City Development Plan, Karjat
Water Supply
And
Sanitation

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Under the guidance

of

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Dissertation Approval Sheet

This report title, “City Development Plan, Water Supply and Sanitaion, Karjat” by “Mr. Narendra Kumar Shah” is approved for a B.Tech Degree in Civil Engineering.

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Supervisors

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Date:

Place:

Abstract

A large number of small and medium towns in India are suffering from the problems of infrastructure, particularly in the areas of water supply and sanitation. The problems range from not having the facilities altogether to extremely inadequate operation and maintenance. Lack of income available to the local bodies, untrained workforce coupled with faulty design is the main reason for problems faced by the local bodies operation and maintenance. This project aims to find the precise problem faced by Karjat Municipal Council in running the water supply scheme. To accomplish this, all aspects of the scheme viz technical, social and financial are analyzed. The main problems found out are financial deficit, low pump efficiency and inadequate design of some areas. The reason for this is large quantity of water supplied as compared to the specified norms and untrained staff. Finally, some measures are suggested to mitigate these problems.

Acknowledgements

I would like to take this opportunity to express my gratitude to my guide Prof M.C. Deo and Co-guide Prof. Mrs. Bakul Rao who has extended their co-operation at every stage of my B.Tech Project. It has been a valuable learning experience for me which would have not been possible without their guidance.

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Chapter 1

Introduction

1.1 Background

This report is a part of City Development Plan being prepared by Centre for Technological Alternatives in Rural Areas (CTARA), IIT Bombay for Karjat. The sectors of Water Supply and Sanitation are covered in this report.

Under JNNURM, cities receive support for their infrastructure development. To avail this support, the city has to first prepare a City Development Plan. Since, most of the cities are unable to develop the plan, they are not able to properly utilize the funds.

For the same reason, the urban local body in Karjat approached CTARA for preparing a development plan and suggesting some mitigation measures for the problems.

1.2 Objectives of the project

The focus of this project is:

1. To Review the past development report and other project reports prepared by KAMC and those prepared for Karjat by other agencies.
2. To review and compile the baseline data on parameters - water supply and sanitation, and institutional capacity.
3. To verify the technical details of the schemes with respect to the standard manual.
4. Develop status report for water supply and sanitation.
5. Compilation of various mitigation measures currently adopted by Karjat Municipality & other related civic agencies for control of social/ environmental / financial issues & assess the adequacy of these measures.
6. Suggestion of additional measures on for mitigating the problems in the sectors of water supply and sanitation.

1.3 Scope

This project aims at preparing a report which would also include compilation of the baseline data for various environmental parameters, its trends and preparation of mitigation plan for eco-friendly development of Karjat Town. The outcome of the study will be a report which will represent the status of the infrastructure for the sectors of water supply and sanitation; major demand and supply issues, service quality, financial status and institutional status and issues. It will also examine possibilities for improvements in the service and governance mechanisms through mitigation and action plan.

1.4 Methodology

a) Meeting with all stake-holders concerning with the sectors such as elected councilors, engineers, operators, valve-men, drains cleaners etc.
b) Collection on secondary data such as DPRs, Census data, Budget data, Maps
c) Household survey for assessing the status of the sectors and people's perception
d) Technical review of the schemes.
e) Identifying problems and proposing solutions.

1.5 Organization of the report

Chapter 2 of this report gives us introduction of the project area, population and other demographic profile and trends and projections

Chapter 3 explains the household survey conducted, the methodology, the results and analysis of those results.

Chapter 4 deals with introduction to water supply in Karjat, its historical background and the present infrastructure of water supply.

Chapter 5 is based on technical analysis of the existing water supply scheme. The designs of pumps, rising mains and distribution mains have been verified. The possible solutions have been suggested to the problems which were identified.

Chapter 6 gives the details of operation and management of water supply network by the municipal council. The important problem of high difference between tax collected and expenditure has been looked in the chapter.

Chapter 7 presents a brief overview of the water treatment plant and the problems its operation.

Chapter 8 describes the present sanitation and drainage conditions and a brief overview of the proposed sewage and sewerage scheme for the city.

Finally, chapter 9 draws on conclusion of the study and explores the scope of future works.

Chapter 2

Project Area

2.1 Introduction

Karjat is a city, a Municipal Council, a tehsil and a sub-district in district Raigad, Maharashtra. As Karjat is a part of Mumbai Metro Region Mumbai metropolitan area, MMRDA has cleared Karjat for advanced Urban Planning with minimum FSI of 1.0 and CIDCO is being entrusted with town planning and implementation

The town in well connected with Mumbai and Pune through Mumbai-Pune Railway line. Almost all short distance and long distance trains stop at this station. Further, the town is connected to Mumbai through local trains and to Bhivpuri Power House and also to Khopoli town. The town is connected to Mumbai-Pune National Highway by an approach road and is about 10 Km. Away from the National Highway.

Being a taluka head quarter, there are a number of Govt. offices such as Tahsil office, Panchayat Samiti office etc located in the town. A number of primary and secondary schools are there in the town. Moreover, a number of engineering and management colleges have sprouted in the town due to its vicinity to Mumbai and Pune.

Karjat has become a major tourist spot for picnics, holidays, river rafting, trekking, hiking and mountain climbing. Many farm houses and residential colonies are situated with all civil amenities.

A lot of movie studios are coming up in the city. Art Director Nitin Chandrakant Desai's "ND Studio" is a major stopover attraction for Karjat Tourists these days and top directors Films are shot here. White Feather Films is also setting up a new studio here. Hollywood production companies such as Twentieth Century

Fox, Walt Disney and DreamWorks (with Reliance Big Studio) are setting up mega studios and production facilities here. Academy Award winning movie Slumdog Millionaire was shot here.

2.2 Location

Karjat is located at 18°55′N 73°20′E. It is located on the feet of Bhor ghat, Sahyadri, Western Ghats as well as at the end of coastal plains of Konkan region near Deccan. It has an average elevation of 194 metres (636 ft). River Ulhas flows through the city.

2.3 Urban Local Body

In the year 1992 as per G.R. dated 1.10.1992 of the Govt. in Urban Development Department, Karjat was declared as a Municipal Council comprising of Karjat, Mudre (Bk), Mudre (Kh), Bhisegaon, Gundge, Akurle and Dahivali

It is a class C Municipal Council on the basis of its population. The council is headed by Nagar Sevak and comprises of 17 elected councilors. Each councilor is elected from each ward.

The civic facilities are operated by the elected councilors of the Municipal Council. These civic facilities include water supply, sanitation, solid waste management, maintenance of roads etc. The area of the city within the limits of Karjat Municipal Council is about 750.91 hectares. The length of municipals roads is about 25 k.m. The norm of water supply for Karjat on the basis of its population is 125 lpcd. The city does not have an underground drainage system.

The annual budget income for the Municipal Council is about Rs 4,9796527 and annual expenditure by the council is Rs 56191850. The detailed analysis of finances of the council is presented in next section.

2.3.1 Receipts of Municipal Council

The main sources of income for the Municipal Council are tax receipts (property tax and water tax) and the government grants.

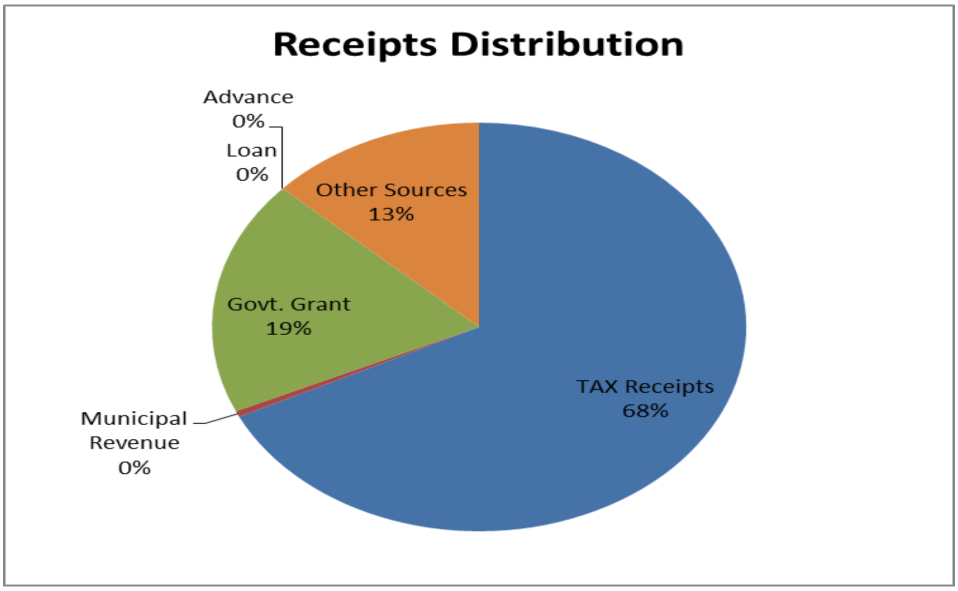


Figure 2.1 Income of the Municipal council
Source: Census of India

2.3.2 Expenditure of Municipal Council

The main expenses of the Municipal Council include administration, public health and public health.

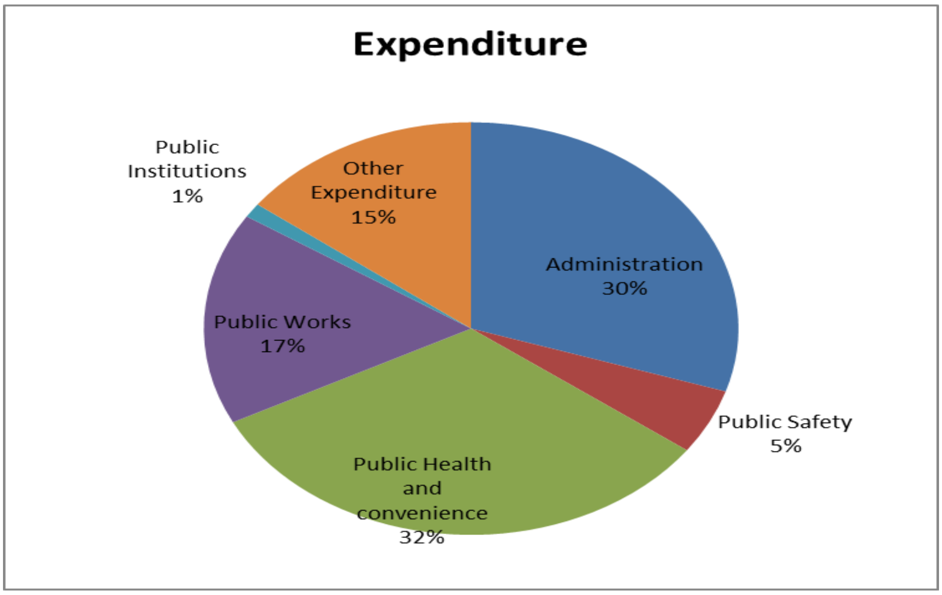


Figure 2.2 Expenditure of the Municipal council
Source: Census of India

2.4 Population and Demography

2.4.1 Population

The population of Karjat has been growing at a very rapid pace since the year 1981. The population of the city according to 2001 census is 25,531. At the same time the density is 3404 person per square kilometer.

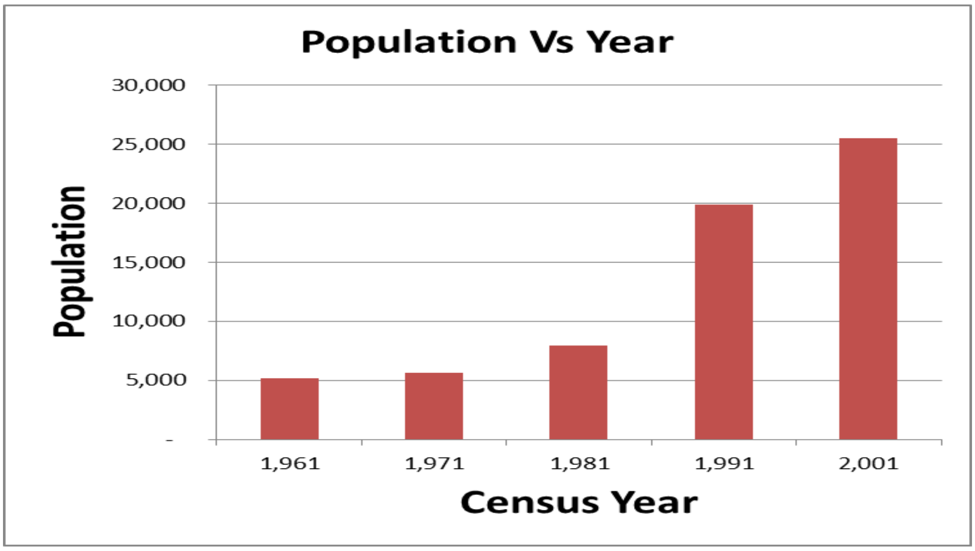


Figure 2.3 Population of Karjat
Source: Census of India

2.4.2 Decadal Growth Rate

Karjat city has had a phenomenal decadal growth since the last two decades. The growth for the year 1981-1991 is 150% while for the year range 1991-2001 is 232%.

The main reason for the same can be attributed to migration of people from the villages surrounding it owing to better employment opportunities as well as migration of working class from greater Mumbai because of relatively low living cost here.

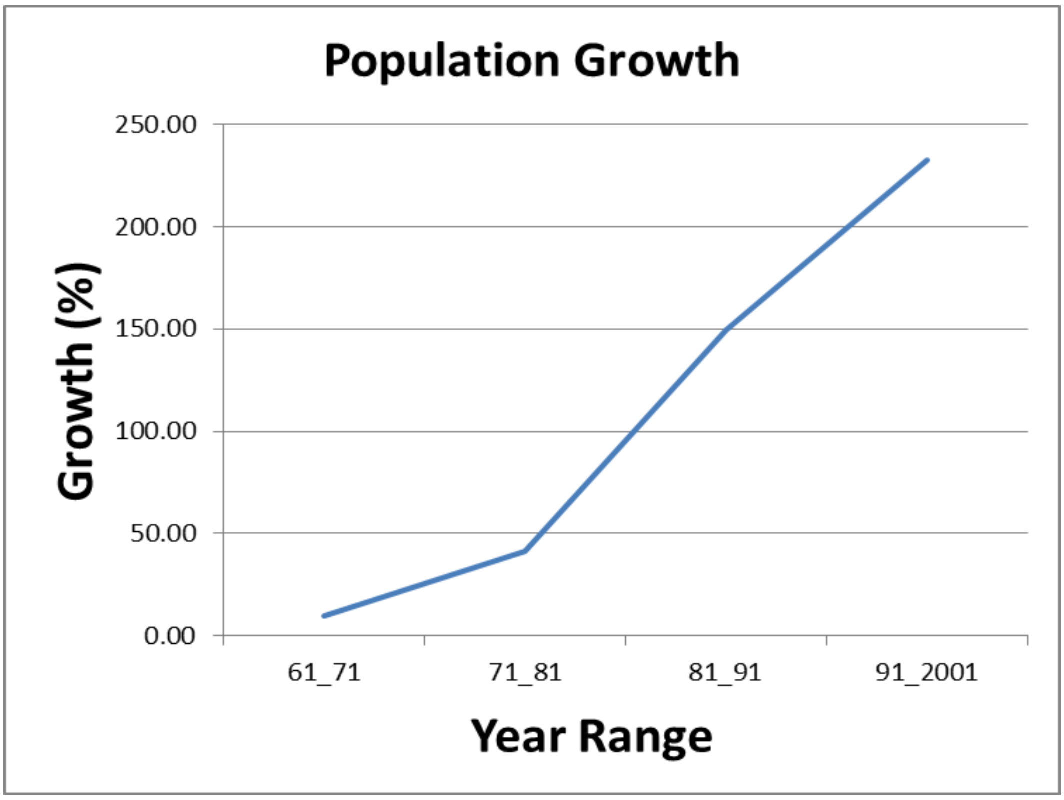


Figure 2.4 Decadal growth of population
Source: Census of India

2.4.3 Ward-wise population

The average ward population is around 1500 with 933 females per thousand males according to 2001 census.

Table 2.1 Ward-wise Population and distribution between sexes

Ward Number	Households	Population	Males	Females
All	**5594**	**25531**	**13206**	**12325**
1	338	1533	777	756
2	317	1435	738	697
3	267	1205	607	598
4	525	2284	1227	1057
5	511	2204	1152	1052
6	382	1710	894	816
7	246	1074	556	518
8	353	1741	902	839
9	235	1185	631	554

10	245	1230	630	600
11	258	1266	690	576
12	230	1104	571	533
13	346	1514	762	752
14	451	1984	1011	973
15	284	1269	641	628
16	380	1639	825	814
17	226	1154	592	562

Source: Census of India

2.4.4 Literacy

The percent literate population in Karjat is 75%, male literacy is 79.3% while female literacy is 70%.

Table 2.2 Literacy rates in the City

WARD	Literate	Males literates	Female literates	Illiterates	Male illiterates	Female illiterate
0	19134	10479	8655	6397	2727	3670
1	1054	581	473	479	196	283
2	1015	577	438	420	161	259
3	983	529	454	222	78	144
4	1816	1029	787	468	198	270
5	1411	788	623	793	364	429
6	1327	729	598	383	165	218
7	797	445	352	277	111	166
8	902	509	393	839	393	446
9	844	486	358	341	145	196
10	867	490	377	363	140	223
11	996	573	423	270	117	153
12	895	488	407	209	83	126
13	1283	669	614	231	93	138
14	1513	801	712	471	210	261
15	1042	540	502	227	101	126
16	1440	732	708	199	93	106
17	949	513	436	205	79	126

Source: Census of India

2.4.5 Working Population

Working population is defined by the census of India as the population:

In the case of seasonal work like cultivation, livestock, dairying, household industries, etc., if a person has some regular work of more than one hour a day throughout the greater part of the working season, he is regarded as a worker. In the case of regular employment in any trade, profession, service, business or commerce the basis for work would be satisfied if the person is employed during any of day of the week preceding the day on which he was enumerated. A person who was working but was absent from his work during the fifteen days preceding the day of enumeration due to illness or other cause is a worker.

A marginal worker is worker who worked for less than 180 days a year.

Table 2.3 Ward-wise working population and marginal workers

WARD	Working population	Males	Females	Marginal Workers	Marginal Males	Marginal Females
All	**8333**	**6683**	**1650**	**1121**	**754**	**367**
1	487	381	106	182	110	72
2	455	369	86	24	18	6
3	365	287	78	44	29	15
4	748	587	161	59	35	24
5	699	568	131	46	38	8
6	579	473	106	69	49	20
7	322	262	60	24	15	9
8	650	469	181	311	207	104
9	343	296	47	112	89	23
10	347	295	52	32	24	8
11	462	398	64	10	3	7
12	354	296	58	8	8	0
13	523	390	133	55	25	30
14	680	518	162	21	16	5
15	399	323	76	47	32	15
16	521	416	105	38	28	10
17	399	355	44	39	28	11

Source: Census of India

2.4.6 Sex Ratio

The sex ratio has been constantly increasing in the city, from 881 found in the census of 1981 the ratio has increased to 933 in 2001 which is equal to national ratio but greater than Maharashtra (922).

