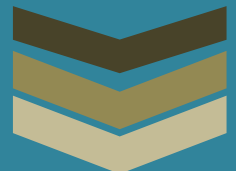


PROJECT MANAGEMENT CONSULTANCY FOR IMPLEMENTATION OF SMART CITY MISSION PROJECTS FOR MANGALURU CITY

DETAILED PROJECT REPORT –

UNDERGROUND DRAINAGE NETWORK IN ZONE V & VI

VOLUME I



The purpose of the Detailed Project Report is to provide details of various considerations made towards the elements proposed for the project as mentioned in the title above. It aims to give a basic design idea to all the stakeholders before proceeding for final design and estimates

**MANGALORE SMART CITY
PROJECT**

Lalbaug, M.G. Road, Mangalore
– 575003

1/18/2019

ISSUE AND REVISION RECORD

| Revision | Date | Originator | Checker | Approver | Description | Standard |
|----------|-----------|--------------------|---------------|------------------------------------|-------------------------------|----------|
| 0 | 1/18/2018 | WTESL/LBI/ CDAC | URVI BHATT | URVI BHATT/ KAVITA WAKADE | DETAILED PROJECT REPORT | |

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ABBREVIATIONS

| | |
|---------|--|
| ABD | Area Based Development |
| ADB | Asian Development Bank |
| BOD | Biological Oxygen Demand |
| BOQ | Bill of Quantities |
| COD | Chemical Oxygen Demand |
| CPHEEO | Central Public Health and Environmental Engineering Organisation |
| DO | Dissolved Oxygen |
| DPR | Detailed Project Report |
| GoI | Government of India |
| GoK | Government of Karnataka |
| KIUWMIP | Karnataka Integrated Urban Water Management Investment Programme |
| KUDCEMP | Karnataka Urban Development and Coastal Environmental Management Project |
| KUIDFC | Karnataka Urban Infrastructure Development & Finance Corporation Limited |
| LPCD | Litres Per Capita per Day |
| MCC | Mangaluru City Corporation |
| MSCL | Mangaluru Smart City Limited |
| MSEZL | Mangalore Special Economic Zone |
| PMC | Project Management Consultants |
| PWD | Public Works Department |
| RCC | Reinforced Cement Concrete |
| RFP | Request for Proposal |
| SCP | Smart City Proposal |
| SPV | Special Purpose Vehicle |
| SCP | Smart City Proposal |
| SOR | Schedule of Rates |
| UGD | Underground Drainage |
| UPVC | Unplasticized Poly Vinyl Chloride |

EXECUTIVE SUMMARY

Karnataka Urban Infrastructure Development & Finance Corporation Limited (KUIDFC) is the State Level Nodal Agency (SLNA) for the Smart Cities Mission in Karnataka. ***Mangaluru was a proud Participant in second round of this Challenge and now aspires to translate the vision i.e. the broad components across both ‘area-based’ and ‘pan-city’ heads identified in the Smart City Proposal (SCP) into Reality.***

Mangaluru Smart City Proposals (SCP) is considered as Area Based Development Proposals (ABD) and Pan City Proposals. The SCP has identified 65 projects/sub projects to be taken up under ABD and Pan City Proposal. Underground drainage scheme for ABD area is one among these projects.

“100% Underground Drainage Network in ABD Area is one of the projects proposed in SCP”. Mangalore City has 10 sewerage zones, out of which ***Zone IV (Full), Zone VI (Full), Zone III (Part) and Zone V (Part) are part of ABD Area*** and proposed to be taken up under Smart City Mission. Further, the ADB and AMRUT Schemes also are under various stages of implementation in the city. Hence, the ***scope under Smart city*** will be restricted to works not being taken up under ADB and AMRUT, and ***includes design of Laterals, mains, and trunk sewer lines in the Zones falling within ABD Area.***

Owing to its rolling terrain and topographical constraints, Mangalore has adopted a decentralized approach in planning of its sewerage Network.

Zone IV and Zone III had been identified and taken up as a priority, owing to other infrastructure and smart road works taken up in this area.

The projected design population for Zone IV is 25,061 with an estimated sewage flow is 3.38 MLD (including infiltration). The projected design population for Zone III is 152,449 with an estimated sewage flow is 43.28 MLD (including infiltration).

The DPR for Zone IV (Part-I) covers **4.5km** laterals to be replaced for the estimated cost of **4.99 crores**. This DPR is technically sanctioned and tendered and work is in progress. Refer Annexure-II for the details of this DPR.

The DPR for Zone IV (Part-II) and Zone III (Part-I) covers **6.37km** in Zone IV and **1.67km** in Zone III totaling to **8.04km**. These laterals are to be replaced for the estimated cost of **9.50 crores**. This DPR is technically sanctioned and tender is in process. Refer Annexure-III for the details of this DPR.

The DPR for Zone III (Part-II) covers **2.60km** laterals to be replaced for the estimated cost of **3.00 crores**. This DPR is technically sanctioned and tender is in process. Refer Annexure-IV for the details of this DPR.

The current DPR covers Design towards Replacements of Sewerage Network in Zone V and Zone VI as indicated in the subsequent sections of the DPR.

The total budget allocated as per SCP for ***“100% underground Drainage Network in ABD Area” is INR 37.5 Cr.***

The rates adopted in the estimates are as per **Schedule of Rates of PWD**, South Zone (2016-17), **KUWSDB, Bangalore**, (2015-16) and **BWSSB** (16-17).

The guidelines provided by the chief Engineer is followed for the Ad-hoc weightage for Roads and Buildings and area weightage is considered as per the directions in the Schedule of Rates 2016-17, Dated 18-12-2017.

The estimated cost of works for Zone V and Zone VI taken up under current DPR is INR 25.20 Cr.

1. INTRODUCTION

1.1. Mangaluru Smart City Proposal

Karnataka Urban Infrastructure Development & Finance Corporation Limited (KUIDFC) is the State Level Nodal Agency (SLNA) for the Smart Cities Mission in Karnataka. ***Mangaluru was a proud Participant in second round of this Challenge and now aspires to translate the vision i.e. the broad components across both ‘area-based’ and ‘pan-city’ heads identified in the Smart City Proposal (SCP) into Reality.***

Mangaluru Smart City Proposals (SCP) is considered as Area Based Development Proposals (ABD) and Pan City Proposals. The SCP has identified 65 projects/sub projects to be taken up under ABD and Pan City Proposal. Underground drainage scheme for ABD area is one among these projects.

“100% Underground Drainage Network in ABD Area is one of the projects proposed in SCP”.

