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

DETAILED PROJECT REPORT – UNDERGROUND DRAINAGE

ISSUE AND REVISION RECORD

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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

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

Figure 1-1 ABD area considered under Mangaluru Smart City

1.2. Necessity of Underground drainage scheme

Mangaluru, located on the west coast is the chief port city in the state of Karnataka. The city has a proper water supply system with three intake structures on Netravathi River at Thumbe. The three intake structures have been constructed in 1956, 1971 and 2007 to cater the demand of 11.35 MLD, 81.7 MLD and 80 MLD respectively under various schemes. 1956 scheme involves the pumping of water from the Jack well at Thumbe to a settling tank and further from the settling tank to en-route villages. The water is pre-treated in clariflocculators at Thumbe and filtered at Bendoor under 1971 scheme. There are 4 Nos of clariflocculators with a capacity of 20.43 MLD each. An 80 MLD WTP has been constructed at Ramalkatte under KUDCEMP Scheme in 2006-07 . Another 23.5 MLD WTP is constructed in Panambur under the same scheme. Conventional water treatment method with tube settlers is being used by the both treatment plants.

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 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.

This DPR is prepared to meet a part of the intended objective of Smart city program, for obtaining the necessary approvals from Technical Committee and implement the project in the project city as per Smart City Guidelines.

This Detailed Project Report covers the replacement of a portion of underground sewer lines in Zone-4 . The sewerage component includes laterals from 200 mm to 250 mm dia uPVC pipe.

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. Scope of Work

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).

1.5. Input Data Available

A detailed project report on Replacement of Old sewerage pumping Main for Mangaluru City under "Karnataka Integrated Urban Water Management Investment Programme" (KIUWMIP) "JALASIRI" with the assistance of the Asian Development Bank (ADB) was prepared by GKW consultants; this report is already approved by the competent authorities and is currently under tendering stage. The above DPR was made available to PMC by MCC authorities.

As part of the present study, PMC has reviewed the above report and based on the population projections (both city wise and ward wise) carried out by GKW Consultants, necessary modifications required for the diversion of flow to STPs at Kavoor and Bajal have been proposed for the design Horizon of 2046 without modifying sewerage zones so that the inflow to the wetwell remains unchanged and accordingly this DPR has been prepared. Further data required were acquired through topographical survey and site visits by the concerned experts to the city.

1.6. Background of the City

Mangalore, officially known as Mangaluru, is the chief port city of the Indian state of Karnataka. It is located about 352 km (219 mi) west of the state capital, Bengaluru, between the Arabian Sea and the Western Ghats mountain range. Mangalore is the largest city and administrative headquarters of the Dakshina Kannada district, and is one of the most multicultural non-metro cities of India. It is also the largest city in the Coastal and Malnad regions of Karnataka, besides being a commercial, industrial, educational and healthcare hub on the West Coast of India. The city has an average elevation of 22 m (72 ft) above mean sea level. Mangalore has a tropical monsoon climate, and is under the influence of the Southwest monsoon.

1.6.1. Topography

Mangalore is located at 12.87°N 74.88°E in the Dakshina Kannada district of Karnataka. It has an average elevation of 22 m above mean sea level. The topography of the city is plain up to 30 km inside the coast, and changes to undulating hilly terrain sharply towards the east in

Western Ghats. The geology of the city is characterized by hard laterite in hilly tracts and sandy soil along the seashore. The Geological Survey of India has identified Mangalore as a moderately earthquake-prone urban centre and categorized the city in the Seismic III Zone. The Netravati and Gurupura rivers encircle the city, with the Gurupura flowing around the north and the Netravati flowing around the south of the city. The rivers form an estuary at the south-western region of the city and subsequently flow into the Arabian Sea. Coconut trees, palm trees, and Ashoka trees comprise the primary vegetation of the city. Mangalore has a tropical monsoon climate and is under the direct influence of the Arabian Sea branch of the southwest monsoon. It receives about 95 per cent of its total annual rainfall within a period of about six months from May to October, while remaining extremely dry from December to March. The average annual precipitation in Mangalore is 3,796.9 millimeters. Humidity is approximately 75 per cent on average, and peaks during May, June and July. The maximum average humidity is 93 per cent in July and average minimum humidity is 56 per cent in January.

1.6.2. Climate

Mangalore has a tropical monsoon climate and is under the direct influence of the Arabian Sea branch of the southwest monsoon. It receives about 95 per cent of its total annual rainfall within a period of about six months from May to October, while remaining extremely dry from December to March. The average annual precipitation in Mangalore is 3,796.9 millimeters. Humidity is approximately 75 per cent on average, and peaks during May, June and July. The maximum average humidity is 93 per cent in July and average minimum humidity is 56 per cent in January.

1.6.3. Tourism

The city is called the Gateway of Karnataka and lies between the Arabian Sea and the Western Ghats. The various temples and buildings in Mangalore include the Mangaladevi Temple, Kadri Manjunatha temple, St Aloysius Chapel, the Rosario Cathedral, Milagres Church, Dargah of Hazrat Shareef ul Madni at Ullal and the Zeenath Baksh Jumma Masjid in Bunder.

The city is also known for beaches such as Panambur, Tannirbavi, NITK beach, Sasihithlu beach, Someshwara beach, Ullal beach, Kotekar beach and Batapady beach. Panambur and Thannirbhavi beaches attract tourists from across the country. Panambur beach has many facilities including jet ski rides, Boating, dolphin viewing food stalls, besides trained beach lifeguards and patrol vehicles to ensure the safety of the visitors. Saavira Kambada Basadi is situated 34 km northeast of Mangalore in the town of Moodabidri. The Sultan Battery watch tower, built by Tipu Sultan, situated in Boloor, is on the banks of Gurupura River where one can take the ferry ride by paying small amount across the river and reach Tannirbhavi Beach. Adyar waterfalls are at the outskirts at about 12 km from the city.

The city has developed and maintains public parks such as Pilikula Nisargadhama, Kadri Park at Kadri, Tagore Park at Light House Hill, Gandhi Park at Gandhinagar, and Corporation Bank Park at Nehru Maidan. Pilikula comprises the zoo, botanical garden, lake, water park (Manasa) and a golf course (Pilikula golf course) which is set in an area of 35 acres

Mangalore Dasara, a ten-day festival at Sri Gokarnatheswara temple attracts devotees from various states of India who visit Mangalore to witness Dasara. Mangaladevi Temple is another temple which attracts devotees from all over India during Navaratri.

1.6.4.Population

As per 2011 census, the population of Mangaluru Municipal Corporation was 488968. The Salient Features of Mangaluru Municipal Corporation is given in Table 1-1.

Table 1-1 General Details

Sl No	Item description	Unit	Details
1	Year of Constitution as a part of Karnataka	Year	1956
2	Area	Sq. Km.	132.45 Sq Km
3	Population (2011 Census)	Total	4,88,968
4	Existing No. Wards	No's	60
5	Slums	No's	1682
6	Slum Households - Population	No's	Population - 7726

Table 1-2 Population details of Mangaluru

Decadal year	Population
1961	1,70,253
1971	2,15,122
1981	2,73,304
1991	3,06,078
2001	3,99,465
2011	4,88,968

2. EXISTING UNDERGROUND DRAINAGE SYSTEM

2.1. City Underground Drainage Scheme for Mangaluru

2.1.1. 1961 Scheme:

Public Health Department, Mangaluru has implemented the underground drainage system in Mangaluru during 1961 along with the preparation of Sewage Master Plan for the corporation area. As per the sewerage Master plan, Mangaluru has been divided into seven zones with a common STP at Kavoor of 5 MGD capacity for Zone 1, zone 2, zone 3, zone 4 and zone 5 covering majority of Corporation area of the city. Sewage from Zone 6 and Zone 7 is diverted to 1 MGD STP at Jeppinamogaru. The Zone-wise population has been assessed and documented in the existing Mater plan suitably. As per the master plan report, the city has been designed for the design horizon of 1991. Thus it is inferred that this scheme is exhausted and the sewerlines laid under this scheme has to be replaced

