STUDY OF WATER SUPPLY TO DURAME TOWN IN ETHIOPIA

A DISSERTATION

Submitted in partial fulfillment of the requirement

for the award of the degree

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MASTER OF TECHNOLOGY

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WATER RESOURCES DEVELOPENT

By

TESHOME MEKETE

(17548040)

DEPARTMENT OF WATER RESOURCE DEVELOPMENT AND MANAGEMENT INDIAN INSTITUTE OF TECHNOLOGY ROORKEE-247667(INDIA)

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CANDIDATE DECLARATION

I hereby declare and certify that the dissertation entitled "**STUDY OF WATER SUPPLY IN ETHIOPIA, IN THE CASE OF DURAME TOWN**" I certify that it is my work presented herein partial fulfillment for the award of the degree of **Master of Technology in Water Resources Development (civil)**, submitted to the Department of Water Resources Development and Management (WRD&M), Indian Institute of Technology, Roorkee. The matter embodied in this work is original and has not been submitted for the award of any other degree. The work has been done under the supervision of Prof. M. L. Kansal and has been conducted during the 2017 to 2019 academic calendar.

TESHOME MEKETE

Date: May 20, 2019 Enrolment No.17548040

CERTIFICATE

This is to certify that the above statement made by the candidate for this report is correct to the best of my knowledge.

(Dr. M.L Kansal)

Professor

Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee

247667(Uttarakhand), India Date ----------------------------

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All the glory goes to the author and finisher of my faith, Lord Jesus Christ and our Godfather in heaven.

Date: May 20, 2019 Teshome Mekete

Place: Roorkee (**WRD&M)**

DEDICATION

This work is dedicated to the memory of my mother Tedelech Eromo (Ayiche), she passed away when I was on my way to India. Her support and encouragement was awesome to me. Also, this work is dedicated to all people who suffer from the domestic water crisis in their cities.

ACRONYMS

SNNPR	Southern Nations, Nationalities and Peoples Regional State, Ethiopia
UNDP	United Nations Development Programme
WHO	World Health Organization
BH	Borehole
E.C.	Ethiopian Calendar
CSA	Central Statistical Agency
EWRMP	Ethiopian Water Resource Management Policy
MoWR	Ministry of Water Resources
DWSS	Durame Water Supply sector
DWDS	drinking water distribution system
IRC	International Water and Sanitation Center, the Netherlands
MOWR	Ethiopian water resource management policy.
UNICEF	United Nations International Children's Emergency Fund
AAU	Addis Ababa University
DWSSO	Durame Water Supply Service Office
WSM	Water Supply Management
NTU	Nephelometric Turbidity
CI	Cast Iron
PSI	Pound per Square Inch
PVC	Polyvinyl Chloride
WTP	Water Treatment Plant
LCD	Liters per Capita Per Day
Mg/l	Milligram per Liter
Lps	Liter per second

ABSTRACT

Providing safe and adequate drinking water for the consumer has been one of the major challenges in developing country mainly in Ethiopia. There is no urban cites of Ethiopia supply 24/7 water for user including Durame town. So that the main aim of this research was to assess and discuss in detail the existing water coverage, water demand, environmental, technical related problems and institutional factors my study on first. To do this: field observation, consultation with different concerned officials and water distribution system design document was used to understand and visualize the level of water in Durame town. Furthermore, the necessary information was collected such as current population, the growth rate of the area, the elevation of point map of the city, source quantity, and water supply distribution system data are collected. The node and the link inputs of water distribution system were simulated to analyze the system by inserting input data by using EPANET 2.0 and parameters. The results of this study indicate the water supply of the Durame town cover only 52 percent of total population (i.e. more than 48% of town population used water from an unprotected source such as hand-dug well, unprotected river and other vendors). The future water demand of town will be 5533m3/day by 2035. If the city water supply (source) not expand in future the gap between demand and supply increased to 65.7% in this year. Furthermore, the output of hydraulic simulation of water distribution network shows, the pressure of node at specific area and velocity of water in the same pipe were below the permissive limit (standard) set by Ethiopia Minister of Water resource design criteria. Also, the chlorine residual in the network were below the permissive limit of 0.2mg/l at varies nodes after 52hr of extended analysis. Finally, to improve pressure and velocity in the water distribution network, it is necessary to use the appropriate boosting station and pressure controlling valve as well as an aged pipe of some line should be replaced by required size pipe. Additionally, the present water deficit of town should be minimized by digging addition wells or another source to fulfill the gaps between demand and supply.

Key words: Durame town, water supply, water demand, distribution network, EPANET.

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CHAPTER 1 INTRODUCTION

1.1 Back Ground

Access to safe and adequate water is one of the top main concern for billions of people everywhere in the world. One billion people have no access to drinkable water and two million people have no access to sanitation. Over 5 million deaths per year are attributed to water-related diseases. The problem is worse than in poor countries; out of 1.4 billion people who do not have adequate drinking water, 450 million people are found in Africa. Average daily water consumption for an American is around 259 litters while a person in poor African countries use a very low amount of water (Bambore, 2011). The adequate and reliable provision of domestic water is a major problem of urban and urban infrastructure which has a major impact on the city's socio-economic performance and also affects human health. On the other hand, many urban areas from place to place in the world are facing a serious problem of water supply. The badly-behaved high in most the third world countries, including Ethiopia, is mainly worst and multidimensional (Fita, March 2011).

Ethiopia is with one of a kind environmental formations and climatic conditions, is gifted with huge water potentials and wetland ecologies with 12 river basins, approximately 14 essential lakes, and a few man-made reservoirs with surface water 122 billion cubic meters and groundwater anticipated to be 40 billion cubic meters. although those quantities of potential the hassle of water delivery are in an awful situation through using multidimensional demanding situations. some of our scarcity of economic resource, The Transboundary nature of Ethiopian waters, Low sectoral basic overall performance and uneven spatial distribution of water resource capability (Girma, 2013).

From the information of SNNPR Water Resource Development Bureau (2014) the overall water supply coverage of the Southern Nation Nationalities Peoples Region is also low which stands at 48 percent. The study area Durame town, one of the fast-growing populations in SNNPR, is suffering from the shortage of water with water coverage of 52 percent. Recognizing the possible cause of water supply problem, exploring additional supply source and expanding the existing water supply infrastructure up to the year 2030 and recommending possible solution will solve the water shortage in the town (Mulu, 2009).

1.2. Statement of the Problem

Inadequate potable water supply may result in the volume of waters associated and water-borne diseases, which automatically affect the health of society. Furthermore, it affects the productivity of the community and the performance of social service. In general, large urban areas take into account centralized demand for both the large population and per capita consumption and waste. Most urban areas have been destroyed, contaminated or destroyed by local water sources such as rivers, lakes, and reservoirs and in many cases even subterranean waters. Rain is generally considered a curse, but not as a result of flood damage, as drainage systems are designed with little predictability (Bambore, 2011).

The study area Durame town like many towns in Ethiopia doesn't have an abundant source of water as well as a distribution network. In addition, the water supply service office (WSSO) emphasis only on collecting bills and paying salaries for the workers. Other issues such as institutional arrangement, future capital repossession plan, coming water supply expansion plan and present physical waters structure maintenance and repair system was not clearly articulated. If the existing water source fails there is no other known option to help the community demand (DWSS, 2018).

The main sources are Kekamo borehole and Wota three boreholes which were drilled by south water construction enterprise. These boreholes were drilled in 2013E.C. due to the population growth of the town, as a result, the big problem of supply and demand unbalance. It is far below the standard set by Ministry of water resource which 70 l/c/d for house connection. As it is known there has not been much research conducted in the study area that tried to define the possible cause for the existing water supply system problems; therefore, it is important to study and identify the existing water supply problem and recommend possible solutions.

1.3 Objectives of the study

General objectives:

The overall purpose of this study is to study the water supply distribution system and challenges in Durame town.

The specific objectives are:

- to evaluate the source and coverage of water supply of the town;
- to examine the water supply distribution system in the town;
- to assess the residual chlorine concentrations in the water distribution system;
- to assess the organizational technical skilled manpower of the sector;

1.4 Research Questions

In this research, the researcher wants to answer the following Questions

- How much water coverage of the town? Is below, above or equal to the country's GTP standard?
- What are the types of water sources in the town of Durame?
- What types of water resources are available in Durame town?
- What is the main challenge with the water supply in the town?
- Are there technical issues of water supply system in Durame town?
- Do organizational capacities affect water supply service delivery?
- Are there environmental factors which affect the Durame town water supply distribution system?

1.5 Significance of the Study

The study area at present needs serious attention under the water supply problem in providing the required amount of water with acceptable quality. Identifying the cause for existing water supply problem and mentioning supportable solution is the concern of this study. In doing so it the area gets advantageous information on the best practices to improve the existing water supply system, and it also helps the concerned management bodies to refer this work on their future plan as an initial point of to solve indicated issues.

1.6 Scope of the Study

Water as a natural resource is utilized in two ways as consumptive and non-consumptive use. Consumptive water use consists of water for domestic doings such as drinking, washing, and irrigation. Whereas non-consumptive water use includes water used for power generation, navigation and refreshment. However, due to the main global challenge with ever-increasing proportions of the world's population, domestic water use must come first. Therefore, the scope of this study is limited to domestic water supply and does not take account of industrial and other consumption of water supply.

1.7. Limitation of study

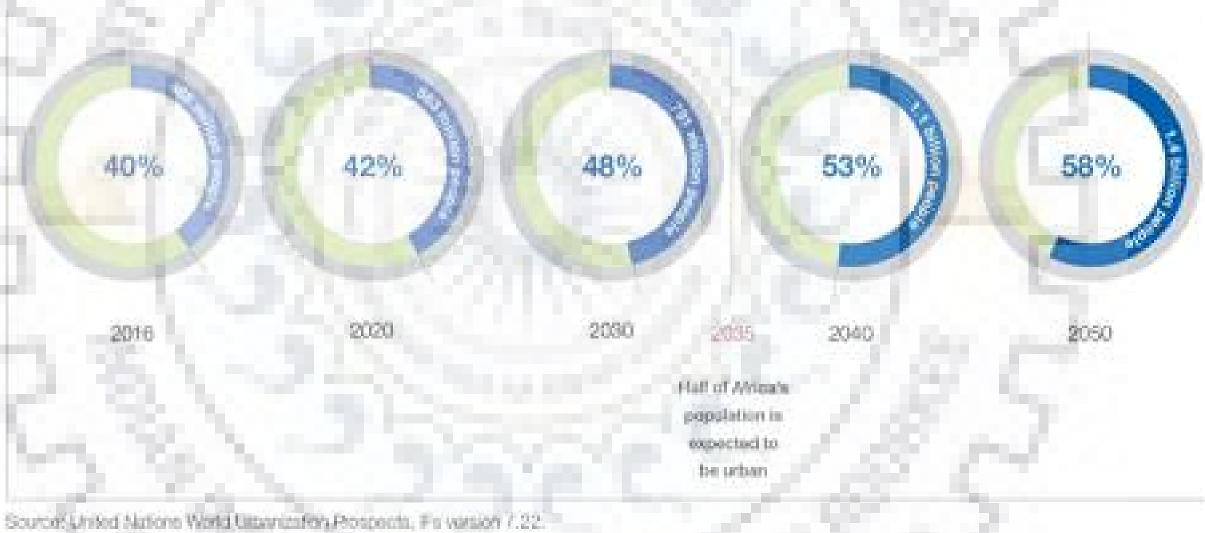
The followings can be considered as the limitations of the study in conducting this research.

- Limitation of documents such as written documents, detail researches for current water supply condition in the area.
- The boundary of the town changed from time to time that fluctuates per capita of water supply due to change of population size.
- Due to undulating topography of town affects the pressure of the distribution system.
- Lack of updated country as well as town's water supply sector standards and regulation.

CHAPTER 2. LITERATURE REVIEW

2.1 Overview of Water Supply in General

The potential of world water sources becoming depleted due to various causes and this problem is increased from time to time by high rate at which the number of populations is growing, predominantly in developing countries, high water consumption industries increasing, global warming and by remaining other main causes depletion increased. At present some with serious water stressed are around 30 countries which considered as in big problem, from the above 20 are absolutely in the center of water scarce. It is predicted that by 2025, the figure of water scarcity will likely approach 35 countries. If we predict and forecasted that, one-third of the population of the developing world will face severe water scarcities by 2030 (Vairavamoorthy, 2007).



https://www.ntusbfcas.com/african-business-insights/content/economy/463-africa-s-future-is-urban

Figure 1 Africa urban population gowth

2.2 Water Consumption in the World

Safe drinking water means that water is largely free of pollutants and microorganisms that often cause disease or death. Dangerous drinking water significantly reduces human progress, and nearly half of all people in developing countries suffer from water-related health problems. To address this challenge, the Global Health Organization identifies remedial action as providing access to sufficient clean water, provision of sanitation and the introduction of sound hygiene practices (UNICEF." 2010).

More than 75% of our planet is covered in water, that's why we call ourselves Blue Planet. But 97.5% of this water is salty. We only have 2.5% of fresh drinking water. However, for everyday use, we use 10 billion tons of fresh water worldwide. Many administrations and ecologists say that our water supply is reduced, but only a few treats it seriously. They see water everywhere, but in fact, more than one billion people in developing countries do not have access to clean drinking water. On the other hand, the United States uses 3.9 trillion liters of water per month. According to the World Health Organization, 80% of all diseases in developing countries are related to water. The UN estimates that by 2025, 30% of the world's population in 50 countries will experience water shortages.

