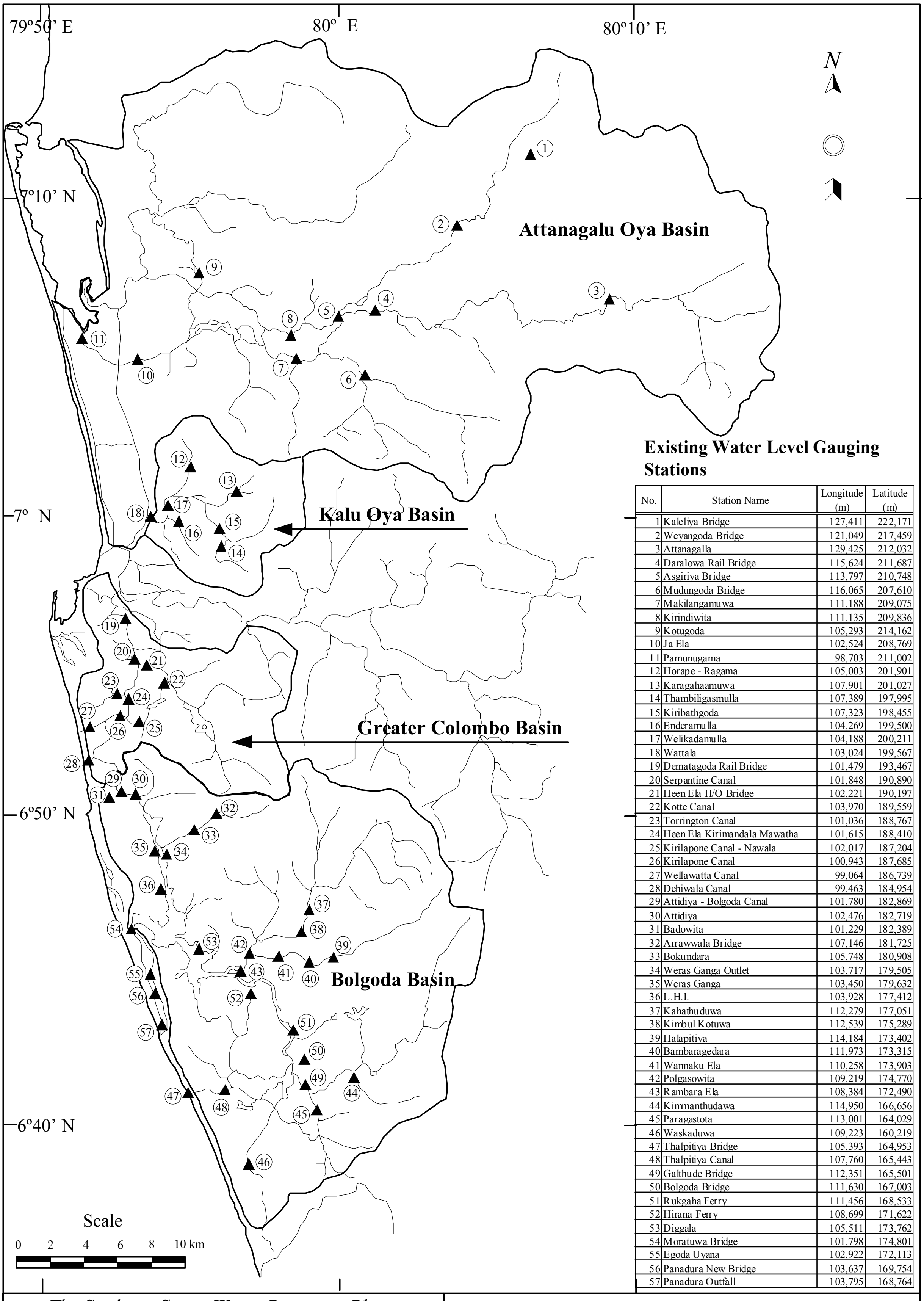
Figure 2.1.2
Rainfall Gauging Stations and Available Daily Rainfall Data in and around the Study Area (3/3)



Existing Water Level Gauging Stations

No.	Station Name	Longitude (m)	Latitude (m)
1	Kaleliya Bridge	127,411	222,171
2	Weyangoda Bridge	121,049	217,459
3	Attanagalla	129,425	212,032
4	Daralowa Rail Bridge	115,624	211,687
5	Asgiriya Bridge	113,797	210,748
6	Mudungoda Bridge	116,065	207,610
7	Makilangamuwa	111,188	209,075
8	Kirindiwita	111,135	209,836
9	Kotugoda	105,293	214,162
10	Ja Ela	102,524	208,769
11	Pamunugama	98,703	211,002
12	Horape - Ragama	105,003	201,901
13	Karagahaamuwa	107,901	201,027
14	Thambiligasmulla	107,389	197,995
15	Kiribathgoda	107,323	198,455
16	Enderamulla	104,269	199,500
17	Welikadamulla	104,188	200,211
18	Wattala	103,024	199,567
19	Dematagoda Rail Bridge	101,479	193,467
20	Serpantine Canal	101,848	190,890
21	Heen Ela H/O Bridge	102,221	190,197
22	Kotte Canal	103,970	189,559
23	Torrington Canal	101,036	188,767
24	Heen Ela Kirimandala Mawatha	101,615	188,410
25	Kirilapone Canal - Nawala	102,017	187,204
26	Kirilapone Canal	100,943	187,685
27	Wellawatta Canal	99,064	186,739
28	Dehiwala Canal	99,463	184,954
29	Attidiya - Bolgoda Canal	101,780	182,869
30	Attidiya	102,476	182,719
31	Badowita	101,229	182,389
32	Arrawwala Bridge	107,146	181,725
33	Bokundara	105,748	180,908
34	Weras Ganga Outlet	103,717	179,505
35	Weras Ganga	103,450	179,632
36	L.H.I.	103,928	177,412
37	Kahathuduwa	112,279	177,051
38	Kimbul Kotuwa	112,539	175,289
39	Halapitiya	114,184	173,402
40	Bambaragedara	111,973	173,315
41	Wannaku Ela	110,258	173,903
42	Polgasowita	109,219	174,770
43	Rambara Ela	108,384	172,490
44	Kimmanthudawa	114,950	166,656
45	Paragastota	113,001	164,029
46	Waskaduwa	109,223	160,219
47	Thalpitiya Bridge	105,393	164,953
48	Thalpitiya Canal	107,760	165,443
49	Galthude Bridge	112,351	165,501
50	Bolgoda Bridge	111,630	167,003
51	Rukgaha Ferry	111,456	168,533
52	Hirana Ferry	108,699	171,622
53	Diggala	105,511	173,762
54	Moratuwa Bridge	101,798	174,801
55	Egoda Uyana	102,922	172,113
56	Panadura New Bridge	103,637	169,754
57	Panadura Outfall	103,795	168,764

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Figure 2.2.1
Location of Water Level Gauging Stations in and around the Objective Drainage Basins

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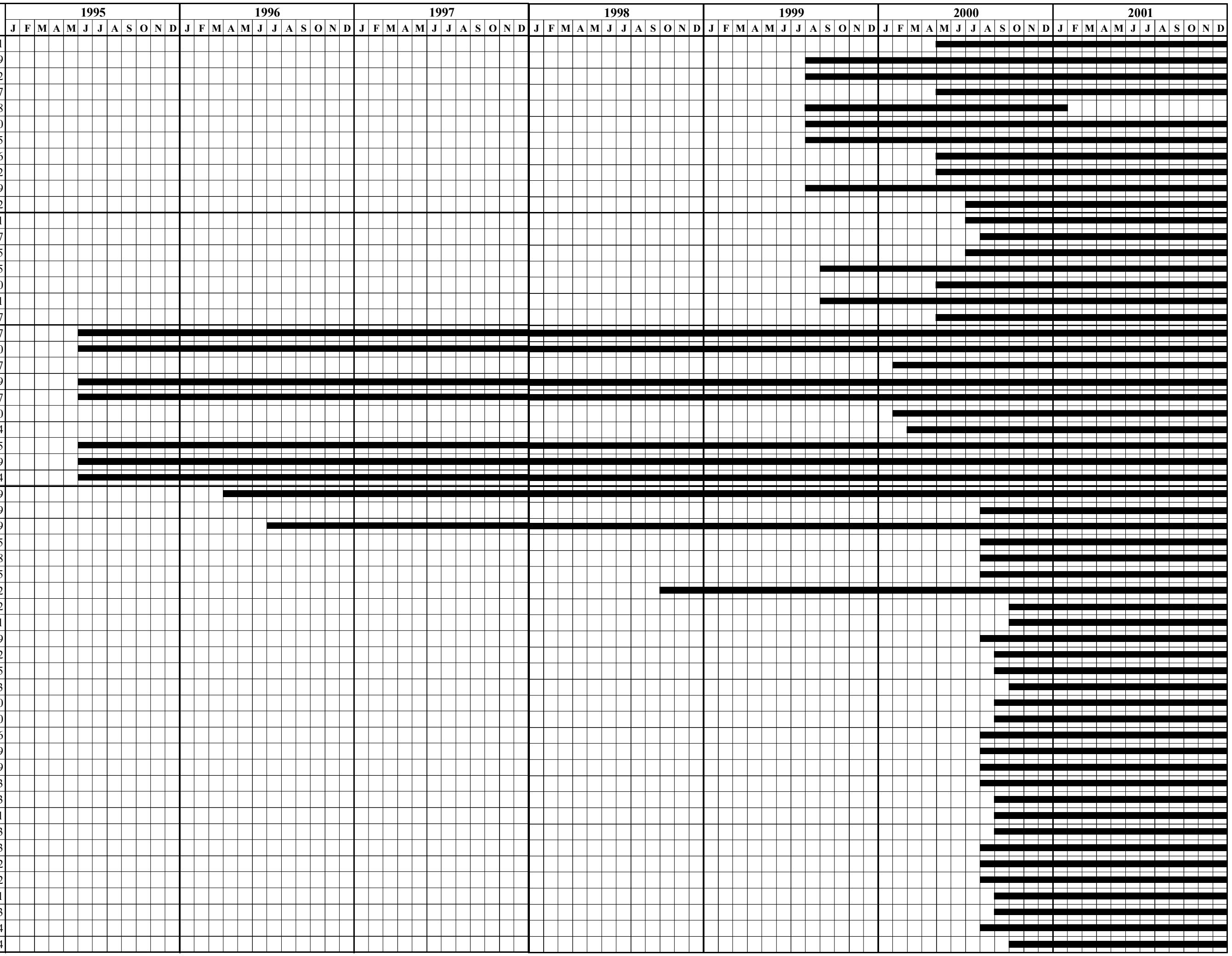
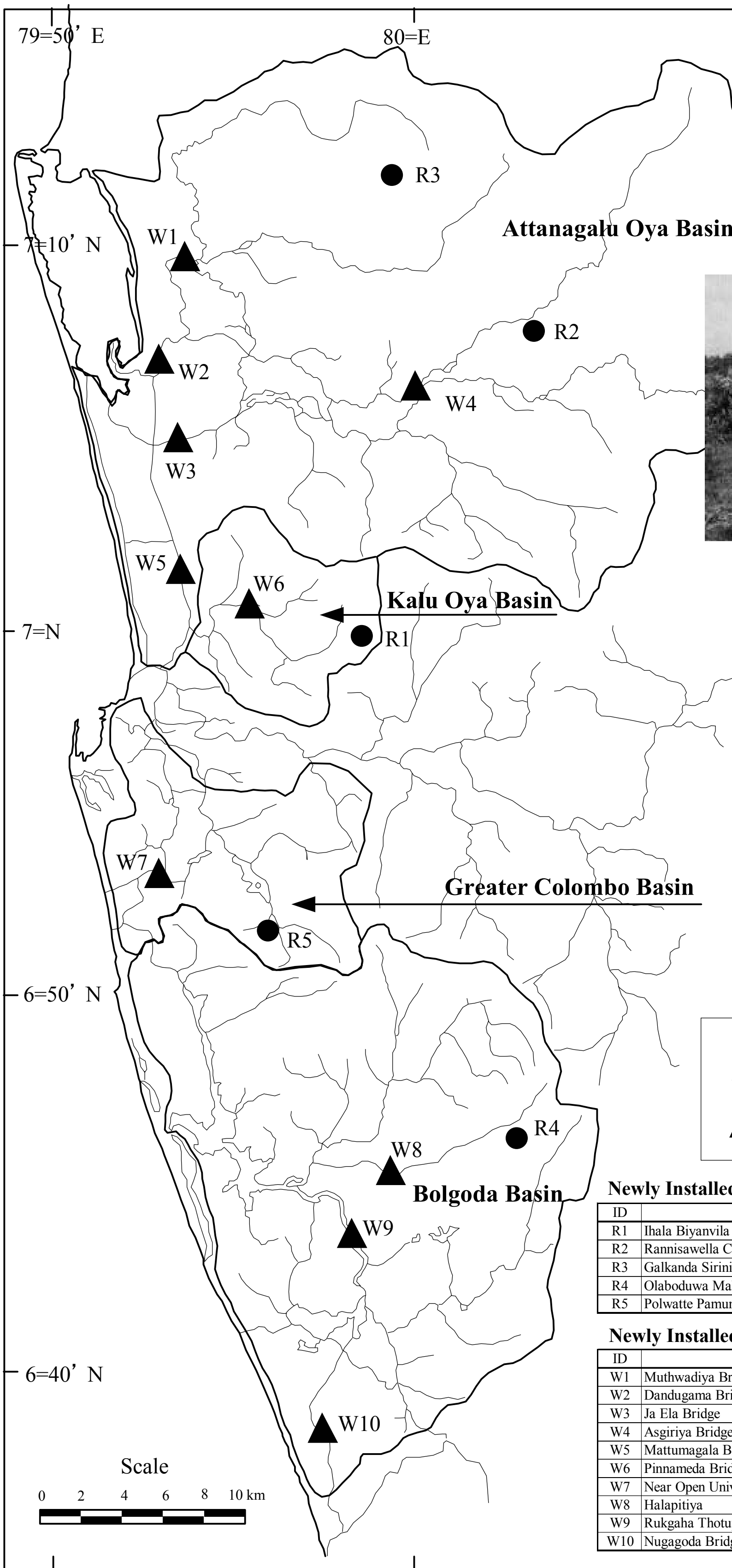
Figure 2.2.2 Water Level Gauging Stations and Available Data in the Study Area