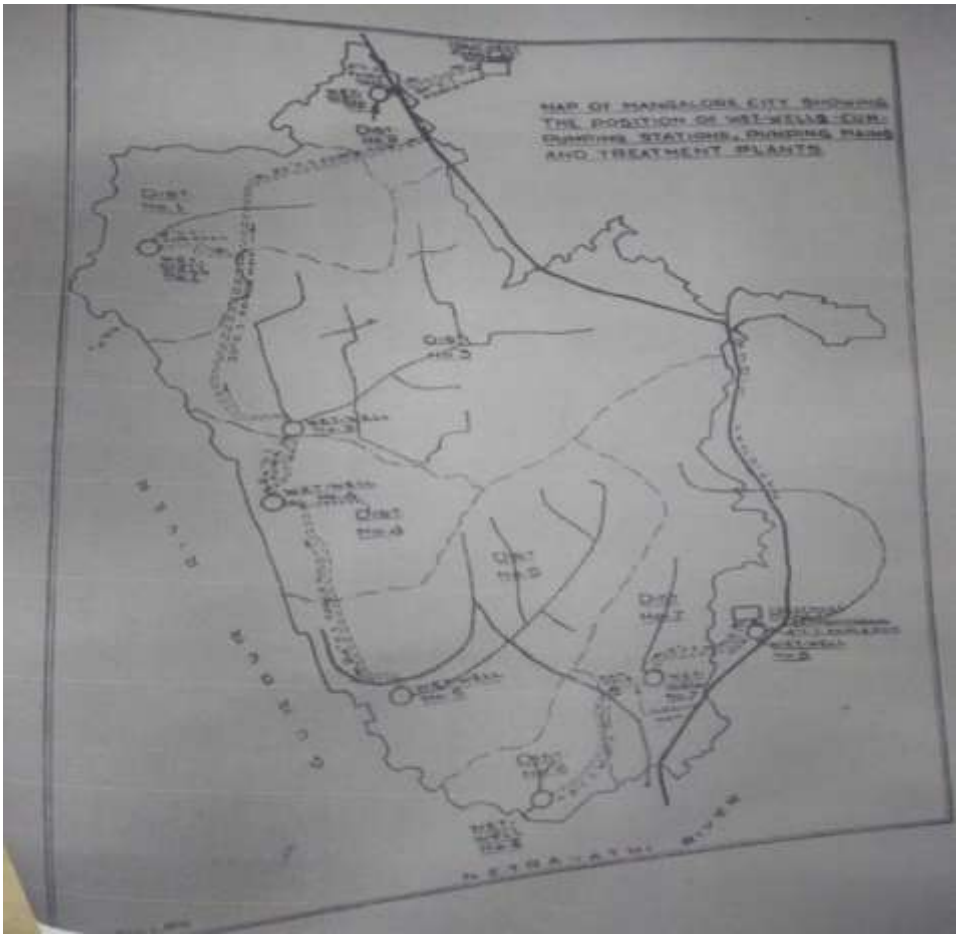

Figure 2-1 Location of Wetwells under 1961 Scheme

2.1.2. KUDCEMP Scheme:

Under KUDCEMP Scheme the sewerage network is extended to the adjoining areas of old city and also extended to the other areas in MCC boundary. Whole Mangalore city is divided into Four sewerage Districts namely North District, East District, West District and South District with each district having one Sewage Treatment Plant. North District covers Surthkal Area with Zones 1 ,2,3,4,5,6,7,8,9 and 10. East District covers Pachanady, Bondel and Shakatinagara area with Zone 9. South District covers Jeppinamogaru, Bajal, Padil with Zone 6, 7 and 8. West Zone covers City centre of Mangalore with zones 1,2,3,4 and 5.The sewage from zone 1 to 5 and zone-10 is pumped to a 43.5 MLD STP at Kavoor. The sewage from zone 6 , 7 and 8 is pumped to a 20 MLD STP at Bajal . The sewage from zone 9 is pumped to 16.5 MLD STP at Pachanady. The sewage from zone 1 to 10 Surathkal is pumped to a 16.5 MLD STP at Surathkal.

2.1.3. KIUWMIP Scheme

This scheme involves the replacement of Old sewerage pumping main in Mangaluru City. The pumping mains are designed for the horizon 2046 considering 25% sewage infiltration due to high water table.

The sewage from zone 3, 4 and 5 is collected in Wet Well 3 located at Kudroli. Total command area of zone 3 is 9.52Sq.Kms with projected population of 1,52,449 with sewage generation of 16.46 MLD for the Ultimate Design year of 2046. Wet well 3 receives sewage of 3.38 MLD from Wet well 4 and 11.75 MLD from Wet well 5 for the ultimate year 2046. It is proposed to provide 1100 mm dia DI-K9 class pipe for pumping of sewage from Wet Well 3 @ Kudroli to 43.5 MLD STP @ Kavoor for a length of 7650 m for the carrying capacity of ultimate Design year of 2046.

The sewage from zone 4 & 5is collected in Wet Well 4 located at Kandathpalli. Total command area of zone 4 is 1.71Sq.Kms with projected population of 25,061 with sewage generation of 3.38 MLD for the Ultimate Design year of 2046. It is proposed to provide 900 mm dia DI-K9 class pipe for pumping of sewage from Wet Well 4 @ Kudroli to Wet well 3@ Kudroli for a length of 950 m for the carrying capacity of ultimate Design year of 2046.

The sewage from zone 6is collected in Wet Well 6 located at Mulihitlu. Total command area of zone 6 is 1.31Sq.Kms with projected population of 25,739 with sewage generation of 3.47 MLD for the Ultimate Design year of 2046. It is proposed to provide 450 mm dia DI-K9 class pipe for pumping of sewage from Wet Well 6 @ Mulihitlu to Ridge Manhole (RMH) near Morgansgate for a length of 1700 m for the carrying capacity of ultimate Design year of 2046.

The sewage from zone 7is collected in Wet Well 7 located at JeppuBappal. Total command area of zone 7 is 1.33Sq.Kms with projected population of 25,041 with sewage generation of 3.38 MLD for the Ultimate Design year of 2046. It is proposed to provide 450 mm dia DI-K9 class pipe for pumping of sewage from Wet Well 7 @ JeppuBappal to Ridge Manhole(RMH) near Ekkur (old STP Site) for a length of 1100 m for the carrying capacity of ultimate Design year of 2046.**Table 2-1** provides the details of Pumping mains proposed to be replaced under this scheme. This Scheme is currently in the tendering stage

Table 2-1 Abstract of Pumping mains

Sl No	Location		Material	Length In m	Economical Pipe Dia (mm)
	From	To			
1	WW-3	Kavoor STP	DI-K9	7650	1100
2	WW-4	WW-3	DI-K9	950	900
3	WW-6	RMH	DI-K9	1700	450
4	WW-7	RMH	DI-K9	1100	450

