# Bruhath Bengaluru Mahanagara Palike

Narashima Raja Square

Bengaluru

## Remodeling of Primary & Secondary Storm Water Drains in Bengaluru Under JNNURM Scheme

## Chalaghatta Valley

## Feasibility & Detailed Project Report

## Volume – I

**December 2006**

STUP Consultants P. Limited

Remodelling of Primary and Secondary Storm Water Drains
In Bangalore City

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Remodelling of Primary and Secondary Storm Water Drains
In Bangalore City

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# EXECUTIVE SUMMARY

## INTRODUCTION

The total area of Bangalore city is approximately 225 Sq.m. and is divided by 4 major valleys namely Vrishabhavathy, Koramangala, Challaghatta and Hebbal valley with total length of primary and secondary drains more than 220 Km. Challaghatta main valley originates from palace ground in Jayamahal and join Bellandur lake. Hebbal main valley starts from Mathikere and joins Hebbal Lake. Koramangala main valley originates from Subhashnagar and joins Bellandur lake and Vrishabhavathy main valley originates from Sankey tank and joins Vrishabhavathy valley near Mysore road.

Due to rapid urbanization, the rate of growth of population in Bangalore has been explosive during the last two decades. Bangalore being a chosen destination for software, Biotech and other industrial entrepreneurs has further escalated the population rise. This has obviously caused additional strain on the already overloaded city infrastructure. The large scale construction of Office premises, residential accommodation and other similar construction, to meet the demands of the rising population has resulted in :

i) Increased ground coverage and pavements

ii) Developments inside the buffer storage areas and tanks

iii) Encroachments into the storm water drain

iv) Uncontrolled discharge of sewage and effluents inside the Storm water drain

v) Constructions inside the drain to facilitate running of other utilities.

Bangalore Mahanagara Palike, agency responsible for the maintenance of the city's infrastructure has taken up the project of remodelling the entire storm water drain to improve the efficiency of the storm water drainage system and entrusted the work to M/s. STUP Consultants P. Limited.

The scope of work includes;

I) Preparation of:

a) Feasibility Report
b) Detailed Project Report
c) Construction Management for 4 valleys :
    i.Vrishabhavathy Valley
    ii.Koramangala Valley
    iii.Chellaghatta
    iv.Hebbal

II) Detailed scope of services includes;

- Detailed topographical and geo-technical survey
- Assessment of quantity and quality of drainage discharge
- Analysis of the existing system
- Prevention of sewerage entering drains (to the possible extent)
- Hydraulic and structural designs and drawings
- Cost estimation and Bill of Quantities
- Technical specifications
- Cost benefit analysis
- Bid documents
- Slicing and Packing (Phasing for Implementation)
- Assistance inviting and evaluating Bids
- Project management and Quality assurance
- Training of BMP staff

While Remodeling proposals on the entire Storm water drain system is in progress, the report on Challagatta valley remodeling is being submitted as a first part in 2 Volumes namely :

Volume 1 - Main Report

Volume 2 - Drain Alignment Plan, Longitudinal Section, Cross Section & General Arrangement Drawings for Challaghatta Valley.

**WORK METHODOLOGY:**

To asses the existing condition of the drain a detailed topographical survey has been carried out using total stations in which the alignment of the drain, length of the drain, adjoining buildings, culverts / bridges, cross section of the drain etc are identified.

Condition survey of the drain and bridges were also carried out in which the bed condition of the drain, walls, level of silting in the drains, obstructions, sewage entry points to the drain, pipe crossings, manholes etc., were also identified and listed in the formats. The condition of bridges and culverts have also been assessed. Various low lying areas are identified during reconnaissance survey which are prone to flooding and the bottle necks and reason causing flooding were identified.

It is an established fact that the high intensity, high volume rainfall follows laws of probability which can be established for a place like Bangalore where rainfall data for over 25 – 30 years is available. These mathematical laws generally called as “extreme value distributions” enable one to correlate the intensity of rainfall and the chances (probability) of that rainfall taking place within a given time frame (1 hour, 12 hours, 24 hours, etc.) when such precipitation takes place, the amount of water that will flow from various parts of the catchment area to the drains can be calculated based on knowledge of the type and characteristics of terrain (in terms of its absorption and runoff) type of drains, sectional areas of drains and their slopes, etc.

This method, (Called Rational Method) being logical and incorporating various actual physical characteristics is considered to be a powerful method for predicting the maximum expected floods. However, to evaluate and fix various physical parameters of catchment

areas (i.e. properties) and to fit rainfall data is a difficult task. Even when carried out, it needs to be "confirmed" by observation of actual water discharge against the calculated discharge., A set of catchment parameters need to be consistently chosen and adjusted in prediction model whose predictions shall match with the actual observations of flood. This stage is termed as the "Calibration of the System".

The rational method is a very powerful method for design of a "Greenfield" project (i.e new towns, new development areas, etc.). However, this method is not adequate on its own for studying the existing systems which have been developed over a period of time without having any systematic design philosophy behind its design.

Therefore, as a first step in improving the existing system it is necessary to take following steps :

a) Repair and rehabilitation of damaged portion of existing drains.
b) Cleaning and clearing of waterway by removal of debris, artificial constrictions, blockages, etc.
c) Making the entire drain system internally consistent over its full length.

Once the above is achieved, the probabilistic predictions of discharge, velocity and capacity can be compared with those of actually observed floods. This will enable one to establish correct mathematical model which is then used for optimizing the design for other portions of drainage channels (i.e. primary, secondary and tertiary drains) and make the whole system internally consistent and cost effective.

At present, the mathematic model for rainfall in Bangalore has been established based on rainfall data of part several years. Also, the parameters of catchment have been evaluated and the first order prediction model is prepared.

This model has been used to make first predictions of the expected flood. This is found to yield higher flood levels than those actually observed and will need second stage corrections. This can be effectively done after completing three stages of repair/rehabilitation mentioned above. Meanwhile, these first order results, have been

used as a guideline in preparing proposals of widening / additional capacity of drains at local portions in such a way as to make the system internally consistent.

**DESIGN PHILOSOPHY:**

The data required for adequacy analysis of drain like rainfall data, topography and land use from satellite imagery are collected. The detailed technical and hydraulic analysis have been carried out to assess the hydraulic capacity of the drain and bridges. Various statistical analysis were studied for rainfall and the method which is best suited to the site condition, i.e. CPHEEO method has been selected and analysed.

**RECOMMENDATIONS:**

To improve the section of the drain and to minimize the flooding, various drain improvement methods are suggested are :-

1. Provision of gratings for closed drain for allowing water to the drain with openings for cleaning the drain.

2. Plugging of all openings to the drain made for draining ground water to the main drain where the drain wall top is higher than the ground level/road level and construct side drain leading off storm water to the down stream end.

3. Provision of pointing to inside of existing stone masonry drain wall.

4. Provision of bed to drain to improve the flow

5. Provision of bed and wall for drain wherever they do not exist to improve the drain hydraulics.

6. Removal and reconstruction of drain wall wherever the drain wall is in dilapidated conditions.

7.Provision of embankment in the pitching and lined bed for drain where enough land is available.

8.Provision of Byepass drains to reduce the load on the existing drain.

9.Provision of cut off drain around the low lying area to prevent outside water entering the low lying area and construction of sump for pumping out water at a location closer to the main drains (downstream end) and easily accessible to reach the truck mounted pump.

10.The improvement shall be taken up from the down stream of the valley. If remodeling is commenced from upstream side, situation at the downstream end would further get aggravated.

11.Increase the drain wall height to increase the carrying capacity of the drain wherever required. Provide parallel drain adjacent to the raised drain wall to dispose the ground water to down stream of drain.

12.All obstructions like bridges/culverts, utility lines, manholes, etc. shall be removed and rebuilt wherever required.

13.All silt/debris from the drain shall be removed.

14.Regading of drain from Shivaji Nagar to down steam of Gurudwara bridge

15. Reconstruction of Gurudwara bridge.

16.Remodeling of Bridges near Ulsoor lake, Indiranagar and Airport road.

17.Set-up a vigilance squad to prevent debris dumping, encroaching of drain, local obstruction, such as, pipe crossing, construction inside the drain, any construction other than required for storm water in drainage.

18.Encourage rain water harvesting in institutions, public parks, open grounds, etc.,

## ENVIRONMENTAL AND SOCIAL IMPACTS

Storm drains carrying sewage and solid wastes are causing environmental hazards such as :

1.Pollution of ground water source.
2.Odour problem
3.Mosquito menace
4.Unhygienic conditions are causing health hazards

The inadequate size of the drains causes flooding of the areas which includes low lying areas such as, Millars tank, Shivaji Nagar, Munireddy Palya, Jogupalya etc, causing damage to properties, affecting social life of local residents.

Therefore, to minimize flooding, proposals for both immediate and long term are prepared for Challagatta valley.

## Cost Estimation

For implementation of the various recommendations a detailed cost estimation has been prepared, and is shown as below;

| Sl.No. | Description | Amount (Rs. In Lakhs) |
|---|---|---|
| 1 | Cost for Remodeling of Primary & Secondary Storm Water Drains, Construction of New Drains near low lying areas, Formation of Service Roads etc., | 10,046.76 |
| 2 | Cost for Remodeling of Bridges / Culverts constructed across Primary & Secondary Storm Water Drains. | 1,333.40 |
| 3 | Cost for shifting utility lines, footpath improvement works, barricading, traffic diversion, strengthening of diversion routes etc. | 569.01 |
| 4 | Construction of Detention Ponds / Retarding Basins | 150.00 |
| 5 | Construction of Wells with pumping arrangement in low lying areas | 200.00 |
| 6 | Procurement of desilting machine | 0.00 |
| 7 | Miscellaneous and rounding off | 0.02 |
| 8 | Advisory, Project Management & Establishment Charges (1.5 % of Item 1 to 7) | 184.50 |
| | **TOTAL** | **12,483.69** |
| 9 | Annual Operation & Maintenance Cost (1.0 % of Item 1 to 7) | 123.00 |

For effective functioning of any system, requires maintenance. The operation and maintenance requirement have been identified and costing is indicated.

# CHAPTER – 1

# INTRODUCTION AND BACKGROUND

## 1.1 GENERAL:

Bangalore, the capital of Karnataka, is one of the fastest growing cities in India with a current estimated population of 5.8 million souls, spread over an area of about 225 Sq.km. and is situated at an altitude of about 894 m. above MSL.

Bangalore was once well known for its open parkland environment with significant number of large traditional tanks with a good network of waterways and thick vegetative cover. Rapid increase in population, industrialization and migration of people from rural Karnataka and rest of the country in a relatively short span of time has put more pressure on the utilities and services, which are already loaded beyond their capacities. Storm water drains are one of the most affected services in the city. The problem is aggravated by uncontrolled urbanisation, infringement by other utilities, encroachments and indiscriminate dumping of solid wastes and over flowing of sewers in drain. Other secondary problems includes sedimentation, vegetation growth and sewage outlets into the drains, etc. Due to the above, there is reduction in carrying capacity of the drains causing localized flooding to the settlements adjacent to the drains and tanks, in low lying areas. Many tank beds have been converted into residential layouts causing disappearance of water body which otherwise would have acted as detention ponds / retarding basins. The damage caused by the floods, are very serious in terms of life and property. Therefore, there is an urgent need to examine the status of existing storm water drainage system, the reasons for the frequent flooding and devise possible remedial measures to alleviate the damage.

## 1.2 PROJECT BACKGROUND:

The stated goal for remodeling of existing storm water drain project is to improve the carrying capacity of the existing system, for the delivery of storm water without flooding the low lying areas of the city and also to provide improvised environmental sanitation services to the city of Bangalore, with emphasis on the urban poor and vulnerable groups and within a process of long term environmental, economic, social and institutional sustainability.

In August 1988 and May 2002, Bangalore city had experienced unusually high intensity rainfall which resulted in substantial damage to both life and property.

Bangalore Mahanagara Palike (BMP), the agency responsible for maintenance of the city's infrastructure with an endeavour to obviate the problems faced by the city, therefore took up the project including preliminary investigations, detailed survey, system analysis and proposals for improvements and capacity augmentations of the existing drainage system in Bangalore.

Bangalore Mahanagara Palike invited proposals from competent consultants based on the approach document prepared by BMP and entrusted the work to M/s. STUP Consultants Private Limited, Bangalore to provide necessary direction and set priorities on existing drainage system rehabilitation needs, and to explore the potential options, considering future hydraulic design requirements, for drainage system rehabilitation and other technical services for remodelling the existing drainage system in Bangalore City.

Further, the outputs of this study will provide the basis for developing a comprehensive plan for the drainage system and detailed proposals for selected improvement projects to be implemented by BMP.

Bangalore city topography is marked by the presence of Four Primary valleys, viz.,

1.Vrishabhavathy Valley

2.Koramangala Valley

3.Challaghatta Valley

4.Hebbal Valley

Based on the Survey conducted, the lengths of the main valleys are as shown in the table below:

| Sl.No. | Name of the Valley | Primary Drain Length (m) |
|---|---|---|
| 1. | Vrishabhavathi Valley | 32,150 |
| 2. | Koramangala Valley | 19,625 |
| 3. | Challaghatta Valley | 16,150 |
| 4. | Hebbal Valley | 25,800 |
| | **Total length of drain** | **93,725** |

This report forms the feasibility study for Challaghatta Valley.

## 1.3 OBJECTIVES OF THE PROJECT:

The objectives, defined in broad terms are:

- To study the main reasons for failure of the existing storm water drains to dispose the storm water without flooding the areas of the city.

- To study the carrying capacity of the existing primary and secondary drains.

- To suggest modifications to the main and secondary drains in respect of improvement in flow characteristics and capacity.

- To study the feasibility of segregating sewage from storm water and the extent practicable.

- To provide rehabilitation of bridges across Storm Water Drains which are hindrances to the carrying capacity of drain.

## 1.4 REPORT OBJECTIVES:

This report provides, details of existing storm water drains in Challaghatta Valley,, wherein it also provides a strategic framework to ensure better management of drainage assets in Bangalore which also has significant implications in:

- Future management of storm drainage system in Challaghatta Valley.

- Strategies to be follow for implementation of improvement measures.

- Resources generation to achieve the stated objectives and targets.

For the report purpose the studies made are:

- Identifying the low lying area and reasons for flooding
- Assessment of existing condition of drainage system
- Evaluation of development options for existing system.
- Examining option / strategies for the preferred options for local applications.
- Preparation of cost estimates for works and associated operation and maintenance.

- Review of existing management of drainage system and the recommendations for institutional improvements.

- Identification of further studies and investigation required for refinement.

Further, for the preparation of this report, supplementary sources are considered at a macro level and also the results of those studies and investigations are integrated into this report.

This report has the following structure:

| | |
|---|---|
| VOLUME I | Main Report |
| VOLUME II | Drain Alignment Plan, Longitudinal Section, Cross Section & General Arrangement Drawings for Challaghatta Valley. |

## 1.5 SCOPE OF ASSIGNMENT:

A Brief scope of assignment to be rendered by the Consultants as defined in the TOR is given below:

- Detailed topographical and geo-technical survey
- Assessment of quantity of runoff
- Adequacy analysis of existing drains
- Hydraulic and structural designs and drawings
- Cost estimation and Bill of Quantities
- Technical specifications.
- Bid Documents
- Slicing and Packaging (Phasing for Implementation)
- Assistance in Inviting and evaluating Bids
- Project management and Quality assurance

## 1.6 PHASES OF THE PROGRAMME

The consultancy services which is to be carried out in three (3) phases are as given below:

**Phase 1:** Technical, Economical and Environmental Feasibility Study of the Project of Remodeling of the Storm Water Drain System.

**Phase 2:** Detailed Engineering Design, preparation of tender documents, cost estimates for the remodeling work, Preparation of Bid document and assist BMP to entrust the work to experienced, competent and successful agency.

**Phase 3:** Supervision of the construction works.

This report is presented for Phase - 1 and Phase -2 works of Challaghatta Valley.

## 1.7 PREAMBLE TO INCEPTION REPORT:

Reference is made to the inception report, which identifies the different valleys and conditions of existing storm drains, new drains (i.e., not considered in TOR) and low lying areas in different drainage zones in this report. The details from previous data, recommendation made during past initiatives, current approach, methodology, design procedure and work plan adopted for preparation of detailed project report, narrated in detail.

# CHAPTER - 2

# ASSESSMENT OF EXISTING STORM WATER DRAINAGE SYSTEM

## 2.1 INTRODUCTION:

Bangalore city is at an altitude of 894 m. above MSL. and has the general advantage of natural valleys offering good drainage arrangement for storm water. However, misuse and inappropriate planning of drainage network in these valleys have resulted in flooding. The main factors responsible for failure of the system in Bangalore are :

- A general neglect of the basic functions of the major drains which has allowed numerous channel restrictions to occur and caused a general down grading of the channel capacities, without having adequate provision for flood discharge to meet the design requirement.

- The apparent acceptance of a design standard for the existing main drains in the core area, for a large city like Bangalore with a rolling topography is extremely low.

- Lack of planning, design standard and maintenance of tertiary drains which is not upto the acceptable standards for a large city.

- Lack of good management practices like adoption of sediment control measures, effective solid waste management, development of land in low lying areas/ tank beds etc.

- Laying of sewer lines inside drainage channels in an unacceptable manner.

In the present study, the functionality of tertiary drains is not considered because it is outside the current scope of work.

The area covered under this study is basically the area administered by Bangalore Mahanagara Palike. Map showing the extent of study area is shown as Figure 2.1.

## 2.2 DESCRIPTION OF CATCHMENTS:

Bangalore is situated on the divide between the Cauvery Basin and the Ponnaiyar Basin, at an elevation of approximately 894 m. above MSL and also with nearly 40% of the projected future population living within the Cauvery Basin. There are four major valleys and five minor drainage valleys. Three of the four major valleys namely, Vrishabhavathy (V-Valley), Koramangala (K-Valley) and Challaghatta (C-Valley), run generally from North to South direction dividing the greater part of the metropolitan area into three separate and distinct drainage zones. A fourth major valley, referred to as the Hebbal series (H-valley), forms the drainage zone to the North of the ridge and runs in Northeast direction.

Five minor valleys, the Kathriguppe and the Tavarekere lie to the South, the Kethamaranahalli and Arkavathi lie to the North-West, Hebbal minor valleys 1 & 2 lie to the North-East. Further, all these minor valleys lie outside the tributary areas of the major valleys and drain independently. The catchment boundaries of major and minor valleys are shown in Figure 2.2.

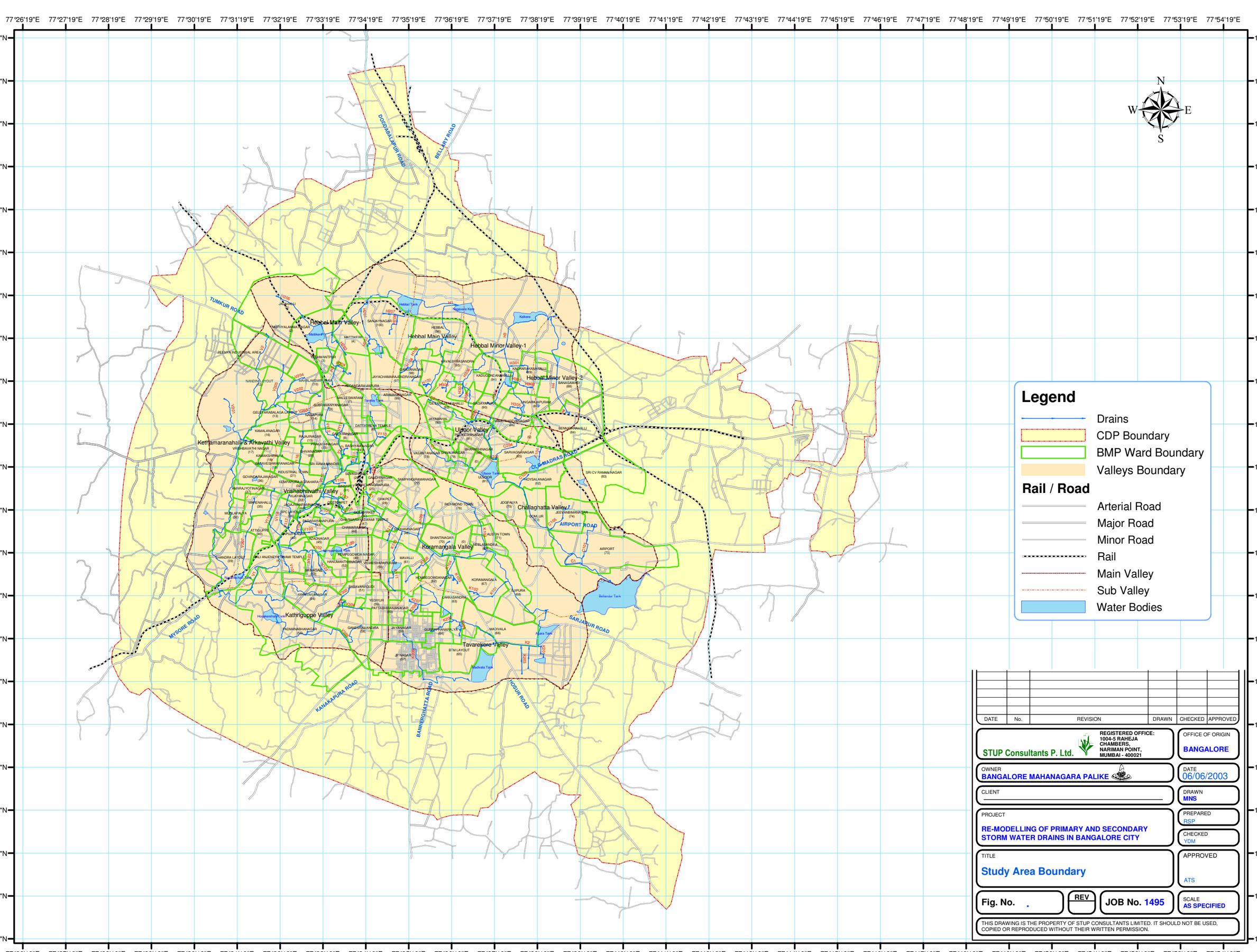
Details of these catchments are as given in Table 2.1.

**TABLE – 2.1 SUMMARY OF STORM WATER DRAINAGE CATCHMENT**

| Valley Names | Major & Minor Valleys | Drop (m.) | Pri. Drain Origin Point | Pri. Drain Terminal Point | Catchment Area (Ha.) | Total Length of Primary Drain (m.) | Municipalities in catchment |
|---|---|---|---|---|---|---|---|

77°26'19"E 77°27'19"E 77°28'19"E 77°29'19"E 77°30'19"E 77°31'19"E 77°32'19"E 77°33'19"E 77°34'19"E 77°35'19"E 77°36'19"E 77°37'19"E 77°38'19"E 77°39'19"E 77°40'19"E 77°41'19"E 77°42'19"E 77°43'19"E 77°44'19"E 77°45'19"E 77°46'19"E 77°47'19"E 77°48'19"E 77°49'19"E 77°50'19"E 77°51'19"E 77°52'19"E 77°53'19"E 77°54'19"E

13°9'7"N 13°8'7"N 13°7'7"N 13°6'7"N 13°5'7"N 13°4'7"N 13°3'7"N 13°2'7"N 13°1'7"N 13°0'7"N 12°59'7"N 12°58'7"N 12°57'7"N 12°56'7"N 12°55'7"N 12°54'7"N 12°53'7"N 12°52'7"N 12°51'7"N 12°50'7"N 12°49'7"N 12°48'7"N

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| | | | | | |

STUP Consultants P. Ltd.

REGISTERED OFFICE: 1004-5 RAHEJA CHAMBERS, NARIMAN POINT, MUMBAI - 400021

OFFICE OF ORIGIN: BANGALORE

OWNER: BANGALORE MAHANAGARA PALIKE

DATE: 06/06/2003

CLIENT:

DRAWN: MNS

PROJECT: RE-MODELLING OF PRIMARY AND SECONDARY STORM WATER DRAINS IN BANGALORE CITY

PREPARED: RSP

CHECKED: YDM

TITLE: Study Area Boundary

APPROVED: ATS

Fig. No. .

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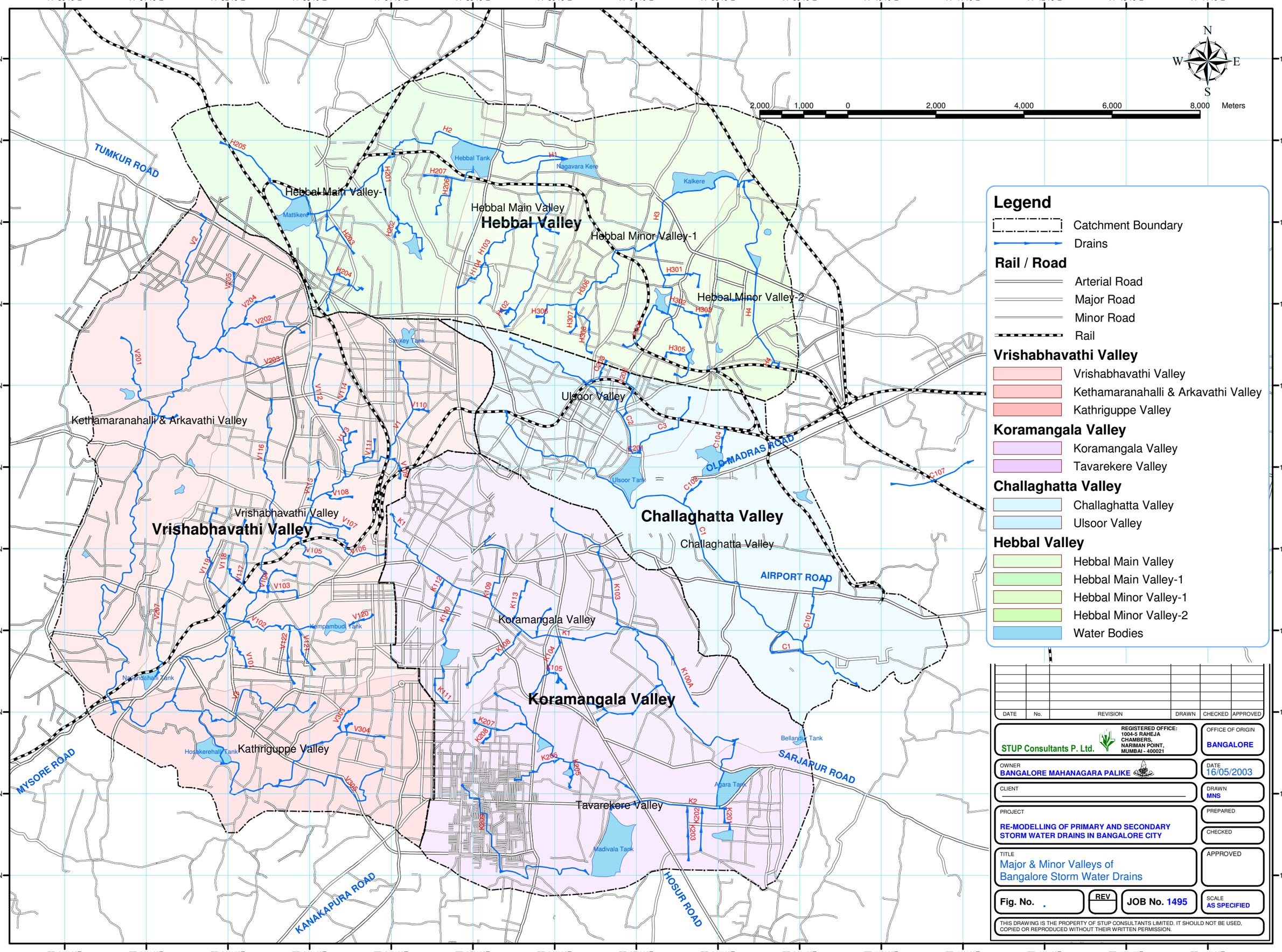
SCALE: AS SPECIFIED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Hebbal Tank
Nagavara Kere
Kalkere
Mattikere
Sankey Tank
Ulsoor Valley
Ulsoor Tank
OLD MADRAS ROAD
Kethamaranahalli & Arkavathi Valley
Vrishabhavathi Valley
Vrishabhavathi Valley
Challaghatta Valley
Challaghatta Valley
AIRPORT ROAD
Kempambudi Tank
Koramangala Valley
Koramangala Valley
Nayandahalli Tank
Kathriguppe Valley
Hosakerehalli Tank
Bellandur Tank
SARJAPUR ROAD
Agara Tank
Tavarekere Valley
Madivala Tank
MYSORE ROAD
KANAKAPURA ROAD
HOSUR ROAD
Legend
Catchment Boundary
Drains
Rail / Road
Arterial Road
Major Road
Minor Road
Rail
Vrishabhavathi Valley
Vrishabhavathi Valley
Kethamaranahalli & Arkavathi Valley
Kathriguppe Valley
Koramangala Valley
Koramangala Valley
Tavarekere Valley
Challaghatta Valley
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Ulsoor Valley
Hebbal Valley
Hebbal Main Valley
Hebbal Main Valley-1
Hebbal Minor Valley-1
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Water Bodies
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REGISTERED OFFICE:
1004-5 RAHEJA CHAMBERS,
NARIMAN POINT,
MUMBAI - 400021
STUP Consultants P. Ltd.
OFFICE OF ORIGIN
BANGALORE
OWNER
BANGALORE MAHANAGARA PALIKE
DATE
16/05/2003
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MNS
PROJECT
RE-MODELLING OF PRIMARY AND SECONDARY STORM WATER DRAINS IN BANGALORE CITY
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TITLE
Major & Minor Valleys of
Bangalore Storm Water Drains
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THIS DRAWING IS THE PROPERTY OF STUP CONSULTANTS LIMITED. IT SHOULD NOT BE USED, COPIED OR REPRODUCED WITHOUT THEIR WRITTEN PERMISSION.

| Valley Names | Major & Minor Valleys | Drop (m.) | Pri. Drain Origin Point | Pri. Drain Terminal Point | Catchment Area (Ha.) | Total Length of Primary Drain (m.) | Municipalities in catchment |
|---|---|---|---|---|---|---|---|
| Vrishabhavathi Valley | Vrishabhavathi Main Valley | 120 | Sankey tank | Kenchanahalli Near Mysore Road | 4,070 | 13,888 | BMP, Kengeri & Patanagere |
| | Kethamaranahalli & Arkavathi Valley | | Near Peenya Indl. area | Kenchanahalli Near Mysore Road | 3,045 | 13,250 | |
| | Kathariguppe Valley | | Near Srinivasnagar | Rajarajeshwarinagar | 1,819 | 4,750 | |
| Koramangala Valley | Koramangala Main Valley | 20 | Near Majestic Area | Bellandur lake | 3,548 | 10,900 | BMP, Bommanahalli & Mahadevepura |
| | Tavarekere Valley | | Near NIMHANS Hospital | Agara lake | 2,690 | 6,075 | |
| Challaghatta Valley | Challaghatta Main Valley | 30 | Near Vasanthanagar | Bellandur lake | 3,168 | 10,275 | BMP, Krishnarajapura |
| | Ulsoor Valley | | Near Jayamahal Extn. | Ulsoor lake | 710 | 4,150 | |
| Hebbal Valley | Hebbal Main Valley | 30 | Near Matadahalli | Nagavara lake | 1,096 | 4,375 | BMP, Dasarahalli & Bayatarayanapura |
| | a) Hebbal Main Valley – 1 | | Near I.I.S.C | Hebbal lake | 2,348 | 7,775 | |
| | b) Hebbal Minor Valley – 1 | | Near Jaibharathnagar | Kalkere lake | 2,230 | 7,375 | |
| | c) Hebbal Minor Valley – 2 | | Near Chikka Banasawadi | Kalkere lake | 764 | 2,875 | |

Note: Catchment areas indicated in the table is inclusive of portion of CMC/TMC areas coming within respective catchment boundaries.

The total length of primary and secondary drain mentioned in the TOR in all the valleys was 179.30 kms. But during reconnaissance survey, it was observed that, the length of secondary drains in all the valleys were exceeding by about 41.85 kms. apart from this few more additional drains have been proposed for reducing the flooding problems which requiring BMP's approval for additional length has also been included in the present study. An abstract of drain lengths considered for remodelling studies is given in Table 2.2 and the same is shown in Figure 2.3. In addition to the drain length mentioned, additional new drains are also designed to cutoff the runoff to the low lying areas.

**Table 2.2 Abstract of Drains considered for Remodelling Studies**

| **Name of the Valley** | **Primary Drains (length in Kms.)** | | | **Secondary Drains (length in Kms.)** | | |
|---|---|---|---|---|---|---|
| | As per Actual Survey | As per TOR | Difference in length | As per Actual Survey | As per TOR | Difference in length |
| Vrishabhavathi | 31.88 | 29.7 | 2.18 | 58.6 | 48 | 10.6 |
| Koramanagala | 16.98 | 16.5 | 0.48 | 28.9 | 23.8 | 5.1 |
| Challaghatta | 14.6 | 14.6 | 0 | 18.05 | 8 | 10.05 |
| Hebbal | 22.4 | 12.6 | 9.8 | 29.74 | 26.1 | 3.64 |
| **Total length (Kms.)** | **85.86** | **73.4** | ***12.46*** | **135.29** | **105.9** | ***29.39*** |
| **Total length of additional drains (Kms.)** | | | | | | ***41.85*** |

Since, Koramangala Valley being the most critical valley, it has been taken up on priority for the preparation of feasibility report and further, followed by Challaghatta, Hebbal & Vrishabhavathi Valley.

## 2.3 DESCRIPTION OF CHALLAGHATTA VALLEY:

### 2.3.1 Challaghatta Valley:

Challaghatta valley comprises of two main drains known as Challaghatta main drain and Ulsoor drain (i.e., Munnireddypalya drain), the first of which starts from Vasanthnagar and flows through Miller tank area, Jasma Bhavana Road, Rajiv Gandhi Colony, Nehrupuram, Corporation Colony, Shivajinagar, Nala Road, Anna Swamy Mudaliar Street, RBAMNS College, Gangadhar Chetty Road, Adjacent to Ulsoor lake, Ulsoor, Munivenkatappa garden, Guptha layout, L.B. Shastrinagar, Cambridge layout, Indiranagar, Domlur Layout, Airport Road and joins at Bellandur tank.

Challaghatta main valley comprises of one primary drain and four secondary drains, details of these drains is as mentioned in Table 2.3 and the same is shown in Figure 2.4.

The second main drain known as Ulsoor valley drain starts from J.C. Nagar near Munireddypalya and runs through Kempiah Block, Krishnamma nagar, Chinnappa Garden, S.K. Garden, Pottery town, Frazer town, Sindhi Colony, Wheelers Road and terminates at Ulsoor lake. Another sub main drain covering rest of the Ulsoor valley, flows independently from Jeevanahalli area and flows through East Railway station area, M.E.G. Centre and terminates at Ulsoor lake.

Ulsoor valley drain comprises one primary drain and four secondary drains and also one sub main drain. Details of these drains is as mentioned in Table 2.3 and the same is shown in Figure 2.4*.*

**TABLE 2.3 CHALLAGHATTA VALLEY DRAINS**

| Sr. No. | Drain ID | Name | Type | Start | End | Length (Mts.) |
|---|---|---|---|---|---|---|
| **Challaghatta Main Valley (C1):** | | | | | | |
| 1 | C100 | Challaghata Valley | Pri. | Vasanthanagar | Bellandur Tank | 12,000 |
| 2 | C101 | Murugesh Palya | Sec. | Anandanagar | Challaghatta | 1,875 |
| 3 | C102 | Shastrinagar | Sec. | Sweepers Colony | Shastrinagar | 1,600 |
| 4 | * C103 | Krishnamurthy nagar | Sec. | Krishnamurthy nagar | Kadariyanapalya Tank | 1,600 |
| 5 | * C104 | Kadariyanapalya | Sec. | Kadariyanapalya | Kadariyanapalya Tank | 2,500 |
| 6 | C105 | ISRO Complex | Sec. | Jeevanbhimanagar | Kodihalli | 3,000 |
| 7 | * C106 | Thippasandra | Sec. | New Thippasandra | ISRO Complex | 650 |
| 8 | C107 | Malleshappanapalya | Sec. | Garmantakanapalya | Dodda Nekundi Tank | 900 |
| 9 | * C108 | HAL Airport - 1 | Sec. | Airport S.E Corner | Upto NAL Road | 600 |
| 10 | * C109 | HAL Airport - 2 | Sec. | Adj. To Airport compound wall | Bellandur tank | 675 |
| | | | | | **Total Length of Primary Drains** | **12,000** |
| | | | | | **Total Length of Secondary Drains** | **13,400** |
| **Ulsoor Valley (C2) :** | | | | | | |
| 1 | C200 | Ulsoor | Pri. | Jayamahal Extn. | Ulsoor Tank | 4,150 |
| 2 | C201 | Ganesh Temple | Sec. | Ganesh Temple | MEG Center | 250 |
| 3 | C202 | Cox Town | Sec. | Richard's Town | Gymkhana Ground | 1,170 |
| 4 | C203 | Sagayapuram | Sec. | Sagayapuram | Cleveland Town | 750 |
| 5 | * C204 | Jeevanahalli | Sec. | Jeevanahalli | Ulsoor Tank | 2,000 |
| | | | | | **Total Length of Primary Drains** | **4,150** |
| | | | | | **Total Length of Secondary Drains** | **4,170** |

* - Storm Drains, exists inside Defence area

77°35'19"E 77°36'19"E 77°37'19"E 77°38'19"E 77°39'19"E 77°40'19"E 77°41'19"E 77°42'19"E

13°1'7"N 13°0'7"N 12°59'7"N 12°58'7"N 12°57'7"N 12°56'7"N

0 750 1,500 3,000 4,500 6,000 Meters

Hebbal Main Valley-1
Hebbal Main Valley
Hebbal Minor Valley-1
Hebbal Minor Valley-2
Vrishabhavathi Valley
Ulsoor Valley
Koramangala Valley
Challaghatta Valley
Tavarekere Valley

C1 C2 C101 C102 C104 C105 C201 C203 C204

OLD MADRAS ROAD
AIRPORT ROAD

Ulsoor Tank
Bellandur Tank

## Legend

- Drains
- Ridge
- Water Bodies

**Rail / Road**

- Arterial Road
- Major Road
- Minor Road
- Rail
- Main Valley
- Sub Valley
- Locality Names

| DATE | No. | REVISION | DRAWN | CHECKED | APPROVED |
|---|---|---|---|---|---|

STUP Consultants P. Ltd.
REGISTERED OFFICE: 1004-5 RAHEJA CHAMBERS, NARIMAN POINT, MUMBAI - 400021

OFFICE OF ORIGIN: BANGALORE

OWNER: BANGALORE MAHANAGARA PALIKE

DATE: 06/06/2003

CLIENT:

DRAWN: MNS

PROJECT: RE-MODELLING OF PRIMARY AND SECONDARY STORM WATER DRAINS IN BANGALORE CITY

PREPARED: RSP

CHECKED: YDM

TITLE: Challaghatta Valley Primary & Secondary Storm Water Drains

APPROVED: ATS

Fig. No. . | REV | JOB No. 1495 | SCALE: AS SPECIFIED

## 2.4 RECONNAISSANCE SURVEY:

Reconnaissance survey has been carried out in Challaghatta main valley and Ulsoor valley. The critical locations which were prone for flooding even for small intensity of rainfall due to various reasons have been identified and also photographed.

Reconnaissance survey has been carried out with a view :

- For describing the contributory areas of the valley i.e., contributing to the existing drains.

- Investigate the condition of drains, cross drains, type of construction, extent of rehabilitation to be provided, possibility of creating new drains, change of alignment, upgradation of drains etc.

- Examine feasibility of widening/deepening of the drain to carry the design flow.

- Status of land use pattern / type and density of development, adjoining the drains (i.e., residential, commercial, industrial or vacant land)

- and other key issues which have bearing for smooth functioning of the drainage system.

## 2.5 REPORT ON FIELD SURVEY OF DRAINS IN CHALLAGHATTA VALLEY:

### •METHODOLOGY:

Having identified the drains, the chainages were marked all along the drains, after measuring the length of the drain starting from `0' m chainage at the upper reaches i.e., starting point and the chainage increasing towards the terminal point i.e., down stream direction.

For the entire survey, traversing with total station was done all along the drain

based on local coordinate system. Total stations were used for surveying of details in and around the drain. Every point is surveyed for its planimetry and height. For heights inside the drain, this was necessary, since conventional levelling was not feasible as the drain bottom is at a very low level at some places compared to the sides of the drain. By resorting to Total station, the names of the roads, localities and important land marks, features adjacent to drains were picked up at site and incorporated along with others details.

The heights were given to points with the help of Total stations based on T.B.Ms established all along the drains at strategic locations, on permanent objects such as culverts etc. Before that, the existing Survey of India GTS B.Ms were checked for stability and after ensuring the stability of these B.Ms the levelling was done to establish T.B.Ms all along the drain.

**•Methodology adopted in representing the drains in the drawing:**

Plan showing details of drains, land marks, bench marks, encroachments, locations where sewage entering into storm water drain, condition of retaining walls, location of bridges and cross drainages and utility crossing are identified in the drawing to a scale of 1:1000 and longitudinal section details of drains in 1:1000 / 1:100 are proposed in the same drawing.

As per TOR, each primary and secondary drains in all the valleys are to be identified with respect to their respective predominant locality names and correspondingly numbering has been made.

For ease of identification, sub drains in all the valleys have been identified from down stream end, accordingly numbers have been assigned for each secondary drains in the respective valleys and the same are to be read as follows.

**Eg**. : 1) C100 = C1 represents Challaghatta main valley first primary storm drain.

2) C101 = C1 represents Challaghatta main valley, first primary storm drain and 01 indicates first secondary storm drain in Challaghatta valley.

**•Elevation drawings of Culverts / Bridges:**

The data required to ascertain the condition of existing cross drainage were collected at site. From the data obtained, the type of construction, condition of culvert, details about vent way, approach slab, support piers, parapet walls, carriage way, foot paths, intensity of traffic, obstructions for flow of water at the culvert location etc. has been assessed and appropriate mitigative measures has been suggested. These culverts were serially numbered and each culvert has an identical number both in strip map and in elevation drawing and the same is enclosed as part of this report in the condition survey volume.

**•Longitudinal Section:**

Longitudinal sections showing drain top levels (Both right side and left side) and bed levels at every 25 m. apart on a horizontal scale of 1:1000 and on vertical scale of 1:100 has been made for every drain and the same is enclosed as part of this report in the drawing volume.

**•Cross-section:**

Drain cross section at every 25 m. interval has been made, showing drain depths, levels at top of the silt, bed level and also at the edges of the drain. Heights were given on top of drain wall and also at the adjoining land. The section also indicate whether the walls/buildings or road edge that rests on the drain, at that particular section.

**•Silt Volume:**

From the drain cross section, silt volume is calculated using Prismoidal formula and the quantity is considered for estimation.

**•Other Items:**

Locations where indiscriminate dumping of debris, garbage and solid waste materials noticed inside the storm drain and also breakage in the drain walls along with its measurements were identified during reconnaissance survey.

## 2.6 DETAILS OF EXISTING STORM DRAINS IN CHALLAGHATTA VALLEY :

Challaghatta Valley comprises of two main drains known as Challaghatta main drain and Ulsoor drain, the first of which starts from Vasanthnagar and terminates at Bellandur tank. The second main drain known as Ulsoor drain starts from Munireddypalya and terminates at Ulsoor Lake. The details of these primary and secondary storm drains is as mentioned in earlier sections of this chapter.

### 2.6.1 OBSERVATIONS DURING SITE INVESTIGATION OF CHALLAGHATTA MAIN VALLEY PRIMARY STORM DRAIN (C100):

For ease of assessment Challaghatta valley nalla is divided into 11 segments. The details of each segment is as discussed below :

**Segment - 1** (Chainage length 0.00 to 1000.00 m.):
(Vasanthanagar Upto Queens Road):

Starts from a very congested residential area near Vasanthnagar and continues upto Queens Road. As per the preliminary investigations made by the consultants, it was noticed that localities surrounding Bangalore Palace grounds, Vasanthnagar, Millers tank area and also area adjoining to Cunningham road forms the part of contributory areas for this section.

The width of drainage channel varies from 2.5 m to 5 m & depth varies from 1.5 to 2.0 m. and is having masonry walls on either sides, the condition of the side walls is in good to moderate condition.

- The drainage channel is covered with RCC deck slab from 1st Cross Vasanthanagar upto Corporation. dobhi ghat and with B.S. Slabs from Millers road upto Millers tank bund road.

- The drain reach inside dobhi ghat is very narrow and inadequate to cater, even for present hydraulic design flow.

- The existing tertiary drains connecting to the primary drain near Vasanthanagar are not designed and constructed as per standards.

- Large quantity of sewage is being contributed to this primary drain through the existing tertiary drains.

- The drainage channel inside Ambedkar bhavan is covered with RCC Slab with reduced drain section.

- Large quantity of construction debris have been dumped over the drain and also vegetal growth is observed behind Mahaveer Jain hospital.

- The existing culverts constructed across storm drain near Millers road and Millers tank bund road are obstructing free flow of water due to inadequate vent space.

- Sewage/waste water generated from badminton association is being directly discharged into the drain and also the approach bridges constructed across the drain for the stadium and also its adjoining property i.e., Indian Council for Social welfare is drastically obstructing the flow.

- Sewer line of 450 mm dia. has been laid and manholes of 1.2 m. dia. which are above drain bed level are noticed inside the drainage channel in this reach.

- The existing drain bed in this reach is in natural condition, and also there is scope for regrading the bed in this reach.

- Dumping of solid waste, garbage, silt deposition and vegetation growth is noticed at many places inside the channel, and also near the vents of cross drains, thereby causing obstruction for the free flow of water in the channel.

- The nalla throughout its stretch has service road on either sides or on one side and residential / commercial buildings on the other side of the channel.

- The drainage channel has 3 culverts in this reach.

**Segment - 2** (Change length 1000.00 m. to 2000.00 m.)
(Queens Road upto Juma Masjid Road):

This part of the drain starts from Queen's road and continues upto Juma Masjid road. As per the preliminary investigations made by the consultants, it was noticed that the localities surrounding Rajiv Gandhi colony, corporation colony, part of Shivajinagar, part of Nehrupuram, Part of Bamboo Bazar area forms the contributory areas for this section.

The width of drainage channel varies from 4.5 m to 7.5 m & depth varies from 1.8 to 2.2 m. and is having masonry walls on either sides, the condition of the side walls is in good to moderate condition.

- This reach of drain is an open drain upto Russell market area and further shops have been constructed over the drain, which intern is obstructing free flow of water.

- The condition of side walls near St. Xavier high school is in moderate condition, which requires rehabilitation .

- The drain reach near Broadway Road upto Seppings Road is very narrow

and inadequate to cater even for present hydraulic design flow.

- Large number of openings have been made to the parapet wall to allow rain water to enter into the main drain.

- The existing tertiary drains connecting to the primary drain near Shivajinagar area is not designed and constructed as per standards.

- Large quantity of sewage is being contributed to this primary drain through the existing tertiary drains.

- The existing culverts constructed across storm drain near Old bamboo bazar road, Charminar Road, Juma Masjid Road are obstructing free flow of water due to inadequate vent space.

- Sewer line of 450 mm dia. has been laid and manholes of 1.2 m. dia. which are above drain bed level are noticed inside the drainage channel in this reach.

- The existing drain bed in this reach is in natural condition, and also there is scope for regrading the bed in this reach.

- Dumping of solid waste, garbage, silt deposition and vegetation growth is noticed at many places inside the channel and also near the vents of cross drains, thereby causing obstruction for the free flow of water in the channel.

- The nalla throughout its stretch has service road on either side of the channel.

- The drainage channel has 7 culverts and number of foot bridges in this reach and as such these foot bridges are not obstructing free flow of water.

- At few places the condition of wall is in poor condition and which requires

reconstruction and also at some places rehabilatation.

•Large number of utility crossing are observed in this reach of drain.

•The tertiary drains near Police quarters and corporation colony are discharging large quantity of sewage into storm drain.

**Segment - 3** (Chainage length 2000.00 m to 3000.00 m.)
(Juma Masjid Road upto A.S.M. Road near Ajantha theatre)

This part of the drain starts from Juma Masjid Road and continues upto A.S.M. Road near Ajantha theatre. As per the preliminary investigations made by the consultants, it has been noticed that localities surrounding Russel market, part of Shivajinagar, part of Nehrupuram, Part of Bamboo Bazar, Bharathi nagar, Shivanchetti Garden, Commercial Street area forms the part of contributory areas for this section.

The width of drainage channel varies from 5 m to 10 m and depth 1.8 to 2.4 m. and is having masonry walls on both the sides. The condition of the side walls is in good to moderate condition.

•In the initial stretch of this drain, shops have been constructed over the drain and further it is an open drain.

•The drain reach near Kamaraj Road and St. Johns Road is narrow and there is scope for widening the drain in this reach.

•The existing tertiary drains connecting to the primary drain near Narayan Pillai street, old post office road, Jewellers street are not designed and constructed as per standards.

•The existing culverts constructed across storm drain near Sepping's Road,

Kamaraj Road and St. Johns Road are obstructing free flow of water due to inadequate vent space.

- Few temporary shops, which are abutting to the drain wall have been constructed near Makkan Road.

- Large number of toilet blocks have been constructed over the drain and intern raw sewage from these toilet blocks are being discharged into this storm drain

- Large quantity of garbage and solid waste materials are stacked adjacent to storm drain near Seppings road and intern these waste materials find their way into storm drain and obstructs free flow of water.

- Sewer line of 600 mm dia. has been laid and manholes of 1.4 m. dia. which are above drain bed level are noticed inside the drainage channel in this reach.

- The existing drain bed in this reach is in natural condition and there is scope for deepening the drain bed in this reach.

- Large number of openings have been made in the parapet wall to allow storm water from road to enter into the main drain.

- Dumping of solid waste, garbage, silt deposition and vegetation growth is noticed at many places inside the channel, and also near the vents of cross drains, thereby causing obstruction for the free flow of water in the channel.

- The nalla throughout its stretch has service road on either side of the channel.

- At few places, the walls are in poor condition and which requires reconstruction and also at some places rehabilitation.

•Large number of utility crossing are observed in this reach of drain.

•Large quantity of sewage is being contributed to this primary drain through the existing tertiary drains.

•The drainage channel has 6 culverts and number of foot bridges in this reach.

**Segment - 4** (Chainage length 3000.00 m to 4000.00 m.)
(A.S.M. Road near Ajantha theatre upto Kensington Road)

This reach of storm water drain starts from A.S.M. Road near Ajantha theatre and continues upto Kensington Road. As per the preliminary investigations made by the consultants, it was noticed that localities surrounding Dickinson Road, A.S.M. street, RBAMNS College, Gangadar shetty Road area forms the part of contributory areas for this section.

The width of drainage channel approximately varies from 8 m to 12 m & depth varies from 2.4 to 2.6 m. Masonry walls are constructed on either side of the channel and it is in good to moderate condition. Further, waste weir of Ulsoor tank is situated opposite to Gurudwara and overflow from Ulsoor tank to Challaghata valley is also noticed at that location.

•This reach of drain is an open drain.

•The drain reach near RBANMS College is narrow and there is scope for widening the drain in this reach.

•The existing tertiary drains connecting to the primary drain near ASM Road and Gangadar shetty Road are not designed and constructed as per standards.

•The existing weir constructed across storm drain near RBANMS college is obstructing free flow of water and also causing accumulation of solid waste materials.

•The existing culverts constructed across storm drain near A.S.M Road is

obstructing free flow of water due to inadequate vent space.

- Accumulation of large quantity of silt, garbage and solid waste materials can be noticed near RBANMS College.

- Sewer line of 900 mm dia. has been laid and manholes of 1.6 m. dia. which are above drain bed level are noticed inside the drainage channel in this reach.

- The existing drain bed in this reach is almost flat and also in natural condition, there is scope for deepening the drain bed in this reach.

- Large quantity of vegetation growth is noticed at many places inside the channel i.e., opposite to Ajantha theatre and also near RBANMS college.,

- The nalla throughout its stretch has service road on one side and tank bund on the other side.

- At few places, the wall is in poor condition and which requires reconstruction and also at some places rehabilitation.

- Large quantity of debris are being dumped into drainage channel near Ulsoor lake

- Large number of utility crossing are observed in this reach of drain.

- The drainage channel has 2 culverts in this reach.

**Segment - 5** (Chainage length 4000.00 m to 5000.00 m.)
(Kensington Road upto Old Madras Road)

This section of the reach starts from Kensinton Road and continues upto Old Madras Road. As per the preliminary investigations made by the consultants, it was noticed that localities surrounding Sweepers colony, Murphy town,

Munivenkatappa garden, Gupta layout, Hoysala nagar, and part of Ulsoor area forms the part of contributory areas for this section.

The width of drainage channel approximately varies from 11 m. to 15 m. & depth varies from 2 to 2.5 m. Masonry walls have been constructed on either side of the channel, the condition of the side walls is in good to moderate condition.

- This reach of drain is an open drain.

- The drain reach behind Gurudwara is having a rocky strata, due to which water/sewage is stagnating in the storm drain and also large quantity of vegetal growth and solid waste accumulation can be noticed opposite to Gurudwara.

- The drain reach adjacent to Gurudwara is covered and a school is being run over the drain by Gurudwara association.

- The existing bridge constructed across Kensington road has been constructed in 2 different stages. Where portion of the bridge i.e, towards Gangadar chetty road is having RCC columns and the other portion of the bridge i.e., main carriage way is resting on masonry piers. The arrangement of columns and piers are obstructing free flow of water and also causing hindrance for the maintenance of drain near the bridge portion.

- Slum development is noticed adjacent to drain near Munivenkapappa Garden and also both liquid and solid wastes generated by the slum dwellers are being discharged into storm drain.

- The existing drain bed in this reach is almost flat and also in natural condition, there is scope for deepening the drain bed in this reach.

- Large quantity of silt accumulation and vegetation growth is noticed near the fringe of the drain at many places.

- The width of the drainage channel opposite to Murphy town market is reduced, and which needs to be widened.

- The nalla throughout its stretch has service road on one side (i.e, left hand side) and densely built residential building, which are abutting to drain wall on the other side (right hand side).

- At few places, the wall is in poor condition and which requires reconstruction and also at some places rehabilitation.

- Large quantity of garbage dumpings are noticed at foot bridge locations near Guptha layout.

- Large number of utility crossing and also few manhole are observed in this reach.

- Large number of sewer outlets are noticed from residential buildings in this reach.

- The drainage channel has 3 culverts and 4 foot bridges in this reach.

**Segment - 6** (Chainage length 5000.00 m to 6000.00 m.)
(Old Madras Road upto Saraswathipura)

This section of the drain starts from Old Madras Road and continues upto Saraswathipura. As per the preliminary investigations made by the consultant, it is noticed that localities surrounding Shammana Gowda layout, Doddaiah layout, Lakshmipura, Lal Bahadur Shastrinagar and Jogupalya area forms part of contributory areas for this section.

The width of drainage channel approximately varies from 15 m to 18 m. & depth varies from 2.5 to 2.8 m. Masonry walls have been constructed on both sides and the condition of the side walls are in good to moderate condition.

- This reach of drain is an open drain.

- Large quantity of silt accumulation and vegetation growth is noticed near the fringe of the drain at many places.

- The width of the drainage channel near Lakshmipura is reduced, and which needs to be widened.

- The nalla throughout its stretch has service road on one side (i.e, Right hand side) and densely built residential building, which are abutting to drain wall on the other side.

- In general condition of drain wall is in good condition. Except at few places, it requires minor rehabilitation.

- The existing drain bed in this reach is almost flat and also in natural condition, there is scope for deepening the drain bed in this reach.

- Large number of utility crossing and also few manholes are observed in this reach.

- The drainage channel has 1 foot bridges near Lakshmipura in this reach.

- A secondary drain (C105) from Indiranagar 1$^{st}$ Stage confluence with this primary drain near Lakshmipura.

- The existing tertiary drains at Jogupalya area are having inadequate size, silted and also not properly networked, hence it is causing localized flooding problems.

- Large number of sewer outlets from residential and commercial establishments are noticed in this reach.

**Segment - 7** (Chainage length 6000.00 m to 7000.00 m.)
(Saraswathipura upto Domlur II $^{nd}$ Stage)

This reach of the drain starts from Saraswathipura and continues upto Domlur II Stage near TERI. As per the preliminary investigations made by

the consultant, it is noticed that localities surrounding Cambridge layout, Gouthampura, Jeevankendra layout, Mottappapalya, Someshwarapura, part of Domlur and Indiranagar area forms the part of contributory areas for this section.

The width of drainage channel approximately varies from 18 m to 24 m. & depth varies from 2.2 to 3.0 m. Masonry walls have been constructed on both the sides and the condition of the side walls is in good to moderate condition.

- In this stretch the drain is in open condition.