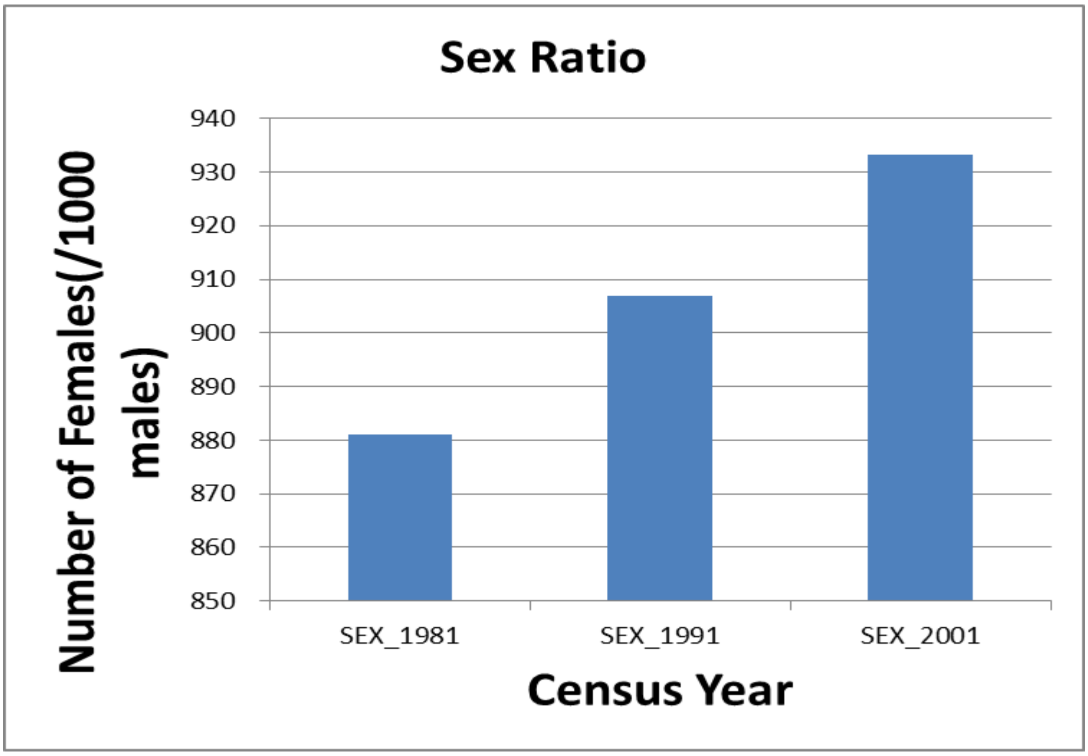


Figure 2.5 Sex ratio with respect to census year

Source: Census of India

2.4.7 Population Projection

Three methods of population projection have been followed; Arithmetic increase method, Geometrical increase method, Incremental increase method. The formula for each of the methods is given below.

Arithmetic increase method, $P_n = P + nl$

Geometrical increase method, $P_n = P(1 + lg/100)^n$

Incremental increase method, $P_n = P + nl + (n(n + 1)r/2)$

First, decadal increase is calculated for each method and then correspondingly population is projected for future.

Table 2.4 Growth per decade

Year	Population	Arithmetical Increase per decade	Geometrical Increase per decade (%)	Incremental Increase per decade
1981	7970			
1991	19904	11934	149.7365119	11934
2001	25531	5627	28.27069936	-6307
Average		8781	65.06	2814

Projected population:

Table 2.5 Projected population

Year	Arithmetical Increase Method	Geometrical Increase Method	Incremental Increase Method
2011	34312	43143	37126
2025	46606	85002	58087
2031	51874	114820	68758
2040	59777	180260	86665

It can be seen that the population of Karjat is growing at a very rapid pace and will lie between 59000 to 180000 in the year 2040. As per prediction done by MJP, the population in 2031 will be 77000.

2.5 Rainfall

The average annual rainfall in the city is 2177 mm.

2.6 Temperature

Average Max temperature: **30.30°C**

Average Min. temperature: **26.60°C**

Chapter 3

Survey

3.1 Introduction

In order to have a basic understanding of the socio-economic profile of the city and the status of water supply and sanitation sectors, secondary data was collected from many different agencies such Census of India, MJP, Municipal Council.

It was found that the available data pertaining to the water supply and sanitation sectors were not enough as well as inadequate. As a result, it was decided to conduct a household survey. In addition to the survey, a number of meetings were conducted with all the stake-holders to have the in-depth understanding of the sectors.

3.2 Sample

While sampling, the large size of the city and the economic and social variations were to be kept in mind. But due to time and resource constraints, the sample size could not have been too large. So, a representative sample size of 1.5% was chosen. To accomplish this, since all the wards have approximately same population, it was decided to collect data from 6 households from each of the 17 wards from a varied geographical as well as economic background so as to cover all sections of the society. The economic variation was taken in to account by the size of the plot. Moreover, the households chosen were from all parts of the wards to cover every area.

3.3 Questionnaire

A questionnaire was prepared for the survey. The questions were divided into 3 categories:

1. Primary household information
2. Water supply

3. Sanitation

The questions were designed to gauge the holistic view of the socio-economic profile of the city as well as the sectors. As far as water supply sector is concerned the survey included questions for analysis of the qualitative as well as quantitative aspects. Since the city does not have an underground sewage system, the questions for sanitation mostly consisted of the present problems the people in Karjat are facing. The sector-wise analysis of the survey is presented later in the chapter.

The questionnaire and the data collection sheet can be found in Appendix I.

3.4 Primary Household Information

The primary household information included questions of address of the household, the ward number, whether the family is above poverty line or below poverty line, annual basic income and the number of people in the household.

According to the data collected the average number of people in a household in the city lies between 4 and 5 (4.67). The average annual income of the household came out to be 2.88 lakh. 16% of the population surveyed was below poverty line while 80% were above poverty line.

3.5 Water Supply

a) Source of water:

Majority of the households (55 %) have house-hold connection, while 17% of the house-holds use public stand-post as their source of water. 21 % of the city population still uses bore-well. Now, only 4.26 % of people using household connection are BPL, while 64.3 % of people using stand-post are BPL. At the same time, neglisible BPL population used bore-well.

This shows that BPL families are not able to fully utilize the water supply scheme due to financial reasons mainly due to water-tax.

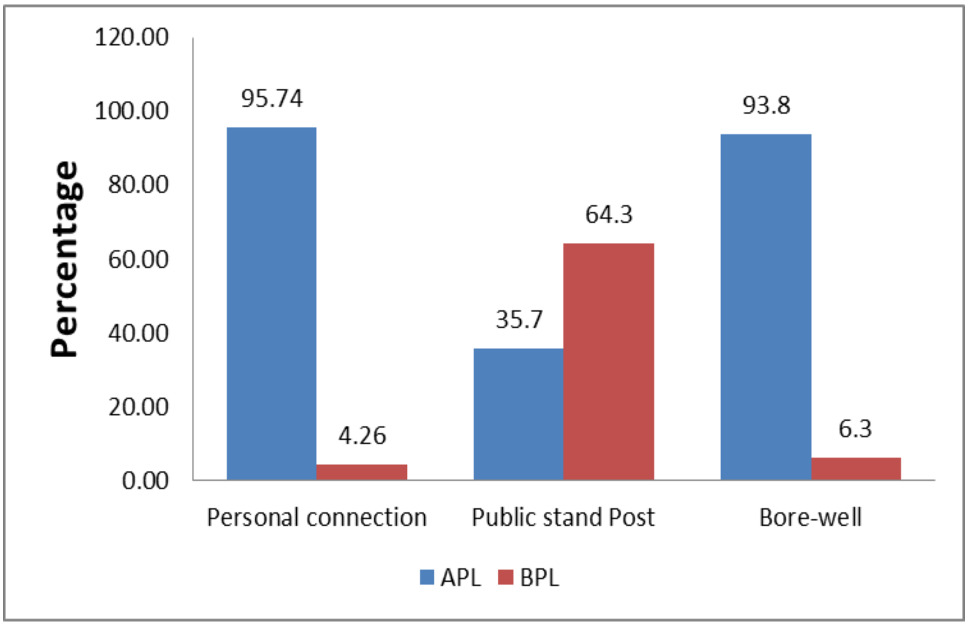


Figure 3.1 Distribution of source of water between APL and BPL
Source: Household Survey

b) Time and duration of supply

Almost every part of the city is supplied water at morning starting at around 6:00 AM to 8:30 AM. The duration of water supplied varies from 15-20 minutes to 2 hours. The following pie-chart shows the distribution.

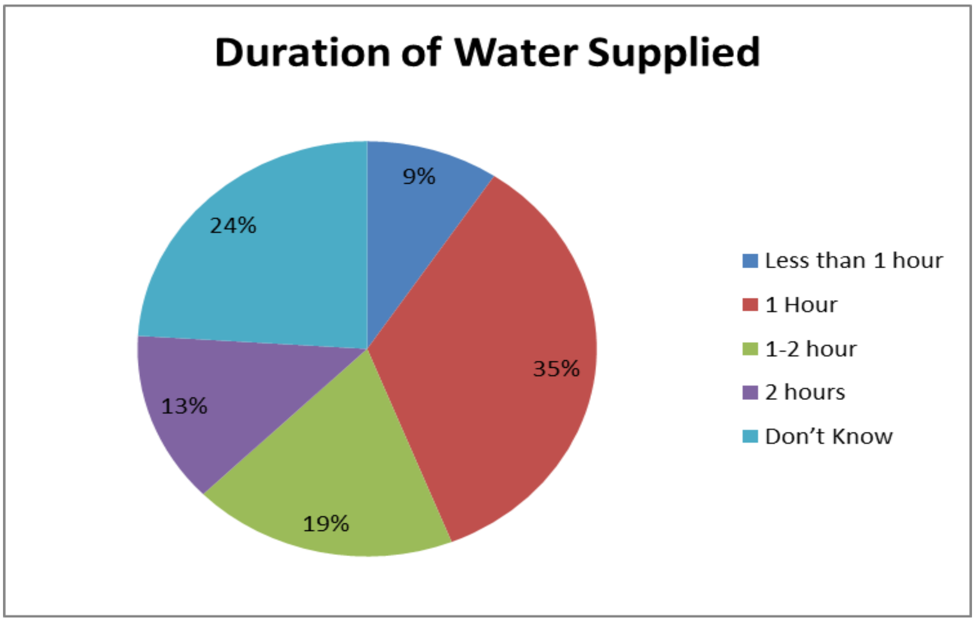


Figure 3.2 Duration of water supplied
Source: Household Survey

c) Water Quantity and Quality

When asked about whether water supply is sufficient, 16% of people strongly agreed to it, while 17% disagreed with it. This shows that there are some areas which get less water. While only 14% people strongly feel that water supplied during summers is sufficient and 32 % of people feel that water in summers is insufficient.

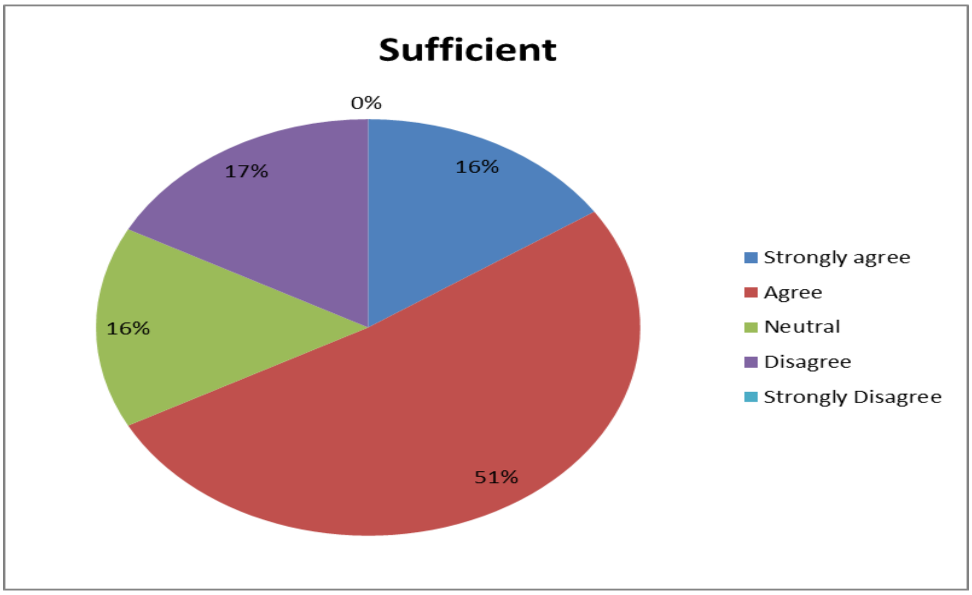


Figure 3.3 Sufficiency of supply water
Source: Household Survey

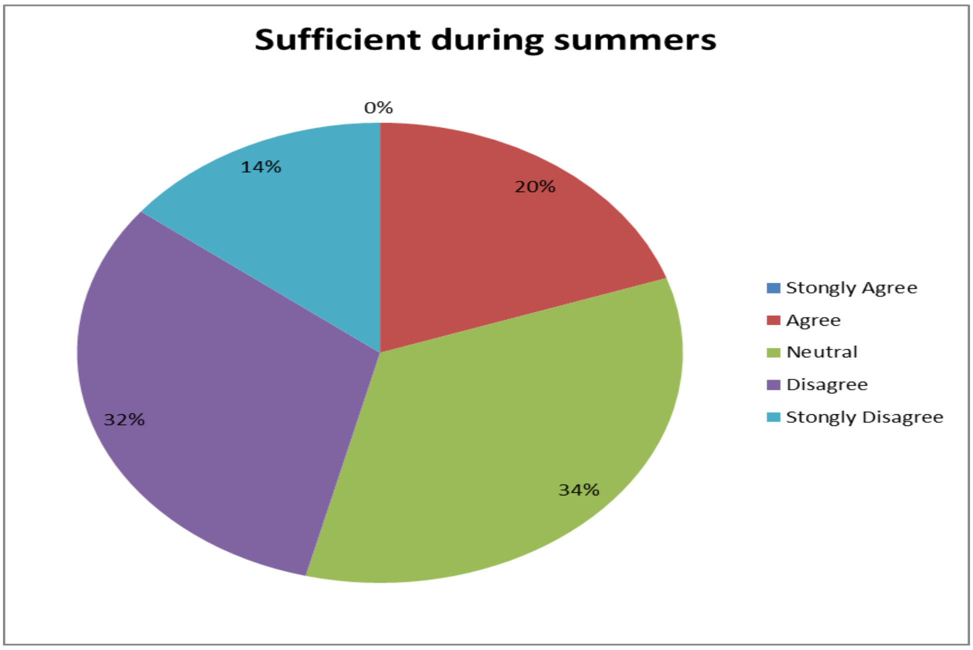


Figure 3.4 Sufficiency during summers
Source: Household Survey

57 % of people believe that water is suitable for drinking while 29% household are neutral when asked the same question. 79 % of the population feel that water is dirty during monsoon.

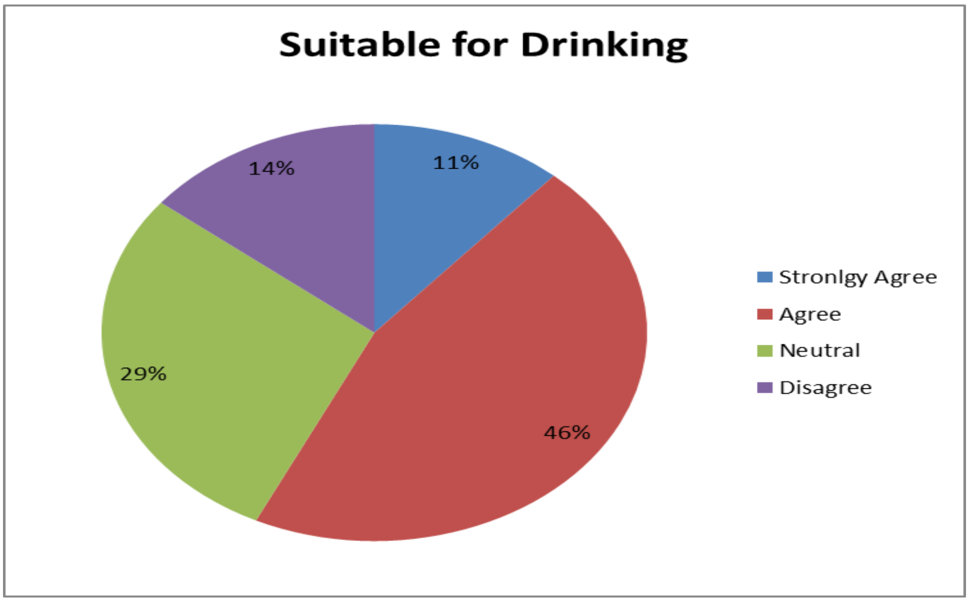
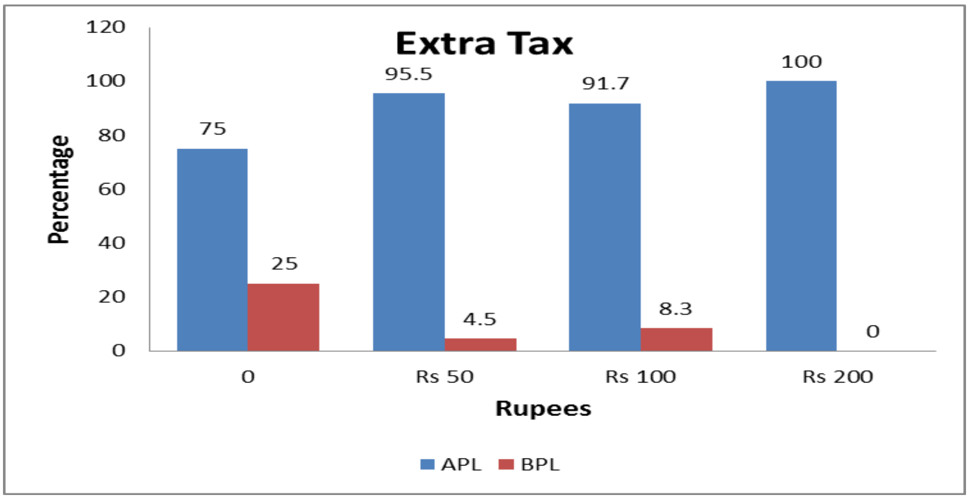


Figure 3.5 Percentage of people thinking water is suitable for drinking
Source: Household Survey

d) Water-Tax

56% of the people feel that water tax charged on them is affordable while 26% households are neutral on this question. 66% of the households are ready to pay extra if water quality is improved.

Figure 3.6 People ready to pay extra if quantity of water supply is increased



Source: Household Survey

At the same time, 77% of the household are ready to pay more if the quality of water is improved. Since, this is more than those willing to pay for quantity improvement, it can be comcluded that people quality is a bigger issue than quantity.

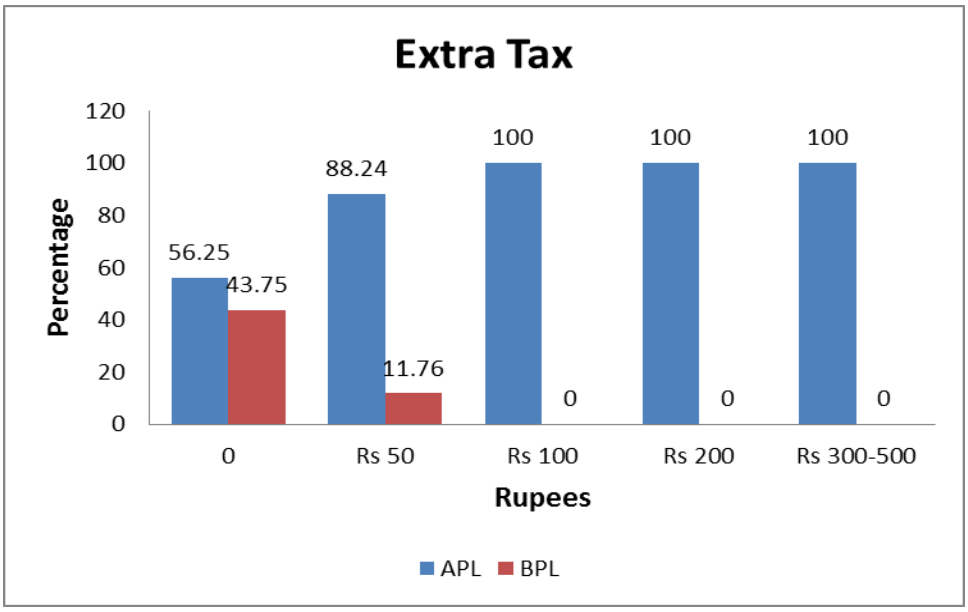


Figure 3.7 People ready to pay extra if quality of water supply is increased.
Source: Household Survey

e) Satisfaction

Only 38% of people are satisfied with the Karjat Municipal Water Supply Scheme while 21% population is neutral.