Basin	No.	Station Name	Longitude (m)	Latitude (m)
Attanagalu Oya	1	Kaleliya Bridge	127,411	222,171
	2	Weyangoda Bridge	121,049	217,459
	3	Attanagalla	129,425	212,032
	4	Daralowa Rail Bridge	115,624	211,687
	5	Asgiriya Bridge	113,797	210,748
	6	Mudungoda Bridge	116,065	207,610
	7	Makilangamuwa	111,188	209,075
	8	Kirindiwita	111,135	209,836
	9	Kotugoda	105,293	214,162
	10	Ja Ela	102,524	208,769
	11	Pamunugama	98,703	211,002
Kalu Oya	12	Horape - Ragama	105,003	201,901
	13	Karagahaamuwa	107,901	201,027
	14	Thambiligasmulla	107,389	197,995
	15	Kiribathgoda	107,323	198,455
	16	Enderamulla	104,269	199,500
	17	Welikadamulla	104,188	200,211
	18	Wattala	103,024	199,567
Greater Colombo	19	Dematagoda Rail Bridge	101,479	193,467
	20	Serpantine Canal	101,848	190,890
	21	Heen Ela H/O Bridge	102,221	190,197
	22	Kotte Canal	103,970	189,559
	23	Torrington Canal	101,036	188,767
	24	Heen Ela Kirimandala Mawatha	101,615	188,410
	25	Kirilapone Canal - Nawala	102,017	187,204
	26	Kirilapone Canal	100,943	187,685
	27	Wellawatta Canal	99,064	186,739
	28	Dehiwala Canal	99,463	184,954
Bolgoda	29	Attidiya - Bolgoda Canal	101,780	182,869
	30	Attidiya	102,476	182,719
	31	Badowita	101,229	182,389
	32	Arrawwala Bridge	107,146	181,725
	33	Bokundara	105,748	180,908
	34	Weras Ganga Outlet	103,717	179,505
	35	Weras Ganga	103,450	179,632
	36	L.H.I.	103,928	177,412
	37	Kahathuduwa	112,279	177,051
	38	Kimbul Kotuwa	112,539	175,289
	39	Halapitiya	114,184	173,402
	40	Bambaragedara	111,973	173,315
	41	Wannaku Ela	110,258	173,903
	42	Polgasowita	109,219	174,770
	43	Rambara Ela	108,384	172,490
	44	Kimmanthudawa	114,950	166,656
	45	Paragastota	113,001	164,029
	46	Waskaduwa	109,223	160,219
	47	Thalpitiya Bridge	105,393	164,953
	48	Thalpitiya Canal	107,760	165,443
	49	Galthude Bridge	112,351	165,501
	50	Bolgoda Bridge	111,630	167,003
	51	Rukgaha Ferry	111,456	168,533
	52	Hirana Ferry	108,699	171,622
	53	Diggala	105,511	173,762
	54	Moratuwa Bridge	101,798	174,801
	55	Egoda Uyana	102,922	172,113
	56	Panadura New Bridge	103,637	169,754
	57	Panadura Outfall	103,795	168,764





Rainfall Gauging Station

Water Level Gauging Station

Newly Installed Rainfall Gauging Stations

ID	Location	Logitude (m)	Latitude (m)
R1	Ihala Biyanvila Premananda Maha Vidyalaya	111,085	199,683
R2	Rannisawella Cemetery	119,192	213,743
R3	Galkanda Sirinikenthane Piruven Viharaya	112,766	220,868
R4	Olaboduwa Maha Vidyalaya	118,783	174,783
R5	Polwatte Pamunuwa Maha Vidyalaya	107,329	184,500

Newly Installed Water Level Gauging Stations

ID	Location	Logitude (m)	Latitude (m)
W1	Muthwadiya Bridge	102,908	217,955
W2	Dandugama Bridge	101,577	212,281
W3	Ja Ela Bridge	102,404	208,886
W4	Asgiriya Bridge	113,654	210,845
W5	Mattumagala Bridge	102,237	202,176
W6	Pinnameda Bridge	105,836	200,557
W7	Near Open University	101,335	187,685
W8	Halapitiya	112,347	172,928
W9	Rukgaha Thotupala	110,767	169,482
W10	Nugagoda Bridge	109,294	160,110

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

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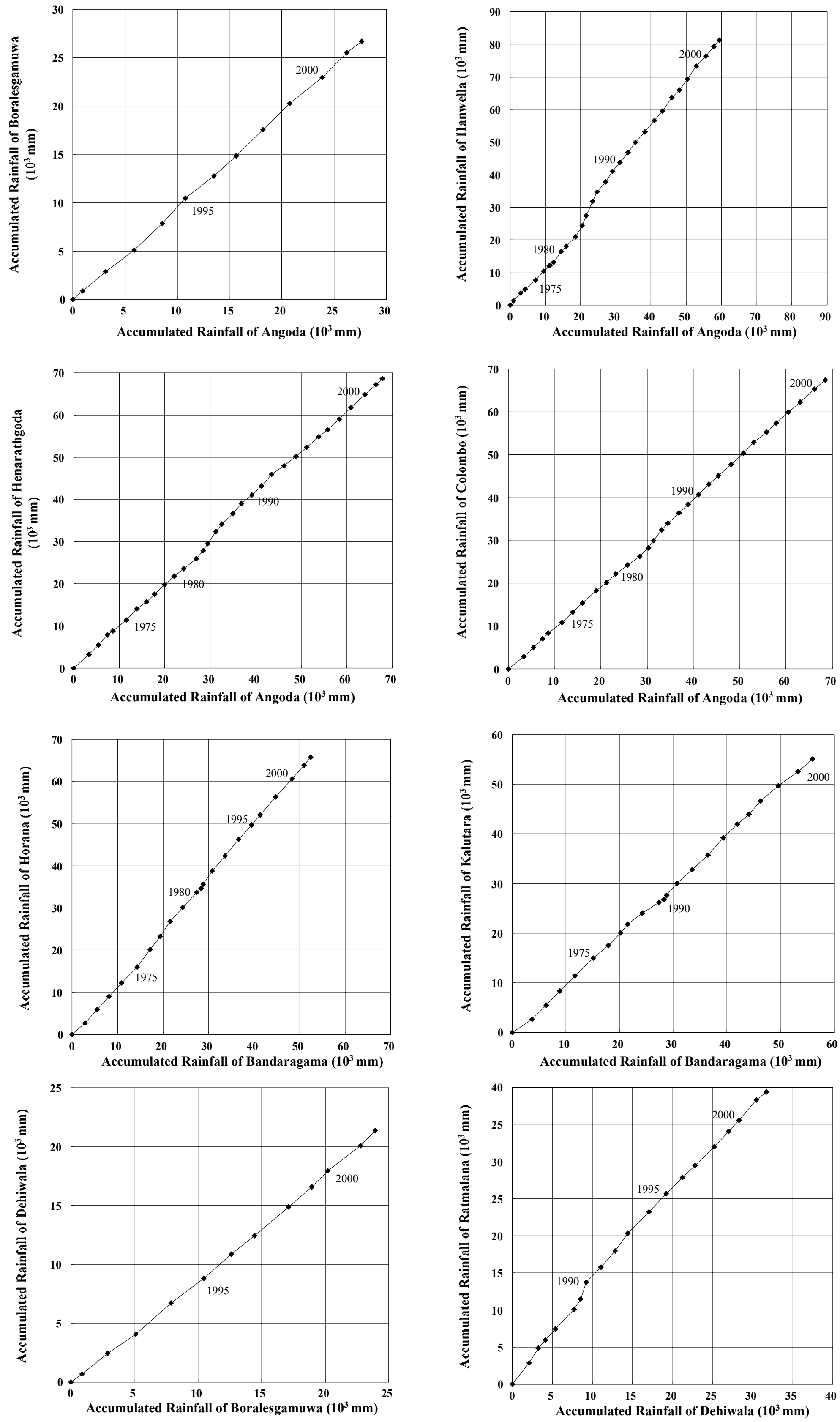
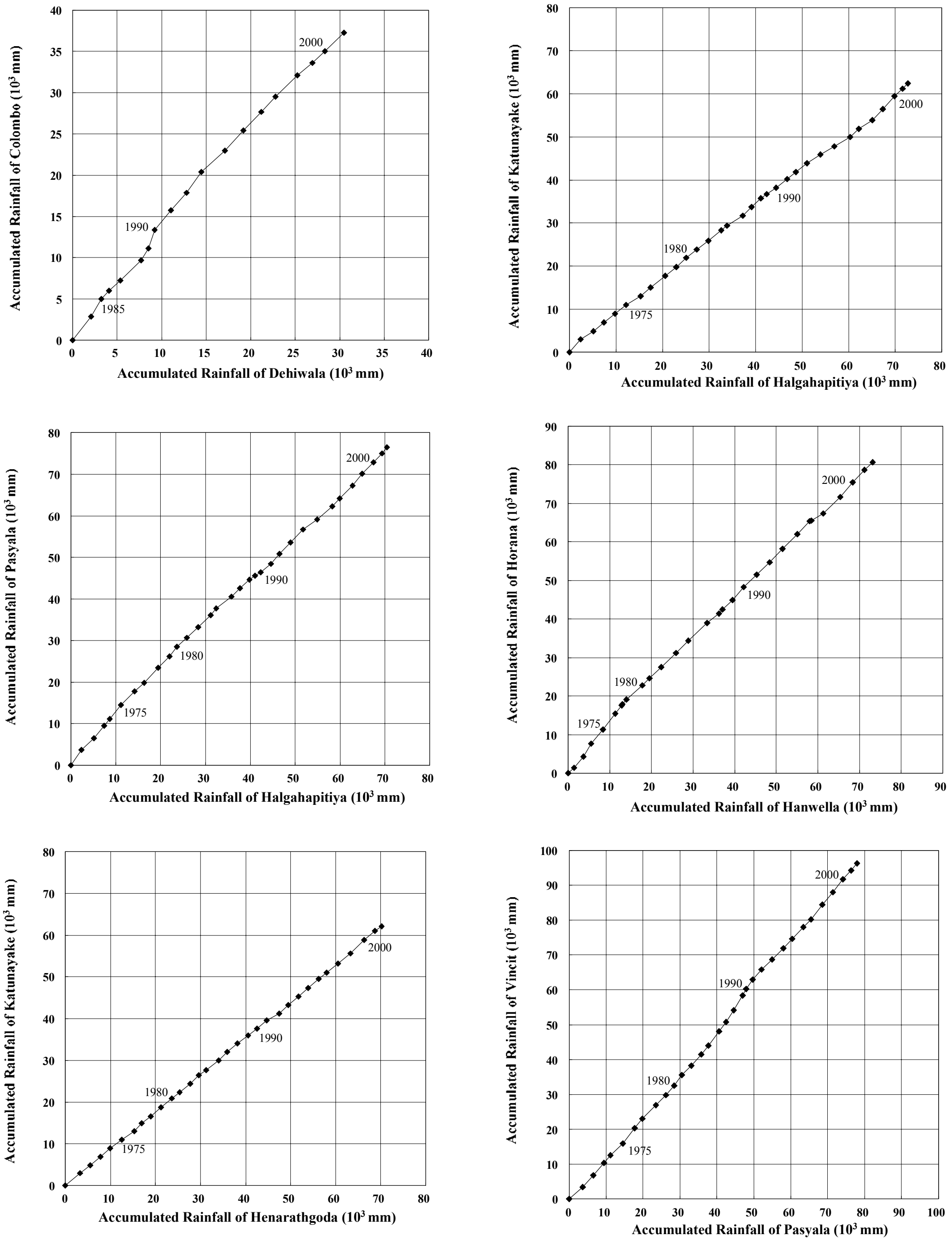
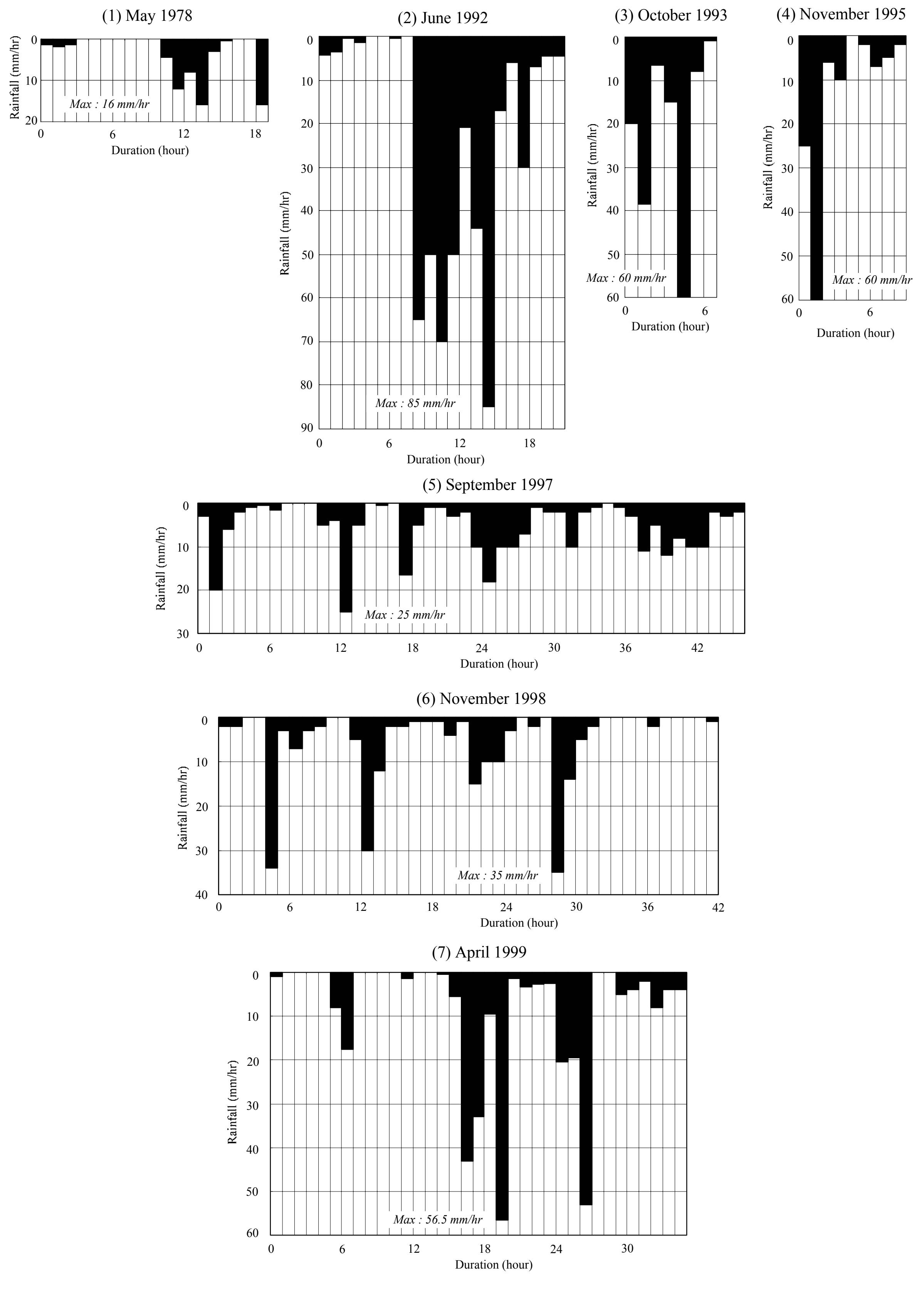
Figure 2.3.1
Location of Newly Installed Rainfall and Water Level Gauging Stations