Figure 1-1 shows the ABD area considered under Mangaluru Smart City Proposal



Figure 1-1 ABD area considered under Mangaluru Smart City

The scope of work includes

- Carrying out Topographical Survey for the identified project components to meet the intended objective of the city.
- Prepare necessary designs, drawings, BOQ including cost estimates for obtaining necessary approvals from the concerned authorities.
- Preparation of tender documents for the project components including tender evaluation, negotiation and
- Implementation of the project in the role of PMC (Project Management Consultants)

1.2. Necessity of Underground drainage scheme

The rapid growth and habitation development in the ABD area demands for the improvements in urban infrastructure like water supply, sewerage system, road networks and storm-water drains etc. The infrastructure development in any town has to be executed in a planned manner and has to be consistent with the pace of development that has taken place in those areas during the past years. Considering the population growth there is a need for sustainable schemes sewerage on long term basis.

Majority of the underground drainage system in the ABD area had been executed under the 1961 scheme by Public Health Department. The underground drainage system is exhausted/lived its design life and a necessity has arisen to replace the existing lines with the new pipelines. Considering the above conditions, the Government of Karnataka has decided to take up underground drainage system for the ABD area of Mangalore under Smart city.

In order to achieve this objective, GoI / GoK in its Smart city program, has approved a underground drainage project to Mangaluru Municipal Corporation for an estimated cost of 37.5 crores to meet the intended objective.

Mangalore City has 10 sewerage zones, out of which **Zone IV (Full), Zone VI (Full), Zone III (Part) and Zone V (Part) are part of ABD Area** and proposed to be taken up under Smart City Mission. Further, the ADB and AMRUT Schemes also are under various stages of implementation in the city. Hence, the **scope under Smart city** will be restricted to works not being taken up under ADB and AMRUT, and **includes design of Laterals, mains, and trunk sewer lines in the Zones falling within ABD Area.**

Owing to its rolling terrain and topographical constraints, Mangalore has adopted a decentralized approach in planning of its sewerage Network.

The projected design population for Zone V is 87,069 with an estimated sewage flow is 25.95 MLD (including infiltration). The Total Road Length in Zone V is 22 Km

The current DPR covers Design towards Replacements of Sewerage Network in Zone V for a total length of 22 km which is 81.8% of the total road length as indicated in the subsequent sections of the DPR.

1.3. Objective of the Report

The objective of the consultancy assignment is to prepare a detailed project report for underground drainage system for Mangaluru covering technical, environmental and social aspects in the ABD area of Mangaluru City Corporation as per Smart city Mission.

This Under Ground Sewerage DPR is prepared for Mangaluru City for the horizon year 2048. The project proposals are in accordance with the guidelines issued by GOI, GOK and CPHEEO manual on waste water & Practical Hand Book on Public Health Engineering and various other relevant codes of BIS. Project report is prepared in adequate details in order to enable timely and proper implementation.

1.4. Structure of the Report

The report has been structured as following sections as detailed in subsequent chapters:

Chapter 1: Introduction

Chapter 2: Baseline Assessments, Field Investigations and Surveys

Chapter 3: Population Growth Trends and Projections

Chapter 4: Design basis – Sewerage Network

Chapter 5: Design for Sewerage Network Zone IV (part 2) and Zone III (part 1)

Chapter 6: Cost Estimates

2. BASELINE ASSESSMENTS, FIELD INVESTIGATION AND SURVEYS

As mentioned in the earlier section, there are various ongoing infrastructure works in Mangaluru being taken up under ADB and AMRUT Schemes. Additional, infrastructure works are being proposed under Smart City Mission. It was pre-requisite and essential to have an overall view of these schemes, work being taken up and proposed. PMC has adopted a holistic planning approach for design of Infrastructure works in ABD Area.

Necessary Review of existing data, coordination with existing consultants of other ongoing works, Surveys and field verification has been carried out and details of the same are furnished in section below:

The Underground drainage scheme has been implemented in Mangaluru by the Public Health Department in 1961. Since then the UGD system has been extended to various parts of the city under KUDCEMP Scheme and KIUWMIP Scheme. The details of the existing UGD system under these schemes have been collected and understood through various discussion held with consultants working on works being taken up ADB and AMRUT during the co-ordination meeting held on 12-10-2017 from GKW consultants. Refer Annexure –II for the sewerage zones and replaced pumping main details under KIUWMIP Scheme.

Another proposal is to execute the trunk mains in all the sewerage zones of Mangaluru under AMRUT Scheme. This scheme is still the stage of preparation of DPR. The proposal under this scheme has been explained to the PMC during the successive co-ordination meetings. As the laying of trunk mains is under AMRUT Scheme the scope of PMC in the UGD DPR for Smart City Mission has been reduced to the laying of Sub- Mains and Laterals. The Population projections, Sewage generation and the sewage flow to wet wells in the respective sewerage zones has been shared by the GKW Consultants and the same has been verified by the PMC.

During the Co-ordination meetings held with GKW Consultants along with the MCC authorities it was agreed by the PMC to adopt the existing sewerage zones for the routing of laterals. This approach has been followed with an intention to not to disturb the inflow to wetwell as 20 wetwells were re-constructed during the KUDCEM 2006-07 Scheme. However PMC has suggested that the sewage flow from ABD area shall be diverted to the STP of 20 MLD capacity at Bajal rather than being pumped to Kavoor STP. The proposed pumping alignment to Kavoor STP involves the pumping of sewer to an elevation upto 23m and further to the STP at Kavoor which is at a lower elevation. Considering the economics of pumping main and the operation &

maintenance involved this option has been suggested and the same has been agreed by the MCC authorities.

The invert levels of the trunk mains are a pre-requisite to connect the laterals to trunk mains. The details of trunk mains to be executed under AMRUT scheme was shared with the PMC in the co-ordination meeting with GKW Consultants held on 01-01-2018. During the subsequent discussions it was also conveyed to the PMC that the laterals are being laid in some parts of Zone –V and Zone-VI in convergence with other schemes. So it was discussed and concluded that laterals along these roads shall not be taken up by the PMC. Also MCC has mandated that the house service connections shall be the scope of PMC.

The current proposal of pumping alignment to Kavoor STP has been justified by existing tertiary treatment facility at Kavoor and the re-use of tertiary treated water from Kavoor STP by Mangalore SEZ. However there is Memorandum of Agreement (MOA) between the Mangalore SEZ and Mangalore City Corporation to operate and maintain three STPs at Kavoor-43.5MLD, Bajal-20 MLD and Suratkal -16.5MLD and connected wetwells on cost sharing basis 70:30 ratio respectively and in turn MSEZL will lift the secondary treated effluent from the 3 STPs at for the next 30 years. This agreement strengthens the proposal by PMC to divert the flow from ABD area to Bajal STP.