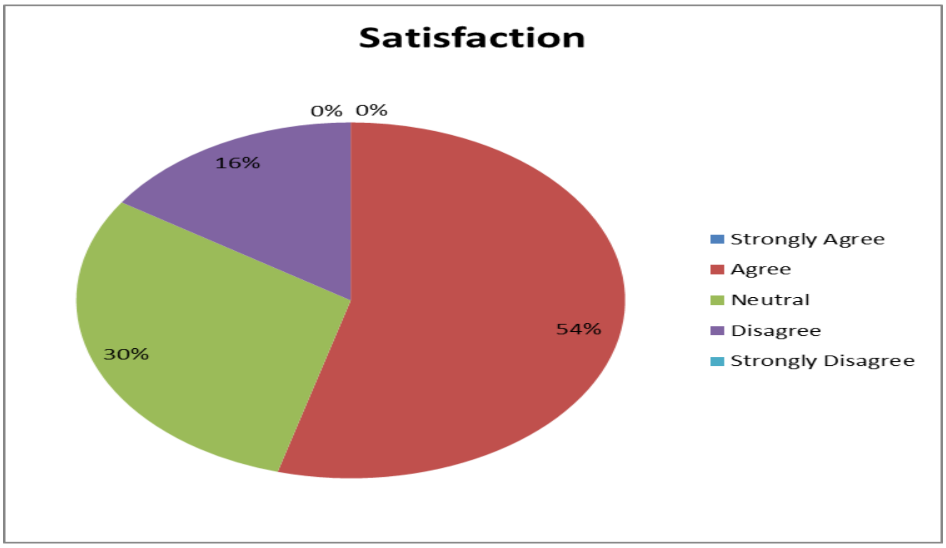


Figure 3.8 Pie-chart showing satisfaction of people with water supply
Source: Household Survey

3.6 Sanitation

a) Number of toilets

20% of people do not have toilets in their homes while 63% have one toilet and 17% have two toilets in their homes. Income-wise distribution of toilets is plotted below.

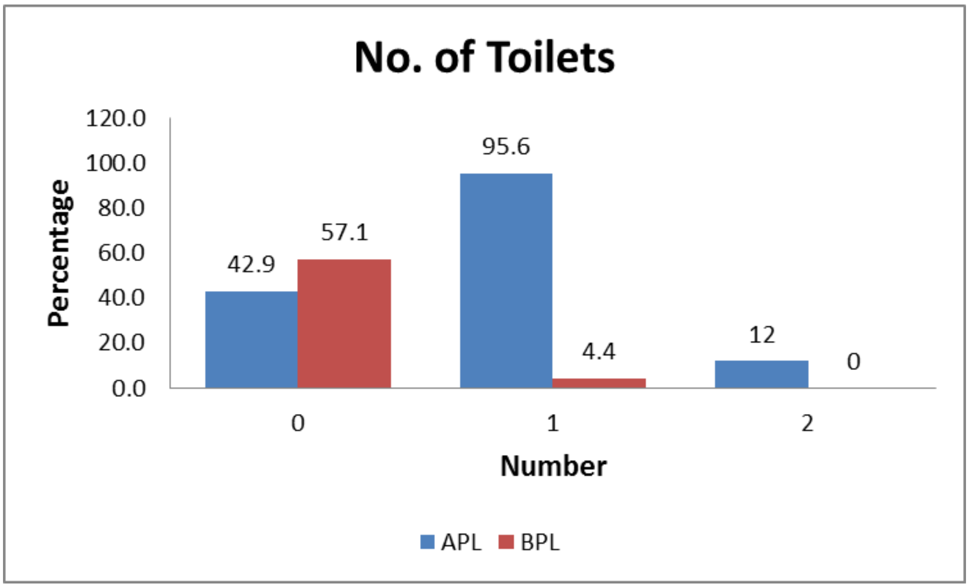


Figure 3.9 Distibution of toilets between APL and BPL families
Source: Household Survey

Out of these toilets only, 63% have septic tanks in them, 21% don't have septic tanks and 16% don't know if their toilet has septic tank or not. Only 39% household knew the depth of their septic tanks. The depth of septic tank in Karjat varied from 5 feet to 9 feet.

b) Problems

93 % of the household surveyed believe that there is a problem of mosquito in Karjat while 54% of households agree that probem of water-borne disease is prevalent in Karjat.

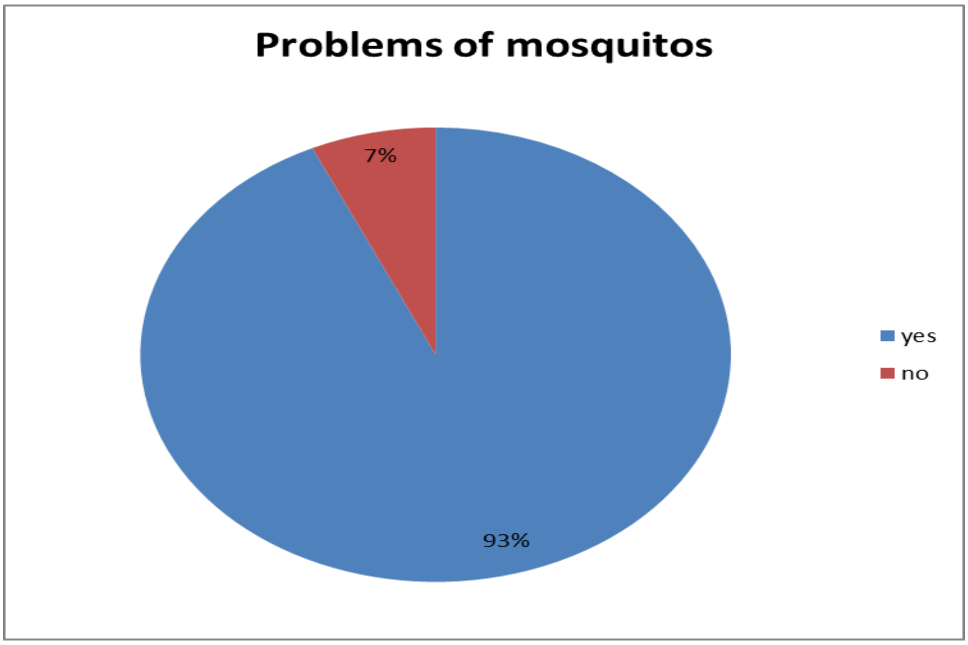


Figure 3.10 Problem of mosquito
Source: Household Survey

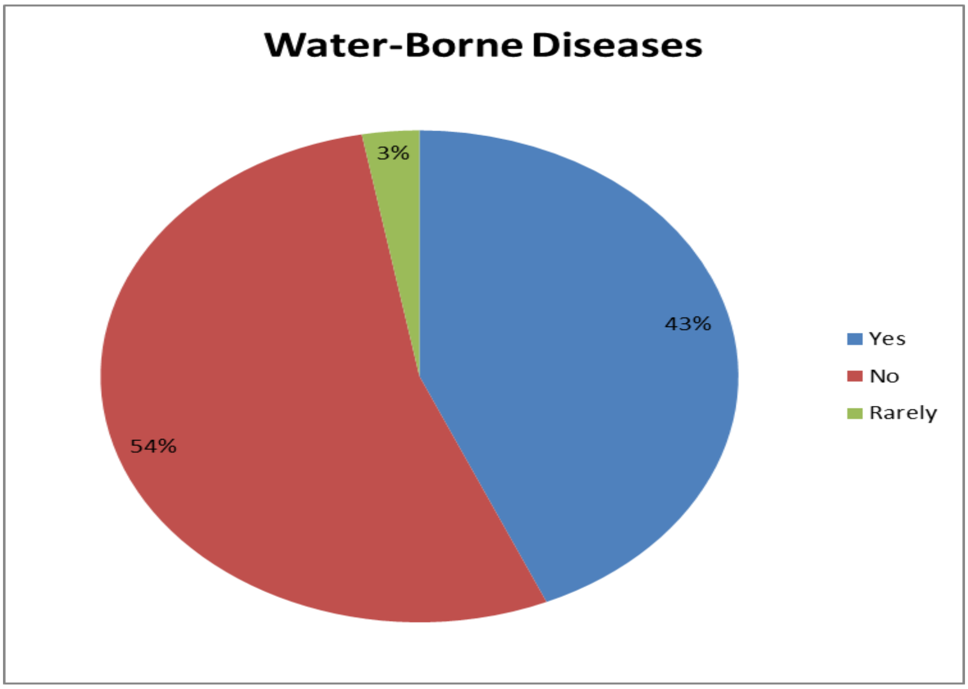


Figure 3.11 Problem of water-borne diseases
Source: Household Survey

c) Drainage

66% of people have not seen open drains being cleaned while 39% of the people don't know if the drains are cleaned ever or not.

91% of the households want a underground drainage system.

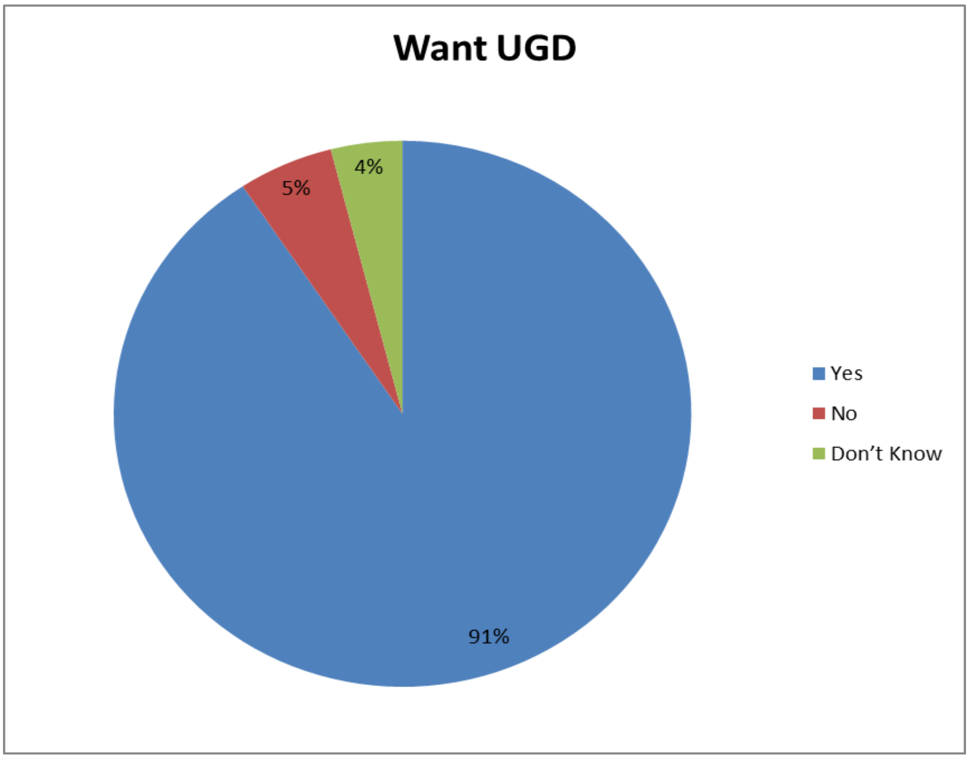


Figure 3.12 People need Under ground drainage system
Source: Household Survey

57% of the people will pay if there is an underground drainage and treament network, while 43% will be unable to pay.

Further, the main problems in open-drainage are blockage of drains due to solid waste falling into the drains, overflowing of drains into the road during rainy season and breeding of mosquitos in the open drains.

Chapter 4

Water Supply

4.1 Historical Background

Proir to the present scheme, a small rural water supply scheme was functional in the city. This scheme used to supply water to Karjat, Mudre (Bk), Mudre (Kh) Bhisegaon and Gundge. The source for this water was Palasdhari dam owned by Central Railway Department. Village Dahivali was included in Kadav RRWSS. Akurle had its own water supply arrangement with bore-well as source. It was executed by Zilla Parishad and was handed over to gram panchayat for its maintenance. In addition to this, people have been using water from bore-well as a source of water.

Palasdhari dam is owned by Central Railway deptt. The capacity of the dam is 96.50 Mcft. It supplied water to ESR at Karjat railway station through 300 mm diameter C.I. rising main. For Karjat water supply, tapping point was taken in that C.I. main near the dam. 300 mm dia A.C. pipe class-15 gravity main of 100 m long was laid upto sump of 107250 litres capacity. From there, water was pumped to the treatment plant through 150 mm diameter C.I. class B rising main. The treatment plant consists of stilling chamber and and settling tank (250 ML).

Settled water was stored in GSR of 3.05 lakh litres. The distribution was as per rural norms. As a result, the diameters of pipes were on the smaller side and A.C. pipes were damaged and leakages were very often.

The water supply for Dahivali had its source as Pej River which gets tail water from Bhivpuri power power station. The Kadav RRWSS scheme covered 19 villages and Dahivali was at tail end. The daily supply was 0.2 MLD.

Since Karjat was changed from Village Panchayat to Municipal Council, the norms of water supply became higher. So it became necessary to supply treated water at 125 lpcd as per urban norms. Further, due to rapid urbanization of the city, the existing scheme was not able to cope up with the demand of the rising population. So, it was necessary to propose a water supply scheme for the town as per urban norms.

4.2 Present Scheme

A new scheme was designed to supply water to the city till the year 2031.The scheme was designed and implemented by Maharashtra Jeevan Pradhikaran (MJP), the nodal agency which is entrusted with design and construction of water supply and sewage schemes in Maharashtra. The supply network is designed for the flow till 2031.

The water is lifted from Pej River from Wanjarwadi by constructing Jack well. Raw water is lifted through 170 BHP vertical turbine pump upto BPT of capacity 80000 litres to store water for 10 minutes. From BPT raw water through gravity mains goes to the treatment plant was constructed at Dahivali.

From treatment plant, pure water is pumped by 250 BHP Centrifugal coupled coupled pump at MBR located at a hill of Dahivali. Water is sent to 4 ESRs through leading mains of different diameters. Finally, through distribution network water is served to people through personal connection or stand-posts.

The scheme is designed for the design population of 77600 for the year 2031. 125 lpcd of water is supplied as per urban norms. At present there are 3807 household connection and 1 industrial connection and 45 commercial connections.

A brief description of the supply scheme from source to distribution mains is given below.

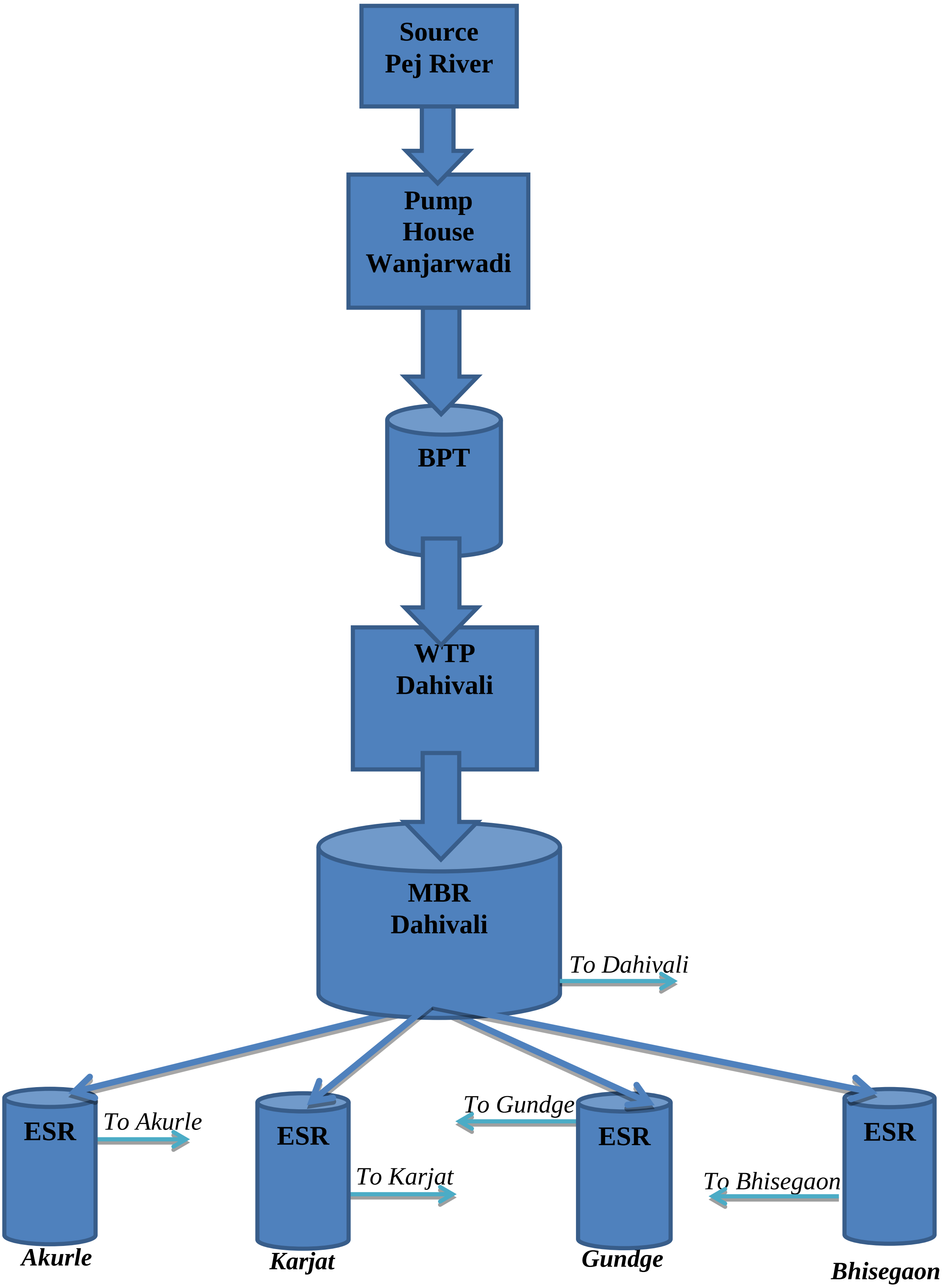


Figure 4.1 Schematic flow of water from source to distribution mains

4.2.1 Design Period

The scheme is designed for 30 years from 2001 to 2031

4.2.2 Source.

The water is lifted from Pej River at Wanjarwadi. It is a perennial source as the water lifted is the tail water released from Bhivpuri hydroelectric plant. The reservoir Andhra Lake lies in Pune taluka and is a part of Krishna River Basin. The catchement area of the basin is 124.32 Sq.Kms. At full capacity, 11.50 MLD water will be lifted from the source.

4.2.3 Jackwell with overhead pump house

A Jack well and an Overhead Pump House is constructed on the bank of Pej River near Wanjarwadi adjacent to the existing Kadav Jack well. An approach channel is constructed so that water flows inside the well. The specifications of Jack well and the pump house are given below

Jack well:

Table 4.1 Specifications of Jack-well

Specifications	
Size	6.0 m dia, 7.00 m depth below G.L
Average GL	93.00 m
Bottom RL	86.00 m
River Bed RL	90.415 m
Suction RL	87.00 m

Source: MJP

Overhead Pump House:

Table 4.2 Specifications of Pump-house

Specifications	
Size	7.00 m X 5.00 m
Plinth RL	95.265 m
Top RL	100.41 m

Source: MJP

4.2.4 Raw Water Pumping Machinery

The pump house consists of two 80 HP vertical turbine pumps and one stand-by pump. The calculations for required BHP and the efficiency of pumps is shown in chapter 5 of this report.

Table 4.3 Specifications of pumping machinery

Specifications	
BHP	80 BHP (one stand-bye)
Pumping hours	20 Hrs
Rate of Pumping	575000 litres/hr
Total head	42.00 m
Type of Pump	Vertical Turbine Pump

Source: MJP

4.2.5 Break Pressure Tank

A break pressure tank has been constructed to hold water for 10 minutes.

Table 4.4 Specifications of Break Pressure Tank

Specifications	
Capacity	80000 litres (10 min. capacity)
G.L.	108.00 m
Bottom RL	119 m
FSL	123.5 m

Source: MJP

4.2.6 Raw Water Gravity Main

Table 4.5 Specifications of Raw Water Gravity Main

Specifications	
Length	11000 m
Dia & Class	500 mm dia PSC pipes Class 6 Kg
Design Discharge	13.80 ML

Source: MJP

4.2.7 Pure Water Pumping Machinery

The pump house consists of two 150 HP vertical Centrifugal pumps and one stand-by pump. The calculations for required BHP and the efficiency of pumps are shown in chapter 5.

