Chapter 1
INTRODUCTION

Sewage (or domestic wastewater or municipal wastewater) is a type of wastewater that is produced from a communityof people. It is characterized by volume or rate of flow, physical condition, chemical and toxic constituents, and itsbacteriologic status (which organisms it contains and in what quantities). It consists mostly of greywater (from sinks, tubs, showers, dishwashers, and clothes washers), blackwater (the water used to flush toilets, combined with the human waste that it flushes away); soaps and detergents; and toilet paper (less so in regions where bidets are widely used instead of paper).

A stormwater drain is designed to drain excess rain and ground water from impervious surfaces such as paved streets, car parks, parking lots, footpaths, sidewalks, and roofs. Storm drains vary in design from small residential dry wells to large municipal systems.

Sewerage is the infrastructure that conveys sewage or surface runoff (stormwater, meltwater, rainwater) using sewers. It encompasses components such as receiving drains, manholes, pumping stations, storm overflows, and screening chambers of the combined sewer or sanitary sewer. Sewerage ends at the entry to a sewage treatment plant or at the point of discharge into the environment. It is the system of pipes, chambers, manholes, etc. that conveys the sewage or storm water.

Nowadays in urban cities it is necessary to maintain hygiene of city. To achieve this we should separate sewage generated in cities to some other place. For that sewer system carry sewage and sometimes both sewage and storm water to pumping station and from there to treatment plant. Sewers separate people and their excrement mostly to protect our health. Storm sewers (a part of a sewage system) are separate from the sewer mains that carry waste and instead carry excess rain water to keep roads from flooding. The underground drainage pipes of the sewerage system in Mumbai are more than 100 years old and needs renovation. In congested parts, the sewerage lines and water pipelines run together and leakages contaminate drinking water. The unplanned and unauthorized growth of the city makes it difficult and, at times, impossible to replace old sewerage lines. The problem of sewer lines of small diameters getting choked due to solid waste and silt entering them is rampant. The result is that instead of getting drained, sewage overflows on to the surface.

This modern water carriage sewerage system not only helps in removing the domestic and industria1 wastewaters, but also helps in removing storm water, drainage. The run off resulting from the storms is also sometimes carried through sewers of the sewage system.

- Separate System.
  A separate system will require laying two sets of conduits, whereas, a combined system requires laying only one set of bigger sized conduits, thus making the former system costlier. Moreover, the separate conduits cannot be laid in congested streets and localities, making it physically unfeasible.
- Combined System.
  In a combined system, the less-foul drainage water gets mixed with the highly foul sewage water, thus necessitating the treatment of the entire flow, needing more capacity for the treatment plant, thereby making it costlier. Whereas, in the separate

system, only the sewage discharge is treated and the drainage discharge is disposed of without any treatment

- Partially Separate or Partially combined system.
  It is generally not possible to attain a 'truly separate system' because some rain water may always find its way into the sewers either through wrong house sewer connections or through open manhole covers. Similarly, wherever the authorities find insufficient sewer capacities they divert part of the sewage into the storm water drains, thus making most of our existing systems as 'partially separate' only.

  Note: In the modern days, a 'separate system' is generally preferred to a 'combined system', although each individual case should be decided separately.

Objective

Our main objective of this project is the improvement of surrounding area environment and prevention of flooding and preservation of water quality in public water bodies by separating sewage from environment. In this project we have design a sewer system for Carter road, Bandra, Mumbai.

Major role of a sewer system can be listed as follows:

1. Improvement in the environment by removing the sewage as it originates
2. Preventing inundation of low lying areas that may be otherwise caused by not sewering.
3. Prevention of vector propagation by sluggish sewage stagnations
4. Avoiding cross connections with fresh water sources by seepage

In addition, There is a strong emphasis on:

1. Avoiding sewer impacts on groundwater quality by infiltration of soil water into sewers and exfiltration of sewage into soil water occurring rather as a cycle depending on the flow conditions in leaky sewers, and

2. Moving away from the mindset that a sewer system shall necessarily be an underground sewer right in the middle of the road with costly construction, upkeep and remediation and making the objective realisable if necessary in an incremental sewerage commensurate with optimizing the areal coverage in the available financial and human resources to create and sustain the system.

Chapter 2
REVIEW AND LITRATURE

2.1) Urban Development on Sewerage and Sewage Treatment (1993) by CPHEEO manual.

In this manual provides objectives, planning of sewerage system, also show design consideration, population forecast, design criteria, parameters. It provides standard assumptions, tables, and design period for various systems. It provides design of sewer, type of pipe materials, velocity flow and also provides STP process, design and related standard considerations.

2.2 Swamee, P. K. (2001). “Design of Sewer Line”. Journal Environmental Engineering.

In this paper provides the major portion of the cost of a wastewater system. In the design of a sewerage system the sewer line is the basic unit occurring repeatedly in the design process. Any savings during the design of this unit will affect the overall cost of the sewerage system. The literature shows that the present status of sewer line designs algorithms use linear programming and dynamic programming. This literature provides the various formulas such as resistance equation, diameter equation, depth equation, maximum velocity and discharge equation and optimization of the equations. Remedial measures are given on minimum cover, self-cleansing velocity. In the description of algorithm, the procedure is stepwise given, design example and its solution. An algorithm for optimal design of a sewer line has been described. The resistance equation was used for elimination of design variables.

2.3 Charalambous, C. and Elimarn, A. A. (1990),
“Heuristic Design of Sewer Networks”. Journal Environmental Engineering.

This paper is presented a Heuristic approaches for the design of sewer networks and the use of standard diameters. This Heuristic provides good and logical (rather than optimal) designs of sewer networks. The necessary and sufficient conditions to determine positions of a lift station are presented in a theorem.Based on this theoretical result, a heuristic design algorithm, using either Manning or the modified Hazen-Williams hydraulic equation, is developed. The proposed heuristic design algorithm takes into account all the structural and hydraulic requirements. In this paper also gives the diagram of geometry of sewer line, shows the level of the pipe. The CPU time for designing sewer networks using the proposed heuristic is less than 10% of the time required for the optimization procedure. Such application indicates the effectiveness of the heuristic in rapidly providing “good” sewer network designs that are comparable to the optimal ones.

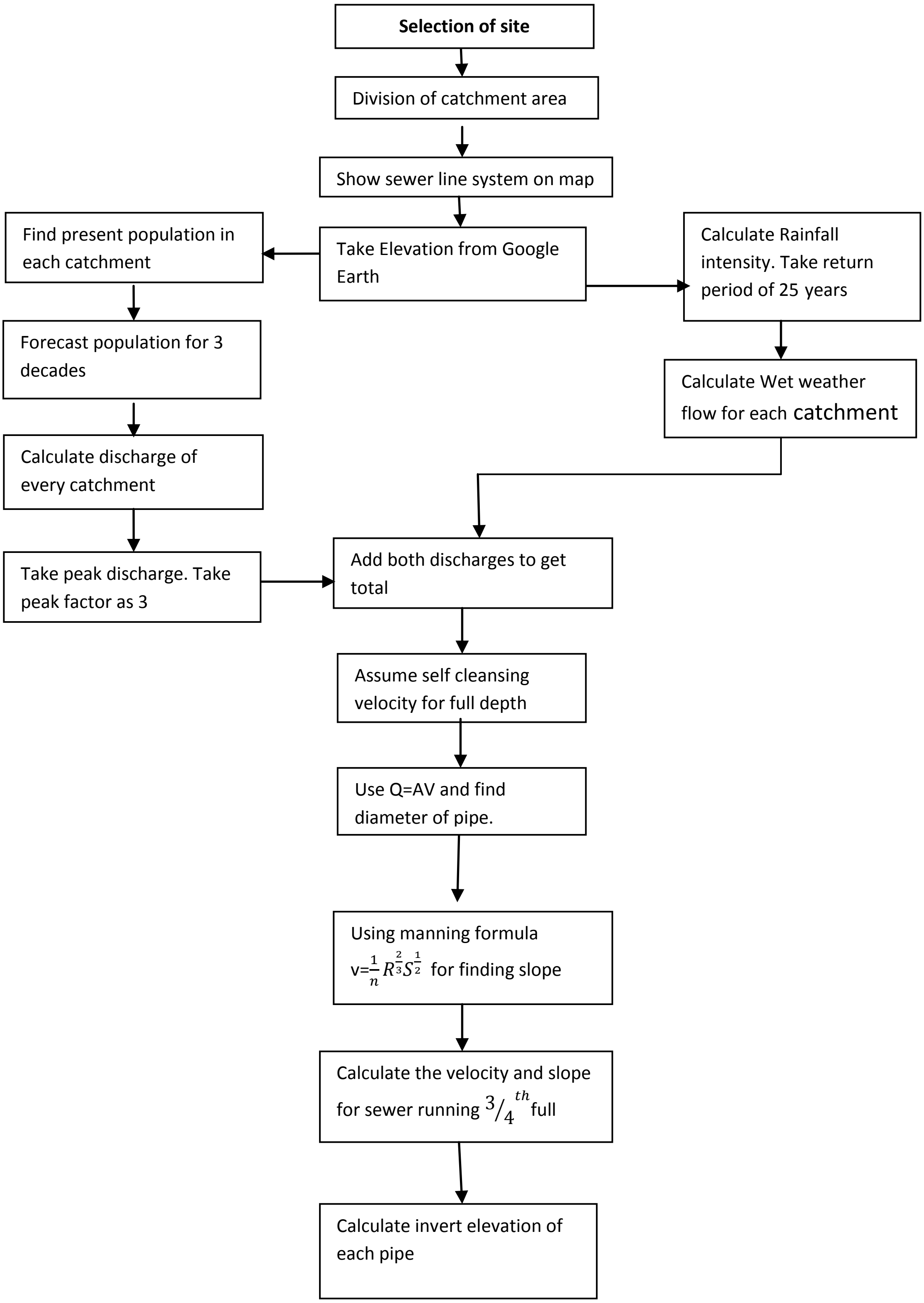
2.4 Greene, R., Agbenowosi, N. and Loganathan, G. V. (1999). "GIS-based approach to sewer system design". Journal Environmental Engineering.

In this paper, planning and design of sewer networks, most decisions are spatially dependent because of the right-of-way considerations and the desire to have flow by gravity. The geographic information system (GIS-) based approach takes advantage of the spatial analysis capability of GIS in combination with a sewer design program to develop an integrated procedure for the design of sewer systems. The program that was developed uses the user specified manholes' locations to generate the sewer network. The GIS is used to analyze the area's topography, surface features, and street network to delineate sub-watersheds, to locate pump stations, and to determine the path for the force main.out the general slope of the ground which helps in finalizing the alignments and directions of the sewers.

CHAPTER 3
THEORY, METHODOLOGY AND ALGORITHM

The flow chart show the procedure of designing of sewer which we have carried out.

Flow chart 3 – procedure of sewer design



3.1. Environmental consideration

Following aspect should be consider while designing of sewer

a) Surface Water Hydrology and Quality Hydrological considerations affect the location of outfalls to rivers with regard to protection of nearby water supply intake points either upstream or downstream, especially at low flow in the river. Hydrological considerations also help determine expected dilutions downstream, frequency of floods and drought conditions, flow velocities, travel times to downstream points of interest, navigation, etc. Surface water quality considerations include compliance with treated effluent standards at the discharge point with respect to parameters like BOD, suspended and floating solids, oil & grease, nutrients, coliforms, etc. Special consideration may be given to the presence of public bathing ghats downstream. The aquatic ecosystem (including fish) may also need protection in case of rivers through minimum dissolved oxygen downstream, ammonia concentrations in the water, uptake of refractory and persistent substances in the food chain, and protection of other legitimate uses to which the river waters may be put.

b) Ground Water Quality Another environmental consideration is the potential for ground water pollution presented by the treatment units proposed to be built. For example, in certain soils, special precautions may be needed to intercept seepage of sewage from lagoons and ponds. Land irrigation would also present a potential for ground water pollution especially from nitrates. In case of low cost sanitation methods involving on-site disposal of excreta and sullage waters, ground water pollution may need special attention if the ground water table is high and the topsoil relatively porous.

c) Coastal Water Quality Shoreline discharges of sewage effluents, though treated, could lead to bacterial and viral pollution and affect bathing water quality of beaches. Discharges have to be made sufficiently offshore and at sufficient depth through marine outfall to benefit from dilution and natural dieaway of organisms before they are washed back to the shoreline by currents. The presence of nutrients could also promote algal growth in coastal waters, especially in bays where natural circulation patterns might keep the nutrients trapped in the water body.

d) Odour and Mosquito Nuisance Odour and mosquito nuisance in the vicinity of sewage treatment plants, particularly in the downwind direction of prevailing winds, can have adverse impacts on land values, public health and well-being and general utility of amenities may be threatened. These factors have to be considered in selecting technologies and sites for location of sewage treatment plants and treated sewage irrigation fields.

e) Public Health Public health considerations pervade through all aspects of design and operation of sewage treatment and disposal projects. Some aspects have already been referred to in earlier part of this Section.