As part of the present study, PMC has reviewed the existing report on ongoing works under various schemes in ABD Area, has stakeholder's consultation with MCC, MSCL and GKW Consultants (working on ADB and AMRUT Scheme). Mentioned below is the summary of key decisions/points noted during various consultations:

- Zone IV,V,VI flow will be diverted to Bajal STP
- Zone III Flow will be diverted to Kavoor STP
- Existing sewerage Zone Boundaries will not be altered and necessary care should be taken in design that inflow to the respective wet wells in various zones remains unchanged
- Design of various works proposed under ADB and AMRUT Scheme shall be integrated while working on smart city components/works
- The sewerage network on existing/already concrete roads shall not be disturbed/ reconstructed. Hence the sewerage network shall be retained. The field verifications of the manholes on the existing concrete roads shall be carried out by PMC for its design works.
- No underground Utility shifting, unless mandated and informed by MSCL, shall be planned on already concrete roads

- Wherever, possible the sewerage Network of the Concrete road shall be connected to the nearest manholes on the asphalt road, so as to enable redesign of the same

In order to maintain uniformity of ground levels and baseline information for all infrastructure works, the population projection details adopted under the ADB and AMRUIH works has been taken forward for design of works under Smart City. Necessary validation of the same has been carried out by PMC.

Necessary field verification on the existing concrete roads has been carried out to establish a baseline for existing invert levels on the Concrete Roads.

The details of coordination meeting held for the project and the field inventory for the concrete roads covered under the scope of this DPR has been annexed to the report.



Joint Site Visit along Rosario Church Road



Joint Site Visit along Rosario Church Road



Joint Site Visit along Rosario Church Road



Joint Site Visit along Pandeshwar Road



Joint Site Visit along Goodshed Road



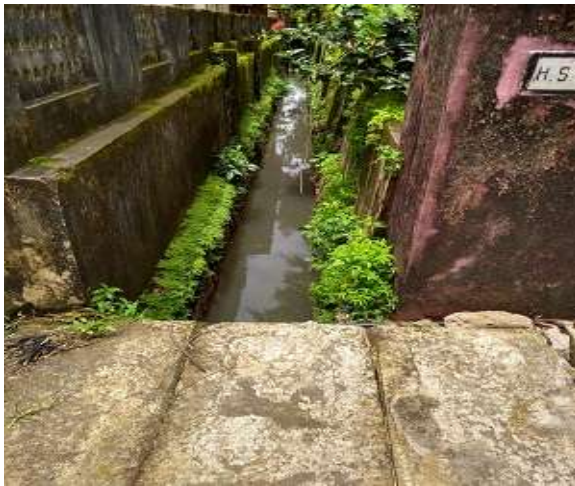
Joint Site Visit along Goodshed Road



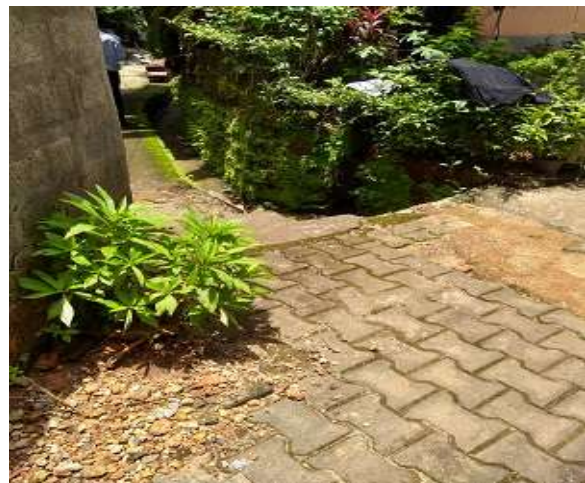
Joint Site Visit along Goodshed Road



Site inspection photos along Rosario Church Road & Hoige Bazar Cross Road



Site inspection photos of cross roads along Mangaladevi 3rd Main Road



Site inspection photos of cross roads along Amar Alva Road



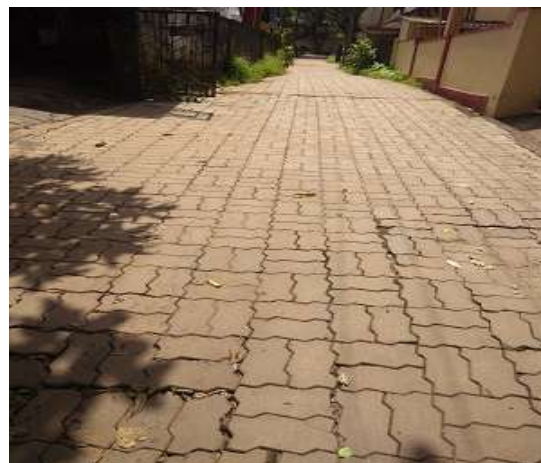
Site inspection photos of interior roads along Jaihind Road



Joint Visit along Bolar Road



Concrete Roads in which UGD is not considered



Interlock Pavements in Zone-6

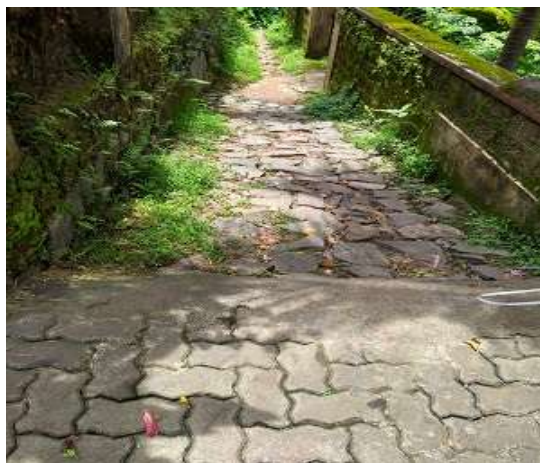


Places where UGD Lines are not considered due to operational difficulties



Site Reconnaissance in Bolar Ferry Area





Site Reconnaissance in other Parts of Zone-6





Measurement of existing inverts in Zone-6

3. POPULATION GROWTH TRENDS AND PROJECTIONS

The population details for the past census records and the projected population details has been collected as prepared for works to be taken up under KIUWMIP Scheme.

Based on review of Census information, it is understood that Mangalore has been witnessing varied growth trends from 1971-2011. While city witnessed increasing growth trend b/w 1991-2001, all other decades has witnessed as negative growth rate.