Water scarcity is now a bigger problem than before, we use existing water consumables; however, our population is growing, and with it a call for further growth. Heating around the world is one in every first level activator. If everyone does not seriously oppose this, we will soon be able to have water disasters in our hands. We use vague water for drinking or bathing or washing clothes, we use it to smooth out the products we consume, they are identical. Most commonly daily drinking water is five liters per day but this number changes by variation of the season of highly hot and with the rainy and cold season, with other and a hot day and cold day the daily individual consumption is different. Additionally, water consumption for an individual for daily activity is different from country to country. For instance, in Americans mean usage is between 100 and 175 gallons every day. A mean American uses 100 to one hundred seventy-five gallons of water every day. In worldwide around four trillion cubic meters of fresh-water potential, each year from this agricultural activity is consumed much ore up to 75 to 90% of an area’s accessible freshwater (Sultana, 2007).

2.3 Urbanization and Water Supply in Africa

The physical growth of urban areas can be explained by demographically and functionally. While demographic rationalization of urbanization is limited to elements consisting of population size and density, the financial functional definition states to the territorial concentration of productive activities (industries and provider) instead of population length and density. As showed by (Amenu, 2014) in 2014 thirty-eight percent of Africa’s population was 297 million people lives in urban and semi-urban parts. In the next 2030 year the population increases with the fast rate and the previous number reaches that 54 percent of total pollution, that is approximately near to 422 million. The level of urbanization level in the continent Africa is nearly the same to the Asian countries and lower than global percent of growth which is 70 percent. On the contrary, (Awulachew, 2007) pointed out that it must be realized in mind that the definition of what set up an urban area differs from one African country to another.

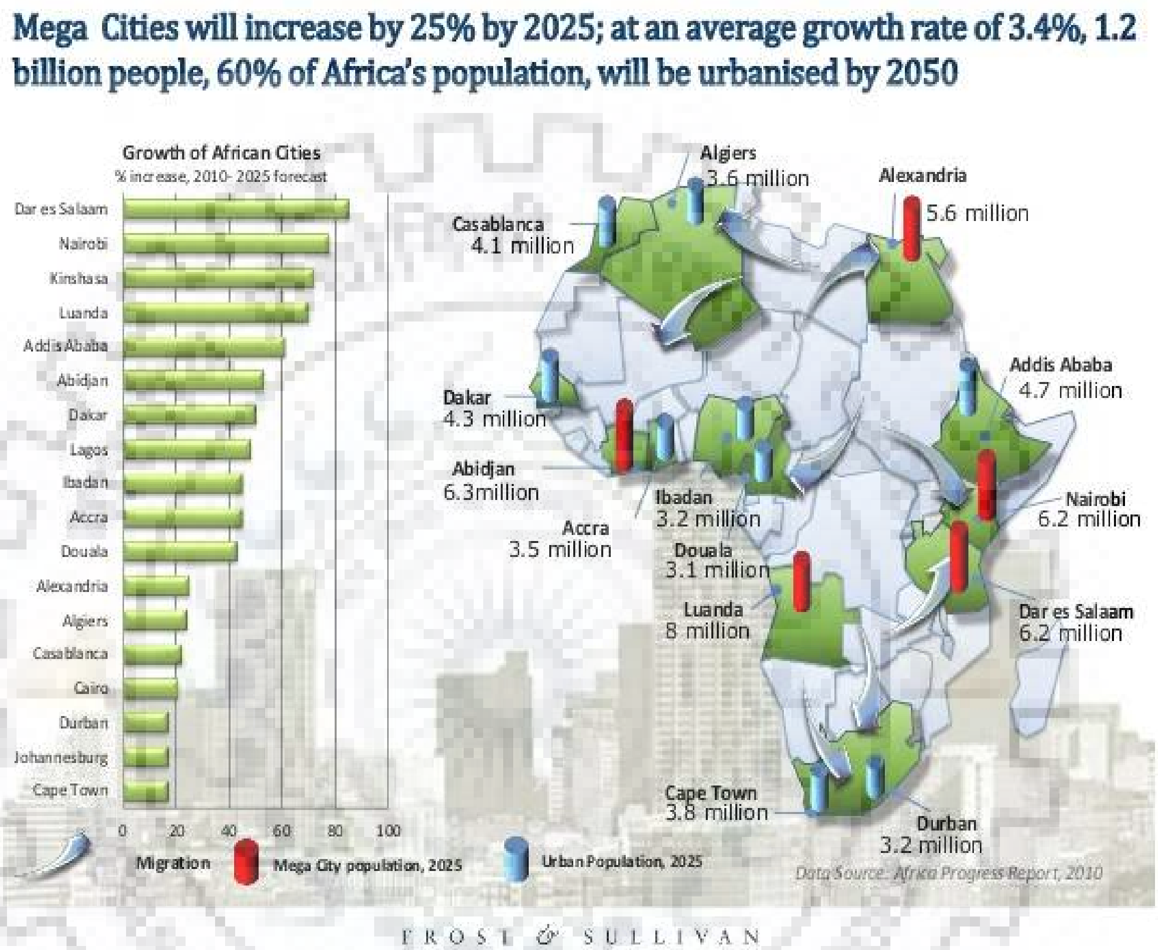


Figure 2.*Africa Mega trends driving mega opportunities in sab Saharan Africa* www.slidesshare.net

The causes of the rapid urbanization and development of the African population are linked to power outside the diversity of challenges, obstacles and service pressures in urban centers. Rapid urbanization over the past five decades has changed the landscape of Africa and has also created serious challenges for water supply and sanitation (ADP, 2008). On the other direction (EDRI, 2009) defined urbanization as the movement of people from communities concerned predominantly with agriculture to other activities such as trade, manufacturing., and other business activities are some of goings-on urban areas.

According to (Thomas, 2009), African urban centers are growing faster than anywhere in the world. In 2009, 40 percent of the population in Africa lives in cities, 60 percent in rural areas, where water supply and sanitation are underdeveloped. A residence in an African city that does not have access to safe drinking water does not work, but the idea sprang up in Africa.

2.4 Urbanization and Water Scarcity

World urban populations, which make up to fifty of the total population of the globe, are growing approximately five each year, this further overloaded water systems leading to life-threatening water shortages worldwide. Sub-Saharan Africa where over forty percent of all people without improved drinking water live (Ashenafi, 2014) (WSM, 2008). In Ethiopia has with more than a million people one city, in between 100,000 and one million people nine cities, and more than 85 cities with between 10,000 and 100,000 people, the towns increase with time today, leads challenge in water supply and demand.

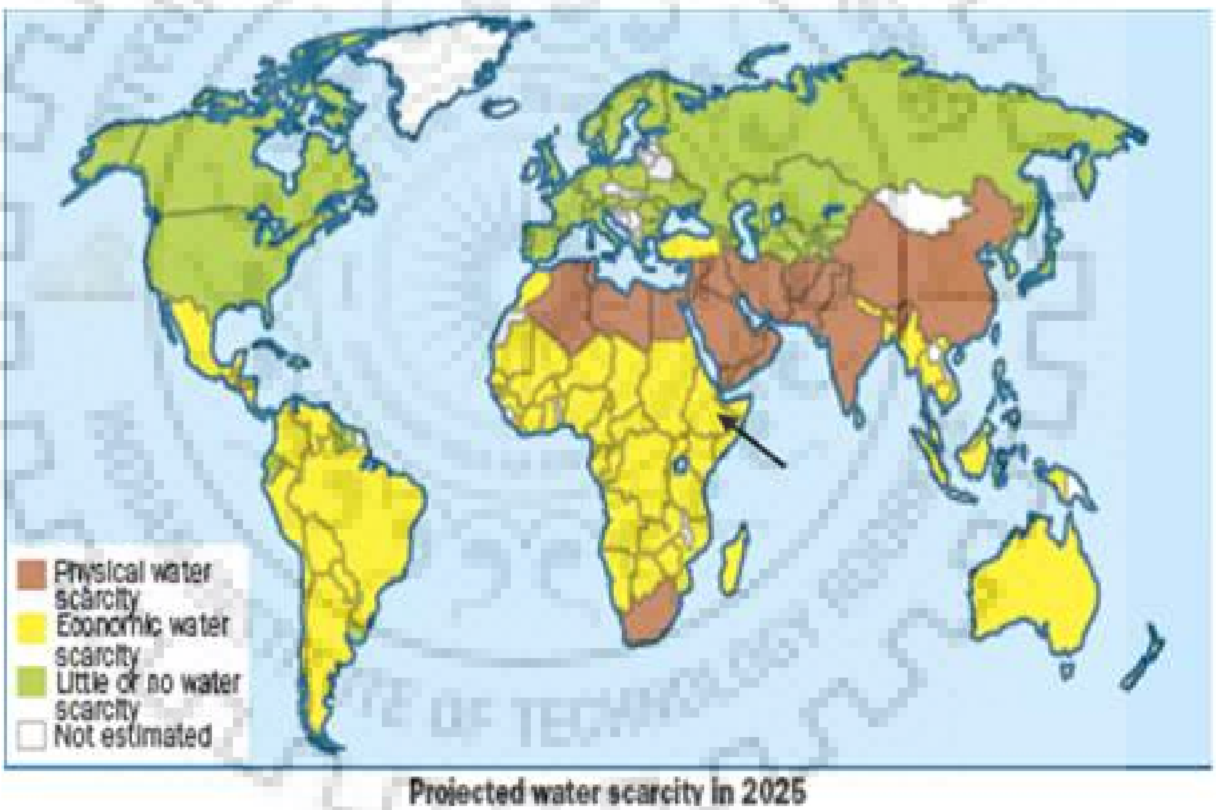


Figure 3. Water Scarcity in world countries
https://revisionworld.com/a2-level-level-revision/geography/global-challenges-and-issues-0/water-conflict

2.5 Urban Water Supply Problem

According to (McKenzie-Ray) urban Water India urban water supply problems include, limited national economic resources, shortage of investments capital, incompetent and inadequate operation and management, power, pollution, lack of training facilities, inadequate financial support of water system and insufficient action on the parts of the government. Lack of effective administrative equipment and of technical staff to promote and design new urban water supplies or to improve existing schemes are other factors to be added to the handicaps already listed. These result mainly from a lack of training abilities and they are frequently due to the influence of conflicting local interest and politics (Khatri K. , 2007) (Brockerhoff, 1999).

2.6 Water Problems in Ethiopia

Ethiopia has nine major rivers and 22 natural and artificial lakes that make her as the water tower of Africa (Dayessa, 2012). Some of the Ethiopian famous rivers are Awash, Baro-Akobo-rivers, Omo, Blue Nile, Tekeze, Wabeshebele, etc. are the main lakes. At the same time, the annual renewable capacity of the country is 122 billion m3 remains at 3% of this amount in the country. It is estimated at 54.4 billion m3 and 2.6 billion surfaces runoff can be developed for use (https). Currently, less than 5% of surface water capacity is used for consumption purposes that make only 39.4% of the population currently has access to safe drinking water, one of the lowest coverage levels worldwide (Fentahun, 2008) (WSM, 2010).

Figure 4.Water potential and scarcity

The upper figure shows that the in Ethiopia there is the high potential of ground and surface but the country has a serious problem of water due to many factors and when we come to the study area the problem is the same. So, this study is to fill the gap in the study area by identifying the potential cause of water supply and suggesting a sustainable solution.

CHAPTER 3 OVERVIEW OF WATER CONSUMPTION AND SUPPLY SYSTEM

3.1 Water supply Coverage

The effectiveness of water utility among varies cities or particular countries differentiates by the amount of water supply coverage or the number of populations addressed by the water utility to deliver potable water. The number of people (percentage) connected with their pipe with water supply system of utility is one of indicator to quantify the performance of the water supply system in both urban and rural area or to compare its coverage The water supply coverage of varies African cities are very low compared to cities in developed county, even though there is a variation of water coverage of among African cities. Data indicates (Amdewoork, 2008), the percentage population connected their house pipe (water coverage) were estimated 43 percent and 21 percent of people used water from public or stand tap in 2008 in African largest cities.

Just like other African countries Ethiopian also has low coverage of water supply in both urban areas and rural even though slight variation among them. Data indicate, in 2010 the water supply coverage of the urban area where estimated 91, 82, and 84 percentage at urban-rural and county respectively. Since the data calculated by the per capita water demand of 15titer per cap per day of within 1.5-kilometer radius for rural area and per capita demand of 20litter per day per cap within the radius of 0.5 kilometers in the urban area. The government of Ethiopia has been planned to improve the rural water supply of country to 85 percentage in 2020 by in per capita water demand of 25 liter per day per cap within 10kilometer radius and to minimize the percentage of consume used public tap to 20 percent and achieve this plan government has been taking good measure by investing a significant amount of money grants for new water supply project in rural area.