- Slum development is noticed adjacent to drain near Cambridge layout bridge and also both liquid and solid wastes generated by the slum dwellers are being discharged into storm drain.

- Manholes constructed below the existing low level bridge (adjacent to cambridge layout bridge) is obstructing free flow of water.

- The existing drain bed in this reach is almost flat and also in natural condition. There is a scope for deepening the drain bed in this reach.

- Large quantity of silt accumulation and vegetation growth is noticed near the fringe of the drain at many places.

- The width of the drainage channel near Domlur 2$^{nd}$ Stage bridge location (RCC hume pipe location) is reduced, and which needs to be widened.

- The nalla throughout its stretch has few open lands on one side and residential building and appartments, which are abutting to drain wall on the other side (i.e., right hand side).

- The existing RCC hume pipe culverts constructed across the drain is obstructing free flow of water near Domlur 2$^{nd}$ Stage

- Large number of utility crossing and also few manholes are observed in this

reach.

•The drainage channel has 2 culverts in this reach.

**Segment - 8** (Chainage length 7000.00 m to 8000.00 m.)
(Domlur II Stage upto Diamond District Apartments)

This section of the drain starts from Domlur II Stage and continues upto Diamond District Appartments near Royal Orchid park plaza hotel. As per the preliminary investigations made by the consultant, it is noticed that localities surrounding part of Indiranagar, Domlur 2nd Stage, Airport Road area, Kodihalli forms the part of contributory areas for this section.
The width of drainage channel approximately varies from 16 m to 26 m. & depth varies from 2.6m to 3.0 m. Masonry walls have been constructed on both the sides and the condition of the side walls is in good to moderate.

•The existing drain bed in this reach is having gentle slope and also in natural condition. There is a scope for deepening the drain bed in this reach.

•Large quantity of silt accumulation and vegetation growth is noticed near the fringe of the drain at many places.

•The width of the drainage channel near Indiranagar bridge location is reduced and which needs to be widened.

•The nalla throughout its stretch has open lands on either side of the channel upto Airport road and further residential apartments buildings have been constructed on either side of the channel.

•Large number of utility crossing and few manholes are observed in this reach.

•The drainage channel has 2 culverts in this reach.

- 1800 mm dia. CI sewer pipe line is crossing the drain behind Diamond district apartment and also it is obstructing free flow of water.

**Segment - 9** (Chainage length 8000.00 m to 9000.00 m.)
(Diamond District Apartments upto K.G.A. Golf Club)

This section of the drain starts from Diamond District apartments and continues upto K.G.A. Golf Club near Texas instruments.

Stone pitching is done on either side of the drain for a height of 1.5 m. The condition of the side walls is in good to moderate. The width of drainage channel approx. varies from 16 m to 28 m. & depth varies from 2.2 to 2.6 m.

- This reach of drain is in open condition.

- The natural coarse of drain has been altered in this reach.

- The existing drain bed in this reach is having gentle slope and also in natural condition. There is a scope for deepening the drain bed in this reach.

- Large quantity of silt accumulation and vegetation growth is noticed near the fringe of the drain at many places.

- Few tertiary drains (i.e, from Ring Road Side) join this primary drain near Park plaza hotel, which needs to be desilted and widened for proper functionality.
- Large quantity of desilted materials has been stacked in the middle of the drain and left without removing near K.G.A. Club.

- The width of the drainage channel adjacent to K.G.A golf club is reduced and which needs to be widened.

- The drainage channel has 2 culverts in this reach.

**Segment - 10** (Chainage length 9000.00 m to 10000.00 m.)
(K.G.A. Golf Club upto Challaghatta Main Road)

This section of the drain starts from K.G.A. Golf Club near Texas instruments and further it flows inside Airport premises and also under the existing runway and continues upto Challaghatta main road i.e., behind Airport compound.

As per the preliminary investigation Jeevanbhimanagar, K.R. Garden, KGA Golf club and Challaghatta village forms part of contributory areas for this reach of drain.

This reach of the drain is in natural condition. The width of drainage channel approximately varies from 16 m to 30 m. & depth varies from 2.0 to 2.8 m.

- The natural coarse of drain has been altered in this reach.

- The existing culvert constructed under the runway is silted and size is also very much inadequate.

- The existing drain bed in this reach is almost flat and also in natural condition and there is a scope for deepening the drain bed in this reach.

- New bypass drain has been constructed by the Airport authorities to divert the flow from the runway area. But, due to silt accumulation, vegetal growth and moderate slope there is very small flow of water is flowing in this drain.

- Secondary drain (C101) from Jeevanbhimanagar and tertiary drains from K.R. Garden area are joining this primary drain inside the Airport area.

- Large quantity of silt, solid waste accumulation and vegetation growth is noticed near the fringe of the drain at many places.

- The drainage channel has 1 culverts in this reach.

- Large number of utility crossings are noticed near Wind tunnel road bridge location.

- A large size grating screen has been placed in the compound wall of Airport across the drain where floating matters getting collected obstructs the free flow of water.

**Segment - 11** (Chainage length 10,000.00 m to 12,000.00 m.)
(Challaghatta Main Road upto Bellandur tank)

This section of the drain starts from Challaghatta Main Road and continues upto a location near Bellandur tank.

These is no defined drain available in these reach and also it is situated in marshy land.

### 2.6.2 OBSERVATIONS DURING SITE INVESTIGATION OF SECONDARY DRAINS IN CHALLAGHATTA MAIN VALLEY:

#### 2.6.2.1 Murugeshpalya Drain (C101):

(Anandanagar upto Challaghatta), (Chainage length of about 1896.00 m.)

This section of the drain starts from a place near Anandanagar and flows through HAL Airport before confluenceing with the main drain. As per the preliminary investigations, it is noticed that localities surrounding

Anandanagar, Sudhamanagar, Shivalingaiah colony, Nanjareddy colony, BDA colony, Airport Road, Murugeshpalya, Konen Agrahara, Cauverynagar, Manjunatha layout, Vinayakanagar and K.R. Garden forms part of contributory areas for this section.

The width of drainage channel is about 1.5 m to 3 m & depth varies from 1.2 m to 2 m in this section.

- This reach of drain is a covered drain except near Airport Road.

- Slum development is noticed adjacent to drain near Sudhamanagar and Sreeramnagar. Further, both liquid and solid wastes generated by the slum dwellers are being discharged into storm drain.

- The existing drain bed near the slum areas are silted heavily.

- The width of the drainage channel near Muniswamy layout, Papaiah layout, Airport road and near Sreeramnagar is drastically reduced and which needs to be widened.

- The nalla throughout its stretch has densely built residential building which are abutting to drain wall on the either side.

- At few places, the condition of wall is poor which requires reconstruction and also at some places rehabilitation.

- Large number of utility crossings and also few manholes are observed in this reach.

- Large number of sewer outlets are noticed from residential buildings in this reach.

- The locality adjacent to SWD (i.e., K.R. Garden) has been developed well below the HFL level of the SWD and intern causing localized flooding and also the drain reach between K.R. Garden and Airport complex is in

natural condition.

But as a part of this remodelling project, BMP has taken up construction of RCC box drain with provisions like desilting openings, inspection openings, manholes for house/lateral sewer connections and also for small dia. utility crossings across the drain in this reach.

•Sewer line of about 450 mm dia. and manholes at regular intervals has been constructed all along SWD near Sir. M. Vishveshwariah Composite college upto Airport compound.

•Further the drain flows inside Airport premises and also under existing runway.

Due to silt accumulation, dense vegetal growth and also due to inadequate vent size of existing culvert (i.e., under the runway) flow is being drastically obstructed.

•600 mm. dia. C.I. sewer pipe line is proposed to be laid across storm drain near Airport compound.

**2.6.2.2 Shastrinagar Drain (C102)**

(Sweepers colony upto Shastrinagar), (Chainage length of about 1600.00 m.)

This section of the drain starts from a place near Kadariyanapalya and flows Shastrinagar before confluenceing with the challaghatta main drain. As per the preliminary investigations, it is noticed that localities surrounding Part of Indiranagar, Shastarinagar and Lakshmipura forms part of contributory areas for this section.

The width of drainage channel is about 1.2 m to 2 m & depth varies from 1.2 to 1.6 m in this section. Masonry wall has been constructed in this reach. The condition of the wall is in good to moderate.

•Initial reaches of this drain lies within defence area (i.e., near Vivekananda road).

- This section of the drain is an open drain upto Lakshmipura and beyond Lakshmipura upto primary drain location is a covered drain.

- Large quantity of silt accumulation and vegetal growth is observed inside the drain near C.M.H. road.

- At few places the condition of wall is in moderate and which requires reconstruction and also at some other places only minor rehabilitation.

- This stretch has residential buildings and apartments on either side of the channel. Large quantity of sewage flow, silt and garbage dump is noticed at many places.

#### 2.6.2.3 Krishnamurthynagar Drain (C103)

(Krishnamurthynagar to Kadariyanapalya tank),(Chainage length of 1600 m.)

This section of the drain starts from a place near Kadarayanapalya and confluence's with the Shastarinagar drain near Kadariyanapalya tank. As per the preliminary investigations it is noticed that this reach of drain lies within defence area.

#### 2.6.2.4 Kadariyanapalya Drain (C104)

(Kadariyanapalya upto Kadariyanapalya tank),(Chainage length of 2500 m.)

This section of the drain starts from a place near N.G.E.F and confluence's with the Shastarinagar drain near Kadariyanapalya tank. As per the preliminary investigations made by the consultant, it is noticed that localities surrounding Kadariyanapalya and part of Krishanmurthynagar forms part of contributory areas for this section. But this reach of drain lies within defence area.

### 2.6.2.5 ISRO Complex Drain (C105)

(Jeevanbhimanagar upto Kodihalli), (Chainage length of about 3500.00 m.)

This section of the drain starts from a place near Jeevanbhimanagar and flows through ISRO complex before confluenceing with the main drain near Airport road.

As per the preliminary investigations, it is noticed that localities surrounding Jeevanbhimanagar, HAL 2nd & 3rd Stage, ISRO Complex and Kodihalli forms part of contributory areas for this section.

The width of drainage channel is about 2.5 m to 6 m & depth varies from 1.2 to 1.8 m. in this section. This stretch has residential buildings and apartments on either side of the channel. The drain reach inside ISRO complex is maintained by ISRO.

- This reach of drain is an open drain.

- The natural coarse of drain has been altered in this reach.

- The existing drain bed in this reach is in natural condition and there is scope for deepening the drain bed in this reach.

- Further, the drain flows inside I.S.R.O. Complex, where it is in lined condition. A trash barrier/steel grating has been installation by I.S.R.O. authorities due to this all the solid waste and water gets accumulated and cause localised flooding problems in the adjacent locality.

- Large quantity of silt, vegetal growth and debris dumps are observed inside the drain i.e., behind I.S.R.O. Complex.

- The drain flows between residential buildings where the drain size is reduced, but there is some scope for deepening the drain bed.

- Large quantity of raw sewage is being discharged into this storm drain from the nearby slum and Kodihalli village.

- Further the drain reach near Kodihalli Village / Domlur, RCC drain walls have been constructed and these walls require minor rehabilitation works.

- Large quantity of silt, solid waste accumulation and vegetation growth is noticed near the fringe of the drain at many places.

- Large number of utility crossings are noticed near Airport road bridge location.

- Large quantity of sewage flow, silt and garbage dump is noticed at many places.

#### 2.6.2.6 Thippasandra Drain (C106)

(New Thippasandra upto ISRO Complex), (Chainage length of 650.00 m.)

This section of the drain starts from a place near New Thippasandra and joins the secondary drain C105 near ISRO complex. As per the preliminary investigations made by the consultants, it was noticed that localities surrounding New Thippasandra and part of Jeevanbhimanagar forms part of contributory areas for this section.

The width of drainage channel is about 2 m to 4 m & depth varies from 1.4 to 1.6 m. in this section. This stretch has residential buildings and apartments on one side and Thippasandra main road on the other.

- This drain reach near Thippasandra main road is covered by BS slab.

- Large quantity of silt and garbage dump is noticed at many places.

- Masonry sidewall have been constructed all along the channel on either side. The condition of the side walls is in good condition.

#### 2.6.2.7 Malleshappanapalya Drain (C107)

(Garmantakanapalya upto Doddanekundi Tank),(Chainage length of 900.00 m.)

This section of the drain starts from a place near Garmanthanapalya and confluences with the Doddanekundi tank. As per the preliminary investigations made by the consultant, it is noticed that localities surrounding Garmanthanapalya, Malleshappanapalya and part of Doddenakundi forms part of contributory areas for this section. But during reconnaissance survey it is observed that this reach of drain lies beyond BMP boundary.

### 2.6.3 OBSERVATIONS DURING SITE INVESTIGATION OF ULSOOR VALLEY PRIMARY STORM DRAIN (C200):

For ease of assessment Ulsoor valley nalla is divided into 4 segments. The details of each segment is as discussed below :

**Segment - 1** (Chainage length 0.00 to 1000.00 m.):
(J.C. Nagar Main Road Upto Ramakka Block Main Road):

This stretch starts from a very congested residential area near J.C. Nagar and continues upto Ramakka Block main road. As per the preliminary investigations made by the consultant, it is noticed that localities surrounding Anchappa Garden, Kempaiah Block, Anjanappa Garden, Marappa Garden, Muddamma Garden, Gundappa Garden, Chinnappa Garden, Munireddypalya and Krishnappa Garden forms the part of contributory areas for this section.

The width of drainage channel varies from 4.0 m to 6 m & depth varies from 1.8 to 2.0 m. and is having masonry walls on either sides, the condition of the side walls is in good to moderate condition.

- The drainage channel is covered with RCC deck slab near J.C. Nagar main road and provision for construction of shops over the drain has been made.

- The drain reach near Ramgeetha block and Krishnammanagar is very narrow and needs to be widened.

- Existing drain wall at few places are in moderate condition and it requires reconstruction.

- BWSSB manholes have been constructed exactly at the vent locations of culverts at many locations near Krishnammanagar.

- Drain reach near Kempiah block (i.e., near Mosque) is covered with RCC slab.

- The existing tertiary drains connecting to the primary drain near Kempaiah Block, Anjanappa Garden, Marappa Garden, Muddamma Garden, Gundappa Garden, Chinnappa Garden, Munireddypalya and Krishnappa Garden are not designed and constructed as per standards.

- The existing culverts constructed across storm drain near Krishnammanagar and Muddammanagar are obstructing free flow of water due to inadequate vent space.

- Large quantity of construction debris have been dumped inside the drainage channel can be noticed at many places.

- Near Aiyappa Swamy temple, a portion of the residential building has been constructed inside the drain area. Further, a KPTCL transformer also has been installed in the drain area.
- Sewer line of 300 & 450 mm dia. has been laid and manholes of 1.2 m. dia. which are above drain bed level (upto a height of about 1.2 to 1.8 m.) are noticed inside the drainage channel in this reach.

- The existing drain bed in this reach is in natural condition, and also there is scope for regrading the bed in this reach.

- Dumping of solid waste, garbage, silt deposition and vegetation growth is noticed at many places inside the channel and also near the vents of cross drains thereby causing obstruction for the free flow of water in the channel.

- The nalla throughout its stretch has residential / commercial buildings on either side of the channel.

- Large number of sewer outlets on either side have been connected to sewer pipe lines which are laid inside the drainage channel in this reach.

- This reach of drain has 12 culverts

**Segment - 2** (Chainage length 1000.00 to 2000.00 m.):
(Ramakka Block Main Road upto S.K. Garden):

Starts from Ramakka Block Main Road and continues upto S.K. Garden main road near Pottery town. As per the preliminary investigations made by the consultant, it is noticed that localities surrounding S.K. Garden, I.T.I. Colony and adjoining defence area forms the part of contributory areas for this section.

The width of drainage channel varies from 5 m. to 8 m. & depth varies from 2.0 to 2.4 m. and is having masonry walls on either side, the condition of the side walls is in good to moderate.

- This reach of drain is in open condition.

- The drain reach near Muddamma garden and I.T.I. Colony is narrow and needs to be widened. But, there is scope for construction of new drain at 13$^{th}$ cross Muddamma garden Extention.

- Existing drain wall at few places are in moderate condition and it requires reconstruction.

- The existing tertiary drains connecting to the primary drain near Muddamma Garden, I.T.I Colony and S.K. Garden are not designed and constructed as per standards.

- The existing culverts constructed across storm drain near S.K. Garden and Pottery town are obstructing free flow of water due to inadequate vent space.

- Steel grating has been provided to existing storm drain near S.K. Garden.

- The drain reach adjacent to defence land near S.K. Garden main road is narrow and also large quantity of debris and garbage dumps are noticed.

- Large quantity of construction debris have been dumped inside the drainage channel can be noticed at many places.

- Sewer line of 300 & 450 mm dia. has been laid and manholes of 1.2 m. dia. which are above drain bed level (upto a height of about 1.2 to 1.8 m.) are noticed inside the drainage channel in this reach.

- The existing drain bed in this reach is in natural condition and also there is a scope for regrading the bed in this reach.

- Dumping of solid waste, garbage, silt deposition and vegetation growth is noticed at many places inside the channel, and also near the vents of cross drains, thereby causing obstruction for the free flow of water in the channel.

- The nalla throughout the stretch has residential buildings on either side of the channel.

- Large number of sewer outlets on either side have been connected to sewer pipe lines which are laid inside the drainage channel in this reach.

- This reach of drain has 8 culverts.

**Segment - 3** (Chainage length 2000.00 to 3000.00 m.):
(S.K. Garden Main Road upto Stephen's cross road):

Starts from S.K. Garden Main Road and continues upto Stephen's cross road near Frazer town. As per the preliminary investigations made by the consultant, it is noticed that localities surrounding part of Pulikeshi nagar, Frazer town, Cleveland town, and Richards town forms the part of contributory areas for this section.

The width of drainage channel varies from 8 m. to 12 m & depth varies from 2.0 to 2.2 m. and is having masonry walls on either sides, the condition of the side walls is in good to moderate condition.

•This reach of drain is in open condition.

•The drain reach near Bore bank road (near Railway bridge) is narrow and needs to be widened.

•Existing drain wall at few places are in moderate condition and it requires reconstruction.

•The existing tertiary drains connecting to the primary drain near Frazer town not designed and constructed as per standards.

•Large quantity of construction debris have been dumped inside the drainage channel can be noticed at many places near tannery road.

Sewer lines of 300 & 450 mm dia. has been laid and manholes of 1.2 m. dia. which are above drain bed level (upto a height of about 1.2 to 1.8 m.) are noticed inside the drainage channel in this reach.

•Some section of the drain wall in this reach is in moderate condition and it requires minor rehabilitation.

•The existing drain bed in this reach is in natural condition and also there is scope for regrading the bed in this reach.

•Dumping of solid waste, garbage, silt deposition and vegetation growth is noticed at many places inside the channel and also near cross drains, thereby causing obstruction for the free flow of water in the channel.

•The nalla throughout its stretch has residential buildings on either side of the channel.

- Large number of sewer outlets on either side have been connected to sewer pipe lines which are laid inside the drainage channel in this reach.

- Silt trap has been constructed near Mosque road and it is totally silted and causing stagnation of water and intern causing unhygenic situation to the adjoining residential areas.

- Large number of utility crossing are noticed at many places in this reach

- This reach of drain has 5 culverts.

**Segment - 4** (Chainage length 3000.00 to 4100.00 m.):
(Stephen's cross road upto Ulsoor tank):

Starts from Stephen's cross Road and continues upto Ulsoor lake. As per the preliminary investigations made by the consultant, it was noticed that localities surrounding part of Frazer town, Sindhi colony and Cox town forms the part of contributory areas for this section.
The width of drainage channel varies from 10 m. to 14 m & depth varies from 2.0 to 2.2 m. and is having masonry walls on either sides, the condition of the side walls is in good to moderate condition.

- This reach of drain is an open drain.

- The drain reach near Sindhi colony is narrow and needs to be widened.

- Existing drain wall at few places are in moderate condition and it requires reconstruction.

- The existing tertiary drains connecting to the primary drain near Frazer town are not designed and constructed as per standards.

- Sewer line of 450 mm dia. has been laid and manholes of 1.2 m. dia. which are above drain bed level (upto a height of about 1.2 to 1.8 m.) are noticed inside the drainage channel in this reach.

- The existing drain bed is almost flat and also it is in natural condition.

- Dumping of solid waste, garbage, silt deposition and vegetation growth is noticed at many places inside the channel, and also near the vents of cross drains, thereby causing obstruction for the free flow of water in the channel.

- The nalla throughout its stretch has service road on one side and open ground on the other side of the channel.

- Some section of the drain wall in this reach is in moderate condition and it requires minor rehabilitation.

- Silt trap has been constructed near Asseye road and it is totally silted and causing stagnation of water and also intern causing unhygenic situation to the adjoining residential areas.

- Large number of utility crossing are noticed at many places in this reach.

- This reach of drain has 4 culverts.

- Large quantity of debris have been dumped inside the drain by the military authorities, behind corporation ward office near Ulsoor lake.

### 2.6.4 OBSERVATIONS DURING SITE INVESTIGATION OF SECONDARY STORM DRAINS IN ULSOOR VALLEY:

#### 2.6.4.1 Ganesh temple Drain (C201):

(Ganesh temple upto MEG Centre), (Chainage length of about 250.00 m.)

This section of the drain starts from the back side of Ulsoor lake near Ganesh temple and continues upto MEG Centre. Since the vent size of the bridge near the temple is inadequate and the excess water from the main drain is diverted through this drain near the temple and further joins Ulsoor lake.

- The width of drainage channel is about 4 m. to 6 m. & depth varies from 1.6 to 1.8 m. in this section.

- Stone revetment has been provided on either side and it is in moderate condition.

- This section of the drain bed is in natural condition.

- This stretch has residential buildings and commercial establishments on one side and military grounds on the other side of the drain.

**2.6.4.2 Cox Town Drain (C202):**

(Richard's Town upto Gymkhana Ground), (Chainage length of about 1150.00 m.)

This reach of the drain starts from Richard's Town and continues upto Gymkhana Ground near Assaya road. As per the preliminary investigations made by the consultants, it was noticed that localities surrounding Richard's Town, part of Frazer town, Cox town and Cooke town forms the part of contributory areas for this section.

The width of drainage channel varies from 1.5 m to 4.2 m & depth varies from 2 to 2.2 m. and is having masonry walls on either sides of the drain. The condition of the side walls is in moderate condition.

- This reach of drain is an open drain except near Frazer town police station (Lazer Road).

- The drain reach opposite to Frazer town police station is covered and also narrow. It needs to be widened.

- Sewer line of 300 mm dia. and construction of manholes of 1.2 m. dia. is noticed at many places inside the drain.

- Large quantity of debris have been dumped inside the drain near KPTCL office can be noticed. and also solid waste dumps and silt depositions are

noticed at many places inside the channel.

- The nalla throughout its stretch has open space, residential and commercial establishments on either side of the drain.

- Silt trap has been constructed near Asseye road, and it is totally silted and causing stagnation of water and also intern causing unhygenic situation to the adjoining residential areas.

- Some section of the drain wall in this reach is in moderate condition and it requires minor rehabilitation.

- The drain bed in this reach is in natural condition, and also there is some scope for regrading the drain bed.

- Large number of utility crossing are noticed at many places in this reach

### 2.6.4.3 Sagayapuram Drain (C203):

(Sagayapuram upto Cleveland town), (Chainage length of about 725.00 m.)

This reach of the drain starts from Sagayapuram and continues upto Cleveland town, before confluenceing with the main drain. As per the preliminary investigations made by the consultants, it was noticed that localities surrounding Sagayapuram, Tannery road, part of Richard's town and Cleveland town, forms the part of contributory areas for this section.

The drain reach between Davis road and Viviani road is covered with BS slab. The width of drainage channel varies from 1.5 m. to 4 m. & depth varies from 1.6 to 2 m. and is having masonry walls on either sides of the drain. The condition of the side walls is in moderate condition.

- This reach of drain is an open drain, except near Tannery Road.

- The drain reach, opposite to K.M.F.C. market, (near Tannery Road) upto railway bridge is covered and also narrow. It needs to be widened.

- Sewer line of 250 mm dia. and construction of manholes of 1.2 m. dia. is noticed at many places inside the drain.

- Large quantity of silt and garbage accumulation can be noticed inside the drain near Roger's road and its adjoining slum area.

- The nalla throughout its stretch has residential buildings on either side of the drain.

- Some section of the drain wall in this reach is in moderate condition and it requires minor rehabilitation.

- The drain bed in this reach is in natural condition, and also there is some scope for regrading the drain bed.

- Large number of utility crossings are noticed at many places in this reach
- Large quantity of sewage flow is noticed inside the drain near Tannery road slum area.

#### 2.6.4.4 Jeevanahalli Drain (C204)

(Jeevanahalli upto Ulsoor Lake), (Chainage length of about 2000.00 m.)

This reach of the drain starts from a place near Jeevanahalli and continues upto M.E.G. centre before confluencing into Ulsoor lake. As per the preliminary investigations made by the consultants, it is noticed that localities surrounding Sanjeevappa layout, Kandaswamy garden, BDA Qtrs. I.T.C Colony, K.H.B. Colony, Jeevanahalli and M.E.G. defence area forms the part of contributory areas for this section.

Recently as part of B.M.P's Ulsoor lake cleaning programme, a steel grating has been installed inside the drain by BMP near MEG centre and also near Ganesh temple to prevent entry of solid waste into Ulsoor lake,. The width of drainage channel varies from 1.5 m to 4.2 m & depth varies from 1.4 to 2.2 m. and is having masonry walls on either sides of the drain only in the initial reaches. The condition of the side walls is in moderate condition.

- This reach of drain is an open drain.

- The drain reach near B.D.A. quarters road, east railway station and M.E.G centre is narrow and it needs to be widened.

- Large quantity of silt and thick vegetal growth is noticed inside the drain at many places.

- Sewer line of 250 mm dia. and construction of manholes of 1.2 m. dia. is noticed at many places inside the drain.

- The nalla throughout its stretch has play grounds and residential and commercial establishments on either side of the drain i.e., upto railway track from railway track onwards it enters into M.E.G centre.

- Some section of the drain wall in this reach is in moderate condition and it requires minor rehabilitation.

- The drain reach inside M.E.G. Centre is in natural condition, and also it is narrow but, there is scope for widening and regrading the drain.

- Large number of utility crossing are noticed at many places in this reach

## 2.7 Condition Survey of Cross Drains :

During reconnaissance survey, the existing cross drains constructed across both primary and secondary storm drains, has been assessed for its structural and hydrological conditions. The details of these existing culverts/bridges is enclosed in Volume 2 - Condition Survey.

## 2.8 OBSERVATIONS DURING SITE INVESTIGATION OF LOW LYING AREAS IN CHALLAGHATTA VALLEY:

During reconnaissance survey of Challaghatta valley a detailed assessment of site conditions, reason for flooding and possible mitigative measures to overcome the flooding problems in low lying areas have been identified and the same is discussed in the subsequent sections.

The list of critical low lying areas identified in Challaghatta valley is as mentioned in Table – 2.4 and the same is depicted in Figure 2.5

**Table 2.4 List of Critical Low Lying Areas in Challaghatta Valley**

| Sl.No. | Location | Valley | BMP Division |
|---|---|---|---|

77°35'19"E 77°36'19"E 77°37'19"E 77°38'19"E 77°39'19"E 77°40'19"E 77°41'19"E 77°42'19"E

13°1'7"N 13°0'7"N 12°59'7"N 12°58'7"N 12°57'7"N 12°56'7"N

0 700 1,400 2,800 4,200 5,600 Meters

N W E S

## Legend

- Drains
- Ridge
- Low Lying Areas
- Water Bodies

### Rail / Road

- Arterial Road
- Major Road
- Minor Road
- Rail
- Main Valley
- Sub Valley

| DATE | No. | REVISION | DRAWN | CHECKED | APPROVED |
|---|---|---|---|---|---|

STUP Consultants P. Ltd.
REGISTERED OFFICE: 1004-5 RAHEJA CHAMBERS, NARIMAN POINT, MUMBAI - 400021

OFFICE OF ORIGIN: BANGALORE

OWNER: BANGALORE MAHANAGARA PALIKE

DATE: 06/06/2003

CLIENT:

DRAWN: MNS

PROJECT: RE-MODELLING OF PRIMARY AND SECONDARY STORM WATER DRAINS IN BANGALORE CITY

PREPARED: RSP

CHECKED: YDM

TITLE: Challaghatta Valley Low Lying Areas

APPROVED: ATS

Fig. No. .

REV

JOB No. 1495

SCALE: AS SPECIFIED

| | | | |
|---|---|---|---|
| 1 | Vasanthanagar, near Millers Tank | Challaghatta Main Valley | East |
| 2. | Shivajinagar | Challaghatta Main Valley | East |
| 3. | Jogupalya - Saraswathipuram | Challaghatta Main Valley | East |
| 4. | Murgeshpalya - K.R. Garden | Challaghatta Main Valley | East |
| 5. | Munireddypalya | Ulsoor Valley | East |
| 6. | Chinnappa Garden | Ulsoor Valley | East |

### 2.8.1 Vasanthanagar, Miller tank & Shivajinagar (Ward No. 78 & 79):

Miller tank & Shivajinagar area is situated in Challaghatta valley. Challaghatta valley primary storm drain (C100) which flows through these localities, and due to the reasons mentioned below, it is causing localised flooding problems in these regions.

These localities are situated at the lower most portion of the valley and also comprises of dense residential buildings and commercial establishments on either side of the drain. The establishments which are situated close to the drain are severely affected even for small intensity of rainfall in these regions.

**Reasons for flooding:**

- Due to large scale encroachment, natural alignment of existing primary storm drain has been altered at many places.

- Due to conversion of Millers tank area into builtup / commercial area.

- Foundation/Floor level of residential buildings in this layout is much below the existing drain bed level.

- Existing storm water drain size inside dobhi ghat is inadequate to cater for both sewage and storm water.

- The existing culvert near Miller's Road is inadequate (near Mount Carmal College Play Ground on Millers Road)

- Existing tertiary drains opposite to Aiyappa swamy temple and Thimmiah Road are not properly networked and also portion of the drain has been encroached.

- At some places tertiary drain does not exists in Vasanthanagar.

- Large quantity of debris has been dumped into SWD near Ambedkar Bhavan, Mahaveer Jain hospital upto Millers tank bund Road and intern it is causing drastic reduction in the carrying capacity of the drain.

  .

- The approach bridge constructed across SWD by Karnataka Badminton Association & Indian Council of social welfare is obstructing free flow of water and also raw sewage that is generated is being discharged into SWD by Karnataka Badminton Association.
- Construction of commercial shops over the drainage channel in Shivajinagar area has restricted the carrying capacity of the drain and also obstructing free flow of water.

- Large Nos. of non functional sewer manholes and utility crossings which are noticed inside the drainage channel in Shivajinagar area is obstructing free flow of water.

- Large Nos. of toilet blocks which have been constructed over SWD in Shivajinagar area is obstructing free flow of water and also discharging raw sewage into SWD.

- Drain Size is drastically reduced near Shivajinagar Nala road and Market area.

- Large quantity of sewage flow is noticed in the existing storm drain.

- Large quantity of debris and garbage dump is noticed at many places inside the existing SWD.

### 2.8.2 Murgeshpalya - K.R. Garden Area (Ward No. 73):

K.R. Garden is located in Murgueshpalya near H.A.L. Airport in Challaghatta Valley. Where as, this Secondary drain (C101) starts from Jeevanbhimanagar and further traverses through Jagadeshnagar, Airport Road and Murgeshpalya before confluencing with Challaghatta Valley Primary Storm drain (C100) inside H.A.L. Airport premises. And also this locality is situated at the lower most portion of the valley.

This locality was recently developed by private land developers, without allowing, adequate space for providing basic amenities. This locality is a newly added ward to Bangalore Mahanagara Palike.

The existing secondary drain (C101) was flowing through this locality in natural condition, and also due to various reasons mentioned below it resulted in localised flooding of this locality and inturn causing sever inconvenience to the residents.

**Reasons for flooding:**

- Foundation/Floor level of residential buildings in this layout is much below the drain bed level.

- Improper drainage facilities.

- Sewerage system has not been extended to the entire area.

- Existing tertiary drains in Nanjareddy colony and Cauvery pura and K.R. garden area are inadequate.

- Large quantity of debris and garbage dump is noticed at many places inside the existing SWD.

- Providing inadequate vent way in the compound wall of Airport for drain.

•Improper drainage arrangement inside Airport premises.

### 2.8.3 Jogupalya and Someshwarapura (Ward No. ):

Jogupalya and Someshwarapura area are situated in Challaghatta valley. These localities are situated at the lower most portion of the valley and also comprises of dense residential buildings and commercial establishments on either side of the drain. The establishments which are situated close to the drain are severely affecting even small intensity of rainfall in these regions.

**Reasons for flooding:**

•Due to large scale encroachment, natural alignment of existing storm drain has been altered at many places.

•Existing tertiary drains at Jogupalya main road, and Someshwara pura are not properly networked and also inadequate.

•Large quantity of debris has been dumped and siltation has occurred in tertiary drains and intern it is causing drastic reduction in the carrying capacity of the drain.

### 2.8.4 Munireddypalya and Chinnappa Garden (Ward No. ):

Munireddypalya and Chinnappa garden area are situated in Ulsoor valley. Ulsoor valley primary storm drain (C200) flows through these localities. These localities are situated at the lower most portion of the valley and also comprises of dense residential buildings and commercial establishments on either side of the drain. The establishments which are situated close to the drain are severely affected even for small intensity of rainfall in these regions.

**Reasons for flooding:**

- Due to large scale encroachment, natural alignment of existing storm drain has been altered at many places.

- Sewerline and Manholes that are constructed inside the drainage channel are obstructing free flow of water.

- The existing culverts near Krishnammanagar are inadequate and intern causing obstructing free flow of water..

- Existing tertiary drains at Pemme gowda road, church street, chinnappa garden and Coles road in Frazer town are inadequate.

- At some places tertiary drain does not exists in Munnireddy playa and Chinnappa garden.

- Large quantity of debris has been dumped and siltation has occurred in tertiary drains and intern it is causing drastic reduction in the carrying capacity of the drain.

- Large quantity of debris and garbage dump is noticed at many places inside the existing SWD.

## 2.9 Existing Operation and Maintenance Practice

During the last two years, BMP has undertaken desilting work of storm water drains on a large scale basis. BMP has set up an emergency squads at the central control room and service of this arrangement is made to be available round the clock. Further, this squad is equipped with truck mounted pumping arrangements and also at each zonal office an emergency telephone connections has been established for public connivence incase of any eventuality.

BMP has also improved the existing solid waste management system and intern this aspect has minimised the load on maintenance of storm drains to a certain extent and also increased the aesthetic appearance of drains at many

locations.

BMP has also taken up projects like improvement of conservancies, foot paths, rejuvenation of parks, Swacha Bangalore and Nirmala Bangalore etc. this intern minimise the load of silt accumulation at tertiary drain level and also increase the aesthetic appearance of the city.

## 2.10 Quantity and Quality of Sewage

The watershed area within the city is having the major problem of domestic sewage and sullage getting into storm water drains contributing to the pollution of the Bellandur lake. Indescriminate dumping of solid waste on the land and also in the storm water drains is yet another cause for the pollution of the Bellandur lake.

The dry weather flow of sewage flow in Challaghatta main valley and Ulsoor valley is as mentioned in the table below Table:

**Results of Dry Weather Flow Measurements in Open Drains**

| Name of Valley | Min flow (MLD.) | Avg. Flow (MLD.) | Max. Flow (MLD.) |
|---|---|---|---|
| Challaghatta Valley | 31.72 | 46.64 | 58.28 |

Source: M/s. Pai Enron Technologies systems limited Bangalore, April 2002.

**Concentration of Pollutants in Dry Weather Flow Drains**

| Parameters (mg/l.) | Challaghatta Valley |
|---|---|
| $BOD_5$ | 780 |
| SS | 200 |
| NO3 | 0.33 |

| **Parameters (mg/l.)** | **Challaghatta Valley** |
|---|---|
| P | 8.835 |

# CHAPTER 3

# STORM WATER DRAINAGE SYSTEM DESIGN AND ANALYSIS

## 3.1 INTRODUCTION:

Application of concepts and methodologies of drainage design requires establishment of design parameters of the system considered for the design. Such parameters specifies the system performance with regard to various inputs. While the design concepts and methodologies are fairly general, design parameters are site specific.. Depending on the design objectives and the availability of supporting data, different design parameters may apply to each region, location and project. Various parameters that are considered and analysed are discussed here under:

## 3.2 DESIGN CRITERIA:

These include planning horizon, design period, catchment physical parameters, process parameters and meteorological parameters.

### 3.2.1 PLANNING HORIZON:

Ideally planning of storm drainage works may be implemented in two levels – planning for short term and the long term. Planning for short term considers the proposed development plans for immediate mitigative measure. Information pertaining to development plan includes population trends, comprehensive land use and zoning plan, location of future roads, airports, and industrial area which may affect the drainage design as well as jurisdictional division and financial arrangement. The long term planning process reflects the ultimate development anticipated over a period of time which may be as long as 25 to 50 years. But, these may not be feasible for well developed cities, to accommodate higher size drains in already developed layouts. Therefore, best alternate is to backfit the drain capacity with respect to the ground conditions and arrive at the suitable return period, which is acceptable.

### 3.2.2 DESIGN PERIOD:

Planning horizon reflects the envisaged land use projected for a certain number of years, the design period of drainage system indicates the expected levels of protection against such phenomena as flooding, health hazard or deterioration in the quality of receiving waters. Besides the desired level of protection, the design period depends on construction cost and damage (losses) resulting from system failures. The planning horizon may be linked to the longest design life of structures under design. Thus, while there is only one planning horizon for a drainage area, the design period may differ for the individual system components.

The TOR specifies that the acceptable design standards commensurate with the anticipated runoff volume in the next 20 years be determined in Phase-I. Thus, it is considered that the adequacy of the existing primary and secondary storm drains be studied, for the anticipated runoff rate over the next 20 years. This needs review in the context of the good conditions.

### 3.2.3 PHYSICAL PARAMETERS OF CATCHMENT:

Base maps showing the project area, topographical details like contour, water courses, tanks, wooded areas, rocky outcrops, marshes, etc., details of existing and proposed land uses, existing and proposed drains for establishing the study area drainage boundaries, general drainage pattern in these areas, surface slopes and total catchment area are developed. The catchment area is divided into pervious and impervious areas. In addition, the existing drainage channels in the catchment need to be characterized in terms of the cross sections, slopes, lengths, and linkages. The extent of development of the catchment has significant bearing on the runoff calculations.

### 3.2.4 PROCESS PARAMETERS:

These include infiltration rates, depression storage, roughness of transport elements and runoff coefficient. Generally, these parameters will be considered together as a lumped aggregate parameter.

### 3.2.5 METEOROLOGICAL DATA:

Important input for runoff computation is rainfall data. Rainfall data processing may be carried out by many approaches. Some of the methods are as listed and explained here under,

1. CPHEEO MANUAL
2. CALIFORNIA METHOD OF RANKING
3. GUMBEL'S DISTRIBUTION METHOD
4. LOG – PEARSON TYPE III DISTRIBUTION

**3.2.5.1 RAIN FALL ANALYSIS USING CPHEEO METHOD:**

The analysis of frequency of storms of stated intensities and duration will be computed from the available rainfall data, for the period of past 25 years (i.e., from 1976 to 2001) and the same will be tabulated.

From the tabulated values, storm occurrences for the different years will be computed and time intensity values for these frequencies will be obtained by interpolation for storm occurring once a year, once in 2 years, once in 5 years, once in 10 years and once in 20 years.

Using log-log sheet, a graph has been plotted using the values of intensity (i), and duration (t) from the above tabulated values for calculating the storm occurrences for different return periods i.e., once a year, once in 2 years, once in 5 years, once in 10 years and once in 20 years respectively. From the best fit line, values a & n are obtained. Further the same is substituted in the equation below.

$$i = \frac{a}{t^n}$$

where, i = intensity of rainfall in mm/hr

t = duration of storm in minutes

a,b,n = constants as appropriate

After substituting values of a and n, different values of " i " for a various values of " t " are calculated and tabulated. A curve is plotted using an ordinary graph paper.

Another graph of runoff coefficients (c) v/s duration time (t) is plotted as per the values given in Horner's table (Table 3.3, Pg. No. 45 of CPHEEO Manuel).

### 3.2.5.2 RAIN FALL ANALYSIS USING RANKING METHOD:

The rainfall data for a period of 25 years is collected from Indian Meteorological Department (IMD). From the rainfall data, intensity of highest rainfall is considered in that particular duration and year which is arranged in descending order and the rank is assigned with a rank one to the highest value, a rank of two to the next highest value and so on. Whenever a particular value occurs more then once, all the values should have the same rank as they are equal. Further, recurrence interval or frequency corresponding to each rank can be calculated using a formula

$$N = T \times m$$

Where m is the number of times, given rain is equalled or exceeded and is known as the ranking of the storm or ranking number

Extracting rainfall of various duration for desired frequency further calculation of rainfall intensity in mm/hour has been done.

Using log-log sheet, graphs have been plotted using the values of intensity (i), and duration (t) from the above tabulated values for calculating the storm occurrences for different return periods i.e., once a year, once in 2 years, once in 5 years, once in 10 years and once in 20 years respectively. From the best fit curve, values a & n are obtained. Further, the same are substituted in the equation below.

$$i = \frac{a}{t^n}$$

where, i = intensity of rainfall in mm/hr

t = duration of storm in minutes

a,b,n = constants as appropriate

After substituting values of a & n different values of 'i' for a various values of 't' are calculated and tabulated. A curve is plotted using an ordinary graph paper.

### 3.2.5.3 RAIN FALL ANALYSIS USING GUMBEL'S DISTRIBUTION METHOD:

The rainfall data for a period of 25 years is collected from IMD and the highest rainfall

intensity in that particular duration and year is considered and it is arranged in a sequential order. For each duration, the mean and standard deviation are calculated. Subsequently, the amount of rainfall for various duration and return period is calculated using the below equation.

$$X_T = X + K S_x$$

Where, X is the mean.

Sx is the standard deviation of the sample of extreme rainfall.

$X_T$ is the rainfall amount which is equalled or exceeded on an average once in T years.

K is the frequency factor which can be expressed in terms of the return period T and the number of years of record N,The value of K can be obtained from standard table.

By substituting the values of X, Sx and K. The value of K can be obtained from standard table (from S.K Garg, Table 10.6 ) for N = 25 and return periods varying from 1 to 20 years.

Amount of rainfall obtained will be tabulated and further the same is converted into rainfall intensities and tabulated.

Using log-log sheet, a graph is plotted using the values of intensity (i), and duration (t) from the above tabulated values for calculating the storm occurrences for different return periods i.e., once a year, once in 2 years, once in 5 years, once in 10 years and once in 20 years. From the best fit curve, values a & n are obtained. Further the same is substituted in the equation below.

$$i = \frac{a}{t^n}$$

where, i = intensity of rainfall in mm/hr

t = duration of storm in minutes

a,b,n = constants as appropriate

After substituting values of a & n, different values of i for various values of 't' are calculated and tabulated, a graph is plotted on an ordinary graph sheet.

Values obtained from the above three methods are compared with other design parameters which is suitable for the present site conditions and that method is adopted for computing storm water runoff.

### 3.2.6 STRUCTURAL DESIGN PARAMETERS :

Parameters and standards considered for design of sub structures, super structures and cross drainage works are as follows;

1. The structures are categorized as per Table-5B of IRC : 21-2000. Since the materials used are RCC, PCC and Stone masonry and in case of bridges total length is generally less than 60 m. In case the total length of the bridge is more than 60 m or any innovative design approach is adopted the same is categorized as per Table-5A of IRC : 21-2000.

2. For design purposes the condition of exposure is considered as SEVERE. Since the structures are in contact with untreated sewage and drainage effluent.

3. The following materials are proposed to be used in the structures.

   i. Minimum Grades of Concretes used are as below

      - M15 - In levelling course below RCC, PCC & Stone masonry foundations, pile caps, approach slabs and in footpath fillings.
      - M20 - In PCC structural elements like retaining walls & abutments
      - M25 - In kerbs, hand rail, and posts, approach slab, retaining walls, piers, pile caps and abutments.
      - M35 - In crash barriers, super structures, box culverts & piles etc.
      - Maximum water cement ratio shall be 0.45.

   ii. Grade of steel to be used is Fe 415.

   iii. Course rubble stone masonry for bridge works such as abutments.

   iv. Random rubble stone masonry for retaining structures other than bridge abutments.

   v. CM 1:3 for stone masonry.

   vi. PVC pipes for weep holes in retaining walls and provision for service lines in superstructure.

vii. Elastomeric bearings for beam and slab type superstructure.

viii. Compression seal expansion joint for joints along longitudinal direction in carriage way portion of superstructure.

ix. PVC water bar type expansion joint for superstructures with beam and slab arrangement.

x. Premoulded bitumen filling joint for solid slab type superstructures covering full depth.

xi. Premoulded bitumen filling joint for retaining walls.

xii. Asphalted concrete wearing coat over mastic asphalt.

xiii. Back filling behind abutments, returns and retaining walls shall be with granular materials with soil as per Appendix-6 of IRC : 78-2000.

xiv. GI drainage spouts as per drawings.

4. Minimum dimensional requirements:

i. Levelling course - 100 mm. thick below RCC / PCC foundations.
- 300 mm. thick below stone masonry foundations on soil base.
- 150 mm. thick below stone masonry foundations on rock base
- 150 mm. thick below approach slabs.

ii. Walls - 200 mm. thick for RCC / PCC walls.
- 500 mm. thick for stone masonry walls.

iii. Wearing coat on deck slabs shall be 50 mm. thick asphalted concrete in two layers of 25 mm. each over 6 mm. thick mastic asphalt. Thickness of asphalted concrete shall be varied suitably to achieve the slopes for camber or super elevation.

iv. Normal camber considered is 2.5 %.

v. Weep holes with PVC pipes (100 mm. dia. in RCC and 150 mm. dia. in stone masonry) shall be used in retaining structures including abutments and retaining walls. The spacing of weep holes shall be 1.0 m. in either direction in staggered way, with lowest at about 150 mm. above the low water level or ground level which ever is higher. (MOST Spec. : 2706).

5. Loading :

| | | |
|---|---|---|
| Density of PCC | = | 2.2 $t/m^3$ |
| RCC | = | 2.4 $t/m^3$ |

Stone masonry = 2.2 t/$m^3$

Back filling = 2.0 t/$m^3$

i.Load due to wearing coat = 0.2 t/$m^2$

ii.Load due to crash barrier = 0.8 t/m On each side.

iii.Load due to hand rail and kerb = 0.95 t/m On each side.

iv.Load due to services in footpath = 0.1 t/m On each side.

v.Foot path live load = 0.5 t/$m^2$ On each side.

vi.Vehicle live loads are as per clause 207.4, Table-2 of IRC:6-2000 for different carriage ways.

vii.Load due to water current as per clause 213 of IRC : 6 -2000.

viii.Live load surcharge is 1.2 m height of back fill.

ix.Buoyancy force as per clause 216 of IRC : 6-2000.

x.One span dislodged condition is not considered in the case of slab bridges not provided with bearings. (As per clause 221.1 of IRC : 6-2000.)

xi.Seismic forces are not considered as the structures are located in Seismic Zone-1. (As per clause 222.1 of IRC : 6-2000.)

6.Miscellaneous details :

i.Bridges or culverts with out footpath are provided with crash barrier / Hand rail.

ii.Bridges or culverts with footpath are provided with hand rails as per SD/202 of MOST STD drawing with or with out crash barrier at the edge of carriage way.

iii.Drainage spouts in the superstructure of the bridge or culverts are as per SD/205 of MOST STD drawing.

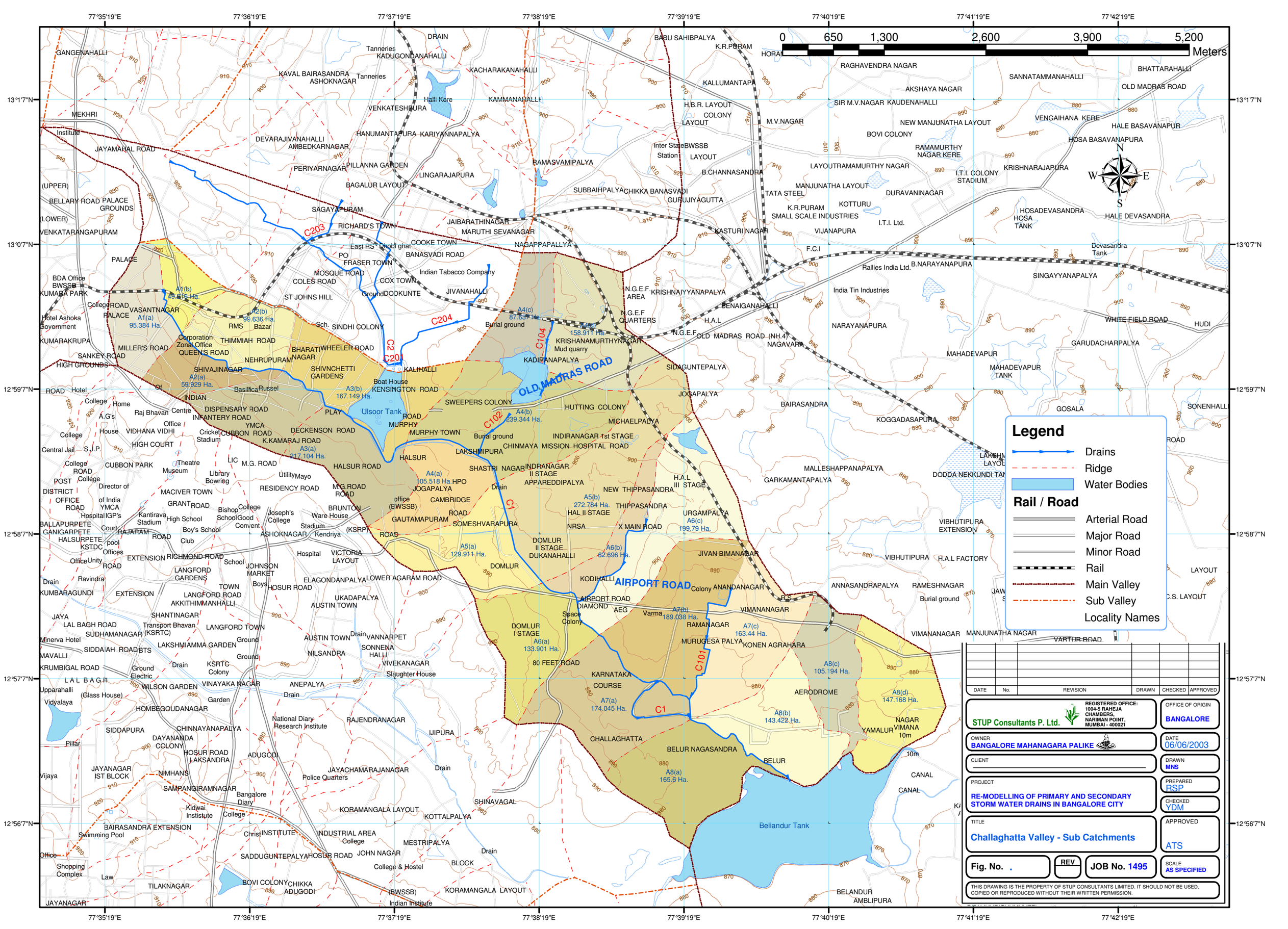
## 3.3 CATCHMENT ANALYSIS:

To study the hydrological conditions and drainage characteristics of the Challaghatta valley catchment the following analysis procedure has been adopted

- Identification of ridge line and demarcation of catchment boundary.
- Demarcation of primary and secondary valleys.
- Demarcation of entire catchment into micro/sub catchments.
- Identification of flow regions within micro catchments.
- Codification of flow regions.
- Characterization of the entire catchment in terms of landuse categories.
- Identification of open and closed reach of drains.
- Assignment of the degree of imperviousness to rainfall for the above categories.
- Computation of weighted average imperviousness for each of the flow region.

The ridge lines of the Challaghatta valley catchment are demarcated based on the available 10 m. interval elevation contour information in the survey of India 1:20,000 scale topo map for Bangalore city. On which the valley lines and the local ridge lines are identified to demarcate the sub catchments and flow regions. These details prepared on 1: 20000 scale map are digitized to generate a vector layer in Arcview GIS as line coverage as well as polygons coverage. After the transformation of the coverages with reference to the map used for digitization, various attribute details on length of arcs and area of polygons are analyzed to obtain the length both primary and secondary drains and area of catchment, sub catchment and micro catchment and the same is also indicated in Figure 3.1 & 3.2.

Further, to calculate the inlet time and time of concentration the sub/micro catchments are segmented into different flow regions based on terrain slope and other aspect derived from contour information. The area details of the micro catchments codes, flow regions, land use characteristics in Challaghatta main valley and Ulsoor valley are provided in Table – 3.1 to Table - 3.4.


77°35'19"E
77°36'19"E
77°37'19"E
77°38'19"E
77°39'19"E
77°40'19"E
77°41'19"E
77°42'19"E
13°1'7"N
13°0'7"N
12°59'7"N
12°58'7"N
12°57'7"N
12°56'7"N
0 650 1,300 2,600 3,900 5,200
Meters
N
S
E
W
C203
C204
C2
C102
C104
C101
C1
OLD MADRAS ROAD
AIRPORT ROAD
Ulsoor Tank
Bellandur Tank
A1(b) 49.815 Ha.
A1(a) 95.384 Ha.
A2(b) 99.636 Ha.
A2(a) 59.929 Ha.
A3(b) 167.149 Ha.
A3(a) 217.104 Ha.
A4(c) 87.653 Ha.
A4(b) 239.344 Ha.
A4(a) 105.518 Ha.
A5(b) 272.784 Ha.
A5(a) 129.911 Ha.
A6(b) 62.696 Ha.
A6(a) 133.901 Ha.
A7(b) 189.038 Ha.
A7(c) 163.44 Ha.
A7(a) 174.045 Ha.
A8(c) 105.194 Ha.
A8(d) 147.168 Ha.
A8(b) 143.422 Ha.
A8(a) 165.6 Ha.
A6(c) 199.79 Ha.
Legend
Drains
Ridge
Water Bodies
Rail / Road
Arterial Road
Major Road
Minor Road
Rail
Main Valley
Sub Valley
Locality Names
DATE
No.
REVISION
DRAWN
CHECKED
APPROVED
STUP Consultants P. Ltd.
REGISTERED OFFICE: 1004-5 RAHEJA CHAMBERS, NARIMAN POINT, MUMBAI - 400021
OFFICE OF ORIGIN
BANGALORE
OWNER
BANGALORE MAHANAGARA PALIKE
DATE
06/06/2003
CLIENT
DRAWN
MNS
PROJECT
RE-MODELLING OF PRIMARY AND SECONDARY STORM WATER DRAINS IN BANGALORE CITY
PREPARED
RSP
CHECKED
YDM
TITLE
Challaghatta Valley - Sub Catchments
APPROVED
ATS
Fig. No. .
REV
JOB No. 1495
SCALE
AS SPECIFIED
THIS DRAWING IS THE PROPERTY OF STUP CONSULTANTS LIMITED. IT SHOULD NOT BE USED, COPIED OR REPRODUCED WITHOUT THEIR WRITTEN PERMISSION.

77°35'19"E 77°36'19"E 77°37'19"E 77°38'19"E

13°1'7"N 13°0'7"N 12°59'7"N

0 320 640 1,280 1,920 2,560 Meters

N S E W

## Legend

- Drains
- Ridge
- Water Bodies

**Rail / Road**

- Arterial Road
- Major Road
- Minor Road
- Rail
- Main Valley
- Sub Valley
- Locality Names

A1(a) 26.258 Ha.
A1(b) 171.153 Ha.
A1(c) 40.853 Ha.
A2 68.529 Ha.
A3(a) 29.525 Ha.
A3(b) 16.928 Ha.
A4 78.012 Ha.
A5 37.995 Ha.
A6 162.421 Ha.
A7 78.059 Ha.