Necessary population projection has been carried out considering 2016 as Base Year. Accordingly, 2046 has been considered as the horizon year for Design Purposes. Out of the Population Projections carried out by various empirical formulas, the Geometrical Progression method was found to be best suited for the Mangaluru city and the same has been adopted for carrying out necessary design of infrastructure works

The projected population for wards falling under Zone V & Zone VI is as shown in table below:

Table 3-1 Ward wise Population Projection (Zone V Total Wards Details)

| Ward No. | Area[ha] | Population 2011 | Population Density 2011[population/ha] | Projected Population | | |
|--------------|------------|-----------------|--|----------------------|---------------|---------------|
| | | | | 2016 | 2031 | 2046 |
| 38 | 91 | 7322 | 80 | 8124 | 11096 | 15155 |
| 39 | 76 | 7740 | 102 | 8588 | 11729 | 16020 |
| 40 | 84 | 6917 | 82 | 7675 | 10482 | 14316 |
| 45 | 38 | 7449 | 196 | 8265 | 11288 | 15418 |
| 46 | 110 | 6908 | 63 | 7665 | 10469 | 14298 |
| 47 | 140 | 7998 | 57 | 8874 | 12120 | 16554 |
| 55 | 132 | 8398 | 64 | 9318 | 12727 | 17382 |
| 56 | 81 | 8216 | 101 | 9116 | 12451 | 17005 |
| 57 | 50 | 7244 | 145 | 8038 | 10978 | 14993 |
| 58 | 40 | 6378 | 159 | 7077 | 9665 | 13201 |
| Total | 842 | 74570 | 1049 | 82740 | 113005 | 154342 |

Table 3-2 Ward wise Population Projection (Zone VI Total Wards Details)

| Ward No. | Area[ha] | Population 2011 | Population Density 2011[population/ha] | Projected Population | | |
|--------------|------------|-----------------|--|----------------------|--------------|--------------|
| | | | | 2016 | 2031 | 2046 |
| 55 | 132 | 8398 | 64 | 9318 | 12727 | 17382 |
| 56 | 81 | 8216 | 101 | 9116 | 12451 | 17005 |
| 57 | 50 | 7244 | 145 | 8038 | 10978 | 14993 |
| 58 | 40 | 6378 | 159 | 7077 | 9665 | 13201 |
| Total | 303 | 30236 | 469 | 33549 | 45821 | 62581 |

There are some wards for where only portion/part is covered in Zone V & Zone VI.
The design population of further working has been taken up accordingly

The total population taking into consideration for design of ZoneV is 87,069 and the total sewage design flow for horizon period (2046) is 25.95 MLD (including infiltration).

The total population taking into consideration for design of Zone VI is 25,739 and the total sewage design flow for horizon period (2046) is 7.42 MLD (including infiltration).

4. DESIGN BASIS – SEWERAGE NETWORK

4.1. Introduction

This section gives the design criteria proposed for the design of various components of the Sewerage system. The broad objective of this section of the report is to determine a technically and economically viable Sewerage Design to be adopted for Mangaluru

The primary scope of the report is to establish the Design basis for the laterals in sewerage system of Mangaluru Municipal Corporation (ABD Area). The Design basis report shall be based on assessment on:

- Evaluating various technologies of sewerage collection
- Per capita sewage and effluent generation
- Peak flow
- Minimum and Maximum velocity of flow
- Flow conditions for various size of pipes
- Material of pipe
- Minimum depth of sewer
- Maximum depth in relation to water table
- Infiltration factor
- Formula for calculation for design of sewer

4.2. Selection of appropriate System

Sewer networks are planned & designed to achieve its intended objective throughout its lifetime without any risk to public health, public safety & environment. The laterals of Sewerage system for the ABD area in Mangaluru Municipal Corporation shall be designed for the expected sewage flows based on the estimated population and water allocation for domestic as well as other sectors such as commercial, institutional and industrial.

This section discusses about the sewerage system alternative based on type of collection system in Mangaluru Municipal Corporation. Two alternatives were studied.

4.2.1. Vacuum Sewerage System

In this system, sewage is collected from households in collection chamber / sump. When a house connection sewer is opened to atmospheric pressure in collection

chamber / sump, the pneumatic pressure-controlled vacuum valve opens and the sewage and air are pulled into the sewer due to pressure difference between valve pit (at atmospheric pressure) and at mains of sewer network (under negative pressure), whereby the air forms a “plug” in the line. Then, air pressure pushes the sewage towards the central vacuum station due to differential pressure. When the vacuum valves closes, atmospheric pressure is restored inside the valve pit. Each valve is provided with valve pit. The amount of air that enters with the sewage is controlled by the time that the valve remains open. Overall, the service lines are installed in a saw-tooth or vertical zigzag configuration so that the vacuum created at the central vacuum station is maintained throughout the network. Vacuum sewers can take advantage of available slope in the terrain, but have a limited capacity to pull water uphill. The disadvantage of this system is the need for ensuring uninterrupted power supply to the grinder pump. Hence this is perhaps limited to high profile condominiums and not the public sewer systems in India.

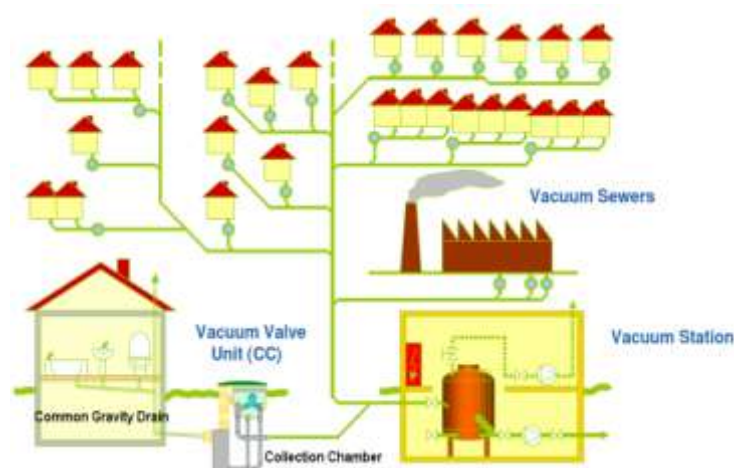


Figure 4-1 Vacuum Sewerage System

4.2.2. Conventional Sewerage System

In this system, separate sewers receive domestic sewage from the households in conduits and convey it to STP for treatment and disposal. The storm water is not collected in such conduits and hence termed as separate sewers. This type of system is conventional and is being widely used in India. The design of conventional system is based on flow in gravity sewer network, velocity, slope, sewer dia. etc.

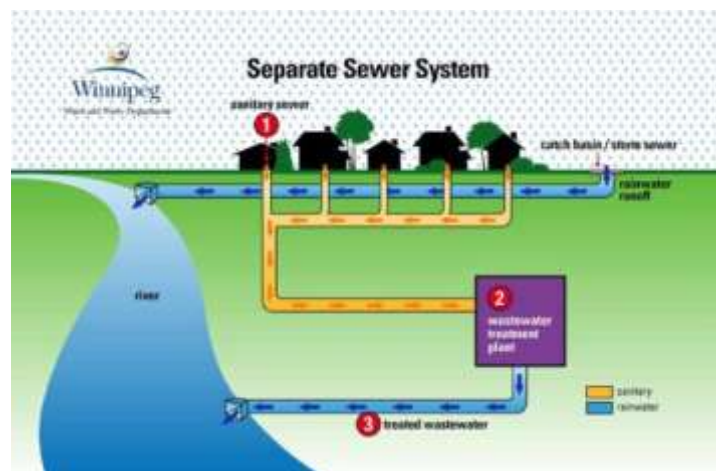


Figure 4-2 Conventional Sewerage System

4.2.3. Recommendation

As per above discussion, it is understood that vacuum sewerage system is feasible for low density developments. Also, it requires high capital cost. Further, it requires skilled manpower & machinery for maintenance of sewer network. Separate sewer system (conventional system) suitable for both high and low density developments. Also, conventional system is a cost-effective system. Hence, considering the site conditions and the cost implications, separate system is the suitable option for the sewerage system in Mangaluru City.