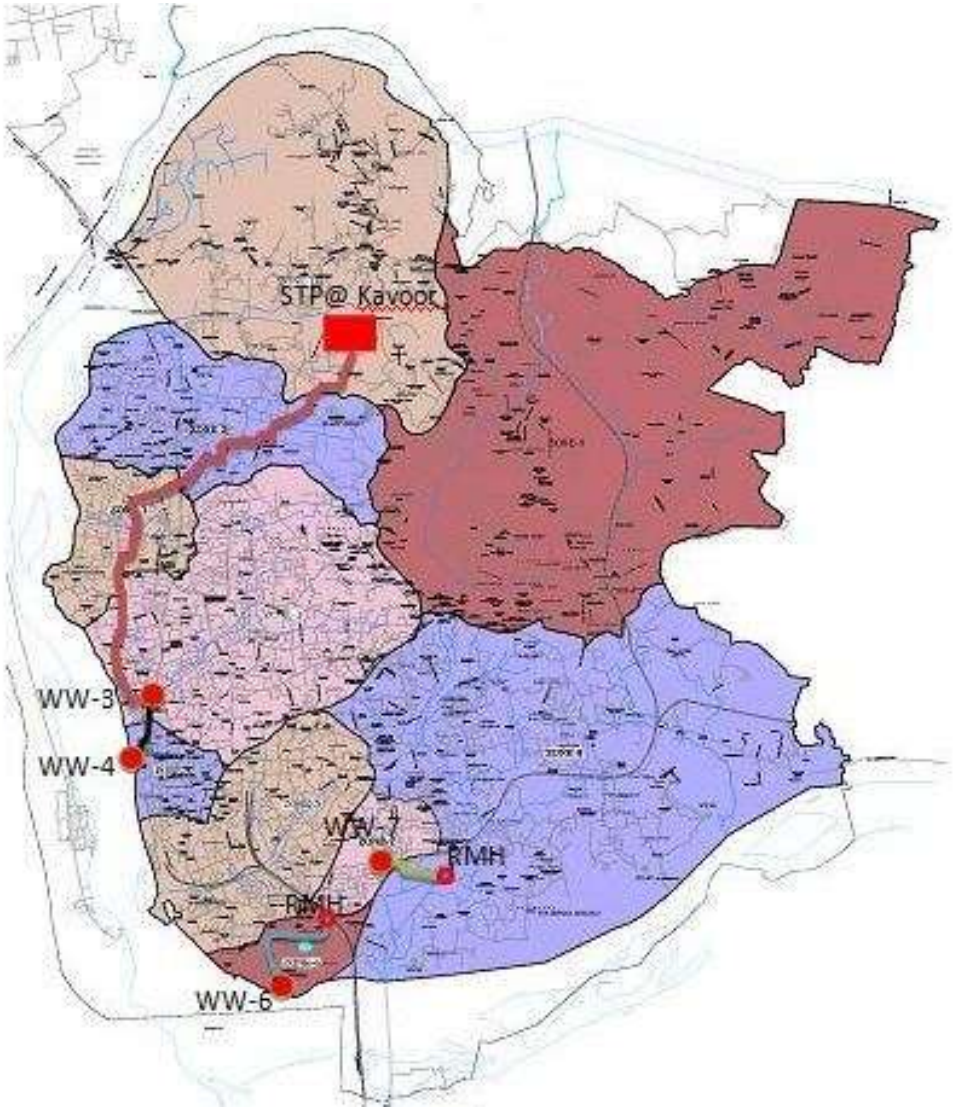

Figure 2-2 Pumping main alignment to wetwells

2.2. Existing Sewage Treatment Plants

Under KUDCEM project four sewage treatment plants are constructed one each in each sewerage Districts. These STPs are designed for ultimate population of 2026.**Table 2-2** Provides the details of existing Sewage Treatment Plants in Mangaluru.

Table 2-2 Details of Existing Sewage Treatment Plants

S.No	Location	Capacity in MLD	Treatment Technology	Provision for Tertiary Treatment
1	Kavoor	43.5	UASBR	Yes
2	Pachanady	8.75	ASP with Extended Aeration	Yes
3	Bajal	20	ASP with Extended Aeration	No
4	Suratkal	16.5	ASP with Extended Aeration	No

2.2.1. 43.5 MLD STP at Kavoor

The Sewage generated from zones 1, 2, 3, 4, 5 and 10 is treated in Kavoor STP. 43.5MLD capacity of Sewage Treatment Plant near Kavoor has been constructed for the designed population of 3,21,219 for the year 2026. Total 10 Wet wells are connected to this STP. The technology used in this treatment plant is Up-flow Anaerobic Sludge Blanket Reactor (UASBR).

Primary Treatment Unit

Secondary Clarifier

UASB Reactors

Layout of STP

Figure 2-3 43.5 MLD STP at Kavoor

2.2.2. 8.75 MLD STP at Pachanady

The Sewage generated from zones 9A, 9B and 9C is treated in Pachanady STP. 8.75MLD capacity of Sewage Treatment Plant at Pachanady has been constructed for the designed population of 69,791 for the year 2026. The technology used in Sewage Treatment Plant is Activated Sludge Process followed by Extended Aeration Process.

Aeration Tank

Primary Treatment Unit

Figure 2-4 8.75 MLD STP at Pachanady

2.2.3. 20 MLD STP at Bajal

The Sewage generated from zones 6, 7, 8, 8E1, 8E2, 8E3 and 8D are treated in STP Jeppinamogaru. 20MLD capacity of Sewage Treatment Plant at Jeppinamogaru has been constructed for the designed population of 1, 12,922 for the year 2026. The technology used in Sewage Treatment Plant is Activated Sludge Process followed by Extended Aeration Process.

Figure 2-5 20 MLD STP at Bajal

2.2.4. 16.5 MLD STP at Suratkal

Sewage generated from zones 1, 2, 4, 5, 6, 7, 8, 9 &10 are treated in STP Surathkal. 16.5MLD capacity of Sewage Treatment Plant at Surathkal has been constructed for the designed population of 1, 20,500 for the year 2026.The technology used in Sewage Treatment Plant is Activated Sludge Process followed by Extended Aeration Process.

Figure 2-6 16.5 MLD STP at Suratkal

2.3. Ongoing Projects

Presently the laying of Trunk mains for all the sewerage Zones other than Suratkal is being carried out under the AMRUT Scheme. The Scheme is still in the DPR preparation stage.

3. FIELD INVESTIGATION AND SURVEYS

3.1. General Information

Field investigations and other survey works are required to assess the road details, terrain and soil conditions in the area, which can impact the design and cost aspects of the project. Detailed primary surveys are required to be carried to ascertain the required characteristics; secondary data has been used for the overall planning of the underground drainage system because of time and cost constraints. However for KIUWMIP Scheme underground drainage components, Topographical Survey has been carried out for the project area and accordingly the designs and cost estimates have been prepared. The above aspects have been discussed with MCC authorities and the concurrence for the same has been taken accordingly.

3.2. Topographical Survey and Spot Levelling

This section elaborates the general guidelines to be followed during topographical Survey. The entire area falling in the project area has to be surveyed and all details such as roads, railways, canals, the ROW width, canal structure, take off and terminal points, falls and other related structures, other details like building, villages, power lines, water courses, tanks, wells, tube well, temples, graves, places if burial, trees, plantation etc. has to be picked up.

The detailed survey has to be carried out by conducting Total Station traverse between DGPS points (These are the horizontal control points established by using Differential Global Positioning System at about 3km apart with pair points) and picking up required details from convenient instrument positions during the course of traverse. The heights have to be derived from the BMs provided all over the area. It has to be ensured that the Total Station traverse is not having a mis-closure more than 0.15m when we go from one station to the adjacent one which is about 3 km away. This mis-closure shall be adjusted during editing of the data captured. Similarly, for the height in Total Station traverse has to be agreed within 5 cm between adjacent BMs which are about 0.5 Km apart. Even this mis-closure shall be adjusted while giving final heights to the points.

A field sketch has to be prepared by the Surveyor showing starting and closing stations for planimetry and all the BMs has to be connected during the total traverse, as well as the various instrument stations. The important details picked up shall also be shown in their relative position in the sketch. The sketch has to cover the following:

(i) All important details like roads, railways, canal / field channels from outlets, drains/streams with their names.

(ii) All villages / hamlets with names.

(iii) Limits of plantation and other vegetation, Kilometer Guide Stone.

(iv) Wells and tube wells.

(v) Water bodies like ponds / lakes (with name in any), water logged area, marshy area saline land with limits.

(vi) Important land marks such as temples, mosques, large public buildings.

(vii) Road Name, type of road (Mud, Bitumen, Concrete Road, Cart Track, WBM, Foot Path Etc.)

(viii) Culvert Details i.e. type of Culvert (Pipe, box culverts etc) Length width, Invert level, Chainage, Cross Section etc.

(ix) Road Embankment sloping direction, types of Pitching or turfing etc.

(x) Railway crossing details i.e. width of crossing type of rail gauge route direction, gate details and levels etc, (separate enlarged details will be given for each railway crossing.

(xi) Road Side drains Details with width and Invert level.