C1 C2 C201 C203 C204 C104

KACHARAKANAHALLI, KAVAL BAIRASANDRA, Tanneries, ASHOKNAGAR, Kacharakana Halli Kere, KAMMANAHALLI, VENKATESHPURA, MEKHRI CIRCLE, Raman Research Institute, SADASHIVANAGAR, JAYAMAHAL ROAD, HANUMANTAPURA, KARIYANNAPALYA, DEVARAJIVANAHALLI, AMBEDKARNAGAR, PERIYARNAGAR, PILLANNA GARDEN, LINGARAJAPURA, Swimming pool, (UPPER), SANKEY ROAD, BELLARY ROAD, PALACE GROUNDS, BAGALUR LAYOUT, PALACE ORCHARD (LOWER), DR. AMBEDKAR ROADSAGAYAPURAM, JAIBARATHINAGAR, VENKATARANGAPURAM, RICHARD'S TOWN, MARUTHI SEVANAGAR, Bangalore East RS, COOKE TOWN, Ground, MADHAVARAYA MUDALIAR ROAD, Dhobi ghat, NAGAPPAPALLYA, MAIN ROAD, PALACE, PO, BANASVADI ROAD, FRASER TOWN, CLEVELAND TOWN, MOSQUE ROAD, Indian Tabacco Company, BDA Office, COLES ROAD, COX TOWN, BWSSB, KUMARA PARK, Gymkhana Ground, DODKUNTE, JIVANAHALLI, ST JOHNS HILL, Mount Carmel College, ROAD, VASANTNAGAR, PALACE, Hotel Ashoka, St.John's Sch., SINDHI COLONY, Burial ground, Government Guest House, RMS Sorting Off., New Bamboo Bazar, Corporation Zonal Office, THIMMIAH ROAD, KUMARAKRUPA, GOLF COURSE, WHEELER ROAD, MILLER'S ROAD, QUEEN'S ROAD, BHARATI NAGAR, Mud quarry, SANKEY ROAD, BRADWAY ROADNEHRUPURAM, KADIRANAPALYA, KUMARAKRUPA ROAD, HIGH GROUNDS, SHIVAJINAGAR, SHIVNCHETTI GARDENS, St. JOHN'S ROAD, KALIHALLI, Boat House, Commisioner Of Police, West End Hotel, CHANDINI CHOWK ROAD, Basillica, Russel Market, KENSINGTON ROAD, RACE COURCE ROAD, Commerce College, Legislators Home, INDIAN EXPRESS, SWEEPE, RACE COURCE, Centre, DISPENSARY ROAD, COMMERCIAL STREET, ULSOOR LAKE Ulsoor Tank, PLAY GROUND, Raj Bhavan, A.G's, INFANTERY ROAD, ROAD, SESHADRI ROAD, P M G's Office, VIDHANA SAUDHA, YMCA, MURPHY, Dhobi Ghat, GANDHINAGAR, Maharani's College, Guest House, VIDHANA VIDHI, DECKENSON ROAD, MURPHY TOWN, Cricket Stadium, CUBBON ROAD, K.KAMARAJ ROAD, Central Jail, S.J.P. Polytechnic, Govt. Press, HIGH COURT, LAKS, HALSUR, Central College, CUBBON PARK, LIC Office, M.G. ROAD, HALSUR ROAD, Play Ground, ROAD, Theatre, Museum, Council Library, Utility, Mayo Hall, Law College, OFFICE, College, POST, BRIGADE ROAD, HPO, Bowring Institute, District Courts, Director of Youth Service, RESIDENCY ROAD, M.G.ROAD, JOGAPALYA, DISTRICT, MACIVER TOWN, ROAD, Subdivision

| DATE | No. | REVISION | DRAWN | CHECKED | APPROVED |
|---|---|---|---|---|---|
| | | | | | |

REGISTERED OFFICE: 1004-5 RAHEJA CHAMBERS, NARIMAN POINT, MUMBAI - 400021

STUP Consultants P. Ltd.

OFFICE OF ORIGIN: BANGALORE

OWNER: BANGALORE MAHANAGARA PALIKE

DATE: 06/06/2003

CLIENT:

DRAWN: MNS

PROJECT: RE-MODELLING OF PRIMARY AND SECONDARY STORM WATER DRAINS IN BANGALORE CITY

PREPARED: RSP

CHECKED: YDM

TITLE: Ulsoor Valley - Sub Catchments

APPROVED: ATS

Fig. No. . | REV | JOB No. 1495 | SCALE: AS SPECIFIED

## Table 3.1 CHALLAGHATTA VALLEY MICRO CATCHMENT CODE

| Sl. No. | Micro Catchment Code | Area (Ha.) |
|---|---|---|
| 1 | A 1 | 144.60 |
| 2 | A 2 | 159.57 |
| 3 | A 3 | 384.25 |
| 4 | A 4 | 591.41 |
| 5 | A 5 | 402.70 |
| 6 | A 6 | 396.39 |
| 7 | A 7 | 526.52 |
| 8 | A 8 | 561.38 |
| | **TOTAL** | **3166.82** |

## Table 3.2 CHALLAGHATTA VALLEY FLOW REGION CODE

| Sl.No. | Flow Region Code | Area (ha.) |
|---|---|---|
| 1. | A1 (a) | 95.38 |
| 2. | A1 (b) | 49.22 |
| 3. | A2 (a) | 59.93 |
| 4. | A2 (b) | 99.64 |
| 5. | A3 (a) | 217.10 |
| 6. | A3 (b) | 167.15 |
| 7. | A4 (a) | 105.52 |
| 8. | A4 (b) | 239.34 |
| 9. | A4 (c) | 87.64 |
| 10. | A4 (d) | 158.91 |
| 11. | A5 (a) | 129.91 |
| 12. | A5 (b) | 272.79 |
| 13. | A6 (a) | 133.90 |
| 14. | A6 (b) | 62.70 |
| 15. | A6 (c) | 199.79 |
| 16. | A7 (a) | 174.05 |
| 17. | A7 (b) | 189.04 |
| 18. | A7 (c) | 163.44 |
| 19. | A8 (a) | 165.60 |
| 20. | A8 (b) | 143.42 |
| 21. | A8 (c) | 105.20 |
| 22. | A8 (d) | 147.17 |
| | **TOTAL** | **3166.82** |

**Table 3.3 ULSOOR VALLEY MICRO CATCHMENT CODE**

| Sl.No. | Micro Catchment Code | Area (ha.) |
|---|---|---|
| 1. | A 1 | 238.27 |
| 2. | A 2 | 68.53 |
| 3. | A 3 | 46.46 |
| 4. | A 4 | 78.01 |
| 5. | A 5 | 38.00 |
| 6. | A 6 | 162.42 |
| 7. | A 7 | 78.06 |
| | **TOTAL** | **709.74** |

**Table 3.4 ULSOOR VALLEY FLOW REGION CODE**

| Sl.No. | Flow Region Code | Area (ha.) |
|---|---|---|
| 1. | A 1 (a) | 26.26 |
| 2. | A 1 (b) | 171.15 |
| 3. | A 1 (c) | 40.85 |
| 4. | A 2 | 68.53 |
| 5. | A 3 (a) | 29.53 |
| 6. | A 3 (b) | 16.93 |
| 7. | A 4 | 78.01 |
| 8. | A 5 | 38.00 |
| 9. | A 6 | 162.42 |
| 10. | A 7 | 78.06 |
| | **TOTAL** | **709.74** |

Using digital image processing technique and also by visual interpretation, satellite image is used to analyze the catchments and categorise the same for various landuse categories as listed below and further at strategic locations the processed results are cross verified at site and accordingly range of percent imperviousness is assigned for each category.

1. Highly / Dense built up area with sparse vegetal cover
2. Dense built up area with medium / thick vegetal cover
3. Built up area with more open space as well as fairly dense vegetal cover
4. Open space with no vegetal cover / Open space with scrubs and other vegetation
5. Parks
6. Water bodies

Further, in order to compute the weighted average percent imperviousness for each, the highest runoff percent imperviousness assigned is 80 - 95 % for the land where settlement density is very high (>90%) and all roads are paved. The lowest runoff percent imperviousness assigned is 5 -20 % for parks with medium dense vegetation. The details of area and assigned percent imperviousness is shown in Table - 3.5.& 3.6.

In order to compute the weighted average percent imperviousness for each flow region, intersection of flow region boundaries with settlement density boundaries is done. A composite plans for Challagatta main valley and Ulsoor valley are generated by incorporating the drainage lines, ridge lines, flow region boundaries and the landuse and land cover categories and the same is indicated in Figure 3.3 & 3.4.

The weighted average percent imperviousness (IW) for each flow region is computed and is given by

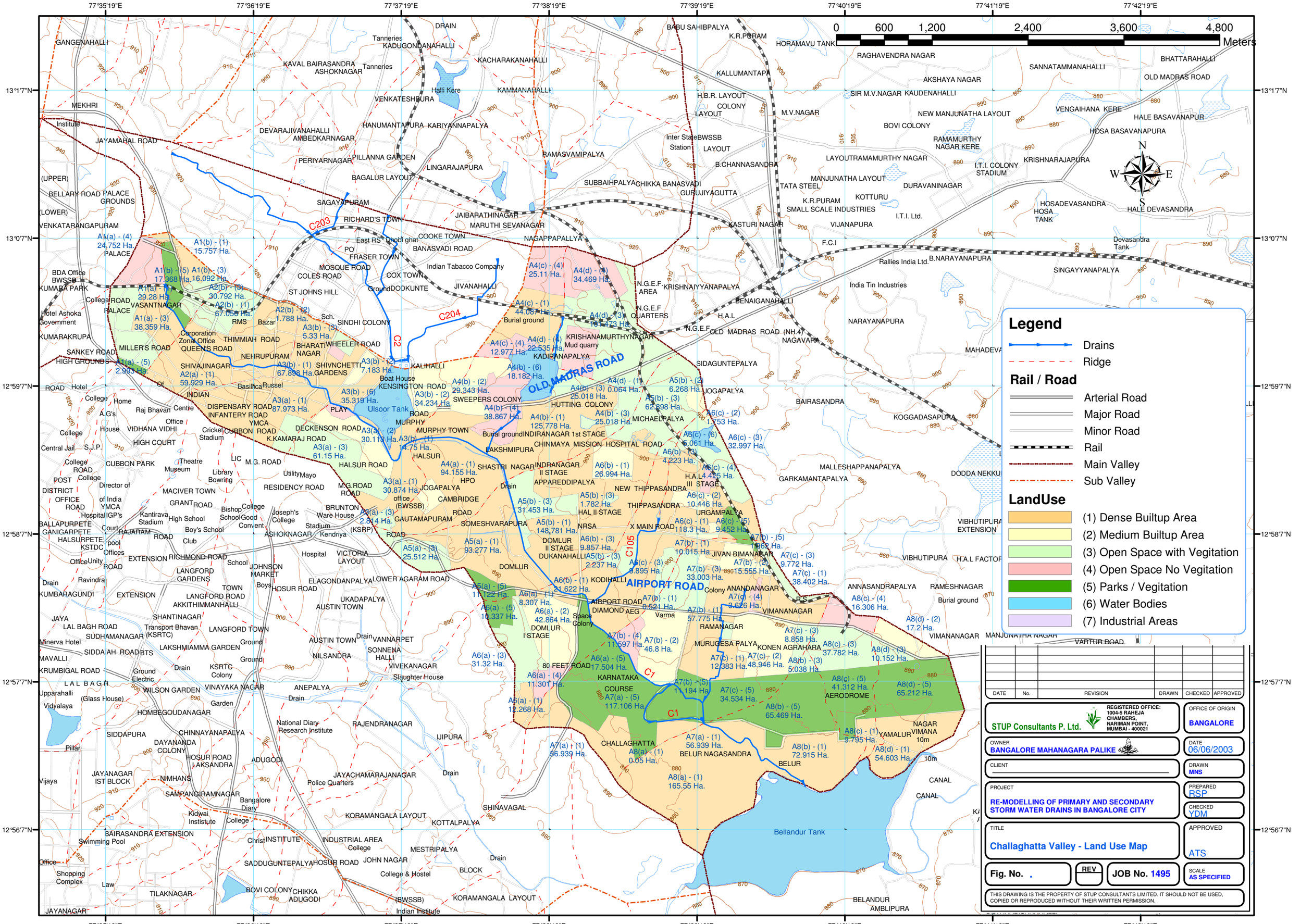
$$IW = \frac{I_1 A_1 + I_2 A_2 + I_3 A_3 + I_4 A_4 \ldots\ldots}{A_1 + A_2 + A_3 + A_4 \ldots\ldots}.$$

where, $I_1$ , $I_2$ , $I_3$ , $I_4$ are assigned imperviousness (%) for each of the land cover category within the flow region and $A_1$ , $A_2$, $A_3$, $A_4$ are the corresponding areas.

**TABLE 3.5 CHALLAGHATTA VALLEY LAND COVER CHARACTERISTICS**

| Sl.No. | Land Cover Characteristics | Area (ha) | Assigned % Imperviousness |
|---|---|---|---|
| 1. | Highly / Dense built up area with sparse vegetal cover | 1548.96 | 75 – 90 |
| 2. | Dense built up area with medium / thick vegetal cover | 328.62 | 65 – 80 |
| 3. | Built up area with more open space as well as fairly dense vegetal cover | 606.70 | 45 – 60 |
| 4. | Open space with no vegetal cover / Open space with scrubs and other vegetation | 212.58 | 10 – 25 |
| 5 | Parks | 405.57 | 05 – 20 |
| 6 | Water Bodies | 64.40 | -- |
| | **Total** | **3166.82** | |

**Table 3.6 ULSOOR VALLEY LAND COVER CHARACTERISTICS**




| DATE | No. | REVISION | DRAWN | CHECKED | APPROVED |
|---|---|---|---|---|---|
| | | | | | |

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OFFICE OF ORIGIN: BANGALORE

OWNER: BANGALORE MAHANAGARA PALIKE

DATE: 06/06/2003

CLIENT:

DRAWN: MNS

PROJECT: RE-MODELLING OF PRIMARY AND SECONDARY STORM WATER DRAINS IN BANGALORE CITY

PREPARED: RSP

CHECKED: YDM

TITLE: Challaghatta Valley - Land Use Map

APPROVED: ATS

Fig. No. .

REV

JOB No. 1495

SCALE: AS SPECIFIED

77°35'19"E 77°36'19"E 77°37'19"E 77°38'19"E

13°1'7"N 13°0'7"N 12°59'7"N

0 325 650 1,300 1,950 2,600 Meters

N W E S

KACHARAKANAHALLI
KAVAL BAIRASANDRA
Tanneries
ASHOKNAGAR
Kacharakana Halli Kere
KAMMANAHALLI
VENKATESHPURA
MEKHRI CIRCLE
Raman Research Institute
SADASHIVANAGAR
HANUMANTAPURA
KARIYANNAPALYA
DEVARAJIVANAHALLI
AMBEDKARNAGAR
JAYAMAHAL ROAD
PERIYARNAGAR
PILLANNA GARDEN
RAMASVAMIPALYA
LINGARAJAPURA
Swimming pool
(UPPER)
BAGALUR LAYOUT
SUBBAIHPALYA
SANKEY ROAD
BELLARY ROAD
PALACE GROUNDS
DR. AMBEDKAR ROADSAGAYAPURAM
PALACE ORCHARD (LOWER)
JAIBARATHINAGAR
RICHARD'S TOWN
MARUTHI SEVANAGAR
VENKATARANGAPURA
C203
Bangalore East RS
COOKE TOWN
NAGAPPAPALLYA
Ground
MADHAVARAYA MUDALIAR ROAD
Dhobi ghat
MAIN ROAD
PALACE
PO
FRASER TOWN
BANASVADI ROAD
C202
CLEVELAND TOWN
MOSQUE ROAD
Indian Tabacco Company
BDA Office
BWSSB
COLES ROAD
COX TOWN
KUMARA PARK
Mount Carmel College
ROAD
Gymkhana Ground
DODKUNTE
JIVANAHALLI
ST JOHNS HILL
VASANTNAGAR
PALACE
Hotel Ashoka
Government Guest House
RMS Sorting Off.
New Bamboo Bazar
St.John's Sch.
SINDHI COLONY
Burial ground
C204
KUMARAKRUPA
GOLF COURSE
Corporation Zonal Office
THIMMIAH ROAD
WHEELER ROAD
Mud quarry
MILLER'S ROAD
QUEEN'S ROAD
BHARATI NAGAR
C104
SANKEY ROAD
BRADWAY ROADNEHRUPURAM
KADIRANAPALYA
KUMARAKRUPA ROAD
HIGH GROUNDS
SHIVAJINAGAR
SHIVNCHETTI GARDENS
St. JOHN'S ROAD
KALIHALLI
C201
Commisioner
Boat House
KENSINGTON ROAD
Basillica
Russel Market
ULSOOR LAKE
Ulsoor Tank
SWEEPE
DISPENSARY ROAD
COMMERCIAL STREET
PLAY GROUND
ROAD
MURPHY
Dhobi Ghat
YMCA
DECKENSON ROAD
MURPHY TOWN
CUBBON ROAD
K.KAMARAJ ROAD
C1
HALSUR
LIC Office
M.G. ROAD
HALSUR ROAD
Council Library
Bowring Institute
Utility
Mayo Hall
BRIGADE ROAD
HPO
Law College
OFFICE
POST
College
District Courts
Director of Youth Service
DISTRICT
RESIDENCY ROAD
M.G.ROAD
JOGAPALYA
MACIVER TOWN
Subdivision

A1(a) - (4) 26.258 Ha.
A1(b) - (5) 18.392 Ha.
A1(b) - (3) 0.612 Ha.
A1(c) - (4) 22.049 Ha.
A1(b) - (3) 1.231 Ha.
A1(b) - (1) 6.153 Ha.
A1(c) - (1) 18.804 Ha.
A1(b) - (1) 65.883 Ha.
A1(b) - (4) 14.59 Ha.
A3(a) - (4) 0.879 Ha.
A3(a) - (4) 15.928 Ha.
A3(b) - (3) 4.064 Ha.
A5 - (3) 3.45 Ha.
A3(a) - (1) 12.718 Ha.
A3(a) - (1) 12.718 Ha.
A1(b) - (4) 9.167 Ha.
A5 - (4) 3.768 Ha.
A6 - (3) 3.007 Ha.
A1(b) - (3) 16.025 Ha.
A3(b) - (1) 12.864 Ha.
A5 - (3) 0.944 Ha.
A2 - (3) 3.779 Ha.
A5 - (1) 16.532 Ha.
A5 - (4) 1.124 Ha.
A1(b) - (2) 39.101 Ha.
A6 - (4) 4.28 Ha.
A7 - (1) 17.683 Ha.
A6 - (2) 8.124 Ha.
A2 - (1) 40.602 Ha.
A5 - (4) 4.614 Ha.
A5 - (2) 5.332 Ha.
A6 - (2) 2.471 Ha.
A6 - (3) 13.923 Ha.
A7 - (3) 9.864 Ha.
A2 - (2) 20.099 Ha.
A4 - (2) 15.566 Ha.
A6 - (1) 99.439 Ha.
A2 - (5) 4.049 Ha.
A4 - (1) 43.28 Ha.
A4 - (3) 9.745 Ha.
A6 - (3) 15.64 Ha.
A4 - (3) 7.895 Ha.
A6 - (4) 15.537 Ha.
A7 - (3) 50.513 Ha.
A4 - (4) 1.525 Ha.

## Legend

**LandUse**

- (1) Dense Builtup Area
- (2) Medium Builtup Area
- (3) Open Space with Vegitation
- (4) Open Space No Vegitation
- (5) Parks / Vegitation
- (6) Water Bodies
- (7) Industrial Areas

Drains
Ridge

**Rail / Road**

- Arterial Road
- Major Road
- Minor Road
- Rail
- Main Valley
- Sub Valley

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DRAWN: MNS

PROJECT: RE-MODELLING OF PRIMARY AND SECONDARY STORM WATER DRAINS IN BANGALORE CITY

PREPARED: RSP

CHECKED: YDM

TITLE: Ulsoor Valley - Land Use Map

APPROVED: ATS

Fig. No. .

REV

JOB No. 1495

SCALE: AS SPECIFIED

| Sl.No. | Land Cover Characteristics | Area (ha) | Assigned % Imperviousness |
|---|---|---|---|
| 1. | Highly / Dense built up area with sparse vegetal cover | 333.96 | 75 – 90 |
| 2. | Dense built up area with medium / thick vegetal cover | 91.82 | 65 – 80 |
| 3. | Built up area with more open space as well as fairly dense vegetal cover | 135.00 | 45 – 60 |
| 4. | Open space with no vegetal cover / Open space with scrubs and other vegetation | 119.72 | 10 – 25 |
| 5 | Parks | 23.55 | 05 – 20 |
| 6 | Water Bodies | 5.70 | -- |
| | **Total** | **709.74** | |

## 3.4 DESIGN PROCEDURE:

### 3.4.1 GENERAL:

Having understood the site conditions and terms of reference it is proposed to adopt the approach, philosophy of which revolves around 4 cardinal points viz.:

1. Understanding the project requirements and the accomplishment of the overall objective of the project.

2. Appreciation of the various factors that help or hinder the overall objective of the project both from the review of available documents and a field visit to support the overall objective.

3. Ensuring ways and means of assuring quality of the contract deliverables taking into considerations the factors – efficiency of function, economy of implementation, ease of construction and recognising the link of designs-operations interactions.

4. Ensuring quality assurance in the materials and methods of execution including modern methods of construction for early completion of the works.

And also review of available data through site appreciation leads us to formulate the method of working to ensure:

•High degree of professional standards in designing the components.
•Clear detailing that will facilitate working and
•Quality assurance in the contract deliverables.
•Quality assurance in execution of contract.

In order to accomplish these objectives, following issues need to be addressed, as applicable for each of the three stages of the project Viz. Feasibility report, Detailed Project Report and Construction Supervision.

### 3.4.2 STORM WATER RUNOFF:

The storm water run off is the balance of rain water precipitation on the ground which flows in drains after a part of storm water getting infiltration into the soil, retention in surface depressions and evaporated. The rate of storm water run off to be used for design of storm sewers is complex to evaluate accurately. The rate of precipitation which causes the runoff is highly variable from place to place even within a smaller region of the City. The rainfall recording stations from which the intensity of precipitation and duration of rain fall is obtained for the design of storm water drains in many instances are remotely located from the area where the storm water drain has to be designed. The geological formation of the sub-surface will also be varying and estimations of these losses are complex. Numerous empirical runoff formulae had been used for estimation of storm water runoff. Some of the methods adopted are:

1.1.Rational method (Lloyd-Davis method evolved in the United Kingdom).
1.2.Hydrographs {Over-land Flow) method.
1.3.Inlet Method.
1.4.Unit Hydrograph method.

Out of the above methods, the rational method is widely used throughout the World. More than 90% of the Engineering offices through out the United States have confirmed in a questionnaire in the year 1956 with the rational method of design has given satisfactory results for urban drainage areas. The Ministry of Urban Development, Government of India, New Delhi, Central Public Health and Environmental Engineering Organization, has also recommended the estimation of storm water runoff by rational method.

### 3.4.2.1. RATIONAL METHOD:

The entire precipitation over the drainage district does not reach the storm water drains. The characteristics of the drainage district such as imperviousness, topography including depressions and water pockets, shape of the drainage basin and duration of the precipitation determine the function of the precipitation, which will reach the drain. This fraction known as the coefficient of runoff needs to be determined for each drainage district. The runoff reaching the drain is given by the expression,

$$Q = 10\ C\ i\ A$$

Where, 'Q' is the runoff in $m^3$/hr;
'C' is the coefficient of runoff;
'i' is the intensity of rainfall in mm/hr. and
'A' is the area of drainage district in hectares.

### 3.4.3. STORM FREQUENCY:

Urban storm drains are generally designed based on the concept of the design storm of a selected return period. In general the selection of the design event return period is affected by the design life of structures involved, construction cost and damage cost resulting from the system failure. Drainage structures are typically characterized by long design life and so the ideal design period should be one for which the total annual drainage costs, defined as the sum of annual construction and drainage failure costs are minimal.

While the foregoing may be true for major system, urban storm drainage system being minor system does not warrant a detailed analysis of construction and failure costs but must evaluate acceptable risk caused by the failure of the system, depending on whether it is a major or minor drainage system.

Major drainage system comprises natural streams and valleys as well as man made elements such as swales, channels, and ponds. The system should accommodate runoff from infrequent storms with long return periods. Damage caused by the failure of

a major drainage system and the associated risks are loss of agricultural yield, damage to properties and even loss of life. Minor drainage system consists of swales, streets gutters, catch basis, storm sewers and surface and subsurface detention facilities. The minor system, designed to convey runoff from frequent storms with return periods i.e. from one to two years, primarily reduces the frequency of inconvenience caused by storm water ponding to both pedestrians and motorists. The consequences of failure of minor drainage are often insignificant provided the connected major drainage system is properly functioning.

Thus the selection of design return period for urban storm drain depends on the importance of area to be drained. Commercial and industrial areas have to be subjected to less frequent flooding. Manual on Sewerage and Sewage Treatment by the Ministry of Urban Development recommend the following:

- Residential area and Peripheral areas Twice a year
- Central and high priced areas Once a year
- Commercial and high period areas Once in two years.

### 3.4.4 INTENSITY OF PRECIPITATION:

The intensity of rainfall decreases with duration. Analysis of the observed data on intensity duration of rainfall of past records over a. period of years in the area is necessary to arrive at a fair estimate of intensity - duration for given frequencies. The longer record available, the more dependable is the forecast. In Indian conditions, intensity of rainfall adopted in design is usually in the range of 12 mm./hr. to 20 mm./hr. Rainfall data over a period of 25 years is collected and considered.

Frequency of storms of intensities 10 mm./hr to 120 mm./hr. for duration of 5 min. to 120 min. are tabulated, and the number of storms that had occurred for the stated intensities and duration for the desired frequency of storms (once in a year and once in two years) are considered.

The relationship between intensity and duration of storm may be expressed by a suitable, mathematical formula, several forms of which are available. The following two equations are commonly used.

$$\text{i) } i = \frac{a}{t^n} \quad \text{------}$$

$$ii)\ i = \frac{a}{t + b} \quad \text{------}$$

where, i = intensity of rainfall in mm/hr

t = duration of storm in minutes

a,b,n = constants as appropriate

The available data on 'i' and 't' are plotted and the values of the intensity (i) can be determined for any given time of consideration, ( $t_c$ ).

### 3.4.5. TIME OF CONCENTRATION:

It is the time required for the rain water to flow over the ground surface from the farthest point of the drainage basin to reach the point under consideration. Time of concentration ( $t_c$ ) is equal to inlet time (t) plus the time of flow in the drain (t). The inlet time is dependent. on the distance of the farthest point in the drainage basin to the inlet of the drain, the shape, characteristics and .topography of the basin may generally vary. The time of flow is determined by the length of SWD and the velocity of flow in the SWD. It is to be computed for each length of SWD to be designed.

### 3.4.6. COEFFICIENT OF RUNOFF:

The portion of rainfall which finds its way to the drain is dependent on the imperviousness and the shape of tributary area, apart from the duration of storm.

**1) Imperviousness:**

The percent imperviousness of the drainage area can be obtained from the records of a particular district. In absence of such data, the following may be serve as a guide.

| **Type of Area** | **Percentage of Imperviousness** |
|---|---|

| | |
|---|---|
| Commercial and industrial area | 70 to 90 |
| Residential area: | |
| •High density | 60 to 75 |
| •Low density | 35 to 60 |
| Parks and undeveloped areas | 10 to 20 |

The weighted average imperviousness of drainage basin for the flow concentrating at a point may be estimated using

$$I = (A_1I_1+A_2I_2+ .....) / (A1+ A2+.....)$$

Where, $A_1$, $A_2$ = Drainage areas tributary to the section under consideration

$I_1$, $I_2$ = Imperviousness respective areas and

I = Weighted average imperviousness of the total drainage basin.

### 3.4.7. TRIBUTARY AREA:

For each length of storm sewer, the drainage area should be indicated clearly on the map and measured. The boundaries of each tributary are dependent on topography, land use, nature of development and shape of the drainage basins. The incremental area may be indicated separately on the compilation sheet and the total area computed.

### 3.4.8. DURATION OF STORM:

The concept of design storm is developed to account for the time varying rainfall input as against the constant intensity design rainfalls. The assumption made in this concept is that the return period of the calculated runoff event is identical to the design storm.

For selected return period, the design storm is characterized by the duration, total amount of rainfall, the maximum rainfall intensity of a certain short duration, the timing of peak intensity and temporal storm rainfall distribution.

Continuously long light rain saturates the soil and produces higher coefficient than that of heavy rainfall for shorter duration. But intermittent rains in the same area causes lesser saturation in the latter case. Runoff from an area is significantly influenced by the saturation of the surface nearest the point of concentration, rather than the flow from the

distant area. The runoff coefficient of a larger area has to be adjusted by dividing the area into zones of concentration and by suitably decreasing the coefficient with the distance of the zones.

### 3.4.9. COMPUTATION OF RUNOFF COEFFICIENTS:

The weighted average runoff coefficients for rectangular areas of length four times the. width as well as for sector shaped areas with varying percentages of impervious surface for different times of concentration are given in Table 3.7. Although these are applicable to particular shapes of areas, they also apply in a general way to the areas which are usually encountered in practice. Errors due to difference in shape of drainage are within the limits of accuracy of the rational method and of the assumption on which it is based.

**TABLE – 3.7 Table of CPHEEO Manual - Runoff Coefficient**

| Duration t, minutes | 10 | 20 | 30 | 45 | 60 | 75 | 90 | 100 | 120 | 135 | 150 | 185 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weighted average coefficients | | | | | | | | | | | | |
| 1. Sector concentrating in stated time | | | | | | | | | | | | |
| a) Impervious | .525 | .588 | .642 | .700 | .740 | .711 | .795 | .813 | .828 | .840 | .850 | .865 |
| b)60% impervious | .365 | .427 | .477 | .531 | .569 | .598 | .622 | .641 | .656 | 670 | .682 | .701 |
| c)40% Impervious | .285 | .346 | .395 | .446 | .482 | .512 | .535 | .554 | .571 | .585 | .597 | .618 |
| d) Pervious | .125 | .185 | .230 | .312 | .312 | .330 | .362 | .382 | .399 | .414 | .429 | .454 |
| 2. Rectangle | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (length = 4 x width) Concentrating in stated time | | | | | | | | | | | | |
| a) Impervious | .550 | .648 | .711 | .768 | .808 | .837 | .856 | .869 | .879 | .887 | .892 | .903 |
| b)50% Impervious | .350 | .442 | .499 | .551 | .590 | .618 | .639 | .657 | .671 | .683 | .694 | .713 |
| c)30% Impervious | .269 | .360 | .414 | .464 | .502 | .530 | .552 | .572 | .588 | .601 | .614 | .636 |
| d) Pervious | .149 | .236 | .287 | .334 | .371 | .398 | .422 | .445 | .463 | .479 | .49 | .522 |

## 3.5. HYDRAULICS OF STORM DRAIN:

Flow capacity of open channels is calculated for each stretch of drain of different bed slope using Manning's formula.

$$V = [(l/n)] \times [R^{2/3} S^{1/2}]$$

The Mannings co-efficient 'n' for various drain surfaces are Masonry;

| | |
|---|---|
| a.Neat cement plaster | 0.013 |
| b.Sand and cement plaster | 0.015 |
| c.Concrete, steel troweled | 0.014 |
| d.Concrete, wood troweled | 0.015 |
| e.Brick in good condition | 0.017 |
| f.Masonry in bad condition | 0.020 |

| | | |
|---|---|---|
| Stone work;(a) Smooth, dressed ashlar | | 0.015 |
| (b) Rubble set in cement | 0.017 | |
| (c) Fine, well packed gravel | 0.020 | |
| Earth; (a) Regular surface in good condition | | 0.020 |
| (b) In-ordinary condition | 0.025 | |
| (c) With stones and weeds | 0.030 | |
| (d) In poor condition | 0.035 | |
| (e) Partially obstructed with debris or weeds | 0.050 | |

### 3.5.1 RATIONAL METHOD:

The Rational method is based on the following assumptions :

1)The peak rate of runoff at any point is a direct function of the average rainfall intensity during the time of concentration to that point.

2)The frequency of the peak discharge is the same as the frequency of the average rainfall intensity. The time of concentration is the time required for the runoff to become established and flow from the most remote part of the drainage area to the point under design.

The later assumption applies to the part most remote in time, not necessarily in distance. In the rational method, average intensities have no time sequence relation to the actual rainfall pattern during the storm. The intensity duration curve used in this method is not a time sequence curve of precipitation.

The determination of values for the coefficient of runoff is difficult because this factor must represent many variable including infiltration, ground slope, ground cover, surface and depression storage, antecedent precipitation and soil moisture, shape of drainage area, overland flow velocity , etc.

**AREA;**

The area of tributary to any point under consideration in a storm-sewer system must be determined.

Boundaries of the drainage area may be established by field surveys or from suitable maps or aerial photographs.

The complete drainage area is subdivided into sub-catchments and further into micro catchments for each tributary upto the point of inlet. This requires a preliminary layout of the system and tentative location of inlet point. Rearrangement of the system layout or of inlet location often is indicated as design proceeds. This requires reorganisation of component parts of the main drainage area to conform to the system layout and inlet scheme finally adopted.

### 3.5.2RAINFALL:

(a) Rainfall intensity factor, Determination of rainfall intensity, ' i ' for storm-sewer design involves consideration of the following factor:

1.Average frequency of occurrence

2.Intensity - duration characteristic of rainfall for selected average frequency of occurrence.

3.Time of concentration.

b) Rainfall frequency: The average frequency of rainfall occurrence used for design determines the degree of protection afforded by a given storm drain system. This protection should be consistent with the amount of damage prevented. But in practice, cost-benefit studies usually are not conducted for the ordinary urban storm drainage project. Judgement supported by records of performance in other similar areas is usually basis of selected frequency.

The range of rainfall frequency used in engineering practices is as follows:

1)For storm drains in residential areas, 2 to 15 years with 5 year most commonly reported.

2)For storm drains in commercial and high value districts, 10 to 50 years, depending on economic justifications.

3)For flood protection works, 50 years or more

In the analysis of point rainfall intensity-duration data, there are two approaches, the annual duration and partial-duration series. In the annual duration series, for each duration selected, the heaviest rainfall that occurred in each year is listed, with no tabulation of lesser intensities during the same calendar year, even though some of them might be greater than rainfall intensities that occurred in other years of record. The first of these methods gives the probability of occurrence that the maximum rainfall in anyone year for a specified duration will equal or exceed in given intensity. In the other treatment of the data, partial duration series, all rainfall intensities above a practical minimum for each duration for the entire period of record are included. The second method gives the frequency or the number of occurrences in a given period of time that a rainfall of given intensity and duration will be equal or exceeded.

Sherman has injected the concept of "extended duration" which has been used widely and is recommended for developing rainfall intensity frequency data. In this method, if the total precipitation in a storm is sufficient to show significant average rates for periods

longer than the actual duration of the rainfall, such storms are included in the data compilations as multiple events as though they had continued for the longer times. For example, a rainfall amount for an actual 50 min storm would be listed not only as a 50-min storm with its corresponding intensity, but also as a 60-min or 90-min, or longer duration storm with a corresponding lesser intensity.

**Table - Empirical Factors for Converting Annual-Duration Series to Partial-Duration Series**

| Return Period (Years) | Multiplier |
|---|---|
| 2 | 1.14 |
| 5 | 1.04 |
| 10 | 1.01 |

Time of Concentration - An estimate of the time of concentration to the point under consideration is made so that the average rainfall rate may be determined. For urban storm sewer the time of concentration consists of the inlet time plus the time of flow in the sewer from the most remote inlet to the point under consideration.

Time of flow in the sewer may be estimated closely from the hydraulic properties of the conduit. Inlet time is the overland flow time for runoff to reach established surface drainage channels such as street gutters and ditches and travel through them to the point of inlet.

Inlet time will vary with surface slope, nature of surplus cover, and length of path of surface flow, as well with the variables influenced by antecedent rainfall intensity and duration such as infiltration capacity.

### 3.5.3 RUNOFF COEFFICIENTS:

General Considerations.- The run coefficient, C, is the variable of. the rational method least susceptible to precise determination. Its use in the formula implies a fixed ratio for any given drainage area, whereas, in reality, the coefficient accounts for abstractions or losses between rainfall and runoff which may vary for a given drainage area as influenced by differing climatological and seasonal conditions.

These losses, together. with their order of magnitude as observed by various investigators include:

1)Interception by vegetation. This is not usually significant in urban drainage but may range from 0.01 to 0.5 in. (0.03 to 0.13 cm.) in forest areas, depending on type of cover.

2)Infiltration into permeable soils. The ability of a soil to absorb water and percolate it to deeper groundwater is affected by certain events before and during a given storm, such as compaction of the surface, in-washing of finer sediments, and swelling of clays or colloidal soils. The Hydrology Handbook gives the following range of value of infiltration capacity. !f various types of bare soils after 1 hr. of continuous rainfall.

| **Soil Group** | **Infiltration (In./hr.)** |
|---|---|
| High (sandy, open structured) | 0.50 to 1.00 |
| Intermediate (loam) | 0.10 to 0.50 |
| Low (clay, dense structured) | 0.01 to 0.10 |

Note: In. x 2.54 = cm.

The hand book also notes the profound influence of ground cover showing that bare-soil infiltration capacity can be increased from 3 to 7.5 times with good permanent forest or grass cover, ranging down. to little or no increase with poor row crops. Antecedent precipitation also affects soil infiltration capacity, but few quantitative data are available to evaluate this factor.

Retention in Surface Depressions.- The excess rainfall fills depressions essentially present in all surfaces. Retention in forest litter may be as much as 0.3 in. (0.08 cm.): in good pasture, 0.2 in. (0.05 cm.): and in smooth cultivated land, 0.05 to 0.10 in. (0.13 to 0:3 cm.). In urban areas of moderate grade, recent gauging shows retention to be about 0.05 in. (0.13 cm.) for impervious surfaces. Retention has been assumed to be 0.10 in. (0.3 cm) for surfaces such as lawns and normal urban pervious surfaces.

Evaporation and Transpiration - These are of little significance for the short rainfall duration encountered in urban storm drainage design.

Average Coefficients.- The use of average coefficients for various surface types, which are assumed not to vary through the duration of the storm is common.

The range of coefficient, classified with respect to the general character of the tributary area reported in use is :

| Description of Area | Runoff coefficients |
|---|---|
| Business | |
| Down Town | 0.70 to 0.95 |
| Neighbourhood | 0.50 to 0.70 |
| Residential | |
| Single Family | 0.30 to 0.50 |
| Multi-Units, detached | 0.40 to 0.60 |
| Multi-Units, attached | 0.60 to 0.75 |
| Residential (Suburban) | 0.25 to 0.40 |
| Apartment | 0.50 to 0.70 |
| Industrial | |
| Light | 0.50 to 0.80 |
| Heavy | 0.60 to 0.90 |
| Parks, Cemeteries | 0.10 to 0.25 |
| Playgrounds | 0.20 to 0.35 |
| Railroad yards | 0.20 to 0.35 |
| Unimproved lands | 0.10 to 0.30 |

It often is desirable to develop a composite runoff coefficient based on the percentage of different types of surface in the drainage area. This procedure often is applied to typical "sample" blocks as a guide to selection of reasonable values of the coefficient for an entire area. Coefficients with respect to surface type currently in use are:

| Character of Surface | Runoff Coefficients |
|---|---|
| Pavement | |
| Asphaltic and Concrete | 0.70 to 0.95 |
| Brick | 0.70 to 0.85 |
| Roofs | 0.75 to 0.95 |
| Lawns, sandy soil | |
| Flat, 2 percent | 0.05 to 0.10 |
| Average, 2 to 7 percent | 0.10 to 0.15 |
| Steep, 7 percent | 0.15 to 0.20 |
| Lawns, heavy soil | |
| Flat, 2 percent | 0.13 to 0.17 |
| Average, 2 to 7 percent | 0.18 to 0.22 |
| Steep, 7 percent | 0.25 to 0.35 |

The coefficient in these two tabulations are applicable for Storms of 5 to 10 years frequencies. Less frequent, higher intensity storms will require the use of higher

coefficients because infiltration and other losses have a proportionally smaller effect on runoff. The coefficient based on the assumption that the designs storm does not occur when the ground surface is frozen.

## 3.6. APPLICATION OF RATIONAL METHOD:

After the items discussed in the proceeding sections have been determined or estimated, a tentative arrangement of the proposed system including the location of inlets is made to permit division of the whole drainage area into sub districts tributary to sections of the storm sewer system.

Coefficients are selected or estimated which are appropriate for the land use and development expected at the end of the period of design.

Rainfall frequency consistent with degree of protection desired is selected and intensity-duration curves for the locality are developed from available rainfall records or from such other data as may be available (6).

Many designers find it convenient to reduce the rainfall – intensity relationship to a family of curves of runoff for rainfall intensities of selected frequencies. Such curves indicate the product of the runoff coefficient and average rain intensity (18). Other designers suggest weighing the size of the areas to reflect the variation imperviousness of individual sub areas from the average imperviousness of the project area. The weighted area size then is applied to the runoff curve developed for the average degree of imperviousness.

## 3.7 PROCESSING OF RAINFALL DATA:

Estimation of storm run-off depends on many factors and is difficult to evaluate accurately. It however demands a study of rainfall data for the past few years with regard to intensity and duration of each spell etc. Indian Meteorological Department, (IMD) Bangalore was contacted to furnish the rainfall data and they made available rainfall data i.e. intensity and duration at 15 minutes intervals for the years 1976 to 2001 (25 years) and it was possible to carry out the analysis of the frequency of storms of stated intensities and durations. In general there are two approaches in the analysis of rainfall intensity - duration data viz., (1) Annual - duration. series and (2) Partial - duration series. In partial - duration series, all rainfall intensities above a practical

minimum for each duration for the entire period of record are included and hence this series is adopted for the analysis with the concept of "extended duration" as recommended by American Society of Civil Engineers manual. Due to practical limitations IMD have not been able to give the amount of spells less than 15 minutes for longer duration of rainfalls i.e. for 5 and 10 minutes durations, having higher intensities. As this is an essential data, corresponding higher intensity rainfall for lesser duration of 5 and 10 minutes was computed, from the available heaviest rainfall. in 15 minutes. The occurrence values thus arrived at are plotted on a graph paper against the time duration for various intensities of rainfall viz. 15 mm/hr to 240 mm/hr., are plotted on graphs, and the line of best fit is drawn for each curve of Occurrence vs. Duration. From these lines of best fit marked in the graphs of each intensities, the frequency of storms for different stated duration are finally derived.

Table – 3.8 gives the analysis of the frequency of storms of stated intensities and duration during the past 25 years.

**Table 3.8**

## Table 3.9 Time intensity values of storms

| Intensity ( i ) mm/hr. | Duration ( t ) in minutes | | | | |
|---|---|---|---|---|---|
| | One year storm ( i.e. 25 times ) | Two year storm ( i.e. 12.5 times ) | Five year storm ( i.e. 5 times ) | Ten year storm ( i.e. 2.5 times ) | Twenty year storm ( i.e.1.25 times ) |
| 15 | 123.75 | 202.50 | - | - | - |
| 20 | 101.25 | 155.63 | 202.50 | - | - |
| 25 | 65.63 | 106.88 | 165.00 | 217.50 | 236.25 |
| 30 | 51.00 | 77.50 | 120.00 | 187.50 | 206.25 |
| 35 | 39.38 | 69.38 | 112.50 | 157.50 | 176.25 |
| 40 | 30.00 | 57.50 | 97.50 | 127.50 | 146.25 |
| 50 | 23.75 | 55.86 | 75.00 | 108.75 | 118.13 |
| 60 | - | 34.39 | 67.50 | 92.50 | 98.75 |
| 70 | - | 16.00 | 30.00 | 48.75 | 58.13 |
| 80 | - | - | 24.00 | 37.50 | 51.63 |
| 90 | - | - | 18.75 | 28.00 | 41.25 |
| 100 | - | - | - | 18.75 | 28.13 |
| 120 | - | - | - | - | - |

The time intensity values for these frequencies are obtained by interpolation and given in Table 3.9, for storm occurring once a year, once in 2 year, once in 5 year, once in 10 year & once in 20 years.

A graph (Fig. 3.5 to 3.9) is plotted using the values of 'i' and 't' from Table-3.9 for once a year, once in two years and once in five years storms on a log-log paper. As per central Public Health and Environmental Engineering organisation (CPHEEO) manual guidelines, once a year frequency of storm is considered for central and comparatively high priced areas, for commercial areas once in two years frequency of storm is to be considered. In addition once in five years, ten year and twenty year frequency is also considered for checking, the adequacy of culverts and the adequacy of drain reach near flood prone areas.

The generalised formula adopted for intensity and duration is :

$$i = \frac{a}{t^n} \quad \text{------}$$

Where, i = intensity of rainfall in mm/hr

t = duration of storm in minutes

a,b,n = constants as appropriate

From the line of best fit marked in the graph (Fig. 3.5 to 3.9) the values of 'a' and 'n' are found out for one, two, five, ten and twenty year storms. From the plotted best fit line, values of 'a' and 'n' are obtained:

(i) a = 414.25 and n = 0.673 for storm once a year.
(ii) a = 511.91 and n = 0.6399 for storm once in two years,
(iii) a = 570.75 and n = 0.5987 for storm once in five years.
(iv) a = 568.72 and n = 0.5476 for storm once in ten years.
(v) a = 976.47 and n = 0.6442 for storm once in twenty years.

Now using the above equation and substituting, the values of' a' and 'n' , different values of 'i' for various values of 't' are calculated and tabulated in Table 3.10.

## TABLE – 3.10

| Duration "t" in minutes | **Intensity (i) = a / $t^n$ (mm/hour)** | | | | |
|---|---|---|---|---|---|
| | One year storm | Two year storm | Five year storm | Ten year storm | Twenty year storm |
| | ( i.e. 25 times) | ( i.e. 12.5 times) | ( i.e. 5 times ) | ( i.e. 2.5 times ) | ( i.e. 1.25 times ) |
| | a = 414.25 | a = 511.91 | a = 570.75 | a = 568.72 | a = 976.47 |
| | n = 0.673 | n = 0.6399 | n = 0.5989 | n = 0.5474 | n = 0.6442 |
| 5 | 140.23 | 182.78 | 217.69 | 235.66 | 346.24 |
| 10 | 87.96 | 117.30 | 143.73 | 161.25 | 221.54 |
| 15 | 66.95 | 90.49 | 112.74 | 129.15 | 170.62 |
| 20 | 55.17 | 75.28 | 94.90 | 110.34 | 141.75 |
| 25 | 47.47 | 65.26 | 83.03 | 97.65 | 122.77 |
| 30 | 41.99 | 58.07 | 74.44 | 88.37 | 109.17 |
| 45 | 31.96 | 44.80 | 58.39 | 70.78 | 84.07 |
| 60 | 26.34 | 37.27 | 49.15 | 60.47 | 69.85 |
| 75 | 22.66 | 32.31 | 43.00 | 53.52 | 60.50 |
| 90 | 20.05 | 28.75 | 38.55 | 48.43 | 53.79 |
| 105 | 18.07 | 26.05 | 35.15 | 44.51 | 48.71 |
| 120 | 16.52 | 23.92 | 32.45 | 41.38 | 44.69 |
| 135 | 15.26 | 22.18 | 30.24 | 38.79 | 41.43 |
| 150 | 14.22 | 20.74 | 28.39 | 36.62 | 38.71 |
| 165 | 13.33 | 19.51 | 26.82 | 34.76 | 36.40 |
| 180 | 12.57 | 18.45 | 25.45 | 33.14 | 34.42 |
| 195 | 11.91 | 17.53 | 24.26 | 31.72 | 32.69 |
| 210 | 11.33 | 16.72 | 23.21 | 30.46 | 31.17 |
| 225 | 10.82 | 16.00 | 22.27 | 29.33 | 29.81 |
| 240 | 10.36 | 15.35 | 21.43 | 28.31 | 28.60 |

A curve is plotted on an ordinary graph paper (Fig 3.10) and from this graph or from log-log paper (Fig. 3.5 to 3.9), value of intensity of storm for any given duration can be worked out for return period of one, two, five, ten and twenty years. .

Another graph (Fig.3.11), run-off coefficient 'c' vs duration time 't' is plotted as per : values given in Homer's table (Table 3.3, Pg. No. 45 of CPHEEO Manuel).

## 3.8 COMPUTATION OF STORM WATER RUN-OFF:

Quantity of storm water run-off is calculated using the rational formula:

$$Q = 10\ C.\ i\ .\ A.$$

Where, Q = run-off in m3/hr
c. = coefficient of run-off
i. = intensity of rainfall in mm/hr
A = area of drainage segment in hectares

Coefficient of run-off (c) is arrived at by interpolation of values given in Homer's table with respect to time of concentration ($t_c$) and for weighted imperviousness. Refer Graph (Fig. 3.11).

As per CPHEEO guide lines, the inlet time which depends on the distance of the farthest point in the drainage basin to the inlet drain, the shape, characteristics and topography of the basin and this may generally vary from 5 to 20 minutes. The inlet time in the present case will be the time taken for the storm water to flow through a network of roadside drains (roads parallel to the main drain and perpendicular to the main drain) till it reaches either a secondary drain or a primary drain. The range of velocities obtained for the secondary/primary drains considering the ground slope and the drain sections as per the existing uncleaned / silted condition of drain, works out to 0.5 to 4.5 m/sec. The mean velocity of flow in the primary drain for 0 to 1000 m distance for clean condition of drain and silted up condition of drain is found to be 5.5 m/sec and 2.25 m/sec respectively. Keeping this velocities in view, a velocity of flow of 1.2 m/sec for terrain and maximum of 3.0 m/sec in drain was chosen to estimate the time of flow (considering cleaned drain with moderate siltation / vegetation).

To arrive at a realistic time of concentration, surface flow velocity of rainwater is taken as 2 m/sec as stated above and the time of flow from the farthest point of the contributory area is worked out, The inlet time varying from 5 to 20 minutes depending on various factors**.** The time thus derived are used to compute design run-off of each segment.

The weighted imperviousness of the drainage area segment-wise, was worked out as stated in earlier section. Due to non-availability of 0.5 m. or 1.0 m. contour map, the entire tributary area has been divided into various segments with respect to the ridge line and flow patterns, using the area map developed from the satellite imagery.

The identification of roadside drains/ feeder drains leading to primary or secondary drains and adequacy check of such drains is not under the scope of work. However, multiple number of small drains existing in reality by the side of roads in each segment of catchment area (to be drained into main valley) is assumed to be replaced by centrally placed storm drain.

Intensity of rainfall (i) is arrived at from the Graphs (Fig. 3.5 to 3.9 or 3.10 ) with respect to time of concentration ($t_c$).

Area of each drainage segment for the entire watershed area has been arrived from the micro catchment area map enclosed in Section 3.3 of this chapter.

Quantity of storm water run-off, worked out segment-wise are furnished for Challaghatta main valley and Ulsoor valley in Table 4.1 & 4.2 is as enclosed in the section 4.2 of Chapter-4 in this report.

# CHAPTER - 4

# REVIEW OF ASSESSMENT AND RECOMMENDATIONS ON EXISTING STORM WATER DRAINAGE SYSTEM

## 4.1 INTRODUCTION:

This chapter on review of assessment has been prepared to identify the reasons for the failure of the system components. Depending on the nature and extent of the system failure, the approach for the system rehabilitation will vary accordingly. A Generic groupings of rehabilitation methodologies for different applications are therefore needed.

To identify and prioritise rehabilitation needs a systematic approach is needed in planning and investigating the most problematic areas. This will involve the establishment of guidelines on levels of service and asset performance, from which decisions can be consistently based and gaining an understanding of existing flooding problems through fieldwork investigations.

As the implementation of a systematic approach to planning and investigation of rehabilitation works can involve significant resource commitments, both in personnel and financial terms, it is proposed that the BMP progressively improve towards this long-term objective.

Further, Improvements to the existing storm drainage system, which is serving the core area is considered to be on priority for five key reasons:

- To rectify current localised flooding problems in the critical low lying areas.
- To cope with additional areas being included into the BMP administered area.
- To improve and extend the security of services in vulnerable areas of the current BMP administered area.
- To improve and protect the quality of environmental attributes including aesthetic appearance of city's environs.
- To minimise cost implication on operation and maintenance of the system.

## 4.2 REPORT ON ADEQUACY ANALYSIS:

An assessment of the existing system for its adequacy has been made using computer modelling. The adequacy of the existing system has been analysed

and correlated for different year return periods.

Further, these analysis results have been once again correlated with the situation and specific site condition to verify the accuracy of the results and to suggest the strategic improvements required at that particular location.

The focus of this section is solely on

•Storm drains
•Cross drains

➢**Storm Water Drains:**

The total catchment area of the Challaghatta valley is 3878 Ha. The localities which contribute and the existing condition of this drain is detailed in Section 2.3 & Section 2.6 of Chapter 2.

Cross section data of the existing drains at every 25 m. apart was collected and spread sheets were developed to analyse for their carrying capacity. The analysis has been done for different year return periods. The calculations and results of these analysis is enclosed in Table 4.1 & 4.2.

These tables show the discharge (Q) in the existing drain at that particular chainage. The procedure adopted to work out the required data are furnished below.

1.Bed levels on either side of the existing drain differ marginally and hence the average of these levels are considered for computation.

2.Top levels of the existing drain side also differ and hence the lower wall/ground level heights are considered for the depth of the drain.

3.Free board is taken as 300 mm. for one and two year storms and 100 mm. for five, ten & twenty year storms.

4.Coefficient of roughness (n) considered as 0.035 and 0.025 for unclean and clean condition respectively for analysis of existing drains and 0.02 – 0.025 for remodeled drain.

5.Design runoff (Q required) are worked out for respective chainages based

on the runoff calculated segment wise. An abstract of the analysis for Challaghatta main valley & Ulsoor valley is presented in Table – 4.1 & 4.2.

From the analysis and the assessment carried out, following outcomes are highlighted:

**➔Challaghatta Main Valley:**

- Near Vasanthanagar the existing storm drain is having a wider catchment area, less time of concentration, drain depth and width is very less, gentle slope is available, severely silted, bed is in natural condition, max. obstructions and also drain walls are in moderate condition. Hence the capacity is adequate only for one year return period.

- Near Shivajinagar the existing storm drain is having a wider catchment area, less time of concentration, drain depth and width is very less, shallow depth, moderate bed slope is available, silted, bed is in natural condition, number of obstructions and also drain walls are in moderate condition. The drain capacity is adequate for two year return period.

- Near Bharathinagar the existing storm drain is having a wider catchment area, less time of concentration, drain depth and width is very less, shallow depth, moderate bed slope is available, silted, bed is in natural condition, max. obstructions and also drain walls are in moderate condition. The drain capacity in this stretch is adequate for five year return period.

- Near Guptha layout the existing storm drain is having a smaller catchment area, more time of concentration, sufficient drain width and depth, good bed slope is available, silted, bed is in natural condition, min. obstructions and also drain walls are in good condition. The drain capacity is adequate for twenty year return period.

- Near Old Madras road / Saraswathipura the existing storm drain is having a smaller catchment area, less time of concentration, sufficient drain width and depth except near Murphy town market, good bed slope is available, silted, bed is in natural condition, min. obstructions and also drain walls are in moderate condition. The drain capacity is adequate for ten year return period.

- Near Shammana Gowda layout the existing storm drain is having a wider catchment area, less time of concentration, sufficient drain width and depth except at few places width gets reduced, moderate bed slope is available, silted, bed is in natural condition, min. obstructions and also drain walls are in good condition. The drain capacity is adequate for five year return period.

- Near Cambridge layout the existing storm drain is having a lesser catchment area, less time of concentration, reduced drain width and depth, moderate bed slope is available, silted, bed is in natural condition, max. obstructions, and also drain walls are in good condition. The drain capacity is adequate for one year return period.

- Near Domlur 2$^{nd}$ Stage the existing storm drain is having a lesser catchment area, less time of concentration, reduced drain width and depth, moderate bed slope is available, silted, bed is in natural condition, min. obstructions, and also drain walls are in good condition. The drain capacity is adequate for two year return period.

- Near Diamond District Apartment the existing storm drain is having a lesser catchment area, more time of concentration, sufficient drain width and depth, moderate bed slope is available, silted, bed is in natural condition, min. obstructions, and also drain walls are in moderate condition. The drain capacity is adequate for five year return period.

- Near Karnataka Golf Club the existing storm drain is having a more catchment area, more time of concentration, reduced drain width and depth, min. bed slope is available, silted, bed is in natural condition, min. obstructions, and also drain walls are in moderate condition. Hence, it is

very inadequate.

- Inside Airport complex the existing storm drain is having a more catchment area, more time of concentration, reduced drain width and depth, moderate bed slope is available, silted, bed is in natural condition, max.. obstructions, and also drain walls are in natural condition. Hence, it is very inadequate.

- Near Anandanagar the existing storm drain is having a more catchment area, less time of concentration, reduced drain width and depth, moderate. bed slope is available, silted, bed is in natural condition, max. obstructions, and also drain walls are in moderate condition. Hence, it is very inadequate.

- Near Kodihalli Village the existing storm drain is having a more catchment area, less time of concentration, reduced drain width and depth, min. bed slope is available, silted, bed is in natural condition, min. obstructions, and also drain walls are in moderate condition. The drain capacity is adequate for one year return period.

**➔Ulsoor Valley:**

- Near J.C. Nagar the existing storm drain is having a smaller catchment area, less time of concentration, sufficient drain width and depth, good bed slope is available, silted, bed is in natural condition, few obstructions and also drain walls are in good condition. The drain capacity is adequate for twenty year return period.