4.3. Design Parameters

The design basis for sewerage system design in the ABD area of Mangaluru Municipal Corporation is explained below.

4.3.1. Design Year and Population Estimation

As per CPHEEO, Under Ground Drainage (UGD) projects have to be designed for the **future 30 years**. Considering the **Base Year as 2016, the design year of sewerage system will be carried out Year 2046**

4.3.2. Design Flow

The design flow is based on the sewage expected to be generated in the year 2046. It would include domestic sewage from residential, commercial and institutional areas. Design flows are essentially peak dry weather flows which comprises peak domestic sewage flow plus infiltration.

4.3.3. Per Capita Sewage Flow

Per capita water supply rate considered for residential, institutional and for floating population is as per CPHEEO manual. Sewage generation rate is calculated for various type of population in the area. The below mentioned Table 4-1 shows the sewage generation rate to be considered for various type of population.

Table 4-1 Sewage Flow

| Sl. No. | Per capita Water demand | Return factor for potable water | Total sewage generation from water demand excluding infiltration | Remarks |
|---------|-------------------------------|------------------------------------|--|-------------------------|
| | lpcd | % | lpcd | |
| 1 | 135 | 80% | 108 | Residential |
| 2 | 45 | 80% | 36 | Commercial/ floating |

4.3.4. Rate of Infiltration

Infiltration into the Sewerage system occurs through defective sewers, manholes, etc. The rate of infiltration into sewers also depends upon the ground water table and permeability of the surrounding soil. ***In the hydraulic design of sewers, an allowance for infiltration for the project area would be considered as 500 ltr/day/manhole as per Part A of CPHEEO Manual, Nov 2013, restricting the max flow to 10% of the waste water generated within the ULB area.***

4.3.5. Peak Factors

The peak factors with respect to contributing population for domestic sewage as per CPHEEO manual, 2013 is furnished in following Table 4-2. Peak factor for population upto 20,000 is not as per CPHEEO manual, but as per Babbitt's formula

Table 4-2 Peak Factor

| Contributing Population | Peak factor |
|-------------------------|-------------|
| Upto 20,000 | 3 |
| 20,000 to 50,000 | 2.50 |
| 50,000 to 7,50,000 | 2.25 |
| Above 7,50,000 | 2.00 |

4.3.6. Frictional Loss Formula

Based on prior experience, it is proposed to use Hazen William's equation for the network analysis.

Hazen William's Equation:

$$Q = 1.292 \times 10^{(-5)} \times C \times D^{2.63} \times (H_f/L)^{0.54}$$

Where

Q= Flow (cum/hr)

D= Diameter of pipe (mm)

H_f = Head loss (m)

L= length of pipe (m)

C= Hazen William's constant.

4.3.7. Design of Sewage Collection System

Design for sewerage components will include designs for sewage collection system including pipelines, manholes, associated Civil, Mechanical, Electrical and Instrumentation equipment, etc.

Gravity sewer system will be designed up to restriction by excessive depth of cutting or by the existing topography. **The sewer network will be designed and analyzed using Sewergems V8i software.** The maximum depth of sewer will be restricted to about 6m.

4.3.8. Design Formula

Manning's formula would be adopted as per CPHEEO Manual, Nov 2013 for design of gravity sewers and explained as under-

$$Q_f = V_f \times A$$
$$V_f = \frac{1}{N} \times R^{2/3} \times S^{1/2}$$

Where,

| | | |
|----------------|---|---------------------------------------|
| Q _f | = | Flow rate (in cumec) |
| A | = | Cross sectional area of pipe (sq. m.) |
| V _f | = | Velocity (in m/s) |
| N | = | Manning's roughness coefficient |
| R | = | Hydraulic radius (m). |
| S | = | Slope of energy gradient |
| A | = | Cross sectional area of pipe (sq. m.) |

4.3.9. Pipe Material

The pipe materials often used for gravity sewers are PVC, UPVC (unplasticized Poly Vinyl Chloride), High Density Poly Ethylene (HDPE), Glass Reinforced Plastic (GRP) and Cement Concrete. The various characteristics of the pipe materials considered are given below

Table 4-3 Pipe Material for Sewer

| Sl. No. | Parameter | UPVC | RCC |
|---------|--|--|---|
| 1 | Applicable IS codes for Manufacture, Laying and Jointing, Fittings | 4985,13592 | 458, 783, 5382 |
| 2 | Sizes (mm) as per SOR | 160-315(OD) | 150-2400 (ID) |
| 3 | Lengths (m) | 3-6 | 2-2.5 |
| 4 | Weight | Light | Heavy |
| 5 | Flexibility | Maximum | Rigid |
| 6 | Available Working Pressure Range (kg/cm ²) | 10 | NA |
| 7 | Tensile Strength | 45-50MPa | NA |
| 8 | Impact Strength | Good | Medium |
| 9 | N-Value | 0.013 | 0.011 |
| 10 | Corrosion Resistance | Very Good | Normally Good but prone to attack by soils with Sulphates |
| 11 | Jointing Method | Solvent cement | S/S or Collar joints with cement mortar, rubber ring |
| 12 | General Availability in India | Available | Available |
| 13 | Availability of corrosion control techniques | NA | Use of Sulphate resisting cement, Epoxy paint |
| 14 | Ease of locating for underground pipes | Not Easy | Not Easy |
| 15 | Suitability for high ground water table | Good. Floatation risk need to be checked at certain locations | Not good |
| 16 | Suitability for high salinity in soil | Good | Not good |
| 17 | Bedding requirements | Granular material compacted to specific Proctor density. Fine sand bedding is ideal. | Granular, concrete cradle or full encasement |
| 18 | Laying speed | Fast | Slow |
| 19 | Pipe performance experience | Good with reputed manufacturers | Good with reputed manufacturers |
| 20 | Basic cost economics | Costlier than PCC | Cheaper than UPVC |

Factors affecting selection of sewer pipe material

For Gravity Sewers, selection of pipe materials for sewage conveyance will be based on following factors-

- Availability of pipe in required sizes, lengths
- Ease of handling and installation

- Physical strength
- Any special bedding requirements.
- Flow characteristics or friction coefficient.
- Joint water-tightness and ease of installation.
- Ease in Repairs and maintenance.
- Cost economics.
- Soil & Ground Water characteristics