Table 4.6 Specifications of Pure water pumping Machinery

Specifications	
BHP	150 BHP (One stand-bye)
Pumping hours	20 hours
Rate of pumping	575000 litres/hours
Total head	68.00 m
Type of Pump	Centrifugal coupled

Source: MJP

4.2.8 Pure Water Rising Main

Pure water is pumped from Water treatment plant to main balancing reservoir through 500 mm dia C.I pipe Class B. The total length of pipe is 1000 m and the design discharge is 13.80 ML.

4.2.9 Master Balancing Reservoir

Table 4.7 Specifications of Master Balancing Reservoir

Specifications	
Capacity	1800000 Litres
Average G.L.	133.0 m
Bottom RL	140.00 m
FSL	143.50 m

Source: MJP

4.2.10 Leading Mains

Water from MBR goes to 4 ESRs in the city through 7170 m of C.I. and PSC pipes.

Table 4.8 Specifications of Leading Mains

Specifications		
Karjat	300 mm dia PSC 6 Kg	1200 m
Bhisegaon	450 mm dia PSC 6 Kg	150 m
	400 mm dia PSC 10 Kg	1150 m
	350 mm dia PSC 8 Kg	1200 m

	300 mm dia PSC 6 Kg	2900 m
Gundge	200 mm C.I. ‘LA’ Class	375 m
Akurle	150 mm C.I. ‘LA’ Class	195 m

Source: MJP

4.2.11 ESR

Table 4.5 Specifications of EGRs and GSRs

Specifications		
ESR at Karjat	Capacity	1550000 litres
	GL	106.00 m
	Bottom RL	116.00 m
	FSL	119.50 m
ESR at Akurle	Capacity	180000 litres
	Average GL	96.95 m
	Bottom RL	108.95 m
	FSL	112.45 m
GSR at Gundge	Capacity	450000 litres
	Average GL	122.00 m
	Bottom RL	119.00 m
	FSL	122.00 m
GSR at Bhisegaon	Capacity	500000 litres
	Average GL	123.00 m
	Bottom RL	120.00 m

Source: MJP

4.2.12 Distribution System

4.2.12.1 Karjat Zone

Table 4.10 Specifications of Distribution Mains Karjat Zone

Diameter (mm)	Length (m)	Class
500	70	C.I. ‘LA’ Class pipe
350	195	C.I. ‘LA’ Class pipe
300	780	C.I. ‘LA’ Class pipe
250	670	C.I. ‘LA’ Class pipe

200	630	C.I. ‘LA’ Class pipe
150	1080	C.I. ‘LA’ Class pipe
125	1870	C.I. ‘LA’ Class pipe
100	4285	C.I. ‘LA’ Class pipe

Source: MJP

4.2.12.2 Dahivali Zone

Table 4.11 Specifications of Distribution Mains Dahivali Zone

Diameter (mm)	Length (m)	Class
400	210	C.I. ‘LA’ Class pipe
350	100	C.I. ‘LA’ Class pipe
300	945	C.I. ‘LA’ Class pipe
200	1965	C.I. ‘LA’ Class pipe
150	750	C.I. ‘LA’ Class pipe
125	1370	C.I. ‘LA’ Class pipe
100	5775	C.I. ‘LA’ Class pipe

Source: MJP

4.2.12.3 Akurle Zone

Table 4.12 Specifications of Distribution Mains Akurle Zone

Diameter (mm)	Length (m)	Class
150	100	C.I. ‘LA’ Class pipe
125	80	C.I. ‘LA’ Class pipe
100	1190	C.I. ‘LA’ Class pipe

Source: MJP

4.2.12.4 Gundge Zone

Table 4.6 Specifications of Distribution Mains Gundge Zone

Diameter (mm)	Length (m)	Class
300	170	C.I. ‘LA’ Class pipe
250	280	C.I. ‘LA’ Class pipe
200	250	C.I. ‘LA’ Class pipe
150	985	C.I. ‘LA’ Class pipe
100	555	C.I. ‘LA’ Class pipe

Source: MJP

4.2.12.5 Bhisegaon Zone

Table 4.14 Specifications of Distribution Mains Bhisegaon Zone

Diameter (mm)	Length (m)	Class
300	135	C.I. ‘LA’ Class pipe
250	215	C.I. ‘LA’ Class pipe
200	1310	C.I. ‘LA’ Class pipe
150	710	C.I. ‘LA’ Class pipe
125	120	C.I. ‘LA’ Class pipe
100	300	C.I. ‘LA’ Class pipe

Source: MJP

Chapter 5

Design Details

5.1 Introduction

To verify the correctness of the design of the scheme, it was decided to check the details of the project by redesigning it with same input parameters. The design of Pumps, rising mains and the distribution mains was done.

While designing the inputs parameters were taken from manuals provided by Central Public Health Engineering and Environment Organization (CPHEEO) and the plan report of the design of network by MJP.

For pumps present efficiency was also calculated. For design of leading mains and distribution mains, Loop and Branch software was used. Since, the project was designed for the most economical design, the cost of pipes, pumps and electricity charges of DSR 1996-97 is used.

5.2 Assumptions

a) The geographical inputs such as elevation of the node points given in the plan report are correct and can be used as inputs.

b) The population depending on one branch of pipe used to calculate flow is correctly estimated in the report.

c) The lengths of pipes are correctly calculated and will give the most economical design.

d) The capacity of MBR, ESR and GSR are adequate enough for the supply.

5.3 Design Parameters

a) **Design Period:** The scheme is designed for the year 2031

b) **Demand:** Initial demand = 4.32 MLD

Intermediate demand = 7.10 MLD

Ultimate demand = 11.50 MLD

c) **Peak Factor:** The scheme is designed for a peak factor of 3 in distribution mains and 1.2 for leading mains.

d) **Minimum Residual Pressure:** The minimum residual pressure of 8 m is required to be maintained at the tail ends.

e) **Hazen's constant:** Hazen's constant for CI pipe is taken from the CPHEEO manual as 100.

f) **Minimum Pipe diameter:** 100 mm

g) **Pumping hours:** 20 hours

5.4 Rising Mains

Different diameter inputs were selected assuming an economic velocity of 1.25 m/s. Overall cost of rising main was calculated for different diameters using an Excel spreadsheet provided by MJP with pre-entered formulae. The most economical diameter was selected and corresponding required pump capacity and piping were selected for the design. The calculations of the most economical size can be found in the Appendix II

Table 5.1 Specifications of Rising Mains.

Specification	Raw water rising main	Pure water rising main
Path	Source point to WTP	WTP to MBR
Length	1250 m	1000 m
Pipe	500 mm Diameter CI Pipe Class B	500 mm Diameter CI Pipe Class B

Source: MJP

5.5 Break-Pressure Tank

Demand = 11.50 MLD

= 11500000 litres

Pumping is done for 20 hours,

Capacity for 10 minutes = 115000000/20/60*10

= 95833.33 litres

~ 100000 litres

This value is very high as compared to the designed value of 80000 litres. The retention time will have to be adjusted to 8 minutes instead of 10 minutes.

5.6 Design of Pumps

The pumps have been designed for the flow till 2015. Hence the demand of 7.10 MLD is used for calculations.

For calculating the break horse-power of the pumps required, we first need to calculate the head against which the pumps have to work. Total head is the sum of static head, velocity head, frictional and other losses. Static head is the difference between full supply level and the suction relative level, while the velocity head can be assumed as 2 m. Frictional head loss depends on the length and diameter of pipe, but for calculation purpose the highest head loss is taken. Total losses are assumed to be 10% of the frictional losses.

After calculation of head, the BHP required is calculated by the formula;

$$BHP = (Q*h*g)/(Efficiency*746)$$

Where Q = Flow (Litres/s)

h = Total Head (m)

g= Acceleration due to gravity (m/s^2)

5.6.1 Raw water pump

Calculation of Head:

Table 5.2 Head Calculation for Raw water pump.

Type (m)	Formula	Head (m)	Approximation (m)
Static Head	FSL of BPT-Suction RL	36.50	37
Frictional Head(m/km)	2.1	2.625	
Total Losses	10%	2.8875	3
Velocity Head		2	2
Total Head (m)		**41.39**	**42**

Calculation of BHP:

Table 5.3 Calculation of BHP for raw water pump.

Design Discharge (MLD)		7.1
Hours of pumping		20
Flow (litres/s) (Q)	*(Design Discharge*10^6)/(Hours*3600)*	98.61
Efficiency		70
Head (m) (h)		42
BHP (kW)	*(Q*g*h*G*)/(Efficiency*1000)*	58.0
BHP (HP)	*BHP (kW)/.746*	**77.80**

At raw water pumping station, three pumps of 80 BHP Vertical Turbine pumps are provided, which is greater than required BHP. Hence, the pumps at the raw water pumping station are adequate.

5.6.2 Pure Water Pump

Calculation of Head:

Table 5.4 Head Calculation for Raw water pump.

Type (m)	**Formula**	**Head (m)**	**Approximation (m)**
Static Head	FSL of MBR-Suction RL	63	63
Frictional Head	2.1	2100	
Total Losses	10%	2310	3
Velocity Head		2	2
Total Head (m)			**68**

Calculation of BHP:

Design Discharge (MLD)		7.1
Hours of pumping		20
Flow (litres/s) (Q)	*(Design Discharge*10^6)/(Hours*3600)*	98.6
Efficiency		70
Specific gravity (G)		1
Head (m) (h)		68
BHP (kW)	*(Q*g*h*G*)/(Efficiency*1000)*	94.0
BHP (HP)	*BHP (kW)/.746*	**126.0**

Table 5.5 Calculation of BHP for pure water Pump.

At pure water pumping station, three Centrifugal coupled pumps of 150 BHP are provided, which is greater than required BHP. Hence, the pumps at the pure water pumping station are adequate.

5.6.3 Efficiency of Pumps

Pump efficiency is defined as the ratio of the power imparted on the fluid by the pump in relation to the power supplied to drive the pump.

For calculating the pump efficiency, the total flow needs to be calculated. To get total flow, annual water tax paid by municipal council to the minor Irrigation department is used. The tax is paid at the rate of Rs. 6.60 per 10,000 litres of water lifted from the source. The total tax paid in the year 2009-2010 is Rs. 1494298.00 which gives the total volume of water lifted in the year as 2264087879 litres. Thus, daily volume of water is 6202980 litres. Thus, for 20 hours of pumping flow can be calculated, which comes out to be 86.15 litres/s.

Further, calculation of head is shown above in the table 5.2 and table 5.4. Thus, hydraulic kilowatt can be calculated as:

$$\text{Hydraulic Kilowatt} = (\text{Head(m)}*\text{Flow (l/s)}*g)/1000$$

This hydraulic kilowatt is the power output from the pump. Now, we know the power input as the rating of the pump. As a result, efficiency can be calculated.

Efficiency at Raw Water Pumping Station:

Table 5.6 Calculation of efficiency of Raw water pump.

Head (m)	*Formula*	42
Hydraulic Kilowatt	*Head(m)*Flow (l/s)*g/1000*	35.50
Hydraulic Horsepower	*Hydraulic Kilowatt*1.341*	47.60
Power Input (HP)		80
Power Factor	*Assume*	1.1
Pump efficiency	***Water Power/Volt*Ampere*Power factor***	**54.09 %**

\

Efficiency at Pure Water Pumping Station:

Table 5.7 Calculation of efficiency of Pure water pump.

Head (m)	*Formula*	68
Hydraulic Kilowatt	*Head(m)*Flow (l/s)*g/1000*	57.47
Hydraulic Horsepower	*Hydraulic Kilowatt*1.341*	77.07
Power Input (HP)		150
Power Factor	*Assume*	1.1
Pump efficiency	***Water Power/Volt*Ampere*Power factor***	**46.71 %**

It can be observed from Table 5.5 and Table 5.7 that the efficiencies of the pumps are very low as compared to the efficiency for which the pumps have been designed.

Reasons for low pump efficiency:

a. Lack of maintenance and repair.

b. Voltage fluctuations.

c. There may be some air in the pumps

d. Long hours of usage.

e. Roughness of pipes might have increased, so that there is more head loss.

f. Muddy water can reduce the pump efficiency.

Steps to increase pump efficiency:

a. Regular repair and proper maintenance of the pumps.

b. Operating pumps in those times during the off-peak electricity demand in the city. This will reduce the voltage fluctuations and thus increase life and efficiency of the pumps.

c. Avoid overheating by using pumps in rotation.

d. Air in the pumps should be removed regularly.

e. Well-balanced scheduled operation, in a way to minimize starts and stops. This will also reduce transient and pressure variations, also the main cause for pipe breaks.

f. The number and size of pumps should be chosen in such a way to counter the effects of seasonal variation of demand.

g. Further, with more efficient pumps now available in the market, after half-life of the project, the pumps should be redesigned and more efficient pumps should be chosen. The number and size of pumps should be chosen in such a way to counter the effects of seasonal variation of demand.

5.7 Distribution Mains

a) For design of distribution networks, the software Loop and Branch is used. The nodes used by MJP for designing the network are used as input in the software. The elevation of the nodes as well as the length of the pipes is also taken from the predesigned scheme.

b) From these inputs, the values of diameter of the pipe and the pressure at the nodes is verified once by designing it for the most economic diameter and then redesigning the network with the actual diameters of the pipes.

c) Since, the software give the most economical pipe diameter, the cost of DSR 1996-97 was used in the softwares.

d) The city has been divided into 6 zones viz. Karjat, Mudre, Bhisegaon, Gundge, Akurle, Dahivali. Since, the projected population of all of these zones is less than 50,000 the peak factor is taken as 3.0. The minimum residual node pressure is taken as 8 m of water.

e) The full design details of the most economic design of the distribution networks of all the zones have been attached in Appendix III.

a) Karjat Zone

The distribution network designed for Karjat Zone supplies water to Karjat, Mudre(Kh) and Mudre (Bh). It has one closed loop inside the network. So, the software loop was used for verifying the diameter and flow.

There are 51 pipes between 51 nodes. The diameters required and diameters provided are tabulated.

Pipe Details:

Table 5.8 Pipe Details verification for Karjat Zone

Pipe No.	Diameter Required (mm)	Diameter Provided (mm)	Difference (m)
1	500	500	0
2	400	350	-50
3	350	300	-50
4	300	250	-50
5	300	250	-50

6	300	250	-50
7	250	200	-50
8	200	150	-50
9	150	125	-25
10	125	100	-25
11	200	200	0
12	200	150	-50
13	200	125	-75
14	150	125	-25
15	100	100	0
16	100	100	0
17	125	125	0
18	125	125	0
19	125	100	-25
20	150	150	0
21	125	100	-25
22	125	100	-25
23	150	125	-25
24	200	125	-75
25	150	125	-25
26	125	100	-25
27	150	150	0
28	150	125	-25
29	100	100	0
30	125	100	-25
31	100	100	0
32	100	100	0
33	100	100	0
34	350	300	-50
35	300	250	-50
36	250	200	-50
37	250	200	-50
38	100	100	0
39	100	100	0
40	250	200	-50
41	200	200	0
42	200	150	-50
43	125	125	0
44	100	100	0
45	100	100	0
46	100	150	50
47	100	100	0

48	100	100	0
49	100	100	0
50	150	100	-50
51	100	100	0

Node Details:

Table 5.9 Node Details verification for Karjat Zone

Node	Design Pressure	Actual Pressure	Pressure Differnce
1 S	10	10	0
2	28.38	28.38	0
3	26.84	26.57	-0.27
4	28.68	27.43	-1.25
5	28.18	26.38	-1.8
6	28.06	27.88	-0.18
7	25.25	24.33	-0.92
8	25.32	23.41	-1.91
9	25.54	22.54	-3
10	24.83	20.6	-4.23
11	24.35	**16.83**	-7.52
12	27.42	27.14	-0.28
13	27.41	26.21	-1.2
14	28.07	25.81	-2.26
15	28.55	26.08	-2.47
16	29.19	26.72	-2.47
17	27.48	26.29	-1.19
18	27.49	25.22	-2.27
19	28.89	25.75	-3.14
20	28.46	27.2	-1.26
21	26.44	24.16	-2.28
22	26.56	24.71	-1.85
23	20.11	**18.04**	-2.07
24	21.16	**18.03**	-3.13
25	25.27	21.67	-3.6
26	24.38	20.82	-3.56
27	24.62	22.71	-1.91
28	23.98	21.47	-2.51
29	23.78	21.87	-1.91
30	26	22.09	-3.91
31	24.9	20.68	-4.22
32	24.88	20.66	-4.22
33	25.73	21.51	-4.22
34	27.64	26.92	-0.72

35	27.95	26.83	-1.12
36	28.05	26.75	-1.3
37	26.79	24.58	-2.21
38	27.95	26.82	-1.13
39	29.13	27.83	-1.3
40	28.89	26.91	-1.98
41	27.88	25.9	-1.98
42	27.71	24.8	-2.91
43	28.35	26.37	-1.98
44	26.85	24.87	-1.98
45	27.89	25.91	-1.98
46	29.17	27.17	-2
47	28.55	26.57	-1.98
48	27.05	25.06	-1.99
49	28.76	24.71	-4.05
50	28.93	24.88	-4.05
51	25.72	25.45	-0.27

From above two tables, it can be concluded that, though the pipe diameters provided in the actual network are smaller as compared to those calculated by software, pressure difference it makes is not so substantial. In fact, the lowest pressure in the network occurs at node 11 which is 16.83 metres. This value is greater than 8 metres for which the network was designed. Hence, the design of distribution network in this zone is correct.

b) Gundge Zone

Gundge Zone has a branched distribution network. The total number of pipes is 11 and there are 12 nodes.

Pipe Details:

Table 5.10 Pipe details verification for Gundge zone.

Pipe No.	**Diameter Required (mm)**	**Diameter Provided (mm)**	**Diameter Difference (mm)**
1	200	300	100
2	200	250	50
3	150	200	50
4	125	200	75
5	100	150	50
6	100	100	0
7	100	150	50

8	100	100	0
9	100	100	0
10	100	100	0
11	125	150	25

Node Details:

Table 5.11 Node details verification Gundge zone.

Node No.	**Calculated Pressure (m)**	**Actual Pressure (m)**	**Pressure Difference (m)**
1 S	0	0	0
2	13.8	16.62	2.82
3	19.49	24.04	4.55
4 T	21.4	28.76	7.36
5	12.78	16.22	3.44
6	7.97	17.26	9.29
7 T	8.26	17.55	9.29
8	17.13	23.24	6.11
9 T	20.53	26.64	6.11
10 T	18.09	24.19	6.1
11 T	8.97	18.27	9.3
12 T	8	15.63	7.63

It can be seen that the diameter of the pipe provided is greater than diameter of pipe required. Also, the pressure at the nodes is much greater than the design for the most economic network. So, the network design was technically correct while economically, it was much expensive than the required network.

c) Bhisegaon

Bhisegaon Zone has a branched distribution network. The total number of pipes is 9 and there are 10 nodes.

Pipe Details:

Table 5.72 Pipe details verification for Bhisegaon Zone

Pipe No.	Design Diameter (mm)	Actual Diameter (mm)	Difference (mm)
1	**150**	**100**	**-50**
2	150	250	100
3	**125**	**200**	**75**

4	100	150	50
5	100	125	25
6	100	100	0
7	100	150	50
8	100	150	50
9	100	100	0

Node Details:

Table 5.13 Node details verification for Bhisegaon zone.

Node	Calculated Pressure	Actual Pressure
No.	(m)	(m)
1 S	0	0
2	19.66	**3.32**
3	21.08	**6.82**
4 T	10.14	**7.72**
5	19.94	**6.62**
6 T	18.3	**5.51**
7 T	22.69	9.37
8	17.89	**2.38**
9 T	16.24	**3.82**
10 T	20.02	**4.51**

It can be seen that actual pressure in the network is very less as compared to the calculated pressure. The reason for this is significant difference in some diameter of the pipes in the network. Due to this, this pressure at many nodes is very less than the designed 8 m. Thus, many areas in Bhisegaon have very less water pressure.

The first pipe in the network should be replaced by a pipe of diameter 150 mm and the pipe no 3 should be replaced by a pipe of diameter 125 mm.

The pressure values in the corrected case are tabulated below

Node Details:

Table 5.14 Node details after correction.