(xii) Canal or River Crossing details with bed levels at regular intervals, flow direction type of bridge with HFL of the River.

Spot heights shall be recorded at 30m intervals with crossing section at 2.0m for a width of 5.0m on either side of road including road width; In addition, all definable points such as junctions / crossings of roads, railways, canals, streams, power line crossings, undulation, depression and other salient points has to be heighted using Total Station.

All the data captured by the Total Station shall be downloaded into a Computer and edited with the help of relevant software to prepare topographic map on 1:1000 scale based on the several spot heights provided over the area.

3.3. Field Verification

The map prepared by editing the downloaded data from Total stations in field has to be verified in the field to see if any details such are missing and to incorporate the missing detail in its correct position on the field edited map. The above data has to be incorporated in the map duly editing these details in the computer.

3.4. Geotechnical Investigation

The available data on the soil strata and visual observations of the pits excavated in the project areas has to be used to arrive at the probable earth work quantities. A representative sample for every 500m has been analysed for the pumping main proposed to be replaced under KIUWMIP Scheme and the concurrence for the same has been obtained.

4. POPULATION PROJECTION AND WATER DEMAND

4.1. Past census data

The population details for the past census records and the projected population details has been collected from GKW Consultants used for Replacement of Old Sewerage Pumping Main for Mangaluru City under KIUWMIP Scheme. The census data of various decades are given in the **Table 4-1**below.

Table 4-1 Decadal Population Details

S.No.	Decadal Year	Population	Increment	% Growth rate
1	1961	170253	-	-
2	1971	215122	44869	26.30
3	1981	273304	58182	27.00
4	1991	306078	32774	11.90
5	2001	399465	93387	30.50
6	2011	488968	89503	22.40

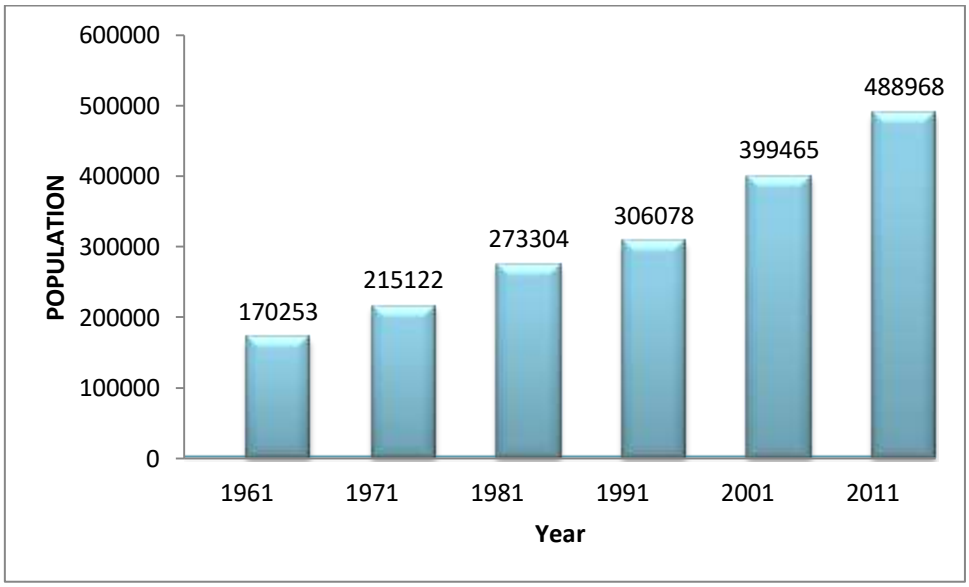

Figure 4-1 Increase in Population

4.2. Design Horizon

For projecting the future population, the census population for year 2016(Base Year), 2031 (Intermediate Year), 2046 (Final Year) been arrived at.

4.3. Population Projection

Population forecast carried with various methods are

a. Arithmetic Progression method
b. Incremental Increase method
c. Geometric progression method
d. Graphical method (polynomial)

Summary of the populations projections carried out by various methods are provided in Table 4-2

Table 4-2 Summary of Population Projection

Projection Method	2011	2016	2021	2031	2046
Arithmetic Increase method	4,88,968	5,32,410	5,65,334	6,31,181	7,29,951
Incremental Increase method	4,88,968	5,37,581	5,79,122	6,72,545	8,38,533
Geometrical Progression method	4,88,968	5,54,183	6,14,868	7,56,903	10,33,778
Polynomial	4,88,968	5,29,564	6,15,929	8,29,145	12,69,397

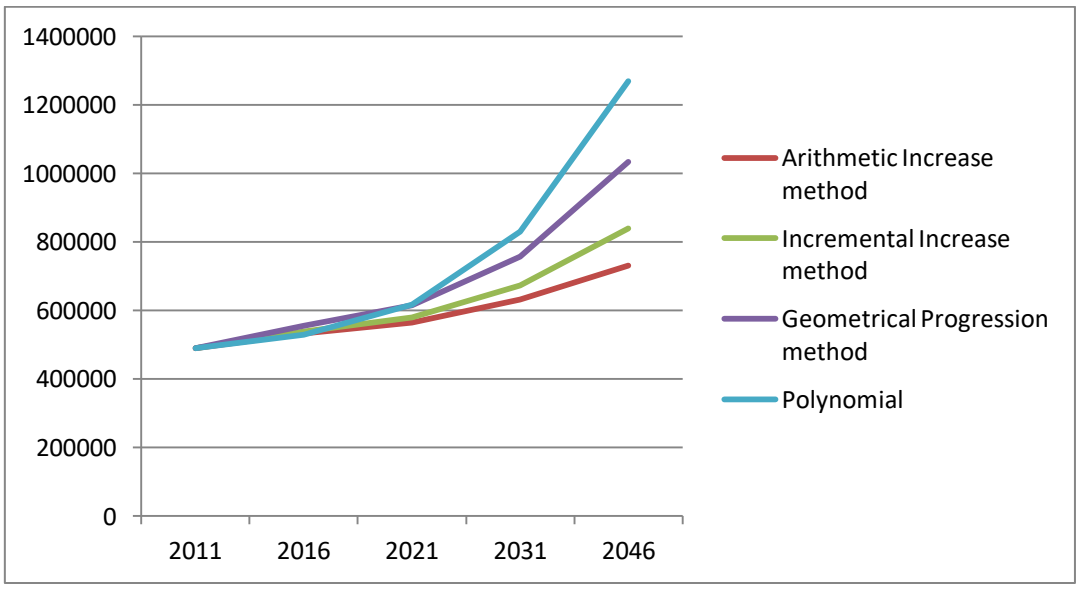

Figure 4-2 Population Projection by Different Methods

From the graphs plotted above, Geometrical Progression method was found to be best suited for the Mangaluru city and the same has been adopted for water demand calculation.

4.4. Ward wise Population Projection

Mangaluru city has a total of 60 Wards. Population projection for the ward is calculated on the basis of population density, predicted future growth of the particular ward and considering the Comprehensive Development Plan of Municipality. **Table 4-3** provides the details of ward wise population projection.