The cost comparison of the pipes is mentioned in the table below

Table 4-4 Cost Comparison of Pipe Material

| Sewer dia (mm) | UPVC(10kg/sq.cm) | RCC NP-3 |
|--------------------|------------------|----------------|
| | Rate (Rs.) / m | Rate (Rs.) / m |
| 150/160/170 | 1450 | - |
| 200 | 1838 | - |
| 225/230 | 2225 | - |
| 250 | 3388 | 1346 |
| 280 | 4292 | - |
| 300/315 | 5455 | 1617 |
| 350/355 | - | 1679 |
| 400 | - | 1742 |
| 450 | - | 1952 |
| 500 | - | 2220 |
| 600/630 | - | 2880 |
| 700/710 | - | 3556 |
| 800 | - | 4464 |
| 900 | - | 510 |
| 1000 | - | 6258 |
| 1200 | - | 8484 |

Note: The Rates for RCC Pipes has been taken from BWSSB SOR

4.3.10. Pipe Material Recommendation

From the above cost comparison, it is evident that the cost of RCC is lower compared to UPVC. The PCC pipes are rigid pipes and have excellent load carrying capacity however it is with reinforcement. The UPVC pipes are flexible pipes and require stringent quality control for bedding and backfilling. The length of RCC pipes is relatively short (2 m to 2.5 m), which will require more number of joints affecting the speed of execution. On other hand, UPVC pipes are available of longer lengths (6 m) which will have less number of joints resulting in relatively quick execution of pipeline and less infiltration. Further UPVC material is more suitable for soils with

high salinity & for strata with high ground water table. Also, the N-value of UPVC is better than RCC pipes providing better carrying capacity of pipes for the same diameter and gradient. RCC pipes are economical compared to UPVC pipes for diameters up to 300mm. However, considering the above aspects, ***in discussions with the MCC authorities, it is recommended to use UPVC pipes for laterals upto 300mm diameter.***

4.3.11. Coefficient of Roughness

The coefficient of roughness is based on type of sewer material proposed for the sewage conveyance. ***The design value of coefficient of roughness 'n' for UPVC pipe would be considered as 0.011 as prescribed in CPHEEO manual.***

4.3.12. Bedding of Sewers

The type of bedding would primarily depend on the soil strata, depth at which sewer is laid and sewer pipe material. Bedding provision for rigid & flexible conduit is different. The type of bedding to be used for rigid conduit depends on the bedding factor as per Part A of CPHEEO Manual, Nov 2013 & mentioned in following table. Granular bedding & sand bedding are used for UPVC pipes

Table 4-5 Types of Bedding

| Bedding Factor | Type of Bedding |
|------------------|------------------------------------|
| Up to 1.9 | Granular (GRB) |
| 1.9 - 2.8 | Plain Concrete Cradle (PCCB) |
| 2.8 - 3.4 | Reinforced Concrete Cradle (RCCB) |
| > 3.4 | Complete Concrete Encasement (CCE) |

4.3.13. Minimum size of Sewers

The diameter of sewer pipe shall be considered as 200 mm as per CPHEEO Manual and for HSC 110mm dia Pipe considered.

4.3.14. Design Capacity of Sewers

Sewers shall be designed to carry estimated peak flows generated in the design year and would be ***designed 80% full at ultimate peak flow.*** This is to ensure proper ventilation and prevent septicity.

4.3.15. Self-cleansing velocity

To ensure that deposition of suspended solids does not take place, self-cleansing velocities estimated using Shield's formula shall be considered in the design of sewers.

$$V = \frac{1}{n} \times \left(R^{\frac{1}{6}} \times \sqrt{(K_s \times (S_s - 1) \times d_p)} \right)$$

Where,

- SS = Specific gravity of particle
dp = particle size in m
KS = dimensionless constant
R = Hydraulic mean radius in m
n = Manning's Coefficient

Considering typical values of particle size and specific gravity, minimum partial flow velocities is considered at present peak flows and at design peak flows. The maximum velocity shall be considered in order to prevent scouring. Following Table 4-6 shows the minimum and maximum velocities in sewer as per CPHEEO Manual, Nov 2013.

Table 4-6: Design Criteria

| Sr. No. | Criteria | Velocity (m/s) |
|---------|--|----------------|
| 1 | Minimum velocity at initial peak flow | 0.6 |
| 2 | Minimum velocity at ultimate peak flow | 0.8 |
| 3 | Maximum velocity | 3.0 |

4.3.16. Depth of Cover

To provide protection to sewers from external loads, the minimum depth of cover to be provided over the top of pipe at the **start of the sewers is 0.9 meters**

4.3.17. Manholes

RCC Circular manholes are stronger than rectangular and arch type manholes and thus are preferred. Manholes shall be provided at every change of alignment, gradient or diameter, at the head of all sewer lines and branches and at every junction of two or more sewer lines.

The Centre to Centre distance between manholes is proposed to be adopted as 30m for ease of maintenance of sewers; however, it will be finally based on sewer size. The clear opening at the top in case of ordinary manholes should be minimum 560mm. PVC encapsulated steps shall be provided at 300mm c/c inside the manhole. The size of manhole shall depend on diameter and depth of sewer.

The manhole frame and cover proposed is of Steel Fiber Reinforced Concrete (SFRC) capable of withstanding heavy duty loads, conforming to the IS: 12592-2002.

The internal diameters of manholes for varying depths are mentioned in following Table 4-7

Table 4-7: Internal diameter of sewer manholes

| Sr. No. | Manhole depth ranges | Internal diameter of sewer manholes |
|---------|----------------------|-------------------------------------|
| 1 | 0.9 – 1.50 m | 900 mm |
| 2 | 1.50 m – 3.00 m | 1200mm |
| 3 | 3.00 m – 8.00 m | 1500mm |

However, considering minimum manhole of 900 mm has been adopted in design

4.3.18. Vent Shaft

RCC vent shaft shall be provided at the starting manhole and at major junctions for ventilation and to avoid septicity and to provide escape to foul gases of sewage.

4.3.19. Sewer Network

Sewergems network model will be prepared for network analysis. Zone wise networks will be analyzed as per design criteria presented in this report. Flow to each manhole is assigned by looking into vicinity, the number and type of consumers served by a particular manhole.

Sewer network layout is planned for the project area keeping in consideration following broad principles.

- Sewers are laid along natural topography to minimize the depth of excavation and considering the soil strata.
- Laterals & sub-trunk mains layout is planned to be laid along major roads avoiding cement concrete roads.

5. PROPOSED SEWERAGE DESIGN – ZONE V & ZONE VI

5.1. General

The proposed sewerage system consists of Laterals and Sub-mains in a portion of Wards 38, 39, 40, 45, 46, 47, 55, 56, 57 and 58 in Zone-V and a portion of Wards 55, 56, 57 and 58 in Zone-VI along with the allied works in Mangaluru as per the existing Sewage Zones. Sewerage network is proposed such that the sewage flows can be collected in an integrated manner in the respective Wet wells in sewerage zones and conveyed to the existing STP for the treatment.