- Near S.K. Garden the existing storm drain is having a smaller catchment area, less time of concentration, sufficient drain width and depth, good bed slope is available, silted, bed is in natural condition, few obstructions and also drain walls are in good condition. The drain capacity is adequate for twenty year return period.

- Near Frazer town the existing storm drain is having a smaller catchment area, less time of concentration, sufficient drain width and depth, good bed slope is available, silted, bed is in natural condition, few obstructions and also drain walls are in good condition. The drain capacity is adequate for twenty year return period.

- Near Wheelers Road the existing storm drain is having a smaller catchment area, more time of concentration, sufficient drain width and depth, good bed slope is available, silted, bed is in natural condition, few obstructions and also drain walls are in good condition. The drain capacity is adequate for twenty year return period.

- Near Sindhi colony the existing storm drain is having a smaller catchment area, more time of concentration, drain width and depth is slightly reduced, moderate bed slope is available, silted, bed is in natural condition, max. obstructions and also drain walls are in moderate condition. The drain capacity is adequate for ten year return period.

- Near Richard's town the existing storm drain is having a smaller catchment area, more time of concentration, sufficient drain width and depth, good bed slope is available, silted, bed is in natural condition, max. obstructions and also drain walls are in good condition. The drain capacity is adequate for twenty year return period.

- Near Cox town the existing storm drain is having a smaller catchment area, more time of concentration, sufficient drain width and depth, good bed slope is available, silted, bed is in natural condition, max. obstructions and also drain walls are in good condition. The drain capacity is adequate for twenty year return period.

- Near Jeevanahalli the existing storm drain is having a wider catchment area, more time of concentration, drain width and depth is drastically reduced, moderate bed slope is available, silted, bed is in natural condition, max. obstructions and also drain walls are in moderate condition. The drain capacity is adequate for one year return period.

➢**Cross Drains:**

Existing culverts based on their structural conditions, no. of vents, no. of utilities laid across SWD at the culvert location which in turn causing obstruction for free flow of water were identified during reconnaissance survey and further analysed for their carrying capacity.

Table 4.3 & 4.4 shows the carrying capacity (Q) near the culverts along with all other data required to derive the same. The procedure adopted to workout the required data are furnished below:

1.Adequacy check is carried out under clean condition only, since the drains on either side of the culvert are proposed to be free of silt and vegetation to achieve optimum carrying capacity.

2.Dimensions shown in the table is the existing dimensions and the vent way considered is actually collected from site, and accordingly vent way has been worked out.

3.The bed slope in the direction of flow is assumed as 1 in 500 (0.002), which may produce a reasonable velocity of flow through the vent way to prevent deposition of silt and a scouring action. Bed slope at existing culvert could not be taken due to flow of water.

4.Free board is taken as 0.3 m. for one, two & five year storms.

5.The percentage area reduction at the vent way of the culvert with reference to the upstream side drain area are worked out for reference and guidance.

6.Coefficient of roughness(n) is considered as 0.02.

7.Design runoff are worked out based on the runoff calculated for the drain segment both upstream and down stream side (near the culvert locations) for the length of about 100 m.

The remarks column of these tables, indicated the existing culvert which are

inadequate to carry the design runoff and such culverts are found to be very few. These culverts which are considered to be inadequate were jointly site inspected with BMP officials and various possibilities are studied and incorporated to increase the carrying capacity before deciding for remodelling.

The existing culvert in Challaghatta main valley & Ulsoor valley which are considered to be inadequate are listed in Table – 4.5

The inspection details of these existing culverts/bridges is enclosed in Volume 2 - Condition Survey.

Based on the assessment, 20 culverts which were in moderate condition and drastically obstructing the flow, has been shortlisted and considered for reconstruction. Out of 20 culverts 3 culverts i.e, near Ulsoor lake, Indiranagar 100 ft. road and Airport Road have been taken up under different projects.

The detailed designs and estimates of these culverts / bridges is enclosed in Volume 3 and relevant drawings in Volume 4. The list of culverts / bridges proposed for reconstruction is as listed below and the same is depicted in Figure 4.1.

**Table - 4.5 List of Culverts / Bridges Considered for Remodeling in Challaghatta Valley**

| Sl. No. | Culvert No. | Chainage (m.) | Location | Remarks |
|---|---|---|---|---|
| 1 | CVC -1 | 377 | Miller's Road | Ex. Culvert/Bridge considered for remodelling |
| 2 | CVC - 1A | 640 | Miller Tank Bund Road (near K.B. Asson.) | Ex. Culvert/Bridge considered for remodelling |
| 3 | CVC – 6 A | 1823 | Old bamboo bazar Road | Ex. Culvert/Bridge considered for remodelling |
| 4 | CVC – 6 B | 1905 | Charminar Masjid Road | Ex. Culvert/Bridge considered for remodelling |
| 5 | CVC – 6 C | 2020 | Jumma Masjid Road | Ex. Culvert/Bridge considered for remodelling |
| 6 | CVC - 7 | 2127 | Seppings Road | Ex. Culvert/Bridge considered for remodelling |
| 7 | CVC - 11 | 2600 | Kamaraj Road | Ex. Culvert/Bridge considered for remodelling |
| 8 | CVC - 12 | 2838 | St. John's Road | Ex. Culvert/Bridge considered for remodelling |
| 9 | CVC - 13 | 3167 | Anna Swamy Mudaliar Road | Ex. Culvert/Bridge considered for remodelling |
| 10 | CVC - 14 | 4015 | Kensington Road (Opp. Gurudwara) | Ex. Culvert/Bridge considered for remodelling |
| 11 | CVC - 22 | 7572 | Indiranagar 100 ft. Road | Note: Considered by BDA under Flyover Project. |
| 12 | CVC - 23 | 7683 | Airport Road (Opp. Diamond Dist. Appartment) | Note : Considered by BDA under Flyover project. |
| 13 | N - 1 | 9232 | Wind Tunnel Road (Near Texas Instrument) | Proposed New Bridge |
| 14 | N - 2 | 9675 | Belur Road (Behind Airport) | Proposed New Bridge |
| **Ulsoor Valley (C2):** | | | | |
| 1 | MVC-4 | 265 | 1st Cross, J.C. Nagar, Ramgeetha Block | Ex. Culvert/Bridge considered for remodelling |
| 2 | MVC-8 | 441 | 1st Main Road, Krishnamanagar | Ex. Culvert/Bridge considered for remodelling |
| 3 | MVC-7 | 468 | 2nd Main Road, Krishnamanagar | Ex. Culvert/Bridge considered for remodelling |
| 4 | N – 3 / MVC 18 | 1462 | S.K. Garden Main Road | Proposed New Bridge |
| 5 | MVC-19 | 1862 | Pottery Town Main Road | Ex. Culvert/Bridge considered for remodelling |
| 6 | MVC-25 | 2982 | Stephen's Cross Road | Ex. Culvert/Bridge considered for remodelling |
| 7 | MVC-26 | 3162 | Wheeler's Road (Opp. Community Centre) (Frazer town) | Ex. Culvert/Bridge considered for remodelling |
| 8 | MVC-30 | 4100 | Near Lake View Maha Ganapathy Temple | Note: Considered by BMP under Ulsoor Lake Restoration Project. |
| **Richard's Town Secondary Storm Drain (C202):** | | | | |
| 1 | | 905 | Wheeler's Road (Opp. Gymkhana Ground) | Ex. Culvert/Bridge considered for remodelling |

## Table 4.3 Check for Existing Culverts with measured Site Slopes for Adequacy ( Challaghatta - Primary Culverts)

( Clean Condition n = 0.015 ) ( with freeboard 100mm)

| Sl.No. | Culvert No. | Chainage | Vent | Width of the drain | Depth of the drain | Slope | (Di) (D- 0.1) | A= (B x Di) | U.S.D Area (Da) | ( Da – A)/Da x 100 | WP = (B+2Di) | R = A / P | (n) | V = ( 1/n) $R^{2/3}$ $S^{0.5}$ | Q = A x V | Q total | Discharge ( $Q_{Reqd.}$ ) | | | | | Remarks | | | | | Width Required(B) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year |
| | | (m) | No. | (B) m | (D) m | (S) | (D- 0.1) m | ($m^2$) | ($m^2$) | % | (m) | (m) | | (m/s) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | | | | | | | | | | |
| 1 | CVC2 | Queens Road @1032 | 1 | 3.000 | 4.000 | 0.0012 | 3.900 | 11.700 | | | 10.800 | 1.083 | 0.015 | 2.436 | 28.501 | | | | | | | | | | | | | | | | |
| | | | 2 | 3.000 | 4.000 | 0.0012 | 3.900 | 11.700 | | | 10.800 | 1.083 | 0.015 | 2.436 | 28.501 | | | | | | | | | | | | | | | | |
| | | | | 6.000 | | | 3.900 | 23.400 | 25.500 | 8.235 | | | | 2.436 | | 57.002 | 10.870 | 15.010 | 19.220 | 22.790 | 28.230 | AD | AD | AD | AD | AD | | | | | |
| 2 | CVC3 | Payappa Garden Road @1062 | 1 | 4.000 | 1.700 | 0.0196 | 1.600 | 6.400 | | | 7.200 | 0.889 | 0.015 | 8.628 | 55.222 | | | | | | | | | | | | | | | | |
| | | | 2 | 3.500 | 1.750 | 0.0196 | 1.650 | 5.775 | | | 6.800 | 0.849 | 0.015 | 8.370 | 48.337 | | | | | | | | | | | | | | | | |
| | | | | 7.500 | | | 1.600 | 12.175 | 33.670 | 63.840 | | | | 8.370 | | 103.560 | 11.160 | 15.420 | 19.740 | 23.410 | 28.990 | AD | AD | AD | AD | AD | | | | | |
| 3 | CVC4 | Old Cemetry Road @1287 | 1 | 2.000 | 2.420 | 0.0025 | 2.320 | 4.640 | | | 6.640 | 0.699 | 0.015 | 2.625 | 12.180 | | | | | | | | | | | | | | | | |
| | | | 2 | 2.000 | 2.250 | 0.0025 | 2.150 | 4.300 | | | 6.300 | 0.683 | 0.015 | 2.584 | 11.111 | | | | | | | | | | | | | | | | |
| | | | 3 | 2.000 | 2.940 | 0.0025 | 2.840 | 5.680 | | | 7.680 | 0.740 | 0.015 | 2.726 | 15.484 | | | | | | | | | | | | | | | | |
| | | | | 6 | | | 2.320 | 14.620 | 19.210 | 23.894 | | | | 2.600 | | 38.775 | 12.480 | 17.240 | 22.080 | 26.180 | 32.420 | AD | AD | AD | AD | AD | | | | | |
| 5 | CVC4A | D' No. 1 Street @1431 | 1 | 2.500 | 1.750 | 0.0080 | 1.650 | 4.125 | | | 5.800 | 0.711 | 0.015 | 4.751 | 19.598 | | | | | | | | | | | | | | | | |
| | | | 2 | 2.500 | 1.750 | 0.0080 | 1.650 | 4.125 | | | 5.800 | 0.711 | 0.015 | 4.751 | 19.598 | | | | | | | | | | | | | | | | |
| | | | | 5 | | | 1.650 | 8.250 | 7.830 | -5.364 | | | | 4.751 | | 39.196 | 13.360 | 18.460 | 23.630 | 28.020 | 34.700 | AD | AD | AD | AD | AD | | | | | |
| 6 | CVC5 | Shivaji Road @1462 | 1 | 5.000 | 1.525 | 0.0040 | 1.425 | 7.125 | | | 7.850 | 0.908 | 0.015 | 3.953 | 28.162 | | | | | | | | | | | | | | | | |
| | | | | 5.000 | | | 1.425 | 7.125 | 10.530 | 32.336 | | | | 3.953 | | 28.162 | 13.500 | 18.660 | 23.890 | 28.330 | 35.080 | AD | AD | AD | IA | IA | | | | 5.03 | 6.23 |
| 7 | CVC6 | Board Way Road @1737 | 1 | 6.000 | 1.500 | 0.0030 | 1.400 | 8.400 | | | 8.800 | 0.955 | 0.015 | 3.540 | 29.736 | | | | | | | | | | | | | | | | |
| | | | | 6.000 | | | 1.400 | 8.400 | 9.460 | 11.205 | | | | 3.540 | | 29.736 | 15.120 | 20.890 | 26.750 | 31.720 | 39.270 | AD | AD | AD | IA | IA | | | | 6.4 | 7.92 |
| 8 | CVC6A | Sri Nanjunda Murthy Temple @1789 | 1 | 2.200 | 1.750 | 0.0034 | 1.650 | 3.630 | | | 5.500 | 0.660 | 0.015 | 2.947 | 10.697 | | | | | | | | | | | | | | | | |
| | | | 2 | 2.200 | 1.750 | 0.0034 | 1.650 | 3.630 | | | 5.500 | 0.660 | 0.015 | 2.947 | 10.697 | | | | | | | | | | | | | | | | |
| | | | | 4.400 | | | 1.650 | 7.260 | 11.590 | 37.360 | | | | 2.947 | | 21.393 | 15.410 | 21.300 | 27.270 | 32.330 | 40.040 | AD | AD | IA | IA | IA | | | 5.61 | 6.65 | 8.23 |

| Sl.No. | Culvert No. | Chainage | Vent | Width of the drain | Depth of the drain | Slope | (Di) (D- 0.1) | A= (B x Di) | U.S.D Area (Da) | ( Da – A)/Da x 100 | WP = (B+2Di) | R = A / P | (n) | V = ( 1/n) R $^{2/3}$ S $^{0.5}$ | Q = A x V | Q total | Discharge ( $Q_{Reqd.}$ ) | | | | | Remarks | | | | | Width Required(B) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year |
| | | (m) | No. | (B) m | (D) m | (S) | (D- 0.1) m | (m$^2$) | (m$^2$) | % | (m) | (m) | | (m/s) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | | | | | | | | | | |
| 9 | CVC7 | Seppings Road @2128 | 1 | 2.500 | 1.500 | 0.0025 | 1.400 | 3.500 | | | 5.300 | 0.660 | 0.015 | 2.528 | 8.847 | | | | | | | | | | | | | | | | |
| | | | 2 | 2.500 | 1.500 | 0.0025 | 1.400 | 3.500 | | | 5.300 | 0.660 | 0.015 | 2.528 | 8.847 | | | | | | | | | | | | | | | | |
| | | | 3 | 2.500 | 1.500 | 0.0025 | 1.400 | 3.500 | | | 5.300 | 0.660 | 0.015 | 2.528 | 8.847 | | | | | | | | | | | | | | | | |
| | | | | 7.500 | | | 1.400 | 10.500 | 8.930 | -17.581 | | | | 2.528 | | 26.542 | 15.700 | 21.700 | 27.790 | 32.950 | 40.800 | AD | AD | IA | IA | IA | | | 7.85 | 9.31 | 11.53 |
| 10 | CVC8 | Jewellery Street @2190 | 1 | 2.500 | 1.500 | 0.0030 | 1.400 | 3.500 | | | 5.300 | 0.660 | 0.015 | 2.769 | 9.692 | | | | | | | | | | | | | | | | |
| | | | 2 | 2.700 | 1.500 | 0.0030 | 1.400 | 3.780 | | | 5.500 | 0.687 | 0.015 | 2.844 | 10.749 | | | | | | | | | | | | | | | | |
| | | | 3 | 2.700 | 1.400 | 0.0030 | 1.300 | 3.510 | | | 5.300 | 0.662 | 0.015 | 2.774 | 9.738 | | | | | | | | | | | | | | | | |
| | | | | 7.900 | | | 1.400 | 10.790 | 13.920 | 22.486 | | | | 2.769 | | 30.179 | 17.760 | 24.540 | 31.420 | 37.250 | 46.130 | AD | AD | IA | IA | IA | | | 8.11 | 9.61 | 11.9 |
| 11 | CVC9 | Narayana Pillai Street @2242 | 1 | 3.500 | 1.250 | 0.0104 | 1.150 | 4.025 | | | 5.800 | 0.694 | 0.015 | 5.329 | 21.449 | | | | | | | | | | | | | | | | |
| | | | 2 | 3.500 | 1.300 | 0.0104 | 1.200 | 4.200 | | | 5.900 | 0.712 | 0.015 | 5.420 | 22.765 | | | | | | | | | | | | | | | | |
| | | | | 7.000 | | | 1.150 | 8.225 | 14.620 | 43.741 | | | | 5.350 | | 44.215 | 18.110 | 25.030 | 32.050 | 38.010 | 47.050 | AD | AD | AD | AD | IA | | | | | 7.65 |
| 12 | CVC10 | Arm Strong Road @2439 | 1 | 3.500 | 1.500 | 0.0032 | 1.400 | 4.900 | | | 6.300 | 0.778 | 0.015 | 3.189 | 15.628 | | | | | | | | | | | | | | | | |
| | | | 2 | 3.500 | 1.500 | 0.0032 | 1.400 | 4.900 | | | 6.300 | 0.778 | 0.015 | 3.189 | 15.628 | | | | | | | | | | | | | | | | |
| | | | | 7.000 | | | 1.400 | 9.800 | 17.580 | 44.255 | | | | 3.189 | | 31.257 | 19.770 | 27.340 | 35.050 | 41.620 | 51.400 | AD | AD | IA | IA | IA | | | 7.85 | 9.32 | 11.51 |
| 13 | CVC11A | Goutham Sound Lights @2730 | 1 | 2.500 | 1.500 | 0.0034 | 1.400 | 3.500 | | | 5.300 | 0.660 | 0.015 | 2.948 | 10.318 | | | | | | | | | | | | | | | | |
| | | | 2 | 2.500 | 1.500 | 0.0034 | 1.400 | 3.500 | | | 5.300 | 0.660 | 0.015 | 2.948 | 10.318 | | | | | | | | | | | | | | | | |
| | | | 3 | 2.500 | 1.500 | 0.0034 | 1.400 | 3.500 | | | 5.300 | 0.660 | 0.015 | 2.948 | 10.318 | | | | | | | | | | | | | | | | |
| | | | | 7.500 | | | 1.400 | 10.500 | 14.010 | 25.054 | | | | 2.948 | | 30.953 | 22.260 | 30.820 | 39.550 | 47.040 | 57.920 | AD | AD | IA | IA | IA | | | 9.58 | 11.4 | 14.03 |
| 14 | CVC12 | St. Jhons Road @2837 | 1 | 3.000 | 1.800 | 0.0022 | 1.700 | 5.100 | | | 6.400 | 0.797 | 0.015 | 2.688 | 13.707 | | | | | | | | | | | | | | | | |
| | | | 2 | 2.500 | 1.850 | 0.0022 | 1.750 | 4.375 | | | 6.000 | 0.729 | 0.015 | 2.533 | 11.083 | | | | | | | | | | | | | | | | |
| | | | 3 | 2.000 | 1.750 | 0.0022 | 1.650 | 3.300 | | | 5.300 | 0.623 | 0.015 | 2.280 | 7.524 | | | | | | | | | | | | | | | | |
| | | | | 7.500 | | | 1.700 | 12.775 | 22.170 | 42.377 | | | | 2.533 | | 32.314 | 23.090 | 31.970 | 41.050 | 48.850 | 60.090 | AD | AD | IA | IA | IA | | | 9.53 | 11.34 | 13.95 |
| 15 | CVC13 | Anna Swamy Mudaliar Street @3167 | 1 | 1.500 | 1.680 | 0.0020 | 1.580 | 2.370 | | | 4.660 | 0.509 | 0.015 | 1.900 | 4.502 | | | | | | | | | | | | | | | | |

| Sl.No. | Culvert No. | Chainage | Vent | Width of the drain | Depth of the drain | Slope | (Di) (D- 0.1) | A= (B x Di) | U.S.D Area (Da) | ( Da – A)/Da x 100 | WP = (B+2Di) | R = A / P | (n) | V = ( 1/n) $R^{2/3}$ $S^{0.5}$ | Q = A x V | Q total | Discharge ( $Q_{Reqd.}$ ) | | | | | Remarks | | | | | Width Required(B) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year |
| | | (m) | No. | (B) m | (D) m | (S) | (D- 0.1) m | ($m^2$) | ($m^2$) | % | (m) | (m) | | (m/s) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | | | | | | | | | | |
| | | | 2 | 1.500 | 1.680 | 0.0020 | 1.580 | 2.370 | | | 4.660 | 0.509 | 0.015 | 1.900 | 4.502 | | | | | | | | | | | | | | | | |
| | | | 3 | 1.500 | 2.030 | 0.0020 | 1.930 | 2.895 | | | 5.360 | 0.540 | 0.015 | 1.977 | 5.724 | | | | | | | | | | | | | | | | |
| | | | 4 | 1.500 | 2.030 | 0.0020 | 1.930 | 2.895 | | | 5.360 | 0.540 | 0.015 | 1.977 | 5.724 | | | | | | | | | | | | | | | | |
| | | | 5 | 1.500 | 2.030 | 0.0020 | 1.930 | 2.895 | | | 5.360 | 0.540 | 0.015 | 1.977 | 5.724 | | | | | | | | | | | | | | | | |
| | | | | 7.500 | | | 1.750 | 13.425 | 30.110 | 55.413 | | | | 1.930 | | 26.177 | 25.780 | 35.730 | 45.930 | 54.710 | 67.160 | AD | IA | IA | IA | IA | | 10.58 | 13.6 | 16.2 | 19.88 |
| 16 | CVC14 | Old Madras Road @4000 | 1 | 2.000 | 3.500 | 0.0058 | 3.400 | 6.800 | | | 8.800 | 0.773 | 0.015 | 4.275 | 29.073 | | | | | | | | | | | | | | | | |
| | | | 2 | 2.000 | 3.500 | 0.0058 | 3.400 | 6.800 | | | 8.800 | 0.773 | 0.015 | 4.275 | 29.073 | | | | | | | | | | | | | | | | |
| | | | 3 | 2.000 | 3.500 | 0.0058 | 3.400 | 6.800 | | | 8.800 | 0.773 | 0.015 | 4.275 | 29.073 | | | | | | | | | | | | | | | | |
| | | | 4 | 2.000 | 3.500 | 0.0058 | 3.400 | 6.800 | | | 8.800 | 0.773 | 0.015 | 4.275 | 29.073 | | | | | | | | | | | | | | | | |
| | | | 5 | 2.000 | 3.500 | 0.0058 | 3.400 | 6.800 | | | 8.800 | 0.773 | 0.015 | 4.275 | 29.073 | | | | | | | | | | | | | | | | |
| | | | | 10.000 | | | 3.400 | 34.000 | 45.600 | 25.439 | | | | 4.275 | | 145.363 | 56.680 | 78.810 | 101.700 | 121.780 | 148.040 | AD | AD | AD | AD | IA | | | | | 10.19 |
| 17 | CVC15 | Yellamma Temple Street @4138 | 1 | 3.500 | 3.000 | 0.0142 | 2.900 | 10.150 | | | 9.300 | 1.091 | 0.015 | 8.421 | 85.475 | | | | | | | | | | | | | | | | |
| | | | 2 | 3.500 | 3.000 | 0.0142 | 2.900 | 10.150 | | | 9.300 | 1.091 | 0.015 | 8.421 | 85.475 | | | | | | | | | | | | | | | | |
| | | | 3 | 3.500 | 3.000 | 0.0142 | 2.900 | 10.150 | | | 9.300 | 1.091 | 0.015 | 8.421 | 85.475 | | | | | | | | | | | | | | | | |
| | | | | 10.500 | | | 2.900 | 30.450 | 26.250 | -16.000 | | | | 8.421 | | 256.426 | 58.480 | 81.310 | 104.930 | 125.640 | 152.740 | AD | AD | AD | AD | AD | | | | | |
| 18 | CVC16 | Sathyanarayana Temple Road @4477 | 1 | 6.000 | 2.000 | 0.0032 | 1.900 | 11.400 | | | 9.800 | 1.163 | 0.015 | 4.171 | 47.553 | | | | | | | | | | | | | | | | |
| | | | 2 | 6.000 | 2.000 | 0.0032 | 1.900 | 11.400 | | | 9.800 | 1.163 | 0.015 | 4.171 | 47.553 | | | | | | | | | | | | | | | | |
| | | | | 12.000 | | | 1.900 | 22.800 | 31.640 | 27.939 | | | | 4.171 | | 95.105 | 62.680 | 87.150 | 112.460 | 134.660 | 163.710 | AD | AD | IA | IA | IA | | | 14.19 | 16.99 | 20.66 |
| 19 | CVC17 | Sada Shiva Mudaliyar Road @4910 | 1 | 6.000 | 2.000 | 0.0020 | 1.900 | 11.400 | | | 9.800 | 1.163 | 0.015 | 3.298 | 37.594 | | | | | | | | | | | | | | | | |
| | | | 2 | 6.000 | 2.000 | 0.0020 | 1.900 | 11.400 | | | 9.800 | 1.163 | 0.015 | 3.298 | 37.594 | | | | | | | | | | | | | | | | |
| | | | | 12.000 | | | 1.900 | 22.800 | 29.760 | 23.387 | | | | 3.298 | | 75.187 | 67.010 | 93.260 | 120.470 | 144.440 | 175.160 | AD | IA | IA | IA | IA | | 14.88 | 19.23 | 23.05 | 27.95 |
| 20 | CVC18 | Old Madras Road @5046 | 1 | 4.000 | 2.400 | 0.0025 | 2.300 | 9.200 | | | 8.600 | 1.070 | 0.015 | 3.487 | 32.077 | | | | | | | | | | | | | | | | |

| Sl.No. | Culvert No. | Chainage | Vent | Width of the drain | Depth of the drain | Slope | (Di) (D- 0.1) | A= (B x Di) | U.S.D Area (Da) | ( Da – A)/Da x 100 | WP = (B+2Di) | R = A / P | (n) | V = ( 1/n) $R^{2/3}$ $S^{0.5}$ | Q = A x V | Q total | Discharge ( $Q_{Reqd.}$ ) | | | | | Remarks | | | | | Width Required(B) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year |
| | | (m) | No. | (B) m | (D) m | (S) | (D- 0.1) m | ($m^2$) | ($m^2$) | % | (m) | (m) | | (m/s) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | | | | | | | | | | |
| | | | 2 | 4.000 | 2.400 | 0.0025 | 2.300 | 9.200 | | | 8.600 | 1.070 | 0.015 | 3.487 | 32.077 | | | | | | | | | | | | | | | | |
| | | | 3 | 4.000 | 2.400 | 0.0025 | 2.300 | 9.200 | | | 8.600 | 1.070 | 0.015 | 3.487 | 32.077 | | | | | | | | | | | | | | | | |
| | | | | 12.000 | | | 2.300 | 27.600 | 31.360 | 11.990 | | | | 3.487 | | 96.231 | 68.270 | 95.030 | 122.800 | 147.300 | 178.490 | AD | AD | IA | IA | IA | | | 15.31 | 18.37 | 22.26 |
| 21 | CVC19 | Cambridge Road @6092 | 1 | 4.000 | 2.500 | 0.0008 | 2.400 | 9.600 | | | 8.800 | 1.091 | 0.015 | 1.998 | 19.183 | | | | | | | | | | | | | | | | |
| | | | 2 | 5.200 | 2.500 | 0.0008 | 2.400 | 12.480 | | | 10.000 | 1.248 | 0.015 | 2.186 | 27.278 | | | | | | | | | | | | | | | | |
| | | | 3 | 4.500 | 1.500 | 0.0008 | 1.400 | 6.300 | | | 7.300 | 0.863 | 0.015 | 1.709 | 10.768 | | | | | | | | | | | | | | | | |
| | | | | 13.700 | | | 2.200 | 28.380 | 36.460 | 22.161 | | | | 1.998 | | 57.229 | 99.120 | 138.150 | 178.790 | 214.890 | 259.430 | IA | IA | IA | IA | IA | 22.55 | 31.43 | 40.67 | 48.89 | 59.02 |
| 22 | CVC21 | Domular Bus Stand @7120 | 1 | 7.500 | 2.950 | 0.0012 | 2.850 | 21.375 | | | 13.200 | 1.619 | 0.015 | 3.185 | 68.071 | | | | | | | | | | | | | | | | |
| | | | 2 | 7.500 | 2.850 | 0.0012 | 2.750 | 20.625 | | | 13.000 | 1.587 | 0.015 | 3.141 | 64.793 | | | | | | | | | | | | | | | | |
| | | | | 15.000 | | | 2.800 | 42.000 | 41.400 | -1.449 | | | | 3.150 | | 132.864 | 110.180 | 153.880 | 199.670 | 240.780 | 288.890 | AD | IA | IA | IA | IA | | 17.45 | 22.64 | 27.3 | 32.75 |
| 23 | CVC24 | Royal Orchid Park Plaza @8060 | 1 | 4.000 | 3.200 | 0.0015 | 3.100 | 12.400 | | | 10.200 | 1.216 | 0.015 | 2.941 | 36.469 | | | | | | | | | | | | | | | | |
| | | | 2 | 4.000 | 3.400 | 0.0015 | 3.300 | 13.200 | | | 10.600 | 1.245 | 0.015 | 2.989 | 39.449 | | | | | | | | | | | | | | | | |
| | | | 3 | 4.000 | 3.200 | 0.0015 | 3.100 | 12.400 | | | 10.200 | 1.216 | 0.015 | 2.941 | 36.469 | | | | | | | | | | | | | | | | |
| | | | | 12.000 | | | 3.200 | 38.000 | 63.180 | 39.854 | | | | 2.950 | | 112.387 | 124.620 | 174.070 | 225.910 | 272.480 | 326.790 | IA | IA | IA | IA | IA | 13.2 | 18.44 | 23.93 | 28.86 | 34.62 |

## Check for Existing Culverts with measured Site Slopes for Adequacy ( Ulsoor - Primary Culverts)

( Clean Condition n = 0.015 ) ( with freeboard 100mm)

| Sl.No. | Culvert No. | Chainage | Vent | Width of the drain | Depth of the drain | Slope | (Di) (D- 0.1) | A= (B x Di) | U.S.D Area (Da) | ( Da – A)/Da x 100 | WP = (B+2Di) | R = A / P | (n) | V = ( 1/n) $R^{2/3}$ $S^{0.5}$ | Q = A x V | Q total | Discharge ( $Q_{Reqd.}$ ) | | | | | Remarks | | | | | Width Required(B) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year |
| | | (m) | No. | (B) m | (D) m | (S) | (D- 0.1) m | ($m^2$) | ($m^2$) | % | (m) | (m) | | (m/s) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | (Cumec) | | | | | | | | | | |
| 1 | MVC3 | 1st Cross J.C. Nagar Ramgeetha Block @75 | 1 | 1.500 | 1.200 | 0.0160 | 1.100 | 1.650 | | | 3.700 | 0.446 | 0.015 | 4.922 | 8.122 | | | | | | | | | | | | | | | | |
| | | | 2 | 1.500 | 1.200 | 0.0160 | 1.100 | 1.650 | | | 3.700 | 0.446 | 0.015 | 4.922 | 8.122 | | | | | | | | | | | | | | | | |
| | | | | 3.000 | | | 1.100 | 3.300 | 9.340 | 64.668 | | | | 1.348 | | 16.243 | 5.170 | 7.190 | 9.280 | 11.110 | 13.510 | AD | AD | AD | AD | AD | | | | | |
| 2 | MVC4 | 1st Cross J.C. Nagar @ 270 | 1 | 4.600 | 1.200 | 0.0128 | 1.100 | 5.060 | | | 6.800 | 0.744 | 0.015 | 6.194 | 31.339 | | | | | | | | | | | | | | | | |
| | | | | 4.600 | | | 1.100 | 5.060 | 11.080 | 54.332 | | | | 6.194 | | 31.339 | 5.960 | 8.280 | 10.680 | 12.790 | 15.560 | AD | AD | AD | AD | AD | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | MVC5 | 2nd Cross J.C. Nagar @380 | 1 | 1.800 | 1.600 | 0.0076 | 1.500 | 2.700 | | | 4.800 | 0.563 | 0.015 | 3.960 | 10.693 | | | | | | | | | | | | | | | | |
| | | | 2 | 1.800 | 1.600 | 0.0076 | 1.500 | 2.700 | | | 4.800 | 0.563 | 0.015 | 3.960 | 10.693 | | | | | | | | | | | | | | | | |
| | | | | 3.600 | | | 1.500 | 5.400 | 11.580 | 53.368 | | | | 3.960 | | 21.386 | 6.510 | 9.060 | 11.680 | 13.990 | 17.010 | AD | AD | AD | AD | AD | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | MVC6 | 1st Main Road Krishnamma Nagar @435 | 1 | 1.000 | 1.600 | 0.0080 | 1.500 | 1.500 | | | 4.000 | 0.375 | 0.015 | 3.101 | 4.651 | | | | | | | | | | | | | | | | |
| | | | 2 | 1.000 | 1.600 | 0.0080 | 1.500 | 1.500 | | | 4.000 | 0.375 | 0.015 | 3.101 | 4.651 | | | | | | | | | | | | | | | | |
| | | | | 2 | | | 1.500 | 3.000 | 10.060 | 70.179 | | | | 3.101 | | 9.302 | 6.740 | 9.370 | 12.080 | 14.460 | 17.600 | AD | IA | IA | IA | IA | | 2.01 | 2.6 | 3.11 | 3.78 |
| 5 | MVC7 | 1st Main Road Krishnamma Nagar @460 | 1 | 3.000 | 1.400 | 0.0072 | 1.300 | 3.900 | | | 5.600 | 0.696 | 0.015 | 4.445 | 17.334 | | | | | | | | | | | | | | | | |
| | | | | 3.000 | | | 1.300 | 3.900 | 8.800 | 55.682 | | | | 4.445 | | 17.334 | 6.850 | 9.520 | 12.290 | 14.700 | 17.890 | AD | AD | AD | AD | IA | | | | | 3.1 |
| 6 | MVC8 | Anjaneyyappa Block @550 | 1 | 1.800 | 1.500 | 0.0065 | 1.400 | 2.520 | | | 4.600 | 0.548 | 0.015 | 3.599 | 9.068 | | | | | | | | | | | | | | | | |
| | | | 2 | 1.800 | 1.500 | 0.0065 | 1.400 | 2.520 | | | 4.600 | 0.548 | 0.015 | 3.599 | 9.068 | | | | | | | | | | | | | | | | |
| | | | | 3.600 | | | 1.400 | 5.040 | 7.640 | 34.031 | | | | 3.599 | | 18.137 | 7.300 | 10.140 | 13.090 | 15.660 | 19.050 | AD | AD | AD | AD | IA | | | | | 3.78 |
| 7 | MVC9 | Mosque Street @660 | 1 | 2.000 | 1.500 | 0.0075 | 1.400 | 2.800 | | | 4.800 | 0.583 | 0.015 | 4.031 | 11.286 | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 | 2.000 | 1.500 | 0.0075 | 1.400 | 2.800 | | | 4.800 | 0.583 | 0.015 | 4.031 | 11.286 | | | | | | | | | | | | | | | | | |
| | | | | 4.000 | | | 1.400 | 5.600 | 7.300 | 23.288 | | | | 4.031 | | 22.572 | 7.740 | 10.760 | 13.890 | 16.620 | 20.220 | AD | AD | AD | AD | AD | | | | | |
| 8 | MVC10 | Anjaneyyappa Block 3rd Cross @710 | 1 | 3.000 | 1.500 | 0.0076 | 1.400 | 4.200 | | | 5.800 | 0.724 | 0.015 | 4.687 | 19.684 | | | | | | | | | | | | | | | | | |
| | | | 2 | 3.000 | 1.500 | 0.0076 | 1.400 | 4.200 | | | 5.800 | 0.724 | 0.015 | 4.687 | 19.684 | | | | | | | | | | | | | | | | | |
| | | | | 6.000 | | | 1.400 | 8.400 | 8.980 | 6.459 | | | | 4.687 | | 39.368 | 7.970 | 11.080 | 14.290 | 17.100 | 20.800 | AD | AD | AD | AD | AD | | | | | |
| 9 | MVC11 | Sheshadri Road @810 | 1 | 2.300 | 0.600 | 0.0048 | 0.500 | 1.150 | | | 3.300 | 0.348 | 0.015 | 2.287 | 2.630 | | | | | | | | | | | | | | | | | |
| | | | 2 | 2.300 | 0.600 | 0.0048 | 0.500 | 1.150 | | | 3.300 | 0.348 | 0.015 | 2.287 | 2.630 | | | | | | | | | | | | | | | | | |
| | | | | 4.600 | | | 0.500 | 2.300 | 11.710 | 80.359 | | | | 2.287 | | 5.261 | 8.410 | 11.700 | 15.090 | 18.060 | 21.970 | IA | IA | IA | IA | IA | 7.35 | 10.23 | 13.19 | 15.79 | 19.21 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | MVC12 | Chinnappa Garden 14th Cross @950 | 1 | 2.200 | 0.900 | 0.0060 | 0.800 | 1.760 | | | 3.800 | 0.463 | 0.015 | 3.091 | 5.441 | | | | | | | | | | | | | | | | | |
| | | | 2 | 2.200 | 0.900 | 0.0060 | 0.800 | 1.760 | | | 3.800 | 0.463 | 0.015 | 3.091 | 5.441 | | | | | | | | | | | | | | | | | |
| | | | | 4.400 | | | 0.800 | 3.520 | 10.030 | 64.905 | | | | 3.091 | | 10.881 | 9.080 | 12.630 | 16.290 | 19.500 | 23.720 | AD | IA | IA | IA | IA | | 5.11 | 6.59 | 7.89 | 9.59 |
| 11 | MVC13 | Muddamma Garden 1st Main Road @1050 | 1 | 3.700 | 1.200 | 0.0056 | 1.100 | 4.070 | | | 5.900 | 0.690 | 0.015 | 3.895 | 15.852 | | | | | | | | | | | | | | | | | |
| | | | | 3.700 | | | 1.100 | 4.070 | 6.880 | 40.843 | | | | 3.895 | | 15.852 | 9.530 | 13.250 | 17.090 | 20.460 | 24.890 | AD | AD | IA | IA | IA | | | 3.99 | 4.78 | 5.81 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | MVC14 | Muddamma Garden 13th Cross @1110 | 1 | 5.100 | 1.900 | 0.0096 | 1.800 | 9.180 | | | 8.700 | 1.055 | 0.015 | 6.770 | 62.149 | | | | | | | | | | | | | | | | | |
| | | | | 5.100 | | | 1.800 | 9.180 | 8.250 | -11.273 | | | | 6.770 | | 62.149 | 9.750 | 13.560 | 17.490 | 20.940 | 25.470 | AD | AD | AD | AD | AD | | | | | |
| 13 | MVC15 | Muddamma Garden 10th Cross @1175 | 1 | 2.200 | 2.100 | 0.0056 | 2.000 | 4.400 | | | 6.200 | 0.710 | 0.015 | 3.969 | 17.465 | | | | | | | | | | | | | | | | | |
| | | | 2 | 2.200 | 2.100 | 0.0056 | 2.000 | 4.400 | | | 6.200 | 0.710 | 0.015 | 3.969 | 17.465 | | | | | | | | | | | | | | | | | |
| | | | | 4.400 | | | 2.000 | 8.800 | 10.050 | 12.438 | | | | 3.969 | | 34.930 | 10.090 | 14.020 | 18.090 | 21.660 | 26.350 | AD | AD | AD | AD | AD | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | MVC16 | @1260 | 1 | 2.000 | 1.900 | 0.0056 | 1.800 | 3.600 | | | 5.600 | 0.643 | 0.015 | 3.716 | 13.378 | | | | | | | | | | | | | | | | | |
| | | | 2 | 2.000 | 1.900 | 0.0056 | 1.800 | 3.600 | | | 5.600 | 0.643 | 0.015 | 3.716 | 13.378 | | | | | | | | | | | | | | | | | |
| | | | | 4.000 | | | 1.800 | 7.200 | 11.230 | 35.886 | | | | 3.716 | | 26.755 | 10.420 | 14.490 | 18.690 | 22.380 | 27.220 | AD | AD | AD | AD | IA | | | | | 4.07 |
| 15 | MVC17 | S.K. Garden @1350 | 1 | 1.800 | 1.500 | 0.0056 | 1.400 | 2.520 | | | 4.600 | 0.548 | 0.015 | 3.340 | 8.417 | | | | | | | | | | | | | | | | | |
| | | | 2 | 1.800 | 1.500 | 0.0056 | 1.400 | 2.520 | | | 4.600 | 0.548 | 0.015 | 3.340 | 8.417 | | | | | | | | | | | | | | | | | |
| | | | | 3.600 | | | 1.400 | 5.040 | 8.540 | 40.984 | | | | 3.340 | | 16.834 | 10.870 | 15.110 | 19.500 | 23.340 | 28.390 | AD | AD | IA | IA | IA | | | 4.17 | 4.99 | 6.07 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | MVC18 | S.K. Garden @1475 | 1 | 1.900 | 0.900 | 0.0060 | 0.800 | 1.520 | | | 3.500 | 0.434 | 0.015 | 2.961 | 4.501 | | | | | | | | | | | | | | | | |
| | | | 2 | 1.900 | 0.900 | 0.0060 | 0.800 | 1.520 | | | 3.500 | 0.434 | 0.015 | 2.961 | 4.501 | | | | | | | | | | | | | | | | |
| | | | | 3.800 | | | 0.800 | 3.040 | 11.160 | 72.760 | | | | 2.961 | | 9.003 | 11.430 | 15.890 | 20.500 | 24.530 | 29.850 | IA | IA | IA | IA | IA | 4.82 | 6.71 | 8.65 | 10.35 | 12.6 |
| 17 | MVC19 | Pottery Town @1850 | 1 | 4.200 | 1.000 | 0.0025 | 0.900 | 3.780 | | | 6.000 | 0.630 | 0.015 | 2.450 | 9.260 | | | | | | | | | | | | | | | | |
| | | | 2 | 4.200 | 1.000 | 0.0025 | 0.900 | 3.780 | | | 6.000 | 0.630 | 0.015 | 2.450 | 9.260 | | | | | | | | | | | | | | | | |
| | | | | 8.400 | | | 0.900 | 7.560 | 10.380 | 27.168 | | | | 2.450 | | 18.519 | 14.220 | 19.770 | 25.530 | 30.580 | 37.150 | AD | IA | IA | IA | IA | | 8.97 | 11.58 | 13.87 | 16.85 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | MVC20 | Bore Bank Road @2075 | 1 | 5.500 | 1.950 | 0.0142 | 1.850 | 10.175 | | | 9.200 | 1.106 | 0.015 | 8.496 | 86.447 | | | | | | | | | | | | | | | | |
| | | | 2 | 5.500 | 1.950 | 0.0142 | 1.850 | 10.175 | | | 9.200 | 1.106 | 0.015 | 8.496 | 86.447 | | | | | | | | | | | | | | | | |
| | | | | 11.000 | | | 1.850 | 20.350 | 22.240 | 8.498 | | | | 8.496 | | 172.895 | 16.340 | 22.730 | 29.360 | 35.190 | 42.690 | AD | AD | AD | AD | AD | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | MVC21 | @2180 | 1 | 1.800 | 2.100 | 0.0060 | 2.000 | 3.600 | | | 5.800 | 0.621 | 0.015 | 3.758 | 13.527 | | | | | | | | | | | | | | | | |
| | | | 2 | 1.800 | 2.100 | 0.0060 | 2.000 | 3.600 | | | 5.800 | 0.621 | 0.015 | 3.758 | 13.527 | | | | | | | | | | | | | | | | |
| | | | 3 | 1.800 | 2.100 | 0.0060 | 2.000 | 3.600 | | | 5.800 | 0.621 | 0.015 | 3.758 | 13.527 | | | | | | | | | | | | | | | | |
| | | | 4 | 1.800 | 2.100 | 0.0060 | 2.000 | 3.600 | | | 5.800 | 0.621 | 0.015 | 3.758 | 13.527 | | | | | | | | | | | | | | | | |
| | | | 5 | 1.800 | 2.100 | 0.0060 | 2.000 | 3.600 | | | 5.800 | 0.621 | 0.015 | 3.758 | 13.527 | | | | | | | | | | | | | | | | |
| | | | | 9.000 | | | 2.000 | 18.000 | 23.570 | 23.632 | | | | 3.758 | | 67.635 | 17.110 | 23.810 | 30.750 | 36.870 | 44.720 | AD | AD | AD | AD | AD | | | | | |
| 20 | MVC22 | More Road @2450 | 1 | 2.750 | 1.300 | 0.0016 | 1.200 | 3.300 | | | 5.150 | 0.641 | 0.015 | 1.982 | 6.541 | | | | | | | | | | | | | | | | |
| | | | 2 | 2.750 | 1.300 | 0.0016 | 1.200 | 3.300 | | | 5.150 | 0.641 | 0.015 | 1.982 | 6.541 | | | | | | | | | | | | | | | | |
| | | | | 5.500 | | | 1.200 | 6.600 | 22.780 | 71.027 | | | | 1.982 | | 13.081 | 17.870 | 24.860 | 32.090 | 38.440 | 46.700 | IA | IA | IA | IA | IA | 7.51 | 10.45 | 13.49 | 16.16 | 19.63 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | MVC23 | Mosque Road @2675 | 1 | 3.000 | 1.600 | 0.0036 | 1.500 | 4.500 | | | 6.000 | 0.750 | 0.015 | 3.302 | 14.859 | | | | | | | | | | | | | | | | |
| | | | 2 | 3.000 | 1.600 | 0.0036 | 1.500 | 4.500 | | | 6.000 | 0.750 | 0.015 | 3.302 | 14.859 | | | | | | | | | | | | | | | | |
| | | | | 6.000 | | | 1.500 | 9.000 | 31.720 | 71.627 | | | | 3.302 | | 29.717 | 19.020 | 26.470 | 34.180 | 40.970 | 49.720 | AD | AD | IA | IA | IA | | | 6.9 | 8.27 | 10.04 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | MVC24 | @2860 | 1 | 7.000 | 3.000 | 0.0040 | 2.900 | 20.300 | | | 12.800 | 1.586 | 0.015 | 5.734 | 116.402 | | | | | | | | | | | | | | | | |
| | | | | 7.000 | | | 2.900 | 20.300 | 28.960 | 29.903 | | | | 5.734 | | 116.402 | 20.070 | 27.940 | 36.110 | 43.310 | 52.480 | AD | AD | AD | AD | AD | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23 | MVC25 | Stephene's Road @3000 | 1 | 2.800 | 0.800 | 0.0032 | 0.700 | 1.960 | | | 4.200 | 0.467 | 0.015 | 2.269 | 4.447 | | | | | | | | | | | | | | | | |

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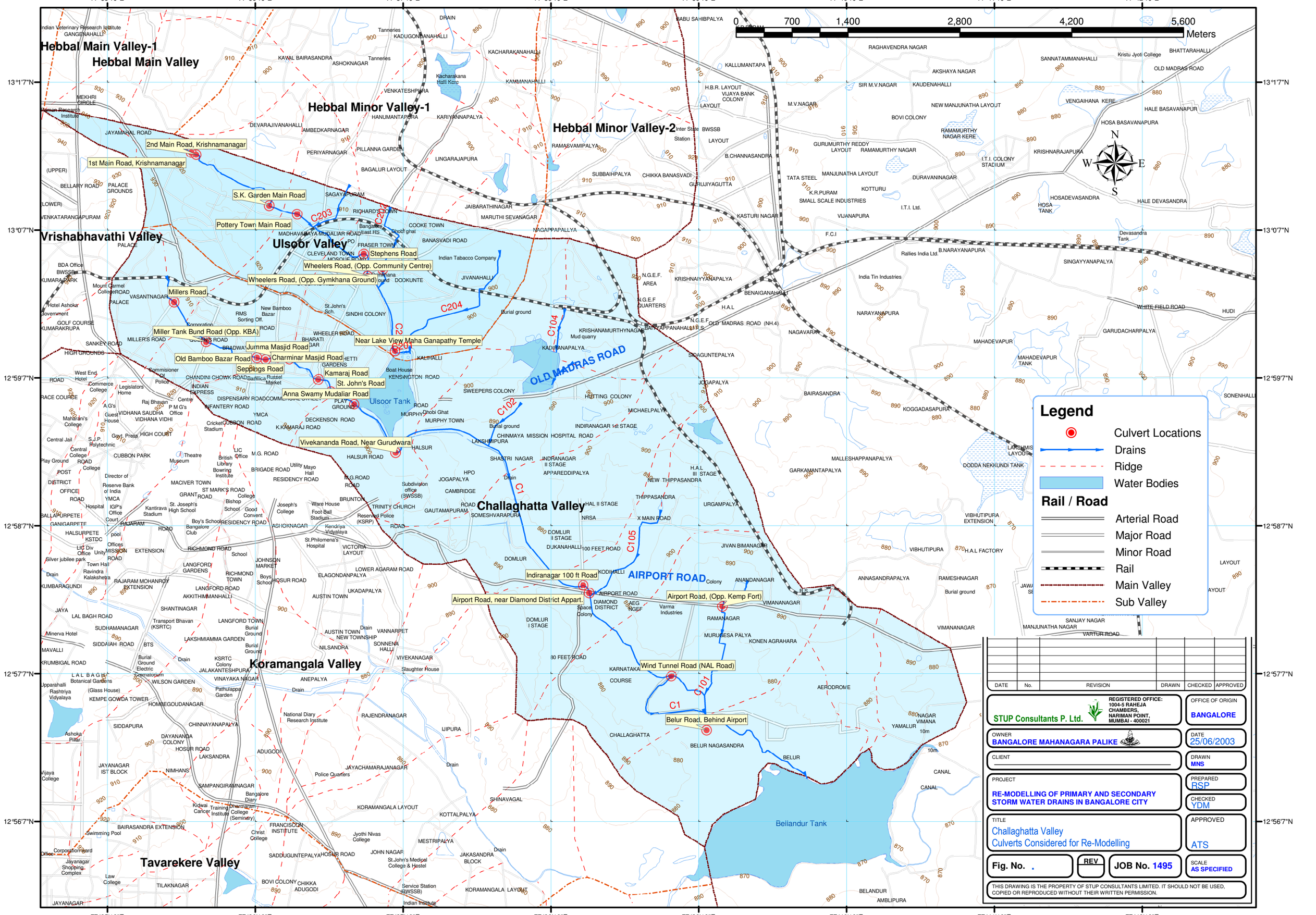
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 | 2.800 | 0.800 | 0.0032 | 0.700 | 1.960 | | | 4.200 | 0.467 | 0.015 | 2.269 | 4.447 | | | | | | | | | | | | | | | | | |
| | | | 3 | 2.800 | 0.800 | 0.0032 | 0.700 | 1.960 | | | 4.200 | 0.467 | 0.015 | 2.269 | 4.447 | | | | | | | | | | | | | | | | | |
| | | | | 8.400 | | | 0.700 | 5.880 | 33.970 | 82.691 | | | | 2.269 | | 13.34 | 21.300 | 29.660 | 38.350 | 46.040 | 55.710 | IA | IA | IA | IA | IA | 13.41 | 18.67 | 24.15 | 28.99 | 35.08 |
| 24 | MVC26 | Wheeler's Road @3100 | 1 | 2.500 | 1.100 | 0.0016 | 1.000 | 2.500 | | | 4.500 | 0.556 | 0.015 | 1.802 | 4.505 | | | | | | | | | | | | | | | | | |
| | | | 2 | 2.500 | 1.100 | 0.0016 | 1.000 | 2.500 | | | 4.500 | 0.556 | 0.015 | 1.802 | 4.505 | | | | | | | | | | | | | | | | | |
| | | | 3 | 2.500 | 1.100 | 0.0016 | 1.000 | 2.500 | | | 4.500 | 0.556 | 0.015 | 1.802 | 4.505 | | | | | | | | | | | | | | | | | |
| | | | 4 | 2.500 | 1.100 | 0.0016 | 1.000 | 2.500 | | | 4.500 | 0.556 | 0.015 | 1.802 | 4.505 | | | | | | | | | | | | | | | | | |
| | | | | 10.000 | | | 1.000 | 10.000 | 25.270 | 60.427 | | | | 1.802 | | 18.021 | 22.000 | 30.640 | 39.640 | 47.600 | 57.550 | IA | IA | IA | IA | IA | 12.21 | 17 | 22 | 26.41 | 31.93 |
| 25 | MVC27 | Hocarkey Stone Road @3300 | 1 | 3.000 | 1.400 | 0.0022 | 1.300 | 3.900 | | | 5.600 | 0.696 | 0.015 | 2.457 | 9.582 | | | | | | | | | | | | | | | | | |
| | | | 2 | 3.000 | 1.400 | 0.0022 | 1.300 | 3.900 | | | 5.600 | 0.696 | 0.015 | 2.457 | 9.582 | | | | | | | | | | | | | | | | | |
| | | | 3 | 3.000 | 1.400 | 0.0022 | 1.300 | 3.900 | | | 5.600 | 0.696 | 0.015 | 2.457 | 9.582 | | | | | | | | | | | | | | | | | |
| | | | | 9.000 | | | 1.300 | 11.700 | 15.710 | 25.525 | | | | 2.457 | | 28.745 | 23.400 | 32.610 | 42.200 | 50.720 | 61.240 | AD | IA | IA | IA | IA | | 10.21 | 13.21 | 15.88 | 19.17 |
| 26 | MVC28 | Cox Town Doddi Kanda Road @3500 | 1 | 3.000 | 1.100 | 0.0004 | 1.000 | 3.000 | | | 5.000 | 0.600 | 0.015 | 0.949 | 2.846 | | | | | | | | | | | | | | | | | |
| | | | 2 | 3.000 | 1.100 | 0.0004 | 1.000 | 3.000 | | | 5.000 | 0.600 | 0.015 | 0.949 | 2.846 | | | | | | | | | | | | | | | | | |
| | | | 3 | 3.000 | 1.100 | 0.0004 | 1.000 | 3.000 | | | 5.000 | 0.600 | 0.015 | 0.949 | 2.846 | | | | | | | | | | | | | | | | | |
| | | | | 9.000 | | | 1.000 | 9.000 | 15.790 | 43.002 | | | | 0.949 | | 8.537 | 24.140 | 33.640 | 43.540 | 52.320 | 63.180 | IA | IA | IA | IA | IA | 25.45 | 35.47 | 45.9 | 55.16 | 66.61 |
| 27 | MVC29 | @3880 | 1 | 3.700 | 1.200 | 0.0028 | 1.100 | 4.070 | | | 5.900 | 0.690 | 0.015 | 2.754 | 11.209 | | | | | | | | | | | | | | | | | |
| | | | 2 | 3.700 | 1.200 | 0.0028 | 1.100 | 4.070 | | | 5.900 | 0.690 | 0.015 | 2.754 | 11.209 | | | | | | | | | | | | | | | | | |
| | | | 3 | 3.700 | 1.200 | 0.0028 | 1.100 | 4.070 | | | 5.900 | 0.690 | 0.015 | 2.754 | 11.209 | | | | | | | | | | | | | | | | | |
| | | | | 11.100 | | | 1.1 | 12.21 | 19.21 | 36.439 | | | | 2.75 | | 33.63 | 25.12 | 35 | 45.27 | 54.36 | 65.72 | AD | IA | IA | IA | IA | | 11.55 | 14.94 | 17.94 | 21.69 |




| DATE | No. | REVISION | DRAWN | CHECKED | APPROVED |
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| | | | | | |

STUP Consultants P. Ltd.
REGISTERED OFFICE: 1004-5 RAHEJA CHAMBERS, NARIMAN POINT, MUMBAI - 400021

OFFICE OF ORIGIN: BANGALORE

OWNER: BANGALORE MAHANAGARA PALIKE

DATE: 25/06/2003

CLIENT:

DRAWN: MNS

PROJECT: RE-MODELLING OF PRIMARY AND SECONDARY STORM WATER DRAINS IN BANGALORE CITY

PREPARED: RSP

CHECKED: YDM

TITLE: Challaghatta Valley
Culverts Considered for Re-Modelling

APPROVED: ATS

Fig. No. .

REV

JOB No. 1495

SCALE: AS SPECIFIED

## 4.2 STRATEGIC ACTIONS AND RECOMMENDATIONS:

### ➢CHALLAGHATTA MAIN VALLEY:

•The existing drain opposite to Kodava Samaja near Vasanthanagar needs to be desilted and a steel grating has to be provided.

•Tertiary drains in Vasanthanagar needs to be desilted and regarded to match the new drain bed level.

•Few old buildings that exists inside corporation dobhi ghat needs to be dismantled and the existing drain needs to be widened and deepened.

•The covered reach of drain needs to be opened, desilted and widened adjacent to Millers Arcade, near Millers Road.

•Existing sewerage system has to be extended to the entire locality and ensured that all house connections are made in Vasanthanagar.

•Silt barriers needs to be constructed near the open ground like Palace grounds, cantonment railway station adjoining areas, Mount carmel college ground etc.

•The tertiary drain starting from Cunningham road upto Aiyappa temple needs to be desilted and a steel grating has to be provided at that location. Further, the drain reach which is encroached by commercial establishments i.e., opposite to Jain Nursing College needs to be restored and properly connected to the main drain near Millers Arcade.