Like rural area the second growth and transformation plan (GDP I) planned to enhance Ethiopian urban water supply coverage to 75 percent by delivering 100litter for the first level town, 80 litter for second.60 litter for third and 50 litter for fourth and 30littre for fifth level town per cap per day. Studies carried out by Ethiopian Ministry of Water, Irrigation, and Electricity in the half of the GDP II the water supply coverage was estimated 65.5 %,54.7% and 65.7% at urban, rural and for overall country respectively. Therefore, more than 12.7 inhabitants were used from this plan. (Balay,2012)

3.2 Water demand

The first duties of any engineers are to determine the total water demand (i.e water consumption for varies uses Viz. Domestic, commercial and institutional, industrial, public and provision of firefighting) for cites design water supply scheme. Hence water demand is defined as the total amount of water required to cities for varies uses. The total needed amount of water calculated based on the average per capita demand of one percent per day and the total number of the population serving the water supply. Hence the per capital demands where depends on varies factor such as type of connection, living standard, size of city habit of people, climatic condition and etc. The assessment of one city's water supply coverage has been carried out by considering average per capital demand or water consumption per person per day and the number of the population using the water per day.

By assuming the water living from the system should characterize as the point of consumption which includes outlet of the customer, the leakage of mainline, or a fire fighting demand and etc. are the most ones. When building a hydraulic model there are necessary technical assumptions are incorporated. These are: 1) the amount of water is currently used. 2) Where are the points of water delivery place water points are selected? And 3) The change in consumption usage as a function of time? For the above water demand considerations are detail classified below (Belay, 2012). Types of demands are:

Domestic water demand: It is the water required for varies domestic purposes such as Drinking, cooking, bathing, washing, toilet, and other. The domestic demand estimated range of 30% to 60% of total water demands (Belay. A 2012)

Institutional and Commercial water demand: The water requirement for a different institute such University, schools, cinema, churches, etc., as well water used for the commercial building having hotel, restaurant, hostel, hospital, and other commercial services.

Industrial water demand: Water needed for different industries and factories, such as for cooling heat conversion and cleaning. It accounts between 20% to 50% of total water demand. Different industries use a different amount of water, but its water used depends on the type and amount of production, some lesser and beverage industries consume high amount water whereas electronic industries use a low amount of water for production. Also, large scale industries used a high amount of water for their production compared to low industries.

Water demand for firefighting: it is the water required for the provision of fire or for purpose on fire accident and protecting fire. The amount of water required for firefighting depends on the size of the city, number of populations in the city and type of city where industrial, commercial or residential dominance city, hence we account fire demand city having for more than 50,000 population.

Public water demand: water requirement for public uses in the cities such as for public gardens, washing of road and sewer, public building, for the public fountain, etc. Water demand for this purpose estimated around 5% to 10% of total water requirement. Its requirement depends on the green area of public, sewer line water conception, length of road in the city and number of stadiums or sports gymnasium in the city (Berhe, 2009).

Unaccounted-for water: Unaccounted water is the part of water wastage in the time of delivery to the intended consumption in the cause of loss due to distribution network system leakage, illegal theft, meter not counted service delivery, and other causes are collectively known as unaccounted water.

Base Demands

Base demand is the basic baseline date required to access the quantify the total water requirement of one city and to forecast future demands. It needs to design different component of water supply schemes such as intake source, main pipeline, treatment facilities, pumping units, and distribution system. Additionally, it is the base for average daily demand. Water utility can measure and record the amount of water utilization using flow information (flow rate produced from water treatment unit), volumetric (measure water used by the user) and hydraulic gradient line information (water level in the tank).

3.2.1 Allocation of demands

The most common approach of allocating base demands method by applying the way of counting the number of water user or customers of given area or block of land and then multiplying that number of allocated demand to all the type of demand on the delivery by units of volume or others measured by the number of gallons, liters, cubic meter according to capita. This is done by in keeping mind that of day demand for the applicable pressure of the node. Basic strategies of existing water for filling the gap between water production(source) and computed number of population usage. Two types of approaches top-down and bottom-up, each of those methods is based totally on trendy mass-stability ideas. Top-down demand determination implicates starting from the water resources and detail calculation to tank capacity and distributing all the volume of water to the node by forecasting the population need or demand in each junction points. The above method from the source to the demand allocation is done by considering source capacity, various season demands, peak hour demands, population pressure of new emerging expansion area, higher commercial area, high water consume industry and other attentions are under consideration. The is the opposite of the bottom to down demand allocation. When we want to allocate water from the bottom to top the very important assumption carried out is population forecasting and density of population in the area, and then each type of demand will be assumed. Additionally, this, the variation of the demand is another issue for calculation of the allocation for the time difference. For to accurate each resident actual sage of the water, will be assumed individual house survey, by using and other recommended data then start bottom to the top allocation of water its own country proclamation standard.

Peak Factors

Water demand changes in three variations such as seasonal variation (the variation of water demand by summer and winter), daily variation (change of water per weeks) and hourly variation (variation of water used between 24hr). Peak factor is the factor to use to adjust the variation of water at a different time. It is calculated as the ratio of maximum daily consumption and average daily water consumption, mathematically.

$$P.F = (Q_{maximum} / Q_{average})$$

Whereas P.F is the peak factor, Q maximum is the maximum amount of water per day, and Q average is an average water demand per day hence Maximum daily flows includes water for firefighting. Firefighting flows are recorded in the maximum daily flow. There are many time-related demands that have been taken into account in the model, such as seasonal demands, weekly requests, population growth and industrial demands on other seasonal demands such as summers.

3.3 Component of water supply system

3.3.1 Water source

Groundwater sources are tube well/bore well, open well, the hand pump sources which leads to water available from the ground.

Open well: groundwater is available in the groundwater. This means that less than 15 meters of water are available and water is available throughout the year.

Hand pump: Safe groundwater is available up to a depth of 60 m; Hand pump is the ideal choice for a cluster or apartment.

Tube well: The groundwater is deeper and open wells or hand pumps are not practical wells or wells.

Surface water: Reservoir, river and pond are sources in which surface water is available. In addition, rainwater can be collected and stored directly in the tank or tank. This water can be drunk after the first rain and used for drinking.

3.3.2 Water transmission

The water that enters the distribution area must be transported through the water supply from the source to the treatment plant. Water supply or extraction takes place using natural topography (gravity) or using external electrical energy (pumping station). Free gravity flow channels are routinely placed on the following contour line (topography) with a slight difference in height in the slope near the hydraulic line. Examples of such pipelines are aqueducts, canals, tunnels or partially contracted pipelines. When the pipeline or tunnel is completely filled, the hydraulic gradient and inclination of the pipe are checked. Closed loop hydraulic instructions are usually called pressure flows and in this case exercises. Depending on the topography and the regulations, the water can also be transported by gravity, closed lines or a combination of both. The pipes can be laid and dropped as needed, provided that they are well below the water quality line, or that a minimum positive load remains in the pipe. External pipes have limited use in water supply systems, as they fear that the water is contaminated. They are never suitable for transporting treated water, but can be used for transporting raw water. For public water supply, pressure hoses are the most common way to pump water. Regardless of whether they are free-flowing or pressurized, water pipes usually require a large capital outlay. Therefore, careful consideration of all technical decisions, costs and discussions with the social groups that manage and control the system is essential when deciding on an exceptional response in a particular case.

3.3.3 Service Reservoirs

Water distribution service reservoirs or tanks are used to provide temporarily accumulate or store water to fulfill the gap between fluctuations in consumption and supply, to deliver the need of sudden happening demand like firefighting storage and to stabilize pressures in the water distribution system. The necessary location of the tank or service reservoir is in most cases near to the center of the user as possible. The level of water in the reservoir must be with high topography or elevation level to allow gravity flow at the standard reasonable pressures to the delivery distribution network system. If the topography does not allow sufficient amount of pressure from a surface reservoir, a standpipe or elevated tank may be used to add the necessary elevation compared to water points and to serve the users efficiently and effectively.

3.3.4 Water Distribution system

The needs of the water distribution system is to facilitate the conveyance of water to the intended population by easing the system technically. The water distribution network includes the necessary types of equipment like pipes, a different type of valves, pumps, tanks and other types of components reliable for supply water with clean, economical used for drinking, non-potable uses like fire suppression and irrigation by means of gravity storage feed or pumps though distribution pumping networks to users. Distribution systems denote the vast majority of physical infrastructure for water supplies. The pipes convey water from the source to the service reservoir or transmission pipes mainly high volume of water supply to the service reservoirs of the town by gravity or pumping with high horsepower, this kind of pipes are very durable to resist the internal water pressure.

The pressure line is pipes are decided with amount of water which the volume of water which decides the amount of water needed to the intended area. or the town needed. The guide line includes the. The three requirements for a pipe include its capacity to distribute the quantity of water required, to resist all external and internal forces acting upon it, and to be durable and have a long life (Arabinda). The types of materials commonly used in this system are many types of quality and usage. Today there is cast iron, prestressed concrete, polyvinyl chloride (PVC), reinforced plastic and steel. The reservoir used as daily service commonly known as tank is store and collect volume of water on the time of low demand time(example night) and it can be available in the time of high consuming (the daytime hours)will be used so that very important to maintain sufficient pressure in the distribution system to protect water it against seepage water created with velocity that leads contamination and pollution (Mohsin, 2013).

Two categories of distribution systems are looped and branched. Looped systems have pipes that are interconnected throughout such that water can transport through the entire system back and forth, depending on the points of largest demand. Branched systems have only one path to follow from the source to the customer. Think of the system as one-way flow (Jeffrey, 2012).

Looped type of distribution systems

Looped systems have pipes that are interconnected throughout such that water can transport through the entire system back and forth, depending on the points of largest demand (Gilbert, 2012).

looped system Advantages

- Fluid velocities are lower, lowering head losses, resulting in a greater capacity.
- Main breaks can be isolated to minimize loss of service to customers.
- Fire protection is greater due to greater capacity and ability to isolate breaks.
- Looped systems usually provide better residual chlorine content due to inline mixing and fewer dead ends.

looped system disadvantages

Looped systems generally more cost because there are pipes that become redundant in order to create the loops.

Branched type of distribution systems

Branched systems have only one path to follow from the source to the customer and have the following advantages

- Lower costs – avoiding construction of pipes and appurtenances just to create a looped system reduces the cost.
- In smaller rural communities, branched systems may be the only type that is feasible, logistically and monetarily.

Branched system disadvantages

- Main breaks forced to make all downstream customers out of service.

- Branched systems cause poor chlorine residuals in low demand areas.
- Velocities are faster, head losses greater and capacity reduced especially during high demand
- Fire protection is at risk due to inability to isolate a break.

3.3.5 Valves

The valve may be a tool which regulates, controls, or controls the fluid flow (gases, beverages, fluidized solids or slurries) by constructing, sealing or partially interfering with a portion of the pipe flow lines. Valves are technically designed to control and smooth facilitate the movement of water o other fluids in hydraulically accepted manner. In operation water distribution network, they are a number of valves that we can use to evaluate our technical input mode. In open valves, the fluid flows through the transient path from higher pressure to lower the pressure. The word comes from the Latin female genitals, which changes the part of the door to a word that changes from valley to valve.

Water in the distribution system or process fluid pressure and flow by performing the technical function using the valve controls and facilitating the negative effects in the form of the following functions.

- The downstream system regulation
- Starting and stopping liquid flow
- Control and variation (regulation) of the fluid flow volume
- Changes the direction of water flow

There are number of valves designed and branded that satisfy one or more uses that discussed in the above system of function. There are large number of valve types available in the market with different cost, strength, brand and kinds and designs accuracy which needed by different users by them required usage. The basic data on the variations between the different types of valves and the way these variations have on the valve can help to verify that the correct use of each valve type during installation is made, and thus the correct use of each valve is sorted during operation.

Due to the diversity of the environment, equipment and conditions where different valve designs must be controlled and developed. The most commonly used types of valves in the water system.

Figure 5. The different types of valves generally used in water supply system:

The gate valve is derived from the idea of the entrance of flow arrival is circular movement and linear motion valve used to start or anticipate the fluid drift. however, it does no longer alter or throttle go with the flow even as the valve is open. For this reason, there is a bit of force of pressure drop for the duration of this type of valve.

The accumulation of air at higher points that creates backward pressure is controlled by providing air valves. Air valves, in general, are frequently broadly speaking named as "Air release valves" or, sometimes frequently, as "Vacuum breakers". So, air valves are as long as at greater influence ability or power to make the collected air withdrawal. Air valves are the most efficient and most cost-effective equipment for air manipulate in pressurized liquid flow conveyance structure.

3.3.6 Water treatment plants

Classification of water treatment plants

Simple type disinfection: - It is by injecting chlorine and pumping directly to the users of water. Mostly applied for treating high quality water.

Filtration plants: - If the source water has good quality with lower solids, flocculation and sedimentation can be omitted, this adjustment is called direct filtration and is used to removes color, taste, turbidity, odor, and bacteria (filtration plant)

Softening plants: - Water softening is a procedure through which calcium, magnesium or one of from them kind metal cations in hard water are eliminated.

3.4 Design pressure

The pressure at client connections or residents should be low pressure. The main factor which increases the pressure of water at transmission line includes; length of pipe become long, undulling topography of the area, presence of aged pipe in the system. Thus, high pressure has responsible for different damage to pipe material, valves and distribution system. Additionally, the pressure in the pipe was used as a basic parameter for pressures system. High velocity in the pipe is also because of the high pressure in the system. The maximum pressure magnate in the water distribution system has the standard limit of 50m to 80 as indicated many studies. The minimum pressure at the junction of WDN is a range between 5m to 20m if it may be less than this value, the required amount of water does not deliver to the consumer at the given time and at all position of the system. Generally, both high pressure and low pressure in the water distribution system has an effect on the water distribution network, so that any design WDS should be considering the specific design standard of pressure which is mainly influence the reliability of water distribution system

At the critical time, the flow from the upstream area can be regulated. When water is pumped to a very high elevation with the long distance the pressure occurs at the zone of a pumping station. To reduce and avoid high pressure in the transmission pipe will be used technically to break power at each length needs application and fixing of multiple pumping stations along the pipe installed direction.