Table 4-3 Ward wise Population Projection

Ward No.	area [ha]	population 2011	population density 2011 [population/ha]	projected population		
				2016	2031	2046
1	393	9346	24	10370	14163	19344
2	413	7109	17	7888	10773	14714
3	147	8599	58	9541	13031	17798
4	80	9522	119	10565	14430	19708
5	104	9935	96	11023	15056	20563
6	241	9336	39	10359	14148	19323
7	257	8046	31	8928	12193	16653
8	226	9535	42	10580	14449	19735
9	286	10649	37	11816	16138	22041
10	655	7503	11	8325	11370	15529
11	265	9930	37	11018	15048	20552
12	231	8555	37	9492	12964	17707
13	202	8615	43	9559	13055	17831
14	395	8342	21	9256	12642	17266
15	157	7137	45	7919	10816	14772
16	229	8300	36	9209	12578	17179
17	131	10393	79	11532	15750	21511
18	464	11781	25	13072	17853	24383
19	374	8120	22	9010	12305	16806
20	517	9146	18	10148	13860	18930
21	392	8354	21	9269	12660	17291
22	153	10955	72	12155	16601	22674
23	125	10096	81	11202	15300	20896
24	173	9367	54	10393	14195	19387
25	105	8253	79	9157	12507	17082
26	148	9023	61	10012	13674	18675
27	80	7077	88	7852	10725	14648
28	62	6741	109	7480	10216	13952
29	34	6650	196	7379	10078	13764
30	66	6380	97	7079	9669	13205
31	63	8370	133	9287	12684	17324
32	104	7158	69	7942	10847	14815

Ward No.	area [ha]	population 2011	population density 2011 [population/ha]	projected population		
				2016	2031	2046
33	73	6497	89	7209	9846	13447
34	107	6396	60	7097	9693	13238
35	247	8859	36	9830	13425	18336
36	305	7460	24	8277	11305	15440
37	164	7797	48	8651	11816	16138
38	91	7322	80	8124	11096	15155
39	76	7740	102	8588	11729	16020
40	84	6917	82	7675	10482	14316
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
47	140	7998	57	8874	12120	16554
48	183	8509	46	9441	12895	17611
49	75	9350	125	10374	14169	19352
50	148	7026	47	7796	10647	14542
51	187	7954	43	8825	12054	16463
52	326	8075	25	8960	12237	16713
53	468	8602	18	9544	13036	17804
54	194	7314	38	8115	11084	15138
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
59	44	7717	175	8563	11695	15972
60	370	8542	23	9478	12945	17680
Total	**11244**	**488968**	**43**	**554183**	**756903**	**1033778**

5. DESIGN BASIS – SEWERAGE NETWORK

5.1. Introduction

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 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 Sewage Collection System.

Sewer networks are designed to collect & convey the sewage generated from project area to the treatment plant and safe disposal of treated water. Sewer networks are planned & designed to achieve its intended objective throughout its lifetime without any risk to public health, public safety & environment.

The primary scope of the report is to form the Design basis for the laterals in sewerage system of Mangaluru Municipal Corporation (ABD Area) . The Design basis report highlights following aspects:

- Evaluating various technologies of sewerage collection, treatment and disposal system.
- 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.
- The influent and effluent standards for processes considered for treatment of sewage generated.

5.2. Selection of appropriate System

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

5.2.1. 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.

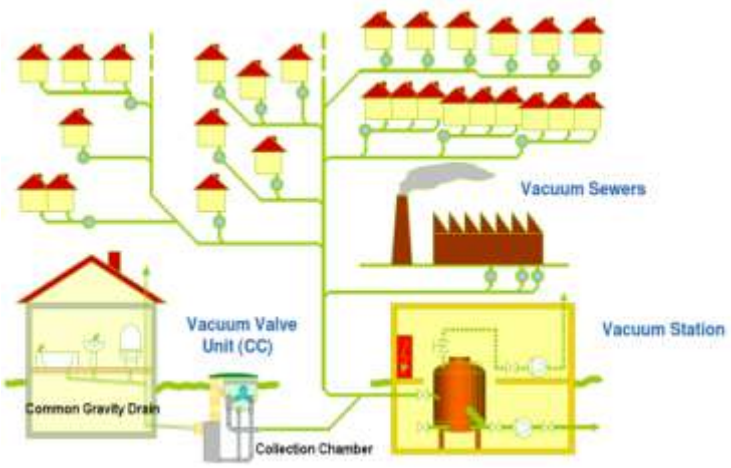

Figure 5-1 Vacuum Sewerage System

5.2.2. 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.

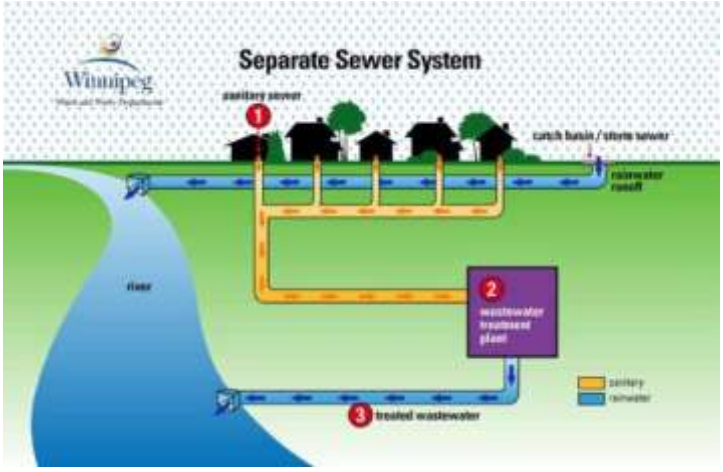

Figure 5-2 Conventional Sewerage System

5.2.3. 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.

5.3. Design Parameters

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

5.3.1. 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 Yr 2016 for Mangaluru Municipal Corporation, the design year of sewerage system will be carried out Yr 2046 i.e. for a span of 30 yrs.

5.3.2. 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.

5.3.3. 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 5-1**shows the sewage generation rate to be considered for various type of population.

Table 5-1 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

5.3.4. 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.

5.3.5. Peak Factors

The peak factors with respect to contributing population for domestic sewage as per CPHEEO manual, 2013 is furnished in following **Table 5-2**. Peak factor for population upto 20,000 is not as per CPHEEO manual, but as per Babbit's formula

Table 5-2 Peak Factor

Contributing Population	Peak factor
Upto 20,000	5/ (P/1000)^0.2*
20,000 to 50,000	2.50
50,000 to 7,50,000	2.25
Above 7,50,000	2.00

5.3.6. Frictional Loss Formula

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

Hazen William's Equation:

$$\mathbf{Q= 1.292x10^{(-5)} \times C \times D^{2.63} \times (H_f/L)^{0.54}}$$

Where

Q= Flow (cum/hr)

D= Diameter of pipe (mm)

Hf = Head loss (m)

L= length of pipe (m)

C= Hazen William's constant.

5.3.7. 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.

5.3.8. 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.)

5.3.9. 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 5-3 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

Sl. No.	Parameter	UPVC	RCC
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 5-4 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	-

Sewer dia (mm)	UPVC(10kg/sq.cm)	RCC NP-3
	Rate (Rs.) / m	Rate (Rs.) / m
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

5.3.10. 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.

5.3.11. 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.

5.3.12. 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 5-5 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)

5.3.13. Minimum size of Sewers

The minimum diameter of sewer pipe shall be considered as 200 mm as per CPHEEO Manual

5.3.14. 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.

5.3.15. 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,

S_S = Specific gravity of particle

d_p = particle size in m

K_S = 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 5-6shows the minimum and maximum velocities in sewer as per CPHEEO Manual, Nov 2013.

Table 5-6: 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

5.3.16. 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

5.3.17. Manholes

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. M.S 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 5-7**

Table 5-7: Internal diameter of sewer manholes

Sr. No.	Manhole depth ranges	Internal diameter of sewer manholes
1	above 0.9m and up to 1.65m	900mm
2	above 1.65m and up to 2.30m	1200mm
3	above 2.30m and up to 9.00m	1500mm

5.3.18. 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.

5.3.19. 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.