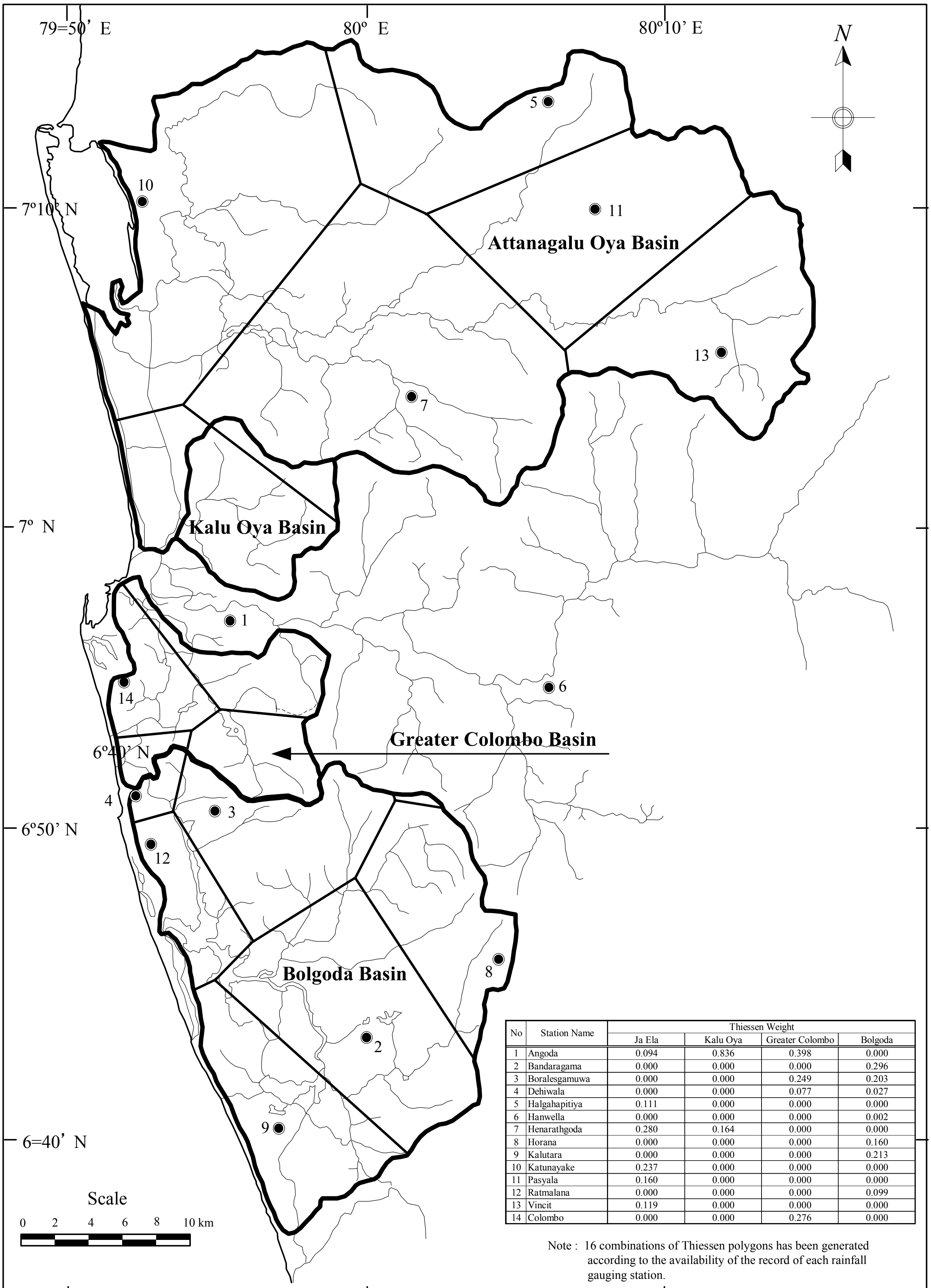
The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 3.1.1 Double Mass Curves of Daily Rainfall Records (1/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 3.1.1 Double Mass Curves of Daily Rainfall Records (2/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.2.1 Storm Record at Colombo Rainfall Gauging Station



No	Station Name	Thiessen Weight			
		Ja Ela	Kalu Oya	Greater Colombo	Bolgoda
1	Angoda	0.094	0.836	0.398	0.000
2	Bandaragama	0.000	0.000	0.000	0.296
3	Boralesgamuwa	0.000	0.000	0.249	0.203
4	Dehiwala	0.000	0.000	0.077	0.027
5	Halgahapitiya	0.111	0.000	0.000	0.000
6	Hanwella	0.000	0.000	0.000	0.002
7	Henarathgoda	0.280	0.164	0.000	0.000
8	Horana	0.000	0.000	0.000	0.160
9	Kalutara	0.000	0.000	0.000	0.213
10	Katunayake	0.237	0.000	0.000	0.000
11	Pasyala	0.160	0.000	0.000	0.000
12	Ratmalana	0.000	0.000	0.000	0.099
13	Vincit	0.119	0.000	0.000	0.000
14	Colombo	0.000	0.000	0.276	0.000

Note : 16 combinations of Thiessen polygons has been generated according to the availability of the record of each rainfall gauging station.

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

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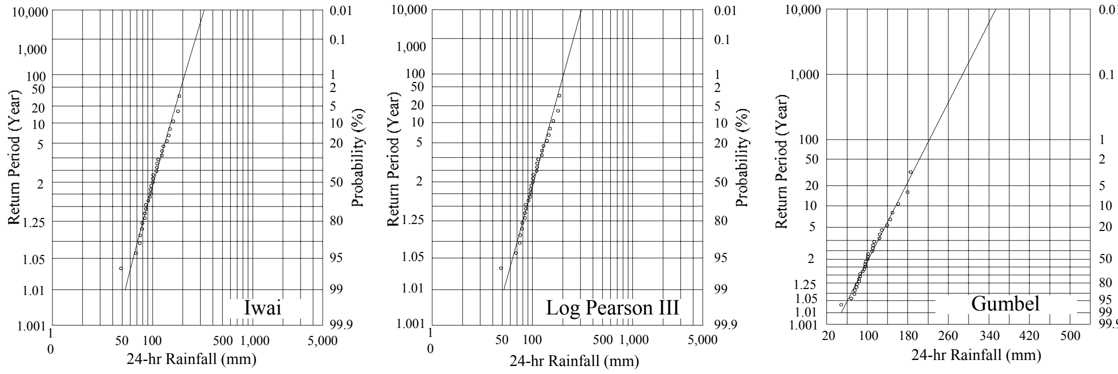
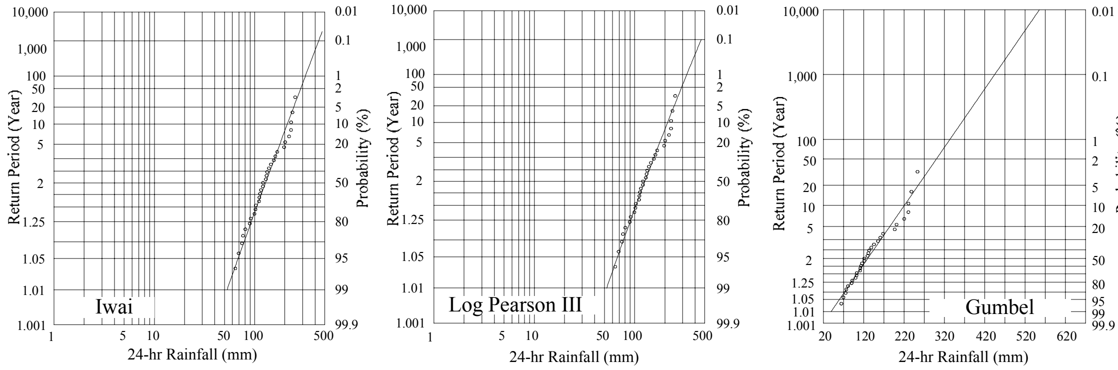
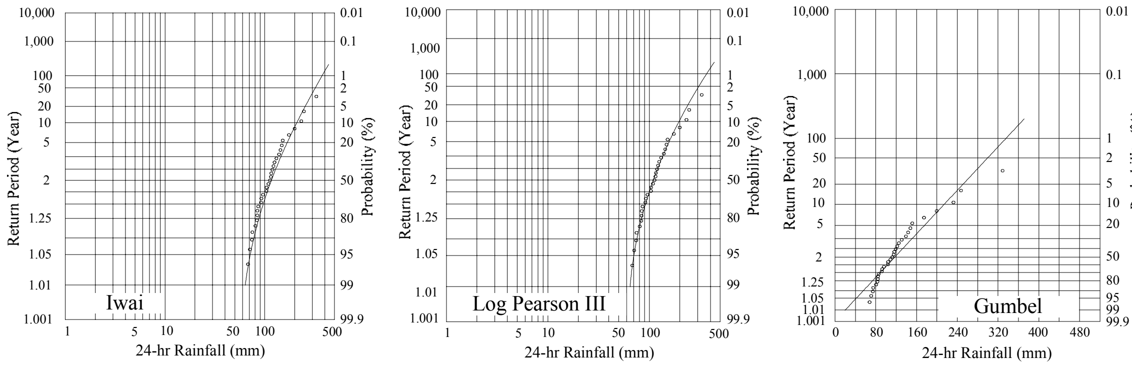
Figure 3.3.1
Thiessen Polygons for Four Objective Drainage Basins