Public health concepts are built into various byelaws, regulations and codes of practice which must be observed, such as:

i) Effluent discharge standards including permissible microbial and helminthic quality requirements
ii) Standards for control of toxic and accumulative substances in the food chain
iii) Potential for nitrate and microbial pollution of ground waters
iv) Deterioration of drinking water resources including wells
v) Deterioration of bathing water quality
vi) Control measures for health and safety of sewage plant operators and sewage farm workers, and nearby residents, who are exposed to bio-aerosols or handle raw and/or treated sewage.

f) Landscaping Sewage treatment plant structures need not be ugly and unsightly. At no real extra cost, some architectural concepts can be used and the buildings designed to suit the main climates (humid or dry) generally met within India. Apart from the usual development of a small garden near the plants office or laboratory, some considerations need to be given to sites for disposal of screenings and grit in an inoffensive manner, general sanitation in the plant area and provision of a green-belt around the treatment plant. Green belt around the treatment plant shall be preferably of plants with shallow roots in order to avoid deep and spread roots

from trees accessing the water retaining structures and635 damaging their construction by ingress to the moist zones.
g) Status of pollution of surface waters, ground waters and coastal waters
h) Remediation needs and realistic solutions to mitigation of pollution
i) Solid wastes disposal and leachates as affecting the likely siting of STPs
j) Fate of sludge generated in STPs and potential to go in for vermin composting
k) Clean Development Mechanism by biomethanation and energy recovery from STPs
l) Vital statistics and frequency of water borne and vector borne diseases.

3.2.Site selection

Before the sewer network can be designed, accurate information regarding the site conditions is essential. This information may vary with the individual scheme but shall, in general, be covered by the following:

a) Site plan – A plan of the site to scale with topographical levels, road formation levels, level of the outfall, location of wells, underground sumps and other drinking water sources.
b) The requirements of local bye-laws
c) Subsoil conditions – Subsoil conditions govern the choice of design of the sewer and the method of excavation.
d) Location of other services (such as position, depth and size of all other pipes, mains, cables, or other services, in the vicinity of the proposed work)
e) Topography

The factors which influence determination of project area include natural topography, layout of buildings, political boundaries, economic factors, city master plan, etc. For larger drainage areas, though it is desirable that the sewer capacities be designed for the total project area, sometimes political boundaries and legal restrictions prevent construction of sewers beyond the limits of the local authority. However, when designing sewers for larger areas, there is usually an economic advantage in providing adequate capacity initially for a certain period of time and constructing additional sewers, when the pattern of growth becomes established. The need to finance projects within the available resources necessitates the design to be restricted to political boundaries. The project area under consideration should be marked on a key plan so that the area can be measured from the map.

For our project we have considered the site close to our college for better implementation and guidance.

Our project site is Carter road, Bandra west, Mumbai.

Total area comes under consideration is 15.52 hectors.

As shown in below figure our total area is further divided into 23 catchment areas for the calculation of discharge in the small portion. And the area of each catchment is shown in the table of rainfall calculation.

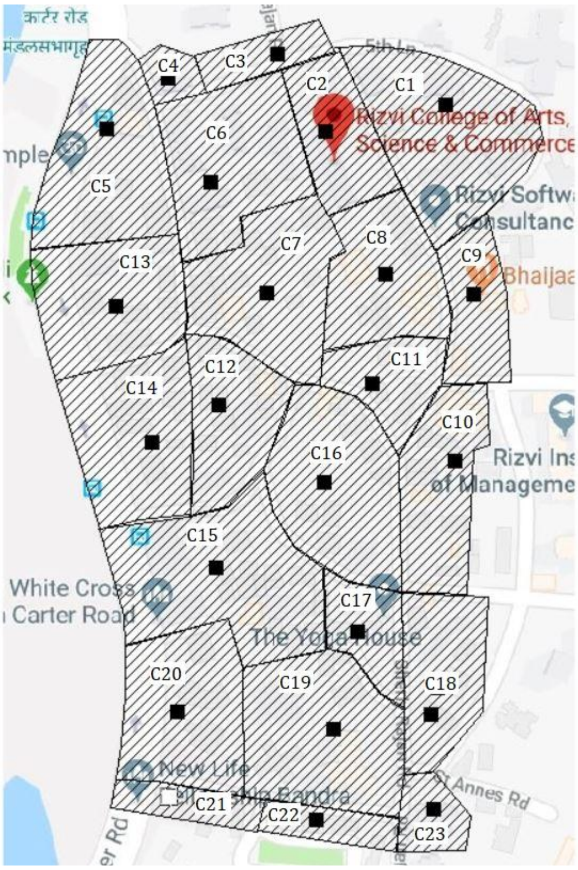


Figure 3.2 – division of catchment area

3.3.Design period

The length of time up to which the capacity of a sewer will be adequate is referred to as the design period. In fixing a period of design, consideration must be given for the useful life of structures and equipment employed, taking into account obsolescence as well as wear and tear. Because the flow is largely a function of population served, population density and water consumption lateral and sub main sewers are usually designed for peak flows of the population at saturation density as set forth in the Master Plan. Trunk sewers, interceptors, and outfalls are difficult and uneconomical to be enlarged or duplicated and hence are designed for longer design periods. In the case of trunk sewers serving relatively undeveloped areas adjacent to metropolitan areas, it is advisable to construct initial facilities for more than a limited period. Nevertheless right of way for future larger trunk sewers can be acquired or reserved. The recommended design period for various components shall be as in Table below

Table 3.3 – design perion

Sr.no	Component	Design period
1	Land Acquisition	30
2	Conventional sewers (A)	30
3	Non-conventional sewers (B)	15

4	Pumping mains	15
5	Pumping Stations-Civil Work	30
6	Pumping Machinery	15
7	Sewage Treatment Plants	15
8	Effluent disposal	30
9	Effluent Utilization	30

Hence we have considered the design period of up to 30 years

3.4. Elevation

The **elevation** of a geographic location is its height above or below a fixed reference point, most commonly a referencegeoid, a mathematical model of the Earth's sea level as an equipotential gravitational surface (see Geodetic system, vertical datum). The term "elevation" is mainly used when referring to points on the Earth's surface, while "altitude" or "geopotential height" is used for points above the surface, such as an aircraft in flight or a spacecraft in orbit, and "depth" is used for points below the surface.

We took elevation from GOOGLE EARTH at every 30 meter interval and change of direction. Ground surface elevation is used to find the invert level of pipe and slope of pipe.

How to take elevation using Google Earth is explained below

Explore the slope, elevation, and distance along a path.

1. Open Google Earth.
2. Draw a path or open an existing path.
3. Click **Edit** › **Show Elevation Profile**.
4. An elevation profile will appear in the the lower half of the 3D Viewer. If your elevation measurement reads "0," make sure the terrain layer is turned on.

- The Y-axis of the chart displays the elevation, and the X-axis of the chart displays the distance.
- To see the elevation and distance at different points along a path, mouse over the path.
- To see data for a portion of the path, left-click and hold. Then, move the cursor along the path you want to see.
- To change measurement systems on a Windows computer, select **Tools** › **Options**. Then, under "Units of measurement," choose feet or meters.
- To change measurement systems on a Mac, select **Google Earth** › **Preferences**. Then, under "Units of measurement," choose feet or meters.

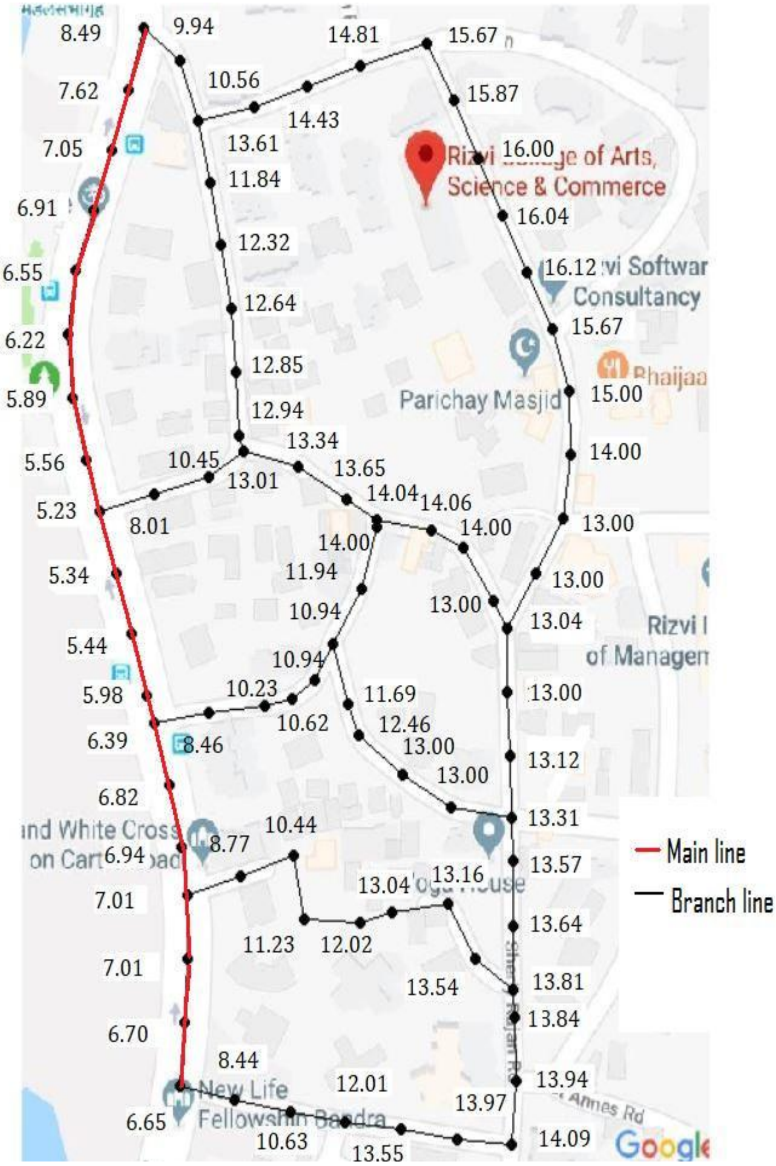


Figure 3.4 - elevation

3.5. Population forecast

The design population should be estimated paying attention to all the factors governing the future growth and development of the project area in the industrial, commercial, educational, social, and administration spheres. Special factors causing sudden immigration or influx of population should also be predicted as far as possible. A judgment based on these factors would help in selecting the most suitable method of deriving the probable trend of the population growth in the area or areas of the project from the following mathematical methods, graphically interpreted where necessary.

While the forecast of the population of a project area at any given time during the design period can be derived by any one of the foregoing methods appropriate to each case, the density and distribution of such population in several areas, zones or districts will again have to be estimated based on the relative probabilities of expansion in each zone or district, according to the nature of development and based on existing and contemplated town planning regulations. Wherever population growth forecast or master plans prepared by town planning authorities or other appropriate authorities are available, the design population should take these figures into account. Floating population should also be considered which includes number of persons visiting the project area for tourism, pilgrimage or for working. The numbers should be decided in consultation with the tourism departments and specified for water supply and sewerage.

PER CAPITA SEWAGE FLOW

The entire spent water of a community should normally contribute to the total flow in a sanitary sewer. However, the observed Dry Weather Flow quantities usually are slightly less than the per capita water consumption, since some water is lost in evaporation, seepage into ground, leakage etc. In arid regions, mean sewage flows may be as little as 40% of water consumption and in well developed areas, flows may be as high as 90%. However, the conventional sewers shall be designed for a minimum sewage flow of 100 litres per capita per day or higher as the case may be. Non-conventional sewers shall be designed as the case may be. For some areas, it is safe to assume that the future density of population for design purpose to be equal to the saturation density.

It is desirable that all sewers serving a small area be designed on the basis of saturation density. For new communities, design flows can be calculated based on the design population and projected water consumption for domestic use and commercial and industrial activity. In case a master plan containing land use pattern and zoning regulation is available, the anticipated population can be based on the ultimate densities.

The flow in sewers varies from hour to hour and also seasonally. But for the purpose of hydraulic design estimated peak flows are adopted. The peak factor or the ratio of maximum to average flows depends upon contributory population as given in Table below

Table 3.4 – peak factor

Contributory population	Peak factor
Up to 20,000	3.0
20,001 – 50,000	2.50
50,001 – 7,50,000	2.25
Above 7,50,001	2

Detailed survey has been carried out for finding the population of the region. After the survey number of flats, bungalows, chawl rooms and shops have been calculated. And according to the standard of living numbers of people per household have been assumed and populations have been calculated. The total area under our consideration is 14.52 hectors.

	Number	People/household
Flats	1484	4
Rooms	245	4

Bungalows	59	5
Shops	43	2

The growth rate of population is taken as 8.29% per decade and the design period is of 3 decade.

According to the standard of leaving the water consumption per person is taken as 135 liters of which 80% is converted into sewage. Hence from this it is calculated that the sewage produce per person is 108 liters per day. From which the discharge is calculated considering the 3 as the peak coefficient factor. This is expressed in Table below.