•The existing culvert/bridge constructed across Millers road needs to be reconstructed with a wider span.

•The covered reach of drain inside Ambedkar bhavan needs to be widened.

- Debris that has been dumped over the drain i.e., behind Mahaveer jain hospital needs to be removed and existing drain needs to be widened. This reach of drain should be kept open for scheduled maintenance.

- The existing culvert/bridge constructed across Millers tank bund road needs to be reconstructed with a wider span.

- Tertiary drains from Cunningham road and adjacent to billiards association needs to be desilted, widened and regarded to match the new drain bed level.

- The approach bridges that are constructed across storm drain by Karnataka badminton association and Indian council association for social welfare needs to be replaced with single span culverts.

- Large quantity of sewage that is flowing from the tertiary drain that exists inside police quarters and also corporation colony needs to be prevented.

- Sewer lines and manholes that are noticed near Shivaji road needs to be relocated and also few disused manholes that exists inside the drain needs to be dismantaled.

- Sewerage system and solid waste management system in this area needs to be improved.

- Shops that are constructed over the storm drain near Broadway road needs to be relocated, desilted, widened and deepened.

- Discharge of liquid wastes that are generated from slaughter house needs to be prevented from entering into the drain and it has to be collected and treated separately.

- Caution boards and sign boards needs to be displayed to create awareness among people about storm drain and its management.

- The existing culverts constructed across storm drain at old bamboo bazaar road, Juma Masjid road, Charminar Masjid road and Seppings road needs to be reconstructed.

- Solid waste management in this region needs to be improved.

- All openings made to the drain wall needs to be closed in this region to avoid back flow of water.

- Construction of public toilet blocks adjacent to storm drain and also discharge of raw sewage from these toilet blocks, needs to be avoided.

- Existing tertiary drain network in Shivajinagar area needs to be desilted and remodeled to match the new drain bed level.
  (As per the sketch enclosed for low lying area improvement works).

- The existing culverts constructed across storm drain at Kamaraj road, St. Johns road and Anna Swamy Mudaliar road needs to be reconstructed and drain reach adjacent to Block Education building needs to be widened to provide access for free flow of water.

- Vegetal growth noticed near St. Johns road and RBANMS college needs to be removed.

- The waste weir and BWSSB manhole constructed across storm drain adjacent to RBANMS college needs to be relocated.

- The drain reach, adjacent to Ulsoor lake needs to be regarded after lowering the drain bed near Gurudwara.

**Kensington Road Proposal:**

**✔Alternative – 1**

•To regrade the drain bed from Shivajinagar and also to prevent stagnatation of water and solid wastes accumulation opposite to Gurudwara it is very much essential to remove the existing school building constructed by Gurudwara association. Further, The existing culverts constructed across storm drain at Kensington road needs to be dismantelled and reconstructed with single span bridge after lowering the rocky outcrop that is encountered near Gurudwara.

**✔Alternative – 2**

•To regrade the drain bed from Shivajinagar and also to prevent stagnatation of water and solid wastes accumulation opposite to Gurudwara it is very much essential to altering the alignment of storm drain and constructing RCC box drain for a length of about 120 m. across Kensington road and extend it in Yellamma temple street. Further, connect the box drain to the existing open drain adjacent to slum. But to execute this proposal a small scale industry and BWSSB sewerline needs to be relocated.
(As per enclosed Sketch).

•Liquid waste and solid wastes generated from Munivenkatappa garden slum needs to be prevented from getting discharged into storm drain.

•Near Guptha layout, solid waste collection system needs to be improved, and caution boards and sign boards needs to be displayed to create awareness among people about storm drain and its management.

•The existing low level bridge constructed adjacent to Cambridge layout bridge needs to be removed and also BWSSB manholes constructed just at the vent portion of this bridge needs to be relocated.

•The existing drain reach needs to be widened on left hand side upto Airport

road.

- Liquid waste and solid wastes generated from the slum, situated adjacent to Cambridge layout bridge needs to be prevented from getting discharged into storm drain.

- The existing RCC hume pipe culvert constructed across storm drain near Domlur 2nd stage needs to be replaced with RCC slab culvert at the later stage of the project.

- The existing RCC hume pipe culvert constructed across storm drain near Indiranagar 100 ft. road needs to be replaced with RCC slab culvert at the later stage of the project.

- The existing RCC hume pipe culvert constructed across Airport Road storm drain needs to be replaced with RCC slab culvert at the later stage of the project.

- The existing 1800 mm dia. BWSSB CI sewerline i.e., noticed behind Diamond district apartments needs to be lowered or relocated or in the drain bed syphon has to be created

- Existing drain reach adjacent to Karnataka Golf Club needs to be widened and stone revetment has to be provided.

- Existing drain alignment near Texas instruments needs to be slightly altered to connect the main drain to the existing drain constructed by Airport authorities inside the Airport compound.

- The drain inside Airport compound after deepening the drain bed (i.e., constructed by Airport authorities), 2 new bridges has to be constructed i.e, one across wind tunnel road and other across Bellur main road. (As per enclosed Sketch)

- For easy access and maintenance of drain by BMP, the compound wall of Airport needs to be shifted on the other side (left side) of the drain so that the drain inside the airport compound will be outside the Airport compound

and the drain can be maintained for smooth flow of storm water.

- Behind Airport, new drain has to be constructed upto Bellandur tank and stone revetment has to be provided.

- Encroachment / Development of land near the tank bed needs to be prevented.

- Provision for future drain requirement and also for service roads needs to be demarcated.

**➢CHALLAGHATTA MAIN VALLEY SECONDARY STORM DRAINS:**

**➢Murugeshpalya drain - C101:**

- The existing closed drain reach Anandapuram needs to desilted, widened and replaced with RCC box drain.

- The open drain reach near Nanjareddy colony needs to desilted, widened and bed improvement to be done upto Airport Road.

- The drain reach near Airport road culvert and also drain reach adjacent to Airport road needs to be desilted, deepened, widened and replaced with RCC Box drain.

- The drain reach adjacent to Composite college needs to desilted and manholes needs to be lowered.

- The box drain construction work which is under progress needs to be expedited.

**➢Shastrinagar Drain - C102:**

- Dense vegetal growth noticed near Indiranagar Bus Depot needs to be removed, minor rehabilitation works to be attended and bed protection to be provided.

- The covered drain reach near CMH Road culvert and also drain reach adjacent to Lakshmipura road needs to be desilted, deepened, and minor rehabilitation works needs to be provided.

➢ **I.S.R.O. Complex Drain - C105:**

- Dense vegetal growth that is noticed near I.S.R.O. complex needs to be removed, minor rehabilitation works to be attended and bed protection to be provided.

- The drain reach near Kodihalli village needs to be desilted, widened, deepened, bed protection, utility shifting and minor rehabilitation works needs to be done.

➢ **ULSOOR VALLEY:**

- Construction of shops over the drain near J.C. Nagar main road needs to be avoided.

- Dumping of debris inside the storm drain needs to be avoided.

- Sewer pipelines and manholes that are constructed inside the drainage channel near Krishnammanagar needs to be relocated.

- Loose gravelly sand / silt that existes / filled inside the drainage channel for providing cover for pipelines needs to be removed.

- Manholes that are constructed exactly at the vent location of culverts needs to be relocated near Krishnammanagar.

- Residential building that is constructed inside the drainage channel near Aiyappa Swamy temple at Krishnammanagar needs to be removed.

- K.P.T.C.L. transformer that has been installed near Krishnammanagar needs to be relocated and drain has to be widened.

- Existing stone slab culverts situated near Ramgeetha block and Krishnammanagar needs to be reconstructed.

- Solidwaste management system near Kempiah block, Krishnammanagar, and Ramgeetha block needs to be improved.

- Existing tertiary drain network Munireddypalya and Chinnappa garden area needs to be desilted and remodeled to match the new drain bed level. (As per the sketch enclosed for low lying area improvement works).

- Caution boards and sign boards needs to be displayed to create awareness among people about storm drain and its management.

- New RCC box drain has to be constructed at 13$^{th}$ Cross Muddamma garden upto S.K. Garden main road and which act as a bypass drain.

- A new open drain has to be constructed adjacent to defence area at S.K. garden main road.

- The existing drain adjacent to defence land near S.K garden needs to be widened and also existing A.C sheet residential buildings that are noticed near Pottery town bridge location needs to be relocated..

- Existing stone slab skew bridge near Pottery town needs to be replaced with RCC slab bridge.

- Existing sewerage system in S.K.Garden and its adjoining areas has to be extended to the entire locality and also it has to be ensured that all the houses are connected to the system.

- Silt barriers needs to be constructed near Tannery road and Pottery town main road to prevent entry of silt from adjoining open areas into storm drains.

- Existing silt traps constructed near Mosque road, Asseya road and Sindhi

colony needs to be desilted.

- Sewerlines and manholes constructed inside drainage channel near More road and Mosque Road needs to be relocated.

- Existing stone slab bridge near Stephen's Cross Road and Wheelers Road needs to be replaced with RCC slab bridge.

- The existing bridge near Ganapati temple near Ulsoor lake needs to be remodelled. (Work is taken up under Ulsoor lake development program)

- Existing drain needs to be widened and debris that are being dumped by defence authorities into storm drain behind corporation ward office (near Lake view Maha Ganapathy temple) needs to be prevented.

➢ **ULSOOR VALLEY SECONDARY STORM DRAINS:**

➢ **Ganesh Temple Drain - C201:**

- The existing drain reach is in natural condition minor rehabilitation works and bed protection to be done.

➢ **Cox Town Drain - C202:**

- Large quantity of mud filled inside the drain near Frazer town police station needs to be removed.

- The existing covered drain reach near Frazer town police station needs to desilted, widened and reconstructed.

- The existing stone slab culvert near wheelers road needs to be replaced with RCC box culvert.

- The drain reach near Gymkhana ground needs to be desilted, widened and bed improvements to be done.

- The existing silt trap near Gymkhana ground needs to be desilted.

➢**Sagayapuram Drain - C203:**

•The existing covered drain reach near Tannery road needs to be desilted, widened and bed protection to be done.

➢**Jeevanahalli Drain - C204:**

•The drain reach near Kandaswamy garden road and BDA qtrs. needs to desilted, deepened, widened and bed protection to be provided.

•Dense vegetal growth noticed near Railway track needs to be removed and bed protection to be provided.

•The drain reach inside M.E.G. Centre needs to be desilted, widened and stone revetment walls to be provided on either side and also bed protection to be provided.

•The drain reach near Ulsoor lake bridge location needs to be desilted, and bed protection to be provided.

## 4.3 MITIGATIVE MEASURES FOR LOW LYING AREAS:

### 4.3.1 Vasanthanagar, Miller tank & Shivajinagar (Ward No. 78 & 79):

**Mitigative Measures:**

➢The existing SWD size inside Dobhi Ghat area has to be increased and also accordingly road side drain bed needs to be regraded immediately.

•The covered portion of existing SWD (with BS slabs) near Millers road adjacent to Mount Carmal College Play Ground/Millers Arcade on Millers Road needs to be removed and the drain has to be desilted and widened immediately.

•The existing bridge constructed across Millers road needs to replaced with single span bridge

(Refer Plate No. 1)

- Steel gratings needs to be provided for the tertiary drain joining this primary drain opposite to Kodava samaja and Aiyappa Swamy temple.

- The encroached portion of tertiary drain opposite to Millers Arcade needs to be properly aligned and widened.

- Existing tertiary drains near Cunningham road, Thimmaiah Road, tank bund road, Venkataswamy naidu road, Chandani chowk road, Dharmaraja Koil street, Veera pillai street and Armugum road needs to be desilted, properly networked and widened. And also these existing tertiary drains needs to be maintained in good condition at all times.
  (Refer: enclosed sketch)

- The construction debris dumped over the SWD near Ambedkar Bhavan needs to be cleared and SWD has to be widened from Millers Road upto Mahaveer Jain hospital to provide access for free flow of water and further this reach of drain needs to be protected from dumping debris into SWD.

- The approach bridges constructed across SWD by Karnataka Badminton Association & Indian Council of social welfare needs to be immediately removed to provide access for free flow of water.
  (Refer Plate No. 2).

- The concerned authority should extend the existing sewerage system to the entire locality to prevent entry of sewage into existing SWD.

- Debris and garbage dump noticed inside the existing storm drain (both upstream & down stream) has to be cleared immediately.

- All the disused manholes noticed near Shivajinagar area inside drainage channel needs to be dismantled immediately to avoid accumulation of silt, garbage etc. and also to provide access for free flow of water.
  (Refer Plate No. 3).

- The commercial shops constructed over storm water drain near Shivajinagar market has to be removed/relocated and drain has to be widened, deepened and accordingly road side drains needs to be regraded inorder to accommodate for free flow of water.
  (Refer Plate No. 4).

- Large Nos. of public toilet blocks which have been constructed over SWD needs to be removed / relocated to provide access for free flow of water and also to prevent entry of raw sewage into storm drain.
  (Refer Plate No. 5).

- The debris and vegetal growth noticed near Ulsoor lake needs to be cleared to provide access for free flow of water.
  (Refer Plate No. 6).

- Large Nos. of garbage heaps noticed at many places inside the storm drain which needs to be cleared immediately to avoid blockage further down stream and also to restrict the quality of storm water from further deterioration.
  (Refer Plate No. 7).

- Retaining walls distracted for desilting needs to be restored immediately to prevent general public from dumping garbage inside the drain.
  (Refer Plate No. 8).

- Caution boards/display boards have to be installed to educate and create public awareness regarding storm water and storm drain management.

- Emergency squads have to be formed to provide necessary assistance to flood affected people during heavy storms.

### 4.3.2 Murgeshpalya - K.R. Garden Area (Ward No. 73):

**Mitigative Measures:**

- Construction activity of RCC Box drain in K.R. Garden area has to be expedited.
  (Refer: Plate 1).

- Proposed RCC Box drain needs to be extended upto Challaghatta valley primary storm drain.
  (Refer: Plate 2).

- Decision on relocating the existing residential building on 8$^{th}$ Main Road has to be taken immediately to expedited the construction work.
  (Refer: enclosed sketch).

- The concerned authority should extend the existing sewerage system to the entire locality to prevent entry of sewage into SWD.

- Existing tertiary drains at Nanjareddy colony and Cauvery pura and K.R. garden needs to be realigned and their carrying capacity needs to be increased and also these drains needs to be maintained at regular intervals.
  (Refer: enclosed sketch)

- Debris and garbage dump noticed inside the drain (both upstream & down stream) has to be cleared immediately before monsoon.

- Caution boards/display boards has to be installed to educate and create public awareness regarding storm water and storm drain management.

- Emergency squads have to be formed to provide necessary assistance to flood affected people during heavy storms.

### 4.3.3 Jogupalya and Someshwarapura (Ward No. ):

**Mitigative Measures:**

- Existing tertiary drains at Jogupalya and Someshwarapura main road needs to be desilted, realigned and their carrying capacity of these drains has to be increased and apart from all these drains needs to be maintained at regular intervals. (Refer: enclosed sketch)

- Large quantity of debris and garbage dumps that are noticed needs to be removed at many places inside the existing SWD.

- Steel gratings needs to be provided at regular intervals and also at all road junctions.

- Street sweeping and solid waste management system needs to be improved in these localities.

- Emergency squads have to be formed to provide necessary assistance to flood affected people during heavy storms.

### 4.3.4 Munireddypalya and Chinnappa Garden (Ward No. ):

**Mitigative Measures:**

- Existing tertiary drains at Pemme gowda road, Church street, Chinnappa garden and Coles road in Frazer town needs to be desilted, realigned and their carrying capacity of these drains has to be increased and apart from all these drains needs to be maintained at regular intervals. (Refer: enclosed sketch)

- Large quantity of debris and garbage dumps that are noticed needs to be removed at many places inside the existing SWD.

•Steel gratings needs to be provided at regular intervals and also at all road junctions.

•Street sweeping and solid waste management system needs to be improved in these localities.

•Drain improvements works suggested for primary drain at these localities needs to be carried out.

•Emergency squads have to be formed to provide necessary assistance to flood affected people during heavy storms.

Apart from above referred strategic actions and recommendations, following Best management practices also needs to be followed to achieve the very objectives of storm drains in totality .

## 4.4 BEST MANAGEMENT PRACTICES:

➢Implement pollution prevention methods.

➢Designate and implement minimum best management practices to protect water quality.

➢Implement a maintenance schedule for all structural controls designed to reduce pollutant discharges and the storm water conveyance system, to include:

•Inspection & removal of waste between May 1$^{st}$ and Sept. 30$^{th}$ .
•Additional cleaning between October 1$^{st}$ and April 30$^{th}$ .
•Records of cleaning and waste removal quantity.
•Proper waste disposal.

➢Measures to eliminate discharges during maintenance & cleaning.

➢Limit infiltration from sanitary sewer to storm drains through routine maintenance.

- Implement an Educational Program for all pertinent target audiences.

- Inspect and clean catch basins and keep appropriate records.

- Remove trash and debris from open channels and properly dispose of these materials to prevent them from being washed into receiving waters.

- Report prohibited non-storm water discharges observed during the course of normal daily activities so they can be investigated, contained and cleaned up or eliminated.

- Review maintenance activities to verify that appropriate storm water maintenance practices are being utilized.

- Educate employees for pollution prevention techniques.

- Inspect and clean as needed all inlets/catch basins at least once every other year (at least 50% of the entire system inspected and cleaned each year)

- Inspect and clean as needed all inlets/catch basins in known problem areas at least once a year.

- Inspect and clean as needed all storm drain lines in known problem areas at least once a year.

- Inspect and clean as needed sumps and debris racks at pump stations, detention basins, drainage ditches and debris basins throughout the year.

- Cleaning activities may occur on a year round basis, however, known problem areas shall be targeted prior to the rainy season.

- Inspect and clean as needed all storm drain facilities that have been affected by emergency response activities.

- Additional cleanings shall be conducted as necessary during the non rainy

season (Oct. 1st through April 30th).

- Slide and Embankment Repair of Channels

To improve the section of the drain and to minimize the flooding problems in low lying areas, various drain improvement methods suggested are :-

1. Increase the carrying capacity of existing tertiary drains.

2. Provision of cut off drain (bypass drains) around the low lying area to prevent adjoining area water entering into the low lying area and construction of sump for pumping out water at a location closer to the main drains (downstream end) and also it should be located in such a way that it should be easily accessible by vehicles that are mounted with pump.

3. The improvement shall be taken up from the down stream of the valley. If remodeling works are commenced from upstream side, situation at the downstream end may get further aggravated.

4. Set-up a vigilance squad to prevent debris dumping, encroachment of drains, local obstruction, such as, pipe crossing, construction inside the drain, any discharges other than storm water.

5. Encourage rain water harvesting in institutions, public parks, open grounds, etc.,

## Table Showing Adequacy Analysis Results for Challaghatta Valley - Existing Hydraulic Flow Conditions

| Sl.No. | Description | Drain Reach | | Chainage (m) | | Catchment Area A (Ha.) | Type | Average Velocity V m/sec | Discharges (Q in m³/sec) | | | | | Existing Av.Drain Depth D in m. | Area required for drain ( A in m²) | | | | | Existing Av. Drain Width W( m.) | Required Drain Width (m) | | | | | Remarks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | From | To | From | To | | | | 1year | 2year | 5year | 10year | 20year | | 1year | 2year | 5year | 10year | 20year | | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year |
| 1 | C100 | Palace Grounds | Millers Road | 0 | 575 | 144.6 | Pri. | 2.61 | 8.22 | 11.32 | 14.43 | 17.01 | 21.3 | 1.5 | 3.15 | 4.34 | 5.53 | 6.52 | 8.16 | 2.5 | 2.1 | 2.89 | 3.69 | 4.34 | 5.44 | AD | IA | IA | IA | IA |
| 2 | C100 | Millers Road | Sepping's Road | 575 | 2200 | 304.17 | Pri. | 2.89 | 18.15 | 25.06 | 32.04 | 37.93 | 47.11 | 2 | 6.28 | 8.67 | 11.09 | 13.12 | 16.3 | 5 | 3.14 | 4.33 | 5.54 | 6.56 | 8.15 | AD | AD | IA | IA | IA |
| 3 | C100 | Sepping's Road | Anna Swamy Mudaliar Road | 2200 | 3175 | 450.74 | Pri. | 2.36 | 26.38 | 36.53 | 46.88 | 55.75 | 68.65 | 2.25 | 11.18 | 15.48 | 19.86 | 23.62 | 29.09 | 9.5 | 4.97 | 6.88 | 8.83 | 10.5 | 12.93 | AD | AD | AD | IA | IA |
| 4 | C100 | Anna Swamy Mudaliar Road | Kensngton Road | 3175 | 3975 | 605.66 | Pri. | 1.81 | 33.98 | 47.14 | 60.65 | 72.36 | 88.58 | 2.68 | 18.78 | 26.04 | 33.51 | 39.98 | 48.94 | 15.5 | 7.01 | 9.72 | 12.5 | 14.92 | 18.26 | AD | AD | AD | AD | IA |
| 5 | C100 | Kensngton Road | Sathya Narayana Temple Street | 3975 | 4500 | 1299.08 | Pri. | 4.16 | 38.04 | 52.83 | 68.08 | 81.37 | 99.25 | 2.69 | 9.14 | 12.7 | 16.37 | 19.56 | 23.86 | 13 | 3.4 | 4.72 | 6.08 | 7.27 | 8.87 | AD | AD | AD | AD | AD |
| 6 | C100 | Sathya Narayana Temple Street | Saraswathpura Road | 4500 | 5500 | 1522.81 | Pri. | 3.06 | 47.38 | 66.06 | 85.56 | 102.93 | 124.06 | 2.48 | 15.48 | 21.59 | 27.96 | 33.64 | 40.54 | 15 | 6.24 | 8.71 | 11.27 | 13.56 | 16.35 | AD | AD | AD | AD | IA |
| 7 | C100 | Saraswathpura Road | Shammana Gowda Layout 4th Main Road | 5500 | 5800 | 1871.98 | Pri. | 3.26 | 66.24 | 92.17 | 119.05 | 142.71 | 173.13 | 2.1 | 20.32 | 28.27 | 36.52 | 43.78 | 53.11 | 17.5 | 9.68 | 13.46 | 17.39 | 20.85 | 25.29 | AD | AD | AD | IA | IA |
| 8 | C100 | Shammana Gowda Layout 4th Main Road | Domlur listage near TERI | 5800 | 7075 | 2274.67 | Pri. | 3.04 | 82.39 | 115.17 | 149.61 | 180.69 | 216.19 | 2.19 | 27.1 | 37.88 | 49.21 | 59.44 | 71.11 | 15 | 12.38 | 17.3 | 22.47 | 27.14 | 32.47 | AD | IA | IA | IA | IA |
| 9 | C100 | Domlur listage near TERI | Airport Road | 7075 | 7675 | 2408.57 | Pri. | 2.66 | 86.96 | 121.69 | 158.31 | 191.54 | 228.4 | 2.48 | 32.69 | 45.75 | 59.51 | 72.01 | 85.86 | 22 | 13.18 | 18.45 | 24 | 29.04 | 34.62 | AD | AD | IA | IA | IA |
| 10 | C100 | Airport Road | Royal Orchid Park Hotel | 7675 | 8225 | 2671.06 | Pri. | 3.16 | 101.18 | 141.52 | 183.99 | 222.42 | 265.64 | 3.02 | 32.02 | 44.78 | 58.22 | 70.39 | 84.06 | 22 | 10.6 | 14.83 | 19.28 | 23.31 | 27.84 | AD | AD | AD | IA | IA |
| 11 | C100 | Royal Orchid Park Hotel | Wind Tunnel Road | 8225 | 9350 | 3034.15 | Pri. | 2.63 | 111.79 | 156.76 | 204.45 | 248.16 | 294.15 | 2.2 | 42.51 | 59.6 | 77.74 | 94.36 | 111.84 | 18 | 19.32 | 27.09 | 35.33 | 42.89 | 50.84 | IA | IA | IA | IA | IA |
| 12 | C100 | Wind Tunnel Road | Bellur Main Road | 9350 | 10275 | 3417.28 | Pri. | 2.77 | 125.45 | 176.14 | 230.11 | 279.9 | 330.46 | 1.83 | 45.29 | 63.59 | 83.07 | 101.05 | 119.3 | 15 | 24.75 | 34.75 | 45.39 | 55.22 | 65.19 | IA | IA | IA | IA | IA |
| 13 | C101 | Anandanagar | K.R. Garden | 0 | 1875 | 217.53 | Sec. | 2.1 | 8.39 | 11.8 | 15.45 | 18.83 | 22.13 | 1.1 | 3.99 | 5.62 | 7.36 | 8.97 | 10.54 | 2 | 3.63 | 5.11 | 6.69 | 8.15 | 9.58 | IA | IA | IA | IA | IA |
| 14 | C105 | Jeevanbhimanagar | Kodihalli | 0 | 2500 | 262.49 | Sec. | 2.62 | 14.22 | 19.83 | 25.68 | 30.88 | 37.24 | 1.8 | 5.43 | 7.57 | 9.8 | 11.79 | 14.21 | 3.65 | 3.02 | 4.2 | 5.45 | 6.55 | 7.9 | AD | IA | IA | IA | IA |

## Table Showing Adequacy Analysis Results for Ulsoor Valley - Existing Hydraulic Flow Conditions

| Sl.No. | Description | Drain Reach | | Chainage (m) | | Catchment Area A (Ha.) | Type | Average Velocity V m/sec | Discharges (Q in $m^3$/sec) | | | | | Existing Av.Drain Depth D in m. | Area required for drain ( A in $m^2$) | | | | | Existing Av. Drain Width W( m.) | Required Drain Width (m) | | | | | Remarks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | From | To | From | To | | | | 1year | 2year | 5year | 10year | 20year | | 1year | 2year | 5year | 10year | 20year | | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year |
| 1 | C200 | J.C.Nagar Main Road | S.K.Garden Main Road | 0 | 1625 | 239.76 | Pri. | 3.76 | 12.47 | 17.31 | 22.27 | 26.57 | 32.52 | 2 | 3.32 | 4.6 | 5.92 | 7.07 | 8.65 | 4.8 | 1.66 | 2.3 | 2.96 | 3.53 | 4.32 | AD | AD | AD | AD | AD |
| 2 | C200 | S.K.Garden Main Road | Bore Bank Road | 1625 | 2150 | 336.94 | Pri. | 3.31 | 17.63 | 24.48 | 31.52 | 37.64 | 45.99 | 2.1 | 5.33 | 7.4 | 9.52 | 11.37 | 13.89 | 7.8 | 2.54 | 3.52 | 4.53 | 5.41 | 6.62 | AD | AD | AD | AD | AD |
| 3 | C200 | Bore Bank Road | More Road | 2150 | 2550 | 353.87 | Pri. | 3.01 | 18.81 | 26.09 | 33.57 | 40.04 | 49.03 | 2.63 | 6.25 | 8.67 | 11.15 | 13.3 | 16.29 | 10.45 | 2.38 | 3.3 | 4.24 | 5.06 | 6.19 | AD | AD | AD | AD | AD |
| 4 | C200 | More Road | Wheeler's Road | 2550 | 3350 | 468.48 | Pri. | 3.12 | 24.94 | 34.63 | 44.63 | 53.33 | 65.07 | 2.46 | 7.99 | 11.1 | 17.09 | 17.09 | 20.85 | 10.41 | 3.25 | 4.51 | 6.95 | 6.95 | 8.48 | AD | AD | AD | AD | AD |
| 5 | C200 | Wheeler's Road | Ulsoor Tank | 3350 | 4200 | 500.59 | Pri. | 3.01 | 27.1 | 37.61 | 48.41 | 57.78 | 70.67 | 2 | 9 | 12.49 | 16.08 | 19.2 | 23.48 | 10.4 | 4.5 | 6.25 | 8.04 | 9.6 | 11.74 | AD | AD | AD | AD | IA |
| 6 | C202 | Richards Town | Gymkana Ground | 0 | 1170 | 32.11 | Sec. | 3.05 | 2.17 | 2.98 | 3.79 | 4.45 | 5.6 | 1.7 | 0.71 | 0.98 | 1.24 | 1.46 | 1.84 | 5.4 | 0.42 | 0.57 | 0.73 | 0.86 | 1.08 | AD | AD | AD | AD | AD |
| 7 | C203 | Sagayapuram | Cleveland Town | 0 | 737 | 16.93 | Sec. | 3.14 | 1.18 | 1.62 | 2.05 | 2.4 | 3.04 | 1.6 | 0.38 | 0.51 | 0.65 | 0.77 | 0.97 | 2.42 | 0.23 | 0.32 | 0.41 | 0.48 | 0.61 | AD | AD | AD | AD | AD |
| 8 | C204 | Jeevanahalli | Ulsoor Tank | 0 | 2000 | 192.83 | Sec. | 2.38 | 10.93 | 15.22 | 19.67 | 23.59 | 28.59 | 1.24 | 4.59 | 6.39 | 8.26 | 9.91 | 12.01 | 4 | 3.7 | 5.16 | 6.66 | 7.99 | 9.69 | AD | IA | IA | IA | IA |

## Land Use Analysis of Challaghatta Valley Storm Water Drain

| Description about drain | Chainage | | Sub Catchment | Total Area ( Ha.) | Area of bulitup and paved areas (Ha.) | Area of parks and open space, etc. (Ha.) | Weighted Imperviousness (%) | Inlet Time in minutes | Slope of terain | Average Velocity in m/sec. | | Flow in drain (min.) | Flow in Terain (min.) | Total time of concentration (min.) | Runoff Coeffiecent "C" | Rainfall Intensity "i" in mm/hour | | | | | Quantity (Q)= 10 C.i A m3/sec. | | | | | Existing Ave.width in m | Ave. Depth of drain m | Area required for Drain in m2 | | | | | Width required for drain in m | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | from | to | | | | | | | | For terain | For Drain | | | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) |
| **C100** | 0 | 575 | A1(a) | 95.38 | 67.64 | 27.74 | 59 | 12.33 | 0.01 | 1.2 | 2.61 | 3.67 | 9.72 | 25.72 | 0.448 | 46.57 | 64.08 | 81.63 | 96.14 | 120.55 | 5.53 | 7.61 | 9.69 | 11.41 | 14.31 | | | | | | | | | | | | |
| | | | A1(b) | 49.22 | 31.85 | 17.37 | 55.59 | 12.82 | 0.01 | 1.2 | 2.61 | 3.67 | 10.42 | 26.91 | 0.437 | 45.18 | 62.26 | 79.44 | 93.79 | 117.08 | 2.7 | 3.72 | 4.74 | 5.6 | 6.99 | | | | | | | | | | | | |
| | | | **Total** | **144.6** | | | | | | | 2.61 | | | | | | | | | | **8.22** | **11.32** | **14.43** | **17.01** | **21.3** | 2.5 | 1.5 | 3.2 | 4.3 | 5.5 | 6.5 | 8.2 | 2.1 | 2.9 | 3.7 | 4.3 | 5.4 |
| **C100** | 575 | 2200 | A2 (a) | 59.93 | 59.93 | 0 | 75 | 10 | 0.02 | 1.5 | 2.89 | 9.37 | 7.78 | 27.15 | 0.524 | 44.91 | 61.91 | 79.03 | 93.34 | 116.42 | 3.91 | 5.4 | 6.89 | 8.14 | 10.15 | | | | | | | | | | | | |
| | | | A2 (b) | 99.64 | 99.64 | 0 | 75 | 10 | 0.01 | 1.2 | 2.89 | 9.37 | 13.19 | 32.57 | 0.547 | 39.74 | 55.10 | 70.87 | 84.49 | 103.55 | 6.01 | 8.34 | 10.72 | 12.78 | 15.67 | | | | | | | | | | | | |
| | | | | **159.57** | | | | | | | | | | | | | | | | | **9.93** | **13.73** | **17.61** | **20.92** | **25.82** | | | | | | | | | | | | |
| | | | **Total** | **304.17** | | | | | | | 2.89 | | | 32.57 | | | | | | | **18.15** | **25.06** | **32.04** | **37.93** | **47.11** | 5 | 2 | 6.3 | 8.7 | 11.1 | 13.1 | 16.3 | 3.1 | 4.3 | 5.5 | 6.6 | 8.2 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 2200 | 3175 | A3 (a1) | 87.97 | 87.97 | 0 | 75 | 10 | 0.01 | 1.2 | 2.36 | 18.36 | 8.33 | 36.69 | 0.561 | 36.67 | 51.05 | 65.98 | 79.15 | 95.88 | 5.03 | 7 | 9.05 | 10.86 | 13.15 | | | | | | | | | | | | |
| | | | A3 (b1) | 58.6 | 56.26 | 2.34 | 72.8 | 10.32 | 0.01 | 1.2 | 2.36 | 18.36 | 10.42 | 39.1 | 0.560 | 35.14 | 49.02 | 63.52 | 76.45 | 92.04 | 3.2 | 4.47 | 5.79 | 6.97 | 8.39 | | | | | | | | | | | | |
| | | | | **146.57** | | | | | | | | | | | | | | | | | **8.23** | **11.47** | **14.84** | **17.82** | **21.54** | | | | | | | | | | | | |
| | | | **Total** | **450.74** | | | | | | | 2.36 | | | 39.1 | | | | | | | **26.38** | **36.53** | **46.88** | **55.75** | **68.65** | 9.5 | 2.25 | 11.2 | 15.5 | 19.9 | 23.6 | 29.1 | 5.0 | 6.9 | 8.8 | 10.5 | 12.9 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 3175 | 3975 | A3 (a2) | 95.44 | 91.26 | 4.18 | 72.59 | 10.35 | 0.01 | 1.2 | 1.81 | 16.34 | 13.19 | 39.89 | 0.560 | 34.66 | 48.40 | 62.76 | 75.61 | 90.86 | 5.14 | 7.18 | 9.31 | 11.22 | 13.48 | | | | | | | | | | | | |
| | | | A3 (b2) | 59.48 | 24.16 | 35.32 | 42.34 | 14.75 | 0.01 | 1.2 | 1.81 | 16.34 | 10.42 | 41.51 | 0.441 | 33.75 | 47.18 | 61.28 | 73.98 | 88.56 | 2.46 | 3.43 | 4.46 | 5.38 | 6.45 | | | | | | | | | | | | |
| | | | | **154.92** | | | | | | | | | | | | | | | | | **7.6** | **10.62** | **13.77** | **16.61** | **19.93** | | | | | | | | | | | | |
| | | | **Total** | **605.66** | | | | | | | 1.81 | | | 41.51 | | | | | | | **33.98** | **47.14** | **60.65** | **72.36** | **88.58** | 15.5 | 2.68 | 18.8 | 26.0 | 33.5 | 40.0 | 48.9 | 7.0 | 9.7 | 12.5 | 14.9 | 18.3 |
| **C200** | 0 | 1625 | A1(a) | 26.26 | 15 | 11.26 | 51.42 | 13.43 | 0.01 | 1.2 | 3.76 | 7.2 | 11.11 | 31.74 | 0.44 | 40.42 | 56.01 | 71.96 | 85.68 | 105.27 | 1.31 | 1.81 | 2.33 | 2.77 | 3.41 | | | | | | | | | | | | |
| | | | A1(b) | 172.64 | 130.49 | 42.15 | 61.57 | 11.95 | 0.01 | 1.2 | 3.76 | 7.2 | 13.89 | 33.05 | 0.492 | 39.35 | 54.59 | 70.25 | 83.82 | 102.58 | 9.29 | 12.89 | 16.59 | 19.79 | 24.22 | | | | | | | | | | | | |
| | | | A1(c) | 40.86 | 18.81 | 22.05 | 45.32 | 14.32 | 0.02 | 1.5 | 3.76 | 7.2 | 12.22 | 33.74 | 0.426 | 38.80 | 53.87 | 69.38 | 82.87 | 101.21 | 1.88 | 2.6 | 3.35 | 4.01 | 4.89 | | | | | | | | | | | | |
| | | | **Total** | **239.76** | | | | | | | 3.76 | | | 33.74 | | | | | | | **12.47** | **17.31** | **22.27** | **26.57** | **32.52** | 4.8 | 2 | 1.5 | 4.6 | 5.9 | 7.1 | 8.6 | 0.8 | 2.3 | 3.0 | 3.5 | 4.3 |

| Description about drain | Chainage | | Sub Catchment | Total Area ( Ha.) | Area of bulitup and paved areas (Ha.) | Area of parks and open space, etc. (Ha.) | Weighted Imperviousness (%) | Inlet Time in minutes | Slope of terain | Average Velocity in m/sec. | | Flow in drain (min.) | Flow in Terain (min.) | Total time of concentration (min.) | Runoff Coeffiecent "C" | Rainfall Intensity "i" in mm/hour | | | | | Quantity (Q)= 10 C.i A m3/sec. | | | | | Existing Ave.width in m | Ave. Depth of drain m | Area required for Drain in m2 | | | | | Width required for drain in m | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | from | to | | | | | | | | For terain | For Drain | | | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C200** | 1625 | 2150 | A2 (a) | 68.53 | 64.48 | 4.05 | 71.75 | 10.47 | 0.01 | 1.2 | 3.31 | 10.83 | 13.61 | 34.91 | 0.537 | 37.92 | 52.71 | 67.98 | 81.34 | 99.01 | 3.88 | 5.39 | 6.95 | 8.32 | 10.13 | | | | | | | | | | | |
| | | | A3 (a) | 28.65 | 12.72 | 15.93 | 44.42 | 14.45 | 0.01 | 1.2 | 3.31 | 10.83 | 9.72 | 35 | 0.425 | 37.86 | 52.62 | 67.88 | 81.23 | 98.86 | 1.28 | 1.78 | 2.3 | 2.75 | 3.35 | | | | | | | | | | | |
| | | | | **97.18** | | | | | | | | | | | | | | | | | **5.16** | **7.17** | **9.25** | **11.07** | **13.47** | | | | | | | | | | |
| | | | **Total** | **336.94** | | | | | | | 3.31 | | | 35 | | | | | | | **17.63** | **24.48** | **31.52** | **37.64** | **45.99** | 7.8 | 2.1 | 2.5 | 7.4 | 9.5 | 11.4 | 13.9 | 1.2 | 3.5 | 4.5 | 5.4 | 6.6 |
| **C203** | 0 | 737 | A3 (b) | 16.93 | 16.93 | 0 | 75 | 10 | 0.01 | 1.2 | 3.14 | 2.12 | 11.11 | 23.23 | 0.503 | 49.87 | 68.39 | 86.75 | 101.64 | 128.71 | 1.18 | 1.62 | 2.05 | 2.4 | 3.04 | | | | | | | | | | | |
| | | | **Total** | **16.93** | | | | | | | 3.14 | | | | | | | | | | **1.18** | **1.62** | **2.05** | **2.4** | **3.04** | 2.42 | 1.6 | 0.4 | 0.5 | 0.7 | 0.8 | 1.0 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 |
| **C200** | 2150 | 2550 | **Total** | **353.87** | | | | | | | 3.01 | | | 37.12 | | | | | | | **18.81** | **26.09** | **33.57** | **40.04** | **49.03** | 10.45 | 2.63 | 6.3 | 8.7 | 11.2 | 13.3 | 16.3 | 2.4 | 3.3 | 4.2 | 5.1 | 6.2 |
| **C200** | 2550 | 3350 | A4 (a) | 78.02 | 76.49 | 1.53 | 73.92 | 10.16 | 0.01 | 1.2 | 3.12 | 17.9 | 9.72 | 37.77 | 0.557 | 35.96 | 50.11 | 64.84 | 77.90 | 94.11 | 4.34 | 6.05 | 7.82 | 9.4 | 11.35 | | | | | | | | | | | |
| | | | A5 (a) | 36.59 | 26.25 | 10.34 | 59.46 | 12.26 | 0.02 | 1.5 | 3.12 | 17.9 | 10 | 40.15 | 0.509 | 34.51 | 48.19 | 62.51 | 75.34 | 90.48 | 1.78 | 2.49 | 3.23 | 3.9 | 4.68 | | | | | | | | | | | |
| | | | | **114.61** | | | | | | | | | | | | | | | | | **6.12** | **8.54** | **11.06** | **13.29** | **16.03** | | | | | | | | | | |
| | | | **Total** | **468.48** | | | | | | | 3.12 | | | 40.15 | | | | | | | **24.94** | **34.63** | **44.63** | **53.33** | **65.07** | 10.41 | 2.46 | 8.0 | 11.1 | 14.3 | 17.1 | 20.9 | 3.2 | 4.5 | 5.8 | 6.9 | 8.5 |
| **C202** | 0 | 1170 | A6 (a) | 32.11 | 32.11 | 0 | 75 | 10 | 0.01 | 1.2 | 3.05 | 6.39 | 8.33 | 24.73 | 0.508 | 47.83 | 65.72 | 83.58 | 98.24 | 123.65 | 2.17 | 2.98 | 3.79 | 4.45 | 5.6 | | | | | | | | | | | |
| | | | **Total** | **32.11** | | | | | | | 3.05 | | | | | | | | | | **2.17** | **2.98** | **3.79** | **4.45** | **5.6** | 5.4 | 1.7 | 0.7 | 1.0 | 1.2 | 1.5 | 1.8 | 0.4 | 0.6 | 0.7 | 0.9 | 1.1 |
| **C200** | 3350 | 4200 | **Total** | **500.59** | | | | | | | 3.01 | | | 46.55 | | | | | | | **27.1** | **37.61** | **48.41** | **57.78** | **70.67** | 11 | 2 | 9.0 | 12.5 | 16.1 | 19.2 | 23.5 | 4.5 | 6.2 | 8.0 | 9.6 | 11.7 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C204** | 0 | 2000 | A6 (b) | 114.77 | 110.49 | 4.28 | 72.95 | 10.3 | 0.01 | 1.2 | 2.38 | 14.01 | 9.72 | 34.03 | 0.542 | 38.58 | 53.58 | 69.03 | 82.49 | 100.66 | 6.66 | 9.25 | 11.92 | 14.24 | 17.38 | | | | | | | | | | | |
| | | | A7 (a) | 78.06 | 78.06 | 0 | 75 | 10 | 0.02 | 1.5 | 2.38 | 14.01 | 16.67 | 40.67 | 0.576 | 34.21 | 47.80 | 62.04 | 74.81 | 89.73 | 4.27 | 5.97 | 7.75 | 9.34 | 11.21 | | | | | | | | | | | |
| | | | **Total** | **192.83** | | | | | | | 2.38 | | | 40.67 | | | | | | | **10.93** | **15.22** | **19.67** | **23.59** | **28.59** | 4 | 1.24 | 4.6 | 6.4 | 8.3 | 9.9 | 12.0 | 3.7 | 5.2 | 6.7 | 8.0 | 9.7 |
| | | | | | | | | | | | | | | | | | | | | | **38.04** | **52.83** | **68.08** | **81.37** | **99.25** | In this chainage, 100% of Ulsoor storm Water overflows from the Ulsoor Lake | | | | | | | | | | | |
| **C100** | 3975 | 4500 | **Total** | **1299.08** | | | | | | | 4.16 | | | 46.55 | | | | | | | **38.04** | **52.83** | **68.08** | **81.37** | **99.25** | 13 | 2.69 | 9.1 | 12.7 | 16.4 | 19.6 | 23.9 | 3.4 | 4.7 | 6.1 | 7.3 | 8.9 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 4500 | 5500 | A4 (a) | 105.2 | 105.2 | 0 | 75 | 10 | 0.01 | 1.2 | 3.06 | 32.68 | 16.67 | 59.35 | 0.629 | 26.53 | 37.53 | 49.47 | 60.83 | 70.35 | 4.87 | 6.89 | 9.09 | 11.17 | 12.92 | | | | | | | | | | | |

| Description about drain | Chainage | | Sub Catchment | Total Area ( Ha.) | Area of bulitup and paved areas (Ha.) | Area of parks and open space, etc. (Ha.) | Weighted Imperviousness (%) | Inlet Time in minutes | Slope of terain | Average Velocity in m/sec. | | Flow in drain (min.) | Flow in Terain (min.) | Total time of concentration (min.) | Runoff Coeffiecent "C" | Rainfall Intensity "i" in mm/hour | | | | | Quantity (Q)= 10 C.i A m3/sec. | | | | | Existing Ave.width in m | Ave. Depth of drain m | Area required for Drain in m2 | | | | | Width required for drain in m | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | from | to | | | | | | | | For terain | For Drain | | | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) |
| | | | A4 (b1) | 118.53 | 79.65 | 38.88 | 56.96 | 12.62 | 0.01 | 1.2 | 3.06 | 32.68 | 20.83 | 66.14 | 0.550 | 24.67 | 35.02 | 46.36 | 57.33 | 65.60 | 4.47 | 6.34 | 8.4 | 10.38 | 11.88 | | | | | | | | | | | | |
| | | | | **223.73** | | | | | | | | | | | | | | | | | **9.34** | **13.23** | **17.48** | **21.56** | **24.8** | | | | | | | | | | | |
| | | | **Total** | **1522.81** | | | | | | | 3.06 | | | 66.14 | | | | | | | **47.38** | **66.06** | **85.56** | **102.93** | **124.06** | 15 | 2.48 | 15.5 | 21.6 | 28.0 | 33.6 | 40.5 | 6.2 | 8.7 | 11.3 | 13.6 | 16.3 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C102** | 0 | 500 | A4 (c) | 87.64 | 44.09 | 43.55 | 47.67 | 13.98 | 0.01 | 1.2 | 2.64 | 3.16 | 8.33 | 25.47 | 0.399 | 46.89 | 64.50 | 82.12 | 96.67 | 121.32 | 4.55 | 6.27 | 7.98 | 9.39 | 11.79 | | | | | | | | | | | | |
| | | | A4 (d) | 158.91 | 101.54 | 57.37 | 55.14 | 12.89 | 0.01 | 1.2 | 2.64 | 3.16 | 13.89 | 29.93 | 0.452 | 42.05 | 58.16 | 74.54 | 88.48 | 109.32 | 8.39 | 11.6 | 14.87 | 17.65 | 21.8 | | | | | | | | | | | | |
| | | | **Total** | **246.55** | | | | | | | 2.64 | | | | | | | | | | **12.94** | **17.86** | **22.84** | **27.04** | **33.59** | 4 | 2.3 | 4.9 | 6.8 | 8.7 | 10.2 | 12.7 | 2.1 | 2.9 | 3.8 | 4.5 | 5.5 |
| **C102** | 500 | 1250 | A4 (b2) | 102.62 | 102.62 | 0 | 75 | 10 | 0.01 | 1.2 | 2.51 | 4.98 | 20.83 | 35.81 | 0.558 | 37.27 | 51.85 | 66.95 | 80.21 | 97.40 | 5.93 | 8.24 | 10.64 | 12.75 | 15.48 | | | | | | | | | | | | |
| | | | | **102.62** | | | | | | | | | | | | | | | | | **5.93** | **8.24** | **10.64** | **12.75** | **15.48** | | | | | | | | | | | |
| | | | | **349.17** | | | | | | | 2.51 | | | | | | | | | | **18.87** | **26.11** | **33.49** | **39.79** | **49.07** | 5 | 2 | 7.5 | 10.4 | 13.3 | 15.9 | 19.6 | 3.8 | 5.2 | 6.7 | 7.9 | 9.8 |
| **C100** | 5500 | 5800 | **Total** | **1871.98** | | | | | | | 3.26 | | | 69.29 | | | | | | | **66.24** | **92.17** | **119.05** | **142.71** | **173.13** | 17.5 | 2.1 | 20.3 | 28.3 | 36.5 | 43.8 | 53.1 | 9.7 | 13.5 | 17.4 | 20.8 | 25.3 |
| **C100** | 5800 | 7075 | A5 (a) | 129.91 | 118.79 | 11.12 | 70.29 | 10.68 | 0.01 | 1.2 | 3.04 | 35.64 | 25 | 71.32 | 0.610 | 23.44 | 33.37 | 44.32 | 55.01 | 62.49 | 5.16 | 7.34 | 9.75 | 12.1 | 13.74 | | | | | | | | | | | | |
| | | | A5 (b) | 272.78 | 272.78 | 0 | 75 | 10 | 0.01 | 1.2 | 3.04 | 35.64 | 27.78 | 73.41 | 0.631 | 22.99 | 32.76 | 43.55 | 54.15 | 61.34 | 10.99 | 15.65 | 20.82 | 25.88 | 29.32 | | | | | | | | | | | | |
| | | | | **402.69** | | | | | | | | | | | | | | | | | **16.15** | **22.99** | **30.56** | **37.98** | **43.06** | | | | | | | | | | | |
| | | | **Total** | **2274.67** | | | | | | | 3.04 | | | 73.41 | | | | | | | **82.39** | **115.17** | **149.61** | **180.69** | **216.19** | 15 | 2.19 | 27.1 | 37.9 | 49.2 | 59.4 | 71.1 | 12.4 | 17.3 | 22.5 | 27.1 | 32.5 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 7075 | 7675 | A6 (a) | 133.9 | 94.76 | 39.14 | 58.92 | 12.34 | 0.01 | 1.2 | 2.66 | 44.49 | 21.6 | 78.42 | 0.559 | 21.99 | 31.40 | 41.87 | 52.23 | 58.78 | 4.57 | 6.52 | 8.7 | 10.85 | 12.21 | | | | | | | | | | | | |
| | | | | **133.9** | | | | | | | | | | | | | | | | | **4.57** | **6.52** | **8.7** | **10.85** | **12.21** | | | | | | | | | | | |
| | | | **Total** | **2408.57** | | | | | | | 2.66 | | | 78.42 | | | | | | | **86.96** | **121.69** | **158.31** | **191.54** | **228.4** | 22 | 2.48 | 32.7 | 45.7 | 59.5 | 72.0 | 85.9 | 13.2 | 18.4 | 24.0 | 29.0 | 34.6 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C105** | 0 | 2500 | A6 (b) | 62.7 | 62.7 | 0 | 75 | 10 | 0.02 | 1.5 | 2.2 | 5.3 | 20 | 35.3 | 0.558 | 37.63 | 52.33 | 67.52 | 80.84 | 98.30 | 3.66 | 5.08 | 6.56 | 7.85 | 9.55 | | | | | | | | | | | | |
| | | | A6 (c) | 199.79 | 180.85 | 18.94 | 69.79 | 10.76 | 0.01 | 1.2 | 2.2 | 5.3 | 23.61 | 39.67 | 0.547 | 34.79 | 48.56 | 62.97 | 75.84 | 91.18 | 10.57 | 14.75 | 19.12 | 23.03 | 27.69 | | | | | | | | | | | | |
| | | | | **262.49** | | | | | | | 2.2 | | | | | | | | | | **14.22** | **19.83** | **25.68** | **30.88** | **37.24** | 3.65 | 1.8 | 6.5 | 9.0 | 11.7 | 14.0 | 16.9 | 3.6 | 5.0 | 6.5 | 7.8 | 9.4 |

| Description about drain | Chainage | | Sub Catchment | Total Area ( Ha.) | Area of bulitup and paved areas (Ha.) | Area of parks and open space, etc. (Ha.) | Weighted Imperviousness (%) | Inlet Time in minutes | Slope of terain | Average Velocity in m/sec. | | Flow in drain (min.) | Flow in Terain (min.) | Total time of concentration (min.) | Runoff Coeffiecent "C" | Rainfall Intensity "i" in mm/hour | | | | | Quantity (Q)= 10 C.i A m3/sec. | | | | | Existing Ave.width in m | Ave. Depth of drain m | Area required for Drain in m2 | | | | | Width required for drain in m | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | from | to | | | | | | | | For terain | For Drain | | | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) |
| **C100** | 7675 | 8225 | **Total** | **2671.06** | | | | | | | 3.16 | | | 83.72 | | | | | | | **101.18** | **141.52** | **183.99** | **222.42** | **265.64** | 22 | 3.02 | 32.0 | 44.8 | 58.2 | 70.4 | 84.1 | 10.6 | 14.8 | 19.3 | 23.3 | 27.8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 8225 | 9350 | A7 (a) | 174.05 | 56.94 | 117.11 | 37.99 | 15.38 | 0.01 | 1.2 | 2.63 | 55.61 | 19.44 | 90.44 | 0.469 | 19.98 | 28.66 | 38.44 | 48.31 | 53.63 | 4.53 | 6.5 | 8.72 | 10.96 | 12.17 | | In this Chainage, Existing drain depth is more than that of the above chainage drain depth, so, Proposed width is less than that of the above width. | | | | | | | | | | |
| | | | A7 (b) | 189.04 | 164.28 | 24.76 | 67.8 | 11.05 | 0.01 | 1.2 | 2.63 | 55.61 | 27.78 | 94.43 | 0.597 | 19.41 | 27.88 | 37.46 | 47.18 | 52.15 | 6.08 | 8.74 | 11.74 | 14.78 | 16.34 | | | | | | | | | | | | |
| | | | | **363.09** | | | | | | | | | | | | | | | | | **10.62** | **15.24** | **20.46** | **25.74** | **28.51** | | | | | | | | | | | |
| | | | **Total** | **3034.15** | | | | | | | 2.63 | | | 94.43 | | | | | | | **111.79** | **156.76** | **204.45** | **248.16** | **294.15** | 18 | 2.2 | 42.5 | 59.6 | 77.7 | 94.4 | 111.8 | 19.3 | 27.1 | 35.3 | 42.9 | 50.8 |
| **C101** | 0 | 1875 | A7 (c) | 163.44 | 74.56 | 88.88 | 45.09 | 14.35 | 0.01 | 1.2 | 2.1 | 14.88 | 19.44 | 48.68 | 0.48 | 30.32 | 42.61 | 55.71 | 67.81 | 79.93 | 6.54 | 9.19 | 12.01 | 14.62 | 17.24 | | | | | | | | | | | | |
| | | | A8(c1) | 54.09 | 13.78 | 40.31 | 34.01 | 15.96 | 0.01 | 1.2 | 2.1 | 14.88 | 25 | 55.84 | 0.45 | 27.64 | 39.02 | 51.31 | 62.89 | 73.16 | 1.85 | 2.61 | 3.43 | 4.21 | 4.9 | | | | | | | | | | | | |
| | | | **Total** | **217.53** | | | | | | | 2.1 | | | | | | | | | | **8.39** | **11.8** | **15.45** | **18.83** | **22.13** | 2 | 1.1 | 4.0 | 5.6 | 7.4 | 9.0 | 10.5 | 3.6 | 5.1 | 6.7 | 8.2 | 9.58 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 9350 | 10275 | A8(a) | 165.6 | 155.55 | 10.05 | 71.66 | 10.49 | 0.01 | 1.2 | 2.77 | 61.82 | 27.78 | 100.09 | 0.61 | 18.66 | 26.86 | 36.18 | 45.7 | 50.24 | **5.27** | **7.58** | **10.21** | **12.9** | **14.18** | | | | | | | | | | | | |
| | | | **Total** | **3417.28** | | | | | | | 2.77 | | | | | | | | | | **125.45** | **176.14** | **230.11** | **279.9** | **330.46** | 15 | 1.83 | 45.3 | 63.6 | 83.1 | 101.0 | 119.3 | 24.7 | 34.7 | 45.4 | 55.2 | 65.19 |