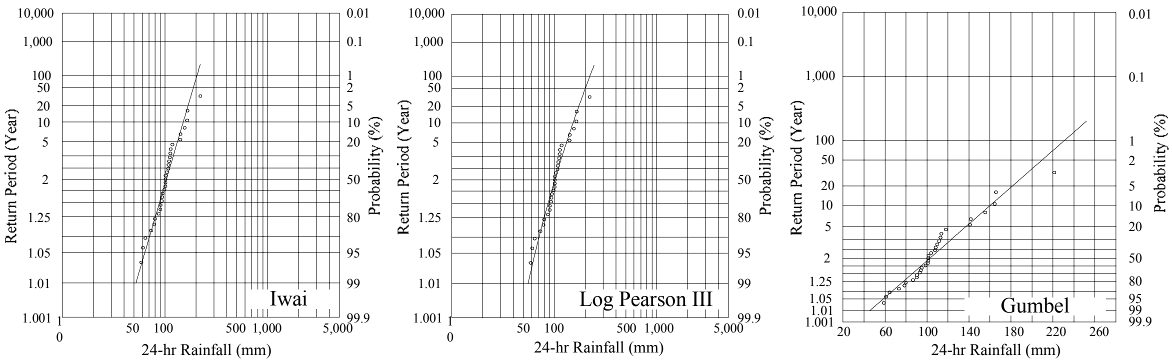
(1) Attanagalu Oya Basin



(2) Kalu Oya Basin

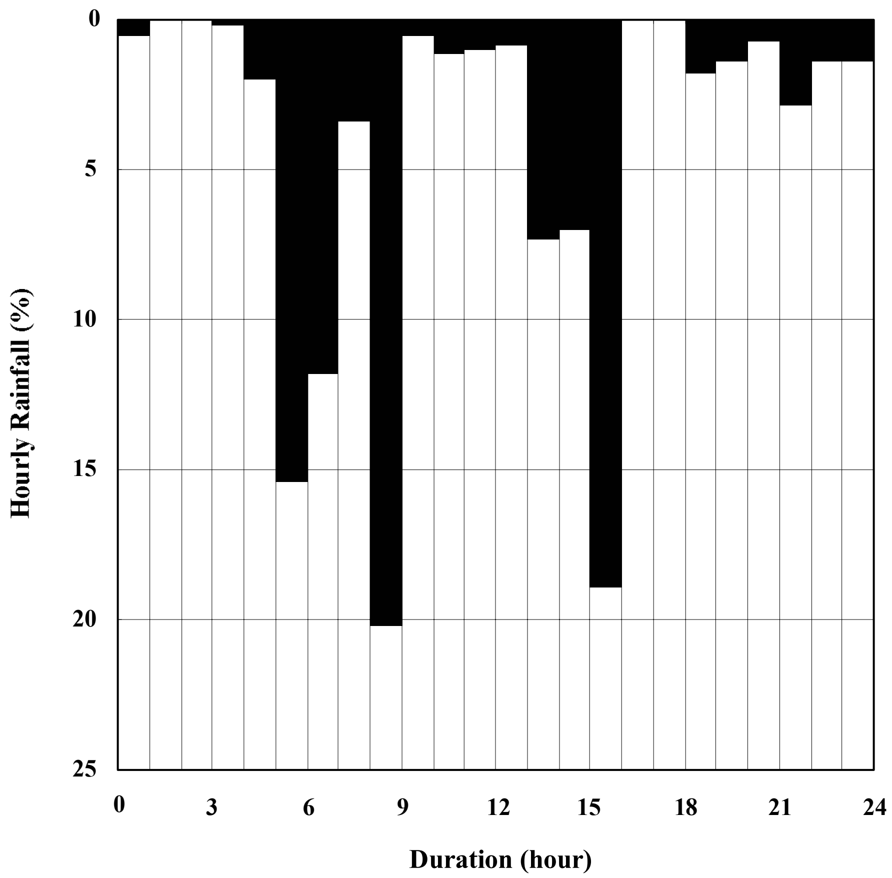


(3) Greater Colombo Basin



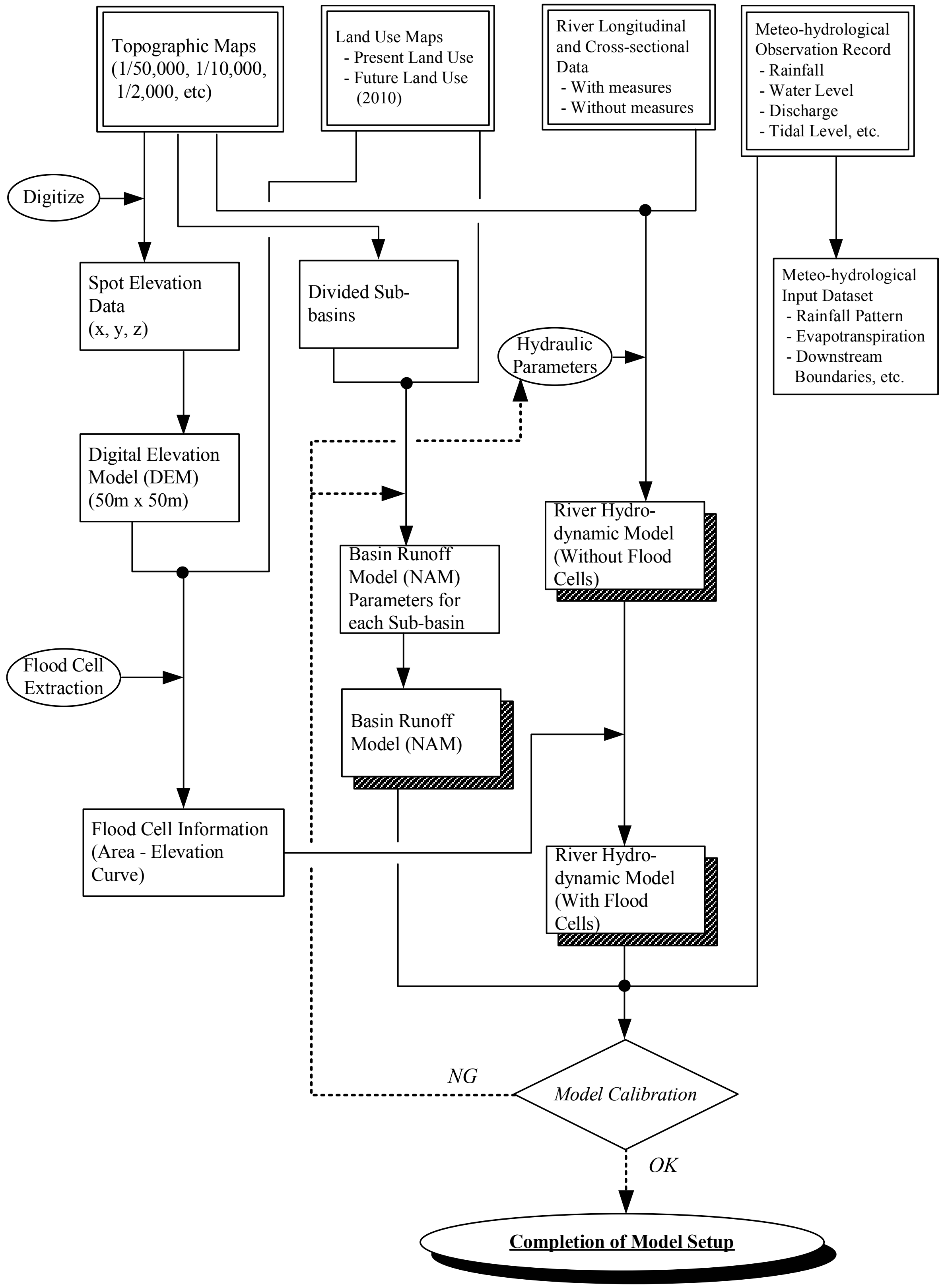
(4) Bolgoda Basin

The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 3.3.2 Results of Extreme Value Analysis on Annual Daily Maximum Basin Average Rainfall
JAPAN INTERNATIONAL COOPERATION AGENCY	

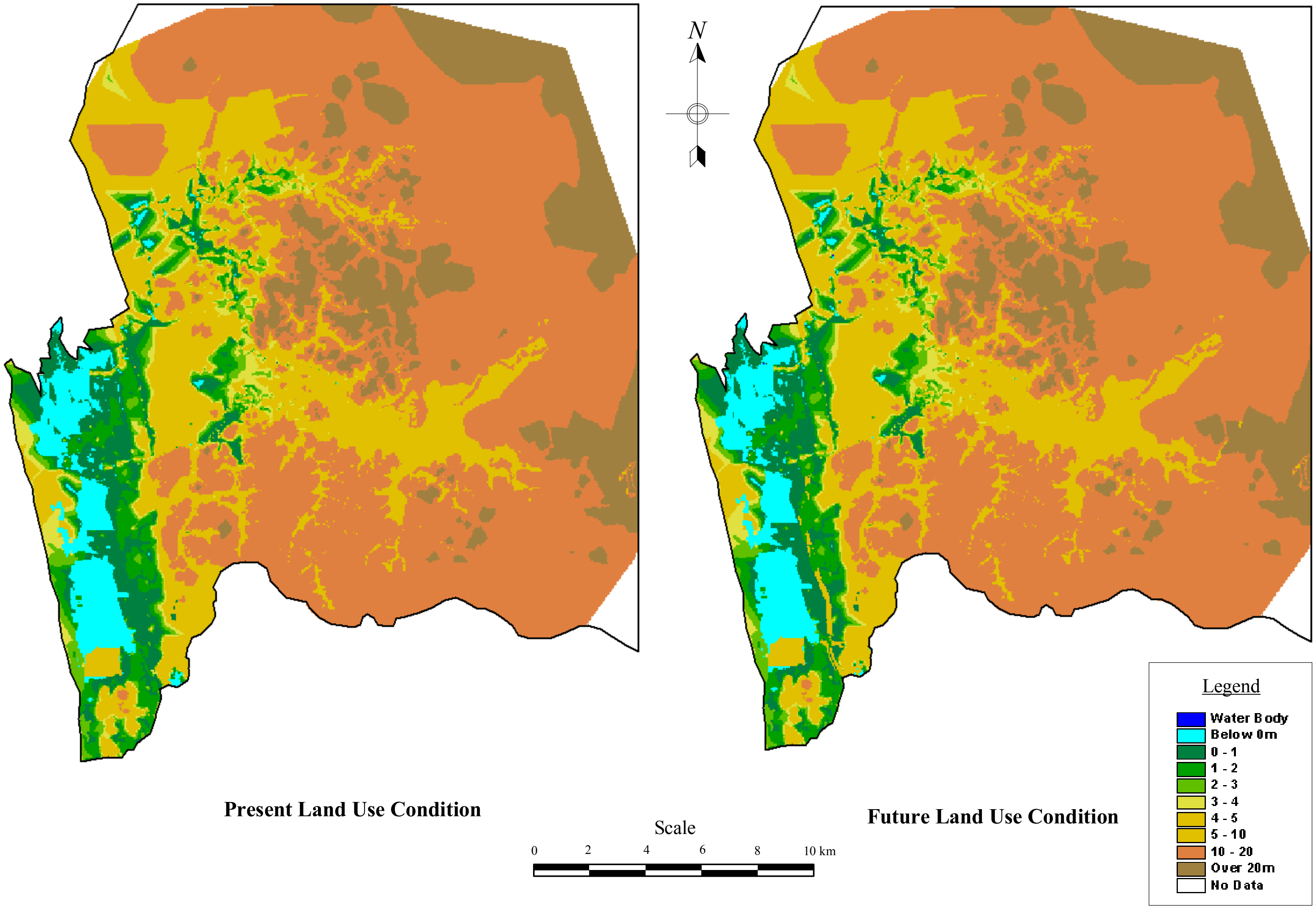


Duration (hr)	Rainfall (%)	Duration (hr)	Rainfall (%)
1	0.54	13	0.89
2	0.00	14	7.33
3	0.00	15	6.98
4	0.18	16	18.96
5	1.97	17	0.00
6	15.38	18	0.00
7	11.81	19	1.79
8	3.40	20	1.43
9	20.21	21	0.72
10	0.54	22	2.86
11	1.16	23	1.43
12	0.98	24	1.43

Figure 3.3.3
Design Storm Rainfall Pattern



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 4.1.1
JAPAN INTERNATIONAL COOPERATION AGENCY	General Workflow of Flood Runoff and Inundation Model Setup



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

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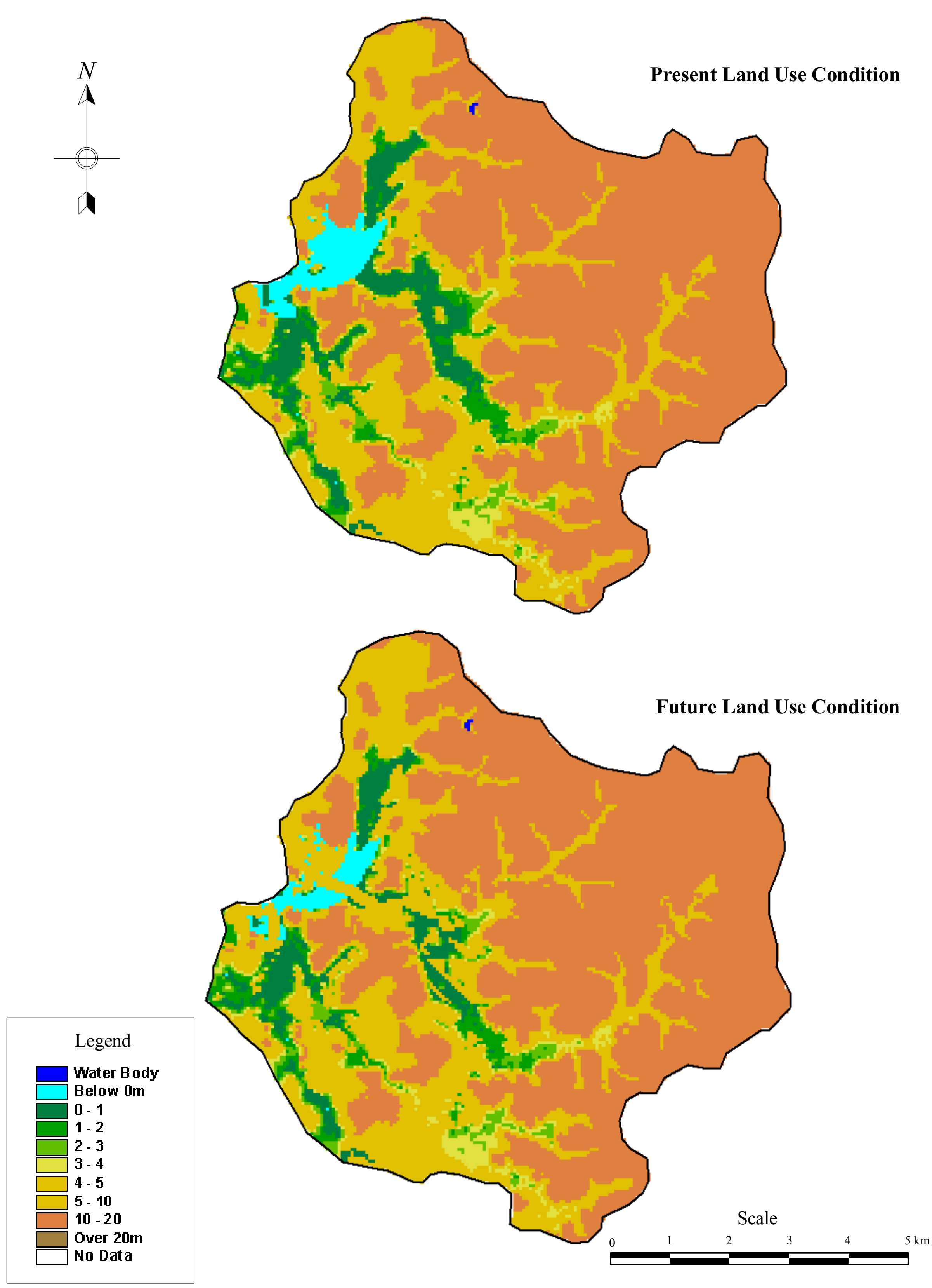
Figure 4.3.1
Generated DEM of Attanagalu Oya Basin (Lower Basin Only)



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 4.3.2 Generated DEM of Kalu Oya Basin
JAPAN INTERNATIONAL COOPERATION AGENCY	

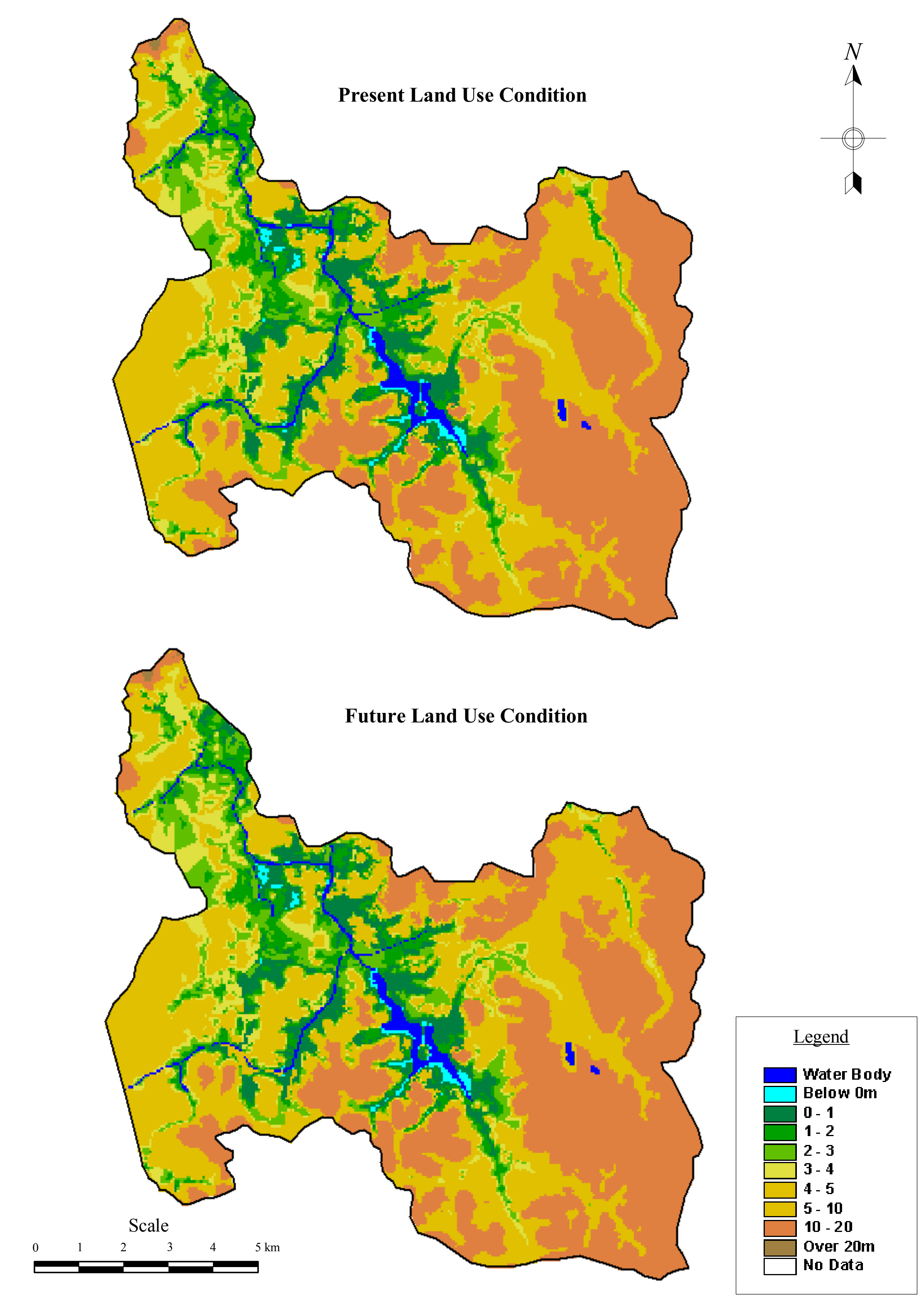


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Figure 4.3.3
Generated DEM of Greater Colombo Basin