3.5 Design velocity and hydraulic gradient

In the stage of designing we consider two main serious causes which the velocity range is established. The amount of maximum velocity in the distribution system have to be required to control head losses in the water distribution system as well as to reduce the effects of water hammer.

On the other hand,when in condition of flow in minimum velocity will be needs to prevent water stagnation which causing sedimentation and bacteriological growth in the conduits.

3.6 Head Losses in the Water Distribution System

The hydraulic loss is the energy loss generated by two cases:

- Friction between the water and the pipe wall/Head loss due to friction/,
- Turbulence caused by obstructions of the flow /minor head loss/.

In distribution, supply network is a gradual or sudden change in the flow system of the water or when there is another type flow obstruction like minor loss compared to this to this is usually much less than the frictional head loss in a long pipe. It is therefore termed as the minor head loss. The frictional head loss in a long pipe is relatively larger than the other head losses, the frictional head loss is also termed major head loss (Garg).

The most known equations used for the determination of friction losses are shown below:

Table 1.Head loss equations and their application area

Friction Losses are estimated with:

Equation	Formula	Remarks
Manning's	$V = \frac{1}{n} R^{2/3} S^{1/2}$	This equation is commonly used for open channel flow.
Chezy's (Kutter's)	$V = C\sqrt{RS}$	Widely used in sanitary sewer design and analysis
Hazen-Williams	$V = 0.85CR^{0.63}S^{0.54}$	Commonly used in the design and analysis of pressure pipe systems
Darcy-Weisbach	$V = \sqrt{\frac{8g}{f}RS}$	Can be used for pressured pipe systems and open channel flows.

The effects of head loss in water distribution system

The pressure at any specified area in a water flow conduit is progressively reduced away from the pressure source (for instance the elevated storage in a water distribution system) because of frictional losses and losses through fittings such as elbows, tees, reducers and valves.

The effects of head loss in the distribution systems are:

- The capacity of the pump will increase due to a high head of pressure line and as result the investment cost and operation & maintenance cost of the pump is high,
- The flow rate of the water in the distribution system does not uniformly reach each node or the junctions of the tap,
- There high water losses in the distribution network

In order to prevent high altitude losses in the water distribution system, a design is required which all hydraulic parameters, such as pressure, speed and optimum pipe diameters, should have in the design criteria for water system design.

3.7 Water distribution simulation

To study water distribution model, there are two types of simulation sed depending of or goal to achieve the average water supply scenario or for long time twenty-four hour or more that discussed below.

- Steady state simulation
- Extended period of simulation

Steady state simulation

This simulation mode evaluates the status of flow parameters over time in distribution systems such as flows, pump operating characteristics, pressure and valve position, provided that the limit conditions and hydraulic requirements do not change over time.

Extended period simulation

Extended period simulation tracks a system over time, and it is a serious of linked steady state run. The need to run extended period simulation is because the system operations vary over time. The variation causes are listed below.

- Demands vary over the course of the day.
- Pumps and wells go on and off.
- Valves open and close.
- Tanks fill and draw

Simulation time: Depending on the purpose of the analysis, the simulation can be done for a longer period of time. The most common simulation time is usually 24 hours, because it is the most recognizable model log for requirements and processes (Epanet, September 2000).

3.8 Water quality

Diseases associated to pollution of drinking water represent a main burden on human health. The Interventions to improve the pleasant and healthy of drinking water supply vital advantages to health. Non-hazardous water supply is beneficial for all household and commercial purposes, including non-public hygiene. The nature and consuming style of drinking-water requirements may differ among countries and regions. There is no one approach that is universally applicable (World Health Organization Geneva 2008).

3.8.1 Physical Properties of drinking water

Turbidity may be a combination of dissolved suspended ions or soil particles that have got to force completely different colors of drinkable and pass water below lower quality most well-liked. In drinking water, the higher the stage of turbidity, the higher the chance that these consuming it should advance gastrointestinal diseases. two Pollutants like viruses and pathogenic microorganism can attach themselves to the suspended solids. These solids then intervene with disinfection.

3.8.2 Microbiological properties

Coliform bacteria: These bacteria mostly found in every environment, regularly as a result of human or animal activity, however, some grow on plant matter. The coliform bacterium in wide range distributed a group of microorganism organisms used as indicators to assist verify if treated water is of an amicrobic quality acceptable for human consumption. Coliform bacterium indicates there's no effective treatment, particularly medical aid, isn't satisfactory. The guidelines apply like absolute value at the treatment works and must be happening by 95 percent of samples taken at service reservoirs (ENDWS, 2011).

3.9 Water treatment for drinking purpose

Water treatment aims to produce water that meets drinking water quality standards at a reasonable cost to consumers. Removal of unwanted solids in water, solids it could be suspended, dissolved or colloidal. Some of the dissolved solids would remain in the water at healthy concentrations. The main aim of treating water is to provide potable water that is chemically and water that can be consumed in any chosen amount without worry for adverse health effects. Potable does not necessarily mean that the water tastes good and biologically harmless for human drinking. It should also be free from unpleasant tastes and smells.

Water treatment methods

Water treatment plants used for many treatment processes to produce water of the desired quality. Most of the treatment methods are coagulation and flocculation, Softening, Reverse osmosis, Electrodialysis, ion exchange, adsorption, Precipitation, disinfection, sedimentation, and filtration. These processes fall into two broad categories by EPA primary drinking water standards: -

1. Removal of contaminants is accomplished by means of physical forces consisting of gravity and screening.
2. Removal is achieved by chemical and biological reactions.

3.9.1 The disinfection of water

The principal goal of the treatment of public water elements is that the elimination of the pathogens that unit responsible for waterborne diseases. The transmission of sicknesses comprehensive of communicable disease and communicable disease fevers, cholera, food poisoning, and infectious disease is additionally managed with remedies that appreciably cut back the entire big choice of viable microorganisms within the water. at a similar time because the attention of organisms in ingesting water once effective treatment is additionally clearly very little, sterilization isn't tried. Sterilization isn't handiest impractical; it cannot be maintained at intervals the distribution system. analysis of the reduction in microbes this is (often this can be) often capable shield in competition to the transmission of pathogens in water is mentioned below. the maneuver of preference for disinfecting water for human intake depends upon on a spread of things (Symons et al., 1977). These include:

- its effectiveness against waterborne pathogens (microorganism, viruses, protozoa, and helminths);
- the accuracy thereupon the procedure is also monitored and managed;
- its capability to produce a residual that offers a brought live of protection against accomplishable place up-remedy infection due to faults within the distribution system;
- the ability smart mental image quality of the treated water; and
- the accessibility of the technology for the adoption of the strategy on the size that's needed for public water provides.

Financial elements may play an aspect inside the final preference; however, this check is confined to a discussion of the five factors indexed above as they exercising to several disinfectants

Distribution of disinfected Water

After treated within the treatment plant the water is delivered to the buyer through a system of pipes and valves, referred to as the distribution network. This water can generally have low murkiness, a pH of 6.8 -7.8 and a residual Cl (chemical element halogen) concentration of 1.0 -

1.2 mg/1. the amount of concentration depends on the length of the pipeline to the primary shopper World Health Organization should not receive over zero.5mg/l. This level of the residual chemical element is going to be adjusted consistent with consumers' activities. The last shopper ought to receive not but zero.20mg/l at periods of most consumers. The medical care system ought to even have the capability to alter emergencies like outbreaks of water-borne diseases, massive water demands, as an example, pipe breaks, fires, repair work. Before a replacement distribution system is a place into service, it should 1st be physically cleaned out. Another drawback space is that of "dead ends" like hydrants. These will cause a growth of bacterium because of the dearth of a residual chemical element. Routine maintenance needs that the hydrants be opened sporadically to flush out these dead ends.

3.10 Simulation of chlorine in water distribution networks

The degradation of water quality in the distribution networks has a significant impact on human health and public acceptance of the tap water it produces. Residual chlorine should be maintained on the mesh tubes to prevent contamination and regrowth of microbes. EPANET 2.0, a free online interim software package developed by the US Environmental Protection Agency (EPA) to simulate the depletion of residual chlorine by water distribution systems, reconcile the water age, and assess the feasibility of the use of water as a calculation and monitoring tool estimate and predict the concentration of chlorine at different points in the water network. In addition, EPANET showed that for the community of waters interested in this aspect, chlorine concentrations at Community limits did not circulate at 0.5 mg / l.

Chlorine used in water treatment

The most well-known use of chlorine in water treatment is water disinfection. It has weaknesses as a disinfectant, but it also has advantages. Unique disinfection strategies, including ultraviolet and ozonation, are active disinfectants. However, they no longer contain residues that would prevent the growth of pathogens during chlorine. Although the flowers to be reconstituted are far from the place of use, chlorination is the ideal way to provide safe water to the end user. For safety reasons, municipal water suppliers usually check the amount of chlorine left in the water after arrival. The remaining requirements are different, but the target concentration remains between 0.2 and 1 mg / l.

Similarly, for disinfection, chlorine can be effectively used for the oxidation of iron, manganese and hydrogen sulfide to facilitate their elimination, reduce the color of the water and provide a useful source for repair strategies such as sedimentation and filtration. Natural chlorine is often not used for water treatment. The three most commonly used materials containing chlorine used for water purification are chlorine gas, sodium hypochlorite, and calcium hypochlorite. Choosing the type of chlorine often depends on the price, it must have garage options and the required pH situation. Chlorination effects. Chlorine gas is green-yellow, heavier than air and high toxicity makes it a quality water disinfectant. However, a risk to human's international organization agency handle with it, and a cause respiration annoyance and may worsen pores and skin and slippery membranes and should cause death with enough packaging. as a result of chemical modifications that occur whereas its miles delivered into the water, gas isn't any larger toxicant to people whereas accustomed treat ingesting water that totally different arrangements of the gas. gas fuel, that's really bought as a compressed liquid, is that the smallest amount luxurious type of gas.

3.10.1 Chlorine Demand

This is the amount of chlorine that must be added to water to produce an excess of chlorine or chlorine residue after reacting with the contaminants in the water.

Handling of Chlorine: -Chlorine must be handled carefully as it is a dangerous substance. Specific safety standards must be adhered to from manufacture to final point of use. Personnel who are required to handle this material should receive proper training and must be equipped with protective clothing such as breathing apparatus, face masks, goggles, gloves, and the facility using chlorine should be equipped with a downpour shower and eye washing facilities.

Effects of high iron on water

Small amount iron is not harmful. Iron in drinking water is classified as secondary impurity according to the US Environmental Protection Agency (EPA). This is as a result of iron usually carries with its bacterium that feeds the iron to survive. bronzed diabetes will result in hemochromatosis, that ends up in the liver, heart and exocrine gland harm, and additionally to the sickness polygenic disorder. Early indicators embrace fatigue, joint pain, and weight loss. Excessive iron is rarely recommended for digestion; This will lead to abdominal problems, nausea, vomiting and alternative problems.

CHAPTER 4 MATERIALS AND METHODS

4.1 DESCRIPTION OF THE STUDY AREA

4.1.1 Ethiopia

Ethiopia, a landlocked country located in the horn of Africa has an area of 1,104,000km2. It is a land of cultural diversity, great geographical and natural beauty place with borders Somalia and Djibouti to the East and South East, Sudan to the West and South West, Eritrea to the north and Kenya to the south (CSA, 2011). The national capital city is Addis Ababa.

Ethiopia is a country of topographical differences from 116 meters below sea level in Danakil depression to more than 4572 meters above sea level in the mountain's regions. Ethiopia has many agroeconomic areas and three main environmental zones: tropical rains, with a height of over 2500 meters above the water. The dry environment with warm and low ground up to 1500 meters above sea level and a warm temperate humid region between 1500-2500 meters above average sea level.

4.1.2 Durame Town

The Durame town is located in Kembata Tembaro zone in SNNPRS at a distance of 125km west of the regional capital Hawassa, 350 km south of Addis Ababa through Shashemene and 298 km via Hossana side road. The town originates at the coordinate of 7o 14o north latitude and 370 350 east longitudes. At present, the total area of the town is 2006ha in an administrative boundary. Out of this only, 400 ha accounting for 20% is constructed up while the remaining area is used for urban farming (Durame, 2017).