## Table Showing Adequacy Analysis Results for Challaghatta Valley - Proposed Hydraulic Flow Conditions

| Sl.No. | Description | Drain Reach | | Chainage (m) | | Catchment Area A (Ha.) | Type | Average Velocity V m/sec | Discharges (Q in $m^3$/sec) | | | | | Proposed Av. Drain Depth D in m. | Area required for drain ( A in $m^2$) | | | | | Proposed Av. Drain Width W( m.) | Required Drain Width (m) | | | | | Remarks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | From | To | From | To | | | | 1year | 2year | 5year | 10year | 20year | | 1year | 2year | 5year | 10year | 20year | | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year |
| 1 | C100 | Palace Grounds | Millers Road | 0 | 575 | 144.6 | Pri. | 3.96 | 8.22 | 11.32 | 14.43 | 17.01 | 21.3 | 1.5 | 2.08 | 2.86 | 3.65 | 4.3 | 5.38 | 2.5 | 1.39 | 1.91 | 2.43 | 2.87 | 3.59 | AD | AD | AD | IA | IA |
| 2 | C100 | Millers Road | Sepping's Road | 575 | 2200 | 304.17 | Pri. | 4.17 | 18.15 | 25.06 | 32.04 | 37.93 | 47.11 | 2 | 4.36 | 6.02 | 7.69 | 9.11 | 11.31 | 5 | 2.18 | 3.01 | 3.85 | 4.55 | 5.66 | AD | AD | AD | AD | IA |
| 3 | C100 | Sepping's Road | Anna Swamy Mudaliar Road | 2200 | 3175 | 450.74 | Pri. | 4.08 | 26.38 | 36.53 | 46.88 | 55.75 | 68.65 | 2.25 | 6.46 | 8.94 | 11.48 | 13.65 | 16.81 | 9.5 | 2.87 | 3.97 | 5.1 | 6.07 | 7.47 | AD | AD | AD | AD | AD |
| 4 | C100 | Anna Swamy Mudaliar Road | Kensngton Road | 3175 | 3975 | 605.66 | Pri. | 2.88 | 33.98 | 47.14 | 60.65 | 72.36 | 88.58 | 2.68 | 11.8 | 16.36 | 21.05 | 25.12 | 30.75 | 15.5 | 4.4 | 6.11 | 7.86 | 9.37 | 11.47 | AD | AD | AD | AD | AD |
| 5 | C100 | Kensngton Road | Sathya Narayana Temple Street | 3975 | 4500 | 1299.08 | Pri. | 5.40 | 38.04 | 52.83 | 68.08 | 81.37 | 99.25 | 2.69 | 7.04 | 9.78 | 12.61 | 15.07 | 18.38 | 13 | 2.62 | 3.64 | 4.69 | 5.6 | 6.83 | AD | AD | AD | AD | AD |
| 6 | C100 | Sathya Narayana Temple Street | Saraswathpura Road | 4500 | 5500 | 1522.81 | Pri. | 4.08 | 47.38 | 66.06 | 85.56 | 102.93 | 124.06 | 2.48 | 11.62 | 16.2 | 20.98 | 25.24 | 30.42 | 15 | 4.68 | 6.53 | 8.46 | 10.18 | 12.27 | AD | AD | AD | AD | AD |
| 7 | C100 | Saraswathpura Road | Shammana Gowda Layout 4th Main Road | 5500 | 5800 | 1871.98 | Pri. | 3.67 | 66.24 | 92.17 | 119.05 | 142.71 | 173.13 | 2.1 | 18.06 | 25.12 | 32.45 | 38.9 | 47.19 | 17.5 | 8.6 | 11.96 | 15.45 | 18.52 | 22.47 | AD | AD | AD | IA | IA |
| 8 | C100 | Shammana Gowda Layout 4th Main Road | Domlur listage near TERI | 5800 | 7075 | 2274.67 | Pri. | 3.50 | 82.39 | 115.17 | 149.61 | 180.69 | 216.19 | 2.4 | 23.54 | 32.9 | 42.75 | 51.63 | 61.77 | 20 | 9.81 | 13.71 | 17.81 | 21.51 | 25.74 | AD | AD | AD | IA | IA |
| 9 | C100 | Domlur listage near TERI | Airport Road | 7075 | 7675 | 2408.57 | Pri. | 2.92 | 86.96 | 121.69 | 158.31 | 191.54 | 228.4 | 2.48 | 29.77 | 41.66 | 54.19 | 65.57 | 78.19 | 22 | 12 | 16.8 | 21.85 | 26.44 | 31.53 | AD | AD | AD | IA | IA |
| 10 | C100 | Airport Road | Royal Orchid Park Hotel | 7675 | 8225 | 2671.06 | Pri. | 3.39 | 101.18 | 141.52 | 183.99 | 222.42 | 265.64 | 3.02 | 29.85 | 41.75 | 54.28 | 65.62 | 78.37 | 22 | 9.88 | 13.83 | 17.97 | 21.73 | 25.95 | AD | AD | AD | AD | IA |
| 11 | C100 | Royal Orchid Park Hotel | Wind Tunnel Road | 8225 | 9350 | 3034.15 | Pri. | 3.10 | 111.79 | 156.76 | 204.45 | 248.16 | 294.15 | 2.8 | 36.06 | 50.57 | 65.95 | 80.05 | 94.89 | 24 | 12.88 | 18.06 | 23.55 | 28.59 | 33.89 | AD | AD | AD | IA | IA |
| 12 | C100 | Wind Tunnel Road | Bellur Main Road | 9350 | 10275 | 3417.28 | Pri. | 3.70 | 125.45 | 176.14 | 230.11 | 279.9 | 330.46 | 2.4 | 33.91 | 47.61 | 62.19 | 75.65 | 89.31 | 26 | 14.13 | 19.84 | 25.91 | 31.52 | 37.21 | AD | AD | AD | IA | IA |
| 13 | C101 | Anandanagar | K.R. Garden | 0 | 1875 | 217.53 | Sec. | 3.80 | 8.39 | 11.8 | 15.45 | 18.83 | 22.13 | 1.4 | 2.21 | 3.11 | 4.07 | 4.96 | 5.82 | 3.5 | 1.58 | 2.22 | 2.9 | 3.54 | 4.16 | AD | AD | AD | IA | IA |
| 14 | C105 | Jeevanbhimanagar | Kodihalli | 0 | 2500 | 262.49 | Sec. | 3.70 | 14.22 | 19.83 | 25.68 | 30.88 | 37.24 | 1.8 | 3.84 | 5.36 | 6.94 | 8.35 | 10.06 | 4 | 2.14 | 2.98 | 3.86 | 4.64 | 5.59 | AD | AD | AD | IA | IA |

## Table Showing Adequacy Analysis Results for Ulsoor Valley - Proposed Hydraulic Flow Conditions

| Sl.No. | Description | Drain Reach | | Chainage (m) | | Catchment Area A (Ha.) | Type | Average Velocity V m/sec | Discharges (Q in $m^3$/sec) | | | | | Existing Av.Drain Depth D in m. | Area required for drain ( A in $m^2$) | | | | | Existing Av. Drain Width W( m.) | Required Drain Width (m) | | | | | Remarks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | From | To | From | To | | | | 1year | 2year | 5year | 10year | 20year | | 1year | 2year | 5year | 10year | 20year | | 1year | 2year | 5year | 10year | 20year | 1year | 2year | 5year | 10year | 20year |
| 1 | C200 | J.C.Nagar Main Road | S.K.Garden Main Road | 0 | 1625 | 239.76 | Pri. | 5.4 | 12.47 | 17.31 | 22.27 | 26.57 | 32.52 | 2 | 2.31 | 3.2 | 4.12 | 4.92 | 6.02 | 4.8 | 1.15 | 1.6 | 2.06 | 2.46 | 3.01 | AD | AD | AD | AD | AD |
| 2 | C200 | S.K.Garden Main Road | Bore Bank Road | 1625 | 2150 | 336.94 | Pri. | 4.49 | 17.63 | 24.48 | 31.52 | 37.64 | 45.99 | 2.1 | 3.92 | 5.45 | 7.02 | 8.38 | 10.24 | 7.8 | 1.87 | 2.59 | 3.34 | 3.99 | 4.87 | AD | AD | AD | AD | AD |
| 3 | C200 | Bore Bank Road | More Road | 2150 | 2550 | 353.87 | Pri. | 4.29 | 18.81 | 26.09 | 33.57 | 40.04 | 49.03 | 2.63 | 4.38 | 6.08 | 7.82 | 9.32 | 11.42 | 10.45 | 1.67 | 2.31 | 2.97 | 3.54 | 4.34 | AD | AD | AD | AD | AD |
| 4 | C200 | More Road | Wheeler's Road | 2550 | 3350 | 468.48 | Pri. | 4.31 | 24.94 | 34.63 | 44.63 | 53.33 | 65.07 | 2.46 | 5.78 | 8.03 | 12.37 | 12.37 | 15.09 | 10.41 | 2.35 | 3.27 | 5.03 | 5.03 | 6.14 | AD | AD | AD | AD | AD |
| 5 | C200 | Wheeler's Road | Ulsoor Tank | 3350 | 4200 | 500.59 | Pri. | 2.59 | 27.1 | 37.61 | 48.41 | 57.78 | 70.67 | 2 | 10.45 | 14.5 | 18.67 | 22.29 | 27.25 | 10.4 | 5.23 | 7.25 | 9.34 | 11.14 | 13.63 | AD | AD | AD | IA | IA |
| 6 | C202 | Richards Town | Gymkana Ground | 0 | 1170 | 32.11 | Sec. | 5.4 | 2.17 | 2.98 | 3.79 | 4.45 | 5.6 | 1.7 | 0.4 | 0.55 | 0.7 | 0.82 | 1.04 | 5.4 | 0.24 | 0.32 | 0.41 | 0.48 | 0.61 | AD | AD | AD | AD | AD |
| 7 | C203 | Sagayapuram | Cleveland Town | 0 | 737 | 16.93 | Sec. | 4.61 | 1.18 | 1.62 | 2.05 | 2.4 | 3.04 | 1.6 | 0.26 | 0.35 | 0.44 | 0.52 | 0.66 | 2.42 | 0.16 | 0.22 | 0.28 | 0.33 | 0.41 | AD | AD | AD | AD | AD |
| 8 | C204 | Jeevanahalli | Ulsoor Tank | 0 | 2000 | 192.83 | Sec. | 3.5 | 10.93 | 15.22 | 19.67 | 23.59 | 28.59 | 1.6 | 3.12 | 4.35 | 5.62 | 6.74 | 8.17 | 4 | 1.95 | 2.72 | 3.51 | 4.21 | 5.1 | AD | AD | AD | IA | IA |

## Land Use Analysis of Challaghatta Valley Storm Water Drain Clean Condiiton

| Description about drain | Chainage | | Sub Catchment | Total Area ( Ha.) | Area of bulitup and paved areas (Ha.) | Area of parks and open space, etc. (Ha.) | Weighted Imperviousness (%) | Inlet Time in minutes | Slope of terain | Average Velocity in m/sec. | | Flow in drain (min.) | Flow in Terain (min.) | Total time of concentration (min.) | Runoff Coeffiecent "C" | Rainfall Intensity "i" in mm/hour | | | | | Quantity (Q)= 10 C.i A m3/sec. | | | | | Existing Ave.width in m | Ave. Depth of drain m | Area required for Drain in m2 | | | | | Width required for drain in m | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | from | to | | | | | | | | For terain | For Drain | | | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) |
| **C100** | 0 | 575 | A1(a) | 95.38 | 67.64 | 27.74 | 59 | 12.33 | 0.01 | 1.2 | 2.61 | 3.67 | 9.72 | 25.72 | 0.448 | 46.57 | 64.08 | 81.63 | 96.14 | 120.55 | 5.53 | 7.61 | 9.69 | 11.41 | 14.31 | | | | | | | | | | | | |
| | | | A1(b) | 49.22 | 31.85 | 17.37 | 55.59 | 12.82 | 0.01 | 1.2 | 2.61 | 3.67 | 10.42 | 26.91 | 0.437 | 45.18 | 62.26 | 79.44 | 93.79 | 117.08 | 2.7 | 3.72 | 4.74 | 5.6 | 6.99 | | | | | | | | | | | | |
| | | | **Total** | **144.6** | | | | | | | 2.61 | | | | | | | | | | **8.22** | **11.32** | **14.43** | **17.01** | **21.3** | 2.5 | 1.5 | **3.2** | **4.3** | **5.5** | **6.5** | **8.2** | **2.1** | **2.9** | **3.7** | **4.3** | **5.4** |
| **C100** | 575 | 2200 | A2 (a) | 59.93 | 59.93 | 0 | 75 | 10 | 0.02 | 1.5 | 2.89 | 9.37 | 7.78 | 27.15 | 0.524 | 44.91 | 61.91 | 79.03 | 93.34 | 116.42 | 3.91 | 5.4 | 6.89 | 8.14 | 10.15 | | | | | | | | | | | | |
| | | | A2 (b) | 99.64 | 99.64 | 0 | 75 | 10 | 0.01 | 1.2 | 2.89 | 9.37 | 13.19 | 32.57 | 0.547 | 39.74 | 55.10 | 70.87 | 84.49 | 103.55 | 6.01 | 8.34 | 10.72 | 12.78 | 15.67 | | | | | | | | | | | | |
| | | | | **159.57** | | | | | | | | | | | | | | | | | **9.93** | **13.73** | **17.61** | **20.92** | **25.82** | | | | | | | | | | | |
| | | | **Total** | **304.17** | | | | | | | 2.89 | | | 32.57 | | | | | | | **18.15** | **25.06** | **32.04** | **37.93** | **47.11** | 5 | 2 | **6.3** | **8.7** | **11.1** | **13.1** | **16.3** | **3.1** | **4.3** | **5.5** | **6.6** | **8.2** |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 2200 | 3175 | A3 (a1) | 87.97 | 87.97 | 0 | 75 | 10 | 0.01 | 1.2 | 2.36 | 18.36 | 8.33 | 36.69 | 0.561 | 36.67 | 51.05 | 65.98 | 79.15 | 95.88 | 5.03 | 7 | 9.05 | 10.86 | 13.15 | | | | | | | | | | | | |
| | | | A3 (b1) | 58.6 | 56.26 | 2.34 | 72.8 | 10.32 | 0.01 | 1.2 | 2.36 | 18.36 | 10.42 | 39.1 | 0.560 | 35.14 | 49.02 | 63.52 | 76.45 | 92.04 | 3.2 | 4.47 | 5.79 | 6.97 | 8.39 | | | | | | | | | | | | |
| | | | | **146.57** | | | | | | | | | | | | | | | | | **8.23** | **11.47** | **14.84** | **17.82** | **21.54** | | | | | | | | | | | |
| | | | **Total** | **450.74** | | | | | | | 2.36 | | | 39.1 | | | | | | | **26.38** | **36.53** | **46.88** | **55.75** | **68.65** | 9.5 | 2.25 | **11.2** | **15.5** | **19.9** | **23.6** | **29.1** | **5.0** | **6.9** | **8.8** | **10.5** | **12.9** |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 3175 | 3975 | A3 (a2) | 95.44 | 91.26 | 4.18 | 72.59 | 10.35 | 0.01 | 1.2 | 1.81 | 16.34 | 13.19 | 39.89 | 0.560 | 34.66 | 48.40 | 62.76 | 75.61 | 90.86 | 5.14 | 7.18 | 9.31 | 11.22 | 13.48 | | | | | | | | | | | | |
| | | | A3 (b2) | 59.48 | 24.16 | 35.32 | 42.34 | 14.75 | 0.01 | 1.2 | 1.81 | 16.34 | 10.42 | 41.51 | 0.441 | 33.75 | 47.18 | 61.28 | 73.98 | 88.56 | 2.46 | 3.43 | 4.46 | 5.38 | 6.45 | | | | | | | | | | | | |
| | | | | **154.92** | | | | | | | | | | | | | | | | | **7.6** | **10.62** | **13.77** | **16.61** | **19.93** | | | | | | | | | | | |
| | | | **Total** | **605.66** | | | | | | | 1.81 | | | 41.51 | | | | | | | **33.98** | **47.14** | **60.65** | **72.36** | **88.58** | 15.5 | 2.68 | **18.8** | **26.0** | **33.5** | **40.0** | **48.9** | **7.0** | **9.7** | **12.5** | **14.9** | **18.3** |
| **C200** | 0 | 1625 | A1(a) | 26.26 | 15 | 11.26 | 51.42 | 13.43 | 0.01 | 1.2 | 3.76 | 7.2 | 11.11 | 31.74 | 0.44 | 40.42 | 56.01 | 71.96 | 85.68 | 105.27 | 1.31 | 1.81 | 2.33 | 2.77 | 3.41 | | | | | | | | | | | | |
| | | | A1(b) | 172.64 | 130.49 | 42.15 | 61.57 | 11.95 | 0.01 | 1.2 | 3.76 | 7.2 | 13.89 | 33.05 | 0.492 | 39.35 | 54.59 | 70.25 | 83.82 | 102.58 | 9.29 | 12.89 | 16.59 | 19.79 | 24.22 | | | | | | | | | | | | |
| | | | A1(c) | 40.86 | 18.81 | 22.05 | 45.32 | 14.32 | 0.02 | 1.5 | 3.76 | 7.2 | 12.22 | 33.74 | 0.426 | 38.80 | 53.87 | 69.38 | 82.87 | 101.21 | 1.88 | 2.6 | 3.35 | 4.01 | 4.89 | | | | | | | | | | | | |
| | | | **Total** | **239.76** | | | | | | | 3.76 | | | 33.74 | | | | | | | **12.47** | **17.31** | **22.27** | **26.57** | **32.52** | 4.8 | 2 | **1.5** | **4.6** | **5.9** | **7.1** | **8.6** | **0.8** | **2.3** | **3.0** | **3.5** | **4.3** |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C200** | 1625 | 2150 | A2 (a) | 68.53 | 64.48 | 4.05 | 71.75 | 10.47 | 0.01 | 1.2 | 3.31 | 10.83 | 13.61 | 34.91 | 0.537 | 37.92 | 52.71 | 67.98 | 81.34 | 99.01 | 3.88 | 5.39 | 6.95 | 8.32 | 10.13 | | | | | | | | | | | | |

| Description about drain | Chainage | | Sub Catchment | Total Area ( Ha.) | Area of bulitup and paved areas (Ha.) | Area of parks and open space, etc. (Ha.) | Weighted Imperviousness (%) | Inlet Time in minutes | Slope of terain | Average Velocity in m/sec. | | Flow in drain (min.) | Flow in Terain (min.) | Total time of concentration (min.) | Runoff Coeffiecent "C" | Rainfall Intensity "i" in mm/hour | | | | | Quantity (Q)= 10 C.i A m3/sec. | | | | | Existing Ave.width in m | Ave. Depth of drain m | Area required for Drain in m2 | | | | | Width required for drain in m | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | from | to | | | | | | | | For terain | For Drain | | | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) |
| | | | A3 (a) | 28.65 | 12.72 | 15.93 | 44.42 | 14.45 | 0.01 | 1.2 | 3.31 | 10.83 | 9.72 | 35 | 0.425 | 37.86 | 52.62 | 67.88 | 81.23 | 98.86 | 1.28 | 1.78 | 2.3 | 2.75 | 3.35 | | | | | | | | | | | | |
| | | | | **97.18** | | | | | | | | | | | | | | | | | **5.16** | **7.17** | **9.25** | **11.07** | **13.47** | | | | | | | | | | |
| | | | **Total** | **336.94** | | | | | | | 3.31 | | | 35 | | | | | | | **17.63** | **24.48** | **31.52** | **37.64** | **45.99** | 7.8 | 2.1 | **2.5** | **7.4** | **9.5** | **11.4** | **13.9** | **1.2** | **3.5** | **4.5** | **5.4** | **6.6** |
| **C203** | 0 | 737 | A3 (b) | 16.93 | 16.93 | 0 | 75 | 10 | 0.01 | 1.2 | 3.14 | 2.12 | 11.11 | 23.23 | 0.503 | 49.87 | 68.39 | 86.75 | 101.64 | 128.71 | 1.18 | 1.62 | 2.05 | 2.4 | 3.04 | | | | | | | | | | | |
| | | | **Total** | **16.93** | | | | | | | 3.14 | | | | | | | | | | **1.18** | **1.62** | **2.05** | **2.4** | **3.04** | 2.42 | 1.6 | **0.4** | **0.5** | **0.7** | **0.8** | **1.0** | **0.2** | **0.3** | **0.4** | **0.5** | **0.6** |
| **C200** | 2150 | 2550 | **Total** | **353.87** | | | | | | | 3.01 | | | 37.12 | | | | | | | **18.81** | **26.09** | **33.57** | **40.04** | **49.03** | 10.45 | 2.63 | **6.3** | **8.7** | **11.2** | **13.3** | **16.3** | **2.4** | **3.3** | **4.2** | **5.1** | **6.2** |
| **C200** | 2550 | 3350 | A4 (a) | 78.02 | 76.49 | 1.53 | 73.92 | 10.16 | 0.01 | 1.2 | 3.12 | 17.9 | 9.72 | 37.77 | 0.557 | 35.96 | 50.11 | 64.84 | 77.90 | 94.11 | 4.34 | 6.05 | 7.82 | 9.4 | 11.35 | | | | | | | | | | | |
| | | | A5 (a) | 36.59 | 26.25 | 10.34 | 59.46 | 12.26 | 0.02 | 1.5 | 3.12 | 17.9 | 10 | 40.15 | 0.509 | 34.51 | 48.19 | 62.51 | 75.34 | 90.48 | 1.78 | 2.49 | 3.23 | 3.9 | 4.68 | | | | | | | | | | | | |
| | | | | **114.61** | | | | | | | | | | | | | | | | | **6.12** | **8.54** | **11.06** | **13.29** | **16.03** | | | | | | | | | | |
| | | | **Total** | **468.48** | | | | | | | 3.12 | | | 40.15 | | | | | | | **24.94** | **34.63** | **44.63** | **53.33** | **65.07** | 10.41 | 2.46 | **8.0** | **11.1** | **14.3** | **17.1** | **20.9** | **3.2** | **4.5** | **5.8** | **6.9** | **8.5** |
| **C202** | 0 | 1170 | A6 (a) | 32.11 | 32.11 | 0 | 75 | 10 | 0.01 | 1.2 | 3.05 | 6.39 | 8.33 | 24.73 | 0.508 | 47.83 | 65.72 | 83.58 | 98.24 | 123.65 | 2.17 | 2.98 | 3.79 | 4.45 | 5.6 | | | | | | | | | | | |
| | | | **Total** | **32.11** | | | | | | | 3.05 | | | | | | | | | | **2.17** | **2.98** | **3.79** | **4.45** | **5.6** | 5.4 | 1.7 | **0.7** | **1.0** | **1.2** | **1.5** | **1.8** | **0.4** | **0.6** | **0.7** | **0.9** | **1.1** |
| **C200** | 3350 | 4200 | **Total** | **500.59** | | | | | | | 3.01 | | | 46.55 | | | | | | | **27.1** | **37.61** | **48.41** | **57.78** | **70.67** | 11 | 2 | **9.0** | **12.5** | **16.1** | **19.2** | **23.5** | **4.5** | **6.2** | **8.0** | **9.6** | **11.7** |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C204** | 0 | 2000 | A6 (b) | 114.77 | 110.49 | 4.28 | 72.95 | 10.3 | 0.01 | 1.2 | 2.38 | 14.01 | 9.72 | 34.03 | 0.542 | 38.58 | 53.58 | 69.03 | 82.49 | 100.66 | 6.66 | 9.25 | 11.92 | 14.24 | 17.38 | | | | | | | | | | | |
| | | | A7 (a) | 78.06 | 78.06 | 0 | 75 | 10 | 0.02 | 1.5 | 2.38 | 14.01 | 16.67 | 40.67 | 0.576 | 34.21 | 47.80 | 62.04 | 74.81 | 89.73 | 4.27 | 5.97 | 7.75 | 9.34 | 11.21 | | | | | | | | | | | | |
| | | | **Total** | **192.83** | | | | | | | 2.38 | | | 40.67 | | | | | | | **10.93** | **15.22** | **19.67** | **23.59** | **28.59** | 4 | 1.24 | **4.6** | **6.4** | **8.3** | **9.9** | **12.0** | **3.7** | **5.2** | **6.7** | **8.0** | **9.7** |
| | | | | | | | | | | | | | | | | | | | | | **38.04** | **52.83** | **68.08** | **81.37** | **99.25** | In this chainage, 100% of Ulsoor storm Water overflows from the Ulsoor Lake | | | | | | | | | | |
| **C100** | 3975 | 4500 | **Total** | **1299.08** | | | | | | | 4.16 | | | 46.55 | | | | | | | **38.04** | **52.83** | **68.08** | **81.37** | **99.25** | 13 | 2.69 | **9.1** | **12.7** | **16.4** | **19.6** | **23.9** | **3.4** | **4.7** | **6.1** | **7.3** | **8.9** |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 4500 | 5500 | A4 (a) | 105.2 | 105.2 | 0 | 75 | 10 | 0.01 | 1.2 | 3.06 | 32.68 | 16.67 | 59.35 | 0.629 | 26.53 | 37.53 | 49.47 | 60.83 | 70.35 | 4.87 | 6.89 | 9.09 | 11.17 | 12.92 | | | | | | | | | | | |
| | | | A4 (b1) | 118.53 | 79.65 | 38.88 | 56.96 | 12.62 | 0.01 | 1.2 | 3.06 | 32.68 | 20.83 | 66.14 | 0.550 | 24.67 | 35.02 | 46.36 | 57.33 | 65.60 | 4.47 | 6.34 | 8.4 | 10.38 | 11.88 | | | | | | | | | | | | |
| | | | | **223.73** | | | | | | | | | | | | | | | | | **9.34** | **13.23** | **17.48** | **21.56** | **24.8** | | | | | | | | | | |
| | | | **Total** | **1522.81** | | | | | | | 3.06 | | | 66.14 | | | | | | | **47.38** | **66.06** | **85.56** | **102.93** | **124.06** | 15 | 2.48 | **15.5** | **21.6** | **28.0** | **33.6** | **40.5** | **6.2** | **8.7** | **11.3** | **13.6** | **16.3** |

| Description about drain | Chainage | | Sub Catchment | Total Area ( Ha.) | Area of bulitup and paved areas (Ha.) | Area of parks and open space, etc. (Ha.) | Weighted Imperviousness (%) | Inlet Time in minutes | Slope of terain | Average Velocity in m/sec. | | Flow in drain (min.) | Flow in Terain (min.) | Total time of concentration (min.) | Runoff Coeffiecent "C" | Rainfall Intensity "i" in mm/hour | | | | | Quantity (Q)= 10 C.i A m3/sec. | | | | | Existing Ave.width in m | Ave. Depth of drain m | Area required for Drain in m2 | | | | | Width required for drain in m | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | from | to | | | | | | | | For terain | For Drain | | | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C102** | 0 | 500 | A4 (c) | 87.64 | 44.09 | 43.55 | 47.67 | 13.98 | 0.01 | 1.2 | 2.64 | 3.16 | 8.33 | 25.47 | 0.399 | 46.89 | 64.50 | 82.12 | 96.67 | 121.32 | 4.55 | 6.27 | 7.98 | 9.39 | 11.79 | | | | | | | | | | | | |
| | | | A4 (d) | 158.91 | 101.54 | 57.37 | 55.14 | 12.89 | 0.01 | 1.2 | 2.64 | 3.16 | 13.89 | 29.93 | 0.452 | 42.05 | 58.16 | 74.54 | 88.48 | 109.32 | 8.39 | 11.6 | 14.87 | 17.65 | 21.8 | | | | | | | | | | | | |
| | | | **Total** | **246.55** | | | | | | | 2.64 | | | | | | | | | | **12.94** | **17.86** | **22.84** | **27.04** | **33.59** | 4 | 2.3 | **4.9** | **6.8** | **8.7** | **10.2** | **12.7** | **2.1** | **2.9** | **3.8** | **4.5** | **5.5** |
| **C102** | 500 | 1250 | A4 (b2) | 102.62 | 102.62 | 0 | 75 | 10 | 0.01 | 1.2 | 2.51 | 4.98 | 20.83 | 35.81 | 0.558 | 37.27 | 51.85 | 66.95 | 80.21 | 97.40 | 5.93 | 8.24 | 10.64 | 12.75 | 15.48 | | | | | | | | | | | | |
| | | | | **102.62** | | | | | | | | | | | | | | | | | **5.93** | **8.24** | **10.64** | **12.75** | **15.48** | | | | | | | | | | | |
| | | | | **349.17** | | | | | | | 2.51 | | | | | | | | | | **18.87** | **26.11** | **33.49** | **39.79** | **49.07** | 5 | 2 | **7.5** | **10.4** | **13.3** | **15.9** | **19.6** | **3.8** | **5.2** | **6.7** | **7.9** | **9.8** |
| **C100** | 5500 | 5800 | **Total** | **1871.98** | | | | | | | 3.26 | | | 69.29 | | | | | | | **66.24** | **92.17** | **119.05** | **142.71** | **173.13** | 17.5 | 2.1 | **20.3** | **28.3** | **36.5** | **43.8** | **53.1** | **9.7** | **13.5** | **17.4** | **20.8** | **25.3** |
| **C100** | 5800 | 7075 | A5 (a) | 129.91 | 118.79 | 11.12 | 70.29 | 10.68 | 0.01 | 1.2 | 3.04 | 35.64 | 25 | 71.32 | 0.610 | 23.44 | 33.37 | 44.32 | 55.01 | 62.49 | 5.16 | 7.34 | 9.75 | 12.1 | 13.74 | | | | | | | | | | | | |
| | | | A5 (b) | 272.78 | 272.78 | 0 | 75 | 10 | 0.01 | 1.2 | 3.04 | 35.64 | 27.78 | 73.41 | 0.631 | 22.99 | 32.76 | 43.55 | 54.15 | 61.34 | 10.99 | 15.65 | 20.82 | 25.88 | 29.32 | | | | | | | | | | | | |
| | | | | **402.69** | | | | | | | | | | | | | | | | | **16.15** | **22.99** | **30.56** | **37.98** | **43.06** | | | | | | | | | | | |
| | | | **Total** | **2274.67** | | | | | | | 3.04 | | | 73.41 | | | | | | | **82.39** | **115.17** | **149.61** | **180.69** | **216.19** | 15 | 2.19 | **27.1** | **37.9** | **49.2** | **59.4** | **71.1** | **12.4** | **17.3** | **22.5** | **27.1** | **32.5** |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 7075 | 7675 | A6 (a) | 133.9 | 94.76 | 39.14 | 58.92 | 12.34 | 0.01 | 1.2 | 2.66 | 44.49 | 21.6 | 78.42 | 0.559 | 21.99 | 31.40 | 41.87 | 52.23 | 58.78 | 4.57 | 6.52 | 8.7 | 10.85 | 12.21 | | | | | | | | | | | | |
| | | | | **133.9** | | | | | | | | | | | | | | | | | **4.57** | **6.52** | **8.7** | **10.85** | **12.21** | | | | | | | | | | | |
| | | | **Total** | **2408.57** | | | | | | | 2.66 | | | 78.42 | | | | | | | **86.96** | **121.69** | **158.31** | **191.54** | **228.4** | 22 | 2.48 | **32.7** | **45.7** | **59.5** | **72.0** | **85.9** | **13.2** | **18.4** | **24.0** | **29.0** | **34.6** |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C105** | 0 | 2500 | A6 (b) | 62.7 | 62.7 | 0 | 75 | 10 | 0.02 | 1.5 | 2.2 | 5.3 | 20 | 35.3 | 0.558 | 37.63 | 52.33 | 67.52 | 80.84 | 98.30 | 3.66 | 5.08 | 6.56 | 7.85 | 9.55 | | | | | | | | | | | | |
| | | | A6 (c) | 199.79 | 180.85 | 18.94 | 69.79 | 10.76 | 0.01 | 1.2 | 2.2 | 5.3 | 23.61 | 39.67 | 0.547 | 34.79 | 48.56 | 62.97 | 75.84 | 91.18 | 10.57 | 14.75 | 19.12 | 23.03 | 27.69 | | | | | | | | | | | | |
| | | | | **262.49** | | | | | | | 2.2 | | | | | | | | | | **14.22** | **19.83** | **25.68** | **30.88** | **37.24** | 3.65 | 1.8 | **6.5** | **9.0** | **11.7** | **14.0** | **16.9** | **3.6** | **5.0** | **6.5** | **7.8** | **9.4** |
| **C100** | 7675 | 8225 | **Total** | **2671.06** | | | | | | | 3.16 | | | 83.72 | | | | | | | **101.18** | **141.52** | **183.99** | **222.42** | **265.64** | 22 | 3.02 | **32.0** | **44.8** | **58.2** | **70.4** | **84.1** | **10.6** | **14.8** | **19.3** | **23.3** | **27.8** |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 8225 | 9350 | A7 (a) | 174.05 | 56.94 | 117.11 | 37.99 | 15.38 | 0.01 | 1.2 | 2.63 | 55.61 | 19.44 | 90.44 | 0.469 | 19.98 | 28.66 | 38.44 | 48.31 | 53.63 | 4.53 | 6.5 | 8.72 | 10.96 | 12.17 | | In this Chainage, Existing drain depth is more than that of the above chainage drain depth, so, Proposed width is less than that of the above width. | | | | | | | | | | |
| | | | A7 (b) | 189.04 | 164.28 | 24.76 | 67.8 | 11.05 | 0.01 | 1.2 | 2.63 | 55.61 | 27.78 | 94.43 | 0.597 | 19.41 | 27.88 | 37.46 | 47.18 | 52.15 | 6.08 | 8.74 | 11.74 | 14.78 | 16.34 | | | | | | | | | | | | |

| Description about drain | Chainage | | Sub Catchment | Total Area ( Ha.) | Area of bulitup and paved areas (Ha.) | Area of parks and open space, etc. (Ha.) | Weighted Imperviousness (%) | Inlet Time in minutes | Slope of terain | Average Velocity in m/sec. | | Flow in drain (min.) | Flow in Terain (min.) | Total time of concentration (min.) | Runoff Coeffiecent "C" | Rainfall Intensity "i" in mm/hour | | | | | Quantity (Q)= 10 C.i A m3/sec. | | | | | Existing Ave.width in m | Ave. Depth of drain m | Area required for Drain in m2 | | | | | Width required for drain in m | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | from | to | | | | | | | | For terain | For Drain | | | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | | | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) | (For 1 Year) | (For 2 Year) | (For 5 Year) | (For 10 Year) | (For 20 Year) |
| | | | | **363.09** | | | | | | | | | | | | | | | | | **10.62** | **15.24** | **20.46** | **25.74** | **28.51** | | | | | | | | | | | |
| | | | **Total** | **3034.15** | | | | | | | 2.63 | | | 94.43 | | | | | | | **111.79** | **156.76** | **204.45** | **248.16** | **294.15** | 18 | 2.2 | **42.5** | **59.6** | **77.7** | **94.4** | **111.8** | **19.3** | **27.1** | **35.3** | **42.9** | **50.8** |
| **C101** | 0 | 1875 | A7 (c) | 163.44 | 74.56 | 88.88 | 45.09 | 14.35 | 0.01 | 1.2 | 2.1 | 14.88 | 19.44 | 48.68 | 0.48 | 30.32 | 42.61 | 55.71 | 67.81 | 79.93 | 6.54 | 9.19 | 12.01 | 14.62 | 17.24 | | | | | | | | | | | | |
| | | | A8(c1) | 54.09 | 13.78 | 40.31 | 34.01 | 15.96 | 0.01 | 1.2 | 2.1 | 14.88 | 25 | 55.84 | 0.45 | 27.64 | 39.02 | 51.31 | 62.89 | 73.16 | 1.85 | 2.61 | 3.43 | 4.21 | 4.9 | | | | | | | | | | | | |
| | | | **Total** | **217.53** | | | | | | | 2.1 | | | | | | | | | | **8.39** | **11.8** | **15.45** | **18.83** | **22.13** | 2 | 1.1 | **3.99** | **5.62** | **7.36** | **8.97** | **10.54** | **3.63** | **5.11** | **6.69** | **8.15** | **9.58** |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **C100** | 9350 | 10275 | A8(a) | 165.6 | 155.55 | 10.05 | 71.66 | 10.49 | 0.01 | 1.2 | 2.77 | 61.82 | 27.78 | 100.09 | 0.61 | 18.66 | 26.86 | 36.18 | 45.7 | 50.24 | **5.27** | **7.58** | **10.21** | **12.9** | **14.18** | | | | | | | | | | | | |
| | | | **Total** | **3417.28** | | | | | | | 2.77 | | | | | | | | | | **125.45** | **176.14** | **230.11** | **279.9** | **330.46** | 15 | 1.83 | **45.29** | **63.59** | **83.07** | **101.05** | **119.3** | **24.75** | **34.75** | **45.39** | **55.22** | **65.19** |

# CHAPTER - 5

# ENVIRONMENTAL AND SOCIAL IMPACT

## 5.1 INTRODUCTION:

This chapter provides a strategic framework to ensure that existing storm drainage system in Bangalore is managed in a reliable, affordable, sustainable and environmentally friendly manner, which is most essential for success of any project. But from the existing management practices followed by the stakeholders and also with the prevailing site conditions, it appears that, along with the resources required to achieve the recommended targets, strategies and actions, they also needs to adopt best storm drain management practices, improvised construction and construction supervision techniques, strengthened organisational setup, major legislative changes, coordination with other stakeholders, public awareness campaigns and their participation to minimise the adverse implications on storm drain functionality and storm drain management practice in the city.

## 5.2 ENVIRONMENTAL CONDITIONS:

Open parks, major waterways and water bodies that exists in a city like Bangalore can be a significant amenity for flood protection. But in recent times, due to lack of planning and rapid changes in the landuse, these amenities have been largely ignored by various stakeholders, service providers and the public in general. In the recent history, there has been no comprehension of the need to provide for storm water drains to service urban development beyond the sub-divisional level of tertiary drainage. As a consequence, the primary and secondary drainage systems in the core (BMP) area have developed on an adhoc basis and now they have reached a saturation level and not in a position to provide security to the low lying areas during most needed situations. Further, there are evidence that in areas outside the BMP administered region, the development authorities do not enforce and adopt even rudimentary practices for planning, construction and maintenance of primary and secondary drains and also they are lack of resources and technical expertise to adopt best storm drain management practices.

Significantly what is seen over a period of time, that many lakes that were existing in BMRDA area have been converted into residential layouts. These lakes otherwise would have acted as flood buffer zone. The tank beds are being the lowest point at the end of valleys, in most of the cases to prevent flooding in such areas,. It requires mechanical means. Therefore public, public representatives and all concerned needs to be educated against encroachment of tank areas. If possible restoration work of tanks need to be taken up on priority, which intern reduce the runoff and flooding problems in some of the adjoining low lying areas.

Challaghatta valley is one such valley which suffers from all the above mentioned reasons. As mentioned earlier in the Chapter 2, storm drains in Challaghatta valley flows through dense residential and commercial areas of the city. Since the drain is flowing through dense residential areas in the initial reaches the natural coarse of the drain is altered at many places due to encroachments and also inappropriate planning by the landuse planners. Further, the carrying capacity is also reduced due to dumping of construction debris, municipal solid wastes and also discharging raw sewage into the drains by the commercial establishments like restaurants, lodges, marriage halls etc. and low income residential houses thereby distracting the visual aesthetic amenity of waterway, causing siltation problems, inconvenience to the surrounding localities and threatening the health aspects of the communities residing in the close proximity of the waterway.

Further, the drainage channel flows through dense commercial areas, wherein large numbers of shops and public toilet blocks have been constructed over the drain and also sewerlines have been laid and manholes protruding well above the bed level are constructed inside the drainage channel. Even though the sewer lines exists, the sewer out lets from the public toilets are not connected to the sewerage system and they are discharging raw sewage directly into storm drains and also due to lack of timely maintenance of chocked sewer pipelines, manholes, under capacity sewer pipelines, and lack of sewer connectivity, raw sewage is also being allowed to enter into storm drain thereby distracting the visual aesthetic amenity of waterway, making place favorable for mosquito breading, causing substantial inconvenience to the surrounding locality resident, pedestrians and vehicular movement and also the slaughter houses located near the drains are also threatening the health aspects of the communities residing in the close proximity of the waterway.

Since the topography of the terrain is sloping towards the drain and also due to improper solid waste collection and conveyance arrangement all the solid waste generated from the commercial establishments and the greasy liquid waste from service stations, find their way into the storm drain, further all the floating materials gets clogged with the utility lines laid across storm drain and culvert locations with inadequate vent sizes at some places obstructing free flow of water and intern causing localized flooding problems and pose substantial damage to both life and property.

Due to lack of sediment erosion control measures and devices, large quantity of silt is being accumulated inside the drain thereby causing siltation, ponding of water and intern making places favorable for mosquito breading.

The more extensive tertiary drains that exists are the key elements of the urban drainage system, but due to deficiencies in designs and maintenance practice, the existing tertiary drains are not serving upto the intended level of service during most needed hour of service.

Further down the stream near the receiving water body, new layouts that are formed are recently developed. But since the land value is very high, widening of drains is restricted and also the existing tertiary drains, due to deficiencies in design and maintenance practices they are not functioning upto the intended level of services during large storms and causing localised flooding problems.

Further, one significant cause of frequent flooding of low-lying areas near the receiving water body is due to large accumulation of sediments and vegetal growth that reduce the capacity of the drains. Insufficient collection of solid wastes and a lack of understanding of the impact of casual litter disposal on drains are significant factors contributing to the high waste volumes found in drains. Similarly, erosion control practices in construction sites, public parklands, private gardens and on the medians and verges of roads are not sufficient to control large silt loads reaching the main drains. These factors, combined with infrequent clearance of drains by responsible authorities, occasionally lead to unsanitary conditions in drains and further aggregate the already aggravated situation.

### 5.2.1 Relationships between Solid Waste and Drainage

Until recent times, the relationship between solid waste materials and drainage system and its impact on the environmental attributes was not considered to be significant due to various reasons, even though the responsibility for both drainage and solid waste management in the core area lies with BMP and outer periphery areas with CMC/TMC.

As observed during reconnaissance survey, disposal of bio degradable and non degradable material dumps into the drains were of a common practice all along the drain and intern factors that were influenced to affect the functionality of the system were also noted and few factors that were noted are as explained in brief here under,

The disposals of house hold garbage and street sweepings into drains near Shivajinagar and Ulsoor is affecting free flow of water, reducing the aesthetic appearance, reducing the quality of environmental attributes in that region. Apart from affecting the flow, solid wastes have particular impact on the smaller tertiary drains, often obstructing flow completely, and causing short term localized flooding that can be especially dangerous to both pedestrians and vehicular movement. Further to improve the situation in that region improvised method of solid waste collection and conveyance system, community awareness campaigns in that region is most essential.

The disposals of house hold garbage, street sweepings and construction debris into drains at J.C. Nagar near Munireddypalya, Chinnappa garden and Frazer town is affecting free flow of water, reducing the aesthetic appearance, quality of environmental attributes in that region. Apart from affecting the flow, solid wastes have particular impact on the smaller tertiary drains, often obstructing flow completely, and causing short term localized flooding that can be especially dangerous to both pedestrians and vehicular movement. Further to improve the situation in that region community awareness campaigns, improvised method of solid waste collection and conveyance system and prevention of dumping debris in that region is most essential.

### 5.2.2 Conflicts between Sewers and Drains:

At present there are some trunk sewers laid within drainage channels. Problems that arise from sewers in drainage channels are numerous and include:

- capacity reduction of drains due to manholes;
- restrictions on channel augmentation options;
- ready opportunities to relieve excess sewage into channels;
- need for parallel programming and close coordination, where rehabilitation of either service is proposed;
- difficult access for sewer maintenance;
- lack of access to sewers under lined inverts and cross drainage culverts
- potential damage to or from drain assets; and
- poor construction due to difficult access and flow diversion problems.

Benefits are few and include:

- no need for separate sewer easement; and
- relatively low excavation cost due to shallow depth.

All the above problems mentioned outweigh the benefits accrued in the Challaghatta valley and therefore urgent efforts are required to cleanse the entire system.

### 5.2.3 Impacts of Poor Storm Water Drainage System:

The importance of adequate storm water and wastewater drainage, in tandem with sufficient water supply, cannot be over emphasised, if full health benefits from provision of services are to be derived. Inadequate drainage causes inconvenience and loss both to life and property varying in nature ranging from:

- Inundation of houses and establishments on the floodplains, caused by large scale "valley" flooding from overflow of primary and secondary drains.

- local area inundation and water stagnation in residential areas, caused by "local" drainage deficiencies and run-off from adjacent local catchments as in

Vasanthanagar, Shivajinagar, Jogupalya area, Munireddypalya, Chinnappa Garden and K.R. garden areas etc.

•Causes extensive damage to infrastructure works and intern reduces the aesthetic appearance of the city and reduces the land value cost adjacent to drains etc.

•Having high solid waste and sewage concentrations, the flood waters which inundate dwellings and their curtilages create particularly very objectionable conditions in Bangalore.

•The frequency and duration of flooding is relatively high in some of the locations, occurring usually during the south west monsoon period. Whilst valley flooding occurs several times per year in down stream areas. Under these latter conditions, poor drainage causes water stagnation and creates the surrounding area favorable for mosquitoes breeding and intern leads to unsanitary conditions. Even the water quality in some of the borewells that are dug adjacent to storm drains are polluted.

•Out of the 360 officially recognized slums in Bangalore, only 30 percent have underground sewerage services. Hence, the major portion of the wastewater generated from such slums will be discharged via the storm water system causing very unhygienic conditions.

## 5.3 ENVIRONMENTAL MANAGEMENT PLAN:

The proposed activities arising from this chapter are strategic in nature, and as such, the detailed investigations required have not been performed. Consequently the environmental assessment of the proposed activities addresses generic environmental impacts and mitigation measures only.

**Recommendations:**

➢Prepare a comprehensive management plan which is acceptable and affordable by the community.

➢Prepare a risk assessment plan and risk management plan.

- Prepare a construction and maintenance schedule to ensure effective functionality of the system.

- Implement an effective, improvised solid waste collection and conveyance system.
- Prepare a strategic plan for development of land in low lying areas.

- Municipal authorities should be more vigilant on the contractors responsible for disposal of solid wastes generated from the market yards, slums and densely populated areas.

- There should be stringent penalty on commercial establishments, hospitals lying in the catchment area, are disposing off their liquid/solid waste in the valley in an inappropriate manner.

- There should be a ban on the construction of public toilets on the banks of the waterway.

- Service station / garages should not be allowed to dispose the greasy effluent into the drain.

- There should be a strict vigil on slaughter houses which are discharging the liquid waste directly into drains and they should be instructed to dispose of their waste in a secured manner.

- Horticulture gardens and nurseries situated along the banks of the valleys should be cordoned off from the valley and should dispose the vegetative waste separately outside as a landfill and not to discard in the drain.

- There should be no UGD inlet into the drain from slums and other residential areas.

- Silt traps and silt barriers must be constructed along the drain at strategic locations to reduce silt load at downstream of the valley.

- Municipal authorities should encourage public and private sector enterprises for usage of recycled water and adopt rain water harvesting techniques in open lands etc.
- Create awareness among the public, regarding importance of the system functionality.

- Detention ponds for recharging ground water should be constructed along the strategic vantage locations in the valley. Some areas where such ponds could be provided apart from existing parks maintained by BMP are as listed below and the same is depicted in ***Figure 5.1.***

**Table 5.1 List of Locations For Construction of Detention Ponds**

1. Bangalore Palace Grounds, near Vasanthanagar.
2. Defence land, near Potters town.
3. Muslim community burial ground, on Nandi Durga Road.
4. Burial ground, near Wahid garden.
5. Educational institutions, near Sagayapuram.
6. Open space area, near East Railway Station.
7. Open space area, near Jeevanahalli.
8. M.E.G. Centre, near Ulsoor lake.
9. Kalpally cemetry.
10. T.B.Sanatorium area, near Indiranagar 1st Stage.
11. Open space area, near Jivanbhimanagar (National Assn. for blind, 10th Cross Road).
12. H.A.L. Staff College.
13. I.S.R.O. Complex near Airport Road.
14. I.S.R.O. Complex near Jivanbhimanagar.
15. ESI hospital/Dr. Ambedkar college, near Indiranagar.
16. Muslim burial ground, near Indiranagar BMTC bus depot.
17. Behind F.M. Cariappa defence qtrs., near Command hospital.
18. Defence land, near Ulsoor.
19. Kendriya Vidhyalaya, near St. Johns Road.
20. K.V.S. Stadium, near St. Johns Church Road.
21. K.K & G defence land at Cubbon Road.
22. Contonment railway property.
23. BMRDA & its adjoining park area on Millers Road.
24. Mount carmel college grounds on Millers Road.
25. Parks near Domlur in Air Port road.

## 5.4 SOCIAL IMPACTS:

77°35'19"E 77°36'19"E 77°37'19"E 77°38'19"E 77°39'19"E 77°40'19"E 77°41'19"E 77°42'19"E

13°1'7"N 13°0'7"N 12°59'7"N 12°58'7"N 12°57'7"N 12°56'7"N

0 700 1,400 2,800 4,200 5,600 Meters

N W E S

Hebbal Main Valley-1
Hebbal Main Valley
Hebbal Minor Valley-1
Hebbal Minor Valley-2
Ulsoor Valley
Challaghatta Valley
Koramangala Valley
Tavarekere Valley
Ulsoor Tank
Beliandur Tank
OLD MADRAS ROAD
AIRPORT ROAD
C2
C204
C1
C101
Muslim community burial ground on Nandi Durga Road.
Burial ground near Wahid garden.
Educational institutions near Sagayapuram.
Bangalore Palace Grounds near Vasanthanagar.
Defence land near Potters town.
Open space area near Jeevanahalli.
Cantonment railway property.
K.V.S. Stadium near St. Johns Church Road.
M.E.G. Centre near Ulsoor Lake.
Burial ground
Kalpally Cemetery.
Kendriya Vidhyalaya near St. Johns Road.
T.B.Sanatorium area near Indiranagar 1st Stage.
Muslim burial ground near Indiranagar BMTC bus depot.
K.K & G defence land at Cubbon Road.
Defence land near Ulsoor.
ESI hospital / Dr. Ambedkar College near Indiranagar.
Behind F.M. Cariappa defence qtrs. near Command hospital.
Open space near Jivan Bimanagar (National Assn. Blind, 10th Main Rd.)
I.S.R.O. Complex near Jivanbhimanagar.
I.S.R.O. Complex near Airport Road.
H.A.L. Staff College.

## Legend

- Drains
- Ridge
- Water Bodies

**Rail / Road**

- Arterial Road
- Major Road
- Minor Road
- Rail
- Main Valley
- Sub Valley
- Potential Location of Detention Ponds

| DATE | No. | REVISION | DRAWN | CHECKED | APPROVED |
|---|---|---|---|---|---|
| | | | | | |

STUP Consultants P. Ltd.
REGISTERED OFFICE: 1004-5 RAHEJA CHAMBERS, NARIMAN POINT, MUMBAI - 400021

OFFICE OF ORIGIN: BANGALORE

OWNER: BANGALORE MAHANAGARA PALIKE

DATE: 25/06/2003

CLIENT:

DRAWN: MNS

PROJECT: RE-MODELLING OF PRIMARY AND SECONDARY STORM WATER DRAINS IN BANGALORE CITY

PREPARED: RSP

CHECKED: YDM

TITLE: Challaghatta Valley - Potential Locations for Construction of Detention Ponds

APPROVED: ATS

Fig. No. .

REV

JOB No. 1495

SCALE: AS SPECIFIED

Baseline data together with data on social and environmental impact of flooding has been collected during reconnaissance survey to ascertain the level of service offered by the existing drainage system at various locations in the BMP, BDA and BMA administered areas.

The Baseline survey provided the following statistics on the incidence, nature and possible cause of flooding:

•7% of the household in B.M.P. area, reported that they faced instances of flooding.

•10% of households of lower socio-economic status reported that they had faced flooding in the past decade-instances of flooding had been more common in the central part of the city.

•Of the house holds that had experienced flooding, 72% reported such occurrences in the last one year, 15% had experienced flooding in the year 1999, 7% during the period 1995 to 1998, while 2% reported that they had experienced flooding prior to 1995.

•Of the households that had experienced flooding, a majority said that the effects had lasted for one to three days, while 3 % said they had extended beyond a week.

•Two thirds of the households ascribed the reasons for flooding to blockages in the sewerage system, 12% to ingress of rain water into the house, while 11% said that it had been caused by a blocked drains or gutter.

•Lower income households and those living in the slums were more vulnerable to flooding caused by blocked drains; and

•All households reported damage to assets and loss of workdays on account of such flooding.

•Few households from the conurbation and green belt areas reported that their houses had been flooded in the recent past, suggesting the high density of houses and lack

of planned development have contributed to the problem of improper drainage in the corporation area.

- Out of 360 officially recognized slum in Bangalore, only 30% have underground sewerage services. Hence, in the majority of slums wastewater must be discharged via. the storm water system, during flooding instances due to water stagnation, it provides a breeding ground for mosquitoes and leads to generally unsanitary conditions and health hazards.

Details on the areas affected, the frequency of flooding, the impacts and the cause of flooding would all be relevant for an effective management of the drainage system, but such records are not kept. But, during reconnaissance survey such information's were collected from public as first hand information and were considered during the evaluation of analysis results to improve the existing situation.

# CHAPTER - 6

# COST ESTIMATION

## 6.1 COST ESTIMATE:

Cost estimate has been worked out for rehabilitation of existing culverts/bridges, construction of new drains and bridges, and providing improvement works for increasing the carrying capacity of the system and also providing measures like increasing the capacity of tertiary drains and other allied works to minimizing the flooding problems in low lying areas.

Rehabilitation work includes drain wall reconstruction, cavity filling, providing pointing and where as carrying capacity improvement work includes plastering, desilting, widening, deepening, wall raising and providing bed protection.

For ease of assessment, carrying capacity improvement works and rehabilitation works have been identified and assessed for every kilometer length and accordingly cost estimates and bill of quantities have been prepared which is given in Volume IV of this report. Further for better understanding strip plans have been prepared and enclosed in this chapter.

For assessment of cost, detailed hydraulic design, structural designs, quantity estimation and cost estimation as per current schedule of rates have been carried out

A lumpsum amount provision for construction of detention ponds, utility shifting, traffic diversion and land acquisition are made in the estimate.

Table 6.1 & 6.2 indicates carrying capacity improvement works & rehabilitation works for Primary storm drain in Challaghatta Main Valley.

Table 6.3 & 6.4 indicates carrying capacity improvement works & rehabilitation works for Secondary storm drains in Challaghatta Main Valley.

Table 6.5 & 6.6 indicates carrying capacity improvement works & rehabilitation works for Primary storm drain in Ulsoor Valley.

Table 6.7 & 6.8 indicates carrying capacity improvement works & rehabilitation works for Secondary storm drains in Ulsoor Valley.

Table 6.9 Indicates abstract of cost for remodelling of existing culverts / bridges and also construction of new bridges in Challghatta Valley.

Lump sum amount provision for improving the existing tertiary drains has been made in the estimate and the same is indicated in Table 6.10.

## 6.2 Work Programme for Challaghatta Valley:

The works proposed in the above referred tables i.e., Table 6.1 to Table 6.10 shall be taken up in two phases,

**✓Phase – I works in Challaghatta Main Valley:**

The works indicated in Table 6.1 and 6.2 for Challaghatta Valley Primary Storm drain prioritized to be takenup in Phase I includes;

➢**Challaghatta Valley Primary Storm Drain – C100:**

- The works proposed near Vasanthanagar i.e., from Vasanthanagr upto Millers tank bund road like desilting, widening, tertiary drain improvement, deepening, culvert reconstruction, debris removal, new wall construction, utility shifting, removal of culvert near Karnataka Badminton Association and minor rehabilitation works may be takenup in Phase I.

- The works proposed near Corporation Colony i.e., from Queens Road upto Old Bamboo Bazar Road like desilting, new wall construction, obstruction removal, utility shifting and minor rehabilitation works may be takenup in Phase I..

- The works proposed near Shivajinagar i.e., from Old bamboo bazaar Road upto St, Johns Road like removal / relocating the shops and desilting, widening, tertiary drain improvement, deepening, new wall construction, culvert reconstruction, drain widening and new wall construction near Block Education department, utility shifting, relocation of toilet blocks and minor rehabilitation works may be takenup in Phase I.
- The works proposed near RBANMS College i.e., from Anna Swamy Mudaliar Road upto Kensington road like desilting, widening, removal of obstructions, deepening of

drain near Gurudwara, bridge reconstruction, new wall construction, utility shifting and minor rehabilitation works may be takenup in Phase I.

- The works proposed near Karnataka Golf Club association i.e., from Royal Orchid Park hotel upto Bellandur tank like desilting, widening, changing the alignment of drain near Wind tunnel road, deepening of drain inside Airport, bridge construction, new drain construction near Belur Road, demarcation of land for drain, service road, utility shifting and minor rehabilitation works may be takenup in Phase I.

- Desilting, debris removal, obstruction removal, encroachment removal and utility shifting works for the entire length of drain may be taken up in Phase I itself.

And phase II works are as mentioned below.

✔**Phase – II works in Challaghatta Main Valley:**

The works indicated in Table 6.1 and 6.2 for Challaghatta Valley Primary Storm drain to be takenup in Phase II includes;

➢**Challaghatta Valley Primary Storm Drain – C100:**

- The works proposed near Karnataka Badminton Association i.e., from Miller tank bund Road upto Queens Road like new wall construction may be takenup in Phase II.

- The works proposed near Guptha layout i.e., from backside of Gurudwara upto Old Madras Road like deepening, widening, wall reconstruction may be takenup in Phase II.

- The works proposed near Saraswathipura i.e., from Old Madras Road upto Cambridge layout like deepening, widening, wall reconstruction, removal of encroachments near Cambridge layout bridge may be taken up in Phase II.

- The works proposed near Cambridge layout i.e., from Cambridge layout bridge location upto Domlur 2$^{nd}$ Stage like desilting, deepening, widening may be takenup in Phase II.

- The works proposed near Domlur 2nd Stage i.e., from TERI upto Airport Road like deepening, widening, wall reconstruction may be taken up in Phase II.

- The works proposed near Diamond District Apartments i.e., from Airport Road upto Karnataka Golf Club like deepening, widening, wall reconstruction works may be takenup in Phase II.

**✔Phase – I works in Challaghatta Main Valley for Secondary storm drains:**

The works indicated in Table 6.3 and 6.4 for Challaghatta Valley Secondary Storm drains prioritized to be takenup in Phase I includes;

**➢Murugeshpalya drain - C101:**

- All the works proposed for this drain near Anandanagar and K.R. Garden needs to be takenup like desilting, widening, deepening, construction of new drains, tertiary drain improvements, utility shifting and minor rehabilitation works deepening of drain inside Airport, utility shifting and minor rehabilitation works may be takenup in Phase I.