The sewage from Zone – V & Zone -6 will be collected and conveyed to the wet well by gravity at Pandeshwar and Mulihitlu respectively and further to the existing STP through Pumping Mains.

5.2. Sewage Generation

The sewage generation for Zone V & Zone VI for various design horizons has been assessed based on the approved unit demand norms along with the approved population projections from the competent authority.

The summary of the sewage generation calculations are provided in the **Table 5-1 & Table 5-2** below:

Table 5-1: Sewage Generation in Zone V

| Zone-5 | | | | | | | | | | | | | |
|---|----------|------------------------------|---------------------------|-----------------------------|-----------------------------------|------------------------------|---------------------------|-----------------------------|-----------------------|------------------------------|---------------------------|-----------------------------|-----------------------|
| Sl.No. | Ward Nos | 2016 | | | | 2031 | | | | 2046 | | | |
| | | Projected Population on 2016 | Percentage of area Coverd | Population Covered for Zone | Sewage Generation MLD @80% of 135 | Projected Population on 2031 | Percentage of area Coverd | Population Covered for Zone | Sewage Generation MLD | Projected Population on 2046 | Percentage of area Coverd | Population Covered for Zone | Sewage Generation MLD |
| 1 | 38 | 8124 | 53.74 | 4366 | 0.472 | 11096 | 53.74 | 5963 | 0.644 | 15155 | 53.74 | 8145 | 0.880 |
| 2 | 39 | 8588 | 33.01 | 2835 | 0.306 | 11729 | 33.01 | 3872 | 0.418 | 16020 | 33.01 | 5289 | 0.571 |
| 3 | 40 | 7675 | 41.48 | 3183 | 0.344 | 10482 | 41.48 | 4348 | 0.470 | 14316 | 41.48 | 5938 | 0.641 |
| 4 | 45 | 8265 | 86.08 | 7114 | 0.768 | 11288 | 86.08 | 9717 | 1.049 | 15418 | 86.08 | 13272 | 1.433 |
| 5 | 46 | 7665 | 80.33 | 6158 | 0.665 | 10469 | 80.33 | 8410 | 0.908 | 14298 | 80.33 | 11486 | 1.240 |
| 6 | 47 | 8874 | 99.54 | 8833 | 0.954 | 12120 | 99.54 | 12064 | 1.303 | 16554 | 99.54 | 16478 | 1.780 |
| 7 | 55 | 9318 | 33.73 | 3143 | 0.339 | 12727 | 33.73 | 4293 | 0.464 | 17382 | 33.73 | 5863 | 0.633 |
| 8 | 56 | 9116 | 73.54 | 6704 | 0.724 | 12451 | 73.54 | 9157 | 0.989 | 17005 | 73.54 | 12506 | 1.351 |
| 9 | 57 | 8038 | 42.65 | 3428 | 0.370 | 10978 | 42.65 | 4682 | 0.506 | 14993 | 42.65 | 6394 | 0.691 |
| 10 | 58 | 7077 | 12.86 | 910 | 0.098 | 9665 | 12.86 | 1243 | 0.134 | 13201 | 12.86 | 1698 | 0.183 |
| Sub Total (MLD) | | | | 46,674 | 5.041 | | | | | 63,749 | 6.885 | 87,069 | 9.403 |
| Total Infiltration 10%(MLD) | | | | 0.50 | | | | 0.69 | | | | 0.94 | |
| Total Sewage Generation in average flow (MLD) | | | | 5.54 | | | | 7.57 | | | | 10.34 | |
| Total Sewage Generation in average flow (MLD) (Bulk Consumers like Hostels, Hospital and Lodges | | | | 1.32 | | | | 1.51 | | | | 1.71 | |
| Peak Factor | | | | 2.50 | | | | 2.25 | | | | 2.25 | |
| Total Sewage Generation in Peak flow (MLD) | | | | 16.40 | | | | 19.59 | | | | 25.95 | |

Table 5-2: Sewage Generation in Zone VI

| Details of Sewage Generation for Zone-6 | | | | | | | | | | | | | |
|--|----------|------------------------------|---------------------------|-----------------------------|-----------------------------------|------------------------------|---------------------------|-----------------------------|-----------------------|------------------------------|---------------------------|-----------------------------|-----------------------|
| Zone-6 | | | | | | | | | | | | | |
| | | 2016 | | | | 2031 | | | | 2046 | | | |
| Sl. No | Ward Nos | Projected Population on 2016 | Percentage of area Coverd | Population Covered for Zone | Sewage Generation MLD @80% of 135 | Projected Population on 2031 | Percentage of area Coverd | Population Covered for Zone | Sewage Generation MLD | Projected Population on 2046 | Percentage of area Coverd | Population Covered for Zone | Sewage Generation MLD |
| 1 | 55 | 9318 | 10.83 | 1009 | 0.109 | 12727 | 10.83 | 1378 | 0.149 | 17382 | 10.83 | 1882 | 0.203 |
| 2 | 56 | 9116 | 26.46 | 2412 | 0.260 | 12451 | 26.46 | 3294 | 0.356 | 17005 | 26.46 | 4499 | 0.486 |
| 3 | 57 | 8038 | 57.35 | 4610 | 0.498 | 10978 | 57.35 | 6296 | 0.680 | 14993 | 57.35 | 8599 | 0.929 |
| 4 | 58 | 7077 | 81.50 | 5768 | 0.623 | 9665 | 81.50 | 7877 | 0.851 | 13201 | 81.50 | 10759 | 1.162 |
| Sub Total (MLD) | | | | 13,799 | 1.490 | | | 18,845 | 2.035 | | | 25,739 | 2.780 |
| Total Infiltration (MLD) (10% of the sewergae generation) | | | | | 0.15 | | | | 0.20 | | | | 0.28 |
| Total Seweage Generation in average flow (MLD) | | | | | 1.64 | | | | 2.24 | | | | 3.06 |
| Total Seweage Generation in average flow (MLD) (Bulk Consumers like Hostels, Hospital and Lodges | | | | | 0.06 | | | | 0.07 | | | | 0.08 |
| Peak Factor | | | | | 3.00 | | | | 3.00 | | | | 2.50 |
| Total Seweage Generation in Peak flow (MLD) | | | | | 4.80 | | | | 6.51 | | | | 7.42 |

5.3. Planning and Design of Proposed Sewerage Network in Zone V and VI

The aim of the UGD DPR is to perform a detailed analysis and design of UGD network. The detailed Sewerage network design has been carried out for Zone V and Zone VI in ABD area. The proposed sewerage system consist lateral and branch networks from zone V and Zone VI which connects to the wet well at Pandeshwar and Mulihitlu respectively . The sewerage system is designed using Bentley Sewer Gems V8i version software.

The sewage from the individual properties will be collected and conveyed to the wet well by gravity sewers. In the proposed system, laterals are proposed along the roads to connect sewage from Individual property chambers and it is connected to branch sewers. Branch sewers are joined to main sewers and which is connected to existing Trunk sewer. Proposed sewers are of UPVC pipes.