Table – 3.4 peak discharge of each catchment

NO	FLATS	ROOMS	BUNGLOWS	SHOPS	POPUL-ATION	FORE CAST	DISCHARGE (LPS)	PEAK DISCHARGE
1	132	0	0	0	528	660	0.825	2.475
2	76	0	0	1	306	383	0.4787	1.436
3	0	0	0	0	0	0	0	0
4	5	0	1	0	25	32	0.04	0.12
5	26	0	6	2	138	173	0.216	0.648
6	122	0	0	0	488	610	0.762	2.268
7	55	50	7	0	455	569	0.711	2.133
8	70	0	0	14	308	385	0.481	1.443
9	34	0	2	9	164	205	0.256	0.768
10	20	55	0	5	310	388	0.485	1.455
11	50	0	0	5	210	263	0.329	0.987
12	63	0	5	0	277	346	0.432	1.296
13	40	0	9	0	205	256	0.32	0.96
14	46	0	17	0	269	336	0.42	1.26
15	197	80	3	0	923	1153	1.441	4.323
16	129	60	3	2	775	968	1.21	3.63
17	3	0	4	0	32	40	0.05	0.15
18	76	0	2	5	324	405	0.506	1.518
19	188	0	0	0	752	940	1.175	3.525
20	34	0	0	0	136	170	0.212	0.636
21	60	0	0	0	240	300	0.375	1.125
22	68	0	0	0	272	340	0.425	1.275
23	40	0	0	0	160	200	0.25	0.75

3.6.Rainfall

Storm runoff is that portion of the precipitation which drains over the ground surface. Estimation of such runoff reaching the storm sewers therefore is dependent on intensity and duration of precipitation, characteristics of the tributary area and the time required for such flow to reach the sewer. The design of storm water sewers begins with an estimate of the rate and volume of surface runoff. When rain falls on a given catchments, a part of the precipitation is intercepted by the vegetation cover which mostly evaporates, some part hits the soil and some of it percolates down below and the rest flows on ground surface. Estimation of such runoff reaching the storm sewers is dependent on intensity and duration of precipitation, characteristics of the tributary area and time required for such flow to reach the sewer. More the intensity of rain, the higher will be the peak runoff rate.

The characteristics of the drainage area such as imperviousness, topography including depressions and water pockets, shape of the drainage basin and duration of the precipitation determine the fraction of the total precipitation, which will reach the sewer. This fraction is known as the coefficient of runoff.

The time period after which the entire area begins contributing to the total runoff, at a given monitoring point, is known as the time of concentration, vis-a-vis, that point -it is also obviously defined as the time it takes a drop of water to flow from hydraulically most distant point of the basin to the outlet of the basin. The duration of rainfall that is equal to the time of concentration is known as the critical rainfall duration. The rational formula expresses the relationship between peak runoff, and rainfall, and is given below.

The storm water flow for this purpose may be determined by using the rational method, hydrograph method, rainfall-runoff correlation studies, digital computer models, inlet method or empirical formulae. The empirical formulae that are available for estimating the storm water runoff can be used only when comparable conditions to those for which the equations were derived initially can be assured.

A rational approach, therefore, demands a study of the existing precipitation data of the area concerned to permit a suitable forecast. Storm sewers are not designed for the peak flow of rare occurrence such as once in 10 years or more but, it is necessary to provide sufficient capacity to avoid too frequent flooding of the drainage area. There may be some flooding when the precipitation exceeds the design value, which has to be permitted. The frequency of such permissible flooding may vary from place to place, depending on the importance of the area. Though such flooding causes inconvenience, it may have to be accepted once in a while considering the economy effected in storm drainage costs.

The maximum runoff, which has to be carried in a sewer section should be computed for a condition when the entire basin draining at that point becomes contributory to the flow and the time needed for this is known as the time of concentration (with reference to the concerned section. Thus, for estimating the flow to be carried in the storm sewer, the intensity of rainfall which lasts for the period of time of concentration is the one to be considered contributing to the flow of storm water in the sewer. Of the different methods, the rational method is more commonly used.

Average Rainfall in Mumbai: The maximum annual rainfall ever recorded was 3,452 mm (136 in) for 1954. The highest rainfall recorded in a single day was 944 mm (37 in) on 26 July 2005. The average total annual rainfall is 2,146.6 mm (85 in) for the Island City, and 2,457 mm (97 in) for the suburbs. The normal Annual rainfall varies from 1000mm to 4000mm.

Estimation of Storm Water Runoff:

Calculation of the rate of storm water runoff is important in determining the size of inlets, drains, sewers, etc. All portions of the storm water system must be designed to handle the peak flow anticipated under certain design conditions. The most widely used method for estimating peak storm water runoff is Rational formula Method.

This formula assumes:

- The rate of storm-water run-off from an area is a direct function of the average rainfall rate during the time that it takes the runoff to travel from the most remote point of the tributary area to the inlet or drain.

- The average frequency of occurrence of the peak runoff equals the average frequency of occurrence of the rainfall rate.
- The quantity of storm water lost due to evaporation, infiltration, and surface depressions remains constant throughout the rainfall.
- The coefficient of runoff is a coefficient which accounts for storm-water losses attributed to evaporation, infiltration, and surface depressions. The peak value of the flow rate Q of storm-water runoff is estimated using the following equation,

Quantity of storm run-off is dependent on intensity and duration of rainfall, characteristics of catchment area and time required for such flow to reach the sewer.
Storm water flow for this purpose may be determined by using rational methods, hydrograph methods or empirical formulae.
Rational formulae
Q = 0.00278 PAIc $m^3/_{sec}$

Where, A- Catchment Area in hectares
P- Runoff Coefficient of Runoff
Ic- Intensity of Rainfall mm/Hr
Ic =Io (2/(tc+1))
tc= $(\frac{0.87L^3}{H})^{0.385}$
Where, tc Time of Concentration in hour
L- The distance from the critical point to the structure in km
Io – One hour Rainfall

DURATION IN HOUR	RETURN PERIOD IN YEAR		
	1	10	25
1	29.911	65.861	76.770

Therefore, Io= 76.770 mm/hour

Table below shows the calculated result of total discharge per catchment area.
Q_{wwf} is the discharge of the wet whether flow which have been calculated using rainfall intensity by rational method

Table 3.6 – storm water discharge of each catchment

No	AREA (HECTORS)	LENGTH (M)	H (M)	t_c hour	I_c $mm/_{hour}$	Q_{wwf} (LPS)
1	1.08	145.24	0.24	0.177	130.45	273.945
2	0.42	100.98	0.06	0.198	128.16	104.664
3	0.21	87.68	0.5	0.074	142.96	58.375
4	0.16	40.61	4.73	0.0128	151.60	47.164
5	0.91	145.66	1.22	0.095	140.22	248.112
6	1.02	114.99	0.43	0.108	130.57	258.964
7	0.94	122.06	1.62	0.069	143.63	262.524
8	0.59	109.68	0.12	0.167	131.56	150.929
9	0.43	95.86	1.4	0.055	145.54	121.687
10	0.63	141.96	0.82	0.107	138.69	169.89
11	0.34	57.16	0.32	0.054	145.54	96.304

12	0.55	131.13	2.97	0.054	145.67	155.048
13	0.68	81.02	0.31	0.082	141.904	187.629
14	0.86	101.78	1.22	0.063	144.44	241.536
15	1.33	153.39	3.25	0.069	143.63	337.443
16	0.89	136.114	2	0.073	143.09	247.625
17	0.33	68.34	1.2	0.039	147.78	94.82
18	0.56	123.90	0.44	0.116	137.58	149.809
19	0.92	172.99	0.42	0.174	130.78	233.951
20	0.92	102.24	0.64	0.082	141.90	253.84
21	0.24	80.13	4.13	0.029	149.21	69.63
22	0.33	99.35	1	0.066	144.03	92.419
23	0.18	129.77	0.12	0.202	127.74	44.709

Sample calculation of catchment no. 1

For catchment no. 1
L=145.24 m
A=1.08 hac
H=0.24

$t_c = \left(\frac{0.87*0.14524^3}{0.24}\right)^{0.385}$

= 0.177 hour

Ic =76.77 (2/0.177+1))

=130.45 mm/hr

Q_{wwf} = 0.00278 *0.7*1.08*130.45 $m^3/_{sec}$

= 0.273945 $m^3/_{sec}$

=273.945 lps

3.7.VELOCITY

Minimum velocity

The flow velocity in the sewers should be such that the suspended materials in sewage do not get silted up; i.e. the velocity should be such as to cause automatic self-cleansing effect. The generation of such a minimum *self cleansing velocity* in the sewer, at least once a day, is important, because if certain deposition takes place and is not removed, it will obstruct free flow, causing further deposition and finally leading to the complete blocking of the sewer.

Table 3.7 – minimum velocity

No.	Criteria	Value
1	Minimum velocity at initial peak flow	0.6 m/s^2
2	Minimum velocity at ultimate peak flow	0.8 m/s^2
3	Maximum velocity	3 m/s^2

For designing we have consider minimum velocity as 0.9 m/s^2 .

Maximum velocity

The smooth interior surface of a sewer pipe gets scoured due to continuous abrasion caused by the suspended solids present in sewage. It is, therefore, necessary to limit the maximum velocity in the sewer pipe. This limiting or non-scouring velocity will mainly depend upon the material of the sewer.

Table 3.7 - Limiting or non-scouring velocity for different sewer material Sewer Material

Limiting velocity	m/sec
Vitrified tiles	4.5 – 5.5
Cast iron	3.5 – 4.5
Cement concrete	2.5 – 3.0
Stone ware sewer	3.0 – 4.5
Brick lined sewer	1.5 – 2.5

The problem of maximum or non-scouring velocity is severe in hilly areas where ground slope is very steep and this is overcome by constructing drop manholes at suitable places along the length of the sewer.

Since we have assumed the sewer we are designing is of cement concrete or maximum velocity have been limited up to 2.5 m/s

Effect of flow variation is sewer

Due to variation in discharge, the depth of flow varies, and hence the hydraulic mean depth (r) varies. Due to the change in the hydraulic mean depth, the flow velocity (which depends directly on $r^{2/3}$) gets affected from time to time. It is necessary to check the sewer for maintaining a minimum velocity of about 0.45 m/s at the time of minimum flow (assumed to be 1/3rd of average flow). The designer should also ensure that a velocity of 0.9 m/s is developed at least at the time of maximum flow and preferably during the average flow periods also. Moreover, care should be taken to see that at the time of maximum flow, the velocity generated does not exceed the scouring value.

3.8.Manning's Formula

Manning equation has been used to calculate the slope of the pipe.

$$V=\frac{1}{n}R^{2/3}S^{1/2}$$

Where:

V=Average velocity m/sec

n=Manning's roughness coefficient

R=Hydraulic radius

S=Longitudinal slope of channel.

Table 3.8 – manning coefficient

Type of material	Condition	N
Salt glazed stone ware pipe	Good	0.012
Salt glazed stone ware pipe	Fair	0.015
Cement concrete pipes and masonry with cement mortar plaster	Good	0.013
Cement concrete pipes and masonry with cement mortar plaster	Fair	0.015
FRP		0.010
HDPE / UPVC		0.010
CI with cement mortar lining		0.010
DI with cement mortar lining		0.010

Table 3.8 – manning design

Constant (n)			Variable (n)		
d/D	v/V	q/Q	$\frac{n_d}{n}$	v/V	q/Q
1.0	1.000	1.000	1.00	1.000	1.000
0.9	1.124	1.066	1.07	1.056	1.020
0.8	1.140	0.968	1.14	1.003	0.890
0.7	1.120	0.838	1.18	0.952	0.712
0.6	1.072	0.671	1.21	0.890	0.557
0.5	1.000	0.500	1.24	0.810	0.405
0.4	0.902	0.337	1.27	0.713	0.266
0.3	0.776	0.196	1.28	0.605	0.153
0.2	0.615	0.088	1.27	0.486	0.070
0.1	0.401	0.021	1.22	0.329	0.017

Where,
D = Depth of flow (internal dia)
d = Actual depth of flow
V = Velocity at full depth
v = Velocity at depth 'd'
n = Manning's coefficient at full
nd = Manning's coefficient at depth 'd'
Q = Discharge at full depth
q = Discharge at depth 'd'

3.9.Discharge calculation

There are total 23 catchment areas under consideration. After calculating sanitary discharge and storm water discharge .we get the total discharge in every catchment. After selecting the start point i.e the point of higher elevation discharge in every pipe line have been calculated. And there are total 84 pipe lines.