Location of study area

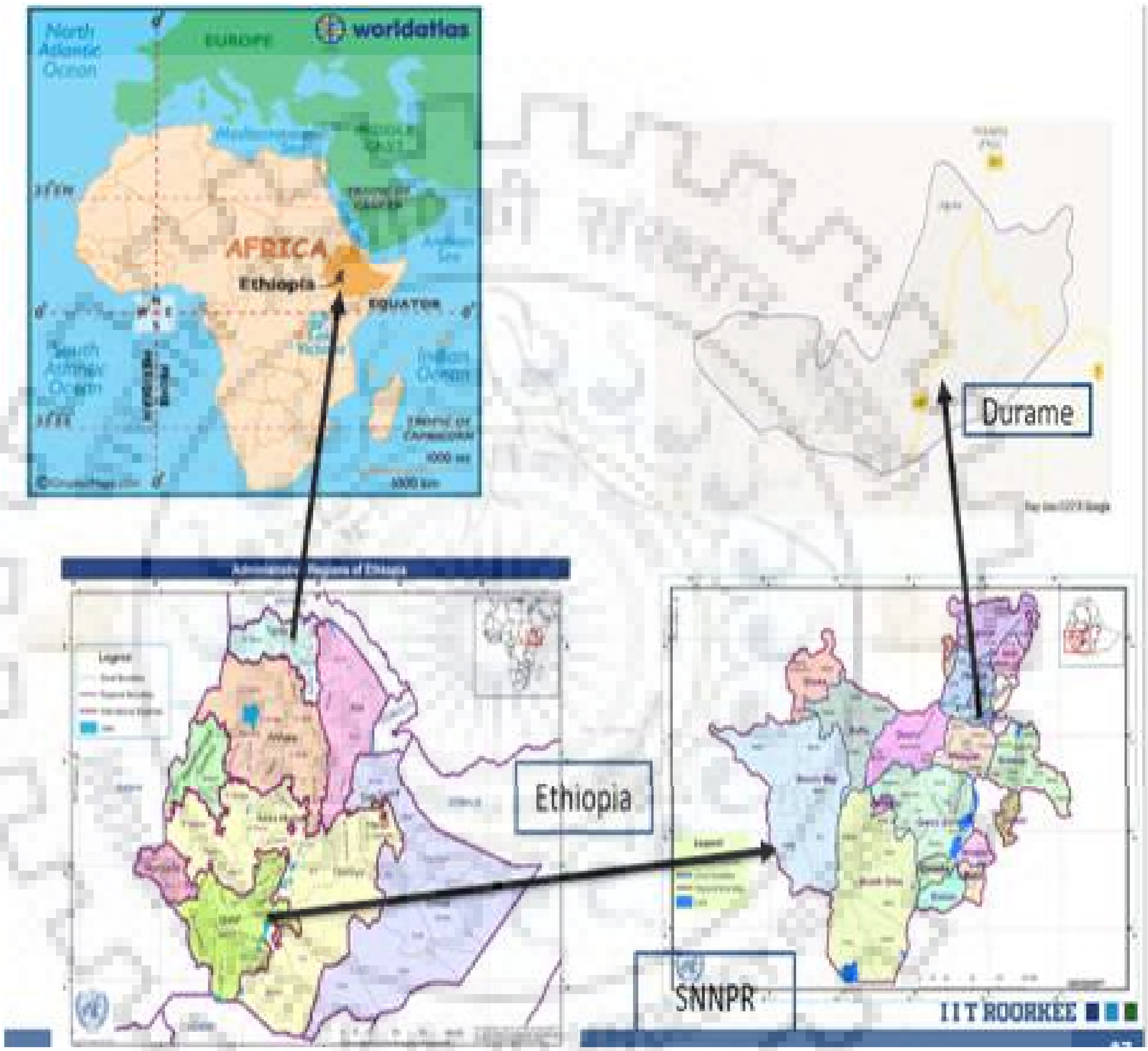


Figure 6.Location of Durame town

Topography

The topography of Durame town is varied consisting of a gently sloping area at about the center following the main road which falls to the west and east and rises again. In general, the town has topography bounded by Ambericho Mountain in the north and also contains small hills and elevated areas. The elevation of the town ranges from 1990-2290m MSL and the topography of the town has a higher elevated area at about the geographic center of the town and then falls down to the boundaries of the town in the northeast and southwest and west. The elevation of the town decreases in all directions from the center except the northwestern part of the town.

Climate

As a consequence of its topography, within the Ethiopian situation, the town of Durame experiences cool temperate climate. According to the traditional temperature zone arrangement of Ethiopia, (Which is based on altitude) the town is found within the "Wonia Dega" Agroecological zone. The maximum temperature is between July and September (NMA, 2016). The air is regularly humid as a result of plentiful vegetation cover and enough rainfall. Durame gets rainfall almost throughout the year. The annual rainfall is 1200-1350mm (ZOFE), and ranges up to 2000mm. The highest rainfall is recorded between July and September and the lowest rainfall happens between November and February which and relatively dry months of the year.

Demographic Characteristics

The study area is characterized by repaid population growth similar with other parts of Ethiopia. Currently, according 2017 of towns and zone finance report of population size when interpolated about 52000 of which 22956 males and 29044 females. The main livelihood of the population is based on small scale trading of agriculture products and merchandises for which the town council is currently supporting through trade extension development program. The majority of the inhabitants are Protestants which consist 86.52% of the population, 7.39% Orthodox Christianity and the remaining 4.93% are others (CSA, 2014).

4.2 Methods

4.2.1 Flow chart of methodology

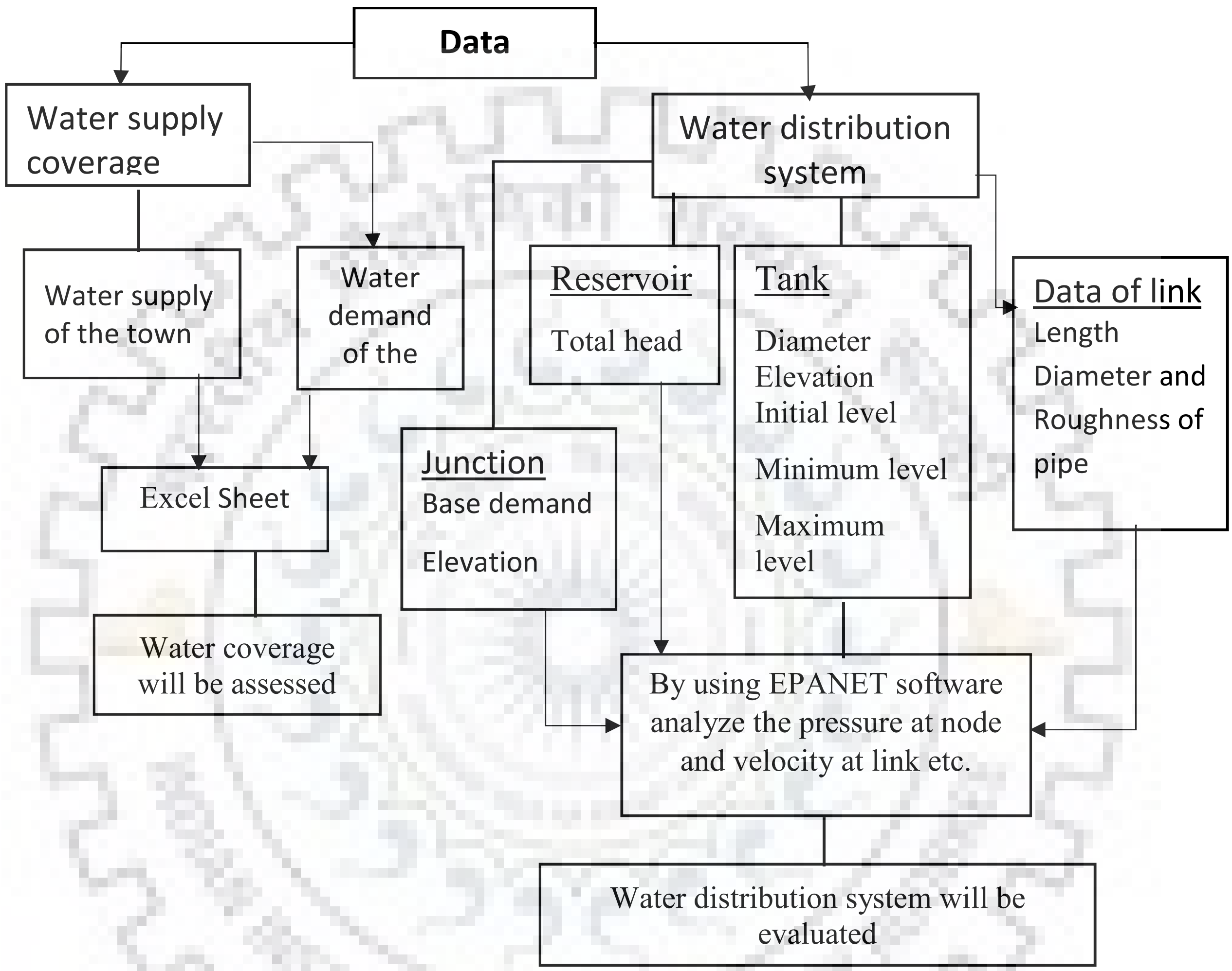


Figure 7.Flow chart of methodology

4.2.2 Data source

Data are collected from direct observation and secondary data will have collected from published and unpublished documents, maps, plans, journals, magazines, books, standard documents, statically information and other related material collected from different sources, etc. are very important to study water supply situation and used to evaluate the overall system in the distribution. The major source of secondary data includes design document in DWSSO, population data from Zonal Finance Office, and regulations from the Federal Minister of water.

Durame new water supply design documents from consultants of DWSP and related literature. Information on organizational structure, manpower situation, and water system detail were collected from the water supply sector and related literature. Policy and related information were collected from proclamation, regulation, guideline, and strategies as a secondary document.

4.2.3 Existing Water Supply System

Water sources

The suitability of water source to meet the basic water demands of Durame town population up to the end of the calculated design time is an important aspect to be considered in interpreting the sustainable water supply facility. The source of Durame water supply are two bores (Wota ad Ekamo) hole with the discharge of 36.5l/s and are located at about 1km and 2km respectively away from town.

Figure 8. Durame town road and water supply distribution network

Distribution Network

The current distribution network is designed by considering the safely and economically capacity to resist the Peak hour demand of the the day . The engineering design of the distribution network has been sketched based on the existing residential block settlement pattern and topographic suitability. The current Schematic layouts showing the proposed pipe distribution network are presented in the drawing.

Table 2.Summary of distribution pipe material, diameter and length.

Pipe material	Diameter(mm)	Length(m)
UPVC	200	70
UPVC	150	950
HDPE	125	1825
HDPE	110	1785
HDPE	100	1550
HDPE	90	2940
HDPE	80	5441

The water distribution network is available in Autocad software having the following system informations.

- The existing water distribution network Layout.
- Pipeline data like material type, size, and length.
- Locations of other system components like reservoirs, tanks and valves in the network.

Service reservoir

The current number and size of service reservoir are determined based sizes of the defined pressure zones, topographic suitability, size of the area selected for reservoirs construction, availability of standard reservoir sizes and the volume of water which has to be stored for demand fluctuation purpose. For this specific project, the capacity of a service reservoir is determined based on the commonly used simplified empirical method by taking 30 to 40% of the maximum day demand (El-Samadoni, 2015) at the end of design periods. The net capacity of service reservoirs required for the town are 600m3 and 300m3 for north and south part of the town respectively.

Figure 9.Water supply tank information of the system

Table 3. The above information where collected from DWSS

No	Schemes	Base Elevation(m)	Capacity (m^3)	Tank Diameter(m)	Height (m)
1	Concrete Service Reservoir	2088	600	13	7
2	Concrete Service Reservoir	2015	300	10	4

Pump Characteristics: The pump is a device used for the water distribution system in supplying external power to push water for the consumer or service reservoir in the case of the topography is not favorable for gravity delivery.

Table 4. Pump and power generator capacity

Pump	Pump Head(m)	Pump power(KW)	Power of generator (KVA)
Pump 1	265	116	178
Pump 2	224	263	405

Source from DWSS

For head loss Hazen-Williams coefficients have been collected for different age, diameter and type of materials will be different.

Table 5. Hazen Williams Coefficients

Pipe	**Pipe Material**		
Pipe Status	UPVC/HDPE	Steel	DCI/GI
New pipe	130	101	120
Existing	100-110	100-110	100-110

Source: Urban Water Supply Design Criteria (MoWRD, 2006)

Transmission Mains

The transmission lines of Durame water supply can be characterized into two direction bore holes. The northern part of town mains which conveys water from the Wota sites to the network after pumping from borehole until it reaches to KMG 600M3 concert reservoirs with transmission line of 3265m length and diameter of 125 mm PVC pipe. This system provides service to the northern parts of the town. However, later concert reservoirs at the southern part of the town were constructed to supply the southern direction of the town direction by pumping from borehole until it reaches to Danshe 300M3 reservoir. Generally, both bore holes comprises two pumping station, two transformer and two generators.

Table 6. Table of pressure Line

Description	Unit	Total
Length of pressure line	m	3625
Flow from both raising mains	l/s	36.5
Diameter	mm	125
Material Type	type	UPVC

Figure 10. The left side is UPVC type and the right side is HDPE

4.3 Major identified problems of Durame town water distribution system

4.3.1 Topography

In general, the topography of the study area is characterized by the highest elevated Ambericho Mountain of 3028 meters above mean sea level and its undulating topography in the high land and plain topography in lowlands. Topography of Durame has been a challenge for many years to equally distribute water to the customers. The following map shows the contour, nodes, main distribution network, borehole and two service reservoirs of the town.