6. PROPOSED SYSTEM

6.1. General

The proposed sewerage system consists of Laterals and Sub-mains in a portion of Ward 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 6-1 Command Area and Wetwell Location in Zone-IV

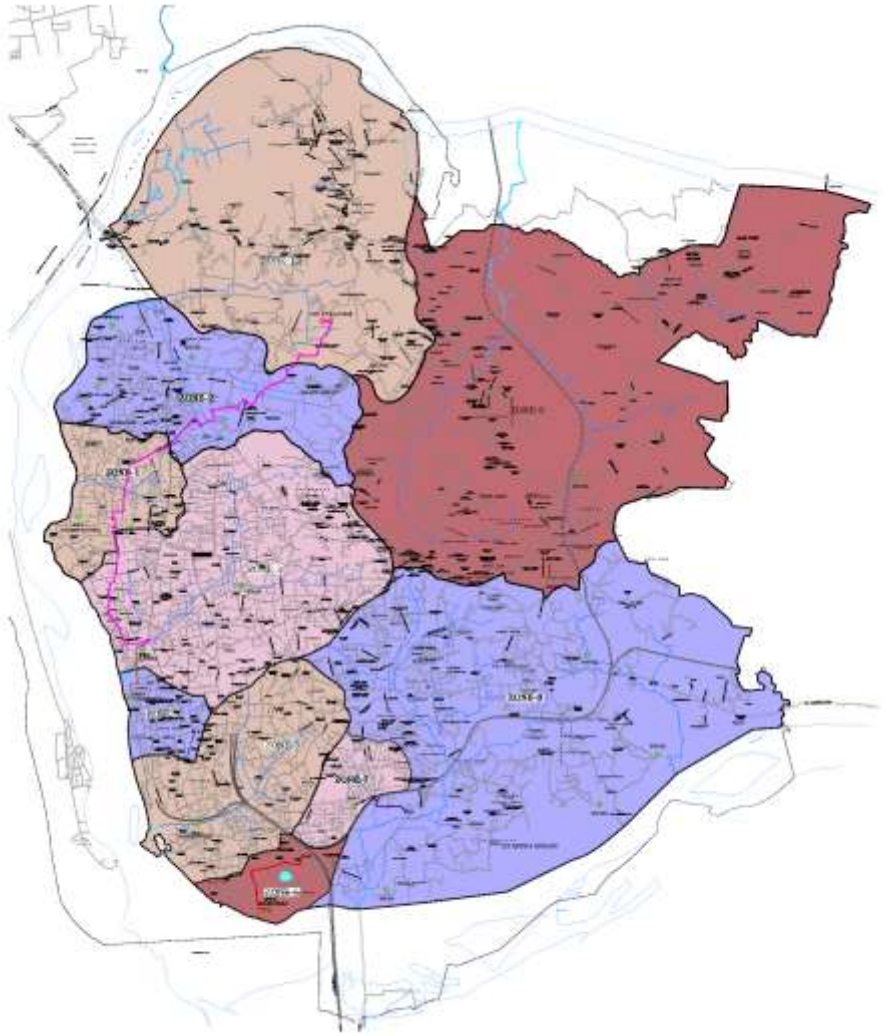

Figure 6-2 Map Showing the Sewerage Zones of Mangaluru

6.2. 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 6-1**below:

Table 6-1: 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

6.3. Design Approach for the Proposed Sewerage System

6.3.1. Data Analysis Review & Inferences

Mangaluru has underground drainage scheme since 1961. With the city's development the UGD system has been extended to various parts of the city under different schemes. Presently there are two main schemes for underground drainage is in progress in Mangaluru. The replacement old sewerage pumping main in Mangaluru is under KIUWMIP scheme funded by the Asian Development Bank. This scheme is sanctioned technically and it is tendered. The design of this has been scheme carried out by GKW Consultants. The DPR and drawings for the same has been shared with the PMC.

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 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.

6.3.2. Detailed Planning and Design of 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

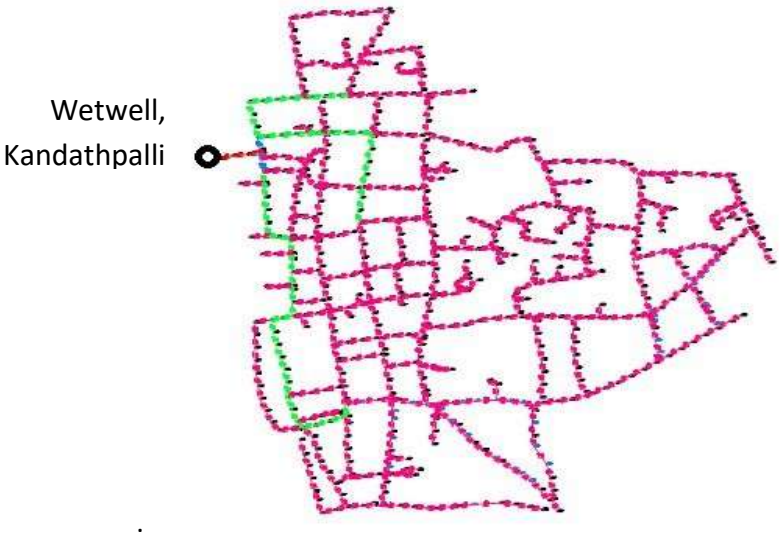

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Figure 6-3 Routing of UGD lines to wet well at Kandathpalli

From the site visits held along these prioritized roads it was observed that the manholes exist in the middle of the carriage way. During the planning of sewer networks in Zone-IV it was ensured that the sewer lines and manholes executed under this scheme shall on one side of the carriage way. This is recommended so that the disturbance to road traffic shall be avoided during maintenance

The ordinary circular manholes of brick masonry are proposed at all the junctions, change of diameters and change in pipe gradients and on straight run of sewer at 30m interval for dia upto 900mm. Drop manholes are proposed where the difference between invert level of lateral / branch sewer and maximum water level (at design peak flows) of main sewer is more than 600mm.

The vent shafts are also proposed in the initial stretches and at critical junctions in the system where flows are reaching from two or three sewers for escape of gases from the system and to prevent septic condition. The minimum soil cover to pipe is considered as 1m.

The proposed sewerage system is designed for 30 years period with design year as 2046. The velocity is checked for 2046 design peak flow. At initial stretches wherever minimum self-cleansing velocities are not achieved, the flushing of sewer line will be required to be done using water tankers.The Proposed Sewerage network will be connected to the wet well at Kandathpalli. The network is designed in such a way that the proposed sewerage network inverts level is above the outfall location invert level.

However the scope in this DPR has been reduced to the UGD networks on certain priority roads in Zone-IV as per discussion with the MD for Smart city Mission. This has been emphasized so that UGD lines shall be in concurrence with the planning of Smart Roads under Smart City Mission.

6.4. Proposed Sewerage System

Majority of the existing sewer pipelines in the ABD area of Zone-IV were executed during the 1961 Scheme. As the pipelines have already exhausted there is a necessity to replace the old UGD. Under the Smart City Mission it is proposed to replace the laterals in the ABD area. This DPR focuses the replacing of laterals in Zone IV for the roads as shown in **Figure 6-4.**

Figure 6-4 Laterals to be replaced as a part of this DPR

The total length of sewer network in Zone –IV is 17.04 km. The total length of laterals to be replaced in this DPR is for 2.137km which is 12.54 % of Zone-IV.

6.5. Design of Pipe Bedding

uPVC pipes are semi flexible pipes and suitable bedding will be provided for these pipes. The type of bedding (Granular Bedding/ Concrete Encasement) depends on the weight of soil above the pipe based on width of trench, depth at which the sewer is laid and the class of superimposed load considered based on the traffic condition. A typical drawing for various types of bedding is as shown in the Figure 6-5

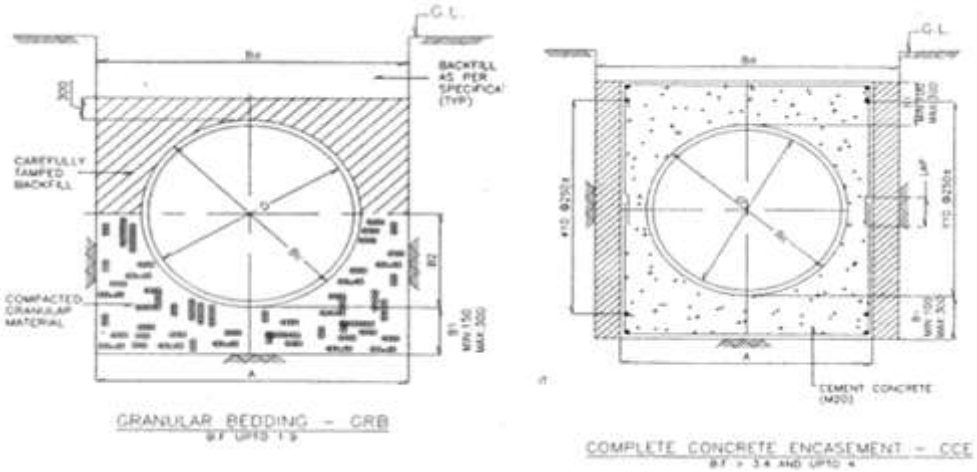

Figure 6-5: Various types of beddings for Gravity Sewers

6.6. Sizes of sewer for the proposed drainage system

Total length of laterals proposed in this DPR is around 2.137 km. Diameters of sewers are ranging from 200 mm to 250 mm. The diameter wise lengths of pipelines both in zone wise and ward wise are depicted in tables below

