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

DETAILED PROJECT REPORT –

UNDERGROUND DRAINAGE NETWORK IN ZONE IV (PART I)

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

12/13/2017

ISSUE AND REVISION RECORD

Revision	Date	Originator	Checker	Approver	Description	Standard
0	13/12/2017	WTESL/LBI/ CDAC	NELSON PIAS	URVI BHATT/ KAVITA WAKADE	DETAILED PROJECT REPORT	

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXURES

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.***

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

Zone IV has been identified and taken up as a priority, owning to other infrastructure and smart road works being 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 Total Road Length in Zone IV in 21 Km

The current DPR covers Design towards Replacements of Sewerage Network in Zone IV (Part) 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 estimated cost of works for Zone IV (part) taken up under current DPR is INR 4.9 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.***

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

Zone IV has been identified and taken up as a priority, owning to other infrastructure and smart road works being 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 Total Road Length in Zone IV in 21 Km

The current DPR covers Design towards Replacements of Sewerage Network in Zone IV (Part) for length of 6.33km which is 30% 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)

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 –I 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 wetwells 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 meeting it was also conveyed to the PMC that the laterals are being laid in some parts of Zone –IV 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 AMRUT 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.

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 IV is as shown in table below:

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

Ward No.	area [ha]	population 2011	population density 2011 [population/ha]	projected population		
				2016	**2031**	**2046**
41	53	5829	110	6468	8834	12065
42	40	7149	179	7932	10834	14797
43	50	6250	125	6935	9472	12936
44	96	6749	70	7489	10228	13969
45	38	7449	196	8265	11288	15418
46	110	6908	63	7665	10469	14298
Total		**40334**		**44754**	**61125**	**83483**

While some of the wards totaling fall in Zone IV, there are some wards for where only portion/part is covered in Zone IV. The design population of further working has been taken up accordingly

The total population taking into consideration for design of Zone IV is 25061 for 2046.

The total sewage design flow for horizon period (2046) is 3.38 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.

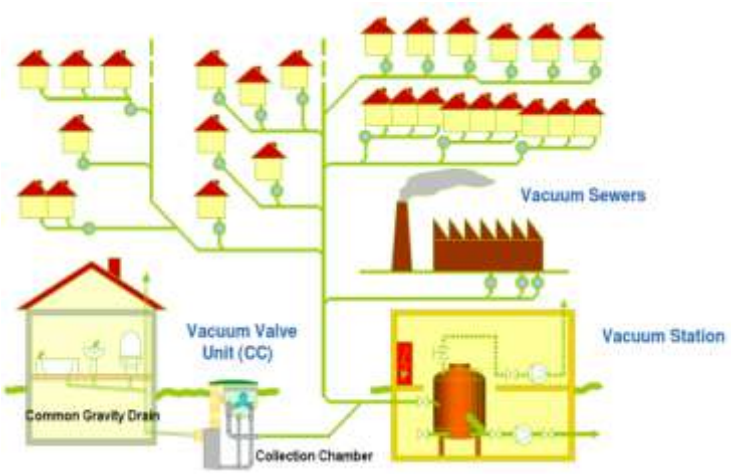

Figure 4-1 Vacuum Sewerage System

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.

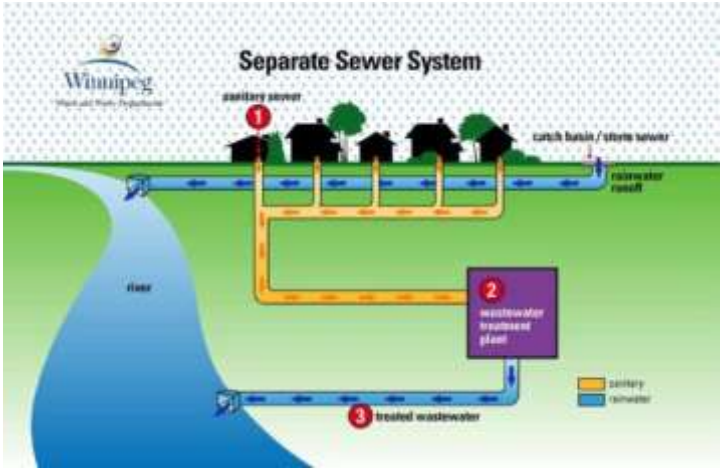

Figure 4-2 Conventional Sewerage System

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 4-1shows 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 Babbit'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)

Hf = 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,

Qf	=	Flow rate (in cumec)
A	=	Cross sectional area of pipe (sq. m.)
Vf	=	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 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/cm2)	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 0.013 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 minimum diameter of sewer pipe shall be considered as 200 mm as per CPHEEO Manual

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 4-6shows 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 – 1.65 m	900 mm
2	1.65 m – 2.30 m	1200mm
3	2.30 m – 9 m	1500mm

However, considering minimum manhole of 1200 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 IV

5.1. General

The proposed sewerage system consists of Laterals and Sub-mains in a portion of Wards 41, 44 and 45 in Zone-IV 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 - IV will be collected and conveyed to the wet wells by gravity and further to the existing STP through Pumping Mains.