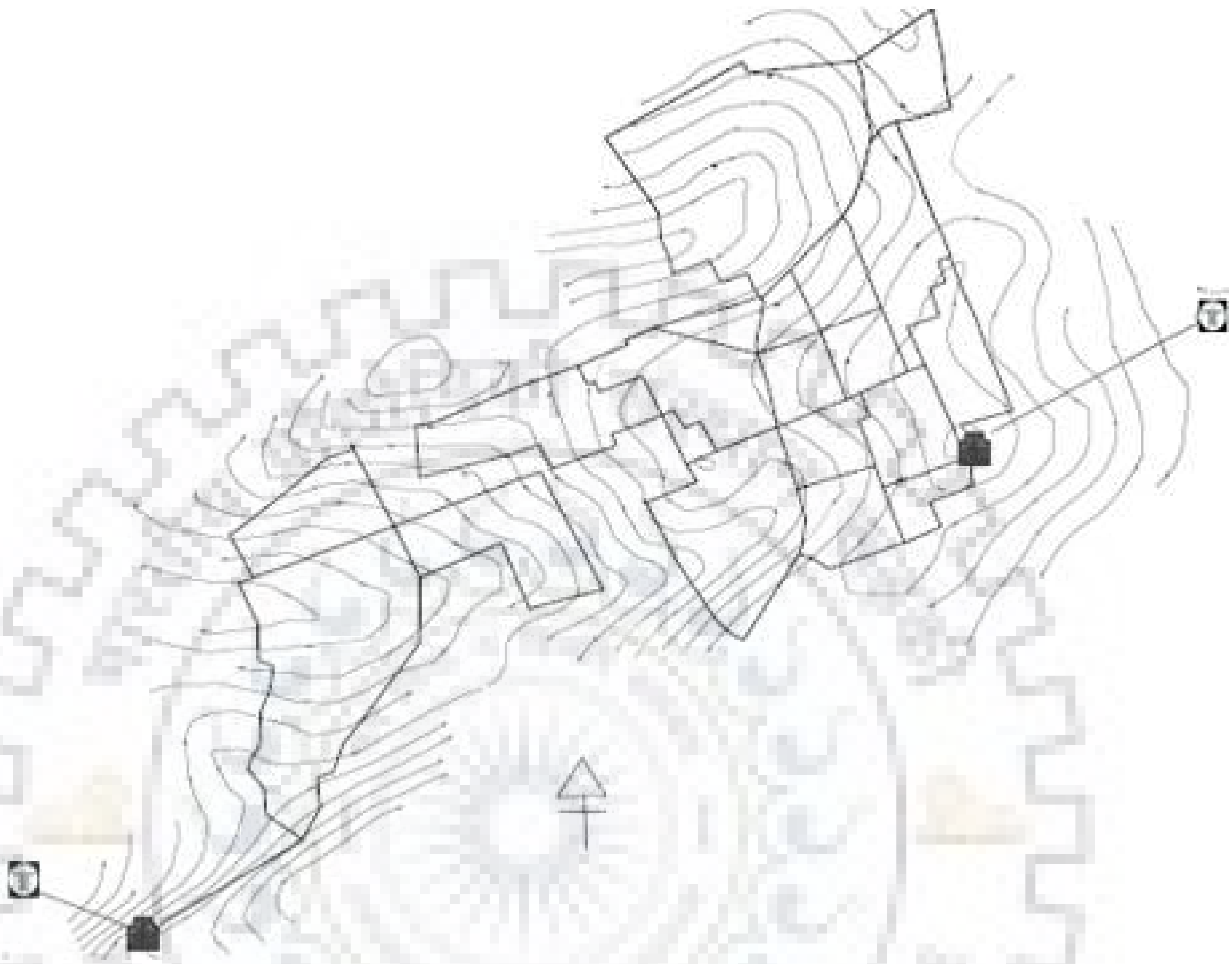


Figure 11 Durame town water distribution network and contour

4.3.2 Quantity of water

According to the Ethiopian water Resource Management policy, any water sector in medium town should provide 70l/d potable water with acceptable quality and adequate quantity. Consequently, the majority of the household user of piped complain that the system has water only twice or three days a week. On average the town experience insufficient water supply for 209 days per years, while countries on southeast Asia and Pacific experience only 3.5 days of interval per year (ADB 2008:5). Production-consumption analysis confirmed that daily production with the assumption of no interruption in the system was 2890m3/day. The per capita consumption pattern on the average per capita is 36.5 l/day which is far below the standard.

4.3.3 Population pressure

In the future, the demand and supply may not be matched in order to meet the future water demand, either expansion of the existing water supply system or developing new water supply sources are important. The present water source, the borehole has been constructed for not more than 35,000 population. Currently, the town has a population of 52, 000, this figure was taken from town municipality. The rapid increase in this figure might be due to the expansion of town administration politically and student who are coming from the different region as per the allocation of the government Industrial College and Durame University campus.

4.3.4 Technical Factors

Demand analysis should consider into account; the standard of living, seasonal activities, currently served the population, long time forecast planning, the tariff of water supplied and the accessibility of water facility always a mismatch between town water production and consumption. Another problem in the water supply is that once the town water distribution system was constructed there were no major expansion works that were executed. There were no major expansion works undertaken, minor expansion works at the request of the beneficiary was done by sector. In reality, the decision to expand the existing system should be made by calculating the existing water production and comparing with consumption. If the existing production is greater than and sufficient quantity to supply the demand, the decision would be made to expand the existing system. Otherwise, simply elongation of the pipe at the request of the customer is a useless expansion simply to enjoy customer which leads most of the pipe to run dry.

4.3.5 Institutional factors

Sustainable operation and management of the water supply schemes can only be achieved if appropriate organizational structure and management systems are put in place. Thus, an appropriate organizational structure has to be developed and implemented parallel to the system improvements. In developing organizational structure various factors should be considered. Among the factors that influence organizational structure, policy and proclamation are the most important and should be considered in developing a new structure. Organizational structure provides a useful frame to organize the workflow in an organization. However, to ensure the work objectives achieved, supportive processes like human resource development system need to be put in place. The institutional framework of the management and administrative structure of the town drinking water supply service enterprise are organized into layers.

The role of organizational technical skill man power capacity in water supply sector

Sustainable operation and organization of the water supply distribution can only be attained if the proper administrative structure and control systems are put in place. Thus, the applicable organizational structure has to be developed and implemented parallel to the system improvements. In developing an organizational structure, numerous factors should be considered. Among the factors that influence organizational structure, policy and proclamation are the most important and should be considered in developing system structure.

In the SNNPR government proclamation provided the institutions of urban water supply service as independent public entities administered by generating their own income in the Region. The significance is that the water service will perform all function independently with limited supervision and support from the Government. As results, the following functions are considered as the major activities of an urban water supply institution.

- Forecasting of the water supply for recent and future demand
- Conducting water supply study and design
- Administration of the water service
- Providing water supply service
- Conducting maintenance of the facilities
- Collecting water service fees and Conduct procurement of goods and service and formulate tariff

Organizational structure provides a useful frame to organize the workflow in an organization. However, to ensure the work objectives achieved, supportive processes like human resource development system need to be put in place.

4.4 Modeling the water distribution system

To analyze and improve the existing water distribution system, a model will utilize using EPANET software to search, evaluate, solve the problem and to simulate by using extended and steady-state period simulation.

4.4.1 Standard for pressure and velocity

For pressurized is one of the main criteria considered in a water supply distribution network. In a consumer's connection of distribution network, the problem pressure is not as the main problem like transition long distance pipes. is not more, in fact, the minimum pressure in the distribution system should be 15m and maximum pressure 100m according to world bank guideline (MOWR, 2013). A standard velocity standard established for style functions for 2 reasons. The distribution system has minimum velocity needed to reduce balance water stagnation inflicting geological phenomenon and bacteriologic growth within the conduits. On the opposite hand, the most rate within the network is sweet for the regulation of head losses within the provide points furthermore on minimizing the outcomes of loud noise or hydraulic. The velocity of flows in the distribution line between 0.3 m/s and 2 m/s (MOWR, 2013).

4.4.2 Modeling the existing distribution system

To analyze and improve the existing water distribution system, a model will utilize using EPANET software will be applied to solve the problem and to simulate extended state and steady period simulation.

4.4.3 Base demand

Population-related studies are usually conducted for the implementation of various development projects in the country. The Town and Kebele Administration counts the population periodically. However, the central statistical Authority (CSA) is the recognized Ethiopian Authority to determine the official population figures and growth rates. The population figure of the Durame town and by the water resource development office and (CSA) is reported as 52000 for the current year.

4.4.4 Population projection

To project the population, as a base year population figure obtained from the Durame town administration office and the growth rate of SNNPRS housing census of Ethiopia result have been used. Accordingly, for the projection of population, the following exponential growth model is used.

$P_n = P_o (1+K)^n$

Where; P_o=initial population

K = percentage (geometric) increase

P_n = population at n decade or years

n = decade or year

Table 7. SNNPR growth rates source DWSS

YEAR	URBAN GROWTH
1995-2000	5.30%
2001-2005	4.80%
2006-2010	4.60%
2011-2015	4.30%
2016-2020	4.10%
2021-2025	3.90%
2026-2030	3.70%
2031-2035	3.5%

4.4.5 Model representation and data entering

All the distribution system components model skeletonization has been sketched and data will be entered into the skeletonized water distribution network. Selection of pipelines for modeling was based on the primary line, all pipelines of the system will have a diameter greater than or equal to 80mm. The following steps are considered.

- In accordance with the requirements of the model, a node was located at all points where the pipeline diameter changed or where three or more pipelines joined.
- The gathered data were entered into the sketched EPANET model.
- The ground elevations of reservoirs, tanks, nodes, pumps, valves, and other locations were entered throughout the system.
- A peak hour demand has been allocated to nodes using a simple unit loading method, the number of customers that contribute to the demand at every node. By careful examination

- of the distribution system, the entire demand has been allocated to a node or combination of nodes, as appropriate.

Hence, the distribution system has been configured for each sub-pressure zone by carefully identifying the location of high domestic and non-domestic customers

4.4.6 Data Analysis

The data collected for the functionality and utilization of the water supply distribution system at the town level of the study areas have been analyzed by using EPANET model for determination hydraulic parameters of existing design water distribution system. The hydraulic Network of the water supply Distribution system and the town water supply design has been analyzed for the present situation. During data analysis, the nodal pressure and pipe link velocity have been determined to identify high or low-pressure zones areas of the node/junction where the pressure is higher or lower than the design criteria of the system network. These findings of hydraulic Network of the water supply and distribution system of the town bring the suggestion and recommendations that will help to improve the water supply system in the future.

The analysis that was done in this study is summarized as follows:

- Development of scenarios for water distribution networks. The layout of the water distribution system is based on the basic needs, elevation and heading data of Northing and Easting Junction, Source and Tanker, as well as piping data in the EPANET software connections.
- The existing network for the design of water resources was actually evaluated on the basis of the existing situation in the various parts of the network.
- Determine the pressure drop, flow rate, and water distribution pressure with EPANET.
- Estimation of distribution / pressure, speed, exit parameters, time / procedure change.
- Check the pressure in the node in all distribution systems, especially in the lower and upper points of the distribution system.
- The water supply system has been redesigned as a continuous supply depending on the fixed and extended model, assuming the availability of water resources and the use of pressure reducing valves to reduce the high pressures in the system when the pressure of the distribution system is higher than the pressure system limit or the design parameters may be higher than the design criteria.

- At high pressure, the area lowers pressure by providing a pressure drop box or pressure reducer in the tank.
- Finally, the recommendations and conclusions were based on the results and discussions of this study.

4.5 Durame existing water quality

Water quality test carry out by regional health bureau revealed that most of the mineral and ions in the water are in compliance with WHO standard. However, the iron concentration at boreholes are on the far side the UN agency customary maximum allowable concentration is 0.3mg/l.

Gathering water from unprotected source

Some percentages of the population collect water from an exposed source such as dug well and unprotected spring. The observation of these wells is not constructed properly, no effective build work at the top of the well, no concrete band inside the well and no manhole cover constructed. Consequently, dirt, debris, runoff, etc. infiltrate to the well and contaminate the water. In addition, people and animals fall in easily and lose their life. No quality examination was undertaken whether to use it for drinking purpose or not. In general, residents that are using these sources are liable to water born and related disease.

Figure 12**.** Hand excavated well with no proper construction of some private users.

Table 8.WHO water quality standard and Durame current water measured results**.**

Current Durame town water quality		WHO water quality standard	
parameter	Approved result	Some parameter	Maximum permissible level
Chlorine residual	0.2 mg/L	Chlorine residual	0.2 mg/L
Iron	0.35 mg/l	Iron	0.34 mg/l
Turbidity	1NTU (Nephelometric Turbidity Unit)	Turbidity	1 NTU (Nephelometric Turbidity Unit)
PH	7mg/l	PH	7mg/l
Fluoride	0.4 mg/L	Fluoride	0.5 mg/L
chlorides	220mg/l	chlorides	220mg/l
Hardness	58 mg/L	Hardness	60 mg/L
Manganese	0.45 mg/L	Manganese	0.5 mg/L
Sulfate	155mg/L	Sulfate	200mg/L
Aluminum	0.1mg/L	Aluminum	0.1mg/L

In the figure above shows that most of the parameter in the table like turbidity, chlorides, fluorides, manganese etc. are acceptable limit of who and other known standards, but iron is above the limit so that the water before reach to ser needs aeration.

Chlorination

Most of the time underground sources are fit for dinking without much treatment, but it may be contaminated during transporting from source to the users. Because Cl in its varied forms is systematically and virtually usually used for disinfecting community water provides. it's reliable, cheap, straightforward to handle, simply measurable and specially, it's capable of providing that residual disinfecting ability for long amount, therefore affording complete protection against the longer-term recommendation of water within the distribution system. Its disadvantages are, that employed in bigger quantity, it imparts a bitter and dangerous style to the water.

Table 9. Amount of chlorine to be added for the following known data.