Table 3.9 – total discharge and slope in each pipe

Pipe No.	Length (m)	Upper Elevation	Lower Elevation	Slope	Discharge
1	30	15.67	15.87	-0.0067	106.1
2	30	15.87	16	-0.0043	106.1
3	30	16	16.04	-0.0013	382.52
4	30	16.04	16.12	-0.0026	382.52
5	30	16.12	15.67	0.015	382.52
6	30	15.67	15	0.0223	534.829
7	30	15	14	0.033	534.892
8	30	14	13	0.033	657.347
9	30	13	13	0	657.347
10	30	13	13	0	657.347
11	30	13	13	0	657.347
12	30	13	13.12	-0.004	925.983
13	30	13.12	13.31	-0.0063	925.983
14	30	14	14.06	-0.002	97.291
15	15	14.06	14	0.004	97.291
16	30	14	13	0.033	97.291
17	15	13	13	0	97.291
18	30	13.31	13	0.0103	925.983
19	30	13	13	0	925.983
20	30	13	12.46	0.018	925.983
21	15	12.46	11.69	0.0512	925.983
22	30	11.69	10.94	0.025	477.208
23	15	10.94	10.95	-0.0066	1177.208
24	15	10.95	10.62	0.022	1177.208
25	15	10.62	10.23	0.026	1333.552
26	30	10.23	8.46	0.059	1333.552
27	30	8.46	6.39	0.069	1333.552
28	30	14	11.94	0.068	
29	30	11.94	10.94	0.033	
30	15	14.04	13.65	0.026	246.657
31	30	13.65	13.34	0.0103	246.657

32	30	13.34	13.01	0.011	246.657
33	20	13.01	10.45	0.128	246.657
34	30	10.45	8.01	0.0813	246.657
35	30	8.01	5.23	0.0926	246,657
36	30	15.67	14.81	0.0286	58.375
37	30	14.81	14.43	0.0126	58.375
38	30	14.43	13.61	0.0273	58.375
39	30	13.61	10.56	0.1016	58.375
40	30	12.94	12.85	0.003	261.25
41	30	12.85	12.64	0.007	261.25
42	30	12.64	12.32	0.01	261.25
43	30	12.32	11.84	0.016	261.25
44	30	11.84	10.56	0.0426	261.25
45	30	10.56	9.94	0.0206	319.625
46	30	9.94	8.49	0.048	319.625
47	30	14.09	13.94	0.005	45.459
48	30	13.94	13.84	0.0033	45.459
49	15	13.84	13.81	0.007	45.459
50	20	13,31	13.57	-0.0086	151.327
51	30	13.57	13.64	-0.0023	151.327
52	30	13.64	13.81	-0.0056	151.327
53	20	13.81	13.54	0.0135	196.786
54	30	13.54	13.16	0.0127	196.786
55	30	13.16	13.04	0.004	196.786
56	10	13.04	12.02	0.102	291.756
57	30	12.02	11.23	0.026	291.756
58	30	11.23	10.44	0.0263	291.756
59	30	10.44	8.77	0.0556	291.756
60	30	8.77	6.94	0.061	667.522
61	30	14.09	13.97	0.005	237.476
62	30	13.97	13.55	0.014	237.476
63	30	13.55	12.01	0.051	331.17
64	30	12.01	10.63	0.046	331.17
65	30	10.03	8.44	0.073	331.17
66	30	8.44	6.65	0.0596	401.926
67	30	8.49	7.62	0.029	319.625
68	30	7.62	7.05	0.019	319.625
69	30	7.05	6.91	0.0046	319.625
70	30	6.91	6.55	0.012	568.393
71	30	6.55	6.22	0.0116	568.393
72	30	6.22	5.89	0.011	568.393
73	30	5.89	5.56	0.011	568.393
74	30	5.56	5.23	0.011	756.982
75	30	5.23	5.34	-0.0036	1003.639

76	30	5.34	5.44	-0.0033	1246.435
77	30	5.44	5.98	-0.018	1246.435
78	15	5.98	6.39	-0.0273	1246.435
79	30	6.39	6.82	-0.0143	2579.985
80	30	6.82	6.94	-0.004	2579.985
81	30	6.94	7.01	-0.0023	2579.985
82	30	7.01	7.01	0	3247.509
83	30	7.01	6.7	0.0103	3247.509
84	30	6.7	6.65	0.0016	3501.985

3.10. Manholes

A manhole (alternatively utility hole, cable chamber, maintenance hole, inspection chamber, access chamber, sewer hole, or confined space) is the top opening to an underground utility vault used to house an access point for making connections, inspection, valve adjustments or performing maintenance on underground and buried public utility and other services
including water, sewers, telephone, electricity, storm drains, district heating and gas.

Provide manhole for every 30 meter interval and for every change in slope and direction of pipe.

A manhole is an opening by which a man may enter a sewer for inspection, cleaning and other maintenance and fitted with a removable cover to withstand traffic loads in sewers. Having designed the sewer system, the manholes are first constructed in identified reaches before the sewers are laid. The diameters of circular manholes for stated depths of sewers are in Table below

Table 3.10 – internal diameter of manhole

No.	Range of depth (m)	Internal diameter
1	0.9 m – 1.65m	0.9 m
2	1.65 m – 2.30 m	1.2 m
3	2.30 m – 9.0 m	1.5 m
4	9.0 m – 14.0m	1.8 m

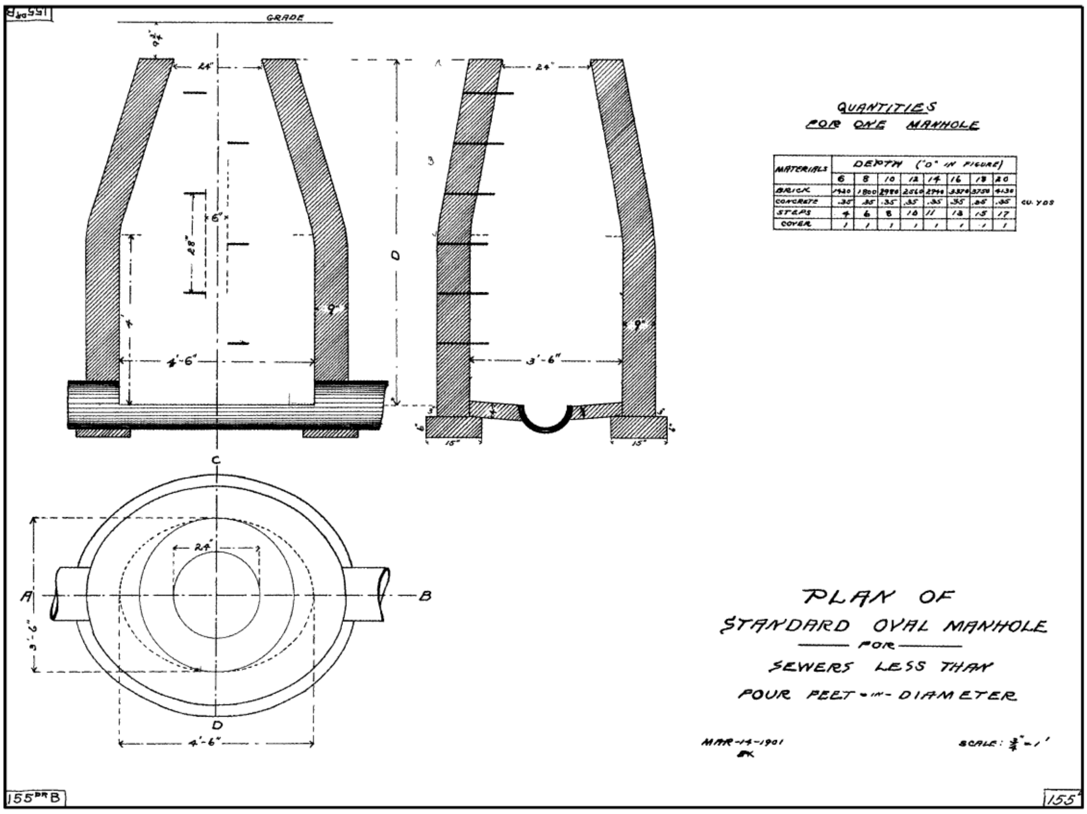


Figure 3.10 – manhole section

3.11. **Pipe-**

The material used for pipe is concrete. Roughness coefficient is 0.013. Minimum diameter used is 200mm while maximum be 2400 meter

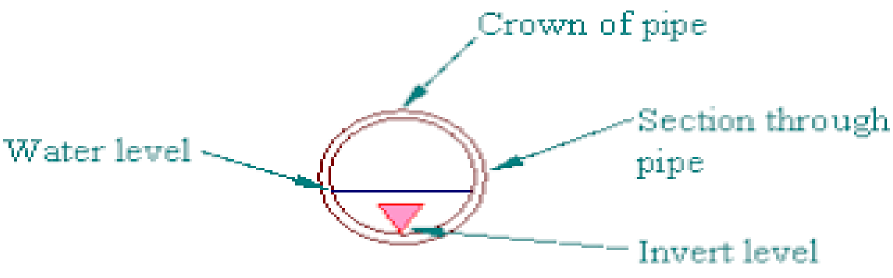
3.12. **Invert level –**

The pipe invert level is thelevel of the INSIDE bottom of the pipe. This level allows of the slope of the pipe to beset at various points so that the fluid will flow by gravity. Using the inside bottominstead of the outside bottom level avoids problems if different pipe thicknesses areused.

The invert level is simply the inside bottom of the pipe. And a drain pipe naturally shouldnever be level. It should have a minimum of 1/8” fall per foot and is always best to haveat least ¼” per foot

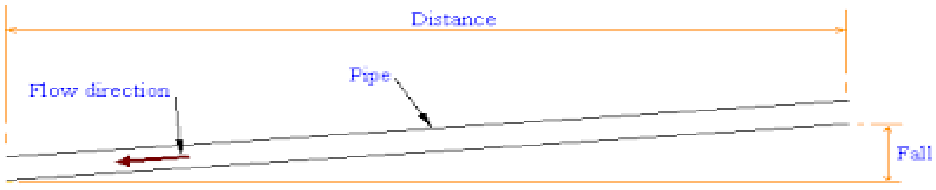
Gradients from 1 in 40 to 1 in 110 will normally give adequate flow velocities. A gradient of 1 in 80 is suitable for commencing calculations for pipe schemes.If a gradient is too steep i.e. steeper than 1 in 40, the liquid may run faster than thesolids in the sloping foul water pipe thus leaving the solids stranded, which could then blockthe pipe.If the gradient is not steep enough, i.e. less than 1 in 110, then the pipe could still blockif the solids slow down and become stranded.The fall in a pipe may be defined as the vertical amount by which the pipe drops over adistance. The distance can be between sections of pipe or between manholes.

Figures shows the invert level in the pipe and relation of fall in the drainage pipe.



INVERT LEVEL OF PIPE

Figure 3.12 - invert pipe



FALL IN DRAINAGE PIPE

Figure 3.12 – fall in drainage pipe

<u>Calculation of invert level of 1st pipe:</u>

1) <u>Calculation of pipe level:</u>

Upward elevation = 15.67m.

Lower elevation = 15.87m.

Take cover of ground = 1m. (Cover is the distance of top of pipe from ground level)

Elevation difference of pipe = Slope of pipe X length of pipe.

= 0.00241 X 30

= 0.0723.

Upper ground level of pipe = Upward elevation - cover of ground

= 15.67 – 1

= 14.67m

Lower ground level of pipe = Upper ground level of pipe – Elevation difference of pipe

= 14.67 – 0.0732

= 14.59m

2) <u>Calculation of invert level of pipe:</u>

Upper invert level of pipe = Upper ground level of pipe – thickness of pipe – diameter of pipe.

= 14.67 – 0.45 – 0.075

= 14.145m.

Lower invert level of pipe = Lower ground level of pipe – thickness of pipe – diameter of pipe.

= 14.67 – 0.45 – 0.075

= 14.065.

Indian Standard 458:2003 is use to determine the standard pipe diameter and wall thickness
Concrete pipe of class NP3 is used.

Table 3 Design and Strength Test Requirements of Concrete Pipes of Class NP3 — Reinforced Concrete, Medium Duty, Non-pressure Pipes

(*Clauses* 6.1.1, 6.1.2.1, 6.1.3, 6.2.2, 7.3.2 *and* 8.1; and *Table* 20)

Internal Diameter of Pipes	Barrel Wall Thickness	Reinforcements			Strength Test Requirements for Three Edge Bearing Test	
		Longitudinal, Mild Steel or Hard Drawn Steel		Spirals, Hard Drawn Steel	Load to Produce 0 25 mm Crack	Ultimate Load
mm	mm	Minimum number	kg/linear metre	kg/linear metre	kN/linear metre	kN/linear metre
(1)	(2)	(3)	(4)	(5)	(6)	(7)
80	25	6	0 59	0 16	13 00	19 50
100	25	6	0 59	0 22	13 00	19 50
150	25	6	0 59	0 46	13 70	20 55
200	30	6	0 59	0 81	14 50	21 75
225	30	6	0 59	1 03	14 80	22 20
250	30	6	0 59	1 24	15 00	22 50
300	40	8	0 78	1 80	15 50	23 25
350	75	8	0 78	2 95	16 77	25 16
400	75	8	0 78	3 30	19 16	28 74
450	75	8	0 78	3 79	21 56	32 34
500	75	8	0 78	4 82	23 95	35 93
600	85	8 or 6+6	1 18	7 01	28 74	43 11
700	85	8 or 6+6	1 18	10 27	33 53	50 30
800	95	8 or 6+6	2 66	13 04	38 32	57 48
900	100	6 + 6	2 66	18 30	43 11	64 67
1 000	115	6 + 6	2 66	21 52	47 90	71 85
1 100	115	6 + 6	2 66	27 99	52 69	79 00
1 200	120	8 + 8	3 55	33 57	57 48	86 22
1 400	135	8 + 8	3 55	46 21	67 06	100 60
1 600	140	8 + 8	3 55	65 40	76 64	114 96
1 800	150	12 +12	9 36	87 10	86 22	129 33
2 000	170	12 +12	9 36	97 90	95 80	143 70
2 200	185	12 +12	9 36	133 30	105 38	158 07
2 400	200	12 +12	14 88	146 61	114 96	172 44
2 600	215	12 +12	14 88	175 76	124 54	186 81

NOTES

1 If mild steel is used for spiral reinforcement, the weight specified under col 5 shall be increased to 140/125

2 The longitudinal reinforcement given in this table is valid for pipes up to 2 5 m effective length for internal diameter of pipe up to 250 mm and up to 3 m effective length for higher diameter pipes

3 Total mass of longitudinal reinforcement shall be calculated by multiplying the values given in col 4 by the length of the pipe and then deducting for the cover length provided at the two ends.