Figure 5-1 Command Area and Wetwell Location in Zone-IV

5.2. Sewage Generation

The sewage generation for Zone IV in ABD area 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**below:

Table 5-1: Sewage Generation in Zone IV

Mangalore Sewerage System zone wise Population Calculation													
Zone-4													
		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	41	6468	53.37	3452	0.373	8834	53.37	4714	0.509	12065	53.37	6439	0.695
2	42	7932	0.01	1	0.000	10834	0.01	1	0.000	14797	0.01	1	0.000
3	43	6935	25.62	1777	0.192	9472	25.62	2427	0.262	12936	25.62	3315	0.358
4	44	7489	74.57	5584	0.603	10228	74.57	7627	0.824	13969	74.57	10416	1.125
5	45	8265	13.92	1151	0.124	11288	13.92	1571	0.170	15418	13.92	2146	0.232
6	46	7665	19.19	1471	0.159	10469	19.19	2009	0.217	14298	19.19	2744	0.296
Sub Total (MLD)				13,436	1.451			18,349	1.982			25,061	2.707
Total Road Length (km)					21				21				21
Total Infiltration (MLD)					0.36				0.50				0.68
Total Seweage Generation in average flow (MLD)					**1.81**				**2.48**				**3.38**
Total Seweage Generation in average flow (MLD) (Bulk Consumers like Hostels, Hospital and Lodges					**0.19**				**0.22**				**0.25**
Total Seweage Generation in Peak flow (MLD)					5.29				7.10				8.06

5.3. Planning and Design of Proposed Sewerage Network in Zone IV

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 IV in ABD area. The proposed sewerage system consist lateral and branch networks which connects to the wet well at Kandathpalli.

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.

Refer Volume –II for the proposed routing of sewer lines in Zone –IV and detailed design drawings

This DPR focuses the replacing of laterals in Zone IV for the roads as shown in Figure 5-2.

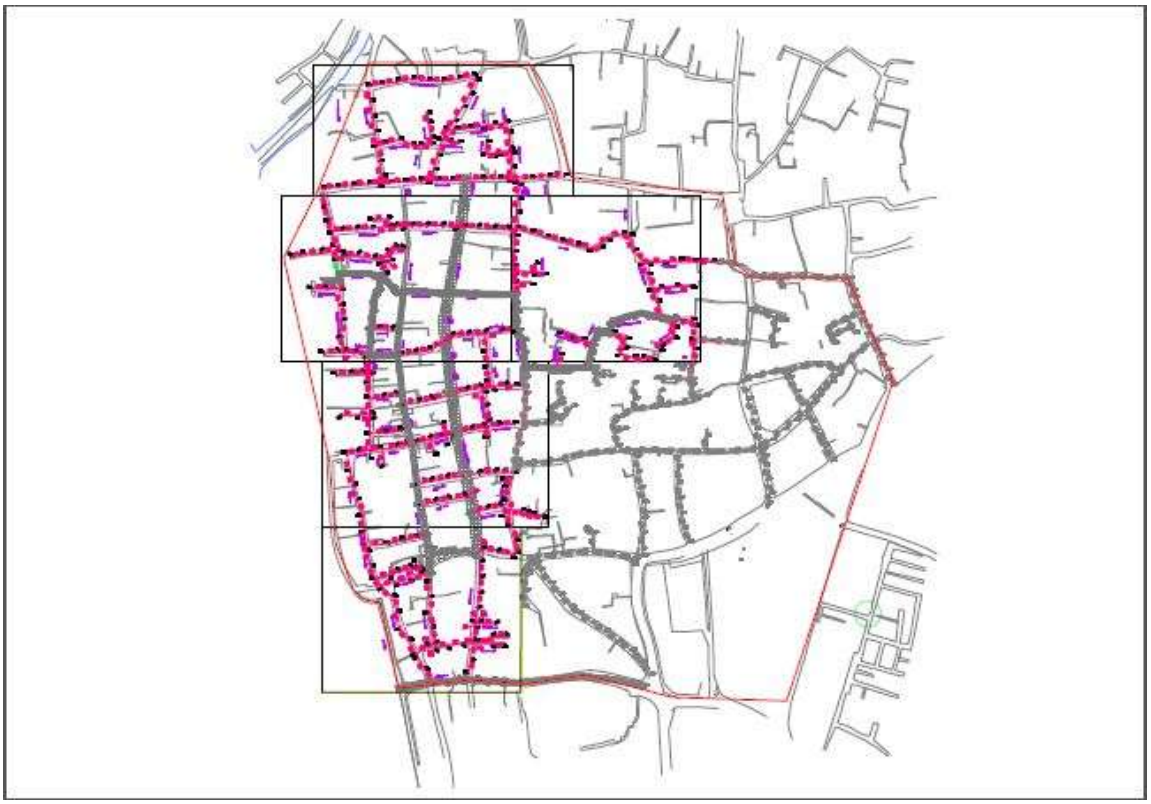

Figure 5-2 Laterals to be replaced as a part of this DPR

Refer **Annexure-III** for Design Report of Zone –IV and Volume II for Detailed Design Drawings

5.4. Summary of Proposed Sewerage Network in Zone IV (part)

A. Overall Summary

Sr No	Description	Minimum Value	Maximum Value
1	Diameter (in mm)	110	200
2	Depth of Excavation (in m)	0.9	3.47

B. Details of sewer length as per Depth of excavation

Depth of Excavation	Length of Sewers (approx) Km
0-2.0m	3.02
2.0m-4.0m	1.463

C. Details of sewer length as per Diameter

Diameter	Length of Sewers (approx)
200 mm	4.483

D. Details of House Service Connections in Zone-IV

Zone	No. Of Premises	Length(km)	Depth of Excavation
IV	900	5.40	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 IV (part) taken up under current DPR is INR 4.9 Cr. 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

Sl. No.	Description	Cost In INR
1	Under Ground Drainage	39118345
	Total Cost	**39,118,345**
	Add Contingency @ 3%	1,173,550
	Add Utility Shifting @ 10%	3,911,834
	Add Amount for Taxes as applicable	1,564,734
	Adminstrative charges & Tender Premium @ 10%	3,911,834
	For Misc.Work	269,703
	Grand Total	**49,950,000**