Population to be served	=52,000
Average water demand	=36.5lpd
Chlorine content in bleaching powder	=30%
Chlorine dose for disinfection	0.3ppm(0.3mg/l)

Amount of chlorine required daily (based on average annual consumption) calculated as

$$= 0.3mg/l * 1.89Mlpd$$

$$= 0.56Mmg = 0.56Kg$$

If the chlorine bleach powder content is 30%, which is why 100kg contain 30 kg chlorine bleach powder. Therefore, the amount needed at the end of the powder on the basis of each day's work is take as the annual average.

4.6 Human capacity of Institution and sector structure

Water supply policy in Ethiopia

Drinking water human rights and main issue for their governments are responsible for the safety of citizens with water. These responsibilities have different care mechanisms constituting water security right to sufficient, safe, physically available, reasonably priced and acceptable water for personal and household uses (Minwuye, 2015). And the water resources management plan to cover the urban centers of the state of siege maintenance of rural water supply and the establishment of the operation. Importantly, the financial requirements to accomplish water supply and sanitation targets are primary on the capacity to implement the approaches outlined in policy (MOWR, Federal Democratic Republic Government of Ethiopia Minister of Water Resources , 2003).

The minister of Resources on the water supply and drinking water included in the Management Section policy are clearly explained in detail in the 1999 Institutes of Laws in the absence of their financial, technical, and administration of the fact that the problems are spent. Identification and support from the drinking water supply, with the provision of exercise of power care.

Some of the detailed objectives of water supply and sanitation policy include:

- Provide healthy and sufficient water for everyone
- Perform operations and maintenance of water and sanitation facilities on the property and under appropriate conditions.
- Encourage the use of long-term water resources through the protection of water resources, the effectiveness of further water use as waste management.
- Creation of real institutional capacity in terms of the formation of human resources, development, regional legislation and regulatory frameworks for water and sanitation.
- Generating contributory setting for promotion of acceptable sanitation services (MoWR, 1999).

Institutional arrangements for water service delivery in Ethiopia

According to the Federal Water Resource (MoWR, 1999) and Sector of water supply strategy (2001), the following institutions and institutional arrangements, are accountable for the delivery of water supply services as shown in diagram below.

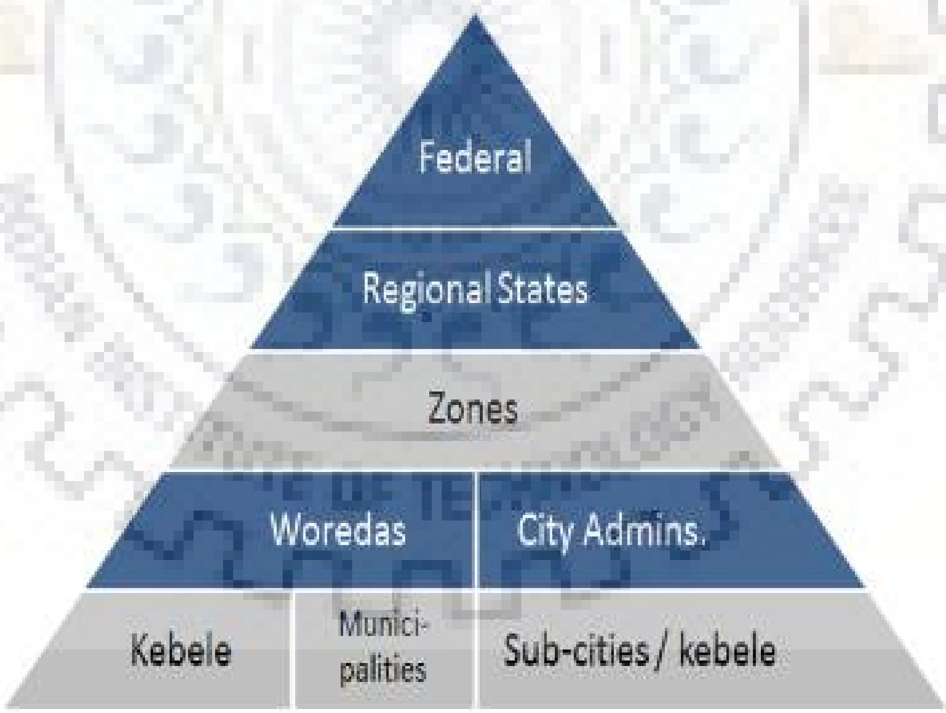


Figure 13. The governmental structure institutions of the Ethiopia.

The disciplines necessary for the success of the water sector are needed to meet the needs of customers such as natural sciences, geologists, plumbers, plumbers, sanitary engineers, and social sciences. Commitment and cooperation between groups of institutions and various sectors required for coordinated planning and implementation of activities. Ability to identify and provide appropriate and economical water technologies, services and infrastructure products through sustainable research, investments and management (Wallece.el, 2008).

4.6.1 Ministry of water resources

Roles and responsibilities in the Ministry of Water Resources

- Responsible for formulating national water policies, strategies and work plans, and for defining national water quality standards, water infrastructure and other related standards.
- is responsible for managing and monitoring the implementation of policies and strategies across all vertical sectors.
- Provides technical support to regional water offices.
- Organizing and facilitating the involvement of the private sector in water supply and raising private sector awareness of business opportunities.
- Facilitate and develop local spare parts production.
- Prepare training programs for officers and waterworks experts

4.6.2 Regional Water Resource Development Bureaus

Some of the roles and responsibilities associated with regional water resources offices

- Make available technical support for lower levels (Zone and Woreda) and build efforts to assure available water for the community is reliable, adequate and potable for drinking.
- Based on the requirement of water supply sector regional water office sets standard guide line on the payment of bill collection tickets for sell at Woreda level. Facilitate and distributes bill collection tickets when requirements and delegation come from Woredas sector.
- Promote the awareness of the private sector to participate in the business opportunities of sector.
- Prepares necessary training programmes for water supply sector of Zonal & Woreda experts.

4.6.3 Zonal Water Resources Development Offices

Some of the roles and Responsibilities of Zone Water Department

- Provide necessary technical support to vertically down sectors Water Office in the preparation action plan, budget.
- Responsible for the organization of activities, the collection of planned activities of woredas and the facilitation of links between the regional offices of water and woreda water offices
- Zonal Water sector are the make communication links between Regional Bureaus and Woreda Water Offices

4.6.4 Woreda Water Resources Development Offices

Roles and Responsibilities of Woreda office

- conducts all regular performance activities which direct contact to customer and utilize time and budget effectively.
- Collect the bills and check finance requirements to sustainable utilization of the water supply schemes
- The office shall enable the maintenance of water points through pump assistants.
- Seriously follow the water quality status of rural water supply structures and undertakes disinfection. (MoWR, 1999).

CHAPTER 5 RESULTS AND DISCUSSION

5.1 Water coverage trend

The past, present and future water supply and demand of the Durame town was access, according to the assessment result the past trend shown that the amount of water supply for the water consumption of Durame town was enough to satisfy their need, hence at that time the water demand of town was relatively equal with the water supply. Then the fast growing of town where increase items of the number of populations and development of the town. The increasing population of the town was applied to increase pressure on the water supply of the town. However, the water demand of the town increase with constant water supply this enhance the gap between water supply and water demand was in high percentage in the last seven years. Besides the deficit of water, supply utility has the main problem related to technical, institutional, manage mental and economical. Among the technical problems many pipes, valves, pumps, reservoir were old and its mechanical reliability is very low.

Furthermore, the assessment result indicate the water supply network covered and concentrated to the central part of the city (i.e. due to development of town the land area of town is larger than previse so that many areas far from the central part still has not connected to the water distribution system and water was not delivered to them. Although the small explanation of the water pipe network and source it was not ought to resist the fast growth of population and development of the town. So that still significant of the population of the town use water from an unprotected source such as hand dug, pond and river.

5.1.1 Population projection

For the projection of the population, Medium town growth rate given in the 1994 population and housing census of Ethiopia result for SNNPR have been considered.

For projection the exponential growth rate model has been used.

For projection the exponential growth rate model has been used.

$$P_n=P_o\,(1+K)^{n}$$

Where;

P_o=initial population

Pn = population in decade or years

n=decade or year

k=percentage (geometric) increase

Table 10. projected population Base population source from DWSS

Year	2017	2020	2025	2030	2035
Growth rate	4.3	4.1	3.9	3.7	3.5%
Population	52000	56568	61301	65921	79052

In the above table shows that when year increases population growth also increases. In 2017 the population is 5200, but 2020 the population grows to 56568 and in year 2035 the number increases to 79052.

5.1.2 Population and average water demand projection

Access to the water system can be judged by the amount of water consumed and the degree of connection. To estimate the water consumption, the annual water consumption is converted into the average daily per capita consumption via the population statistics for each zone.

Table 11.Trend of water supply Coverage of the town

Year	2015	2020	2025	2030	2035
Population	47000	56568	61301	65921	79052
Demand(m3/d)	3290	3959	4291	4614	5533

Population growth and urban expansion is becoming a worldwide challenge to satisfy urban infrastructure mainly in the developing world like Ethiopia. According to Durame town administration survey of 2015, the population of the town was 47000 in 2015, 56,565 in 2020, 61301 in 2025,65921 in 2030 and predicted to be 79052 by 2035. This indicates that without immediate balancing actions are taken in the provision of water supply infrastructures to meet the demands of a rapidly increasing population, the condition may be found worsening from time to time. Hence, because of the serious issue of future, every concerning body should give attention to the issues and develop strategies on the problem of service provision should be increased to out from cope up due to high population growth and urbanization rate.

The distribution of water supply services is assessed using these numerical tools. The consumption distribution was first checked using a histogram, as shown in the figure

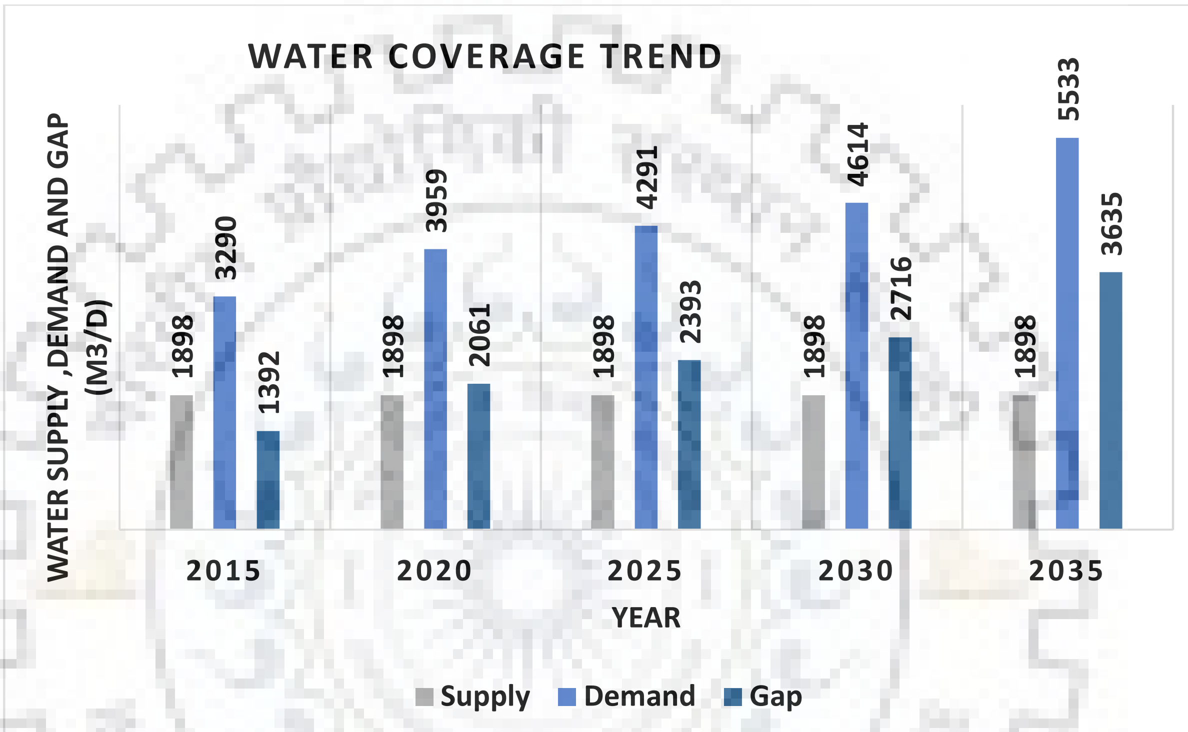


Figure 14. Water coverage trend from year 2015 to 2035

The histogram shown in the above describes that water demand increases from time to time but supply of water is the same each year. In the above figure year 2015 water supply capacity was 1898m3/d and the same supply also in 2019.With average scenario if we forecast 2035 population will be 79052 and demand of source will be 5533m3/d and supply demand deficit increase about 36353m3/d which implicates that if no other sources supposed to be added, there will be high tendency of happening unbalance of water supply and demand needs serios attention for future.