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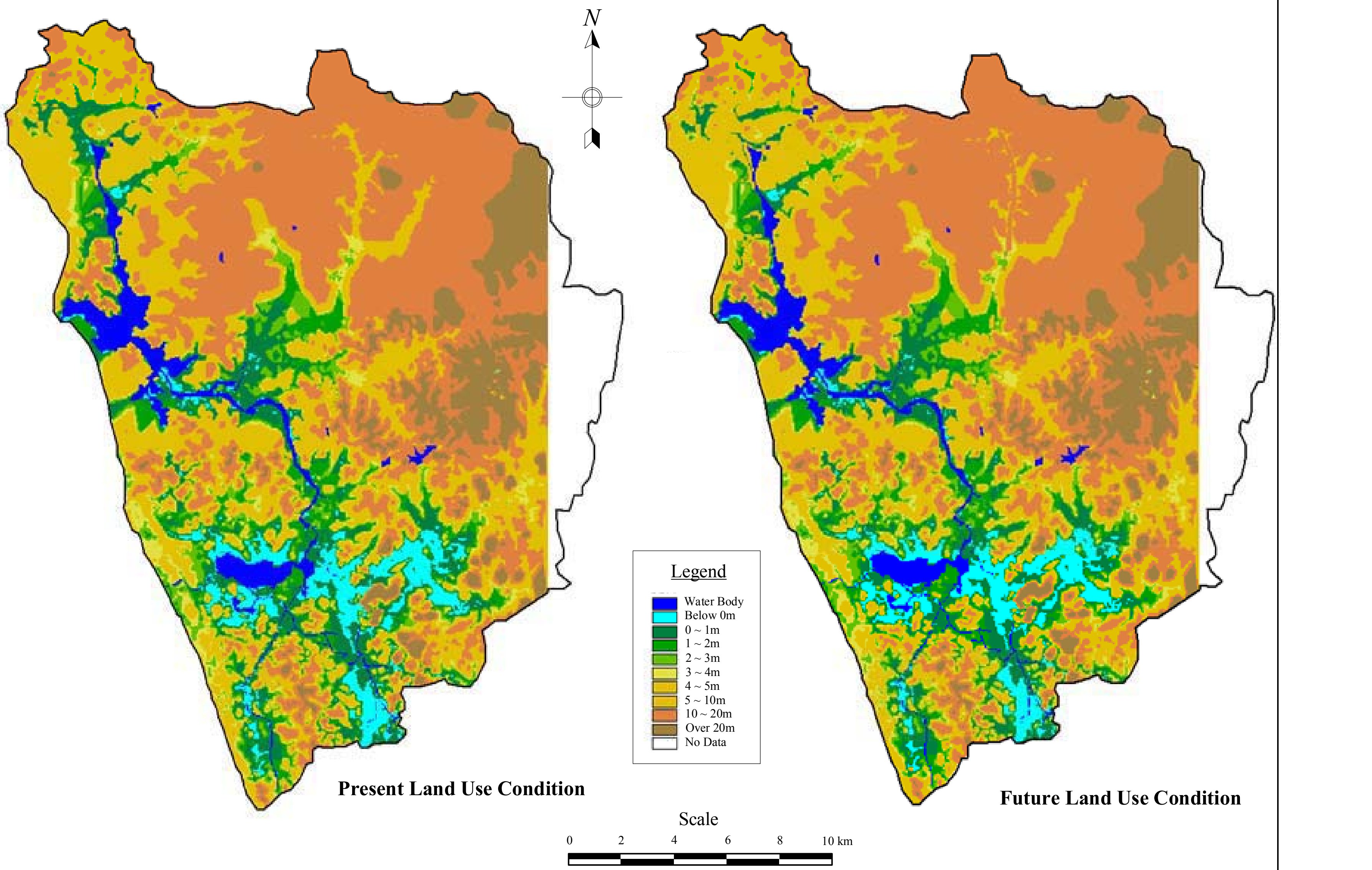
Figure 4.3.4

Generated DEM of Bolgoda Basin



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

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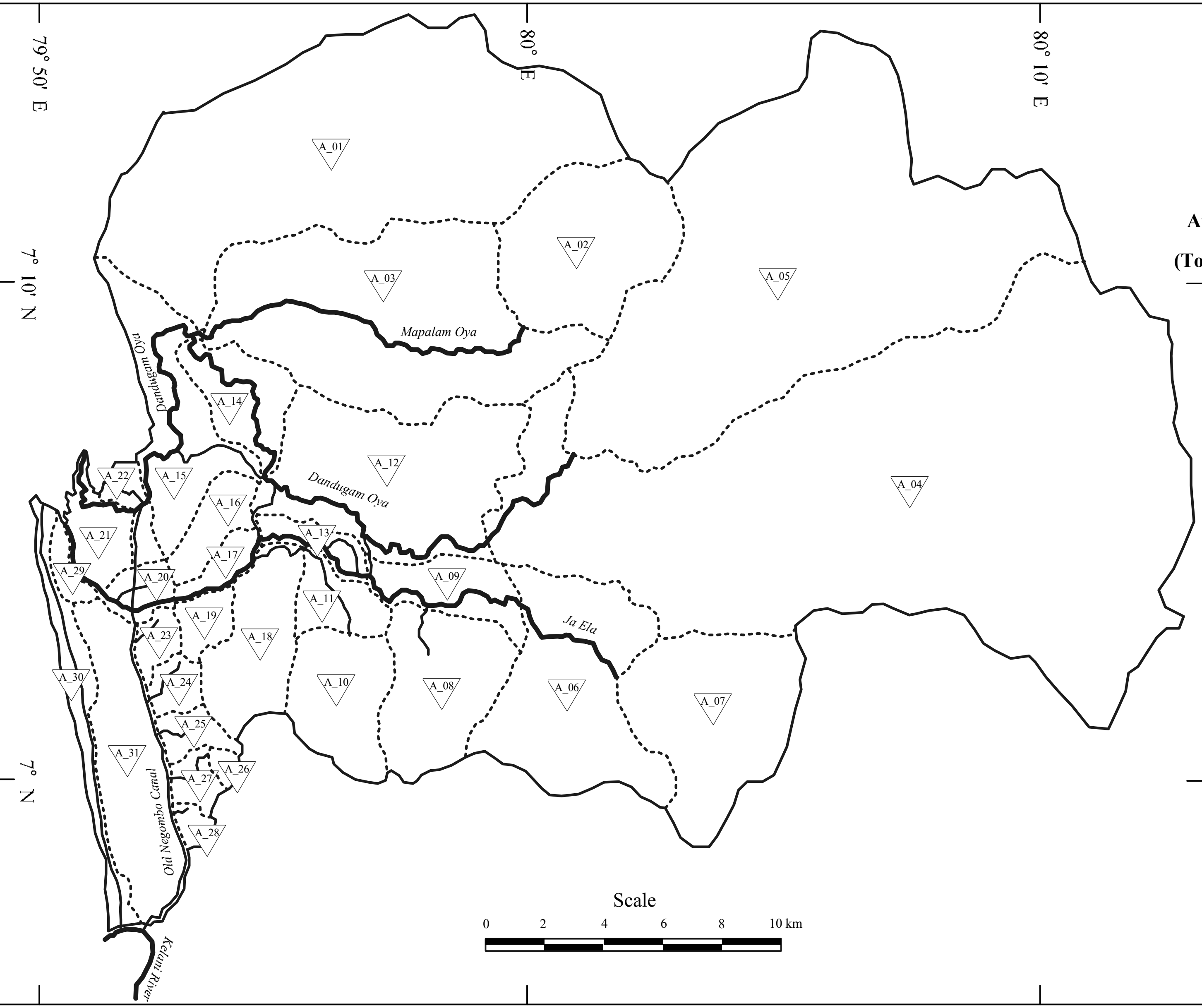
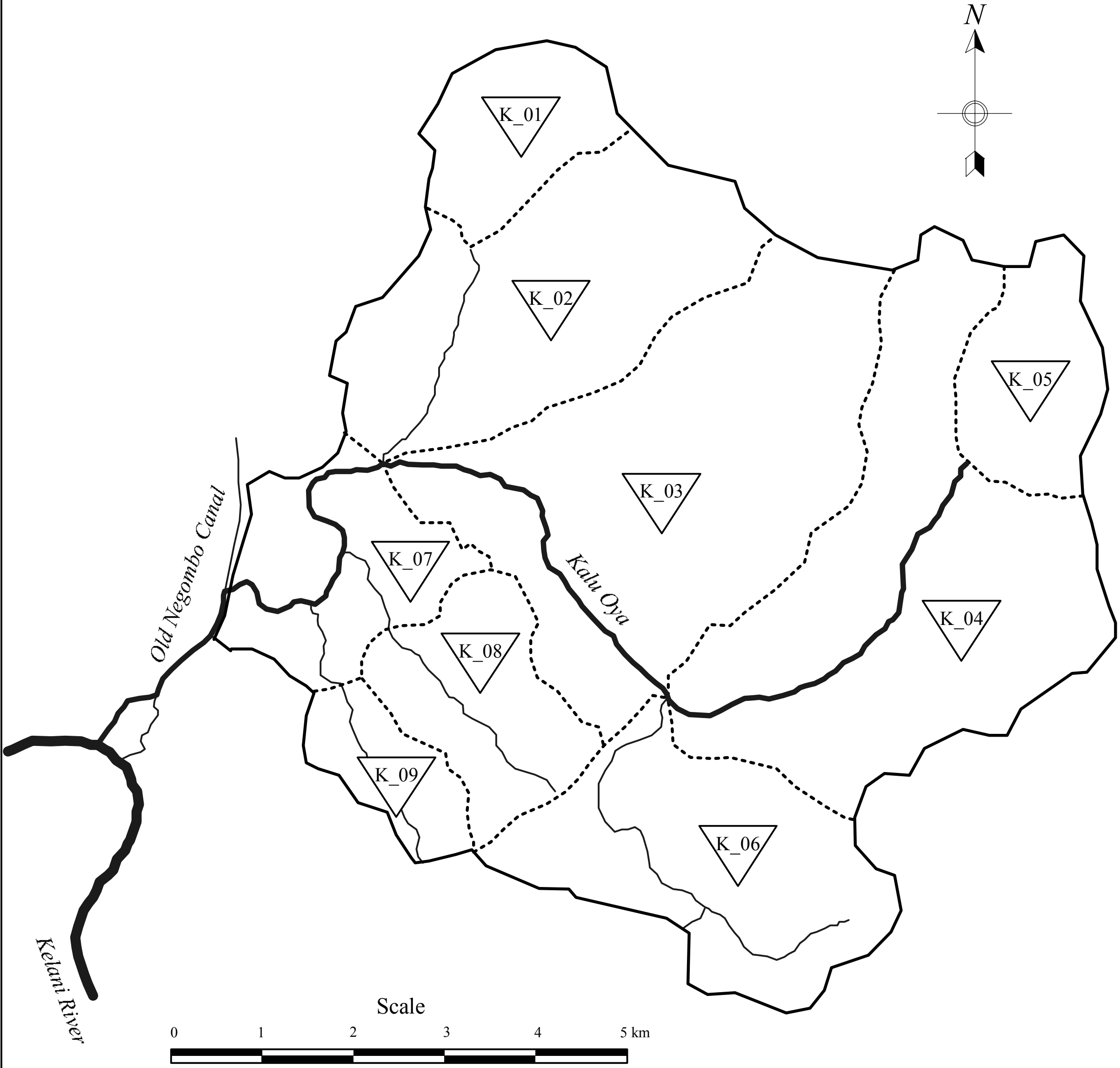
Figure 4.4.1 Channel Network and Basin Division of Attanagalu Oya Basin



Attanagalu Oya Sub-catchments (Total Area : 860.6 km²)

Sub-basin ID	Area (km²)
A_01	107.0
A_02	27.0
A_03	54.0
A_04	224.0
A_05	150.0
A_06	34.8
A_07	40.2
A_08	20.0
A_09	9.0
A_10	14.9
A_11	9.1
A_12	41.0
A_13	9.0
A_14	10.0
A_15	22.0
A_16	5.7
A_17	3.3
A_18	15.0
A_19	4.0
A_20	1.4
A_21	6.0
A_22	2.8
A_23	2.8
A_24	3.3
A_25	2.3
A_26	1.7
A_27	3.7
A_28	1.6
A_29	3.0
A_30	12.0
A_31	20.0



Kalu Oya Sub-catchments (Total Area : 57.6 km^2)

Sub-basin ID	Area (km^2)	Sub-basin ID	Area (km^2)
K_01	2.8	K_06	7.3
K_02	8.5	K_07	4.2
K_03	13.4	K_08	3.8
K_04	12.8	K_09	1.7
K_05	3.1		

The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 4.4.2 Channel Network and Basin Division of Kalu Oya Basin