**➢Shastrinagar Drain - C102:**

- All the works proposed for this drain near Shastrinagar and Lakshmipura needs to be takenup like desilting, widening, deepening, construction of new drains, tertiary drain improvements, utility shifting and minor rehabilitation works, dense vegetation growth removal near CMH Road, utility shifting and minor rehabilitation works may be takenup in Phase I.

**➢I.S.R.O. Complex Drain - C105:**

- All the works proposed for this drain near Jeevanabhimanagar, Indiranagar and Kodihalli Village needs to be takenup like desilting, widening, deepening, tertiary drain improvements, dense vegetal growth removal near ISRO, utility shifting and minor rehabilitation works may be takenup in Phase I.

**➢Thippasandra Drain - C106:**

•All the works proposed for this drain near Jeevanabhimanagar needs to be takenup like desilting, tertiary drain improvements, utility shifting utility shifting and minor rehabilitation works may be takenup in Phase I.

## 6.3 Work Programme for Ulsoor Valley:

The works proposed in the Table 6.3 to Table 6.4 shall be taken up in two phases,

**✔Phase – I works in Ulsoor Valley:**

The works indicated in the above referred tables for Ulsoor Valley Primary Storm drain which are prioritized and to be takenup in Phase I includes;

**➢Ulsoor Valley Primary Storm Drain – C200:**

•The works proposed near J. C. Nagar i.e., from J. C, Nagar upto S.K. Garden Main Road like desilting, widening, tertiary drain improvement, deepening, culvert reconstruction, debris removal, new wall construction, utility shifting and minor rehabilitation works may be takenup in Phase I.

•The works proposed near S.K. Garden i.e., from S.K. Garden Main Road upto Bore Bank Road like desilting, widening, tertiary drain improvement, deepening, culvert reconstruction, debris removal, new wall construction, utility shifting and minor rehabilitation works may be takenup in Phase I.

•The works proposed near Frazer Town i.e., from Stephens Cross Road upto Ulsoor Lake like desilting, widening, tertiary drain improvement, deepening, culvert reconstruction, debris removal, desilting of silt traps, new wall construction, utility shifting and minor rehabilitation works may be takenup in Phase I.

•Desilting, debris removal, obstruction removal, encroachment removal and utility shifting works for the entire length of drain may be taken up in Phase I itself.

**✔Phase – II works in Ulsoor Valley:**

**➢Ulsoor Valley Primary Storm Drain – C200:**

The works indicated in Table 6.3 and 6.4 for Ulsoor Valley Primary Storm drain to be takenup in Phase II includes;

- The works proposed near Frazer Town i.e., from Bore Bank Road upto Stephens Cross Road like widening, tertiary drain improvement, deepening, new wall construction may be takenup in Phase II.

**✔Phase – I works in Ulsoor Valley for secondary drains:**

The works indicated in Table 6.7 and 6.8 for Ulsoor Valley Secondary Storm drains prioritized to be takenup in Phase I includes;

**➢Ganesh Temple Drain - C201:**

- All the works proposed for this drain near Ganapathi temple needs to be taken up like deepening may be taken up in Phase I.

**➢Cox Town Drain - C202:**

- All the works proposed for this drain near Richards town and Cooke town needs to be taken up like widening, deepening may be takenup in Phase I.

**➢Sagayapuram Drain - C203:**

- All the works proposed for this drain near Tannery Road needs to be takenup like widening, deepening may be takenup in Phase I.

**➢Jeevanahalli Drain - C204:**

- All the works proposed for this drain near Jeevanahalli and M.E.G. Centre needs to be takenup like widening, deepening works may be takenup in Phase I.

- Desilting, debris removal, obstruction removal, encroachment removal and utility shifting works for the entire length of drain may be taken up in Phase I itself.

Bed protection works and other allied works may be takenup in Phase II for all primary and secondary storm drains both in Challaghatta main valley and Ulsoor valley.

## 6.4 Operation and Maintenance Cost:

For maintaining the existing drains in good condition and to have maximum hydraulic carrying capacity, the drainage system has to be maintained in good condition. The general maintenance envisaged are:

1.Removal of weeds
2.Removal of silt
3.Removal of debris and garbage
4.Repair the drain wall
5.Creating public awareness
6.Maintenance of desilting equipments
7.Administrative cost of drain monitoring squad.

Table 6.11 Indicates abstract of cost for annual operation and maintenance of the drainage system in Challaghatta Valley.

**Abstract of Cost**

**for Remodeling of Primary and Secondary Storm Water Drains, Culverts/Bridges & its appurtenant works in Challaghatta Valley**

| Sl.No. | Description | Amount (Rs. In Lakhs) |
|---|---|---|
| 1 | Cost for Remodeling of Primary & Secondary Storm Water Drains, Construction of New Drains near low lying areas, Formation of Service Roads etc., | 10,046.76 |
| 2 | Cost for Remodeling of Bridges / Culverts constructed across Primary & Secondary Storm Water Drains. | 1,333.40 |
| 3 | Cost for shifting utility lines, footpath improvement works, barricading, traffic diversion, strengthening of diversion routes etc. | 569.01 |
| 4 | Construction of Detention Ponds / Retarding Basins | 150.00 |
| 5 | Construction of Wells with pumping arrangement in low lying areas | 200.00 |
| 6 | Procurement of desilting machine | 0.00 |
| 7 | Miscellaneous and rounding off | 0.02 |
| 8 | ✔Advisory, Project Management & Establishment Charges (1.5 % of Item 1 to 7) | 184.50 |
| | **✔TOTAL** | **12,483.69** |
| 9 | Annual Operation & Maintenance Cost (1.0 % of Item 1 to 7) | 123.00 |

## Table 6.11 Abstract of Cost for Operation and Maintenance of Primary and Secondary Storm Water Drains in Challaghatta Valley

| *Sl. No.* | *Description* | *Amount (Rs. In lakhs)* | *Remarks* |
|---|---|---|---|
| **1** | **Operation & Maintenance** | | (Cost considered is for per annum). |
| 1.1 | Establishment Charges | 12.30 | |
| 1.2 | Purchase & maintenance of equipments. | 12.30 | |
| 1.3 | Construction of new components | 36.90 | |
| 1.4 | Drain Desilting works | 24.60 | Av. Silt depth of Min. 0.3 to 0.5 m. per year |
| 1.5 | Rehabilitation works | 30.75 | |
| 1.6 | Staff training, community awareness etc. | 6.15 | |
| | **Total** | **123.00** | |

## Table - 6.1 Schedule For Improving the Carrying Capacity of Existing Primary Storm Drain in Challaghatta Main Valley (C100)

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain - Carrying Capacity Improvements Works | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Widening | | | Drain Desilting & Deepening | | | Drain Wall Raising | | | Bed Protection | | | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | | |
| 1 | 2 | 3 | 4 | 5 | 6 | | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | |
| **C100 – Challaghatta Valley Primary Storm Drain** | | | | | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | Bangalore Palace Ground | Queens Road | a) 275 - 357<br><br>b) 400 - 625 | | a) Right Side – Corp. Dobhi Ghat upto Miller Road<br>From 2.5 m to 4.5 m; ht. 2.0 m<br>b) Left Side - Millers Road upto Millers Tank Bund Road<br>From 3.0 m to 6.0 m; ht. 2.0 m | a) 0 - 275<br>b) 275 - 357<br>c) 400 - 625<br>d) 275 - 1000 | - | a) Existing drains to be desilted.<br>b) After desilting drain bed to be deepened by 500 mm from Corpn. Dhobi Ghat upto Millers<br>c) After desilting drain bed to be deepened by 500 mm from Millers Road upto Millers Tank Bund Road<br>d) Existing drain to be desilted | a) 275 - 357 | - | a) Left Side<br>Corp. Dobhi ghat upto Millers Road<br>From 1.4 m to 2 m | a) 0 - 275<br>b) 275 - 357<br>c) 400 - 625<br>d) 650 - 1000 | - | a) Existing drain bed relevant<br>b) After desilting for full length & width<br>c) After desilting for full length & width<br>d) After desilting for full length & width | |
| 2 | 1,000 | 2,000 | Queens Road | Juma Masjid Road | a) 1800 - 2000 | | a) Both side Old Bamboo Bazar Road upto Juma Masjid Road<br>From 4.5 m to 7.5 m ht. 2.2 m | a) 1050 – 1475<br>b) 1475 - 2000 | - | a) After desilting drain bed is to be deepened by 400 mm<br>From Queens Road to Shivaji Road<br>b) After desilting drain bed is to be deepened by 300 mm<br>From Shivaji Road upto Juma Masjid Road | - | - | - | a) 1000 - 2000 | - | a) After desilting for full Length & width | | |
| 3 | 2,000 | 3,000 | Juma Masjid Road | ASM Road (Near Ajantha Road) | a) 2610 - 2725 | | a) Right Side – Kamaraj Road down along Nala Road beside Block Educ. Dept. Building<br>From 7.0 m to 10.5 m ht.2.5 m | a) 2000 – 3000 | - | a) After desilting Drain bed is to be deepened by 500 mm from Juma Masjid Road upto ASM Road. | a) 2000 – 2610<br>b) 2610 - 2725<br>c) 2725 - 3000 | - | a) Both Side<br>Juma Masjid Road upto Kamaraj Road<br>From 1.8 m to 2.4 m<br>b) Left Side<br>Kamaraj Road down along Nala Road<br>From 2.2 m to 2.60 m<br>c) Both Side<br>Nala Road upto ASM Road from 2.2 m to 2.6 m | a) 2000 – 3000 | - | a) After desilting for full Length | | |
| 4 | 3,000 | 4,000 | ASM Road (near Ajantha theatre) | Kensington Road | 3075 - 3150 | | Left Side<br>RBANMS College upto ASM Road<br>From 8.0 m to 12.0 m; ht. 2.0 m | a) 3000 - 4000 | - | a) After desilting drain bed to be deepened by 750 mm from ASM Road upto Kensington Road | a) 3500 - 3900 | - | a) Left Side<br>Drain wall on Ulsoor lake side needs to be raised from 3.0 m to 3.2 m | a) 3000 - 4000 | - | a) After desilting, for full length & width | | |

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Carrying Capacity Improvements Works | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Widening | | | Drain Desilting & Deepening | | | Drain Wall Raising | | | Bed Protection | | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 5 | 4,000 | 5,000 | Kensington Road | Old Madras Road | a) 4925 - 5000 | | a) Left Side<br>Near Murphy Town Market<br>From 11.0 m to 15.0 ht. 3.2 m | a) 4250 - 5000 | | a) After desilting drain bed to be deepened by 200 mm from 12th cross, M.V. Garden upto Old Madras Road | a) 4250 - 4925<br>b) 4925 - 5000 | | a) Both Side - Drain wall open M.V. Garden needs to be raised from 2.6 m to 3.2 m.<br>b) Right Side<br>Drain wall near Murphy Town Market needs to be raised from 2.8 m to 3.2 m | a) 4000 - 5000 | | a) After desilting, for full length & width | |
| 6 | 5,000 | 6,000 | Old Madras Road | Someshwapura 6th Main Road | a) 5000 - 5050<br>b) 5650 - 6000 | | a) Left Side<br>Behind Sri Ram Ashram, Opp. Murphy Town Market, From 11.5 m to 15.0 m ht. 3.2 m<br>b) Left Side<br>Near Lakshminarayanapura From 17 m to 20.0 m ht. 3.0 m | a) 5000 - 6000 | | a) After desilting drain bed to be deepened by 300 mm from Old Madras Road upto Someshwarapura 6th Main Road. | | | | a) 5000 - 6000 | | a) After desilting, for full length & width | |
| 7 | 6,000 | 7,000 | Someshwarapuram 6th Main Road | Domlur II Stage, Near TERI | a) 6000 - 6725<br>b) 6750 - 7000 | | a) Left Side - Someshwarapura 6th Main Road upto Domlur IInd Stage, from 14.5 m to 24 m ht. 3.0 m<br>b) Left Side - Near TERI Domlur IInd Stage From 13.0 m to 24 m ht. 3.0 m | a) 6150 - 7000 | | a) After desilting drain bed to be deepened by 400 mm from Someshwapura 6th Main Road upto Domlur IInd Stage. | | | | a) 6000 - 7000 | | a) After desilting for full length & width | |
| 8 | 7,000 | 8,000 | Domlur IInd Stage, Near TERI | Diamond District Apartments | a) 7000 - 7550<br>b) 7625 - 7700 | | a) Left Side - Domlur IInd Stage upto Indiranagar 100 FL Road, from 14 m to 26 m ht. 3.0 m<br>b) Left Side - Between Indiranagar 100 FL Road upto Airport Road From: 20 m to 26 m ht. 3.0 | a) 7000 - 8000 | | a) After desilting, drain bed to be deepened by 450 mm from Domlur IInd Stage, near TERI upto Diamond District Apartments. | a) 7000 - 7500<br>b) 7500 - 8000 | | a) Right Side<br>Drain wall from Domlur IInd Stage to Indiranagar 100 Ft. Road - From 2.8 m to 3.0 m<br>a) Right Side -<br>Drain wall from Indiranagar 100 Ft. Road to Diamond District Apartments<br>From 2.8 m to 3.0 m | a) 7000 - 8000 | | a) After desilting for full length & width | |
| 9 | 8,000 | 9,000 | Diamond District Apartments | K.G.A. Gold Club (near Texas Insts.) | a) 8075 - 8600<br>b) 8600 - 9000 | | a) Both Side - Opp. Royal Orchid Park Hotel<br>From 16 m to 28 m width and 2.6 m ht. Stone rivetment and also with 0.5 m ht. Parapet wall to be constructed<br>b) Right Side - After Royal Orchard Park Hotel and inside KGA.<br>From 17 m to 28 m width and 2.8 m ht. Stone rivetment and also with 0.5 m ht. Parapet wall to be constructed. | 8000 - 9000 | | After desilting drain bed to be deepened by 500 mm from Diamond Dist. Apartments upto K.G.A. Golf Club | | | | a) 8000 - 9000 | | After desilting drain bed to be provided for full length & width | |

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain - Carrying Capacity Improvements Works | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Widening | | | Drain Desilting & Deepening | | | Drain Wall Raising | | | Bed Protection | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | | 12 | 13 | 14 | 15 | 16 | 17 |
| 10 | 9,000 | 10,000 | K.G.A. Golf Club (near Texas Insts.) | Challaghatta Main Road (behind Airport) | 9000 - 10000 | | a) Both Side<br>K.G.A. Golf Club (near Texas Insts.) upto Challaghatta Main Road. New drain has to be constructed for 30 m wide and 2.8 m ht. Providing stone rivetment along with parapet wall to be constructed for a ht. of 0.5 m | | | | | | | | 9000 - 1000 | | After desilting bed protection to be provided for full length and width |
| 11 | 10,000 | 12,000 | Challaghata Main Road (behind Airport) | Location near Bellandur tank | 10000 - 12000 | | a) Both Side<br>Challaghatta Main Road upto Bellandur tank. Kacha drain has to be dug for a width of 35 m and 2.5 m depth from G.L. Also stone rivetment to be provided for a ht. of 2.5 m<br>Land demarcation to be made on either side for formation of Service Road. Provision for providing good stone @ every 50 m interval has to be made in the estimate. | | | | | | | | 10000 - 11000 | | After desilting bed protection to be provided for full length and width |

## Table - 6.2 Schedule For Providing Rehabilitation to the Existing Primary Storm Drain in Challaghatta Main Valley (C100)

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Rehabilitation Works | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Wall Reconstruction | | | Drain Wall Restoration | | | Utility Shifting & Other Obstruction Removals | | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| C100 – Challaghatta Valley Primary Storm Drain | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | Bangalore Palace Ground | Queen's Road | a) 900 - 925 | | a) Left Side<br>4 m length, 2 m ht. wall to be reconstructed. | a) 275 - 357<br>b) 400 - 625<br>c) 625 - 100 | | a) Left Side<br>After desilting pointing to be provided to a ht. of 1 m from drain bed<br>b) Right side<br>After desilting pointing to be provided to a height of 1 m from drain bed.<br>c) Both side<br>After desilting pointing to be provided to a height of 1 m from drain bed. | 1) 0 - 500<br>2) 500 - 1000 | | 1) a) Nil<br>2) a) 4 nos. of telephone cable @ 1 m ht. above drain bed level exists between Ch. 825 - 850<br>b) 2 no. of 1.2 m dia. manhole between 0.1 m ht. exists between Ch. 825 - 925 m | |
| 2 | 1,000 | 2,000 | Queens Road | Juma Masjid Road | | | | a) 1000 - 1600 | | a) Both Sides<br>After desilting pointing to be provided for full height from the drain bed. | 1) 1000 - 1500<br>a) 1500 - 2000 | | a) 5 nos. of 12 mm dia. encasement pipe<br>b) 7 nos. of telephone cables of 6 mm dia. @ about 1.2 m ht. above drain bed level.<br>c) 3 nos. of 7.5 mm dia. Cable lines<br>d) 3 nos. of 250 mm dia. water supply (w/s) pipeline exists between 1100 - 1500<br>e) 17 nos. of manhole of 1.2 m dia. & 0.6 m t. from drain bed exists.<br>a) 1 no. of 40 mm dia cable line exists @ Ch. 1750 m<br>b) 5 nos. of 40 mm dia. W/s pipeline exists @ Ch. 1700 m<br>c) 6 nos. of 1.2 m dia M.H. & 6.5 m ht. & 0.6 m from drain wall exists between 1550 - 1800 | |
| 3 | 2,000 | 3,000 | Juma Masjid Road | Anna Swamy Mudaliar Road | a) 2125-2150<br>b) 2450 - 2475<br>c) 2725 - 2750<br>d) 2825 - 2850<br>e) 2850 - 2925<br>f) 2975 - 3000 | | a) Right Side<br>10 m length, 2.4 m ht. wall to be reconstructed<br>b) Right Side<br>10 m length, 2.4 m ht. wall to be reconstructed<br>c) Left Side<br>5 m length, 2.6 m ht. wall to be reconstructed<br>d) Right Side<br>10 m length; 2.6 m ht. wall to be reconstructed.<br>e) Right Side<br>75 m length; 1.0 m ht parapet wall to be reconstructed.<br>f) Left Side<br>10 m length, 2.6 m ht. wall to be reconstructed. | a) 2000 - 2610<br>b) 2610 - 2725<br>c) 2725 - 3000 | | a) Both sides<br>After desilting pointing to be provided to a ht. of 1.0 m from drain bed.<br>b) Left Side<br>After desilting pointing to be provided to a ht. of 1.0 m from drain bed.<br>c) Both Sides<br>After desilting pointing to be provided to a ht. of 1.0 m from drain bed. | 2000 - 2500<br>2500 - 3000 | | a) 4 nos. of 15 mm dia. cable lines exists between Ch. 2425 - 2450<br>b) 2 nos. of 50 mm dia. cable lines exists between Ch. 2525 - 2550<br>c) 6 nos. of 2.0 m dia., manholes 0.5 m ht. from drain bed.<br>d) 15 nos. of 1.2 m dia. manholes & 0.2 m ht. from drain bed.<br>a) 2 nos. of 110 mm dia. water supply pipeline<br>b) 1 no. of 40 mm dia. cable line.<br>c) 8 nos. of 2.0 m dia manholes & 0.70 m ht from drain bed exists.<br>d) 8 nos. of 1.2 m dia. Manholes & 0.50 m ht. from drain bed. | |

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Rehabilitation Works | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Wall Reconstruction | | | | Drain Wall Restoration | | Utility Shifting & Other Obstruction Removals | | | |
| | From | To | From | To | Chainage (m.) | [illegible] | Remarks | Chainage (m.) | [illegible] | Remarks | Chainage (m.) | | Remarks | [illegible] |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 4 | 3,000 | 4,000 | ASM Road (near Ajantha Theatre) | Kensington Road | a) 3225 - 3250<br>b) 3250 - 3500 | | a) Left Side<br>20 m length, 3.4 m ht wall to be reconstructed<br>b) Left Side 50 m length, 3.4 m ht. Wall to be reconstructed. | a) 3000 - 4000 | | a) Both Side<br>After desilting pointing to be provided to a ht. of 1.5 m ht. from drain bed. | 1) 3000 - 3500<br>2) 3500 - 4000 | | 1) a) 6 nos. of 180 mm dia. Telephone cable lines exists<br>b) 1 no. of 750 mm dia. w/s pipeline exists. | |
| 5 | 4,000 | 5,000 | Kensington Road | Old Madras Road | a) 4175 - 4200<br>b) 4400 - 4425 | | a) Right Side 10 m lenth, 3.2 m ht. drain wall to be reconstructed.<br>Right Side - 10 m length, 3.2 m ht.<br>b) wall to be reconstructed. Drain wall to be reconstructed. | a) 4000 - 5000<br>b) 4500 - 5000 | | a) Both Side<br>After desilting pointing to be provided to a ht. f 0.5 m ht. from drain bed. | 1) 4000 - 4500<br>b) 4500 - 5000 | | 1. a) 5 nos. of 110 mm dia. w/s pipeline exists @ ch. 4100 m<br>b) 2 nos. of cable lines<br>c) 7 nos. of 110 mm dia. w/s pipe line exists @ Ch.4450 - 4475 m<br>d) 2 nos. of 1.6 m dia. Manhole & 1.2 m ht. above drain bed.<br>2. a) 4 nos. of 1.2 m dia. Manholes & 1.0 m ht. above drain bed. | |
| 6 | 5,000 | 6,000 | Old Madras Road | Someshwarapura 6th Main Road | - | - | | a) 5000 - 6000 | | a) *Both Sides*<br>*After desilting pointing to be provided to a ht. of 0.5 m from drain bed.* | 1) 5000 - 5500<br>2) 5500 - 6000 | | 1. a) 2 nos. of 110 mm dia w/s pipeline exists @ Ch. 5100 m<br>b) 2 nos. of cable lines exists @ Ch. 5350 m<br>2. a) 1 no. of 2.0 m dia. Manhole of 1.0 m ht. exists @ Ch.5775 m<br>b) 5 nos. of 1.2 m dia. Manhole of 1.0 m ht. exists b/w ch. 5725 -5900 m. | |
| 7 | 6,000 | 7,000 | Someshwarapura Main Road | Domlur IInd Stage, near TERI | - | - | | a) 6000 - 7000 | | b) Both Sides<br>After desilting pointing to be provided to a ht. of 1 no. from drain bed. | 1) 6000 - 6500<br>2) 6500 - 7000 | | 1) 2 nos. of 150 mm dia & 4 nos. of 110 mm dia. Sewer line exists @ ch. 6150 - 6175 m<br>b) 4 nos. of 120 mm dia, 1 no. of 200 mm dia, 2 nos. of 75 mm dia. w/s line and 5 nos. of 110 mm dia. Cable lines exists between Ch. 6400 - 6500 m<br>c) 2 nos. of 2.0 m dia & 1.2 m ht. Manhole exists @ Ch. 6125 m<br>2) Nil | |
| 8 | 7,000 | 8,000 | Domlur IInd Stage near TERI | Diamond District Apartments | a) 7400 - 7475<br>b) 7500 - 8000 | | Right Side - 5 m length, 3.0 m ht. wall to be reconstructed.<br>Right Side - 50 m length, 3.0 m ht. wall to be reconstructed. | a) 7000 - 8000 | | a) Both side - After desilting pointing to be provided to a ht. of 1.0 m from drain bed. | a) 7000 - 7500<br>b) 7500 - 8000 | | a) 2 nos. of w/s lines of 300 mm dia. Exists @ Ch. 7915 m<br>b) 10 nos of PVC service pipeline exists near Ch. 7975 m<br>c) 1 no. of 2 m dia manhole, 1 m ht. From drain bed exists between Ch. 7775-7800 m<br>d) 1 no. of 1800 mm dia. C.I. Sewer pipeline exists near Ch. 7925 m @ ht. Of 0.0 m above drain bed. | |
| 9 | 8,000 | 9,000 | Diamond District Apartments | K.G.A. Golf Club (near Texas Instruments) | - | - | - | a) 8600 - 9000 | | Left Side - After desilting and drain widening, pointing to be provided to a ht. of 1.5 m from drain bed. | a) 8000 - 8500 | | a) 3 nos. of w/s line of 150 mm dia. | |

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Rehabilitation Works | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Wall Reconstruction | | | Drain Wall Restoration | | | Utility Shifting & Other Obstruction Removals | | | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
| | | | | | | | | | | | b) 8500 - 9000 | | b) 5 nos. of 110 mm dia. Cable lines exists near Ch. 8200 m. | | |
| 10 | 9,000 | 10,000 | K.G.A. Golf Club near Texas Insts. | Challaghatta Main Road (behind Airport) | | | | | | | a) 9000 - 9500 | | a) 3 nos. of w/s line of 110, 150 & 180 mm dia.<br>b) 3 nos. of 110 mm dia. Cable lines exists | | |
| 11 | 10,000 | 12,000 | Challaghatta Main Road (behind Airport) | Location near Bellandur Tank | | | | | | | | | | | |

## Table - 6.3 Schedule For Improving the Carrying Capacity of Existing Secondary Storm Drains in Challaghatta Main Valley

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Carrying Capacity Improvements Works : | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Widening | | | Drain Deepening | | | Drain Wall Raising | | | Bed Protection | | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| **C101 – Challaghatta Valley Secondary Storm Drain: Murugeshpalya drains** | | | | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | Sudhamanagar | K.R. Garden | 250 - 500 | | Right Side<br>Near Muniswamyappa Layout. Existing covered drain (1.2 x 1.0 m) needs to be replaced with RCC Box drain of size (3 m x 2m) | a) 500 - 630 | | a) After desilting existing open drain needs to be deepened by 500 mm near Papaiah Layout | a) 500 - 630 | | Drain wall on Heritage Centre Side near Papaiah Layout needs to be raised from 1.2 m to 2.0 m | a) 0 - 250 | | a) After desilting drain bed lining to be provided for full length & width.<br>Existing width : 3 m | |
| | | | | | 500 - 630 | | Right Side<br>Near Papaiah Layout. Existing open drain to be widened From 1.5 m to 3 m ht. 2 m. | b) 700 - 950 | | b) After desilting existing open drain needs to be deepened by 500 mm From Airport Road upto Sriram Nagar. | | | | | | b) After desilting drain bed lining to be provided for full length & width<br>(Existing width : 3 m) |
| | | | | | 660 - 700 | | Left Side<br>Adjacent to Airport Road B.S. Slab covered Existing drain (1.2 x 1.0 m) needs to be replaced with RCC Box drain of size (3 m x 2 m) | | | | | | | | | | |
| 2 | 1,000 | 1,875 | K.R. Garden | Airport | 1000 - 1875 | | Note:- Construction of RCC Box drain of size (3 x 2 m) under progress. | - | - | - | - | - | - | - | - | - | - |
| **C102 – Challaghatta Valley Secondary Storm Drain: Shastrinagar Drains** | | | | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | Sweepers Colony near Indiranagar BMTC Depot | Shastrinagar near CMH Road | 0 - 600 | - | Note:- Drain Reach is under Defence Controlled Area | - | - | - | - | - | - | a) 600 - 1000 | - | a) After desilting chain bed lining to be provided for full length & width<br>(Existing width = 4 m) | |
| 2 | 1,000 | 1,600 | Shastrinagar near CMH Road | Challaghatta Valley Primary Storm drain | - | - | - | a) 1000 - 1600 | | *a) Existing covered drain needs to be opened @ regular interval) further desilted and deepened by 500 mm from Lakshmi-pura Main Road upto Challaghatta Valley Primary Storm Drain.* | - | - | - | b) 1000 - 1600 | | b) After desilting drain bed lining to be provided for full length and width<br>(Existing width = 4 m) | |
| **C105 – Challaghatta Valley Secondary Storm Drain: ISRO Complex Drains** | | | | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | Jeevanbhima Nagar | Kodihalli Main Road | - | - | - | 400 - 1000 | | *After desilting drain bed to be deepened by 500 mm near Jeevanbhima Nagar Main Road* | - | - | - | 400 - 1000 | | After desilting drain bed lining to be provided for full length & width<br>(Existing width - 4 m) | |
| 2 | 1,000 | 2,000 | Kodihalli Main Road | Indiranagar | - | - | - | 1000 - 2000 | | *After desilting drain bed to be deepened by 300 mm near Kodihalli Village.* | - | - | - | 1000 - 2000 | | After desilting drain bed lining to be provided for full length & width<br>(existing width - 4 m) | |
| 3 | 2,000 | 3,000 | Indiranagar | Airport Road | - | - | - | - | - | | - | - | - | 2000 - 3000 | | After desilting drain bed lining to be provided for full length and width<br>(Existing width : 6 m) | |

## Table - 6.4 Schedule For Providing Rehabilitation to the Existing Secondary Storm Drain in Challaghatta Main Valley

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Rehabilitation Works | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Wall Reconstruction | | | Drain Wall Restoration | | | Utility Shifting & Other Obstruction Removals | | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| **C101 – Challaghatta Valley Secondary Storm Drain: Murugeshpalya drains** | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | Anandnagar | K.R. Garden | 700 - 950 | | Right Side<br>Drain wall to be reconstructed for a length of 250 m & 2 m ht. from Airport Road upto Sriramnagar | - | - | | 1 a) 0 - 500<br>2 a) 500 - 1000 | | 1 a) 1 no. of 1.2 m dia. manhole & 1.2 m ht. from drain bed exists<br>2 a) 1 no. of 110 mm dia. w/s pipeline<br>b) 6 nos. of 100 mm dia. cable line exists.<br>c) 12 nos. of 1.2 m dia manhole & 1.2 m ht exists between Ch.700 to 950 m. | |
| 2 | 1,000 | 1,875 | K.R. Garden | Airport | 1000 - 1875 | | Note: Construction of RCC Box drain of size (3 x 2 m) under progress. | - | - | | 1) a)1000 - 1875 | | 1) a) 1 no. of 450 mm dia & C.I. Sewer Pipe line @ ht. of 0.4 m from drain bed exists @ Ch. 1460 m (Adjacent to Airport Compound) | |
| **C102 – Challaghatta Valley Secondary Storm Drain: Shantinagar Drains** | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | Sweepers Colony near Indiranagar BMTC Depot | Shantinagar near CMH Road | - | - | | a) 600 - 1000 | | a) Both side<br>a) After desilting, pointing to be provided for 1 m ht. From chain bed level. | 1) a) 0 - 500<br>2) 500 - 1000 | | 1)<br>2) a) 2 nos. of 160 mm dia. w/s pipeline exists.<br>b) 4 nos. of cable line exists | |
| 2 | 1,000 | 1,600 | Shantinagar near Cliff Road | Challaghatta Valley Primary Storm Drain | 1350 - 1375 | | Left Side<br>10 m length, 2 m ht. wall to be reconstructed. | a) 1000 - 1600 | | a) Both side<br>After desilting and deepening, pointing to be provided for 1 m ht. from chain bed level. | a) 1000 - 1600<br>- | - | - | |
| **C105 – Challaghatta Valley Secondary Storm Drain: ISRO Complex Drains** | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | Jeevanbhima Nagar | Kodihalli Main Road | - | - | - | a) 400 - 1000 | | a) Both side<br>After desilting, pointing to be provided for a ht. of 1 m from the drain bed. | 1) a) 0 - 500<br>2) 500 - 1000 | | 1) a) 7 nos. of 110 mm dia PVC w/s pipeline exists<br>b) 9 nos. of 50 mm dia. cable line exists.<br>2) a) 2 sewer outlets are closed.<br>b) 1 no. of 1.2 m dia. M.H. at 2 m ht. from drain bed exists. | |
| 2 | 1,000 | 2,000 | Kodihalli Main Road | Indiranagar | 1200 - 1225 | | Right Side<br>10 m length 2 m ht. wall to be reconstructed. | a) 1000 - 2000 | | a) Both sides<br>After desilting pointing to be provided for a ht. of 1 m from the drain bed. | 1) a) 1000 - 1500<br>2) 1500 - 2000 | | 1) a) 24 nos. 50 to 300 mm dia GI & PVC w/s pipeline exists<br>b) 6 nos. of 150 mm dia cable line exists.<br>c) 4 nos. of Sewer outlets are noticed.<br>2) - | |
| 3 | 2,000 | 3,000 | Indiranagar | Airport Road | - | - | - | a) 2000 - 3000 | | a) Both sides<br>After desilting pointing to be provided for a ht. of 1 m from the drain bed. | 1) 2000 - 2500<br>2) 2500 - 3000 | | 2) a) 1 no. of 300 mm dia. C.I. Sewer pipe line exists @ ht. of 0.5 m from drain bed. | |

**Table - 6.5 Schedule For Improving the Carrying Capacity of Existing Primary Storm Drain in Ulsoor Valley (C 200)**

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Carrying Capacity Improvements Works | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Widening | | | Drain Desilting & Deepening | | | Drain Wall Raising | | | Bed Protection | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| C200 – Ulsoor Valley Primary Storm Drain | | | | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | J.C. Nagar Main Road | Ramakka Block Main Road | a) 270 - 320<br><br>b) 445 - 465 | | Right Side<br>Near J.C. Nagar Ramageetha Block, 1st Cross, from 4.5 m to 6.0 m, 2m ht. wall to be reconstructed.<br>Right Side<br>Near Krishnammanagar 1st Main Road from 4 m to 6.5 m 2 m ht. wall to be reconstructed. | a) 0 - 250<br><br>b) 250 - 1000 | | a) Existing drain to be desilted.<br>a) After desilting drain bed to be deepened by 500 mm from 1st Cross, Rama-geetha Block upto Ramakka Block Main Road | - | - | - | a) 75 - 1000 | | After desilting drain bed to be provided for full length and width. | |
| 2 | 1,000 | 2,000 | Ramakka Block Main Road | S.K. Garden Main Road near Pottery Town | a) 1050 - 1200<br><br>b) 1200 - 1500<br><br>c) 1500 - 1625<br><br>d) 1675 - 1975 | | a) New RCC Box drain of size 4 m width, 2 m ht, for a length of about 150 m needs to be constructed.<br>b) New open drain of size 6 m wide, 2.4 m ht, for a length of about 300 m needs to be constructed<br>Right Side<br>c) Near S.K. Garden Main Road (Adjacent to Defence Land) from 5m to 9m ht. 2.4m<br>Left Side<br>Near Pottery Town bridge location from 8 m to 10 m ht. 2.4 m | a) 1000 - 2000 | | a) After desilting drain bed to be deepened by 500 mm from Ramakka Block upto S.K. Garden Main Road | a) 1500 - 1825<br><br>b) 1875 - 1975<br><br>c) 1975 - 2000 | - | Left Side<br>Near S.K.Garden Main Road (Adjacent to Defence Land) from 2.0m to 2.4m<br>b) Right Side<br>Near Pottery Town bridge location from 2 m to 2.4 m<br>c) Both side<br>Corp. Kalyana Mantap near Pottery Town from 2m to 2.4m | a) 1000 - 2000 | | After desilting drain bed to be provided for full length & width | |
| 3 | 2,000 | 3,000 | S.K. Garden Main Road near Pottery Town | Stephen's Cross Road | a) 2075 - 2175 | | Right Side<br>Near Bore Bank Road (near Railway Bridge) from 8 m to 11 m ht. 2.4 m | a) 2000 - 2200<br><br>b) 2200 - 2700<br><br>c) 2700 - 3000 | | a) Existing drain to be desilted<br>After desilting drain bed to be deepened by 300 mm from<br>b) Bore Bank Road (near Railway Bridge) upto Mosque Road<br>c) Existing drain to be desilted. | - | - | - | a) 2000 - 3000 | | After desilting drain bed to be provided for full length and width. | |
| 4 | 3,000 | 4,100 | Stephen's Cross Road | Ulsoor Lake | a) 4050 - 4100 | | Right Side<br>4th Cross, Sindhi Colony to be Lake View Maha Ganapathy temple from 11 m to 14 m ht. 2.6 m | a) 3000 - 4100 | | After desilting, drain bed to be deepened by 300 mm | - | - | - | a) 3000 - 4100 | | After desilting drain bed to be provided for full length & width. | |

## Table - 6.6 Schedule For Providing Rehabilitation to the Existing Primary Storm Drain in Ulsoor Valley (C 200)

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Rehabilitation Works | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Wall Reconstruction | | | Drain Wall Restoration | | | Utility Shifting & Other Construction Removals | | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| **C200 – Ulsoor Valley Primary Storm Drain** | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | J.C. Nagar Main Road | Ramakka Block Main Road | a) 125 - 150<br>b) 175 - 200<br>c) 375 - 400 | | Right Side<br>10 m length, 2.6 m ht. walls to be reconstructed.<br>Both side<br>15 m length, 2.6 m ht. walls to be reconstructed.<br>Left Side<br>25 m length, 2.6 m ht. wall to be reconstructed. | 2) 80 - 1000 | | Both Side<br>a) After desilting pointing to be provided for a ht. of above 1 m from the draina bed. | 1) a) 0 - 500<br>2) b) 500-1000 | | 1) a) 1 no. 110 mm dia. w/s pipe line exists<br>b) 12 nos. of 110 mm dia. Sewer outlets are noticed<br>c) 27 nos. of 1.2 m dia. manhole & 0.5 m ht. From drain bed exists.<br>2) a) Nil | |
| 2 | 1,000 | 2,000 | Ramakka Block Main Road | S.K. Garden Main Road near Pottery Town | a) 1350 - 1475<br>b) 1350 - 1475 | | a) Left Side<br>25 m length, 2.6 m ht. wall to be reconstructed.<br>b) Right Side<br>10 m length, 2.6 m ht. wall to be reconstructed. | a) 1000 - 2000 | | a) After checking, pointing to be provided for a ht. of about 1 m from the drain bed. | a) 1000 - 1500<br>b) 1500 - 2000 | | a) 11 nos. of 300 mm dia stoneware pipes exists between Ch. 1000 - 1500<br>b) 22 nos. of 110 mm dia. PVC pipe sewer outlets are noticed.<br>c) 5 nos. of 1.2 m dia manhole & 0.75 m ht. from drain bed exists.<br>2) a) 15 nos. of 110 mm dia PVC sewer outlets are noticed.<br>b) 5 nos. of 1.2 m dia. manhole 0.5 m ht. from drain bed exists. | |
| 3 | 2,000 | 3,000 | S.K. Garden Main Road near Pottery Town | Stephen's Cross Road | a) 2225 - 2250<br>b) 2325 - 2500<br>c) 2925 - 3000 | | Right Side<br>6.0 m length, 2.6 m ht. wall to be reconstructed.<br>Right Side<br>10.0 m length 2.6 m ht. wall to be reconstructed.<br>Left Side<br>15 m length 2.6 m ht. wall to be reconstructed. | a) 2000 - 3000 | | Both Side<br>a) After desilting, pointing to be provided for a ht. of about 1 m from drain bed. | a) 2000 - 2500<br>b) 2500 - 3000 | | 1) a) 2 nos. of 750 mm dia. GI w/s pipelines.<br>b) 8 nos. of 110 mm dia PVC w/s pipeline exists.<br>c) 9 nos. of PVC Sewer outlets are noticed.<br>d) 10 nos. of 1.2 m dia. Manhole 0.5 m ht. from drain bed (left side) exists.<br>e) 7 nos. of 1.2 m dia, Manhaole 0.8 m ht. from drain bed (Right Side) exists.<br>2) a) 6 nos. of 110 mm dia w/s pipeline<br>03 nos. of 1.2 m dia. manhole, 0.7 m ht.<br>b) From drain bed exists between Ch.2550 - 3000 | |

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Rehabilitation Works | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Wall Reconstruction | | | | Drain Wall Restoration | | | Utility Shifting & Other Obstruction Removals | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 4 | 3,000 | 4,100 | Stephen's Cross Road | Ulsoor Lake | a) 3500 - 3525<br><br>b) 3800 - 3825<br><br>c) 3075 - 3125<br><br>d) 3300 - 3425<br><br>e) 3600 - 3625<br><br>f) 3975 - 4000 | | a) Left Side<br>15 m length, 2.4 m ht wall to be reconstructed.<br>b) Right Side<br>10 m length, 2.4 m ht wall to be reconstructed.<br>c) Right Side<br>10 m length, 2.4 m ht. wall to be reconstructed.<br>d) Right Side<br>15 m length, 2.4 m ht. wall to be reconstructed.<br>e) Right Side<br>10 m length, 2.4 m ht wall to be constructed.<br>f) Right Side<br>15 m length, 2.4 m ht wall to be constructed. | a) 3000 - 4100 | | Both Side<br>After desilting, pointing to be provided for a ht. of about 1 m from the drain bed. | 1) 3000 - 3500<br><br>2) 3500 - 4100 | | 1) a) 2 nos. of telephone line exists<br>b) 5 nos. of 1.2 m dia Manhole at 0.8 m ht from drain bed.<br>2) a) 2 nos. of 110 mm dia. cable line exists @ Ch. 3525 m<br>b) 1 no. of 250 mm dia. w/s pipline exists @ Ch.3850 | |

## Table - 6.7 Schedule For Improving the Carrying Capacity of Existing Secondary Storm Drains in Ulsoor Valley

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Carrying Capacity Improvements Works | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Widening | | | Drain Desilting & Deepening | | | Drain Wall Raising | | | Bed Protection | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| **C201 – Ulsoor Valley Secondary Storm Drain: Ganesh Temple Drains** | | | | | | | | | | | | | | | | | |
| 1 | 0 | 250 | Ganesh Temple | MEG Centre | - | - | - | a) 0 - 250 | | a) After desilting, drain bed to be deepened by 300 mm near Ganesh Temple | - | - | - | a) 0 - 250 | | a) After desilting drain bed to be provided for full length & width.<br>(Existing width : 4 m) | |
| **C202 – Ulsoor Valley Secondary Storm Drain: Cox Town Drain** | | | | | | | | | | | | | | | | | |
| 1 | 0 | 1,170 | Richard Town | Gymkhana Ground near Assayee Road | a) 400 - 600<br><br>a) 1000 - 1075 | | a) <u>Both Side</u><br>Existing covered reach of drain Opp. Corp. Health Centre upto Frazer Town Police Station needs to be widened.<br>From 2.5 m to 5.5 m ht. 1.8 m<br>b) <u>Right Side</u><br>Near Gymkhana Play-ground from 5.5 m to 7.5 m ht. 2.0 m | a) 250 - 600 | | a) After desilting, drain bed to be deepened by 500 mm from KPTCL Office upto Frazer Town Police Station. | a) 1000 - 1075 | | a) <u>Left Side</u><br>Near Gymkhana Grounds<br>From 1.6 m to 2.0 m | a) 400 - 1170 | | a) After desilting drain bed to be provided for full length and width<br>(existing width: 5 - 6 m) | |
| **C203 – Ulsoor Valley Secondary Storm Drain: Sagayapuram Drain** | | | | | | | | | | | | | | | | | |
| 1 | 0 | 750 | Sagayapuram | Cleaveland Town | a) 450 - 750 | | a) <u>Left Side</u><br>Existing covered reach of drain, Opp. KMFC Market upto Railway Bridge location need to be widened<br>From 1.5 m to 4.0 m ht. 2.0 m | a) 300 - 750 | | a) After desilting, drain bed to be deepened by 500 mm.<br>From M.M. Road upto Railway Bridge location near Bore Bank Road | - | - | - | a) 300 - 450 | | a) After desilting drain bed to be provided for full length & width<br>(Existing width : 4.0 m) | |
| **C204 – Ulsoor Valley Secondary Storm Drain: Jeevanahally Drain** | | | | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | ITC Colony near Jeevanahally | Inside MEG Centre towards Railway Bridge | a) 100 - 350<br><br>b) 350 - 500 | | a) <u>Both Side</u><br>Kandaswamy Garden 2nd Cross upto BDA Qrts. Road. Existing drain is in natural conditon and it has to be widened on left hand side from 1 m to 2.5 m ht. 1.8 m and new wall to be constructed on both side.<br>b) <u>Both Side</u><br>BDA Quarters Road upto Railway track. Existing drain is in natural condition and it has to be widened on left hand side from 2.0 m to 4.5 m and ht. 1.8 m and further new wall has to be constructed on both side. | a) 0 - 1000 | | a) After desilting drain bed to be deepened by 500 mm. From ITC Colony upto MEG Centre compound. | - | - | - | a) 0 - 1000 | | a) After desilting bed protection be provided for full length & width. | |

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Carrying Capacity Improvements Works | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Widening | | | Drain Desilting & Deepening | | | Drain Wall Raising | | | Bed Protection | | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| | | | | | c) 600 - 1000 | | c) Both Side<br><br>Existing drain is in natural condition i.e. inside MEG Centre and it has to be widened on Right hand side from 3 m to 6 m. Further, dry stone revetment has to be provided for a ht. of 2.0 m. | | | | | | | | | | |
| 2 | 1,000 | 2,000 | Inside MEG Centre (towards Rly. Bridge) | Ulsoor Lake | a) 1000 - 2000 | | a) Both Side<br><br>Inside MEG Centre existing drain is in natural condition and it has to be widened from 3.5 m to 8.0 m. Further, dry stone, revetment has to be provided for a ht. of 2.0 m. | a) 1000 - 2000 | | a) After desilting drain bed to be deepened by 300 mm inside MEG Centre<br><br>Inside MEG Centre | - | - | - | a) 1000 - 2000 | | a) After desilting bed protection to be provided for full length and width. | |

## Table - 6.8 Schedule For Providing Rehabilitation to the Existing Secondary Storm Drains in Ulsoor Valley (C 200)

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Rehabilitation Works | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Wall Reconstruction | | | Drain Wall Restoration | | | Utility Shifting & Other Obstruction Removals | | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| **C201 – Ulsoor Valley Secondary Storm Drain: Ganesh Temple drains** | | | | | | | | | | | | | | |
| 1 | 0 | 250 | Ganesh Temple | MEG Centre | - | - | - | a) 0 - 250 | | a) Both Sides<br>After desilting, pointing to be provided to the existing stone revetment wall for a ht. of 1 m from drain bed. | - | - | - | |
| **C202 – Ulsoor Valley Secondary Storm Drain: Cox Town Drain** | | | | | | | | | | | | | | |
| 1 | 0 | 1,170 | Richard Town | Gymkhhana Ground near Assayee Road | - | - | | a) 0 - 400<br>b) 600 - 1000<br>c) 1000 - 1075<br>d) 1075 - 1170 | | a) Both side<br>After desilting, pointing to be provided for 1 m ht. from drain bed.<br>b) Both side<br>After desilting, pointing to be provided for 1 m ht. from drain bed.<br>c) Left side<br>After desilting, pointing to be provided for a ht. of 1 no. from drain bed.<br>d) Both Sides<br>After desilting, pointing to be provided for a ht. of 1 no. from drain bed. | 1) a) 0 - 500<br>2) a) 500-1170 | - | 1) a) 4 nos. of 100 mm dia Cable lines.<br>b) 2 nos. of 160 mm dia. w/s pipeline exists.<br>c) 10 nos. of Sewer outlets<br>d) 12 nos. of 1.2 m dia. Manhole at 0.8 m ht. from drain wall.<br>2) Nil | |
| **C203 – Ulsoor Valley Secondary Storm Drain: Sagayapura Drain** | | | | | | | | | | | | | | |
| 1 | 0 | 750 | Sagayapuram | Cleave Land Town | a) 0 - 75<br>b) 75 - 100 | | Both Sides<br>60 m length 1.6 m ht. drain wall to be reconstructed.<br>Right Side<br>25 m length 1.6 m ht. drain wall to be reconstructed. | a) 0 - 75<br>b) 300 - 450<br>c) 450 - 750 | | a) Right Side<br>After desilting, pointing to be provided for a ht. of 1 m from the drain bed.<br>b) Both Side<br>After desilting, pointing to be provided for a ht. of 1 m from the drain bed.<br>c) Right Side<br>After desilting pointing to be provided for a ht. of 1 m from drain bed. | 1) 0 - 725 | | 1) a) 1 no. of 60 mm dia w/s pipeline at a ht. of 1 m from drain bed. | |

| Sl. No. | Chainage (m.) | | Location | | Existing Storm Drain – Rehabilitation Works | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drain Wall Reconstruction | | | Drain Wall Restoration | | | Utility Shifting & Other Obstruction Removals | | | |
| | From | To | From | To | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | Chainage (m.) | | Remarks | |
| 1 | 2. | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| **C204 – Ulsoor Valley Secondary Storm Drain: Jeevanahalli Drain** | | | | | | | | | | | | | | |
| 1 | 0 | 1,000 | ITC Colony near Jeevanahalli | Inside MEG Centre (towards Rail-way Bridge) | - | - | - | a) 500 - 600 | | Both Side<br>After desilting pointing to be provided for a ht. of 1 m from drain bed. | 1) a) 0 - 500<br>2) a) 500-1000 | | 1) a) 1 no. of 1.2 m dia Manhole at 0.6 m ht. above drain bed exists.<br>2) a) 1 no. of 50 mm dia cable line exists.<br>b) 1 no. of 110 mm dia. w/s pipeline at a ht. of 0.8 m from drain bed exists.<br>c) 1 no. of 1.2 m dia. manhole exists | |
| 2 | 1,000 | 2,000 | Inside MEG Centre (towards Rail-way Bridge) | Ulsoor Lake | - | - | - | - | | - | - | | - | - |

# CHAPTER – 7

# TECHNO – ECONOMIC ANALYSIS

## 7.1 INTRODUCTION:

CHALLAGHATTA valley is located east of Bangalore, where natural lakes and trees abound. The valley is spread in around 60 sq. km out of a total area of 225 sq. km for the Bangalore city. The total population of Bangalore city as per 2001 census is 4.5 million (the municipal limits are divided into 100 wards) and around 0.6 million people live in the 15 wards of CHALLAGHATTA valley area. There are 49,451 residential and 9107 non-residential properties in the area. CHALLAGHATTA Valley project is part of the overall modernization program of BMP for all four major valleys in the city (other three valleys being Hebbal, Vrishabavathi and Koramangala).

The Valley projects when implemented would not generate additional revenue for the principal implementing agency viz. BMP. Thus, it is a social infrastructure project attempting to restore the eco-system and relieve the citizens and residents of hardships that they are currently exposed by way of polluted drains, flooding and potential danger of public health hazards. These characteristics of the project lend itself for grants, aid and soft loans. Not withstanding the above social aspects, BMP would provide appropriate support to the project by means of initial seed amount and through budget provision to support the operation and maintenance of the SWD's once constructed.

## 7.2 OUT COME OF THE VALLEY PROJECTS:

Sustainable ecosystem for lakes, river beds and other water bodies around river valleys; prevention and management of floods in low-lying areas and livable environ for citizens and residents.

## 7.3 STAKE HOLDERS OF THE PROJECT:

The project is designed to address the varying requirements of the stakeholders. They are:

| INTERNAL | EXTERNAL |
|---|---|
| Bangalore Mahanagara Palike (BMP) | Citizens (residents of the area) |
| Bangalore Water, Sewage and Sanitation Board (BWSSB) | Industries and other occupants of the area |
| Lake Development Authority (LDA) | NGOs |
| City Municipal Corporations (CMC/TMC) | Funding Agencies |
| Bangalore Development Authority (BDA) | Government of Karnataka (GOK) |
| Karnataka State Pollution Control Board (KSPCB) | Karnataka Urban Infrastructure Development Finance Corporation (KUIDFC) |
| Elected representatives | Government of India (GOI) |

## 7.4 STAKEHOLDER REQUIREMENTS, OUTPUTS AND BENEFITS:

| | |
|---|---|
| Residents: | No flooding |
| | Odour less and free flow of drain |
| | Green environment |
| | Separation of sewage and storm water |
| | Excellent Bellandur lake and tanks |
| | Financially not inconvenienced |
| | Selected owners of land will benefit from and value appreciation |
| Lake Development Authority: | Water entering the lakes is as per the acceptable technical standards; |
| | Visually fresh water fish should thrive in the lakes |
| | Possibility for increased tourism |

| | |
|---|---|
| Bangalore Mahanagara Palike: | One major issue resolved in line with 'citizen first' approach<br><br>Good branding possibility<br>Success can be replicated in other valley projects<br><br>Publish a comprehensive book<br><br>Success will enhance and ensure better flow of funds for future projects |
| BWSSB | One major issue resolved, rehabilitation of existing sewerage system to collect, treat and dispose the treated sewage there by abating the raw sewage flow into drains and lakes<br><br>Diversion of sewage lines from the storm water drain network enabling proper care and maintenance of the sewerage system |
| GOK | Rediscover Bangalore as city of gardens, lakes etc. |
| GOI | A template for urban development; model to empower local governments |
| Funding Agency | Better chance of realizing ROI; fulfilling the purpose to assist developing countries in their efforts to develop economic and social infrastructure and stabilize their economies |

## 7.5 PROJECT OBJECTIVES:

- To rectify current localized flooding problems in the critical low lying areas identified in the study.
- To cope with additional areas being included into the BMP administered area in terms of expansion of the storm water drain network.
- To prevent polluted water getting into lakes and river beds
- Encourage rain water harvesting in institutions, public parks, open grounds, etc
- To improve and extend the security of services in vulnerable areas of the current BMP administered area.

- To improve and protect the quality of environmental attributes including aesthetic appearance of city's environs.
- To minimize cost implication on operation and maintenance of the system.
- To educate the residents and citizens to be aware of the effect of dumping solid waste and other wastes into the drains (which are open by design)
- To educate and enforce measures to prevent industries and commercial establishments from discharging toxic and wastewater into drains, lakes and river beds
- To design, develop and implement information architecture to capture and incorporate vector and raster data to be used by multiple agencies on a shared basis. Information architecture is designed to support sustainability.

## 7.6 VARIABLES AND MEASUREMENTS:

It would be essential to translate the requirements in to variables that could be subject to measurement in order to monitor the performance. The table below depicts the variables and measurements and the scale as applicable for measurement.

| VARIABLE | MEASURE | METRICS |
|---|---|---|
| Capacity of the local body of the Government (BMP) | Capacity to carry out environment management plan; ability to enforce relevant rules or regulations | Scale 1 to 5 |
| Flexibility to accept change in terms of new approaches to environment plans | Willingness of employees and authorities of BMP and other internal stakeholders to accept professional and outcome based approaches to maintenance of ecosystem | Scale 1 to 5 |
| Commitment to the implementation of the project | Demonstration by allocating required resources and competencies on a timely basis; enacting office orders and other instruments to facilitate implementation | Definitive |
| Effort to build awareness | Including a component for education and awareness in the project cost and engaging the citizens at various levels of project formulation and implementation | Definitive |
| Plan quality | Clarity of scope of work and definitiveness | Scale 1 to 5 |
| Risk of flooding | Property loss, public health hazard, damages to structures | Scale 1 to 3 |

| | | |
|---|---|---|
| Regulatory policies | Permitted land uses, density controls over land use, transfer of development rights, cluster development provisions, set back requirements, site review requirements, spatial study or impact assessment requirements, building standards for flood prone area developments, financing for mitigation | Combinatio n |
| Awareness | Educational awareness, voluntary real estate disclosure, flood warning systems, posting of signs to indicate flood prone areas | Definitive |
| Emergency planning provisions | Evacuation provisions, sheltering provisions, emergency plan provision | Scale 1 to 3 |
| Change interventions | Willingness to train and orient personnel to achieve common and shared objectives of the local body | Scale 1 to 5 |

The parameters and indicators identified above have been studied in detail while preparing the detailed project report for the valley as well to develop the risk management plan. The primary risk identified for the implementation of the storm water drain project relates to coordination among various stakeholders in terms of timely execution of individual projects and schemes in order that the overall environmental condition of the valleys is restored.

## 7.7 ABSTRACT OF COST:

For Remodeling of Primary and Secondary Storm Water Drains, Culverts/Bridges & its appurtenant works in Challaghatta Valley;

| Sl. No. | Description | Amount (Rs. In Crores) |
|---|---|---|
| 1 | Cost for Remodeling of Primary & Secondary Storm Water Drains, Construction of New Drains near low lying areas, Formation of Service Roads etc., | 100.47 |
| 2 | Cost for Remodeling of Bridges / Culverts constructed across Primary & Secondary Storm Water Drains. | 13.33 |
| 3 | Cost for shifting utility lines, footpath improvement works, barricading, traffic diversion, strengthening of diversion routes etc. | 5.69 |
| 4 | Construction of Detention Ponds / Retarding Basins | 1.50 |
| 5 | Construction of Wells with pumping arrangement in low lying areas | 2.00 |
| 6 | Procurement of desilting machine | 0.00 |
| 7 | Miscellaneous and rounding off | 0.02 |
| 8 | Advisory, Project Management & Establishment Charges (1.5 % of Item 1 to 7) | 1.85 |
| | **TOTAL** | **124.84** |
| 9 | Annual Operation & Maintenance Cost (1.0 % of Item 1 to 7) | 1.23 |

For the purpose of seeking external funding only the core capital expenditure of Rs.124.84 crores is considered whereas the amount required for operation and maintenance would be funded by Bangalore Mahanagara Palike out of its budget allocations (internal resources).