4 Concrete for pipes shall have a minimum compressive strength of 35 N/mm² at 28 days

Chapter 4

C0ST OF PROJECT

EXCAVATION

For any individual connection involving excavation, the applicant shall cover the costs of keeping the excavation free of water, pumping, timbering and shoring for installation, removal of excavated materials from site, (where these are necessary) and excavating to required depth plus all items incidental to the work.

All trenching shall have vertical sides unless otherwise permitted or ordered by Council. The trench shall be of sufficient width to easily and safely allow operations necessary for the laying and jointing of pipes, fittings and placing and compaction of backfill material.

In all instances, excavation shall be carried out by a registered drain-laying contractor or under the direct supervision of the same

No Contractor [or Applicant] shall have more than 40 meters of trench opened at any time and at night or weekends, this open trench shall be reduced to a maximum length of 10 meters where trenches are on public or community accessed land.

When the Contractor (or Applicant) is not on site, all trenches shall be fenced off or filled in, with hazard warning signs about the work site. Warning lights shall be placed at strategic points where open trenches are located on road reserves, footpaths or parking areas.

Pipe Laying

Pipe Bedding

Only approved materials are allowed to be used for pipe embedment.

They shall be in accordance to the approved longitudinal and cross sectional sewer profile drawings, which shall also provide details of the designed bedding types. The bedding material shall be placed as soon as possible after the base of the trench is prepared and excess water has been removed.

Granular bedding shall be placed, compacted and graded so that it offers continuous support to the sewer. The compacting, where required, shall achieve a uniform density. Where the bedding is disturbed, the pipe shall be raised again to repair the bedding. Pipe and fittings shall not be dropped into the trench. Instead, pipes shall be lowered into the trench using approved slings. Pipes shall be laid from the downstream end towards the upstream end. The laying of pipes shall proceed carefully to ensure the line, level and grade are within the specified tolerances.

Backfill of Trench

a) Selected excavated material shall be placed above the specified pipe support until 300 mm above the sewer. They shall be in accordance to the approved longitudinal and cross-sectional sewer profile drawings,

which also give the bedding details and the types of fill material. Trench support shall be progressively removed as the backfill is
placed. There shall be at least 300 mm of cover over the sewer before light
mechanical compaction can commence. There shall be at least 1000 mm of cover over the sewer before
heavy mechanical compaction can commence. For plastic pipe, a metallic marker tape shall be laid along the line of the sewer at approximately 500 mm below the surface level.
Earthwork
The cost of excavation depends on the depth of excavation, type of soil, method of excavation to be carried out and the distance where the excavated soil has to be disposed. The cost of all these are added for unit volume of excavation to get the rate of excavation.

The cost of excavation based on depth is generally divided into categories as:

For depth upto 1.5m
For depth between 1.5m to 3m.
For depth more than 3 m

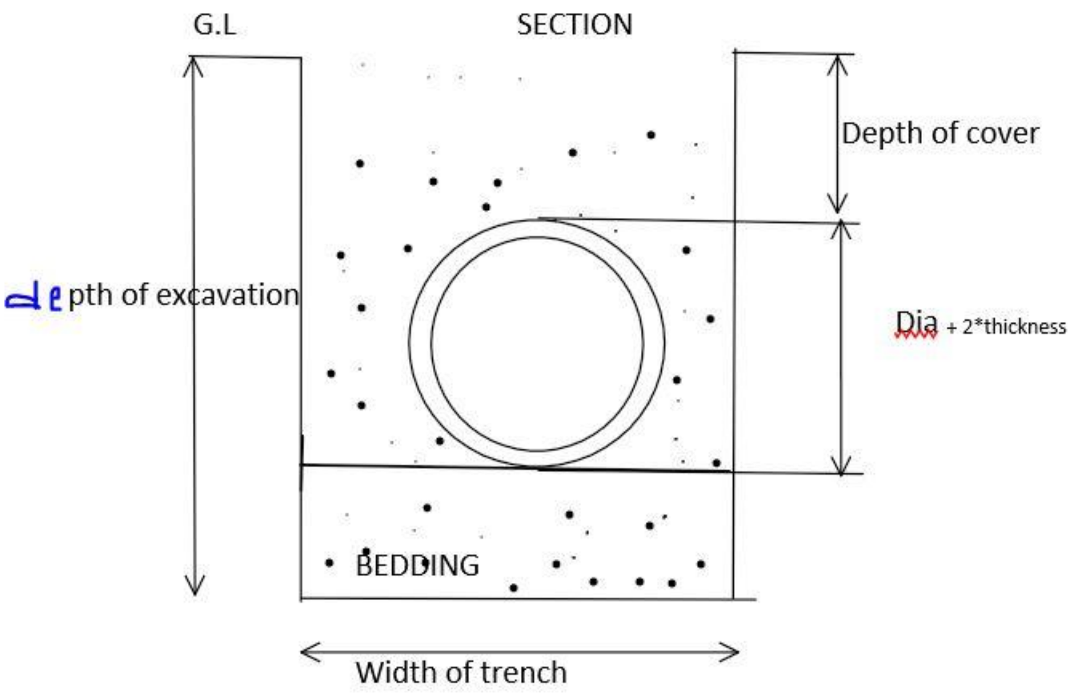


Figure 4 – depth of excavation

Earthwork(depth upto 1.5m)

Table 4.1 – Earthwork

TRENCH WIDTH meter	depth of excavation meter	length meter	volume of excavation upto 1.5m (cum)	VOLUME OF FILLING (cum)	surface area for timbering and shoring
0.68	1.42	15	14.484	13.42371	21.3
0.68	1.0585	30	21.5934	19.47282	31.755
0.68	1.108	30	22.6032	20.48262	33.24
0.68	1.165	20	15.844	14.43028	23.3
0.68	1.2565	30	25.6326	23.51202	37.695
0.43	1.13	30	14.577	14.4262	33.9
0.43	1.2674	30	16.34946	16.19866	38.022
0.68	1.38	30	28.152	26.03142	41.4
0.68	1.3407	30	27.35028	25.2297	40.221
0.68	1.3914	30	28.38456	26.26398	41.742
0.68	1.4421	30	29.41884	27.29826	43.263
0.68	1.4928	30	30.45312	28.33254	44.784
0.43	1.13	30	14.577	14.4262	33.9
0.43	1.133	30	14.6157	14.4649	33.99
0.43	1.186	15	7.6497	7.574302	17.79
0.84	1.28	20	21.504	20.87568	25.6
0.585	1.464	20	17.1288	16.33358	29.28
0.585	1.2516	30	21.96558	20.77276	37.548
0.585	1.29	30	22.6395	21.44668	38.7
0.8	1.4426	10	11.5408	10.57869	14.426
0.8	1.487	30	35.688	32.80166	44.61
0.8	1.4817	30	35.5608	32.67446	44.451
0.68	1.38	30	28.152	26.03142	41.4
0.68	1.3107	30	26.73828	24.6177	39.321
1.174	1.337	30	47.08914	35.54379	40.11
		TOTAL	579.6918	533.244	871.748

Table 4.2 – Excavating trenches

EXCAVATING TRENCHES

	ITEM	UNIT	RATE	QUANTITY	AMOUNT
1	EARTHWORK	CUM	352	579.6918	204051.5
2	Machinery and labour include hydraulic machine, labours, 1% water charges)		166.4	579.6918	96460.72
3	shoring and timbering per sqm		55.9	1743.496	97461.43
4	Filling	cum	125.75	533.244	67055.43
			TOTAL COST		465029.1
		OTHER TOOLS AND PLANTS=2.5%			11625.73
		ELECTRIFICATION= 7.5% OF TOTAL COST			34877.18
		unforseen items=2% of TC			9300.582
	WORKCHARGED ESTABLISHMENT=7.5% OF TC				34877.18
		GRAND TOTAL			555709.8

Table 4.3-Earthwork (Depth more than 1.5m not exceeding 3m)

TRENCH WIDTH meter	depth of excavation meter	length meter	volume of excavation upto 1.5m (cum)	volume for depth 1.5m to 3 m (cum)	Total voume of excavation (cum)	VOLUME OF FILLING (cum)	surface area for timbering and shoring
0.9	1.6	30	40.5	2.7	43.2	38.42871	96
0.9	1.887	30	40.5	10.449	50.949	46.17771	113.22
1.29	2.497	30	58.05	38.5839	96.6339	81.55426	149.82
1.29	2.5739	30	58.05	41.55993	99.60993	84.53029	154.434
1.29	2.6908	30	58.05	46.08396	104.134	89.05432	161.448
1.4	2.3877	30	63	37.2834	100.2834	81.19822	143.262
1.4	1.7471	30	63	10.3782	73.3782	54.29302	104.826
1.53	1.9065	30	68.85	18.65835	87.50835	63.94641	114.39
1.53	1.9581	30	68.85	21.02679	89.87679	66.31485	117.486
1.53	1.9581	30	68.85	21.02679	89.87679	66.31485	117.486
1.53	1.9839	30	68.85	22.21101	91.06101	67.49907	119.034
1.74	2.21739	30	78.3	37.44776	115.7478	81.81856	133.0434
1.74	2.35788	30	78.3	44.78134	123.0813	89.15214	141.4728
0.85	1.55	30	38.25	1.275	39.525	35.75509	93
0.85	1.7018	15	19.125	2.57295	21.69795	19.81299	51.054
0.85	1.703	30	38.25	5.1765	43.4265	39.65659	102.18
0.85	1.7948	15	19.125	3.7587	22.8837	20.99874	53.844
1.74	2.5684	30	78.3	55.77048	134.0705	100.1413	154.104
1.74	2.27886	30	78.3	40.65649	118.9565	85.02729	136.7316
1.74	2.29935	30	78.3	41.72607	120.0261	86.09687	137.961
1.74	2.31984	15	39.15	21.39782	60.54782	43.58322	69.5952
1.4	1.99574	30	63	20.82108	83.82108	64.7359	119.7444
1.97	2.58424	15	44.325	32.03929	76.36429	53.27359	77.5272
1.97	2.5554	15	44.325	31.18707	75.51207	52.42136	76.662
2.18	2.82154	15	49.05	43.21436	92.26436	62.10507	84.6462
2.2	2.84954	30	99	89.06964	188.0696	127.7511	170.9724
2.18	2.84564	30	98.1	88.00486	186.1049	125.7863	170.7384
0.68	1.567	30	30.6	1.3668	31.9668	29.84622	94.02
0.43	1.5422	30	19.35	0.54438	19.89438	19.74358	92.532
0.43	1.6796	30	19.35	2.31684	21.66684	21.51604	100.776
0.8	1.6635	30	36	3.924	39.924	37.03766	99.81
0.8	1.7052	30	36	4.9248	40.9248	38.03846	102.312
0.84	1.57435	30	37.8	1.87362	39.67362	38.73114	94.461
0.84	1.6902	30	37.8	4.79304	42.59304	41.65056	101.412
0.8	1.5262	30	36	0.6288	36.6288	33.74246	91.572
1.15	1.9206	30	51.75	14.5107	66.2607	51.18106	115.236
1.174	1.8557	30	52.83	12.52775	65.35775	53.8124	111.342

1.174	1.8962	30	52.83	13.95416	66.78416	55.23881	113.772
1.294	2.0978	30	58.23	23.2066	81.4366	66.35695	125.868
1.174	2.1209	30	52.83	21.8681	74.6981	63.15274	127.254
1.174	2.1626	30	52.83	23.33677	76.16677	64.62142	129.756
1.174	2.2043	30	52.83	24.80545	77.63545	66.09009	132.258
1.53	2.462	30	68.85	44.1558	113.0058	89.44386	147.72
1.53	2.1304	30	68.85	28.93536	97.78536	74.22342	127.824
1.53	2.15876	30	68.85	30.23708	99.08708	75.52514	129.5256
1.53	2.1872	30	68.85	31.54248	100.3925	76.83054	131.232
1.53	2.2156	30	68.85	32.84604	101.696	78.1341	132.936
1.97	2.67892	30	88.65	69.67417	158.3242	112.1428	160.7352
1.97	2.80836	30	88.65	77.32408	165.9741	119.7927	168.5016
1.97	2.9252	30	88.65	84.22932	172.8793	126.6979	175.512
		TOTAL	2836.98	1382.387	4219.367	3260.978	5971.05

	ITEM	UNIT	RATE	QUANTITY	AMOUNT
1	EARTHWORK	CUM	352	2836.98	998617
2	(include hydraulic machine, labours, 1% water charge)		166.4	2836.98	472073.5

Table 4.4 excavating trenches up to 3m

EXCAVATING TRENCHES Upto3m

	ITEM		UNIT	RATE	QUANTITY	AMOUNT
1	EARTHWORK		CUM	800.31	1382.39	1106341
2	Machinery and labour (include hydraulic machine, labours, 1% water charges)			166.4	1382.39	230029.7
3	shoring and timbering			55.9	5971.05	333781.7
4	filling		Cum	125.75	3260.98	410068.2
					TOTAL	3550911

	OTHER TOOLS AND PLANTS=2.5%			88772.76
	ELECTRIFICATION= 7.5% OF TOTAL COST			266318.3
	unforseen items=2% of TC			71018.21
WORKCHARGED ESTABLISHMENT=7.5% OF TC				266318.3
	GRAND TOTAL			4243338