Node	Peak Flow	Elevation	H G L	Calculated Pressure
No.	(lps)	(m)	(m)	(m)
1 S	22.474	120	120	0
2	0	97.71	117.37	19.66
3	0	94.02	117.18	23.16
4 T	-9.722	91.79	104	12.21
5	0	94.07	117.03	22.96

6 T	-4.32	94.91	116.76	21.85
7 T	-2.056	91.15	116.86	25.71
8	0	98.52	117.23	18.71
9 T	-4.32	96.58	116.74	20.16
10 T	-2.056	95.92	116.76	20.84

It can be seen from above that all the nodes have pressure greater than 8 m.

d) Akurle

Pipe Details:

Table 5.15 Pipe details verification for Akurle zone.

Pipe No.	Diameter Required (mm)	Diameter Provided (m)	Difference (mm)
1	150	200	50
2	125	150	25
3	100	100	0
4	100	100	0
5	100	100	0
6	100	100	0
8	100	100	0

Node Details:

Table 5.16 Node details verification for Akurle zone

Node No.	Calculated Pressure (m)	Actual Pressure (m)	Difference (m)
1 S	12	12	0
2	13.53	14.36	0.83
3	14.25	15.7	1.45
4 T	14.69	16.14	1.45
5	14.02	14.84	0.82
6 T	14.01	14.83	0.82
7 T	13.55	14.37	0.82
8 T	13.32	14.77	1.45

It can be seen that pipe diameter provided are either equal or greater than the diameter calculated. As a result, the actual pressure is more than the calculated pressure. Thus, the design is correct, though it is not the most economical design.

e) Dahivali

The elevation and the flow values for three nodes and thus the pipe lengths and diameters are missing in the report. It is not possible to verify the design without these values. Other methods such as field visits should be used to solve the problem.

Chapter 6

Operation and Maintenance

6.1 Introduction

After construction of the project and test for its adequate running, it was handed over to the Municipal Council in the year 2006 for its operation and maintenance. The council has to manage the economics of operation and maintenance so as to run the project efficiently.

6.2 Income

The main source of income for Municipal Council from water supply is water tax collected from each connection. The water tax charged was small and proved inadequate for successful operation and maintenance. So recently, it has proposed by the Municipal Council to hike the taxes though the resolution for it has not been passed yet.

Table 6.1 Tax Structure.

Type of Connection	Old Tax (Rs/year)	New tax (Rs/year)
Industrial	6000.00	12000.00
Commercial (hotels)	4000.00	8000.00
Commercial (construction)	5000.00	10000.00
Society	3440.00	9600.00
Institutions (schools, colleges etc)	1720.00	4800
Household Connection	860.00	2400.00

Source: Karjat Municpal Council

Total Tax = 860*3800 + 4000*25 + 5000*20 + 6000*1

= Rs **3474000**

There is an urgent need to have volumetric charge for water usage to minimize wastage. According to the Municipal Council, the metering for the city has been proposed by the MJP and will be sanctioned soon.

6.3 Expenditure

As far as expenditure is concerned, the main sources are:

a) Loan repayment
b) Water tax paid to the minor irrigation department. At present Rs 6.60 is collected for every 10000 litres of water lifted from the source.
c) Electricity charges for operation of pumps and water treatment plant. The electricity charges at present are Rs 5.50 per kWh.
d) Sampling and testing costs of water
e) Salary paid to the staff
f) Bills of contractor for maintenance of the mains. For maintenance for the pipe-lines, the work is issued to a contractor annually on the basis of tender.
g) Maintenance of Pumps and water treatment plant. For major repair of pumps, the pumps are transported to Panvel for maintenance.

Last year's expenditure of municipal council in water supply has been summarized below:

Table 6.2 Operation and Maintenance cost.

Heads	Amount (Rupees)
Permanent establishment	2013249
Temporary establishment	0
Water Cess	1494298
Water supply charge	3966704
Maintenance (Contractor)	698060
Sampling and testing charge	4000
Tapping Charge	536259
Equipments for Water supply	336841
Diesel/Oil Purchase	2750
Bleaching powder	223680

Pump Maintenance	2400
Repair of Municipal Council Bore-well	68080
Tank Maintenance and cleaning	0
Energy/ Water audit	0
Total (Rs/year)	**9346321**

Source: Karjat Municpal Council

Thus, total tax collected (Rs 3474000) is around 1/3rd of the total expenditure (Rs 9346321).

From above, it can be seen that water cess paid to minor irrigation department is Rs 1494298.00. It can be used to calculate the annual volume of water lifted from the source. The price of water per 10,000 litres of water is Rs 6.60. So, volume of water lifted can be found out by;

*Volume (litres/year) = (Water cess)*10000/(Price)*

= 1494298*10000/6.6

= 2264087879.00

Now, total number of connections in the city is 3800. And the average household size form the survey came out to be 4.67. So, lpcd of water supplied to the households comes out to be around 350 litres (349.54), which is around 3 times the designed norm of 125 lpcd.

6.4 Staff

The council has employed its own staff for operation of the water supply network.

Table 6.3 Staff for Water-Supply.

Post	Number
Junior Engineer	1
Operator	5
Valve-man	5
Plumber	1
Line-man	1

Source: Karjat Municpal Council

For maintenance, the council allots, work on contract basis through annual tenders.

6.5 Problems in Operation and maintenance

a) The expenditure on water supply is 3 times the total amount of tax which can be collected in the city.

b) The amount of water supplied is also around 3 times the norms for which the scheme was designed.

c) The water tax collected is around 80-85 % of total tax than can be collected.

d) The staff for water supply is inadequate in number and untrained. The same staff is responsible for operation, maintenance as well as tax collection from households.

e) The efficiency of the pumps is very less as compared to the design efficiency. Refer chapter 5.

f) Some areas have low pressure due to improper design of the distribution network. Refer chapter 5.

g) The scheme is not well accepted by the people. The total number of connections in the intermediate stage (2016) should be 11360. But, the number of connections is far below this. 21 % of the people still use bore-well.

h) The timings of electricity are erratic, resulting in inadequate filling of MBR. Thus, the time of supply of water is not uniform. Often, there is power in Wanjarwadi but not in Karjat, thus water lifted during that time is not treated.

i) The laboratory at the Water treatment plant is not functional. Other equipment at Water treatment plant such as mixer, pipes is not working. The employees at water treatment plant are not trained to operate the equipment.

j) During rainy season, dirty water is supplied.

6.6 Solutions

a) Instead of trying to increase the water tax, the council should decrease the amount of water being supplied per capita to 125 lpcd from the current supply of 350 lpcd. This can be done by reducing the number of pumping hours by a factor of 3. This will reduce most of the costs of operation and maintenance such as electricity bill, water cess, costs of chemicals by 33%. This will reduce most of the deficit of the Municipal Council. Rest can be recovered from increasing the efficiency of pumps.

Table 6.4 Change in O&M costs after decreasing the water-supply.

Heads	Amount (Rupees)	New Amount (Rupees)
Permanent establishment	2013249	2013249
Temporary establishment	0	0
Water Cess	1494298	498099.3333
Water supply charge	3966704	1322234.667
Maintenance	698060	698060
Sampling and testing charge	4000	4000
Tapping Charge	536259	536259
Equipment for Water supply	336841	336841
Diesel/Oil Purchase	2750	2750
Bleaching powder	223680	74560
Pump Maintenance	2400	2400
Repair of Municipal Council Bore-wells	68080	68080
Tank Maintenance and cleaning	0	0
Energy/ Water audit	0	0
Total	**9346321**	**5556533**

It can be seen that reducing water to original norms will reduce the operation cost by Rs 3800000.

After some years, the availability per capita is going to decrease since a limited amount of water (11.5 MLD) can be lifted from the source point. Moreover, decreasing the amount of water supplied will reduce wastage.

On the contrary, increasing the tax will further reduce the number of people paying tax, number of connections and increase the number of people using bore-wells. As a result, there should be minimal increase in tax and a large reduction in amount of water supplied.

b) The taxing system should be based on the volume of water used by the house-holds. The council should immediately start the deploying meters in the house-holds. This will decrease wastage and increase conservation of water. According to the Municipal Council the MJP has proposed a metering system for the city and will be sanctioned soon.

c) Regular maintenance and repair of pumps so that their efficiency is high. After, the design life of these pumps (2016), new pumps of higher efficiency should be purchased.

d) The staff should be trained in water supply.

e) The equipment at water treatment plant should be repaired and a standard operation procedure should be followed.

f) People should be educated for conservation of water and use of water supply scheme against the use of bore-wells. For example, the municipal council should try to educate people that operating 1.5 hp borewell pump for 2 hours a day can cost around Rs 4492.78 per year which is 5 times more than what the council charges for water supply.

Chapter 7

Water Treatment Plant

7.1. Introduction

Water treatment is a process of making water hygienically safe, aesthetically attractive and palatable in an economical manner. The goal of water treatment is to remove existing contaminants in the water to make it suitable for desired end-use.

Physical processes such as settling and filtration, chemical processes such as disinfection and coagulation and sometimes biological processes such as aerated lagoons, activated sludge are used for treatment of water. Unit processes in water treatment include aeration, flocculation, filtration, disinfection, softening, deferrization, defluoridation and water conditioning and many different combinations of these processes. The selection will be based on the raw water, the desired characteristics of the treated water and the economics involved.

Figure 7.1 Water Treatment Plant at Dahivali. Karjat

7.2. Processes

The treatment plant in Karjat consists of an

a) **Aeration Fountain:** Aeration is done by circulating air through the water. It is done to add oxygen, remove gases such as carbon dioxide and remove metals such as iron and manganese in the form of precipitate. An aeration fountain is used in Karjat for Aeration. Air is blown from below in the water which is coming from the pump house

b) **Flash Mixer:** Flash mixer is used for rapid mixing and complete mixing of coagulants in the water.

c) **Clariflocculator:** Clariflocculator has two concentric tanks with inner tank serving as flocculation basin and outer tank serving as clarifier.

Coagulants are added in the process of flocculation. Coagulants are metal salts such as aluminium sulphate or iron sulphate. These metal salts have positive charge salts which neutralize the negative salts of dissolved and suspended impurities. When the reaction occurs, the particles combine to form bigger particles known as coagulates. This process is called flocculation. Alum is used for flocculation in the water treatment plant.

After flocculation these particles are filtered on the outer tank.

d) **Rapid Sand Filter**: Rapid sand filters use relatively coarse sand and other granular media to remove particles and impurities that have been trapped by the use of flocculator. Water flows through the filter medium under gravity or under pumped pressure and the flocculated material is trapped in the sand matrix.

e) **Disinfection:** TCL powder is used for disinfection.

f) **Pure water sump and pump-house:** The sump is 3 meters deep and the pump-house consists of 3 pumps (1 stand-by) of 150 HP each.

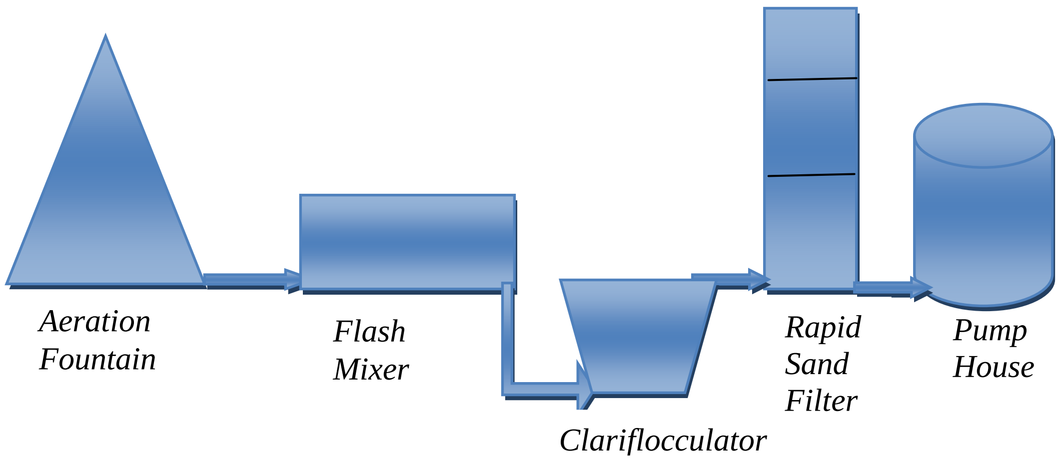


Figure 7.2 Schematic flow of water in the water treatment plant

7.3. Operation of plant

The operation and maintenance of water treatment is the responsibility of the Municipal Council of Karjat. The council pays for the charges for electricity, the chemicals required and employs the staff for the plant.

Chemical	**TCL powder**	**Alum**
Normal Time	4 Kg/MLD	8 Kg/MLD
Rainy Season	4 Kg/MLD	10 Kg/MLD

Table 7. 1 Amount of chemicals required.
Source: MJP

Further, the council is also entrusted with the responsibility of sampling and testing of the water. Since, the plant does not have a chemist, the water is tested by sending water samples to Alibaug twice a month.

Routine maintenance such as oiling, greasing is done by operators while major maintenance is done from outside. The pumps are sent to Panvel for repair. Other infrastructural maintenance is done through contractors.

Since, the pumping station at lift-up point is operated at night, the treatment plant is also operated at the same time. The processes in the plant are carried out by 2 operators. They are employed on a permanent basis and their salary is around Rs 13,000 per month. The shift of the operators is mostly of 8-10 hours.

Though there is training of operators in Nashik once a year, they are higly untrained and unequipped to operate the plant of this size.

7.4. Problems

Figure 7.3 Dysfunctional equipment for adding chlorine to water

a) The staff at the plant is not trained enough to operate the plant.

b) There is a lack of standard procedure for the operation of the plant. Everything is done on an estimate basis. For example, 25 kg TCL powder is added every 2-3 hours. This value is much more than the prescribe value of 4 kg/MLD.

c) Chemist is not present.

d) The equipment for adding chemicals are not used and the pipes which carried chemicals to the clariflocculator are choked.

e) The valves, pumps etc are rusting due to lack of painting.

f) The laboratory at the treatment plant has not been used since chemist is not present. As a result, the instruments are not in working conditions.

g) During rainy season, the plant is not able to clean the water properly, due to which muddy water is provided to the people.

7.5. Solutions

a) Training should be given to the staff for operation of the plant.

b) The equipment at water treatment plant should be repaired and a standard operation procedure should be followed.

c) The chemicals at the plant should be checked for quality and added as per specified by MJP

d) A chemist should be employed in the plant and the laboratory should be repaired.

Chapter 8

Sanitation

8.1. Introduction

Oxford dictionary defines sanitation as conditions relating to public health, especially clean drinking water and adequate sewage disposal. In general terms, sanitation is the hygienic means of promoting health through proper disposal of human wastes. The importance of hygienic sanitation facilities through low cost onsite sanitation, conventional sewerage and sewage treatment is enormous as 80% of the water supplied to the community comes out of the house in the form of waste water.

In this report, mainly two aspects of sanitation toilets and sewage of Karjat are studied. The city has open drains for disposal of waste water. Moreover, the council has prepared a plan for underground sewage and sewerage treatment scheme. The proposed scheme has got technical sanction but not financial sanction.

A brief overview of the scheme along with design of rising mains and pumps is presented in this chapter.

8.2. Toilets

a. Household Toilets

According to the survey, 80% of the people have toilets in their homes. Out of these only 63% of the toilets have septic tanks installed. This suggests that sewage 37% of the toilets goes directly into surface drains.

b. Community toilets

At present there are 5 community toilets in the city. Since, the city has been included in MMRDA, 22 sites are under construction for community toilets.

These toilets are maintained by Karjat Municipal Council. No fee is charged for using the toilets. These toilets are mostly used by BPL families who cannot afford to have toilets in their homes.

The main problem in community toilets is improper use by the people. These toilets are often found dirty and stinking. Further, disinfection is not done properly and regularly.

8.3. Drainage

a. Existing situation

The drainage system in Karjat is surface drainage system. The waste water generated from the households is disposed of either into open drains or closed drains. The effluents from septic tanks are either connected to soak pits or directly discharged to the surface water drains.

Around 42.6% of the households dispose of their waste water in closed drains, 42% in open drains and 15.4% of the households don't have drainage facility at all.

The drains finally discharge the effluents into Ulhas River at many locations. There is not system of treating the sewage. Thus, the river is getting polluted at a very rapid pace.

Figure 8.1 Open-drain in Karjat

b. Proposed system

The Karjat Municipal Council has proposed a scheme for underground drainage sewage and sewerage system in Karjat. The city has been divided into three zone viz. the area to the right of Ulhas river, the area between Ulhas River and the railway line and the area to the right of railway line.

Table 8.1 Zones for sewerage

Zone	Location	Area covered	Road Length	Population
Zone I	Right of Ulhas River	Akurle, Dahivali, Nigade, Engineering College Area, Sanjay Nagar, Baudhwada, Sonar Gali, Shivaji Nagar, Suyog Nagar, Market Yard Area, Govt. hospital Area	7040	30182
Zone II	Between Ulhas River and Railway line	Mudre, Railway Station Area, Mahavirpath, Bazaar Path, Nagarpalika office area, Guru Nagar, Dasrath Nagar, Shivaji Chouk	12949	23525
Zone III	Left side of Ulhas River	Railway Colony, Gundge, Pahchsil Nagar, Bhisegaon, Agricultural Research Centre	4895	32228
Total			24884	85935

Source: Karjat Municipal Council

Two types of pipes are used for sewer lines, RCC NP-4 and RCC NP-3.

Table 8.2 Length and diameter of sewer lines

Pipe Diameter (mm)	Pipe Material	Length (m) Zone I	Length (m) Zone II	Length (m) Zone III
200	RCC NP-4	5293	10241	3186
250	RCC NP-4	730	726	110
300	RCC NP-3	459		562
350	RCC NP-3	578		220
400	RCC NP-3		402	817
500	RCC NP-3		906	
600	RCC NP-3		674	

There are 3 sewage pumping station, 1 in each zone which pumps sewage to the sewage treatment plant. The calculations of BHP of pumps can be found in the Appendix IV.

Table 8.3 Pumps for the proposed sewage pumping station

Zone	**Head (m)**	**Pump B.H.P (HP)**	**Type of pump**
Zone I	9.00	4.0	Non clog Submersible sewage pumps
Zone II	13.00	12	Non clog Submersible sewage pumps
Zone III	16.70	6.0	Non clog Submersible sewage pumps

The calculations of most economical pipe diameter can be found in the Appendix V.

Table 8.4 Zone wise diameter and length rising mains

Zone	**Length (m)**	**Pipe Diameter (mm)**	**Type of pipe**	**Cost (Rs'000)**
Zone I	20	150	DI K-9	675
Zone II	575	250	DI K-9	4562
Zone III	540	200	DI K-9	2604

A sequential batch reactor type sewage treatment plant in Dahivali is proposed for the three zones. The treated waste water is finally dumped into Ulhas River.

8.4. Design Parameters

a) Design Period

Table 8.5 Design-life

Sr. No.	Description	Design Period
1	Sewage collection System (laterals, branch, main sewers), out fall sewers	30
2	Sewage pumping station: Civil Works Pumps	30 15
3	Sewage pumping station	30
4	Sewage Treatment Plant	30

Source: Karjat Municipal Council

b) Sewage Flow

Sewage flows are calculated based on the assumption that 80% of the per capita water supply is discharged from the house-holds in the form of waste water. The city has household supply of 135 lpcd, so the daily per capita discharge is 108 lpcd. Thus, ultimate daily flow will be 9.36 MLD

The ground water infiltration is 5000 litre/km-day.

c) Peak factor

According to clause 3.2.5 of manual of sewage and sewerage treatment by CPHEEO, the peak flows for city with population between 50,000-7,50,000 the peak factor should be 2.25.

d) Manning's coefficient

According to table 3.4 of manual of sewage and sewerage treatment by CPHEEO, the manning's coefficient for RCC spun pipes will be taken as 0.011.

e) Depth of flow

All sewers are designed for the maximum depth of flow of 0.8 full at ultimate peak flow. Clause 3.4.2.6 of the manual can be referred for this.

f) Velocity

The sewers are designed to have self-cleansing velocities to avoid silting. The minimum velocity for ultimate peak flow is 0.80 m/s. The maximum velocity is 3 m/s to scouring of sewers. Clauses 3.4.3.1 and 3.4.3.2 can be referred for these.

g) Minimum cover

The minimum cover is taken as 1.2 m above the pipe and the pipes which are laid in regions of low traffic minimum is 1.0 m at the dead ends.

h) Width of trench

The trench width is standardized as width of outer pipe diameter plus 500 mm at the pipe bottom level. The trench width should be adequate for easy laying and jointing of pipes while it should be small for large trench may cause disturbance to the adjoining structures and increase the cost.

i) Pipe material

RCC spun cast pipes with spigot and socket ends are used and jointed through a rubber sealing ring type.

j) Manholes

Manholes have been adopted as per IS 4111, circular in shape and constructed in brick masonry. The depth and diameter of man hole adopted are as follows:

Table 8.6 Manhole specifications

Type of Manhole	Depth (m)	Diameter (mm)
A	Upto 2	1200
B	2-5	1500
C	5-9	1500

Source: IS 4111

The spacing of Manholes:

I. The maximum spacing on straight reaches cannot be more than 30 m.
II. Manholes are provided at all intersections
III. Manholes will be provided to meet the change of alignment irrespective of distance criterion.