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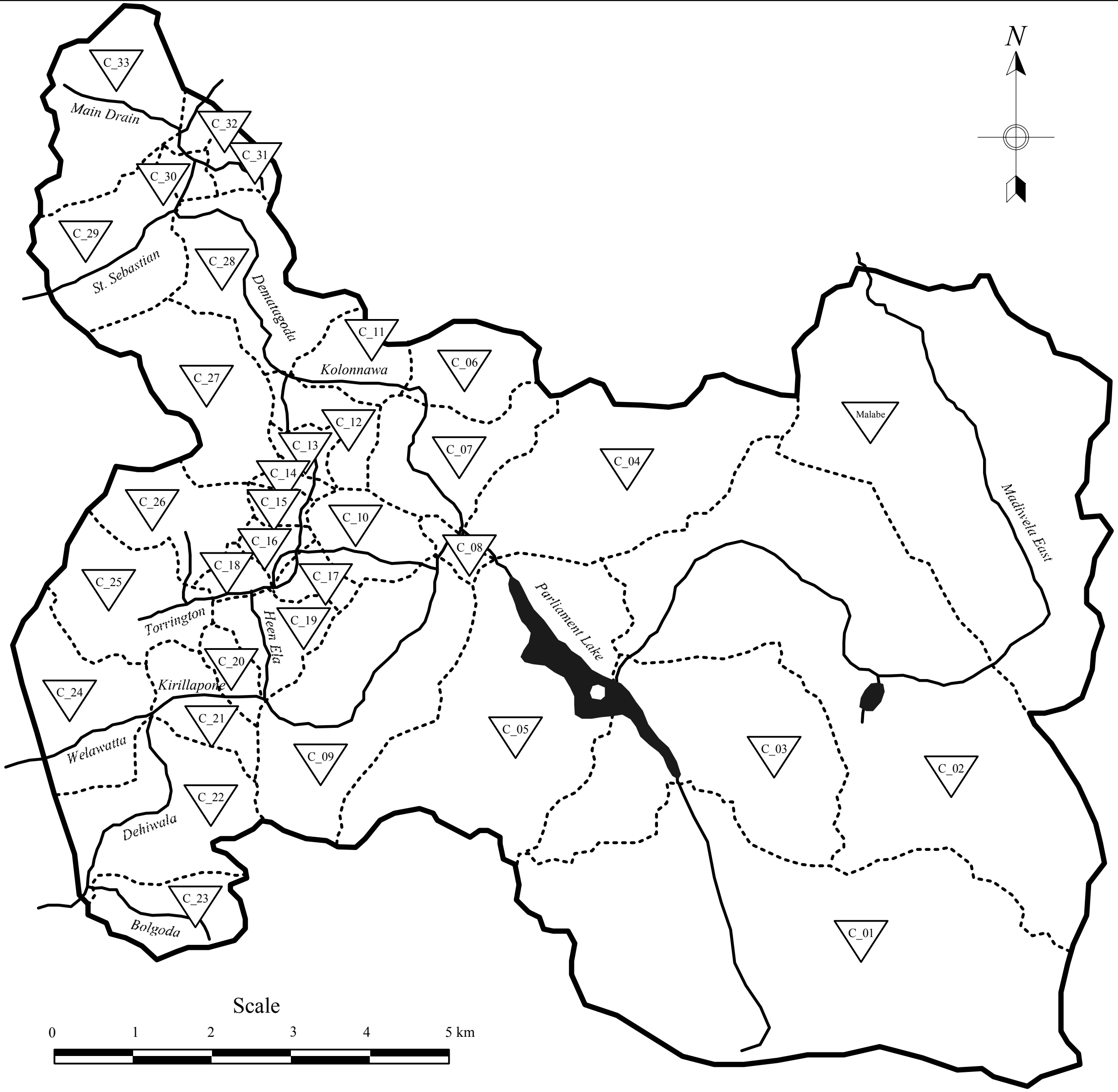
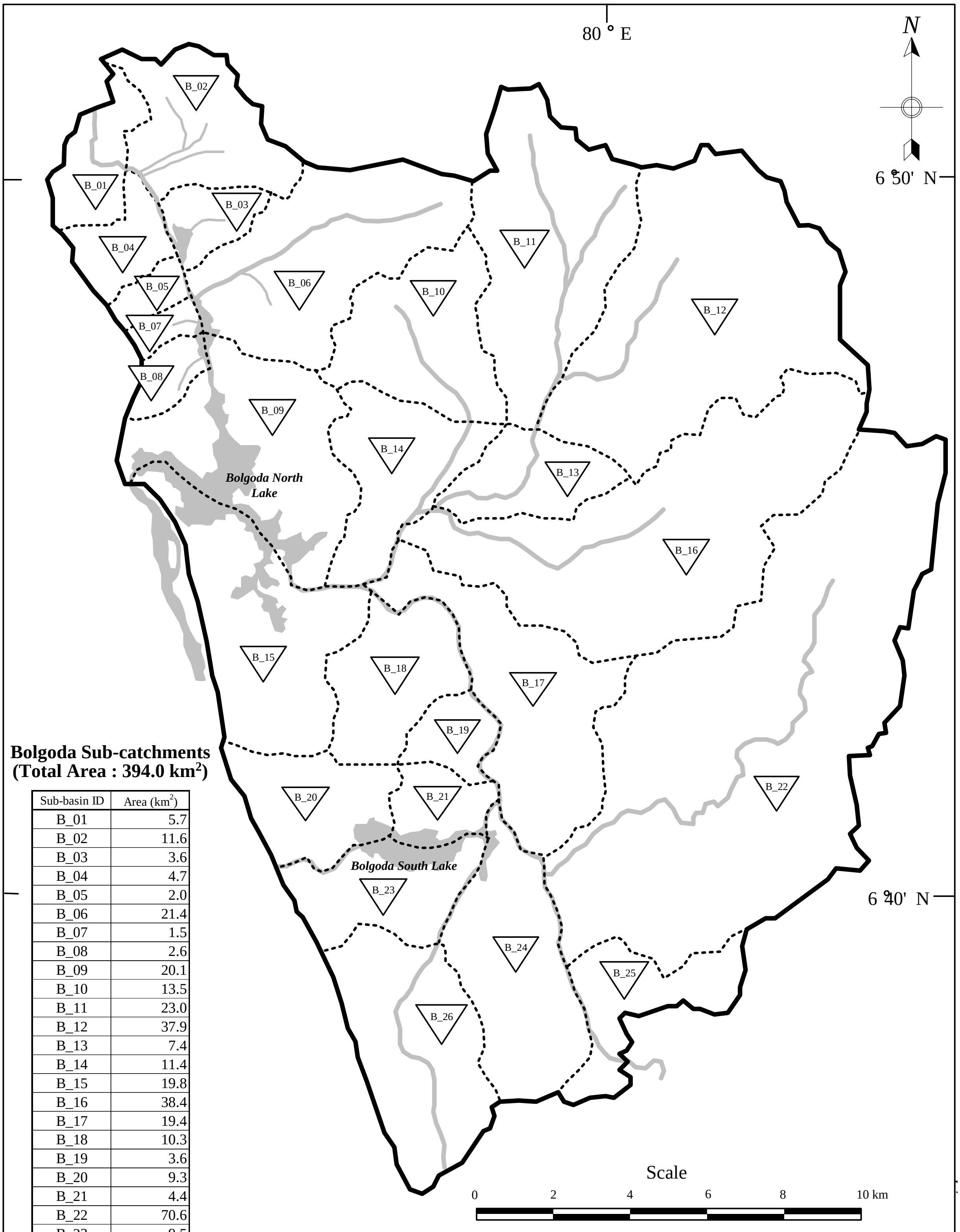
Figure 4.4.3
Channel Network and Basin Division of Greater Colombo Basin



Greater Colombo Sub-catchments (Total Area : 98.5 km²)

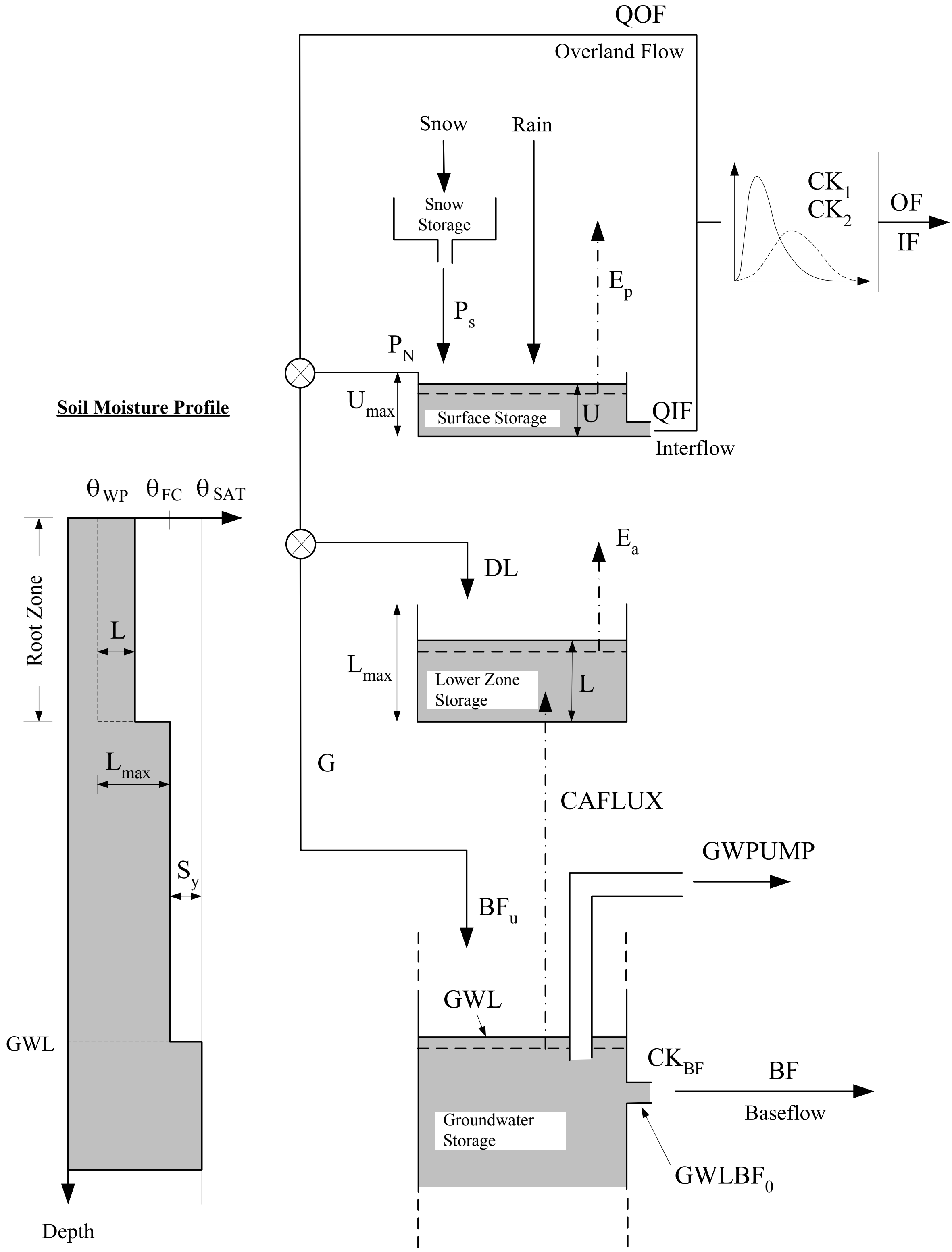
Sub-basin ID	Area (km^2)
C_01	14.48
C_02	15.56
C_03	5.57
C_04	5.59
C_05	6.68
C_06	1.48
C_07	2.18
C_08	0.30
C_09	4.44
C_10	1.22
C_11	0.97
C_12	0.84
C_13	0.46
C_14	0.28
C_15	0.32
C_16	0.35
C_17	0.59
C_18	0.33
C_19	0.93
C_20	0.27
C_21	1.00
C_22	3.17
C_23	1.19
C_24	2.09
C_25	2.06
C_26	1.60
C_27	2.99
C_28	2.49
C_29	2.91
C_30	0.31
C_31	0.49
C_32	0.35
C_33	2.30
MALABE	12.75



Bolgoda Sub-catchments (Total Area : 394.0 km²)

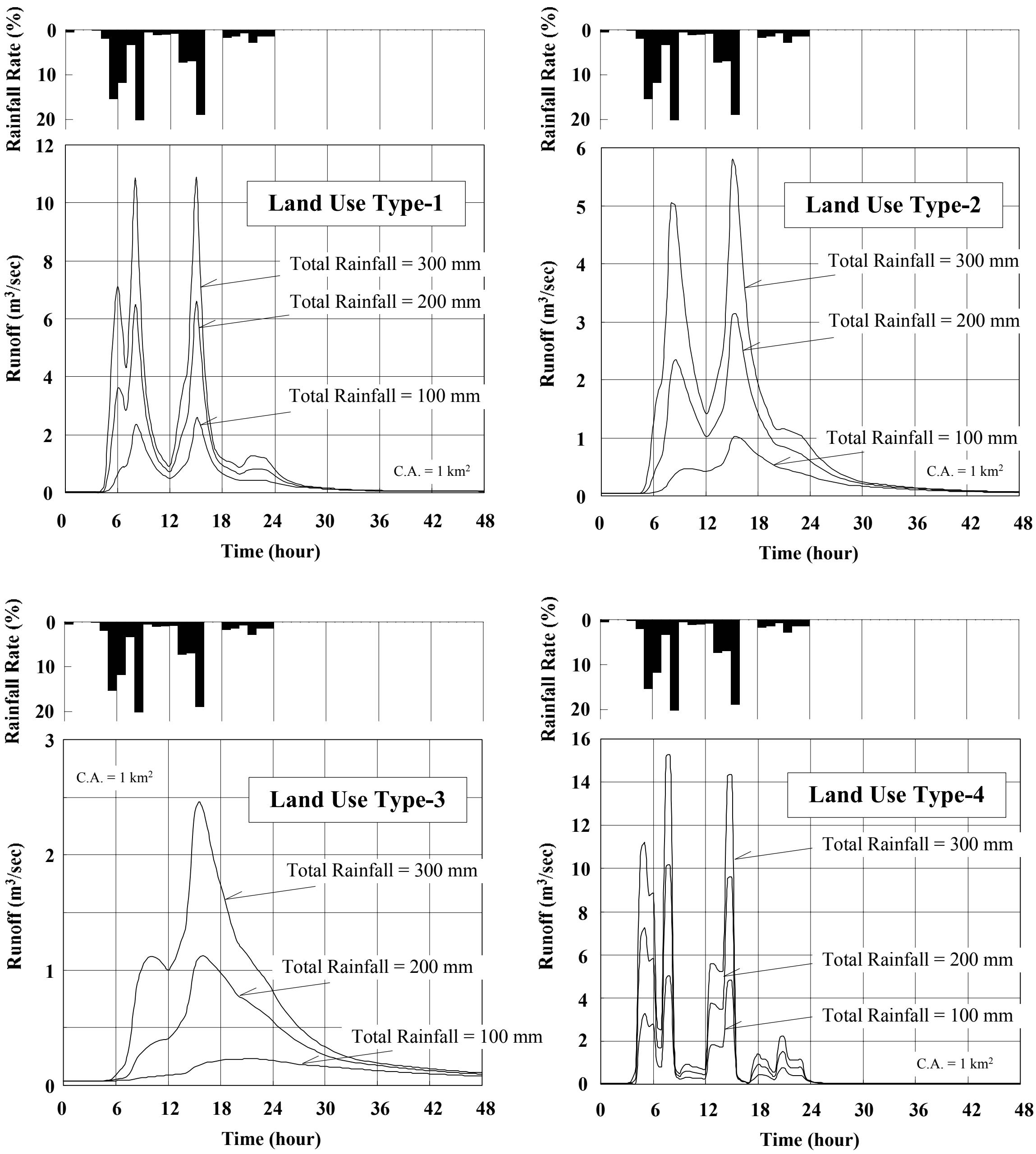
Sub-basin ID	Area (km^2)
B_01	5.7
B_02	11.6
B_03	3.6
B_04	4.7
B_05	2.0
B_06	21.4
B_07	1.5
B_08	2.6
B_09	20.1
B_10	13.5
B_11	23.0
B_12	37.9
B_13	7.4
B_14	11.4
B_15	19.8
B_16	38.4
B_17	19.4
B_18	10.3
B_19	3.6
B_20	9.3
B_21	4.4
B_22	70.6
B_23	9.5
B_24	15.9
B_25	8.6
B_26	17.6