The direct beneficiaries of the clean environment that would ensue upon implementation of the project are the residents spread over 15 wards in the city. The demographic details of them are provided herewith:

## 7.8 WARD AND DEMOGRAPHICS OF CHALLAGHATTA VALLEY:

| Description | Ward No | Ward Names | Population | Properties | |
|---|---|---|---|---|---|
| | | | | Residential | Non-Residential |
| Challaghatta Main Valley (C100) | 72 | Domlur | 44,339 | 4436 | 274 |
| | 73 | H.A.L. Airport | 41,465 | 6807 | 748 |
| | 74 | Jeevanbhimanagara | 39,670 | 4755 | 635 |
| | 75 | Jogpalya | 35,984 | 4139 | 184 |
| | 78 | Vasanthanagara | 36,928 | 3707 | 1665 |
| | 79 | Shivajinagara | 34,941 | 2977 | 3543 |
| | 80 | Bharathinagara | 35,569 | 2352 | 404 |
| | 81 | Ulsoor | 39,715 | 2954 | 1017 |
| | 82 | Hoyasalanagara | 33,283 | 2543 | 227 |
| | 83 | Sri. C.V. Ramannagara | 49,487 | 1890 | 31 |
| | 85 | Sarvagnanagara | 34,984 | 2420 | 153 |
| Ulsoor Valley (C200) | 86 | Maruthisevanagara | 39,620 | 4241 | 51 |
| | 90 | Sagayapura | 43,399 | 1281 | 96 |
| | 91 | Pulikeshinagara | 42,010 | 5136 | 280 |
| | 92 | Jayamahal | 39,726 | 4249 | 73 |
| **Total** | | | **5,91,120** | **49,451** | **9,107** |

# CHAPTER – 8

# SUSTAINABILITY EVALUATION

## 8.1 LEGAL ASSESSMENT:

### 8.1.1 LAND ACQUISITION:

The optimal engineering solution emerging in the techno economic study would require removal of structures and houses that have sprung up along the sides of the storm water drain. There are instances where structures have been built on the side walls of the drain itself impairing scope for widening of the drains. The width of the storm water drains right through the city is greatly reduced by encroachments thus reducing the carrying capacity of the drains. There are instances of dwellings built right on top of the drains in certain areas (Yeshwantpur – beginning of Hebbal Valley drain).

Considering the prolonged process that would be necessary to enforce vacation of properties built around the storm water drain network the solution proposed avoids land acquisition on a large scale for the initiative. Where it is absolutely necessary land acquisition is envisaged considering the rehabilitation programme for people who would get displaced on account of the project implementation. The land acquisition is proposed through a process of conferring development rights (Transfer of Development Rights) by which the owner of the land who has surrendered the part of the land towards infrastructure projects would be allowed to carry out construction based on enhanced floor space index (FSI) conferred by the TDRs.

### 8.1.2 ENFORCEMENT MEASURES:

To deal with indiscriminate dumping of solid waste in to the storm water drains, apart from education and awareness programme, enforcement measures that act as deterrent are also required to be imposed. Based on experience in dealing with such situations it is recommended that the civic authority is empowered to deal firmly with violators of law in respect of dumping of solid waste that include construction debris, dead animals and hazardous waste material. To sustain the initiative enforcement measures are proposed against unauthorized constructions and to deal with encroachments.

Further, there are many instances of evidence that in areas outside the BMP administered region, the development authorities do not enforce and adopt even rudimentary practices for planning, construction and maintenance of primary and secondary drains and also they lack resources and technical expertise to adopt best storm drain management practices. In the new areas strict enforcement of law and procedures would discourage the citizens and commercial establishments from treating storm water drains as mere sewage drains.

## 8.2 ESTABLISHMENT OF INSTITUTIONAL FRAME WORK:

There are multiple agencies of the Government that are directly involved and accountable to ensure that the storm water drains in Bangalore carry only storm water and nothing else (0% impurity whether liquid waste or solid waste). The agencies are Bangalore Mahanagara Palike (BMP) who is directly responsible as the implementing agency as well as the entity vested with the construction and maintenance of the drains in the city. The other agency is Bangalore Water Supply and Sanitation Board (BWSSB) whose function is to ensure that sewage is collected and conveyed to the sewage network and that it does not mix with the storm water. The current situation, however reveals that the storm water drains in Bangalore carry much of sewage as these are either directly disposed in to the drains or they overflow from the manholes and pipes located inside the storm water drains. The third agency having a stake in the upkeep of the storm water drains is the Lake Development Authority (LDA) whose mandate is to keep the lakes on the down streams to be pollution free.

The fourth agency involved in the issue is Bangalore Development Authority (BDA) who allots and plans residential and commercial sites in and around Bangalore. When sites are allotted without considering the existence of water and sanitation networks, citizens have little choice in the disposal of waste and most often they find their way in to the storm water drains.

| Institution | Primary Role | Impact on SWDs | Area of cooperation | Severity of non-cooperation/ inaction |
|---|---|---|---|---|
| BMP | Planning, Development, Financing, Construction, operation and maintenance | Carrying capacity, flooding, pollution of the environment | Timely execution of projects<br><br>Educating the citizens on proper solid waste disposal | Medium to High |
| BWSSB | Collection, Conveyance and disposal of sewerage | Mixing of sewage with storm water polluting the drains, clogging, spreading odour and finally polluting the lakes and water bodies | Integrated planning and removal of sewage network components form the storm water drains | High |
| BDA | Land Use Planning and allotment of sites | Residents forced to discharge sewage in to SWDs where sewage networks have not been planned but construction permits given | Coordination with BMP/BWSSB to create the infrastructure in a coordinated manner while allotting sites | Medium |
| LDA | Upkeep of lakes and water bodies | Closing of entry points in to lakes due to polluted water entering the lakes thus making the environment around the lake unhygienic (lake itself may be pure of sewage and other contaminations) | Participate in planning and development of schemes to treat the unclean water before entry in to the lakes | Medium |

To realize the outcome of 100% pure flow of storm water in the drains all the above agencies need to participate and implement plans in an integrated and coordinated manner. The Government of Karnataka represented by the Urban Development Department has constituted an inter-institutional committee with members drawn from the following to give shape to the proposal for coordination and effective management of the storm water drain initiatives:

- Commissioner, BMP – Chairman of the Committee
- Secretary, Urban Development, GOK
- Chairman, BWSSB
- Chairman, BDA
- Chairman, LDA

Another critical institutional aspect for the storm water drain projects is the need to establish a dedicated project management cell within BMP to undertake such a massive and citizen sensitive project.

## 8.3 RATIONALE FOR A PROJECT MANAGEMENT UNIT:

There is a need for an organization which could handle joint projects among stakeholders cutting across various government entities. Such an organization should address the needs of the city – Greater Bangalore – a Techno polis, fast emerging as an intelligent city. The informal arrangement that was started a few years back in the form of BATF (Bangalore Agenda Task Force) needs to be formalized now by establishing a new organization that would focus on delivering citizen services by concentrating on urban infrastructure planning and execution. A strategic plan for the city development in terms of urban infrastructure shall be developed by the proposed organization along with a clear road map with milestones to translate the strategy to actions.

To execute a project with multiplicity of stakeholders profound project management skills and inter-disciplinary approaches are essential. In order to effectively implement, monitor and control the schemes envisaged under the storm water drain initiative it is strongly recommended that a Project Management Unit (PMU) as an exclusive entity responsible for storm water projects be established. Funding agencies stipulate evidence of professional management skills and best practices for sanction and disbursal of funds for such of these schemes. BMP readily accepted the recommendation and it has been suggested that PMU be established as part of BMP functioning independently to carry out the storm water drain projects in accordance with JNNURM guidelines and reforms agenda agreed among the stakeholders.

It has been observed in many infrastructure project implementation schemes that cost and time overruns could have been avoided if a separate dedicated unit or cell were vested with the authority and powers to deal with the project implementation cycle. There has been a significant improvement in performance of dedicated units wherein policy, implementation and regulation are clearly isolated and delineated. It is proposed that PMU functions as an execution agency of policies framed by BMP / Government and thus focusing on deliverables in terms of performance. Weak institutional mechanism coupled with lack of application of contracting skills affect the implementation of large infrastructure schemes. Channeling right competencies required for handling such schemes is vital but found to be non-existent under bundled institutional setups created around budgetary focus for expenditure monitoring. Performance measurement in terms of timely completion and construction as per requirements and specifications, are few aspects that are not given due importance under current functioning of these institutions.

Projects executed as part of many government schemes are susceptible to delays on account of slow decision making process and sometimes by the application of bureaucratic procedures. Focused attention and clearly defined roles among implementation agencies are seldom noticed in routine schemes funded either through budgetary allocations or through external funding mechanisms. Systems of the government remain inflexible and unable to cope up and address the needs of the funding agencies and contractors to deal effectively with emerging situations, uncertainties and risks.

While establishing the PMU, its governance structure, its inter-play with various internal and external stakeholders and its role, responsibility, powers, authority and liabilities need to be defined. More importantly the framework should highlight on the organization structure, the profile and attributes of the Chief Executive Officer and outsourcing mechanisms to pool resources. The recommendation would lay the basis for the establishment and operation of the PMU as well as its future role in respect of similar large urban infrastructure projects in Bangalore city.

The likelihood of achieving the project outcomes as per the specifications and within the timeframe planned would be greatly enhanced if the PMU is mandated to design, develop, implement and oversee the operation and maintenance phases. Performance orientation and achievement of measurable goals would be the hallmark of PMU and the knowledge gained should also be gradually transferred to its contractors, outsource partners and stakeholders.

PMU should be designed and structured in such a way that it is independent and allowed to function as an autonomous unit and be part of BMP. Performance measures of PMU shall be agreed between the designated state government agency and PMU and also in consultation with major stakeholders like BMP, BWSSB, LDA, BDA, CMCs etc. PMU should be evaluated based on its efficiency and effectiveness parameters and evolve initiatives and projects that are economically viable and politically sustainable. PMU could have its resources picked up from among various constituents of the government apart from external professional pool. An organization structure that would primarily meet with the engineering and enforcement aspects of the project is developed and presented here. The administrative functions like land acquisition and arrangement of finance are to be dealt with by the inter-institutional committee recommended as part of the reforms agenda.

Organization structure of the Project Management Unit (PMU) for implementing the remodeling of storm water drain network in Bangalore City.

## 8.4 EDUCATION AND AWARENESS PROGRAMME:

Awareness program as a tool is designed to address issues and propagate messages relevant to segmented consumers in respect of maintaining the environment to defined standards. The messages would include the types of technology, sources (availability), behavior pattern, ways to prevent dumping of waste, significance of clean environment with respect to health and safety and impact (social & economic) of not adhering to recommended rules and procedures.

Communication in the form of scientific intervention is critical to educate the economically weaker sections of the society, policy makers from health department, local bodies in charge of maintaining the environment around the storm water drains, lakes and other water bodies. They need to be aware of the systems governing safe environment, clean air and lakes with fresh water allowing fish to thrive. Unclean environment and the resultant odour and mosquito infestation affect their livelihood and also their health. The awareness in respect of impact of letting out wastewater without treatment on the environment and personal health are equally important. The communication program aims to create awareness on the ill-effects of having unclean storm water drain and water bodies and living in the midst of polluted environment caused by letting out un-treated wastewater and solid waste in to the open. It has been established through studies that more than 60% of the diseases caused are water borne and by effectively controlling sections of the society to seek and resort to safe disposal of both solid and liquid waste substantial savings would be made in the outlays currently made by the health department to address the public-health concerns. Orientation of the society through communication is an effective tool to achieve the desired results concerning behavior of citizens. They would emulate what is told if they are convinced of the impact in their lives. Practical demonstrations with test reports and certificates from authorized agencies entwined with communications program for spreading the message would achieve the desired result. Messages propagated in the local lingua and through personalities accepted by the community would have a significant impact in terms of acceptability and remembrance.

## 8.5 OBJECTIVES OF THE INTERVENTION:

The segmented target groups for this program are primarily economically weaker sections of the society, policy makers from health sector, local bodies in charge of wastewater and solid waste disposal, commercial establishments in the Hebbal Valley apart from potential polluting industrial units. For them the objectives are to:

- Introduce awareness on disposal pattern of waste and environmental factors associated with water and wastewater; especially focusing on organic matter in the form of bacteria, viruses and the like.
- Develop and administer awareness programs and education material in simple forms for school children.
- For the local bodies' material containing information on availability of cost effective technologies, transportation, quality control, costs, impact on environment would be developed and disseminated.
- Structure media programs along with direct campaigns to instill the awareness program.
- Sustain the message and effective follow up with repeated contacts and innovative schemes.
- Craft slide presentations, printable handouts, posters, and short movies for effective communication. The material prepared and administered would be in local language and simple to understand.

## 8.6 TARGET GROUP(S) WITH LOCATION SPECIFIC INFORMATION:

Bangalore City consists of 100 wards and the total population in the four valleys is around 4,500,000. The target group for the communications program will comprise segmented sections of weaker sections, schools (primary, middle and higher), and policy makers from health sector and local bodies in charge of storm ware drains, sanitation and lake maintenance. These would be chosen from the wards of the valleys. The target audience would be graded into government and the private sector comprising the policy makers, influencers, decision makers and implementing authorities. Citizens would be targeted through a network of non-government organizations (NGOs) who have established direct contact at various levels of communities.

## 8.7 DURATION OF THE INTERVENTION:

It is estimated that the intervention would be completed within a period of 36 months from commencement. There would be an intensive planning and requirement analysis process in the initial three months period formulating plans for implementing the awareness and communications program. Review and monitoring activities would form part of the intervention schedule to make an effective impact of the awareness program. The intervention would be administered both during the construction (remodeling of the drains) and the operation phase.

## 8.8 JUSTIFICATION FOR UNDERTAKING THE PROPOSED INTERVENTION:

A large engineering project with an outlay over Rs 7000 million without an education and awareness component is not likely to produce sustainable results. One of the key assumptions of the storm ware project is that raw sewage will not enter the drains once remodeling is complete. This assumption can not be satisfied through and engineering intervention alone. People have to be educated and made aware of the importance of sustaining the eco-system in order to protect the environment. If practices that are currently in vogue continues after the remodeling the purpose of the project initiative would have been completely missed. In order to realize the core objectives the proposed intervention is viewed as absolutely necessary. A program of Rs 30 million administered over a period of 36 months is likely to protect the investments made to the tune of Rs 7000 million. Enforcement alone is not likely to result in achieving the desired results. By directly engaging the segmented citizens the likelihood of protecting the investment and the maintenance of the eco-system of Hebbal Valley would be greatly enhanced.

## 8.9 APPROACH & METHODOLOGY:

Basic research in terms of segmentation of communities in terms of language, income level, literacy and vocation would be conducted in the first three months to gather data which will enable development of suitable programs for spreading the awareness. It is proposed to conduct an analysis and requirement planning to identify the areas where communication channels for the segmented target groups should be established and improved. The identification process would also focus on designing the content of the communication and awareness program suited to the target groups identified in terms of simplicity, vernacular and easy to comprehend and relate to real life situations. In case of school children curriculum on environmental health dealing with aspects of safe disposal of waste and keeping the environment clean and health aspects would be designed and promoted to authorities in the educational sector. Similarly, biological effects of living in unclean and polluted environ and methods to prevent unsafe methods of disposal of waste would be packaged in program for the health sector department. Impact of use of safe environment around the storm water drains on the spending by the health department would be clearly captured and popularized. Pilot schemes with focus target groups would be developed and administered. Lessons from the pilot schemes would be analyzed and evaluated for use in subsequent interventions in other community development programs as part of the education and awareness intervention.

## 8.10 DESCRIPTION OF THE TARGET AREA, TARGET GROUP (S) ALONG WITH THEIR CURRENT SOCIOECONOMIC STATUS:

The target area comprises four valleys (Challaghatta, Hebbal, Koramangala & Vrishabavathi) spread over 100 municipal corporation wards. The socioeconomic conditions of people living in the target area and in the target groups are quite mixed but predominantly economically weaker sections. For the target groups and in fact for all consumers, health costs arising out of water borne diseases are proving to be a great burden and continuously rising. Problems of flooding in the low lying areas due to clogging of drains with silt and waste have been witnessed in the past. Residents, commercial establishments and industries today are unaware of the ill-effects of throwing waste and discharging sewage in to storm water drains.

## 8.11 RELEVANCE OF THE INTERVENTION TO THE WORK ALREADY GOING ON:

A number of NGOs today interact with communities in regard to various socio-economic issues affecting the lives of the society. The proposed program would be designed in such a way to take advantage of the existing communication channels and also the network of NGOs to effectively promote the campaign. The emphasis would be to prevention of dumping of solid waste in to the storm water drains. The current programme would be suitably intermixed with ongoing communication programmes that are underway so that the citizens do not feel another massive programme thrust on them.

## 8.12 UTILISATION OF THE EXPECTED OUTCOME FROM THE INTERVENTION AND ITS BENEFICIARIES:

The outcomes expected from this intervention are two fold: firstly, it is to ensure acceptance of the program by the community in terms of change in practices for disposal of waste; effectives to be measured in terms of creating and sustaining a clean and green environment around the storm ware drains in the Hebbal Valley. Opportunities for employment creation within the local community for operation and maintenance of facilities would also be explored and established.

## 8.13 RISK ASSESSMENT:

Internal risks come mainly from three sources: the project, the organizations involved, and the relationships among partners. Most projects suffer at least temporarily, from a deficient project structure: many are launched even though objectives are not clear, a business case had not been completed, and milestones were only vaguely defined, if defined at all. On the organizational side, lack of project control mechanisms is the factor that most impede many projects. Finally, risks associated with the relationships among partners has been the major source of concern present in all projects, lack of definition of role and responsibility as the most important problem for project implementation.

The risks associated with the storm water drain projects fall in to three categories:

- Multiple stakeholder coordination risk during execution of work
- Project risk
- Acquisition of land and removal of encroachments while widening the drains

Continuing discharge of sewerage in to the drains – BWSSB is expected to draw up plans for connecting the households that now discharge the sewerage direct to the drains. Coordination and integration of BWSSB's plans with that of BMP alone will ensure the drains carrying the storm water of acceptable quality

Indiscriminate dumping of solid waste and debris in to the drains is another aspect exposed to risk. BMP has earmarked areas in each of the wards in the city where construction debris could be dumped. The exercise has begun and once implemented would greatly reduce the amount of debris being dumped in to the storm water drains. This combined with proper education and awareness programmes would help prevention of debris getting in to the drains.

## 8.14 RISK MANAGEMENT:

| **Risk** | **Stakeholders** | **Severity of risk** | **Solution** |
|---|---|---|---|
| Acquisition of land | BMP, Government of Karnataka | Medium | A combination of enforcement and rehabilitation measures is required to notify the affected people and provide alternate arrangements for living |
| Removal of encroachments | BMP, BDA, Government of Karnataka | Medium | Legislation followed by proper enforcement; affected people to be considered for housing under basic services to urban poor plan |

Internal risks associated with storm water drain projects in the four valleys of Bangalore city with suggested measures to address the risks.

| | |
|---|---|
| Risks associated with the project itself | ***Characteristics of clients/users of the service:*** resistance to change, lack of involvement, inadequate education level, difficulties in communicating, unrealistic expectations. (to overcome BMP is seeking citizen participation through ward committees and other for a)<br><br>***Scope of the project:*** universality or specificity of the service, number of partners involved, number of clients, size of budget. (contract documentation being revamped to define the role and responsibility very clearly)<br><br>***Complexity of the project:*** especially organizational and technological complexity. (consultant would evaluate various assumptions made in the design and detailed engineering)<br><br>***Definition and structure of the project:*** unclear objectives, ill-defined specifications and functional requirements, changes in the scope or the reach of the project, difficulties in integrating data or processes. (flexibility to accommodate changes from contractors) |
| Organizational risks | ***Lack of resources:*** uncertainty of funding, inadequate resources, lack of expertise in complex resource management.<br><br>***Project team competencies:*** lack of experience, expertise, stability, and communication skills. (it is proposed to establish a PMU with requisite skills and experience)<br><br>***Management strategy:*** inadequate or inappropriate organizational support and control, absence of a champion, lack of leadership, unavailability of tested management tools and processes. (inter-institutional committee proposed to deal with policy level decisions)<br><br>***Technological know-how:*** absence of an adequate technological infrastructure and of in-house technological competencies. (Competencies being upgraded). |
| Relationship risks | ***Form of collaboration:*** inadequate or inappropriate type of agreement, misunderstandings regarding the content of the agreement; inappropriate selection of partners. (all contractual frameworks to define the role, responsibility and liability of various parties clearly)<br><br>***Collaborative process:*** problems occurring with coordination, communications, inertia, dependency, mistrust, lack of consensus or involvement. (change management proposed) |

## CHAPTER 9

## FINANCIAL AND OPERATING PLAN

The storm water drain valley projects when implemented would not generate additional revenue for the principal implementing agency viz. BMP. Thus, it is a social infrastructure project attempting to restore the eco-system and relieve the citizens and residents of hardships that they are currently exposed by way of polluted drains, flooding and potential danger of public health hazards. These characteristics of the project lend itself for grants, aid and soft loans. Not withstanding the above social aspects, BMP would provide appropriate support to the project by means of initial seed amount and through budget provision to support the operation and maintenance of the SWDs once constructed.

However, BMP is examining the possibility of levying a one time collection charges from property owners in the city towards partial recovery of capital cost that is estimated for the remodeling of the storm water drains. It is under consideration to recover at the maximum 40% of the capital cost through such cess. The recovery would be made over a period of five years from the property owners. This scheme is subject to willingness and affordability criteria of the residents and the approval of the BMP council and the State Government.

The revenue accrual on account of the proposed cess is summarized below – a total collection of Rs 302.50 Crores from the years 2007-08 till 2011-12.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Storm Water Drain Cess | | | 45.00 | 55.00 | 65.00 | 67.50 | 70.00 |

**Estimated Capital Costs**

**Cost in Rs Crores**

| **Name of Component** | **Capital Cost as per DPR** | **Years** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **2006-07** | **2007-08** | **2008-09** | **2009-10** | **2010-11** | **2011-12** |
| Storm Water Drain Network | | | | | | | |
| Challaghatta Valley | 124.83 | 49.93 | 49.93 | 24.97 | - | - | - |
| Hebbal Valley | 190.13 | 76.05 | 76.05 | 38.03 | - | - | - |
| Koramangala Valley | 118.43 | 47.37 | 47.37 | 23.69 | - | - | - |
| Vrishabhavathi valley | 245.54 | 98.22 | 98.22 | 49.11 | - | - | - |
| **Sub-total for four valleys** | **678.93** | **271.57** | **271.57** | **135.79** | **0.00** | **0.00** | **0.00** |

**Funding pattern for Storm Water Drain Valley Projects (Rs Crores)**

| **Funding Pattern** | **Total** | **2006-07** | **2007-08** | **2008-09** |
|---|---|---|---|---|
| GOI Grant 35% | 237.63 | 95.05 | 95.05 | 47.53 |
| GOK Grant 15 % | 101.84 | 40.74 | 40.74 | 20.37 |
| BMP financing | 339.47 | 135.79 | 135.79 | 67.89 |
| **Total** | **678.93** | **271.57** | **271.57** | **135.79** |

The funding pattern is based on the JNNURM guidelines.

The fund flow statement for BMP for the next 10 years has been developed taking into consideration the financing of major infrastructure projects under JNNURM stream and non-JNNURM stream. These projections are under review by SBI Caps who are carrying out a due diligence exercise as well as the evaluation of viability for seeking external funding (viability gap after grant funding). The viability gap is proposed to be funded by direct loans as well as tax free municipal bonds that is under active consideration of both the State and the Central governments.

The basic assumptions in the financial projections are:

The property tax collection would move from Rs 320 crores in the year 2006-07 to Rs 750 Crores in the year 2015-16; this is being achieved with reforms in the property tax collection mechanism aided by GIS system for all the 100 municipal wards of BMP. The collection efficiency is estimated to go up to 85% by the year 2015-16 (the efficiency currently is 60%).

The revenue accretion from the State Government is estimated to move up from Rs 121 Crores in the year 2006-07 to Rs 302 Crores in the year 2015-16. This is based on the devolution criteria and guidelines provided by the Urban Development Department of the Government of Karnataka

Levy of storm water drain cess as a one time fee to be collected from all property owners – 10% cess on property tax paid – this would result in revenue accretion of Rs 302.50 crores over a period of 5 years

The total capital expenditure programme envisaged by BMP under JNNURM is approximately Rs 8000 crores including the basic services to urban poor component. Out of this BMP needs to mobilize Rs 4000 crores. It is assumed that BMP would arrange for term loans to the extent of Rs 1000 crores and the balance Rs 3000 crores would be obtained through issuing a series of tax free municipal bonds

Government of Karnataka would provide guarantees for the issue of municipal bonds to the extent of viability gap identified by the financial advisor

The cost of the municipal bonds is taken as 7% per annum and the bonds would be redeemed after 7 years period

The interest rate for future loans is assumed as 7.5 % per annum

The projections show a deficit in the terminal years when the bonds get redeemed; BMP proposes to identify additional sources of revenue from the year 2008-09 to improve its financial position in order to fund capital expenditure as well as honour financial commitments

The projections based on the assumptions are as follows:

## Projected Funds Flow Statement for BMP

## (Rs. In Crores)

| REVENUE | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **REVENUE RECEIPTS** | | | | | | | | | | | |
| **Tax Revenues** | | | | | | | | | | | |
| Property Tax | 320.00 | 400.00 | 450.00 | 550.00 | 650.00 | 675.00 | 700.00 | 725.00 | 750.00 | 750.00 | 750.00 |
| Advertisement Taxes | 15.47 | 16.86 | 18.55 | 20.40 | 22.44 | 24.68 | 27.15 | 29.87 | 32.86 | 36.14 | 39.75 |
| Surcharge on Stamp Duty | 15.00 | 20.00 | 22.00 | 24.20 | 26.62 | 29.28 | 32.21 | 35.43 | 38.97 | 42.87 | 47.16 |
| | 350.47 | 436.86 | 490.55 | 594.60 | 699.06 | 728.97 | 759.36 | 790.30 | 821.83 | 829.01 | 836.91 |

| **Non Tax Revenues** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Grants | | | | | | | | | | | |
| SFC Grants | 110.00 | 131.00 | 149.00 | 182.00 | 219.00 | 231.00 | 240.00 | 257.00 | 257.00 | 257.00 | 257.00 |
| Other Grants: | 11.00 | | | | | | | | | | |
| Grants towards electricity | | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| Incentivisation | | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Twelfth Finance Commission | | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| | 121.00 | 176.00 | 194.00 | 227.00 | 264.00 | 276.00 | 285.00 | 302.00 | 302.00 | 302.00 | 302.00 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Service Charges** | | | | | | | | | | | |
| Infrastructure Cess / User charges | 20.00 | - | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| SWM Cess | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 36.00 | 36.00 | 36.00 | 36.00 |
| Service chgs on Tax exempt Props | 15.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| | 65.00 | 55.00 | 75.00 | 75.00 | 75.00 | 75.00 | 75.00 | 81.00 | 81.00 | 81.00 | 81.00 |
| | | | | | | | | | | | |
| **Fees & Fines** | | | | | | | | | | | |
| Building License Fees | 5.25 | 11.60 | 11.60 | 11.60 | 11.60 | 11.60 | 11.60 | 12.76 | 12.76 | 12.76 | 12.76 |
| Compounding Fees | 4.50 | 10.00 | 11.00 | 12.10 | 13.31 | 14.64 | 16.11 | 17.72 | 19.49 | 21.44 | 23.58 |
| Development Charges | 3.00 | 8.86 | 9.75 | 10.72 | 11.79 | 12.97 | 14.27 | 15.70 | 17.27 | 18.99 | 20.89 |
| Ground Rent | 3.06 | 8.24 | 9.06 | 9.97 | 10.97 | 12.06 | 13.27 | 14.60 | 16.06 | 17.66 | 19.43 |
| Road Cutting Charges | 6.02 | 0.45 | 0.50 | 0.54 | 0.60 | 0.66 | 0.72 | 0.80 | 0.88 | 0.96 | 1.06 |
| Khata Transfer & Extract fees | 8.94 | 11.35 | 12.49 | 13.73 | 15.11 | 16.62 | 18.28 | 20.11 | 22.12 | 24.33 | 26.76 |
| Hotel / Power License Fees | 3.50 | 5.00 | 5.50 | 6.05 | 6.66 | 7.32 | 8.05 | 8.86 | 9.74 | 10.72 | 11.79 |
| Fee for Quality Control | - | 5.00 | 5.50 | 6.05 | 6.66 | 7.32 | 8.05 | 8.86 | 9.74 | 10.72 | 11.79 |
| Others | 44.94 | 24.86 | 27.35 | 30.08 | 33.09 | 36.40 | 40.04 | 44.04 | 48.45 | 53.29 | 58.62 |
| | 79.21 | 85.36 | 92.74 | 100.85 | 109.77 | 119.59 | 130.39 | 143.43 | 156.50 | 170.87 | 186.68 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Receipts from Corporation Properties** | | | | | | | | | | | |
| Rent from Shops /Leased | 9.31 | 23.50 | 23.50 | 23.50 | 23.50 | 23.50 | 23.50 | 25.85 | 25.85 | 25.85 | 25.85 |
| Others | 1.08 | 0.81 | 0.85 | 0.89 | 0.94 | 0.98 | 1.03 | 1.09 | 1.14 | 1.20 | 1.26 |
| | 10.39 | 24.31 | 24.35 | 24.39 | 24.44 | 24.48 | 24.53 | 26.94 | 26.99 | 27.05 | 27.11 |
| | | | | | | | | | | | |
| **Total Revenue Receipts** | **626.07** | **777.53** | **876.63** | **1,021.8** | **1,172.2** | **1,224.04** | **1,274.2** | **1,343.67** | **1,388.32** | **1,409.93** | **1,433.70** |

| REVENUE | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Capital Grants** | | | | | | | | | | | |
| MOU Grants | 81.90 | - | - | - | - | - | - | - | - | - | - |
| JNNURM Funds | - | 434.04 | 902.54 | 929.64 | 666.75 | 603.75 | 457.75 | | - | - | - |
| | 81.90 | 434.04 | 902.54 | 929.64 | 666.75 | 603.75 | 457.75 | - | - | - | - |
| | | | | | | | | | | | |
| **Long Term Loans** | | | | | | | | | | | |
| Loans from Financial Institutions for JNNURM matching grants | - | 108.06 | 224.70 | 231.45 | 166.00 | 150.31 | 113.96 | - | - | - | - |
| Bonds for JNNURM matching grants | | 325.98 | 677.84 | 698.20 | 500.75 | 453.44 | 343.79 | - | - | - | - |
| Loans from Financial Institutions others | 545.53 | 396.60 | - | - | - | - | - | - | - | - | - |
| | 545.53 | 830.64 | 902.54 | 929.65 | 666.75 | 603.75 | 457.75 | - | - | - | - |
| **Others** | | | | | | | | | | | |
| Improvement Charges | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 36.00 | 36.00 | 36.00 | 36.00 | 36.00 |
| Bldg Deviation Regularisation | 100.00 | 10.00 | 100.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Sale of Properties | 16.25 | 21.50 | 21.50 | 21.50 | 21.50 | 21.50 | 21.50 | 21.50 | 21.50 | 21.50 | 21.50 |
| | 146.25 | 61.50 | 151.50 | 61.50 | 61.50 | 61.50 | 67.50 | 67.50 | 67.50 | 67.50 | 67.50 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Capital Receipts** | **773.68** | **1,326.1** | **1,956.58** | **1,920.7** | **1,395.0** | **1,269.00** | **983.00** | **67.50** | **67.50** | **67.50** | **67.50** |

**Other Receipts**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cesses collected on Property Tax | 108.80 | 136.00 | 153.00 | 187.00 | 221.00 | 229.50 | 238.00 | 246.50 | 255.00 | 255.00 | 255.00 |
| Storm Water Drain Cess | | | 45.00 | 55.00 | 65.00 | 67.50 | 70.00 | | | | |
| Deposits, Statutory Deductions etc | 52.45 | 62.14 | 143.48 | 143.48 | 143.48 | 143.48 | 143.48 | 20.00 | 20.00 | 20.00 | 20.00 |
| | | | | | | | | | | | |
| | 161.25 | 198.14 | 341.48 | 385.48 | 429.48 | 440.48 | 451.48 | 266.50 | 275.00 | 275.00 | 275.00 |
| **TOTAL RECEIPTS** | **1,561.00** | **2,301.85** | **3,174.68** | **3,328.11** | **2,996.75** | **2,933.52** | **2,708.76** | **1,677.67** | **1,730.82** | **1,752.43** | **1,776.20** |

| EXPENDITURE | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Administrative Expenses** | | | | | | | | | | | |
| **Salaries** | | | | | | | | | | | |
| Pay of Officers | 6.26 | 5.81 | 6.39 | 7.03 | 7.73 | 8.51 | 9.36 | 10.29 | 11.32 | 12.45 | 13.70 |
| Pay of Establishment | 62.37 | 72.74 | 80.01 | 88.02 | 96.82 | 106.50 | 117.15 | 128.86 | 141.75 | 155.92 | 171.52 |
| Allowances | 63.00 | 64.18 | 70.60 | 77.66 | 85.42 | 93.97 | 103.36 | 113.70 | 125.07 | 137.58 | 151.33 |
| Pension / Gratuity | 30.50 | 34.50 | 37.95 | 41.75 | 45.92 | 50.51 | 55.56 | 61.12 | 67.23 | 73.95 | 81.35 |
| | 162.13 | 177.23 | 194.95 | 214.45 | 235.89 | 259.48 | 285.43 | 313.97 | 345.37 | 379.91 | 417.90 |
| | | | | | | | | | | | |
| Advertisement & Publicity | 2.12 | 2.33 | 2.80 | 3.36 | 4.03 | 4.83 | 5.80 | 6.96 | 8.35 | 3.08 | 3.69 |
| Printing & Stationery | 3.25 | 1.58 | 1.74 | 1.91 | 2.10 | 2.31 | 2.54 | 2.80 | 3.08 | 3.39 | 3.73 |
| Telephone Charges | 0.84 | 1.19 | 1.25 | 1.31 | 1.38 | 1.45 | 1.52 | 1.59 | 1.67 | 1.76 | 1.85 |
| Electricity Charges | 30.54 | 25.60 | 26.88 | 28.22 | 29.64 | 31.12 | 32.67 | 34.31 | 36.02 | 37.82 | 39.71 |
| Water Charges | 4.30 | 2.20 | 2.31 | 2.43 | 2.55 | 2.67 | 2.81 | 2.95 | 3.10 | 3.25 | 3.41 |
| Council related Expenditure | 3.90 | 5.49 | 5.76 | 6.05 | 6.36 | 6.67 | 7.01 | 7.36 | 7.72 | 8.11 | 8.52 |
| Office Infrastructure | 3.98 | 4.61 | 4.84 | 5.08 | 5.34 | 5.60 | 5.88 | 6.18 | 6.49 | 6.81 | 7.15 |
| Vehicles - M & R Cost | 10.03 | 10.25 | 10.76 | 11.30 | 11.87 | 12.46 | 13.08 | 13.74 | 14.42 | 15.14 | 15.90 |
| Other Expenses | 93.63 | 65.66 | 68.95 | 72.40 | 76.02 | 79.82 | 83.81 | 88.00 | 92.40 | 97.02 | 101.87 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 152.59 | 118.91 | 125.29 | 132.06 | 139.26 | 146.93 | 155.12 | 163.87 | 173.25 | 176.38 | 185.83 |
| | | | | | | | | | | | |
| **Welfare Activities** | | | | | | | | | | | |
| 18% Allocation | 14.53 | 27.76 | 27.76 | 27.76 | 27.76 | 27.76 | 27.76 | 27.76 | 27.76 | 27.76 | 27.76 |
| Backward Classes & Minority Welfare | 2.58 | 11.35 | 11.35 | 11.35 | 11.35 | 11.35 | 11.35 | 11.35 | 11.35 | 11.35 | 11.35 |
| Women Welfare | 6.48 | 4.99 | 4.99 | 4.99 | 4.99 | 4.99 | 4.99 | 4.99 | 4.99 | 4.99 | 4.99 |
| General | 0.70 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 |
| | 24.29 | 44.90 | 44.90 | 44.90 | 44.90 | 44.90 | 44.90 | 44.90 | 44.90 | 44.90 | 44.90 |
| **Educational Promotion Activities** | | | | | | | | | | | |
| 18% allocation | 2.02 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| General | 3.47 | 7.20 | 7.78 | 7.78 | 7.78 | 7.78 | 7.78 | 7.78 | 7.78 | 7.78 | 7.78 |
| Sports Activities | 1.55 | 1.07 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 |
| | 7.04 | 8.47 | 9.50 | 9.50 | 9.50 | 9.50 | 9.50 | 9.50 | 9.50 | 9.50 | 9.50 |

**Health & Sanitation**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cleaning of Garbage | 40.00 | 50.00 | 52.50 | 55.13 | 57.88 | 60.78 | 63.81 | 67.00 | 70.36 | 73.87 | 77.57 |
| Decentralised Composting | 0.10 | 0.10 | 0.11 | 0.11 | 0.12 | 0.12 | 0.13 | 0.13 | 0.14 | 0.15 | 0.16 |
| Street Dog Management | 0.85 | 1.50 | 1.58 | 1.65 | 1.74 | 1.82 | 1.91 | 2.01 | 2.11 | 2.22 | 2.33 |
| Tipping Fees | 2.50 | 2.00 | 2.10 | 2.21 | 2.32 | 2.43 | 2.55 | 2.68 | 2.81 | 2.95 | 3.10 |
| Others | 3.95 | 15.61 | 16.39 | 17.21 | 18.07 | 18.97 | 19.92 | 20.92 | 21.96 | 23.06 | 24.22 |
| | 47.40 | 69.21 | 72.67 | 76.30 | 80.12 | 84.13 | 88.33 | 92.75 | 97.39 | 102.25 | 107.37 |
| **EXPENDITURE** | **2005-06** | **2006-07** | **2007-08** | **2008-09** | **2009-10** | **2010-11** | **2011-12** | **2012-13** | **2013-14** | **2014-15** | **2015-16** |

**Financial Expenses**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Interest on Loans | 76.51 | 120.61 | 147.68 | 220.20 | 278.55 | 320.47 | 355.84 | 385.78 | 364.64 | 304.37 | 237.50 |
| Interest on Municipal Bonds | - | 21.00 | 63.00 | 112.00 | 147.00 | 178.50 | 199.50 | 199.50 | 199.50 | 178.50 | 136.50 |
| | 76.51 | 141.61 | 210.68 | 332.20 | 425.55 | 498.97 | 555.34 | 585.28 | 564.14 | 482.87 | 374.00 |
| | | | | | | | | | | | |
| **Total Revenue Expenditure** | **469.96** | **560.33** | **657.99** | **809.42** | **935.23** | **1,043.91** | **1,138.62** | **1,210.27** | **1,234.55** | **1,195.81** | **1,139.50** |

**CAPITAL EXPENDITURE**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Public Works** | | | | | | | | | | | |
| Solid Waste Management | 7.90 | 6.60 | 6.93 | 7.28 | 7.64 | 8.02 | 8.42 | 8.84 | 9.29 | 9.75 | 10.24 |
| Engineering - Zonal | 462.44 | 383.19 | 25.00 | 26.25 | 27.56 | 28.94 | 30.39 | 31.91 | 33.50 | 35.18 | 36.94 |
| Multi Purpose Engg Divisions | 33.77 | 29.55 | 20.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Projects | 138.27 | | | | | | | | | | |
| Infrastructure | 134.37 | | | | | | | | | | |
| Comprehensive Development Plan | 43.60 | | | | | | | | | | |
| **Storm Water Drain Network** | | | | | | | | | | | |
| Challaghatta Valley | | 49.93 | 49.93 | 24.97 | - | - | - | - | - | - | - |
| Hebbal Valley | | 76.05 | 76.05 | 38.03 | - | - | - | - | - | - | - |
| Koramangala Valley | | 47.37 | 47.37 | 23.69 | - | - | - | - | - | - | - |
| Vrishabhavathi valley | | 98.22 | 98.22 | 49.11 | - | - | - | - | - | - | - |
| **Sub-total for four valleys** | | **271.57** | **271.57** | **135.79** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| **Extension work into CMC areas** | | **86.00** | **106.00** | **106.00** | **106.00** | **106.00** | **-** | **-** | **-** | **-** | **-** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Environment Management** | | | | | | | | | | | |
| Tanks | | 15.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | - | - | - | - |
| Parks | | 15.00 | 8.00 | 8.00 | 7.00 | 6.00 | 6.00 | - | - | - | - |
| Incinerator, Crematorium and Abattoirs | | 9.00 | 16.00 | 16.00 | 17.00 | 17.00 | 16.00 | - | - | - | - |
| Tree Plantation and Nurseries | | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | - | - | - | - |
| **Urban Renewal** | | | | | | | | | | | |
| Decongestion | | | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | - | - | - | - |
| Development of CBD | | | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | - | - | - | - |
| | | | | | | | | | | | |
| **Road Network** | | | | | | | | | | | |
| Arterial and Sub arterial roads | | 125.00 | 150.00 | 400.00 | 325.00 | 250.00 | 250.00 | - | - | - | - |
| * **Includes IT/BT, Flood damaged roads** | | | | | | | | | | | |
| Grade Separators | | 120.00 | 200.00 | 150.00 | 150.00 | 200.00 | 80.00 | - | - | - | - |
| Pedestrian subways | | 5.00 | 15.00 | 15.00 | 15.00 | 15.00 | 10.00 | - | - | - | - |
| Foot Over Bridges | | - | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | - | - | - | - |
| Foot Path improvements | | - | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | - | - | - | - |
| Internal Core Ring Road | | | 200.00 | 200.00 | | - | - | - | - | - | - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Road Widening | | 120.00 | 180.00 | 180.00 | 110.00 | 110.00 | 100.00 | - | - | - | - |
| **Waste Management** | | | | | | | | | | | |
| Scientific Land fill stations at Mandur, Mavallipura, Manavarthekaval and near Ramanagaram | | - | 175.00 | 70.00 | - | - | - | - | - | - | - |
| Transfer stations | | - | 40.00 | 35.00 | 60.00 | 60.00 | 60.00 | - | - | - | - |
| Basic Services to Urban Poor | - | 100.00 | 350.00 | 450.00 | 450.00 | 350.00 | 300.00 | - | - | - | - |
| Traffic Engineering Cell | 14.91 | 43.85 | | | | | | | | | |
| Electrical Engg | 23.72 | 34.40 | 42.40 | 42.40 | 42.40 | 42.40 | 42.40 | 42.40 | 42.40 | 42.40 | 42.40 |
| Horticulture | 56.84 | 28.72 | 30.16 | 31.66 | 33.25 | 34.91 | 36.65 | 38.49 | 40.41 | 42.43 | 44.55 |
| | **915.82** | **1,665.96** | **2,201.13** | **2,112.66** | **1,454.35** | **1,331.77** | **1,043.37** | **131.64** | **135.60** | **139.76** | **144.13** |
| **Repayment of Long Term Liabilities** | | | | | | | | | | | |
| Repayment of Loans to Fin Instns | 70.18 | 112.46 | 160.59 | 216.36 | 257.10 | 280.35 | 289.54 | 207.18 | 146.27 | 108.88 | 78.63 |
| Repayment of Municipal Bonds | - | - | - | - | - | - | - | - | 300.00 | 600.00 | 700.00 |
| | 70.18 | 112.46 | 160.59 | 216.36 | 257.10 | 280.35 | 289.54 | 207.18 | 446.27 | 708.88 | 778.63 |
| | | | | | | | | | | | |
| **Total Capital Expenditure** | **986.00** | **1,778.42** | **2,361.72** | **2,329.03** | **1,711.45** | **1,612.12** | **1,332.91** | **338.82** | **581.88** | **848.64** | **922.76** |
| | | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Other Payments** | | | | | | | | | | | |
| Repayment of Cesses - Current | 27.84 | 36.00 | 114.75 | 140.25 | 165.75 | 172.13 | 178.50 | 184.88 | 191.25 | 191.25 | 191.25 |
| Repayment of Cesses - Arrears | - | 32.73 | - | - | - | - | - | - | - | - | - |
| Repayment of Statutory Deductions / Deposits | 41.52 | 45.48 | 43.04 | 43.04 | 100.43 | 100.43 | 100.43 | 14.00 | 14.00 | 14.00 | 14.00 |
| | 69.36 | 114.21 | 157.79 | 183.29 | 266.18 | 272.56 | 278.93 | 198.88 | 205.25 | 205.25 | 205.25 |
| | | | | | | | | | | | |
| **TOTAL PAYMENTS** | **1,525.32** | **2,452.97** | **3,177.51** | **3,321.74** | **2,912.86** | **2,928.59** | **2,750.46** | **1,747.97** | **2,021.67** | **2,249.69** | **2,267.51** |
| | | | | | | | | | | | |
| **Net Surplus / Deficit** | **35.68** | **(151.12)** | **(2.82)** | **6.38** | **83.89** | **4.93** | **(41.70)** | **(70.30)** | **(290.85)** | **(497.26)** | **(491.31)** |

# CHAPTER - 10

## IMPLEMENTATION PLAN

### 10.1 INTRODUCTION:

This chapter provides a strategic framework to ensure that the Remodeling of storm water drain project proposed for Bangalore city is managed in a reliable, affordable, sustainable and environmentally friendly manner, and which is most essential for success of any project.

But from the existing management practices followed by the stakeholders and also with the prevailing site conditions, it appears that, along with the resources required to achieve the recommended targets, strategies and actions, they also needs to adopt best storm drain management practices, improvised construction and construction supervision techniques, strengthened organizational setup, major legislative changes, coordination with other stakeholders, public awareness campaigns including their participation to minimize the adverse implications on storm drain functionality and storm drain management practice in the city.

In order to achieve the overall objectives of the project, it is very much essential to have a proper implementation programme that could ensure better control over the project cost and resources mobilized etc. BMP also proposes to have a separate project implementation unit within BMP (other than members from stake holders dept.), headed by a senior officer from the Engineering wing, Revenue wing, consortia of Technical consultants, Financial advisors, Project management consultants, co ordination committee members (other stake holders dept. members), PRO's & NGO's.

## 10.2 STAGES OF THE PROJECT:

The proposed project is take up in two stages and it is proposed that Stage – I activities will be carried out by external Technical Consultants and Stage – II activities shall be monitored by the design consultants and the same will be over seen by BMP.

### Stage – I PREPARATION OF DETAILED PROJECT REPORT:

**Phase 1:** Technical, Economical and Environmental Feasibility Study of the Project of Remodeling of the Storm Water Drain System.

**Phase 2:** Detailed engineering design, preparation of tender documents, cost estimates for the remodeling work, Preparation of Bid document and assist BMP to entrust the work to experienced, competent and successful agency.

A brief scope of assignment to be rendered by the Technical Consultants is given below:

- Detailed topographical and geo-technical survey
- Assessment of quantity of runoff
- Adequacy analysis of existing drains
- Hydraulic and structural designs and drawings
- Cost estimation and Bill of Quantities
- Technical specifications.
- Bid Documents
- Slicing and Packaging (Phasing for Implementation)
- Assistance in Inviting and evaluating Bids
- Project management and Quality assurance

The outline methodology Phase – I & Phase- II works & activity bar chart for Stage – I works is enclosed in this chapter as Fig. 10.1, Fig. 10.2 & Fig. 10.3.

### Stage – II PROJECT IMPLEMENTATION:

The works envisaged in the project are grouped into 16 packages and each package costing around Rs. 20 Crores.

The details of the works identified are narrated in detail in the previous chapters and the summary of the same is indicated packages are as mentioned in the Table 10.1. and the same is depicted in Figure no. 10.4.

| Name of the Valley | Drain Length, (Km.) | | Total No. of Culverts/Bridges Considered for Remodelling | Tender Package No. |
|---|---|---|---|---|
| | Primary | Secondary | | |
| **Koramangala Valley** | | | | |
| Koramangala Main Valley | 12.000 | 17.710 | 12 | K1VD – I, K1VD- II & K1VD- IV |
| Tavarekere Valley | 7.650 | 18.825 | 9 | K2VD - III |
| **Challaghatta Valley** | | | | |
| Challaghatta Main Valley | 12.000 | 13.400 | 14 | C1VD - II & C1VD- III |
| Ulsoor Valley | 4.150 | 4.170 | 9 | C2VD - I |
| **Hebbal Valley** | | | | |
| Hebbal Main Valley | 4.425 | 4.800 | 5 | H1VD- I |
| Hebbal Main Valley - I | 9.000 | 10.695 | 6 | H2VD- II |
| Hebbal Minor Valley - I | 7.375 | 9.330 | 16 | H3VD- III |
| Hebbal Minor Valley - II | 5.000 | 0.950 | 1 | H4VD- IV |
| **Vrishabhavathi Valley** | | | | |
| Vrishabhavathi Main Valley | 14.000 | 30.945 | 18 | V1VD - I & V1VD- II |
| Kethmaranahalli & Arkavathi Valley | 13.300 | 14.675 | 15 | V2VD - III & V2VD- IV |
| Kathriguppe Valley | 4.850 | 11.400 | 6 | V3VD- V |

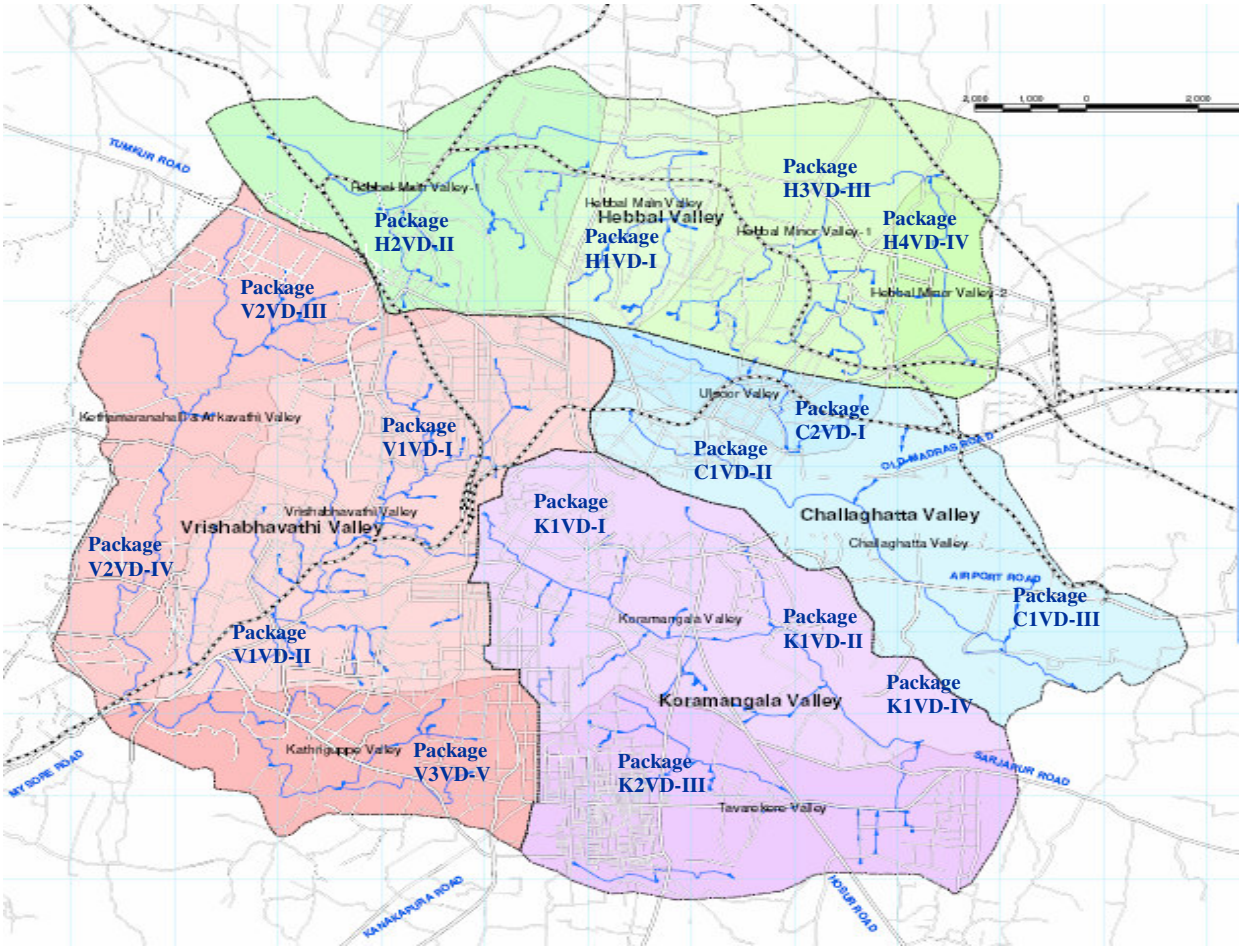


Figure 10.4 Packages Details

The site activities envisaged in all the 16 packages are classified into five categories viz'

**Rehabilitation works to existing system:**

I. Reconstruction of collapsed wall
II. Restoration of broken wall
III. Cavity filling, restoration of eroded stones, providing pointing to the existing drain walls etc.

**Carrying capacity improvement works:**

I. Widening of Drains
II. Desilting and drain deepening
III. Drain bed protection

**Remodeling of existing inadequate vent way/Structurally unstable - bridges/culverts.**

**Removal of obstacles – pipe lines, manholes, cables etc.**

**Training & Community awareness campaigns.**

The works proposed for remodeling of storm drains shall be taken up in a phased manner simultaneously in all the packages. Since, some of the critical issues like coordination from other agencies in several instances, community participation, acquisition of land from government & public, shifting of major utilities, traffic diversion at several places etc., are envisaged in all the packages.

After having several discussion with senior officials of BMP and other stake holders and beneficiaries of the project. Work programme with a broader contest has been formulated keeping in view the availability of the resources, minimum distraction to the adjoining properties, to cause less inconvenience to the public, considering the environmental aspects etc., also for smooth and successful implementation of the project, which is as narrated below,

**Brief Work Programme for Remodeling of Storm Water Drains in Bangalore City:**

- All the works considered under remodeling project shall start simultaneously from down stream end of respective packages.
- Vegetation growth noticed inside the drain at various locations shall be removed in all the packages.
- Shifting of service lines which are noticed all along the entire length of the drain at various locations, shall be taken up simultaneously in coordination with various agencies in all the packages.
- Stoppage of sewage and other undesirable liquid wastes entry into storm drains which are noticed over the entire length shall be taken up simultaneously in all the packages.
- Desilting of drains, removal of debris/solid wastes etc., which are noticed over the entire length of storm drain, shall be taken up simultaneously in all the packages.
- Widening of storm drains at the critical reaches, which are identified at various locations under the project, shall be taken up simultaneously in all the packages.
- Culvert/bridges considered for remodeling under the project, at various locations shall be taken up simultaneously in all the packages.
- Construction of new drains considered for minimizing the flooding problems in low lying areas which are spread over at various locations shall be taken up simultaneously in all the packages.
- Reaches of existing drain walls proposed for reconstruction/restoration under the project at various locations in the entire length of drain, shall be taken up simultaneously in all the packages.
- Providing rehabilitation works to existing drain walls and other structures considered under the project at various locations, shall be taken up simultaneously in all the packages.
- Construction of new drain wall / stone revetment in the reaches identified at various locations under the project shall be taken up simultaneously in all the packages.
- Providing pointing and skin reinforcement to the entire length of existing SSM storm drain walls shall be taken up simultaneously in all the packages.

- Construction of water recharging structures and development of land along side of the drain shall be taken up simultaneously in all the packages.
- Providing bed protection to the entire length of storm drains shall be taken up simultaneously in all the packages.
- Restoration of roads, cross drains and other infrastructure facilities, after completion of the works at various locations, shall be taken up simultaneously in all the packages.
- Providing improvements works at along side of the storm drains, shall be taken up simultaneously in all the packages.
- Periodic maintenance of storm drainage system shall be taken up for the entire length of the drains in all the packages.

## 10.3 IMPLEMENTATION PROGRAMME:

It is estimated that the work envisaged under remodeling of storm water drain project would involve period of 24 months from bidding with first six months dedicated to tender process and award of contract, which will be done as per KTTP act and 18 months for the execution of civil works.

It is proposed that BMP, the nodal agency will set up a separate implementation unit whose responsibilities would include ensuring the deployment of adequate staff, usage of quality materials, construction practices of acceptable standards and quality of works carried out, monitoring and reporting the project progress to the project monitoring agencies.

Tender specifications and construction practices are reflected in the bid document issued by BMP for its works related to construction of system components. The contractor would also adhere to the environmental regulations in practices and keep the citizens informed of the scheduled of the project underway in a periodic manner.

Detailed item wise implementation schedule for the execution of the project is enclosed in this report.