8.5. Sewage Treatment Plant

The Karjat Municipal Council has 3 acres of land available in Dahivali which will be used for construction of Sewage treatment plant. The plant will be constructed in two phases: Phase I will be designed for flow till the year 2025 while Phase II will be designed for the flow till the year 2040.

The sewage treatment plant will utilize sequential batch reactor technology.

Chapter 9

Conclusions

The pumps, rising mains and distribution mains are satisfactorily correctly designed. The pump efficiency is very low and is a main source of wastages. Some areas have low pressure due to inadequate diameters. The design of break pressure tank is not correct for holding water for 10 minutes at the ultimate capacity of the scheme.

Further, the Karjat Municipal council is not able to operate and maintain the scheme properly. There is wide deficit between income and the expenditure in the water supply sector. The main reason for this was high amount of water being supplied and low pump efficiency. The only solution to this problem will be to reduce water supply to cover the specified norms.

The water treatment plant is adequately designed and sufficient to treat 8.52 MLD of water. But the personnel employed to operate the plant is untrained. Due to long time of not being operated a lot of instruments in the plant have become dysfunctional. Thus, the plant is not utilized properly.

The city urgently needs an underground sewerage network and a sewage treatment plant. The design parameters used in the plan prepared by Municipal council are correct. The plan has got technical sanction from MJP. The plan should get financial sanction as soon as possible and then it should be executed urgently.

Appendix-I
Survey

Household Survey Questionnaire

Basic Info

1. Name of head
2. House no (address)
3. Ward no
4. Phone number
5. Are you
   (a) Above poverty line
   (b)Below poverty line
6. Annual basic income
7. Number of people in your household?

Water Supply Related Questions

8. What is the source of water for you?
   a) Personal water connection
   b) Public tap
   c) Bore - well
   d) Any other, please specify
9. Do you know where the tap water comes from? If yes, then pls specify.

10. Do you have any water storage facility? If yes, what is its capacity?
    a) 200 litres
    b) 200-500 litres
    c) 500-750 litres
    d) 750-1000 litres

11. At what time, is the water being supplied?

12. Duration of water being supplied in hours?

13. How much time does it take to fill a bucket of 20 litres in minutes?

14. For what purposes do you utilize the water being supplied?
    a) Drinking
    b) Washing
    c) Cleaning
    d) Gardening
    e) Toilet
    f) Any other (please specify)

15. Water supply is sufficient
    a) Strongly agree
    b) Agree
    c) Neutral
    d) Disagree
    e) Strongly disagree

16. Is water sufficient during summers?
    a) Strongly agree
    b) Agree
    c) Neutral
    d) Disagree
    e) Strongly disagree

17. Do you use bore-well water?If yes, since when?
    a) 1 year
    b) 2-5 years
    c) 5-7 years
    d) More than 7 years

18. Did you take permission for installation?

a) Yes
b) No

19. Is your bore-well adequate in summers too?
    a) Yes
    b) No
20. How many times did you need to take water from tanker supply in past 1 year?
21. Do you think water being supplied is suitable for drinking?
    a) Strongly agree
    b) Agree
    c) Neutral
    d) Disagree
    e) Strongly disagree
22. Is water supplied dirty during some time of the year? If yes, during what time?
    a) Jan – Mar
    b) Apr – Jun
    c) Jul – Sep
    d) Oct – Dec
    e) Throughout the year

23. Is the smell of water normal?
    a) Yes
    b) No
24. If no, please explain

25. Do you use any secondary filtering?
    a) No
    b) Water filter
    c) Aqua-guard
    d) Zero-B
    e) Other, please specify
26. What is the water tax that is levied on you?

27. Tax is affordable to you
    a) Strongly agree
    b) Agree
    c) Neutral
    d) Disagree
    e) Strongly disagree
28. Will you like to pay extra if water quality is improved? If yes, then how much are you ready to pay more per annum;
    (a) 50
    (b) 100
    (c) 200
    (d) 300-500
29. Will you like to pay extra if water **quantity** is improved? If yes then how much?
    (a) 50
    (b) 100
    (c) 200
    (d) 300-500
30. Are you satisfied with the Karjat Water Supply system?
    a) Strongly agree
    b) Agree
    c) Neutral
    d) Disagree
    e) Strongly disagree
31. To whom do you complain about your grievance?

____

Sanitation Questionnaire

32. How many toilets do you have?
    a) 0
    b) 1
    c) 2
    d) 3
33. Do you have septic tank in you toilet?
    a) Yes
    b) No

34. How deep is your septic tank?
35. When was it constructed?
    a) 1-3 years back
    b) 3-5 years back
    c) 5-7 years back
    d) 7-10 or more years back
36. Do you have problems of mosquitos?

37. Do you have problems of water borne diseases like diarrhea, jaundice, etc?

38. Does it stink in your house during some part of the year? If yes, please specify

39. Is any tax collected for sewage water collection and disposal? If yes, how much?

40. Do you want underground drainage system?

41. Will you pay for it? How much?

42. When are the open drains cleaned?

43. Are there any dry latrines in Karjat?

44. Scene in rainy season?

45. Current problems in sanitation?

Appendix-II

Water Supply Rising Mains Calculations

Raw water Rising Main

Inputs

Scheme	Augmentation to Karjat Water Supply (U)		
SR NO.	PARTICULARS	VALUES	UNITS
1)	Water requirements		
a)	Initial	4.3	mld
b)	Intermediate	7.1	mld
c)	Ultimate	11.5	mld
2)	Length of pumping main	1250	m
3)	Static head for pump	37	m
4)	Combined efficiency of pumping set	60	%
5)	Cost of pumping unit	12000	Rs./ kw
6)	Interest rate	11.25	%
7)	Energy charges	2.3	Rs./ unit
8)	Pump as standby arrangement	100	%

Solution

SR NO.	PARTICULARS	1SI 15 YEARS		2ND 15 YEARS	
		VALUE	UNIT	VALUE	UNIT
1)	Discharge at Installations	4.3	mld	7.1	mld
2)	Discharge at the end of 15 yrs.	7.1	mld	11.5	mld
3)	Average discharge	5.7	mld	9.3	mld
4)	Hours of pumping for discharge at the end of 15 yrs.	16	hrs.	16	hrs.
5)	Average hrs of pumping for average discharge	12.85	hrs.	12.94	hrs.
6)	K.W required	2.014	k.w x H1	3.262	k.w x H2
7)	Annual Energy Cost	10790.53	Rs. per kw1	10869.54	Rs. per kw2
8)	Pump capitalised cost factor	4.949			
9)	Energy charges capitalisation factor	7.093			

Calculations:

Sr no.	Pipe size in mm	Type / Class of pipe proposed	Rate of pipe per ' m' length.	Pipe cost for full proposed length	Cvalue	Frictional head loss per 1000 mm		Velocity in m/s	
						1st Stage	2nd Stage	1st Stage	2nd Stage
1)	500	CI B	5265	6581	100	1.28	3.13	0.63	1.02
2)	500	MS	5450	6813	100	1.28	3.13	0.63	1.02
3)	500	DI	5361	6701	100	1.28	3.13	0.63	1.02
4)	600	C I B	6983	8729	100	0.53	1.29	0.44	0.71
5)	600	MS	7015	8769	100	0.53	1.29	0.44	0.71

Sr no.	Pipe size in mm	Total head in 'm' for pipe length mentioned in data including static head					
		1st stage flow			2nd stage flow		
		hf in m	10% of hf	Total	hf in m	10% of hf	Total
1)	500	1.60	0.16	39	3.91	0.39	41
2)	500	1.60	0.16	39	3.91	0.39	41
3)	500	1.60	0.16	39	3.91	0.39	41
4)	600	0.66	0.07	38	1.61	0.16	39
5)	600	0.66	0.07	38	1.61	0.16	39

Pipe size in mm			500	500	500	600	600
Kilowatts required and cost of pump sets for different pipe sizes	1st stage flow	kw	157	157	157	153	153
		Pump Cost '000	1884	1884	1884	1836	1836
		Ann. Energy Charge	847	847	847	825	825
		Capitalised energy charges	6008	6008	6008	5855	5855
		Total capitalised charge	14473	14705	14593	16420	16460
	2nd stage flow	kw	268	268	268	254	254
		Pump Cost '000	3216	3216	3216	3048	3048
		Ann. Energy Charge	1457	1457	1457	1380	1380

		Capitalised energy charges	10331	10331	10331	9791	9791
		Total capitalised charge	2737	2737	2737	2594	2594
Ground total of capitalised cost for 30 years in '000 Rs.			17210	17442	17330	19014	19054

Clearly, the most economical pipe diameter is 500 mm dia CI Class B pipe with the total capitalized cost of Rs. 17210,000 for 30 years. This clearly, matches with the actual design.

Calculation of Head including Hammer Head

Daily Demand (MLD)	11.5
Hours of Pumping	20
Design capacity of Rising Main (MLD)	13.8
Velocity (m/s)	0.977
Water Hammer Head	
a =1425/(1+Kd/Ec)^0.5	1058.68
K	2.07*10^-8
d (mm)	500
c (mm)	17
E (Kg/Sqm)	7.5*10^-9
Head = aXv/g	105.40
Static Head (m)	42
Total Head including Hammer Head (m)	147.40

Pure water rising mains

Inputs

DESIGN OF ECONOMIC SIZE OF PUMPING MAINS.			
Scheme	**Augmentation to Karjat Water Supply (U)**		
SR NO.	PARTICULARS	VALUES	UNITS
1)	Water requirements		
a)	Initial	4.3	mld
b)	Intermediate	7.1	mld
c)	Ultimate	11.5	mld
2)	Length of pumping main	1250	m
3)	Static head for pump	37	m
4)	Combined efficiency of pumping set	60	%
5)	Cost of pumping unit	12000	Rs./ kw
6)	Interest rate	11.25	%
7)	Energy charges	2.3	Rs./ unit
8)	Pump as standby arrangement	100	%

Solutions

SR NO.	PARTICULARS	1SI 15 YEARS		2ND 15 YEARS	
		VALUE	UNIT	VALUE	UNIT
1)	Discharge at Installations	4.3	mld	7.1	mld
2)	Discharge at the end of 15 yrs.	7.1	mld	11.5	mld
3)	Average discharge	5.7	mld	9.3	mld
4)	Hours of pumping for discharge at the end of 15 yrs.	16	hrs.	16	hrs.
5)	Average hrs of pumping for average discharge	12.85	hrs.	12.94	hrs.
6)	K.W required	2.014	k.w x H1	3.262	k.w x H2
7)	Annual Energy Cost	10790.53	Rs. per kw1	10869.54	Rs. per kw2
8)	Pump capitalised cost factor	4.949			
9)	Energy charges capitalisation factor	7.093			

Calculations:

Sr no.	Pipe size in mm	Type / Class of pipe proposed	Rate of pipe per ' m' length.	Pipe cost for full proposed length	Cvalue	Frictional head loss per 1000 mm		Velocity in m/s	
						1st Stage	2nd Stage	1st Stage	2nd Stage
1)	500	CI B	5265	6581	100	1.28	3.13	0.63	1.02
2)	500	MS	5450	6813	100	1.28	3.13	0.63	1.02
3)	500	DI	5361	6701	100	1.28	3.13	0.63	1.02
4)	600	C I B	6983	8729	100	0.53	1.29	0.44	0.71
5)	600	MS	7015	8769	100	0.53	1.29	0.44	0.71

Sr no.	Pipe size in mm	Total head in 'm' for pipe length mentioned in data including static head					
		1st stage flow			2nd stage flow		
		hf in m	10% of hf	Total	hf in m	10% of hf	Total
1)	500	1.60	0.16	39	3.91	0.39	41
2)	500	1.60	0.16	39	3.91	0.39	41
3)	500	1.60	0.16	39	3.91	0.39	41
4)	600	0.66	0.07	38	1.61	0.16	39
5)	600	0.66	0.07	38	1.61	0.16	39

Pipe size in mm			500	500	500	600	600
Kilowatts required and cost of pump sets for different pipe sizes	1st stage flow	kw	157	157	157	153	153
		Pump Cost '000	1884	1884	1884	1836	1836
		Ann. Energy Charge	847	847	847	825	825
		Capitalised energy charges	6008	6008	6008	5855	5855
		Total capitalised charge	14473	14705	14593	16420	16460
	2nd stage flow	kw	268	268	268	254	254
		Pump Cost '000	3216	3216	3216	3048	3048
		Ann. Energy Charge	1457	1457	1457	1380	1380
		Capitalised energy charges	10331	10331	10331	9791	9791

		Total capitalised charge	2737	2737	2737	2594	2594
Ground total of capitalised cost for 30 years in '000 Rs.			17210	17442	17330	19014	19054

Clearly, the most economical pipe diameter is 500 mm dia CI Class B pipe with the total capitalized cost of Rs. 17210,000 for 30 years. This clearly, matches with the actual design.

Calculation of Head including Hammer Head:

Daily Demand (MLD)	11.5
Hours of Pumping	20
Design capacity of Rising Main (MLD)	13.8
Velocity (m/s)	0.977
Water Hammer Head	
a =1425/(1+Kd/Ec)^0.5	1058.68
K	2.07*10^-8
d (mm)	500
c (mm)	17
E (Kg/Sqm)	7.5*10^-9
Head = aXv/g	105.40
Static Head (m)	42
Total Head including Hammer Head (m)	147.40

Appendix-III

Distribution Mains

Karjat Zone:

Echoing Input Variables

Title of the Project		: Distribution Karjat
Name of the User		: CTARA
Number of Pipes		: 51
Number of Nodes		: 51
Type of Pipe Materials Used		: CI/
Number of Commercial Dia per Material		: 9/
Peak Design Factor		: 3
Newton-Raphson Stopping Criterion	lps	: .001
Minimum Pressure	m	: 8
Maximum Pressure	m	: 40
Design Hydraulic Gradient m in km		: 2
Simulate or Design?	(S/D)	: D
No. of Res. Nodes with Fixed HGL		: 1
No. of Res. Nodes with Variable HGL		:
No. of Booster Pumps		:
No. of Pressure Reducing Valves		:
No. of Check Valves		:
Type of Formula		: Hazen's

Pipe Data

Pipe No.	From Node	To Node	Length m	Diameter mm	Hazen's Const	Pipe Material	Status (E/P)
1	1	2	70.00	500.0	100.00000	CI	
2	2	3	195.00	400.0	100.00000	CI	
3	3	4	480.00	350.0	100.00000	CI	
4	4	5	140.00	300.0	100.00000	CI	
5	2	6	50.00	300.0	100.00000	CI	
6	6	7	330.00	300.0	100.00000	CI	
7	7	8	285.00	250.0	100.00000	CI	
8	8	9	200.00	200.0	100.00000	CI	
9	9	10	285.00	150.0	100.00000	CI	
10	10	11	550.00	125.0	100.00000	CI	
11	3	12	30.00	200.0	100.00000	CI	
12	12	13	120.00	200.0	100.00000	CI	
13	13	14	100.00	200.0	100.00000	CI	

14	14	15	95.00	150.0	100.00000	CI
15	15	16	105.00	100.0	100.00000	CI
16	12	51	290.00	100.0	100.00000	CI
17	13	17	330.00	125.0	100.00000	CI
18	14	18	380.00	125.0	100.00000	CI
19	15	19	170.00	125.0	100.00000	CI
20	4	20	50.00	150.0	100.00000	CI
21	20	21	170.00	125.0	100.00000	CI
22	20	22	100.00	125.0	100.00000	CI
23	6	23	290.00	150.0	100.00000	CI
24	7	24	160.00	200.0	100.00000	CI
25	24	25	110.00	150.0	100.00000	CI
26	24	26	110.00	125.0	100.00000	CI
27	8	27	110.00	150.0	100.00000	CI
28	27	28	160.00	150.0	100.00000	CI
29	27	29	200.00	100.0	100.00000	CI
30	9	30	150.00	125.0	100.00000	CI
31	10	31	50.00	100.0	100.00000	CI
32	31	32	90.00	100.0	100.00000	CI
33	31	33	120.00	100.0	100.00000	CI
34	2	34	300.00	350.0	100.00000	CI
35	34	35	150.00	300.0	100.00000	CI
36	35	36	30.00	250.0	100.00000	CI
37	36	37	170.00	250.0	100.00000	CI
38	35	38	90.00	100.0	100.00000	CI
39	36	39	200.00	100.0	100.00000	CI
40	34	40	350.00	250.0	100.00000	CI
41	40	41	120.00	200.0	100.00000	CI
42	41	42	190.00	200.0	100.00000	CI
43	40	43	60.00	125.0	100.00000	CI
44	43	44	120.00	100.0	100.00000	CI
45	43	45	120.00	100.0	100.00000	CI
46	41	46	520.00	100.0	100.00000	CI
47	46	42	220.00	100.0	100.00000	CI
48	41	47	120.00	100.0	100.00000	CI
49	47	48	400.00	100.0	100.00000	CI
50	35	49	270.00	150.0	100.00000	CI
51	49	50	80.00	100.0	100.00000	CI

Node Data

Node No.	Peak	Flow lps	Elevation m	Min Press m	Max Press m
1	3.00	0.000	106.00	8.00	40.00
2	3.00	0.000	87.43	8.00	40.00
3	3.00	0.000	88.67	8.00	40.00
4	3.00	0.000	85.95	8.00	40.00
5	3.00	-16.088	86.07	8.00	40.00
6	3.00	0.000	87.62	8.00	40.00
7	3.00	0.000	89.92	8.00	40.00
8	3.00	0.000	89.35	8.00	40.00
9	3.00	0.000	88.76	8.00	40.00
10	3.00	0.000	88.63	8.00	40.00
11	3.00	-1.713	87.43	8.00	40.00
12	3.00	0.000	88.01	8.00	40.00
13	3.00	0.000	87.72	8.00	40.00
14	3.00	0.000	86.93	8.00	40.00
15	3.00	0.000	86.31	8.00	40.00
16	3.00	-0.509	85.57	8.00	40.00
17	3.00	-1.713	86.64	8.00	40.00
18	3.00	-1.713	86.36	8.00	40.00
19	3.00	-1.366	85.63	8.00	40.00
20	3.00	0.000	85.95	8.00	40.00
21	3.00	-1.713	87.45	8.00	40.00
22	3.00	-1.713	87.54	8.00	40.00
23	3.00	-3.440	94.25	8.00	40.00
24	3.00	0.000	93.76	8.00	40.00
25	3.00	-2.740	89.32	8.00	40.00