The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 4.4.4 Channel Network and Basin Division of Bolgoda Basin
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source : MIKE11 Reference Manual

The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 4.5.1 Structure of the NAM Model
JAPAN INTERNATIONAL COOPERATION AGENCY	



Runoff Characteristics of Each Land Use Type Basin

24-hr Rainfall (mm)	Land Use Condition							
	Type-1 (Urbanized area)		Type-2 (Semi-urbanized area)		Type-3 (Rural area, Paddy)		Type-4 (Marsh, Water)	
	Specific Discharge ($m^3/sec/km^2$)	Runoff Rate	Specific Discharge ($m^3/sec/km^2$)	Runoff Rate	Specific Discharge ($m^3/sec/km^2$)	Runoff Rate	Specific Discharge ($m^3/sec/km^2$)	Runoff Rate
100	2.6	0.81	1.0	0.54	0.2	0.31	4.9	0.98
200	6.6	0.82	3.1	0.59	1.1	0.35	10.1	0.94
300	10.9	0.82	5.8	0.63	2.5	0.39	15.2	0.93

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

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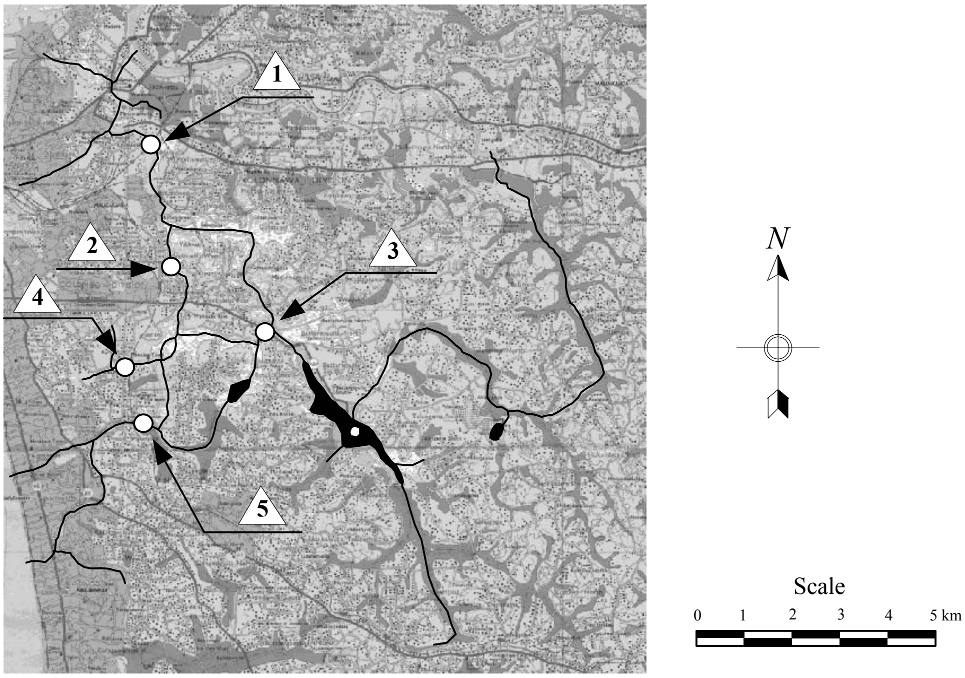
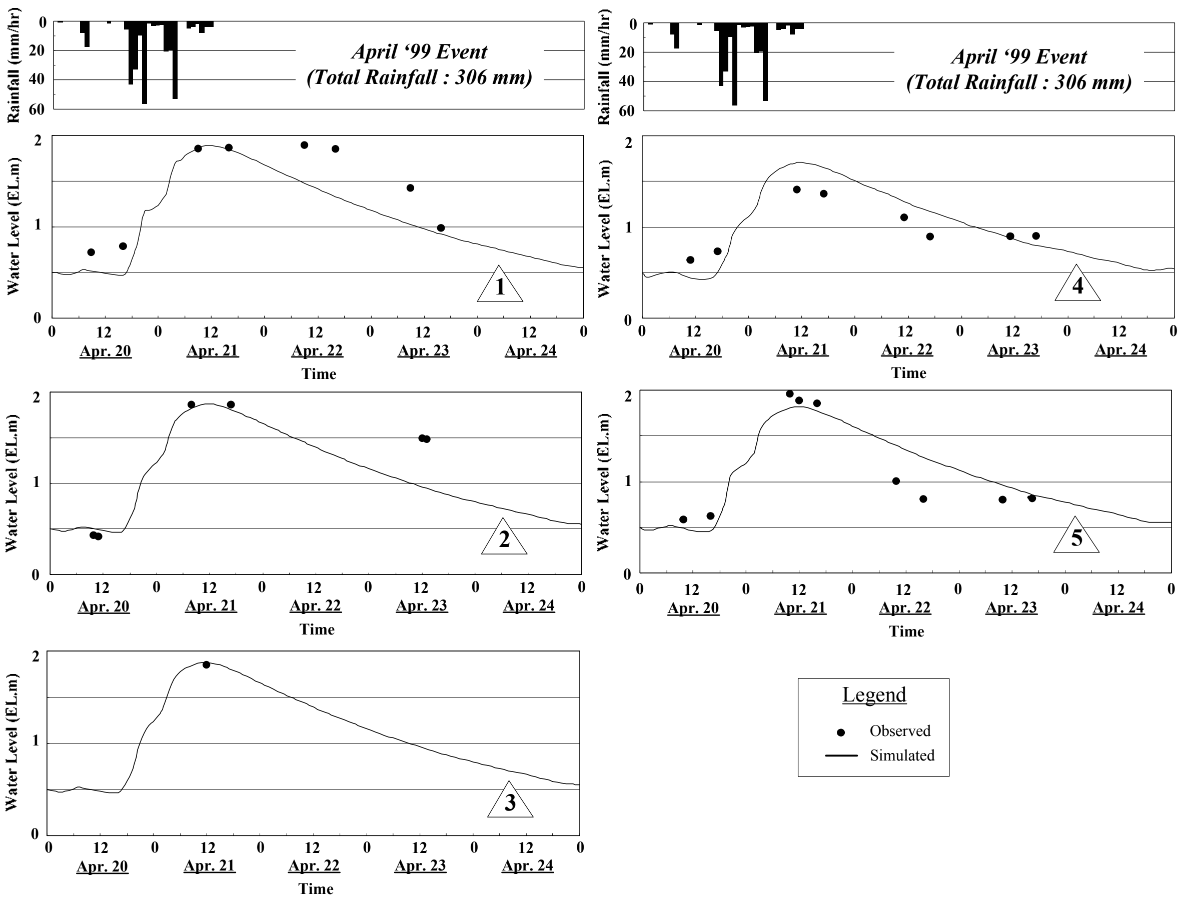
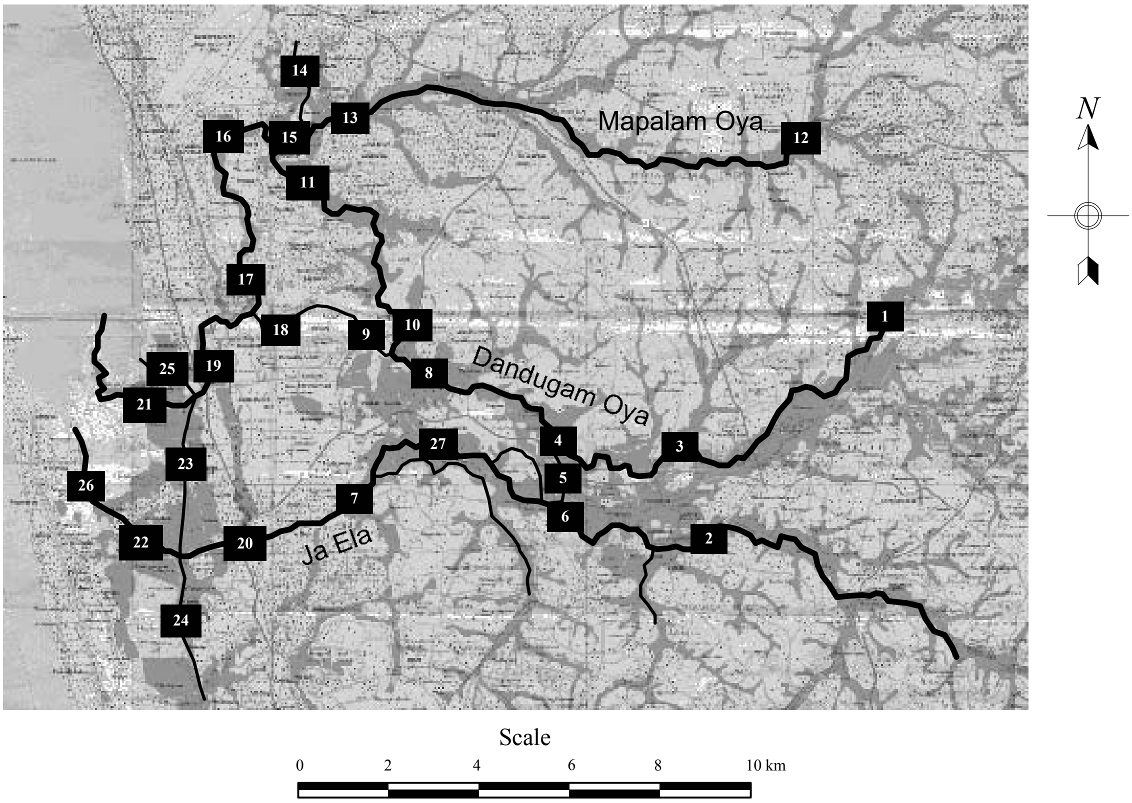
Figure 4.5.2
Runoff Hydrograph from Each Land Use Type Basin

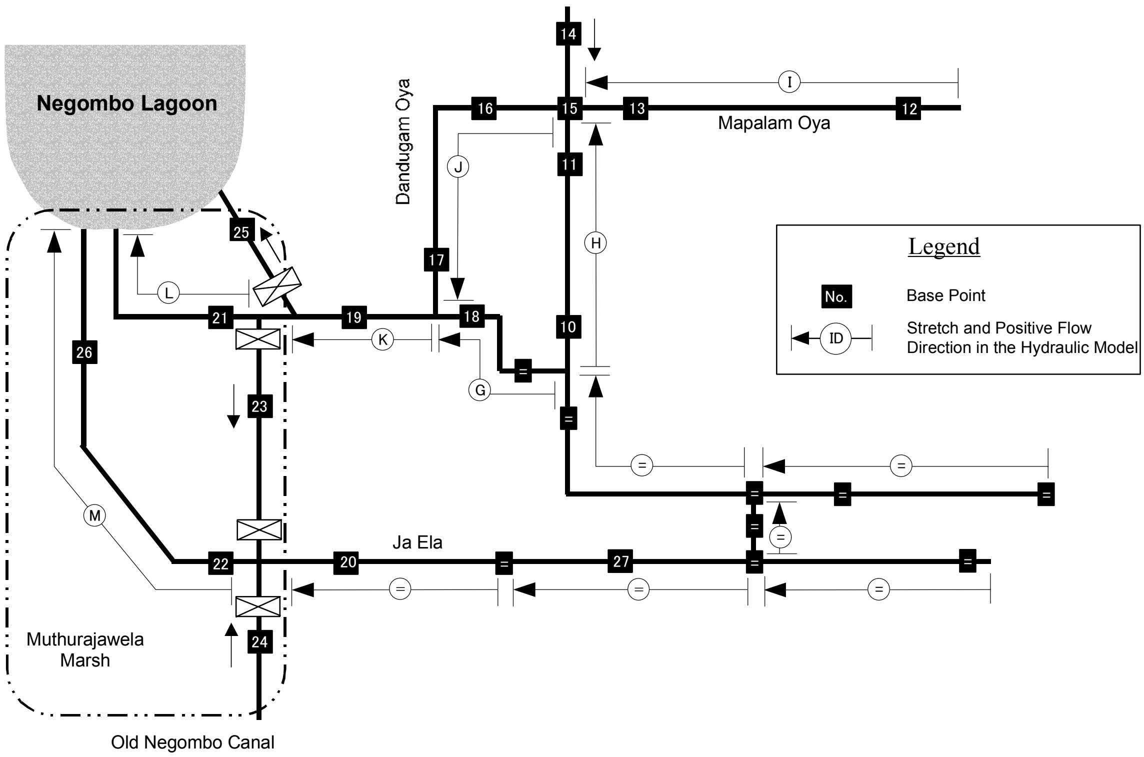


Location of Calibration Points

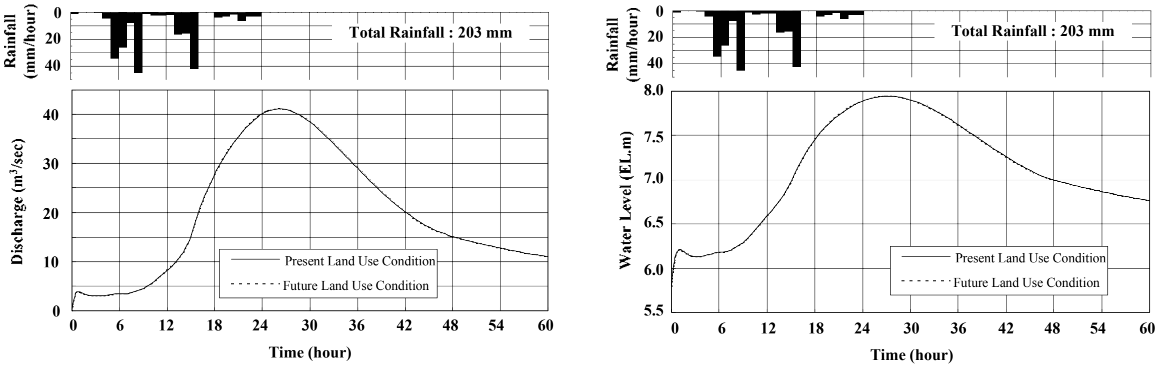


The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 4.7.1 Result of Model Calibration
JAPAN INTERNATIONAL COOPERATION AGENCY	