This DPR focuses the replacing of laterals in Zone V and Zone VI for the roads as shown in

Figure 5-1 and Figure 5-2.

Figure 5-1 Laterals to be replaced in Zone V as a part of this DPR



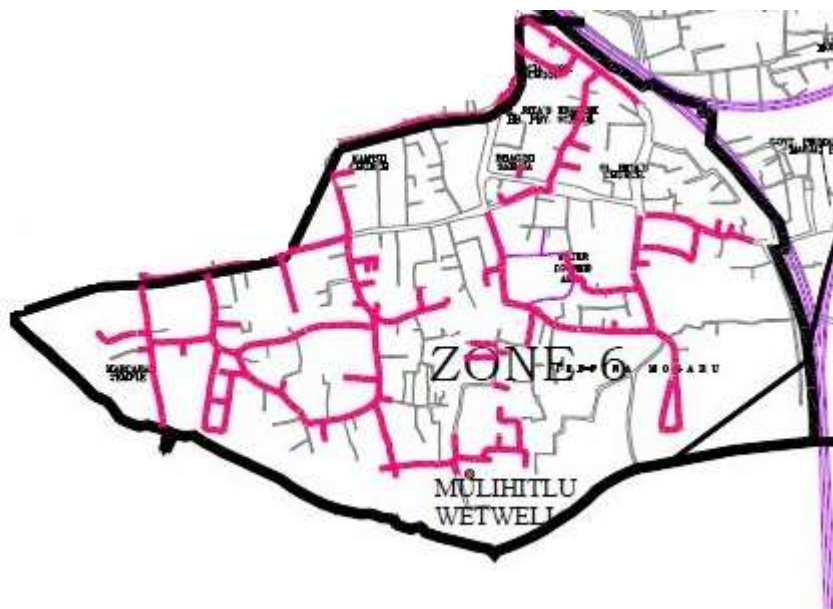


Figure 5-2 Laterals to be replaced in Zone VI as a part of this DPR

Refer **Annexure-I** for Design Report of Zone –V and Volume II for Detailed Design Drawings

5.4. Summary of Proposed Sewerage Network in Zone V and Zone VI

A. Overall Summary for Zone -V(Road Width >6m)

| Sr. No | Description | Minimum Value | Maximum Value |
|--------|----------------------------|---------------|---------------|
| 1 | Diameter (in mm) | 110 | 200 |
| 2 | Depth of Excavation (in m) | 0.90 | 4.67 |

B. Details of sewer length as per Depth of excavation in Zone -V

| Depth of Excavation | Length of Sewers (approx) Km |
|---------------------|------------------------------|
| 0-2.0m | 1.348 |
| 2.0m-4.0m | 5.442 |
| 4.0m-6.0m | 0.219 |
| 6.0m-8.0m | - |

C. Details of sewer length as per Diameter in Zone -V

| Diameter | Length of Sewers (approx) |
|----------|---------------------------|
| 200 mm | 7.009 Km |

D. Details of House Service Connections in Zone -V

| Zone | No. Of Premises | Length(km) | Depth of Excavation |
|------|-----------------|------------|---------------------|
| V | 1124 | 5.62 | 0.9 |

A. Overall Summary for Zone -V(Road Width <6m)

| Sr. No | Description | Minimum Value | Maximum Value |
|--------|----------------------------|---------------|---------------|
| 1 | Diameter (in mm) | 110 | 250 |
| 2 | Depth of Excavation (in m) | 0.90 | 4.64 |

B. Details of sewer length as per Depth of excavation in Zone -V

| Depth of Excavation | Length of Sewers (approx) Km |
|---------------------|------------------------------|
| 0-2.0m | 3.434 |
| 2.0m-4.0m | 7.227 |
| 4.0m-6.0m | 0.010 |
| 6.0m-8.0m | - |

C. Details of sewer length as per Diameter in Zone -V

| Diameter | Length of Sewers (approx) |
|--------------|---------------------------|
| 200 mm | 7.009 Km |
| 250mm | 0.472 Km |
| Total | 10.667 Km |

D. Details of House Service Connections in Zone -V

| Zone | No. Of Premises | Length(km) | Depth of Excavation |
|------|-----------------|------------|---------------------|
| V | 1760 | 8.80 | 0.9 |

A. Overall Summary for Zone -VI

| Sr. No | Description | Minimum Value | Maximum Value |
|--------|----------------------------|---------------|---------------|
| 1 | Diameter (in mm) | 110 | 200 |
| 2 | Depth of Excavation (in m) | 0.90 | 4.09 |

B. Details of sewer length as per Depth of excavation in Zone -VI

| Depth of Excavation | Length of Sewers (approx) Km |
|---------------------|------------------------------|
| 0-2.0m | 3.63 |
| 2.0m-4.0m | 0.608 |

C. Details of sewer length as per Diameter Zone -VI

| Diameter | Length of Sewers (approx) |
|----------|---------------------------|
| 200 mm | 4.280 Km |

D. Details of House Service Connections in Zone -VI

| Zone | No. Of Premises | Length(km) | Depth of Excavation |
|------|-----------------|------------|---------------------|
| VI | 856 | 4.28 | 0.9 |

6. COST ESTIMATES

6.1. Budget as per SCP

The total budget allocated as per SCP for **“100% underground Drainage Network in ABD Area”** is **INR 37.5 Cr.**

6.2. Cost Estimate

The estimated cost of works for Zone V & Zone VI taken up under current DPR is INR 25.20Cr. Summary of same is presented in Volume III of the DPR

Table 6-1 provides the abstract of cost estimate for this DPR.

Table 6-1: Cost Abstract

| DESCRIPTION | ZONE | COST IN INR |
|--|------------------------|------------------------|
| Under Ground Drainage | Zone-5(Road Width >6m) | 6,20,68,395.00 |
| | Zone-5(Road Width <6m) | 9,01,22,989.00 |
| | Zone-6 | 3,95,69,171.00 |
| Utility Shifting-Compound wall, Culvert and RCC Drain | Zone-5(Road Width >6m) | 18,40,569.00 |
| | Zone-5(Road Width <6m) | 27,03,063.00 |
| | Zone-6 | 12,26,493.00 |
| Electrical Pole Shifting | Zone-5(Road Width >6m) | 19,94,179.00 |
| | Zone-5(Road Width <6m) | 33,26,214.00 |
| | Zone-6 | 12,87,912.00 |
| Total Cost | | 20,41,38,986.00 |
| Add Tender Premium @ 10% | | 2,04,13,899.00 |
| Add Contingency @ 3% | | 61,24,170.00 |
| Taxes as applicable | | 2,44,96,678.00 |
| Administrative charges & Tender Premium @ 10% | | 18,26,268.00 |
| Grand Total | | 25,70,00,001.00 |