26	3.00	-1.360	90.32	8.00	40.00
27	3.00	0.000	89.55	8.00	40.00
28	3.00	-2.570	89.76	8.00	40.00
29	3.00	-0.856	89.89	8.00	40.00
30	3.00	-1.713	87.85	8.00	40.00
31	3.00	0.000	88.38	8.00	40.00
32	3.00	-0.683	88.25	8.00	40.00
33	3.00	-0.336	87.50	8.00	40.00
34	3.00	0.000	87.52	8.00	40.00
35	3.00	0.000	86.93	8.00	40.00
36	3.00	0.000	86.74	8.00	40.00
37	3.00	-9.960	87.54	8.00	40.00
38	3.00	-0.509	86.85	8.00	40.00
39	3.00	-0.680	85.33	8.00	40.00
40	3.00	0.000	85.63	8.00	40.00
41	3.00	0.000	86.22	8.00	40.00
42	3.00	-5.670	85.92	8.00	40.00
43	3.00	0.000	85.99	8.00	40.00
44	3.00	-0.856	87.19	8.00	40.00
45	3.00	-0.856	86.15	8.00	40.00
46	3.00	0.000	84.60	8.00	40.00
47	3.00	0.000	85.35	8.00	40.00
48	3.00	-0.683	86.20	8.00	40.00
49	3.00	-1.366	85.65	8.00	40.00
50	3.00	-0.683	85.35	8.00	40.00
51	3.00	-0.336	89.58	8.00	40.00

Fixed Head Reservoir Data

Source Node	Head m	Ref Res? (R)
1	116.00	R

Commercial Diameter Data

Pipe Dia. Int. (mm)	Hazen's Const	Unit Cost Rs /m length	Allow Press m	Pipe Material
100.0	100.00000	515.00	0.00	CI
125.0	100.00000	630.64	0.00	CI
150.0	100.00000	785.58	0.00	CI
200.0	100.00000	1159.08	0.00	CI
250.0	100.00000	1548.13	0.00	CI
300.0	100.00000	1996.13	0.00	CI
350.0	100.00000	2511.00	0.00	CI
400.0	100.00000	3084.20	0.00	CI
500.0	100.00000	4451.38	0.00	CI

Looped Water Distribution Network Design OutPut

```
BandWidth                  =       1
Number of Loops            =       1
Newton Raphson Iterations =       2
```

Pipe Details

Pipe No.	From Node	To Node	Flow (lps)	Dia (mm)	HL (m)	HL/1000m (m)	Length (m)	Velocity (m/s)
1	1	2	185.475	500.0	0.19	2.73	70.00	0.94
2	2	3	75.453	400.0	0.30	1.53	195.00	0.60
3	3	4	58.542	350.0	0.88	1.83	480.00	0.61
4	4	5	48.264	300.0	0.38	2.71	140.00	0.68
5	2	6	46.233	300.0	0.13	2.51	50.00	0.65
6	6	7	35.913	300.0	0.52	1.57	330.00	0.51
7	7	8	23.613	250.0	0.50	1.76	285.00	0.48
8	8	9	13.335	200.0	0.36	1.81	200.00	0.42
9	9	10	8.196	150.0	0.85	2.98	285.00	0.46
10	10	11	5.139	125.0	1.68	3.05	550.00	0.42
11	3	12	16.911	200.0	0.08	2.80	30.00	0.54
12	12	13	15.903	200.0	0.30	2.50	120.00	0.51
13	13	14	10.764	200.0	0.12	1.21	100.00	0.34
14	14	15	5.625	150.0	0.14	1.48	95.00	0.32
15	15	16	1.527	100.0	0.10	0.95	105.00	0.19
16	12	51	1.008	100.0	0.13	0.44	290.00	0.13
17	13	17	5.139	125.0	1.01	3.05	330.00	0.42
18	14	18	5.139	125.0	1.16	3.05	380.00	0.42
19	15	19	4.098	125.0	0.34	2.00	170.00	0.33
20	4	20	10.278	150.0	0.23	4.53	50.00	0.58
21	20	21	5.139	125.0	0.52	3.05	170.00	0.42
22	20	22	5.139	125.0	0.30	3.05	100.00	0.42
23	6	23	10.320	150.0	1.32	4.56	290.00	0.58
24	7	24	12.300	200.0	0.25	1.56	160.00	0.39
25	24	25	8.220	150.0	0.33	2.99	110.00	0.47
26	24	26	4.080	125.0	0.22	1.99	110.00	0.33
27	8	27	10.278	150.0	0.50	4.53	110.00	0.58
28	27	28	7.710	150.0	0.43	2.66	160.00	0.44
29	27	29	2.568	100.0	0.50	2.50	200.00	0.33
30	9	30	5.139	125.0	0.46	3.05	150.00	0.42
31	10	31	3.057	100.0	0.17	3.45	50.00	0.39
32	31	32	2.049	100.0	0.15	1.65	90.00	0.26
33	31	33	1.008	100.0	0.05	0.44	120.00	0.13
34	2	34	63.789	350.0	0.64	2.15	300.00	0.66
35	34	35	39.594	300.0	0.28	1.88	150.00	0.56
36	35	36	31.920	250.0	0.09	3.07	30.00	0.65
37	36	37	29.880	250.0	0.46	2.71	170.00	0.61
38	35	38	1.527	100.0	0.09	0.95	90.00	0.19
39	36	39	2.040	100.0	0.33	1.63	200.00	0.26
40	34	40	24.195	250.0	0.64	1.84	350.00	0.49
41	40	41	19.059	200.0	0.42	3.50	120.00	0.61
42	41	42	15.786	200.0	0.47	2.47	190.00	0.50
43	40	43	5.136	125.0	0.18	3.04	60.00	0.42
44	43	44	2.568	100.0	0.30	2.50	120.00	0.33
45	43	45	2.568	100.0	0.30	2.50	120.00	0.33
46	41	46	1.224	100.0	0.33	0.63	520.00	0.16
47	46	42	1.224	100.0	0.14	0.63	220.00	0.16
48	41	47	2.049	100.0	0.20	1.65	120.00	0.26
49	47	48	2.049	100.0	0.66	1.65	400.00	0.26
50	35	49	6.147	150.0	0.47	1.75	270.00	0.35
51	49	50	2.049	100.0	0.13	1.65	80.00	0.26

Note: Negative value indicates the flow in reverse direction in that Pipe

Pipe Pressure Details

Pipe	From	To	Dia	Hazen's	Pipe	Max Press	Allow Press	Status

No.	Node	Node	(mm)	Const	Material	(m)		(m)	(E/P)
1	1	2	500.0	100.00000	CI	28.38	HI	0.00	
2	2	3	400.0	100.00000	CI	28.38	HI	0.00	
3	3	4	350.0	100.00000	CI	28.68	HI	0.00	
4	4	5	300.0	100.00000	CI	28.68	HI	0.00	
5	2	6	300.0	100.00000	CI	28.38	HI	0.00	
6	6	7	300.0	100.00000	CI	28.06	HI	0.00	
7	7	8	250.0	100.00000	CI	25.32	HI	0.00	
8	8	9	200.0	100.00000	CI	25.54	HI	0.00	
9	9	10	150.0	100.00000	CI	25.54	HI	0.00	
10	10	11	125.0	100.00000	CI	24.83	HI	0.00	
11	3	12	200.0	100.00000	CI	27.42	HI	0.00	
12	12	13	200.0	100.00000	CI	27.42	HI	0.00	
13	13	14	200.0	100.00000	CI	28.07	HI	0.00	
14	14	15	150.0	100.00000	CI	28.55	HI	0.00	
15	15	16	100.0	100.00000	CI	29.19	HI	0.00	
16	12	51	100.0	100.00000	CI	27.42	HI	0.00	
17	13	17	125.0	100.00000	CI	27.48	HI	0.00	
18	14	18	125.0	100.00000	CI	28.07	HI	0.00	
19	15	19	125.0	100.00000	CI	28.89	HI	0.00	
20	4	20	150.0	100.00000	CI	28.68	HI	0.00	
21	20	21	125.0	100.00000	CI	28.46	HI	0.00	
22	20	22	125.0	100.00000	CI	28.46	HI	0.00	
23	6	23	150.0	100.00000	CI	28.06	HI	0.00	
24	7	24	200.0	100.00000	CI	25.25	HI	0.00	
25	24	25	150.0	100.00000	CI	25.27	HI	0.00	
26	24	26	125.0	100.00000	CI	24.38	HI	0.00	
27	8	27	150.0	100.00000	CI	25.32	HI	0.00	
28	27	28	150.0	100.00000	CI	24.62	HI	0.00	
29	27	29	100.0	100.00000	CI	24.62	HI	0.00	
30	9	30	125.0	100.00000	CI	26.00	HI	0.00	
31	10	31	100.0	100.00000	CI	24.90	HI	0.00	
32	31	32	100.0	100.00000	CI	24.90	HI	0.00	
33	31	33	100.0	100.00000	CI	25.73	HI	0.00	
34	2	34	350.0	100.00000	CI	28.38	HI	0.00	
35	34	35	300.0	100.00000	CI	27.95	HI	0.00	
36	35	36	250.0	100.00000	CI	28.05	HI	0.00	
37	36	37	250.0	100.00000	CI	28.05	HI	0.00	
38	35	38	100.0	100.00000	CI	27.95	HI	0.00	
39	36	39	100.0	100.00000	CI	29.13	HI	0.00	
40	34	40	250.0	100.00000	CI	28.89	HI	0.00	
41	40	41	200.0	100.00000	CI	28.89	HI	0.00	
42	41	42	200.0	100.00000	CI	27.88	HI	0.00	
43	40	43	125.0	100.00000	CI	28.89	HI	0.00	
44	43	44	100.0	100.00000	CI	28.35	HI	0.00	
45	43	45	100.0	100.00000	CI	28.35	HI	0.00	
46	41	46	100.0	100.00000	CI	29.17	HI	0.00	
47	46	42	100.0	100.00000	CI	29.17	HI	0.00	
48	41	47	100.0	100.00000	CI	28.55	HI	0.00	
49	47	48	100.0	100.00000	CI	28.55	HI	0.00	
50	35	49	150.0	100.00000	CI	28.76	HI	0.00	
51	49	50	100.0	100.00000	CI	28.93	HI	0.00	

Node Details

Node No.		Flow (lps)	Elev. (m)	H G L (m)	Pressure (m)
1	S	185.475	106.00	116.00	10.00
2		0.000	87.43	115.81	28.38
3		0.000	88.67	115.51	26.84
4		0.000	85.95	114.63	28.68
5		-48.264	86.07	114.25	28.18
6		0.000	87.62	115.68	28.06
7		0.000	89.92	115.17	25.25
8		0.000	89.35	114.67	25.32
9		0.000	88.76	114.30	25.54

10	0.000	88.63	113.46	24.83
11	-5.139	87.43	111.78	24.35
12	0.000	88.01	115.43	27.42
13	0.000	87.72	115.13	27.41
15	0.000	86.31	114.86	28.55
16	-1.527	85.57	114.76	29.19
17	-5.139	86.64	114.12	27.48
18	-5.139	86.36	113.85	27.49
19	-4.098	85.63	114.52	28.89
20	0.000	85.95	114.41	28.46
21	-5.139	87.45	113.89	26.44
22	-5.139	87.54	114.10	26.56
23	-10.320	94.25	114.36	20.11
24	0.000	93.76	114.92	21.16
25	-8.220	89.32	114.59	25.27
26	-4.080	90.32	114.70	24.38
27	0.000	89.55	114.17	24.62
28	-7.710	89.76	113.74	23.98
29	-2.568	89.89	113.67	23.78
30	-5.139	87.85	113.85	26.00
31	0.000	88.38	113.28	24.90
32	-2.049	88.25	113.13	24.88
33	-1.008	87.50	113.23	25.73
34	0.000	87.52	115.16	27.64
35	0.000	86.93	114.88	27.95
36	0.000	86.74	114.79	28.05
37	-29.880	87.54	114.33	26.79
38	-1.527	86.85	114.80	27.95
39	-2.040	85.33	114.46	29.13
40	0.000	85.63	114.52	28.89
41	0.000	86.22	114.10	27.88
42	-17.010	85.92	113.63	27.71
43	0.000	85.99	114.34	28.35
44	-2.568	87.19	114.04	26.85
45	-2.568	86.15	114.04	27.89
46	0.000	84.60	113.77	29.17
47	0.000	85.35	113.90	28.55
48	-2.049	86.20	113.25	27.05
49	-4.098	85.65	114.41	28.76
50	-2.049	85.35	114.28	28.93
51	-1.008	89.58	115.30	25.72

Pipe Cost Summary

Diameter (mm)	Pipe Material	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
100.0	CI	2725.00	1403.38	1403.38
125.0	CI	2020.00	1273.89	2677.27
150.0	CI	1370.00	1076.24	3753.51
200.0	CI	920.00	1066.35	4819.87
250.0	CI	835.00	1292.69	6112.55
300.0	CI	670.00	1337.41	7449.96
350.0	CI	780.00	1958.58	9408.54
400.0	CI	195.00	601.42	10009.96
500.0	CI	70.00	311.60	10321.56

Pipe-wise Cost Summary

Pipe No	Diameter (mm)	Pipe Material	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
1	500.0	CI	70.00	311.60	311.60

2	400.0	CI	195.00	601.42	913.02
3	350.0	CI	480.00	1205.28	2118.30
4	300.0	CI	140.00	279.46	2397.75
5	300.0	CI	50.00	99.81	2497.56
6	300.0	CI	330.00	658.72	3156.28
7	250.0	CI	285.00	441.22	3597.50
8	200.0	CI	200.00	231.82	3829.32
9	150.0	CI	285.00	223.89	4053.21
10	125.0	CI	550.00	346.85	4400.06
11	200.0	CI	30.00	34.77	4434.83
12	200.0	CI	120.00	139.09	4573.92
13	200.0	CI	100.00	115.91	4689.83
14	150.0	CI	95.00	74.63	4764.46
15	100.0	CI	105.00	54.08	4818.53
16	100.0	CI	290.00	149.35	4967.88
17	125.0	CI	330.00	208.11	5175.99
18	125.0	CI	380.00	239.64	5415.64
19	125.0	CI	170.00	107.21	5522.85
20	150.0	CI	50.00	39.28	5562.13
21	125.0	CI	170.00	107.21	5669.33
22	125.0	CI	100.00	63.06	5732.40
23	150.0	CI	290.00	227.82	5960.22
24	200.0	CI	160.00	185.45	6145.67
25	150.0	CI	110.00	86.41	6232.08
26	125.0	CI	110.00	69.37	6301.45

Pipe-wise Cost Summary cont`d

Pipe No	Diameter (mm)	Pipe Material	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
27	150.0	CI	110.00	86.41	6387.87
28	150.0	CI	160.00	125.69	6513.56
29	100.0	CI	200.00	103.00	6616.56
30	125.0	CI	150.00	94.60	6711.16
31	100.0	CI	50.00	25.75	6736.91
32	100.0	CI	90.00	46.35	6783.26
33	100.0	CI	120.00	61.80	6845.06
34	350.0	CI	300.00	753.30	7598.36
35	300.0	CI	150.00	299.42	7897.78
36	250.0	CI	30.00	46.44	7944.22
37	250.0	CI	170.00	263.18	8207.40
38	100.0	CI	90.00	46.35	8253.75
39	100.0	CI	200.00	103.00	8356.75
40	250.0	CI	350.00	541.85	8898.60
41	200.0	CI	120.00	139.09	9037.69
42	200.0	CI	190.00	220.23	9257.91
43	125.0	CI	60.00	37.84	9295.75
44	100.0	CI	120.00	61.80	9357.55
45	100.0	CI	120.00	61.80	9419.35
46	100.0	CI	520.00	267.80	9687.15
47	100.0	CI	220.00	113.30	9800.45
48	100.0	CI	120.00	61.80	9862.25
49	100.0	CI	400.00	206.00	10068.25
50	150.0	CI	270.00	212.11	10280.36
51	100.0	CI	80.00	41.20	10321.56

Gundge Zone:

Echoing Input Variables

Title of the Project		: Distribution Gundge
Name of the User		: CTARA
Number of Pipes		: 11
Number of Nodes		: 12
Number of Commercial Diameters		: 9
Peak Design Factor		: 3
Minimum Headloss in	m/km	: .1
Maximum Headloss in	m/km	: 25
Minimum Residual Pressure	m	: 8
Type of Formula		: Hazen's

Pipe Data

Pipe No.	From Node	To Node	Length m	Diameter mm	Hazen's Const	Status (E/P)
1	1	2	170.00			
2	2	3	280.00			
3	3	4	320.00			
4	2	5	30.00			
5	5	6	350.00			
6	6	7	90.00			
7	5	8	165.00			
8	8	9	135.00			
9	8	10	100.00			
10	6	11	230.00			
11	3	12	470.00			

Node Data

Node No.	Peak Factor	Flow lps	Elevation m	Res. Press m	Meet Res. Pres (Y/N)?
1	3.00	0.000	119.00	8.00	
2	3.00	0.000	101.93	8.00	
3	3.00	0.000	93.62	8.00	
4	3.00	-5.660	87.99	8.00	
5	3.00	0.000	102.26	8.00	
6	3.00	0.000	100.27	8.00	

Node Data cont`d

Node No.	Peak Factor	Flow lps	Elevation m	Res. Press m	Meet Res. Pres (Y/N)?
7	3.00	-0.856	99.75	8.00	
8	3.00	0.000	94.81	8.00	
9	3.00	-1.157	90.81	8.00	
10	3.00	-1.366	93.25	8.00	
11	3.00	-1.715	97.15	8.00	
12	3.00	-5.090	97.55	8.00	

Reference Node Data

Node No.	Grade Line m
1	119.00

Commercial Diameter Data

Pipe Dia. Int. (mm)	Hazen's Const	Unit Cost Rs /m length
100.0	100.00000	515.88
125.0	100.00000	630.64
150.0	100.00000	785.58
200.0	100.00000	1149.08
250.0	100.00000	1548.13
300.0	100.00000	1996.34
350.0	100.00000	2511.56
400.0	100.00000	3084.20
500.0	100.00000	4451.38

Branched Water Distribution Network Design OutPut

Pipe Details

Pipe No.	From Node	To Node	Peak Flow (lps)	Diam (mm)	Hazen's Const	HL (m)	HL/1000 (m)	Length (m)	Status (E/P)
1	1	2	47.532	200.0	100.00000	3.27	19.24	170.00	
2	2	3	32.250	200.0	100.00000	2.62	9.36	280.00	
3	3	4	16.980	150.0	100.00000	3.72	11.63	320.00	
4	2	5	15.282	125.0	100.00000	0.70	23.33	30.00	
5	5	6	7.713	100.0	100.00000	6.80	19.43	350.00	
6	6	7	2.568	100.0	100.00000	0.23	2.56	90.00	
7	5	8	7.569	100.0	100.00000	3.10	18.79	165.00	
8	8	9	3.471	100.0	100.00000	0.60	4.44	135.00	
9	8	10	4.098	100.0	100.00000	0.60	6.00	100.00	
10	6	11	5.145	100.0	100.00000	2.11	9.17	230.00	
11	3	12	15.270	125.0	100.00000	5.23	23.21	225.33	
				150.0	100.00000	2.33	9.52	244.67	

Node Details

Node No.		Peak Flow (lps)	Elevation (m)	H G L (m)	Cal Pres (m)		Spc Pres (m)	Meet Pres.	Res (Y)
1	S	47.532	119.00	119.00	0.00		8.00		
2		0.000	101.93	115.73	13.80		8.00		
3		0.000	93.62	113.11	19.49		8.00		
4	T	-16.980	87.99	109.39	21.40		8.00		
5		0.000	102.26	115.04	12.78		8.00		
6		0.000	100.27	108.24	7.97	*	8.00		
7	T	-2.568	99.75	108.01	8.26		8.00		
8		0.000	94.81	111.94	17.13		8.00		
9	T	-3.471	90.81	111.34	20.53		8.00		
10	T	-4.098	93.25	111.34	18.09		8.00		
11	T	-5.145	97.15	106.12	8.97		8.00		
12	T	-15.270	97.55	105.55	8.00		8.00		

Cost Summary

Diameter (mm)	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
100.0	1070.00	551.99	551.99
125.0	255.33	161.02	713.01
150.0	564.67	443.59	1156.61
200.0	450.00	517.09	1673.69

Pipe-wise Cost Summary

Pipe No	Diameter (mm)	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
1	200.0	170.00	195.34	195.34
2	200.0	280.00	321.74	517.09
3	150.0	320.00	251.39	768.47
4	125.0	30.00	18.92	787.39
5	100.0	350.00	180.56	967.95
6	100.0	90.00	46.43	1014.38
7	100.0	165.00	85.12	1099.50
8	100.0	135.00	69.64	1169.14
9	100.0	100.00	51.59	1220.73
10	100.0	230.00	118.65	1339.38
11	125.0	225.33	142.10	1481.48
	150.0	244.67	192.21	1673.69