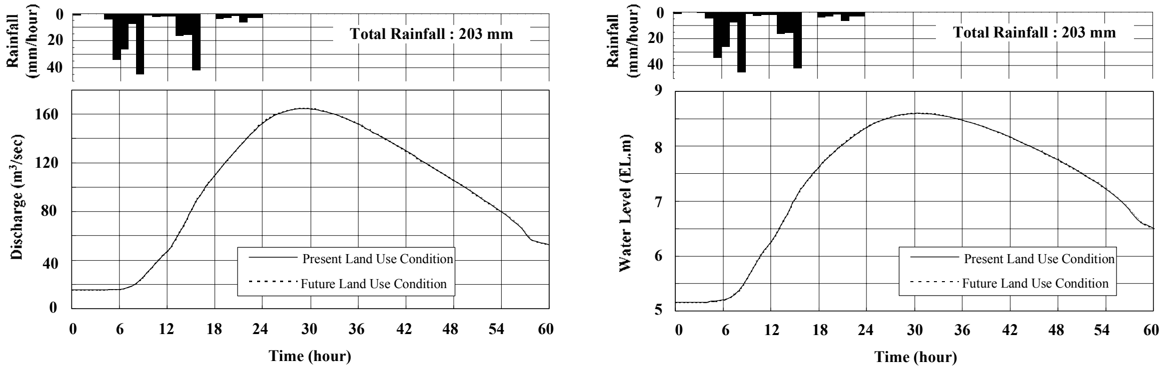




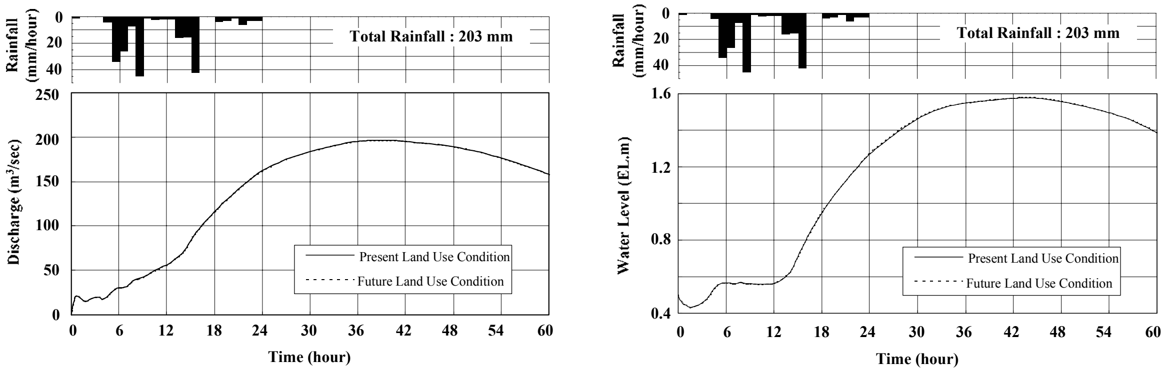
The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 4.8.1 Base Points in the Attanagalu Oya Drainage System
JAPAN INTERNATIONAL COOPERATION AGENCY	



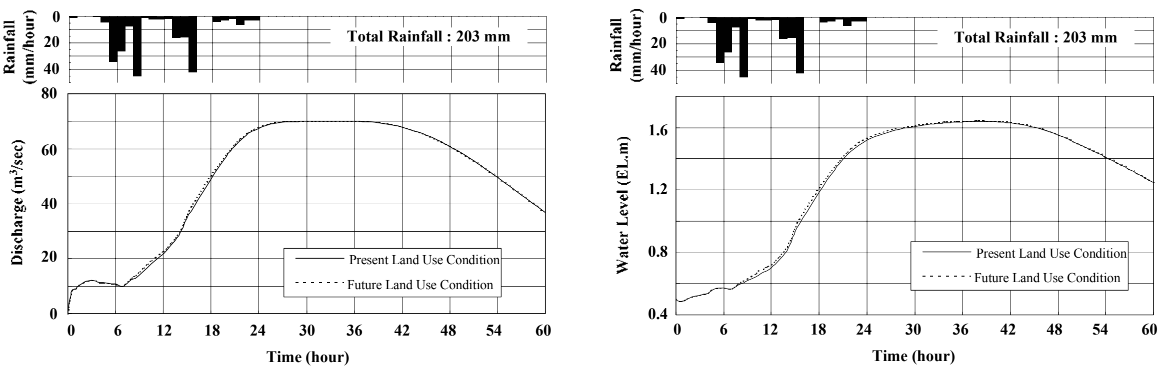
Discharge and Water Level Hydrographs at Base Point 2 (BP-2)



Discharge and Water Level Hydrographs at Base Point 3 (BP-3)

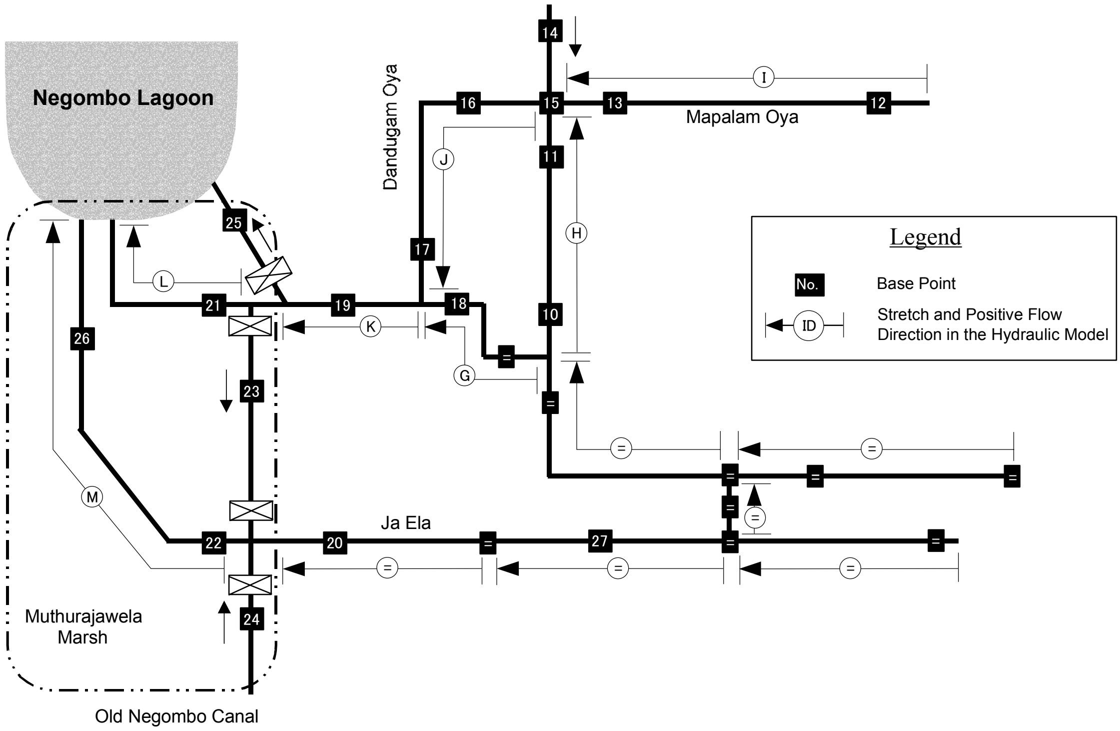


Discharge and Water Level Hydrographs at Base Point 19 (BP-19)



Discharge and Water Level Hydrographs at Base Point 20 (BP-20)

The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 4.8.2
JAPAN INTERNATIONAL COOPERATION AGENCY	Calculated 50-yr Probable Flood Hydrographs for the Attanagalu Oya Basin



Simulated Maximum Water Level and Discharge at Base Points and Stretches

BP	2-year Probable Flood				5-year Probable Flood				10-year Probable Flood				25-year Probable Flood				50-year Probable Flood			
	PLU		FLU		PLU		FLU		PLU		FLU		PLU		FLU		PLU		FLU	
	H_{max}	Q_{max}	H_{max}	Q_{max}	H_{max}	Q_{max}	H_{max}	Q_{max}	H_{max}	Q_{max}	H_{max}	Q_{max}	H_{max}	Q_{max}	H_{max}	Q_{max}	H_{max}	Q_{max}	H_{max}	Q_{max}
1	-	20.1	-	20.1	-	34.2	-	34.2	-	48.0	-	48.0	-	68.6	-	68.6	-	85.0	-	85.0
2	-	10.4	-	10.5	-	17.6	-	17.7	-	24.2	-	24.3	-	33.7	-	33.8	-	41.1	-	41.2
3	6.42	51.3	6.43	51.4	7.21	83.8	7.22	84.1	7.68	107.7	7.69	108.1	8.22	139.4	8.23	139.9	8.60	164.7	8.61	165.1
4	4.04	-	4.04	-	4.79	-	4.79	-	5.22	-	5.22	-	5.68	-	5.68	-	5.98	-	5.99	-
5	-	-0.4	-	-0.4	-	-2.8	-	-2.8	-	-5.7	-	-5.8	-	-10.2	-	-10.3	-	-14.2	-	-14.2
6	4.34	-	4.34	-	4.41	-	4.42	-	4.76	-	4.76	-	5.17	-	5.17	-	5.45	-	5.45	-
7	0.99	23.6	1.00	23.8	1.39	37.8	1.39	38.0	1.64	47.7	1.65	47.9	1.94	60.1	1.95	60.3	2.15	69.2	2.16	69.4
8	-	53.6	-	53.7	-	82.5	-	82.8	-	102.2	-	102.4	-	125.3	-	125.6	-	142.1	-	142.4
9	-	-0.2	-	-0.2	-	-0.3	-	-0.3	-	-0.4	-	-0.4	-	1.6	-	1.7	-	3.4	-	3.4
10	2.28	54.9	2.29	55.0	3.02	84.0	3.02	84.2	3.47	103.1	3.48	103.4	3.93	124.9	3.94	125.1	4.23	140.0	4.24	140.3
11	-	54.5	-	54.6	-	81.3	-	81.5	-	100.7	-	101.0	-	123.0	-	123.2	-	138.3	-	138.5
12	-	6.6	-	6.6	-	12.3	-	12.3	-	17.4	-	17.4	-	24.9	-	24.9	-	31.2	-	31.2
13	-	10.6	-	10.6	-	16.0	-	16.0	-	20.2	-	20.2	-	26.5	-	26.5	-	31.8	-	31.8
14	-	14.4	-	14.4	-	24.4	-	24.4	-	34.3	-	34.3	-	49.3	-	49.3	-	61.4	-	61.4
15	1.02	-	1.02	-	1.43	-	1.44	-	1.73	-	1.73	-	2.06	-	2.06	-	2.29	-	2.29	-
16	-	79.0	-	79.1	-	116.0	-	116.2	-	141.2	-	141.4	-	170.4	-	170.6	-	191.2	-	191.4
17	0.83	79.6	0.83	79.6	1.12	116.8	1.13	117.0	1.34	142.0	1.34	142.2	1.58	171.2	1.58	171.4	1.75	192.1	1.75	192.3
18	-	1.0	-	1.0	-	1.9	-	1.9	-	2.7	-	2.7	-	3.8	-	3.8	-	4.7	-	4.7
19	0.78	80.5	0.78	80.6	1.03	117.8	1.04	118.0	1.22	143.3	1.22	143.5	1.43	173.9	1.43	174.1	1.58	196.4	1.58	196.6
20	0.79	24.4	0.80	24.6	1.05	38.7	1.06	38.9	1.24	48.7	1.25	48.9	1.47	61.1	1.47	61.3	1.64	70.0	1.65	70.2
21	0.72	80.5	0.72	80.6	0.93	117.8	0.94	118.0	1.08	143.3	1.09	143.5	1.26	173.9	1.26	174.1	1.38	196.5	1.38	196.7
22	-	24.4	-	24.7	-	38.7	-	38.9	-	48.7	-	48.9	-	61.1	-	61.3	-	70.0	-	70.2
23	0.65	0.2	0.65	0.2	0.83	0.2	0.83	0.2	0.94	0.2	0.95	0.2	1.09	-0.2	1.09	-0.2	1.19	-0.2	1.19	-0.2
24	-	-0.2	-	-0.2	-	-0.3	-	-0.4	-	-0.4	-	-0.5	-	-0.6	-	-0.6	-	-0.7	-	-0.7
25	-	0.5	-	0.5	-	0.7	-	0.7	-	0.9	-	0.9	-	1.3	-	1.3	-	1.6	-	1.6
26	0.57	-	0.57	-	0.67	-	0.67	-	0.74	-	0.75	-	0.85	-	0.85	-	0.93	-	0.94	-

Stretch	2-year Flood Discharge (m^3/sec)		5-year Flood Discharge (m^3/sec)		10-year Flood Discharge (m^3/sec)		25-year Flood Discharge (m^3/sec)		50-year Flood Discharge (m^3/sec)	
	PLU	FLU	PLU	FLU	PLU	FLU	PLU	FLU	PLU	FLU
A	53.0	53.2	86.3	86.6	110.6	110.9	142.1	142.5	166.9	167.3
B	14.8	14.9	25.0	25.1	32.7	32.9	43.8	44.0	52.3	52.5
C	0.6	0.6	-3.0	-3.0	-5.9	-6.0	-10.5	-10.5	-14.5	-14.6
D	54.4	54.6	85.4	85.6	106.2	106.4	133.1	133.4	154.1	154.5
E	16.8	16.8	29.3	29.5	39.1	39.2	52.5	52.6	62.9	63.1
F	24.4	24.6	38.7	38.9	48.7	48.9	61.1	61.3	70.1	70.2
G	1.2	1.2	2.2	2.2	3.1	3.1	4.4	4.4	5.4	5.4
H	55.0	55.1	84.0	84.3	103.3	103.5	125.0	125.3	140.2	140.4
I	10.8	10.8	17.6	17.6	24.3	24.3	34.5	34.5	42.9	42.9
J	79.6	79.6	116.8	117.0	142.0	142.2	171.2	171.4	192.1	192.3
K	80.5	80.6	117.8	118.0	143.3	143.5	173.9	174.1	196.5	196.7
L	80.5	80.6	117.8	118.0	143.3	143.5	173.9	174.1	196.5	196.7
M	38.0	38.3	47.3	47.9	53.5	54.1	62.3	62.6	70.1	70.2

BP : Base Point, PLU : Present Land Use Condition, FLU : Future Land Use Condition,
H_{max} : Maximum Water Level (EL.m), Q_{max} : Maximum Discharge (m^3/sec)

The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 4.8.3
JAPAN INTERNATIONAL COOPERATION AGENCY	Simulated Maximum Water Level and Discharge at Base Points in the Attanagalu Oya Basin