Table 6-2: Diameter-wise lengths

	Length(km)		Total
Dia of Pipe	**200**	**250**	
Length(km)	2.012	0.125	**2.137**

6.7. Raw Sewage Characteristics

Understanding of the nature of physical, chemical and biological characteristics of sewage is essential in planning, design and operation of treatment and disposal facilities and in the engineering management of environmental quality. The raw sewage characteristics are referred from Table 5.4 of CPHEEO Manual, 2013. The typical expected influent characteristics of raw domestic sewage are given in Table 6-3.

Table 6-3: Raw Sewage Characteristics

Sr. No.	Parameters	Concentration Values (Expected)	Concentration Values (CPHEEO 2013)
1	pH	6.5 - 8.5	-
2	BOD5 @ 20°C, mg/L	250 – 300	250
3	COD , mg/L	425 – 600	425

Sr. No.	Parameters	Concentration Values (Expected)	Concentration Values (CPHEEO 2013)
4	Total suspended solids, mg/L	300 – 400	375
5	Oil and grease, mg/L	10 – 20	-
6	Total kjeldahl Nitrogen (as N), mg/L	50 – 60	45
7	Total Phosphorus, mg/L	8 – 10	7.1
8	Feacal Coliforms MPN/100 ml	10^6 to10^8	-

6.8. Effluent Standards

It is proposed that the sewage which is generated is to be treated to such standards that it can be used for various purposes like flushing, make up water for HVAC system, pond water top-up, gardening & irrigation of lawn, shrubs etc..

From the point of view of better environment, it is contemplated that the residential project will have treatment system which treats the entire sewage to 10mg/l (BOD and TSS) standards. The effluent standards of treated sewage as per latest CPHEEO manual are mentioned in **Table 6-4.**

Table 6-4: CPHEEO Standards of Treated Sewage

Type of Reuse	All types of landscape irrigation, vehicle washing, toilet flushing, use in fire protection systems and commercial air conditioners and other uses with similar access or exposure to the water
Treatment	Secondary, Filtration, Disinfection
pH	6.5 - 8.3
BOD (mg/L)	≤ 10
COD (mg/L)	≤ 50
TSS (mg/L)	≤ 5
Turbidity (NTU)	≤ 2
Fecal Coli/100mL	Not Detectable
Residual Chlorine (mg/L)	≤ 1

- The reclaimed water should not contain measurable levels of viable pathogens.
- Reclaimed water should be clear and odourless.
- Higher chlorine residual and/ or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed.
- Chlorine residual of 0.3-0.5 mg/l or greater in the distribution system is recommended to reduce odours, slime and bacterial re-growth.

Ref : CPHEEO guidelines for treated water reuse.

Reclaimed water from tertiary treatment of STP is proposed to be stored in treated water tank near STP. This treated/ recycled water is proposed to be supplied for flushing, make up water for HVAC system, pond top up, gardening & irrigation of lawns, shrubs etc. Hence, expected standard will be as given in Table 6-5.

Table 6-5: Treated Sewage Standards

Parameters	After secondary treatment (CPCB Dec 2016)	After tertiary treatment (CPHEEO 2013)
BOD5 (mg/L)	<10	<10
COD (mg/L)	<50	<50
TSS (mg/L)	<10	≤ 5
Total Nitrogen (mg/L)	<10	<10
Total Phosphorous (mg/L)	<2	<1
pH	6.5 – 8.5	6.5 – 8.5
Turbidity (NTU)	-	<2
Ammonical Nitrogen (NH4-N)	<5	-
Residual chlorine	-	0.3 – 0.5
FecalColiform, (MPN/100ml)	< 230	Nil

7. COST ESTIMATES

7.1. General

The present Sewerage System is designed for Mangaluru taking into the consideration of the ultimate year 2046. At present, the sewerage infrastructure in Zone-IV of the ABD area has to be replaced to serve the needs of the population residing in the area. The objective of the present DPR is to replace the laterals in a portion of Zone-IV in the ABD area. The proposed laterals in the Zone-IV is planned and designed taking into consideration of the demography, topography, present service levels, existing system, functionality and existing conditions.

7.2. Cost Estimate

The detailed cost estimate is prepared based on the quantities arrived. Refer Annexure-I for the detailed BOQ and Cost Estimates.

8. ENVIRONMENTAL MANAGEMENT PLAN

8.1. Introduction

In this Chapter potential impacts on the environment from the proposed project on the ULB are identified based on the nature and extent of various activities associated during construction and after completion of the project. The proposed expansion activities will have impact of varying magnitude on environmental components both beneficial (positive) and adverse (negative) impacts. Both these (positive) and adverse (negative) impacts are considered for the impact prediction studies. The details of impact prediction and assessment are given in this chapter.

8.2. Legal and Regulatory Frame Works

The project is expected to bring significant environmental and health benefits, such as improvements in the sustainability of water sources and improvements in public health through better quality of treated water. Although no major environmental issues are anticipated, certain investments items to be funded under the project may require special mitigation measures to protect the environment and enhance health safety.

8.3. Local Regulatory Framework

As per the Environmental regulations in India, the S.0.1533 no Environmental clearance is required for water supply projects. However, Pollution Control Board can be approached for funding for STP projects and the regulatory frame works of PCB norms shall be adhered to.

8.4. Impacts during Construction

8.4.1. Impacts during construction of Air Quality

The potential ambient air quality impacts arising from the proposed project would occur mainly during construction phase. During construction, the project would have two major impacts on ambient air quality due to an increase in gaseous emissions by heavy construction equipments and vehicles, and an increase in dust by construction activities. Earth excavation work, foundation work, superstructure work, material storage, transportation and handling of construction materials, and wind erosion are the major factors that would produce a temporary, localized increase in SPM and RPM levels. The increased movement of heavy vehicles carrying construction materials, operation of DG sets as standby power back up system would generate gaseous emissions. However as DG sets are used as standby, the impacts are insignificant. The degree of dust generated would depend on the soil compaction and moisture content of the ground surface during construction. Dust and exhaust particulate emissions from heavy equipment operations would temporarily degrade air quality in the immediate construction zone. The increase in air particulates would be minimized by the performance of the work. The construction contractor will visually monitor dust levels on the site during construction. Dust suppression will be instituted, using water tankers mounted on tractors, sprinklers and other means as necessary, in the event that high levels of dust are observed, strong winds and dry conditions make dust generation likely, and complaints about dust are received.

8.4.2. Impacts during construction of Noise Quality

Construction activities normally result in temporary and short duration increases in noise levels. The main sources of noise during construction period include movement of vehicles for loading and unloading of construction materials, fabrication, handling of equipment and materials, operation of concrete mixing plants, generators etc. The areas affected are those close to the site.

Under the worst case scenario, considered for prediction of noise levels during construction phase, it has been assumed that all these equipments generate noise from a common point at an average noise level of 85 dB (A).

8.4.3. Impacts of Construction Wastes

The generation of waste material is inevitable during the construction phase of the development. Waste is generated at different stages of construction process. Waste during construction activity relates to excessive cement mix or concrete left after work is over, rejection caused due to change in design or wrong workmanship etc. Excavation of earth and rock generates muck. Other wastes include top soil, clay, sand, and gravel. These are normally re-used as filler at the same site after completion of excavation work. Other miscellaneous materials that arise as waste include glass, plastic material, general refuse, scrap metal, cardboard, plastics, and sewage wastes from the construction workers housing. Construction waste is bulky and heavy and is mostly unsuitable for disposal by incineration or composting. Unutilized or unused solid wastes generated during construction will be disposed of to a designated landfill sites in the project area.