Table 4.5 - Earthwork (Depth more than 3m)

TRENCH WIDTH meter	depth of excavation meter	length meter	volume of excavation upto 1.5m (cum)	volume for depth 1.5m to 3 m (cum)	volume for depth more than 3m (cum)	Total voume of excavation (cum)	VOLUME OF FILLING (cum)	SURFACE AREA FOR TIMBERING AND SHORING
1.97	3.48202	15	44.325	44.325	14.243691	102.893691	79.80298	104.4606
2.64	4.57	30	118.8	118.8	124.344	361.944	267.7327	274.2
2.64	5.01077	30	118.8	118.8	159.252984	396.852984	302.6052	300.6462
2.64	5.14112	30	118.8	118.8	169.576704	407.176704	312.9289	308.4672
3.1	5.68147	30	139.5	139.5	249.37671	528.37671	392.6599	340.8882
3.1	5.69035	30	139.5	139.5	250.20255	529.20255	393.4857	341.421
3.1	5.38923	30	139.5	139.5	222.19839	501.19839	365.4816	323.3538
		TOTAL	819.225	819.225	1189.195029	2827.645029	2114.697	1993.437

Table 4.6 excavating trench

EXCAVATING TRENCH						
	ITEM	UNIT	RATE	QUANTITY	AMOUNT	REMARK
1	EXCAVATION UPTO 1.5 M	CUM	352	819.225	288367.2	
4	Machinery and labour (include hydraulic machine, labours, 1% water charge)		166.4	819.225	136319	
1A	1.5M TO 3M		800.31	819.225	655634	RATE 127% EXTRA
			166.4	819.225	136319	

	Machinery and labour (include hydraulic machine, labours, 1% water charge)					
1B	3M AND ABOVE		1460.8	1189.195029	1737176	RATE 315% EXTRA
	Machinery and labour per cum (include hydraulic machine, labours, 1% water charge)		166.4	1189.195029	197882.1	
3	shoring and timbering		55.9	1993.437	111433.1	
4	filling	cum	125.75	2114.697	265923.1	
				TOTAL	3529054	
		OTHER TOOLS AND PLANTS=2.5%			91049.58	
		ELECTRIFICATION= 7.5% OF TOTAL COST			264679	
		unforseen items=2% of TC			70581.07	
		WORKCHARGED ESTABLISHMENT=7.5% OF TC			264679	
		GRAND TOTAL			4220042	

Table 4.7 Price of Pipe

DIA PROVIDED MM	PRICE PER METER	LENTH OF PIPE METER	TOTAL PRICE	JOINTS
80	190	195	37050	78
200	250	80	20000	32
225	270	80	21600	32
300	400	365	146000	146
350	725	160	116000	64
400	800	90	72000	36
450	860	60	51600	24
700	1700	180	306000	72
800	2250	150	337500	60
900	2800	90	252000	36
1000	3300	270	891000	108
1200	4700	165	775500	66
1400	6200	165	1023000	66

1600	8000	90	720000	36
2000	12000	90	1080000	36
2400	18000	90	1620000	36
	TOTAL	2320	7469250	928
ADD 18% GST			1344465	
		TOTAL	8813715	
			TOTAL	8813717
	TRANSPORTATION COST=10% 0F TOTAL			881371.7
	GRAND TOTAL			9695089

Table 4.8 CONSTRUCTION OF MANHOLE

ITEM	Unit	Quantity	rate	amount
PROVIDING AND CONSTRUCTING MANHOLE OF 1.2 METER DIAMTER AND DEPTH UPTO 2.5 M	Nos	84	12636.76	1061488

GST 18%	191067.8
TOOLS AND PLANTS=2.5%	26537.2
UNFORESEEN ITEMS =2%	21229.76
WORK CHARGED ESTABLISHMENT=7.5%	79611.59
GRAND TOTAL	1379934

LOWERING,LAYING AND JOINTING

(in proper grade and alingnment socketed rcc pipes with rubber joints including cost of conveyance from stores to site of work, cost of jointing material, labour, giving hydraulic testing etc. completes as directed by engineer-in-charge (for all class of pipes.))

Table 4.9 – lowering laying and jointing

DIA PROVIDED MM	LENTH OF PIPE METER	UNIT	RATE PER METER	AMOUNT
80	195	RMT	18.3	3568.5
200	80	RMT	43.8712	3509.696
225	80	RMT	56.2054	4496.432
300	365	RMT	65.7946	24015.03
350	160	RMT	72.651	11624.16
400	90	RMT	80.2394	7221.546

450	60	RMT	84.9852	5099.112
700	180	RMT	126.1114	22700.05
800	150	RMT	157.6362	23645.43
900	90	RMT	191.906	17271.54
1000	270	RMT	237.1436	64028.77
1200	165	RMT	338.6354	55874.84
1400	165	RMT	400.2698	66044.52
1600	90	RMT	478.4108	43056.97
2000	90	RMT	551.501	49635.09
2400	90	RMT	633.058	56975.22

TOTAL=458766.9

OTHER TOOLS AND PLANTS=2.5%	11469.17
ELECTRIFICATION= 7.5% OF TOTAL COST	34407.52
unforseen items=2% of TC	9175.338
WORKCHARGED ESTABLISMENT 7.5%	34407.52
GRAND TOTAL	548226.5

Table 4.10 - REINSTATING OF ROAD

ITEM	UNIT	RATE	QUANTITY	AMOUNT
Reinstating the road surface with excavation,murum bingade, 40mm size metal, 25mm thick bitumen carpet, including compacting at all stage.	sqm	212.28	3008.94	638737.8

OTHER TOOLS AND PLANTS=2.5%	15968.44
ELECTRIFICATION= 7.5% OF TOTAL COST	47905.33
unforseen items=2% of TC	12774.76
WORKCHARGED ESTABLISHMENT=7.5% OF TC	47905.33
GRAND TOTAL	763291.7

COST OF PROJECT

DESCRIPTION	AMOUNT
EXCAVATION(UPTO DEPTH OF 1.5M)	555709.8
(DEPTH MORE THAN 1.5M NOT EXCEEDING 3 M	4243338
DEPTH MORE THAN 3M	4220042
PIPE	9695089
MANHOLE	1379934
LOWERING ND JOINTING	548226.5
REINSTATING OF ROAD	763291.7
TOTAL	21405631
CONTIGENCY CHARGES=4%OF TOTAL	856225.2
GRAND TOTAL	22261856
CONTRACTORS PROFIT=15%OF GRAND TOTAL	4452371
COST OF PROJECT	26714227

Therefore, approximate cost of the project is 26,714,227 rupees

Chapter 5

RESULT AND DISCUSSION

The below table shows the calculated result of pipe slope(S_S), diameter of pipe (D) and the thickness of pipe taken from Indian standard code which depends upon the diameter. As it can be seen below there are total numbers of 84 pipe lines and the total length of the pipe line which we have calculated is 2350 meter. The table also shows the upward and downward Ground level as well as Inverted level which is expressed in meter

Table 5 – diameter and thickness

Pipe No.	Length (M)	Total Discharge (lps)	S_s	Diameter meter	Thickness in meter	Pipe level (meter)		Invert level (meter)	
						Upward	Downward	Upward	Downward
1	30	106.1	0.00241	0.45	0.075	14.67	14.583	14.145	14.058
2	30	106.1	0.00241	0.45	0.075	14.583	14.493	14.058	13.968
3	30	382.52	0.00102	0.8	0.095	14.493	14.456	13.598	13.561
4	30	382.52	0.00102	0.8	0.095	14.4561	14.4192	13.5611	13.5242
5	30	382.52	0.00102	0.8	0.095	14.4192	14.3823	13.5242	13.4873
6	30	534.829	0.000815	0.9	0.1	14.3823	14.3529	13.3823	13.3524
7	30	534.892	0.000815	0.9	0.1	14.3529	13.3235	13.3529	12.3235
8	30	657.347	0.000716	1	0.115	13.3235	12.2977	12.2085	11.1827
9	30	657.347	0.000716	1	0.115	12.2719	12.2461	11.1827	11.1569
10	30	657.347	0.000716	1	0.115	12.2719	12.2461	11.1569	11.1311
11	30	657.347	0.000652	1	0.115	12.2461	12.22261	11.1311	11.10761
12	30	925.983	0.000568	1.2	0.12	12.22261	12.20212	10.9026	10.88281
13	30	925.983	0.000568	1.2	0.12	12.20212	12.18163	10.88212	1086163
14	30	97.291	0.00255	0.4	0.075	13	12.9082	12.525	12.4332
15	15	97.291	0.00255	0.4	0.075	12.9082	12.847	12.4332	12.4395
16	30	97.291	0.00255	0.4	0.075	12.847	11.7552	12.372	11.2802
17	15	97.291	0.00255	0.4	0.075	11.7552	11.7449	11.28-2	11.2699
18	30	925.983	0.000568	1.2	0.12	12.1816	12.16114	10.18163	10.84114
19	30	925.983	0.000568	1.2	0.12	12.16114	12.14065	10.84114	10.82065
20	30	925.983	0.000568	1.2	0.12	12.14065	11.58016	10.82065	10.26016
21	15	925.983	0.000568	1.2	0.12	11.58016	10.79426	10.22016	9.47426
22	30	477.208	0.000883	0.9	0.1	10.79426	10.02576	9.79426	9.02576
23	15	1177.208	0.000516	1.4	0.135	10.02576	10.01646	8.49076	8.48146
24	15	1177.208	0.000516	1.4	0.135	10.0646	9.67846	8.48146	8.14346
25	15	1333.552	0.000416	1.6	0.14	9.67846	9.28046	7.93846	7.54046
26	30	1333.552	0.000416	1.6	0.15	9.28046	7.49436	7.54046	5.75436
27	30	1333.552	0.000416	1.6	0.14	7.49436	5.40876	5.75436	3.66876
28	30	Min flow	0.000416	1.6	0.14				
29	30	Min flow	0.000416	1.6	0.14				
30	15	246.657	0.00137	0.3	0.04	13	12.9715	12.6315	12.6325
31	30	246.657	0.00137	0.3	0.04	12.9715	12.612	12.6313	12.308
32	30	246.657	0.00137	0.3	0.04	12.612	12.2225	11.8825	11.8825
33	20	246.657	0.00137	0.3	0.04	12.225	9.623	11.8825	9.283
34	30	246.657	0.00137	0.3	0.04	9.263	7.1335	9.283	6.7935
35	30	246,657	0.00137	0.3	0.04	7.1335	4.2161	6.7935	3.5761
36	30	58.375	0.00381	0.08	0.025	14.67	13.6726	14.565	12.8476

37	30	58.375	0.00381	0.08	0.025	13.6726	13.0178	13.5676	12.9128
38	30	58.375	0.00381	0.08	0.025	13.0178	12.0604	12.9128	11.9554
39	30	58.375	0.00381	0.08	0.025	12.0604	8.873	11.9554	8.768
40	30	261.25	0.00141	0.3	0.04	11.94	11.8893	11.6	11.7843
41	30	261.25	0.00141	0.3	0.04	11.8893	11.6286	11.5493	11.2093
42	30	261.25	0.00141	0.3	0.04	11.6286	11.2579	11.2886	10.9179
43	30	261.25	0.00141	0.3	0.04	11.2579	10.7272	10.9173	10.3872
44	30	261.25	0.00141	0.3	0.04	10.7272	9.3965	10.3872	9.0565
45	30	319.625	0.00116	0.35	0.075	9.3965	8.7348	8.715	8.3098
46	30	319.625	0.00116	0.35	0.075	8.7348	7.2431	8.3098	6.8181
47	30	45.459	0.00425	0.08	0.025	13.09	12.937	12.985	12.832
48	30	45.459	0.00425	0.08	0.025	12.937	12.784	12.832	12.679
49	15	45.459	0.00425	0.08	0.025	12.784	12.631	12.678	12.531
50	20	151.327	0.00191	0.2	0.17	12.57	12.53565	12.2	12.16565
51	30	151.327	0.00191	0.2	0.17	12.53565	12.4898	12.1656	12.1198
52	30	151.327	0.00191	0.2	0.17	12.4898	12.4215	12.1198	12.0515
53	20	196.786	0.00159	0.225	0.03	12.631	12.5734	12.376	12.3184
54	30	196.786	0.00159	0.225	0.03	12.5734	12.155	12.3184	11.9
55	30	196.786	0.00159	0.225	0.03	12.155	12.0974	11.9	11.8424
56	10	291.756	0.00123	0.35	0.075	12.0974	11.033	11.6724	10.608
57	30	291.756	0.00123	0.35	0.075	11.033	10.2482	10.628	9.8232
58	30	291.756	0.00123	0.35	0.075	10.2483	9.4138	9.8232	8.9888
59	30	291.756	0.00123	0.35	0.075	9.4138	7.6994	8.9888	7.274
60	30	667.522	0.000701	0.8	0.025	7.6994	5.8439	6.8744	5.0189
61	30	237.476	0.00141	0.3	0.04	13.09	13.0393	12.75	12.6993
62	30	237.476	0.00141	0.3	0.04	13.0393	12.5683	12.6993	12.2283
63	30	331.17	0.00132	0.7	0.087	12.5683	10.9878	11.7833	10.2028
64	30	331.17	0.00132	0.7	0.087	10.9878	9.567	10.2028	8.78
65	30	331.17	0.00132	0.7	0.087	9.567	7.3362	8.782	6.5512
66	30	401.926	0.00099	0.8	0.097	7.3362	5.5087	6.4412	4.6137
67	30	319.625	0.00116	0.7	0.087	7.2431	6.3314	6.4581	5.5464
68	30	319.625	0.00116	0.7	0.087	6.3314	5.7197	5.464	5.9347
69	30	319.625	0.00116	0.7	0.087	5.7197	5.678	4.9347	4.893
70	30	568.393	0.00078	1	0.115	5.678	5.6496	4.563	4.5346
71	30	568.393	0.00078	1	0.115	5.6496	5.29124	4.5346	4.17624
72	30	568.393	0.00078	1	0.115	5.29124	4.9328	4.17624	3.8174
73	30	568.393	0.00078	1	0.115	4.9328	4.5744	3.8178	3.4594
74	30	756.982	0.00649	1	0.115	4.5744	4.22108	3.4594	3.1068
75	30	1003.639	0.000539	1.4	0.135	4.22108	4.20164	2.68608	2.66664
76	30	1246.435	0.000467	1.4	0.135	4.20164	4.1848	2.66664	2.6498
77	30	1246.435	0.000467	1.4	0.135	4.1848	4.16798	2.6498	2.63248
78	15	1246.435	0.000467	1.4	0.135	4.16798	4.14954	2.63208	2.62458
79	30	2579.985	0.000287	2	0.17	4.15954	4.14923	1.98958	1.98923
80	30	2579.985	0.000287	2	0.17	4.14923	4.13888	1.97923	1.9688
81	30	2579.985	0.000287	2	0.17	4.13888	4.12853	1.96888	1.95853
82	30	3247.509	0.000246	2.4	0.2	4.12853	4.11965	1.52853	1.51961
83	30	3247.509	0.000246	2.4	0.2	4.11965	4.11077	1.51965	1.51077
84	30	3501.985	0.000235	2.4	0.2	4.11077	4.10231	1.51077	1.5032