Bhisegaon Zone:

Echoing Input Variables

Title of the Project		: Distribution Bhisegaon
Name of the User		: CTARA
Number of Pipes		: 9
Number of Nodes		: 10
Number of Commercial Diameters		: 9
Peak Design Factor		: 1.2
Minimum Headloss in	m/km	: .1
Maximum Headloss in	m/km	: 25
Minimum Residual Pressure	m	: 8
Type of Formula		: Hazen's

Pipe Data

Pipe No.	From Node	To Node	Length m	Diameter mm	Hazen's Const	Status (E/P)
1	1	2	135.00			
2	2	3	215.00			
3	3	4	1310.00			
4	3	5	80.00			
5	5	6	120.00			
6	5	7	100.00			
7	2	8	70.00			
8	8	9	540.00			
9	8	10	280.00			

Node Data

Node No.	Peak Factor	Flow lps	Elevation m	Res. Press m	Meet Res. Pres (Y/N)?
1	1.20	0.000	120.00	8.00	
2	1.20	0.000	97.71	8.00	
3	1.20	0.000	94.02	8.00	
4	1.20	-8.102	91.79	8.00	
5	1.20	0.000	94.07	8.00	
6	1.20	-3.600	94.91	8.00	
7	1.20	-1.713	91.15	8.00	
8	1.20	0.000	98.52	8.00	
9	1.20	-3.600	96.58	8.00	
10	1.20	-1.713	95.92	8.00	

Reference Node Data

Node No.	Grade Line m
1	120.00

Commercial Diameter Data

Pipe Dia. Int. (mm)	Hazen's Const	Unit Cost Rs /m length
100.0	100.00000	515.88
125.0	100.00000	630.64
150.0	100.00000	784.58
200.0	100.00000	1149.08
250.0	100.00000	1548.13
300.0	100.00000	1996.34
350.0	100.00000	2511.56
400.0	100.00000	3084.20
500.0	100.00000	4451.38

Branched Water Distribution Network Design OutPut

Pipe Details

Pipe No.	From Node	To Node	Peak Flow (lps)	Diam (mm)	Hazen's Const	HL (m)	HL/1000 (m)	Length (m)	Status (E/P)
1	1	2	22.474	150.0	100.00000	2.63	19.48	135.00	
2	2	3	16.098	150.0	100.00000	2.26	10.51	215.00	
3	3	4	9.722	125.0	100.00000	13.18	10.06	1310.00	
4	3	5	6.376	100.0	100.00000	1.09	13.63	80.00	
5	5	6	4.320	100.0	100.00000	0.80	6.67	120.00	
6	5	7	2.056	100.0	100.00000	0.17	1.70	100.00	
7	2	8	6.376	100.0	100.00000	0.96	13.71	70.00	

8	8	9	4.320	100.0	100.00000	3.59	6.65	540.00
9	8	10	2.056	100.0	100.00000	0.47	1.68	280.00

Node Details

Node No.		Peak Flow (lps)	Elevation (m)	H G L (m)	Cal Pres (m)	Spc Pres (m)	Meet Res Pres. (Y)
1	S	22.474	120.00	120.00	0.00	8.00	
2		0.000	97.71	117.37	19.66	8.00	
3		0.000	94.02	115.10	21.08	8.00	
4	T	-9.722	91.79	101.93	10.14	8.00	
5		0.000	94.07	114.01	19.94	8.00	
6	T	-4.320	94.91	113.21	18.30	8.00	
7	T	-2.056	91.15	113.84	22.69	8.00	
8		0.000	98.52	116.41	17.89	8.00	
9	T	-4.320	96.58	112.82	16.24	8.00	
10	T	-2.056	95.92	115.94	20.02	8.00	

Cost Summary

Diameter (mm)	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
100.0	1190.00	613.90	613.90
125.0	1310.00	826.14	1440.04
150.0	350.00	274.60	1714.64

Pipe-wise Cost Summary

Pipe No	Diameter (mm)	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
1	150.0	135.00	105.92	105.92
2	150.0	215.00	168.68	274.60

3	125.0	1310.00	826.14	1100.74
4	100.0	80.00	41.27	1142.01
5	100.0	120.00	61.91	1203.92
6	100.0	100.00	51.59	1255.51
7	100.0	70.00	36.11	1291.62
8	100.0	540.00	278.58	1570.19
9	100.0	280.00	144.45	1714.64

Akurle Zone:

Echoing Input Variables

Title of the Project		: Distribution Akurle
Name of the User		: CTARA
Number of Pipes		: 7
Number of Nodes		: 8
Number of Commercial Diameters		: 9
Peak Design Factor		: 3
Minimum Headloss in	m/km	: .1
Maximum Headloss in	m/km	: 25
Minimum Residual Pressure	m	: 8
Type of Formula		: Hazen's

Pipe Data

Pipe No.	From Node	To Node	Length m	Diameter mm	Hazen's Const	Status (E/P)
1	1	2	100.00			
2	2	3	80.00			
3	3	4	30.00			
4	2	5	30.00			
5	5	6	20.00			
6	5	7	50.00			
8	3	8	60.00			

Node Data

Node No.	Peak Factor	Flow lps	Elevation m	Res. Press m	Meet Res. Pres (Y/N)?
1	3.00	0.000	96.95	8.00	
2	3.00	0.000	94.32	8.00	
3	3.00	0.000	92.54	8.00	
4	3.00	-2.060	91.71	8.00	
5	3.00	0.000	93.56	8.00	
6	3.00	-1.030	93.50	8.00	
7	3.00	-0.683	93.95	8.00	
8	3.00	-1.713	92.92	8.00	

Reference Node Data

Node No.	Grade Line m
1	108.95

Commercial Diameter Data

Pipe Dia. Int. (mm)	Hazen's Const	Unit Cost Rs /m length
100.0	100.00000	515.88
125.0	100.00000	630.64
150.0	100.00000	785.58
200.0	100.00000	1149.08
250.0	100.00000	1548.13
300.0	100.00000	1996.34
350.0	100.00000	2511.56
400.0	100.00000	3084.20
500.0	100.00000	4451.38

Branched Water Distribution Network Design OutPut

Pipe Details

Pipe No.	From Node	To Node	Peak Flow (lps)	Diam (mm)	Hazen's Const	HL (m)	HL/1000 (m)	Length (m)	Status (E/P)
1	1	2	16.458	150.0	100.00000	1.10	11.00	100.00	
2	2	3	11.319	125.0	100.00000	1.07	13.38	80.00	
3	3	4	6.180	100.0	100.00000	0.39	13.00	30.00	
4	2	5	5.139	100.0	100.00000	0.28	9.33	30.00	
5	5	6	3.090	100.0	100.00000	0.07	3.50	20.00	
6	5	7	2.049	100.0	100.00000	0.08	1.60	50.00	
8	3	8	5.139	100.0	100.00000	0.55	9.17	60.00	

Node Details

Node No.	Peak Flow (lps)	Elevation (m)	H G L (m)	Cal Pres (m)	Spc Pres (m)	Meet Pres. Res (Y)
1 S	16.458	96.95	108.95	12.00	8.00	
2	0.000	94.32	107.85	13.53	8.00	
3	0.000	92.54	106.79	14.25	8.00	
4 T	-6.180	91.71	106.40	14.69	8.00	
5	0.000	93.56	107.58	14.02	8.00	
6 T	-3.090	93.50	107.51	14.01	8.00	
7 T	-2.049	93.95	107.50	13.55	8.00	
8 T	-5.139	92.92	106.24	13.32	8.00	

Cost Summary

Diameter (mm)	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
100.0	190.00	98.02	98.02
125.0	80.00	50.45	148.47
150.0	100.00	78.56	227.03

Pipe-wise Cost Summary

Pipe No	Diameter (mm)	Length (m)	Cost (1000 Rs)	Cum. Cost (1000 Rs)
1	150.0	100.00	78.56	78.56
2	125.0	80.00	50.45	129.01
3	100.0	30.00	15.48	144.49
4	100.0	30.00	15.48	159.96
5	100.0	20.00	10.32	170.28
6	100.0	50.00	25.79	196.07
8	100.0	60.00	30.95	227.03

Appendix-IV
Capacity of Pump for Sewage Pumping Stations

Zone I

Demand (MLD)	*Formula*	2.09
Hours of pumping		24
Flow (litres/s) (Q)	*(Design Discharge*10^6)/(Hours*3600)*	24.19
Efficiency		75
Head (m) (h)		9
BHP (kW)	*(Q*g*h*G*)/(Efficiency*1000)*	2.85
BHP (HP)	*BHP (kW)/.746*	**3.82**

Hence, the provided 3 pumps of 4 HP are sufficient for 15 years.

Zone II

Demand (MLD)	*Formula*	4.17
Hours of pumping		24
Flow (litres/s) (Q)	*(Design Discharge*10^6)/(Hours*3600)*	48.26
Efficiency		75
Head (m) (h)		13
BHP (kW)	*(Q*g*h*G*)/(Efficiency*1000)*	8.21
BHP (HP)	*BHP (kW)/.746*	**11.00**

Hence, the provided 3 pumps of 12 HP are sufficient for 15 years.

Zone III

Demand (MLD)	*Formula*	1.52
Hours of pumping		24
Flow (litres/s) (Q)	*(Design Discharge*10^6)/(Hours*3600)*	17.59
Efficiency		75
Head (m) (h)		16.7
BHP (kW)	*(Q*g*h*G*)/(Efficiency*1000)*	3.84
BHP (HP)	*BHP (kW)/.746*	**5.15**

Hence, the provided 3 pumps of 6 HP are sufficient for 15 years.

Appendix-V

Sewage Rising Mains calculation

Zone I:

DESIGN OF ECONOMIC SIZE OF PUMPING MAINS

Inputs:

Scheme	**Karjat Sewage Rising Mains: Zone I**		
SR NO.	PARTICULARS	VALUES	UNITS
1)	Water requirements		
a)	Initial	0.892	mld
b)	Intermidiate	1.438	mld
c)	Ultimate	2.262	mld
2)	Length of pumping main	20	m
3)	Static head for pump	9.15	m
4)	Combined efficency of pumping set	75	%
5)	Cost of pumping unit	3500	Rs./ kw
6)	Interest rate	12.5	%
7)	Energy charges	5.5	Rs./ unit
8)	Pump as standby arrangement	100	%

Solution:

SOLUTION CHART					
SR NO.	PARTICULARS	1SI 15 YEARS		2ND 15 YEARS	
		VALUE	UNIT	VALUE	UNIT
1)	Discharge at Installations	0.892	mld	1.438	mld
2)	Discharge at the end of 15 yrs.	1.438	mld	2.262	mld
3)	Average discharge	1.165	mld	1.85	mld
4)	Hours of pumping for discharge at the end of 15 yrs.	22	hrs.	22	hrs.
5)	Average hrs of pumping for average discharge	17.82	hrs.	17.99	hrs.
6)	K.W required	0.237	k.w x H1	0.373	k.w x H2
7)	Annual Energy Cost	35803.93	Rs. per kw1	36144.55	Rs. per kw2
8)	Pump capitalised cost factor	5.852			
9)	Energy charges capitalisation factor	6.633			

Calculations:

Sr no.	Pipe size in mm	Type / Class of pipe proposed	Rate of pipe per ' m' length.	Pipe cost for full proposed length	Cvalue	Frictional head loss per 1000 mm		Velocity in m/s	
						1st Stage	2nd Stage	1st Stage	2nd Stage
1)	100	DI	1215	24	140	50.21	116.16	2.31	3.64
2)	150	DI	1769	35	140	6.97	16.12	1.03	1.62
3)	200	DI	2351	47	140	1.72	3.97	0.58	0.91
4)	250	DI	3199	64	140	0.58	1.34	0.37	0.58
5)	300	DI	4008	80	140	0.24	0.55	0.26	0.40

Sr no.	Pipe size in mm	Total head in 'm' for pipe length mentioned in data including static head					
		1st stage flow			2nd stage flow		
		hf in m	10% of hf	Total	hf in m	10% of hf	Total
1)	100	1	0.1	10	2.32	0.23	12
2)	150	0.14	0.01	9	0.32	0.03	10
3)	200	0.03	0	9	0.08	0.01	9
4)	250	0.01	0	9	0.03	0	9
5)	300	0	0	9	0.01	0	9

Pipe size in mm			100	150	200	250	300
Kilowatts required and cost of pump sets for different pipe sizes	1st stage flow	kw required	5	4	4	4	4
		Pump Cost '000	18	14	14	14	14
		Ann. Energy Charge	90	72	72	72	72
		Capitalised energy charges	594	475	475	475	475
		Total capitalised charge	636	524	536	553	569
	2nd stage flow	kw required	9	7	7	7	7
		Pump Cost '000	32	25	25	25	25
		Ann. Energy Charge	163	127	127	127	127
		Capitalised energy	1079	839	839	839	839

		charges					
		Total capitalised charge	190	148	148	148	148
Ground total of capitalised cost for 30 years in '000 Rs.			825	672	684	701	717

Hence, the most economical pipe diameter for zone I is 150mm with total cost of Rs 672,000.

Zone II

DESIGN OF ECONOMIC SIZE OF PUMPING MAINS

Inputs

Scheme	**Karjat Sewage Rising Mains: Zone II**		
SR NO.	PARTICULARS	VALUES	UNITS
1)	Water requirements		
a)	Initial	2.044	mld
b)	Intermidiate	4.17	mld
c)	Ultimate	6.02	mld
2)	Length of pumping main	575	m
3)	Static head for pump	10.5	m
4)	Combined efficency of pumping set	75	%
5)	Cost of pumping unit	3500	Rs./ kw
6)	Interest rate	12.5	%
7)	Energy charges	5.5	Rs./ unit
8)	Pump as standby arrangement	100	%

Solution:

SOLUTION CHART					
SR NO.	PARTICULARS	1SI 15 YEARS		2ND 15 YEARS	
		VALUE	UNIT	VALUE	UNIT
1)	Discharge at Installations	2.044	mld	4.17	mld
2)	Discharge at the end of 15 yrs.	4.17	mld	6.02	mld
3)	Average discharge	3.107	mld	5.095	mld
4)	Hours of pumping for discharge at the end of 15 yrs.	22	hrs.	22	hrs.
5)	Average hrs of pumping for average discharge	16.39	hrs.	18.62	hrs.
6)	K.W required	0.688	k.w x H1	0.994	k.w x H2
7)	Annual Energy Cost	32928.27	Rs. per kw1	37403.43	Rs. per kw2
8)	Pump capitalised cost factor	5.852			
9)	Energy charges capitalisation factor	6.633			

Calculations:

Sr no.	Pipe size in mm	Type / Class of pipe proposed	Rate of pipe per ' m' length.	Pipe cost for full proposed length	Cvalue	Frictional head loss per 1000 mm		Velocity in m/s	
						1st Stage	2nd Stage	1st Stage	2nd Stage
1)	100	DI	1215	699	140	360.58	711.71	6.71	9.68
2)	150	DI	1769	1017	140	50.05	98.78	2.98	4.30
3)	200	DI	2351	1352	140	12.33	24.33	1.68	2.42
4)	250	DI	3199	1839	140	4.16	8.21	1.07	1.55
5)	300	DI	4008	2305	140	1.71	3.38	0.75	1.08

Sr no.	Pipe size in mm	Total head in 'm' for pipe length mentioned in data including static head					
		1st stage flow			2nd stage flow		
		hf in m	10% of hf	Total	hf in m	10% of hf	Total
1)	100	207.33	20.73	239	409.23	40.92	461
2)	150	28.78	2.88	42	56.80	5.68	73
3)	200	7.09	0.71	18	13.99	1.40	26
4)	250	2.39	0.24	13	4.72	0.47	16
5)	300	0.98	0.10	12	1.94	0.19	13

Pipe size in mm			100	150	200	250	300
Kilowatts required and cost of pump sets for different pipe sizes	1st stage flow	kw required	329	58	25	18	17
		Pump Cost '000	1152	203	88	63	60
		Ann. Energy Charge	5417	955	412	296	280
		Capitalised energy charges	35928	6334	2730	1966	1856
		Total capitalised charge	37779	7554	4170	3868	4221
	2nd stage flow	kw required	916	145	52	32	26
		Pump Cost '000	3206	508	182	112	91
		Ann. Energy Charge	17131	2712	972	598	486

		Capitalised energy charges	113627	17987	6450	3969	3225
		Total capitalised charge	19965	3160	1133	697	567
Ground total of capitalised cost for 30 years in '000 Rs.			57743	10714	5302	4565	4787

Hence, the most economical pipe diameter for zone I is 250mm with total cost of Rs 4565,000.

Zone III

DESIGN OF ECONOMIC SIZE OF PUMPING MAINS

Inputs

Scheme	Karjat Sewage Rising Mains: Zone II		
SR NO.	PARTICULARS	VALUES	UNITS
1)	Water requirements		
a)	Initial	0.75	mld
b)	Intermidiate	1.52	mld
c)	Ultimate	2.43	mld
2)	Length of pumping main	540	m
3)	Static head for pump	16.5	m
4)	Combined efficency of pumping set	75	%
5)	Cost of pumping unit	3500	Rs./ kw
6)	Interest rate	12.5	%
7)	Energy charges	5.5	Rs./ unit
8)	Pump as standby arrangement	100	%

Solution:

SOLUTION CHART					
SR NO.	PARTICULARS	1SI 15 YEARS		2ND 15 YEARS	
		VALUE	UNIT	VALUE	UNIT
1)	Discharge at Installations	0.75	mld	1.52	mld
2)	Discharge at the end of 15 yrs.	1.52	mld	2.43	mld
3)	Average discharge	1.135	mld	1.975	mld
4)	Hours of pumping for discharge at the end of 15 yrs.	22	hrs.	22	hrs.
5)	Average hrs of pumping for average discharge	16.43	hrs.	17.88	hrs.
6)	K.W required	0.251	k.w x H1	0.401	k.w x H2
7)	Annual Energy Cost	33000.15	Rs. per kw1	35919.02	Rs. per kw2
8)	Pump capitalised cost factor	5.852			
9)	Energy charges capitalisation factor	6.633			

Calculations:

Sr no.	Pipe size in mm	Type / Class of pipe proposed	Rate of pipe per ' m' length.	Pipe cost for full proposed length	Cvalue	Frictional head loss per 1000 mm		Velocity in m/s	
						1st Stage	2nd Stage	1st Stage	2nd Stage
1)	100	DI	1215	656	140	55.64	132.64	2.44	3.91
2)	150	DI	1769	955	140	7.72	18.41	1.09	1.74
3)	200	DI	2351	1270	140	1.90	4.53	0.61	0.98
4)	250	DI	3199	1727	140	0.64	1.53	0.39	0.63
5)	300	DI	4008	2164	140	0.26	0.63	0.27	0.43

Sr no.	Pipe size in mm	Total head in 'm' for pipe length mentioned in data including static head					
		1st stage flow			2nd stage flow		
		hf in m	10% of hf	Total	hf in m	10% of hf	Total
1)	100	30.04	3.00	50	71.63	7.16	95
2)	150	4.17	0.42	21	9.94	0.99	27
3)	200	1.03	0.10	18	2.45	0.24	19
4)	250	0.35	0.03	17	0.83	0.08	17
5)	300	0.14	0.01	17	0.34	0.03	17

Pipe size in mm			100	150	200	250	300
Kilowatts required and cost of pump sets for different pipe sizes	1st stage flow	kw required	25	11	9	9	9
		Pump Cost '000	88	39	32	32	32
		Ann. Energy Charge	413	182	149	149	149
		Capitalised energy charges	2736	1204	985	985	985
		Total capitalised charge	3480	2198	2287	2744	3181
	2nd stage	kw required	76	22	15	14	14
		Pump Cost	266	77	53	49	49

	flow	'000					
		Ann. Energy Charge	1365	395	269	251	251
		Capitalised energy charges	9053	2621	1787	1668	1668
		Total capitalised charge	1593	461	314	293	293
Ground total of capitalised cost for 30 years in '000 Rs.			5072	2658	2600	3036	3473

Hence, the most economical pipe diameter for zone I is 200mm with total cost of Rs 2600,000.