8.5. Impacts during Operation

8.5.1. Impacts during operation of Air Quality

None of the proposed structures of STP, Pumping Stations etc at the project site would be expected to have an impact on air quality during their normal operation.

8.5.2. Impacts during operation of Noise Quality

None of the proposed structures of STP, Pumping Stations at the project site would be expected to have an impact on Noise during their normal operation.

8.6. Mitigation Measures

8.6.1. Mitigation Measures of Air Quality

Since the project involves large-scale construction (Sewage Treatment Plant, laying of pipes, etc) of activity the negative impacts on the air quality would be significant during this phase. The impact on the air quality due to the operation of construction machineries in the site is found to be insignificant given the vast area of the proposed project site. However, the negative impacts created as a result of movement of construction vehicles needs critical attention. For mitigation of these impacts following measures are suggested:

- Vehicles transporting construction materials prone to fugitive dust emissions should be covered.
- Trucks carrying sand should be provided with tarpaulin sheets to cover the bed and sides of the trucks.
- Idling of delivery trucks or other equipment should not be permitted during loading and unloading
- All construction vehicles should comply with air emission standards and be maintained properly.
- Dust suppression measures in addition to the traffic management should be followed on the roads.

8.6.2. Mitigation Measures of Land Environment

The solid waste generated during the construction phase is usually Excavated earth material and Construction debris. Excavated earth material will be reused for backfilling between foundations; to fill up the low-lying areas and whereas, topsoil will be reused for Landscaping/Greenbelt development purpose.

8.6.3. Mitigation Measures of water quality

- Construction equipment requiring minimum water for cooling and operation for optimum effectiveness should be chosen.
- High pressure hose should be used for cleaning and dust suppression purposes.
- Appropriate sanitation facilities, septic tank and soak pits should be provided for the workers onsite and offsite to reduce impact on water resources
- Discharge of construction wastes to surface water bodies or ground water should not be allowed during construction.
- During construction period in rainy season, the water quality is likely to be affected due to the construction work and loosening of topsoil. This is likely to increase the suspended solids in the run – off during heavy precipitation. In order to reduce the impact on water quality, temporary sedimentation tanks shall be constructed for the settlement of suspended matter. However, it is envisaged that the monsoon period will be avoided for cutting and filling of earthwork.

8.7. Socio Economic Impacts of the Proposed Project

The project will generate employment opportunities to the local people. There will also be secondary growth that will create self-employment opportunities for the local villagers like small hotels, shops etc., which would lead to improvement in the quality of the life of the local population. The positive impact of the proposed activity is expected during the start-up of construction activities. Besides the local population would have employment opportunities in service activities, contracts and supply of construction materials. This will lead to economic up-liftment of the area.

8.8. Potential Environmental Impact Matrix

This methodology incorporates a list of project activities with a checklist of environmental components that might be affected. Matrix methods incorporate environmental conditions on one axis and proposed actions on the other.

The impact of each action on various environmental components are filled in a tabular format to estimate the impacts may be either qualitative, insignificant, high, adverse, beneficial or quantitative by assessing a numerical score, but in the end there should be a grand total to signify the magnitude of the impact. The activities discussed above are likely to affect the environment in varying degrees. Relevant components of environment, which are likely to experience some impacts due to the proposed project activities, have been identified.

Environmental parameters are broadly classified under three following groups considering the cause - effect relationship:

- Physical Environment
- Biological Environment
- Non Biophysical Components (NBP)

The parameters selected for impact identification are site activities and project specific. Different parameters considered under the said groups are as follows:

- Ambient Air Quality
- Noise
- Soil stability / erosion
- Vegetation
- Resource use
- Health
- Socio economic

The interaction between project activities and environmental parameters described above are shown in the impact matrix in the Table below, the matrix points out each activity and its impact on specific environmental parameters. This is a qualitative work and does not indicate quantitative impact. Some of the impacts are temporary and localized and some impacts are short term and long term in the matrix.

The predicted impacts of the proposed project have been discussed in Table below. The environmental management measures to reduce the adverse impacts are detailed in this Section.

Table 8-1: Potential Environmental Impact Matrix

Project Activities	Physical				Biological	Non Biophysical Components (NBP)	
	Air Quality	Noise	Soil stability / erosion	Water Quality	Vegetation	Health (Individual /Community, Occupational)	Socio-economic (Population, Community Infrastructure, Employment)
- Implementation Phase							
Pumping Stations	ST, -ve	ST, -ve	ST, -ve	Nil	ST, -ve	Nil	ST, +ve
Wet wells and Pipelines	ST, -ve	ST, -ve	ST, -ve	Nil	Nil	Nil	ST, +ve

Project Activities	Physical				Biological	Non Biophysical Components (NBP)	
	Air Quality	Noise	Soil stability / erosion	Water Quality	Vegetation	Health (Individual /Community, Occupational)	Socio-economic (Population, Community Infrastructure, Employment)
Operation Phase							
Operation of STP, Pumping Stations and Reservoirs	Nil	LT, -ve	Nil	LT, +ve	LT, +ve	LT, +ve	LT, +ve

Note: *ST – Short Term, LT – Long Term, +ve – Potential Positive Impact, -ve – Potential Negative Impact (require mitigation measures)*

8.9. CONCLUSION

To summarize; from the proposed project in ULB, the following beneficial and adverse impacts can be attributed,

- The proposed project will have positive impacts on the socio-economic environment of the study area. The project will provide direct and indirect employment for Technical, Skilled, and unskilled personnel.
- Improvement of resources: Reuse of tertiary quality of treated sewage can be used in sustainable landscaping irrigation, to recharge ground water aquifers, to meet commercial and industrial water needs. Also it can be used for stream flow augmentation to benefit ecosystems and improve aesthetics.
- The project provides the reuse of treated sewage can be utilised for water reclamation and non potable uses such as: Washing cars, flushing toilets, cooling water for power plants, concrete mixing, artificial lakes, irrigation for golf courses and public parks, and for hydraulic fracturing. Where applicable, systems run a dual piping system to keep the recycled water separate from the potable water.
- Dust suppression measures in addition to the traffic management should be followed.
- The sewage generated from the city will be treated in sewage treatment plant.
- Regular monitoring of air, water and noise parameters shall be carried out and to keep a check on routine compliance of statutory requirements.

Certain positive and negative impact may be encountered during the implementation of the proposed project.

The proponent, MSCL strongly believe in the concept of sustainable development and understand the impacts as identified above from the proposed project and shall take all measures to mitigate such negative impacts and also lay emphasis on the implementation of the recommendations of the Environmental Management Plan in true spirits.

9. DRAWINGS

Table 9-1 below provides the List of drawings presented in this DPR

Table 9-1: List of Drawings

No.	Drawing no	Drawing Title
1	WTE_2292_00_U_1.01	Sewerage Collection Network for UGD (SHEET 1 OF 2)
2	WTE_2292_00_U_1.01	Sewerage Collection Network for UGD (SHEET 2 OF 2)
3	WTE_2292_00_U_2.01	Sewerage Collection Network L Section for UGD (SHEET 1 OF 1)
4	WTE_2292_00_U_2.02	Sewerage Collection Network L Section for UGD (SHEET 1 OF 2)
5	WTE_2292_00_U_2.02	Sewerage Collection Network L Section for UGD (SHEET 2 OF 2)
6	WTE_2292_00_U_2.03	Sewerage Collection Network L Section for UGD (SHEET 1 OF 2)
7	WTE_2292_00_U_2.03	Sewerage Collection Network L Section for UGD (SHEET 2 OF 2)
8	WTE_2292_00_U_2.04	Sewerage Collection Network L Section for UGD (SHEET 1 OF 1)
9	WTE_2292_00_U_3.01	Typical Masonry Manhole Details