Chapter 6
CONCLUSION

This paper gives the details about design of sewer system and the problems which occurs while designing the sewer.

In this paper the population at the end of year 2048 for the respective places has also been calculated.

The maximum rainfall intensity is also been calculated for every catchment area.

After carrying out the study it was concluded there are no pumps required the flow is according to the elevation.

In the design of sewer it can clearly be seen that discharge is varying at different catchment this is clearly due to variation of population and difference in catchment area.

The material used in sewers should be non corrosive.

At certain points the flow was in upward direction and since no pumps are provided at those points more excavation should be carried out and slope of the pipe is maintained in downward direction to maintain the steady flow.

The length of the sewer pipe is 2350 meters and the diameter and thickness of the sewer vary every 30 meter as per the requirement to reduce the cost of the project.

Chapter 7
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Published Paper
Design of Sewer System

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Abstract: The paper is based on design of one of the optional sewerage system for carter road, Bandra in Mumbai. The design aims at effective abatement of pollution by providing a comprehensive waste water collection, treatment and disposal system using laterals, branches and main lines. Since present sewage system are old and sometime not very efficient designs of new sewerage system. The design done here covers the entire area between the loop and neighboring area and the population within the loop and also the population of neighboring areas. In this paper, the design a sewer system for Carter road, Bandra, Mumbai has been carried out using EPANET and manual calculation.

Key Words: *Sewer, EPANET, Invert Level.*

1. INTRODUCTION

Nowadays in urban cities it is necessary to maintain hygiene of city. To achieve sewage generated from the societies/colonies are to be disposed in the proper means, such away it doesn't mix with the potable water. There is a special system of pipe called as sewer system, which carry sewage and sometimes both sewage and storm water to pumping station and final destination to the treatment plants [1]. Storm sewers (a part of a sewage system) carries excess rain water to safeguard the roads from flooding. The underground drainage pipes of the sewerage system in Mumbai are more than 100 years old and needs renovation. In congested parts, the sewerage lines and water pipelines run together and leakages may contaminate drinking water [6]. The unplanned and unauthorized growth of the city makes it difficult and, at times, impossible to replace old sewerage lines. The problem of sewer lines of small diameters, getting choked due to solid waste and silt entering them is rampant. The result is that instead of getting drained, sewage overflows on to the surface [2]. For network design of sewer EPANET software has been used. EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves and storage tanks or reservoirs

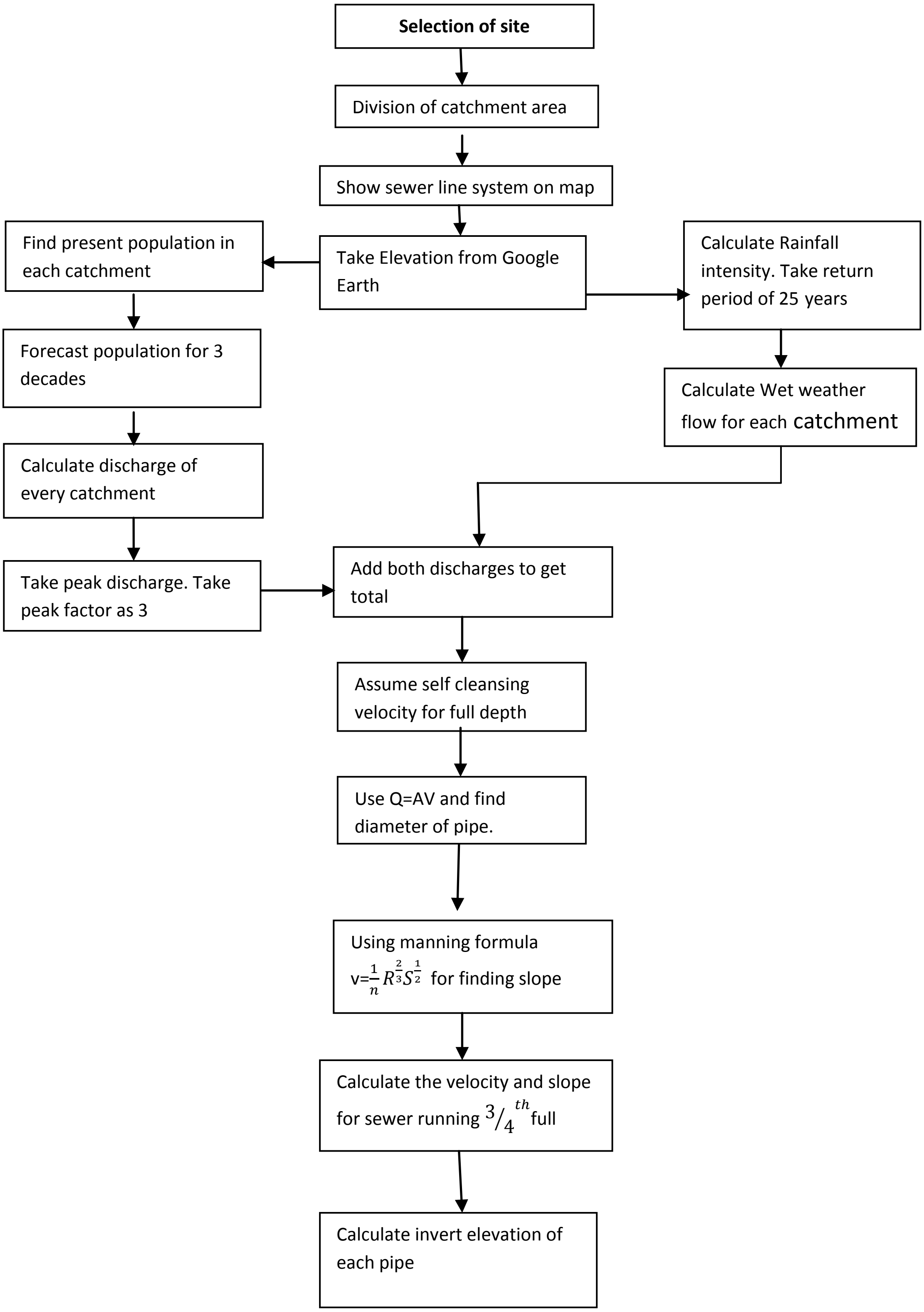
2. STUDY AREA

The study area is located at Carter road, Bandra in Mumbai and this places is situated at an off coast of Arabian sea. At this location heavy rainfall always occur in monsoon which causes sewer to overflow.

3. METHODOLOGY

The flow chart 3.1, shows the procedure of designing of sewer which we have carried out.

Flow Chart: 3.1: Design Procedure



Detailed survey has been carried out for finding the population of the region. During the survey number of flats, bungalows, chawl rooms and shops have been calculated (Table.2.1). And according to the standard of living, numbers of people per household have been assumed and population data have been generated. The total area under consideration is 14.52 hectors.

Table:2.1: Population Data

	number	People/household
Flats	1484	4
Rooms	245	4
Bungalows	59	5
Shops	43	2

The growth rate of population is taken as 8.29% per decade and the design period is of 3 decade. According to the standard of living the water consumption per person is taken as 135 liters of which 80% is converted into sewage. Hence from this it is calculated that the sewage produce per person is 108 liters per day. From which the discharge is calculated considering the 3 as the peak coefficient factor. This is expressed in Table.2.1.

Figure 3.1 shows the layout of the pipe network. The line which is marked in red in the figure 1 is the main pipe line and the remaining lines which are marked in black are the branch line. Figure 1also shows the elevation of nodes which have been marked at every 30 meter and at every change of slope and direction. The elevations have been calculated with the help of Google earth application which gives the elevation with respect to mean sea level. Figure 3. 2 show the distribution of our total area into small number of catchment area. Our total area is 14.52 hectors which is divided into 23 small catchment areas, for the ease of calculation of rainfall intensity.

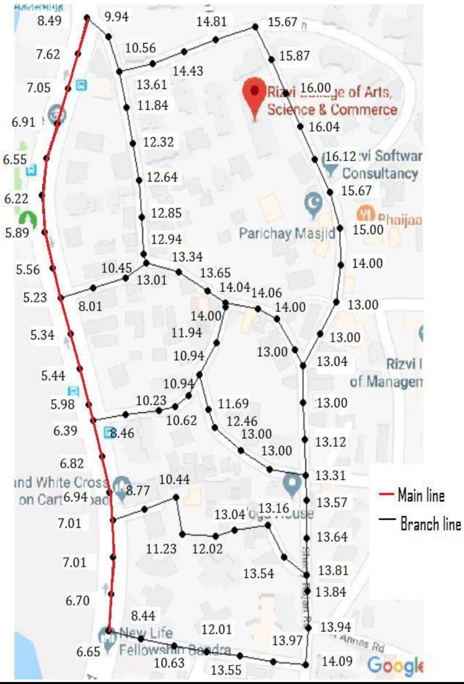


Figure: 3.1: Pipe Network

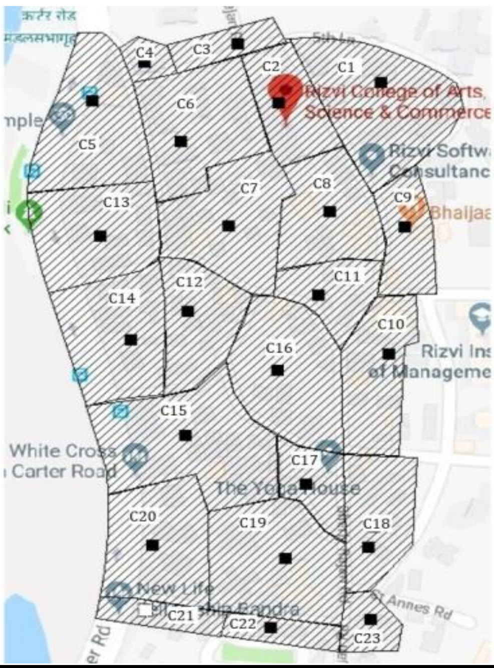


Figure: 3.2: Catchment Area

4.RESULT AND DISCUSSION

Rainfall intensity calculation:

Quantity of storm run-off is dependent on intensity and duration of rainfall, characteristics of catchment area and time required for such flow to reach the sewer. Storm water flow for this purpose can be determined by using rational methods, hydrograph methods or empirical formulae [3].

Rational formulae:

Q = 0.00278 PAIc $m^3/_{sec}$

Where, A- Catchment Area in hectares

P- Runoff Coefficient of Runoff

Ic- Intensity of Rainfall mm/Hr

Ic =Io (2/(tc+1))

tc= $(\frac{0.87L^3}{H})^{0.385}$

Where, tc Time of Concentration in hour

L- The distance from the critical point to the structure in km

Io – One hour Rainfall

DURATION IN HOUR	RETURN PERIOD IN YEAR		
	1	10	25
1	29.911	65.861	76.770

Therefore, Io= 76.770 mm/hour

Self Cleansing Velocity - It is necessary to- maintain a minimum velocity or self-cleansing velocity in a sewer to ensure that suspended solids do not deposit and cause blockage. A minimum velocity of 0.8 mps at design peak flow in the sanitary sewers is recommended. So velocity has been taken as 0.9m/sec for design.

Maximum Velocity - Erosion of sewers is caused by sand and other gritty material in the sewer at excessive velocity. Velocity of flow in a sewer is recommended not to exceed 2.0 m/sec

Size of Sewer

Minimum diameter of sewer shall be 200 mm except for hilly areas where steep slopes are available. In the present study, the minimum size can be 100 mm.

Manholes - A manhole is an opening constructed on the alignment of a sewer to facilitate a person to access the sewer for the purpose of inspection, testing, cleaning and removal of obstructions from the sewer line. Provide manhole for every 30 meter interval and for every change in slope and direction of pipe is recommended by Indian code.

Pipe- The material used for pipe is concrete. Roughness coefficient is 0.013. Minimum diameter used is 200mm.

Invert level - It is the level taken at the crown of the pipe plus internal diameter plus wall thickness of pipe. Figure 3.3 and Figure 3.4 shows the invert level in the pipe and relation of fall in the drainage pipe.

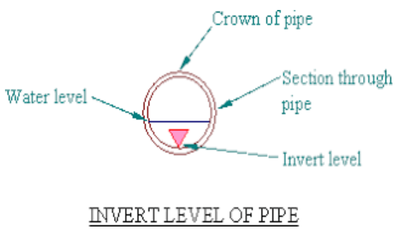


Figure: 3.3: Invert Level of Pipe

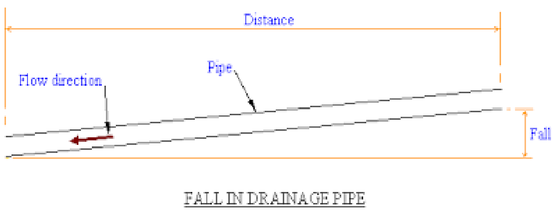


Figure: 3.4: Fall in Drainage Pipe

Table 4.1, shows the calculated result of total discharge per catchment area. Q_{wwf} is the discharge of the wet whether flow which have been calculated using rainfall intensity by rational method [4]. Q_{dwf} is the discharge of dry whether flow which have been calculated using population in the respective catchment area. And for finding the peak flow peak coefficient has to be considered. As standard peak coefficient of 3 has been considered.

Table: 4.1: Total discharge per catchment area.

CATCHMENT NO.	AREA (HECTORS)	LENGTH (M)	H (M)	t_c hour	I_c $mm/_{hour}$	Q_{wwf} (LPS)	Q_{dwf} peak (LPS)
1	1.08	145.24	0.24	0.177	130.45	273.945	2.475
2	0.42	100.98	0.06	0.198	128.16	104.664	1.436
3	0.21	87.68	0.5	0.074	142.96	58.375	0
4	0.16	40.61	4.73	0.0128	151.60	47.164	0.12
5	0.91	145.66	1.22	0.095	140.22	248.112	0.648
6	1.02	114.99	0.43	0.108	130.57	258.964	2.268
7	0.94	122.06	1.62	0.069	143.63	262.524	2.133
8	0.59	109.68	0.12	0.167	131.56	150.929	1.443
9	0.43	95.86	1.4	0.055	145.54	121.687	0.768
10	0.63	141.96	0.82	0.107	138.69	169.89	1.455
11	0.34	57.16	0.32	0.054	145.54	96.304	0.987
12	0.55	131.13	2.97	0.054	145.67	155.048	1.296
13	0.68	81.02	0.31	0.082	141.90	187.629	0.96
14	0.86	101.78	1.22	0.063	144.44	241.536	1.26
15	1.33	153.39	3.25	0.069	143.63	337.443	4.323
16	0.89	136.114	2	0.073	143.09	247.625	3.63
17	0.33	68.34	1.2	0.039	147.78	94.82	0.15
18	0.56	123.90	0.44	0.116	137.58	149.809	1.518
19	0.92	172.99	0.42	0.174	130.78	233.951	3.525
20	0.92	102.24	0.64	0.082	141.90	253.84	0.636
21	0.24	80.13	4.13	0.029	149.21	69.63	1.125
22	0.33	99.35	1	0.066	144.03	92.419	1.275
23	0.18	129.77	0.12	0.202	127.74	44.709	0.75

Table:4.2, shows the calculated result of pipe slope(S_S), diameter of pipe (D) and the thickness of pipe, taken from Indian standard code which depends upon the diameter [5]. As it can be seen that there are total number of 84 pipe lines and the total length of the pipe line which have been calculated as 2350m. The table also shows the upward and downward Ground level as well as Inverted level.

Table: 4.1: Pipe Dimensions

Pipe No.	Length (M)	Total Discharge (lps)	S_s	Diameter in meter	Thickness in meter	Ground level (meter)		Invert level (meter)	
						Upward	Downward	Upward	Downward
1	30	106.1	0.00241	0.45	0.075	14.67	14.583	14.145	14.058
2	30	106.1	0.00241	0.45	0.075	14.583	14.493	14.058	13.968
3	30	382.52	0.00102	0.8	0.095	14.493	14.456	13.598	13.561
4	30	382.52	0.00102	0.8	0.095	14.4561	14.4192	13.5611	13.5242
5	30	382.52	0.00102	0.8	0.095	14.4192	14.3823	13.5242	13.4873
6	30	534.829	0.000815	0.9	0.1	14.3823	14.3529	13.3823	13.3524
7	30	534.892	0.000815	0.9	0.1	14.3529	13.3235	13.3529	12.3235
8	30	657.347	0.000716	1	0.115	13.3235	12.2977	12.2085	11.1827
9	30	657.347	0.000716	1	0.115	12.2719	12.2461	11.1827	11.1569

10	30	657.347	0.000716	1	0.115	12.2719	12.2461	11.1569	11.1311
11	30	657.347	0.000652	1	0.115	12.2461	12.22261	11.1311	11.10761
12	30	925.983	0.000568	1.2	0.12	12.22261	12.20212	10.9026	10.88281
13	30	925.983	0.000568	1.2	0.12	12.20212	12.18163	10.88212	1086163
14	30	97.291	0.00255	0.4	0.075	13	12.9082	12.525	12.4332
15	15	97.291	0.00255	0.4	0.075	12.9082	12.847	12.4332	12.4395
16	30	97.291	0.00255	0.4	0.075	12.847	11.7552	12.372	11.2802
17	15	97.291	0.00255	0.4	0.075	11.7552	11.7449	11.28-2	11.2699
18	30	925.983	0.000568	1.2	0.12	12.1816	12.16114	10.18163	10.84114
19	30	925.983	0.000568	1.2	0.12	12.16114	12.14065	10.84114	10.82065
20	30	925.983	0.000568	1.2	0.12	12.14065	11.58016	10.82065	10.26016
21	15	925.983	0.000568	1.2	0.12	11.58016	10.79426	10.22016	9.47426
22	30	477.208	0.000883	0.9	0.1	10.79426	10.02576	9.79426	9.02576
23	15	1177.208	0.000516	1.4	0.135	10.02576	10.01646	8.49076	8.48146
24	15	1177.208	0.000516	1.4	0.135	10.0646	9.67846	8.48146	8.14346
25	15	1333.552	0.000416	1.6	0.14	9.67846	9.28046	7.93846	7.54046
26	30	1333.552	0.000416	1.6	0.15	9.28046	7.49436	7.54046	5.75436
27	30	1333.552	0.000416	1.6	0.14	7.49436	5.40876	5.75436	3.66876
28	30	Min Flow	0.000416	1.6	0.14	-	-	-	-
29	30	Min Flow	0.000416	1.6	0.14	-	-	-	-
30	15	246.657	0.00137	0.3	0.04	13	12.9715	12.6315	12.6325
31	30	246.657	0.00137	0.3	0.04	12.9715	12.612	12.6313	12.308
32	30	246.657	0.00137	0.3	0.04	12.612	12.2225	11.8825	11.8825
33	20	246.657	0.00137	0.3	0.04	12.225	9.623	11.8825	9.283
34	30	246.657	0.00137	0.3	0.04	9.263	7.1335	9.283	6.7935
35	30	246,657	0.00137	0.3	0.04	7.1335	4.2161	6.7935	3.5761
36	30	58.375	0.00381	0.08	0.025	14.67	13.6726	14.565	12.8476
37	30	58.375	0.00381	0.08	0.025	13.6726	13.0178	13.5676	12.9128
38	30	58.375	0.00381	0.08	0.025	13.0178	12.0604	12.9128	11.9554
39	30	58.375	0.00381	0.08	0.025	12.0604	8.873	11.9554	8.768
40	30	261.25	0.00141	0.3	0.04	11.94	11.8893	11.6	11.7843
41	30	261.25	0.00141	0.3	0.04	11.8893	11.6286	11.5493	11.2093
42	30	261.25	0.00141	0.3	0.04	11.6286	11.2579	11.2886	10.9179
43	30	261.25	0.00141	0.3	0.04	11.2579	10.7272	10.9173	10.3872
44	30	261.25	0.00141	0.3	0.04	10.7272	9.3965	10.3872	9.0565
45	30	319.625	0.00116	0.35	0.075	9.3965	8.7348	8.715	8.3098
46	30	319.625	0.00116	0.35	0.075	8.7348	7.2431	8.3098	6.8181
47	30	45.459	0.00425	0.08	0.025	13.09	12.937	12.985	12.832
48	30	45.459	0.00425	0.08	0.025	12.937	12.784	12.832	12.679
49	15	45.459	0.00425	0.08	0.025	12.784	12.631	12.678	12.531
50	20	151.327	0.00191	0.2	0.17	12.57	12.53565	12.2	12.16565
51	30	151.327	0.00191	0.2	0.17	12.53565	12.4898	12.1656	12.1198
52	30	151.327	0.00191	0.2	0.17	12.4898	12.4215	12.1198	12.0515
53	20	196.786	0.00159	0.225	0.03	12.631	12.5734	12.376	12.3184
54	30	196.786	0.00159	0.225	0.03	12.5734	12.155	12.3184	11.9
55	30	196.786	0.00159	0.225	0.03	12.155	12.0974	11.9	11.8424
56	10	291.756	0.00123	0.35	0.075	12.0974	11.033	11.6724	10.608
57	30	291.756	0.00123	0.35	0.075	11.033	10.2482	10.628	9.8232
58	30	291.756	0.00123	0.35	0.075	10.2483	9.4138	9.8232	8.9888
59	30	291.756	0.00123	0.35	0.075	9.4138	7.6994	8.9888	7.274
60	30	667.522	0.000701	0.8	0.025	7.6994	5.8439	6.8744	5.0189
61	30	237.476	0.00141	0.3	0.04	13.09	13.0393	12.75	12.6993

62	30	237.476	0.00141	0.3	0.04	13.0393	12.5683	12.6993	12.2283
63	30	331.17	0.00132	0.7	0.087	12.5683	10.9878	11.7833	10.2028
64	30	331.17	0.00132	0.7	0.087	10.9878	9.567	10.2028	8.78
65	30	331.17	0.00132	0.7	0.087	9.567	7.3362	8.782	6.5512
66	30	401.926	0.00099	0.8	0.097	7.3362	5.5087	6.4412	4.6137
67	30	319.625	0.00116	0.7	0.087	7.2431	6.3314	6.4581	5.5464
68	30	319.625	0.00116	0.7	0.087	6.3314	5.7197	5.464	5.9347
69	30	319.625	0.00116	0.7	0.087	5.7197	5.678	4.9347	4.893
70	30	568.393	0.00078	1	0.115	5.678	5.6496	4.563	4.5346
71	30	568.393	0.00078	1	0.115	5.6496	5.29124	4.5346	4.17624
72	30	568.393	0.00078	1	0.115	5.29124	4.9328	4.17624	3.8174
73	30	568.393	0.00078	1	0.115	4.9328	4.5744	3.8178	3.4594
74	30	756.982	0.00649	1	0.115	4.5744	4.22108	3.4594	3.1068
75	30	1003.639	0.000539	1.4	0.135	4.22108	4.20164	2.68608	2.66664
76	30	1246.435	0.000467	1.4	0.135	4.20164	4.1848	2.66664	2.6498
77	30	1246.435	0.000467	1.4	0.135	4.1848	4.16798	2.6498	2.63248
78	15	1246.435	0.000467	1.4	0.135	4.16798	4.14954	2.63208	2.62458
79	30	2579.985	0.000287	2	0.17	4.15954	4.14923	1.98958	1.98923
80	30	2579.985	0.000287	2	0.17	4.14923	4.13888	1.97923	1.9688
81	30	2579.985	0.000287	2	0.17	4.13888	4.12853	1.96888	1.95853
82	30	3247.509	0.000246	2.4	0.2	4.12853	4.11965	1.52853	1.51961
83	30	3247.509	0.000246	2.4	0.2	4.11965	4.11077	1.51965	1.51077
84	30	3501.985	0.000235	2.4	0.2	4.11077	4.10231	1.51077	1.5032

CONCLUSION

This paper gives the details about design of sewer system using rational method with the help of EPANET software. The maximum rainfall intensity is also been calculated for every catchment area. After carrying out the study it has been observed that there are no pumps required the flow in accordance with the elevation. In the design of sewer it can clearly be seen that discharge is varying at different catchment and this is clearly due to variation of population and difference in catchment area. The material used in sewers should be non corrosive. The slope of the pipe is maintained in downward direction to maintain the steady flow. The length of the sewer pipe is 2350 meters and the diameter and thickness of the sewer vary every 30 meter as per the requirement to reduce the cost of the project. The proper design of Sewerage system ensures the friendly environment and the water in the area will also be pollution free to some extent and hence health related issues resulting due to pollution and water will also decrease.

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