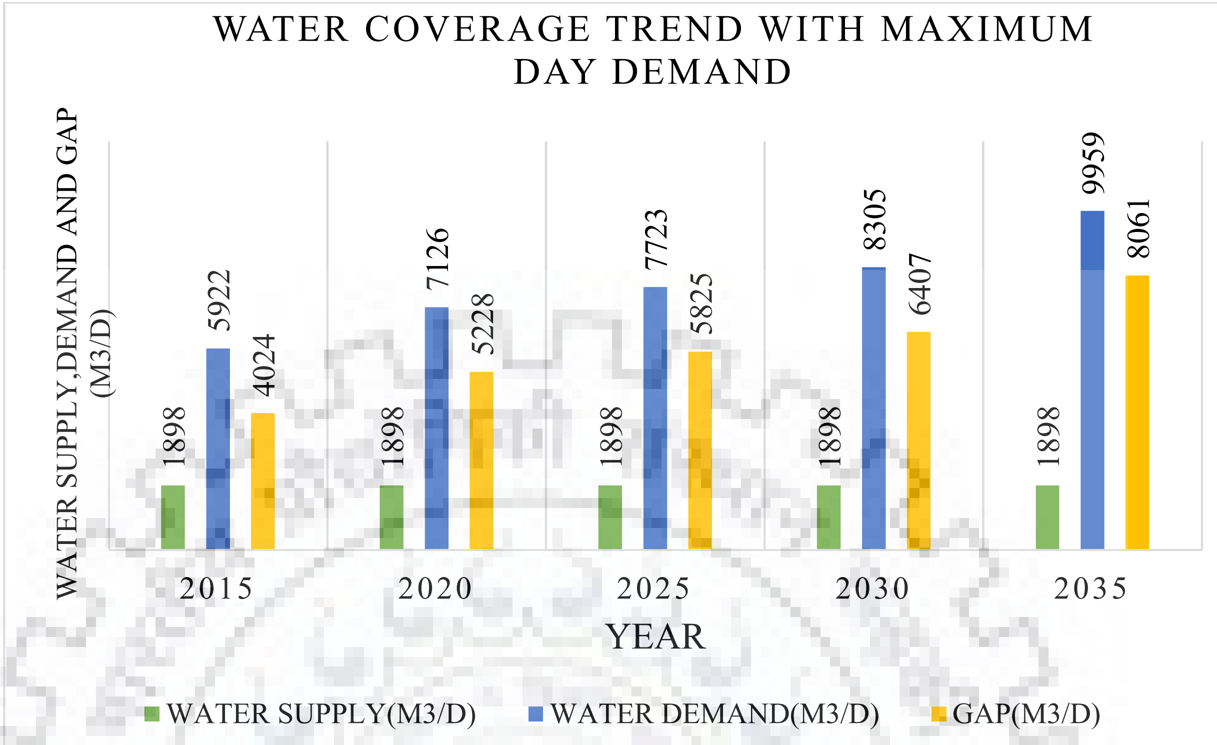


Figure 15 Water coverage trend from year 2015 to 2035 with maximum day demand

In the above figure year 2015 water supply capacity was 1898m3/d and if the same supply will be delivered in 2019 shows water coverage future situation. With maximum day demand scenario if we forecast 2035 population will be 79052 and demand of source will be 9959m3/d and supply demand deficit increase about 8061m3/d which implicates that if no other sources supposed to be added, there will be high tendency of happening unbalance of water supply and demand needs serios attention for future.

5.2 Durame town water supply sector institution structures

Durame water supply institution structure is arranged from top to bottom to perform decisions with hierarchy, in the chain of line the top is water supply board and then next water supply sector manager. The sector divided in to two main Cor process and one subordinate process. All core process coordinated to function similar works with necessary discipline.

Durame town water supply sector strucutre

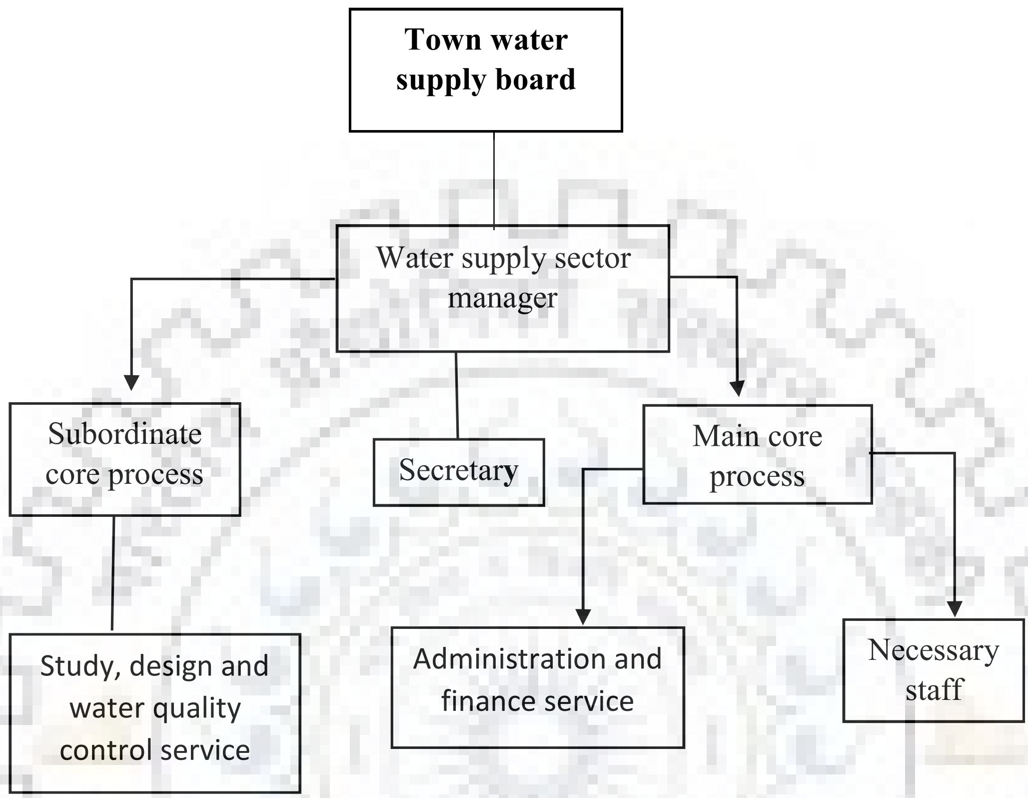


Figure 16.Existing organizational structure of Durame town

5.2.1 Problem in organizational structure of the town

Concerning to the management system of the office, there are no updated administrative procedures, guide lines and working manuals for uses by both the management and the employees of the water institution.

The DWSSO has set its vision, mission and objective reports, however, it hasn't yet settled and implemented service delivery progress on the organization. Due to this reason, the activities carried out by sector staffs have very little relationship to the mission and objective set and not aligned with the interest of the customers.

Looking at the internal operation of DWSSO, clear delegation of duties and responsibilities among and between employees is lacking, and also relationship between staff members, the management and the town water board have not been clearly defined. Job description, duties and responsibility of all personnel including the General Manager are not fully developed and documented.

5.2.3 Standards of sectorial technical non-technical staff situation

The staff includes general manager, customer service team, design and water control service, finance administration and other services. In Ethiopia SNNPR regional state medium towns water supply sector manpower standard as shown below.

Table 12.Durame water supply sector existing staff situation Source: DWSSO

No	Team	Standard man power as per manual	Existing man power in sector	Vacant (without manpower)	Deficit in percentage
1	General manager's office	2	1	1	50%
2	Organization & Management Service	12	7	6	50%
3	Customer Service	2	1	2	50%
4	Administration & Finance	30	16	16	53%
5	Design, Study & Water quality control	4	2	2	50%

Inadequate manpower

According to the information from water supply sector human resource management coordinator the human power of the office requires 50 stuff members but currently only 27 employee which is 54% of the employee occupied and others still a vacant workplace. From all capacity of staff, only 4(8 %) are educated technical skilled professional workers (i.e. diploma holders and above) and others are grouped under support staff. From the above-skilled manpower of 4, only 2 technicians (50 percent) positions are still unfilled. In general, skilled manpower is necessary for the success of any institutional goals.

In the above table institutional manpower if we consider shows general office manager, organization and management stuff, customer service, water quality control, and other core processes are fulfilled by only half of power. From an organizational and supervision perspective, manpower composition of the water supply sector is not strong to function effectively and professionally.

In general, the Durame water supply sector is lack expert such as hydraulic engineer, designer, electromechanical engineer, planner, plumber, surveyor, and data manager. With the nonattendance of the above professionals accomplishing the task of the office effectively and efficiently might be difficult. Therefore, the offices should take care to adjust ask the reasonable question to the regional and zone offices to get the required manpower for their vacant work position so as to serve the community capably and efficiently.

5.3 Water supply distribution system

5.3.1 Summary of water demand

The revised and projected total water demand is summarized and presented in Table 4.4. Hence, the distribution system was configured for each sub pressure zone by carefully identifying the location of high domestic and non-domestic customers finally the hydraulic analysis carried out using EPANET software.

Table 13:Summary of Water Demand

Description	unit	Year			
		2020	2025	2030	2035
Total average day demand	m3/day	2065	2238	2406	2885
Maximum Day demand	m3/day	3717	4028	4330	5193
Peak Hour Demand	m3/day	5575	6042	6496	7789

5.3.2 Analysis of the Model

The water supply distribution system pipe lines are includes different length of pipe with its acceptable diameter size as shown below.

Table 14. The distribution system pipe length and diameter

Link ID	Length (m)	Diameter (mm)	Link ID	Length (m)	Diameter (mm)	Link ID	Length (m)	Diameter (mm)
Pipe P1	30	200	Pipe P23	120	90	Pipe 24	291	125
Pipe P2	300	150	Pipe P24	120	90	Pipe P35	2404	150
Pipe P3	90	150	Pipe P25	220	90	Pipe P2A	405	110
Pipe P4	195	125	Pipe P26	120	90	Pipe P4A	285	110
Pipe P5	145	125	Pipe P27	195	90	Pipe 47	555	80
Pipe P6	185	100	Pipe P28	205	80	Pipe P20	195	80
Pipe P7	65	110	Pipe P29	55	80	Pipe P17	390	80
Pipe P8	260	110	Pipe P31	400	80	Pipe P18	110	90
Pipe P9	265	100	Pipe P33	240	110	Pipe P30	400	80
Pipe P10	55	125	Pipe 42	595	90	Pipe 80	17	200
Pipe P11	605	80	Pipe 43	133.10	80	Pipe P51	478	80
Pipe P12	240	80	Pipe 44	400	50	Pipe P52	278	80
Pipe P13	230	80	Pipe 49	113.15	125	Pipe P32	980	100
Pipe P14	280	90	Pipe 46	267.31	110	Pipe 24	291	125
Pipe P15	295	80	Pipe 48	175.75	90	Pipe P35	2404	150
Pipe P16	240	110	Pipe 45	98.00	90	Pipe P2A	405	110
Pipe P19	20	90	Pipe 35	120	90	Pipe P4A	285	110
Pipe P21	200	50	Pipe P46	492.71	150	Pipe 47	555	80
Pipe P22	115	50	Pipe P34	1000	90	Pipe 50	277.93	110
Pipe HH	725	90	Pipe P37	1200	125	Pipe P45	628.67	125

The water pressure line and distribution main model has a total length of 14561m, which integrates with the following percentage.

- 200mm pipe of length 70m and covering 0.5%.
- 150mm pipe of length 950m and covering 6.5%.
- 125mm pipe of length 1825m and covering 12.5%.
- 110mm pipe of length 1785m and covering 12.3%.
- 100mm pipe of length 1550m and covering 10.6%.
- 90mm pipe of length 2940m and covering 20.2%.
- 80mm pipe of length 5441m and covering 37.3%.

The for modeling the hydraulic performance of the water supply distribution system we must consider the elevations, base demand by considering neighbor consumption are also very important which shown below.

Table 15 The distribution system node elevation and base demand

Node ID	Elevation (m)	Base Demand (CMD)	Node ID	Elevation (m)	Base Demand (CMD)	Node ID	Elevation (m)	Base Demand (CMD)
Junc J1	2180	21	Junc J14	2149	45	Junc J27	2120	52
Junc J2	2178	24	Junc J15	2140	65	Junc J28	2105	40
Junc J3	2155	40	Junc J15	2122	65	Junc J29	2106	40
Junc J4	2151	52	Junc J17	2120	30	Junc J30	2144	65
Junc J5	2155	52	Junc J18	2120	20	Junc J31	2140	65
Junc J6	2162	63	Junc J19	2121	20	Junc 61	2054	26
Junc J7	2171	63	Junc J20	2075	44	Junc 62	2074	40
Junc J8	2173	58	Junc J21	2100	45	Junc 64	2090	70
Junc J9	2127	58	Junc J22	2101	44	Junc 65	2056	48
Junc J10	2145	63	Junc J23	2139	30	Junc 68	2088	90
Junc J11	2158	55	Junc J24	2139	33	Junc 67	2060	60
Junc J12	2175	55	Junc J25	2139	50	Junc 66	2062	50
Junc J13	2159	55	Junc J26	2138	52	Junc 63	2087	40

5.3.3 Identified Problems

Models useful in problem-solving and for clarification of issues. The Durame city water distribution system has the following major issues.

- Undersized piping
- Oversized piping
- Low pressure

If the pipeline is too small diameter, this can only be a problem at high flow conditions. The best time to diagnose the problem is probably the simulation of the model during the leaks.

When the pipes are undersized (below the standard) it leads to the velocity above permissible limit, to solve this serious problem changing the pipes with relevant large link gives the solution to the problem.

There is no fixed rule for the maximum velocity in the main structure. The permissible speed in the main and pressure distribution systems may vary between 0.6 and 1.5 m / s and between 0.6 and 2.2 m / s depending on the recommendation, depending on the relative proportions of the peak currents and the average (MOWR, 2006).

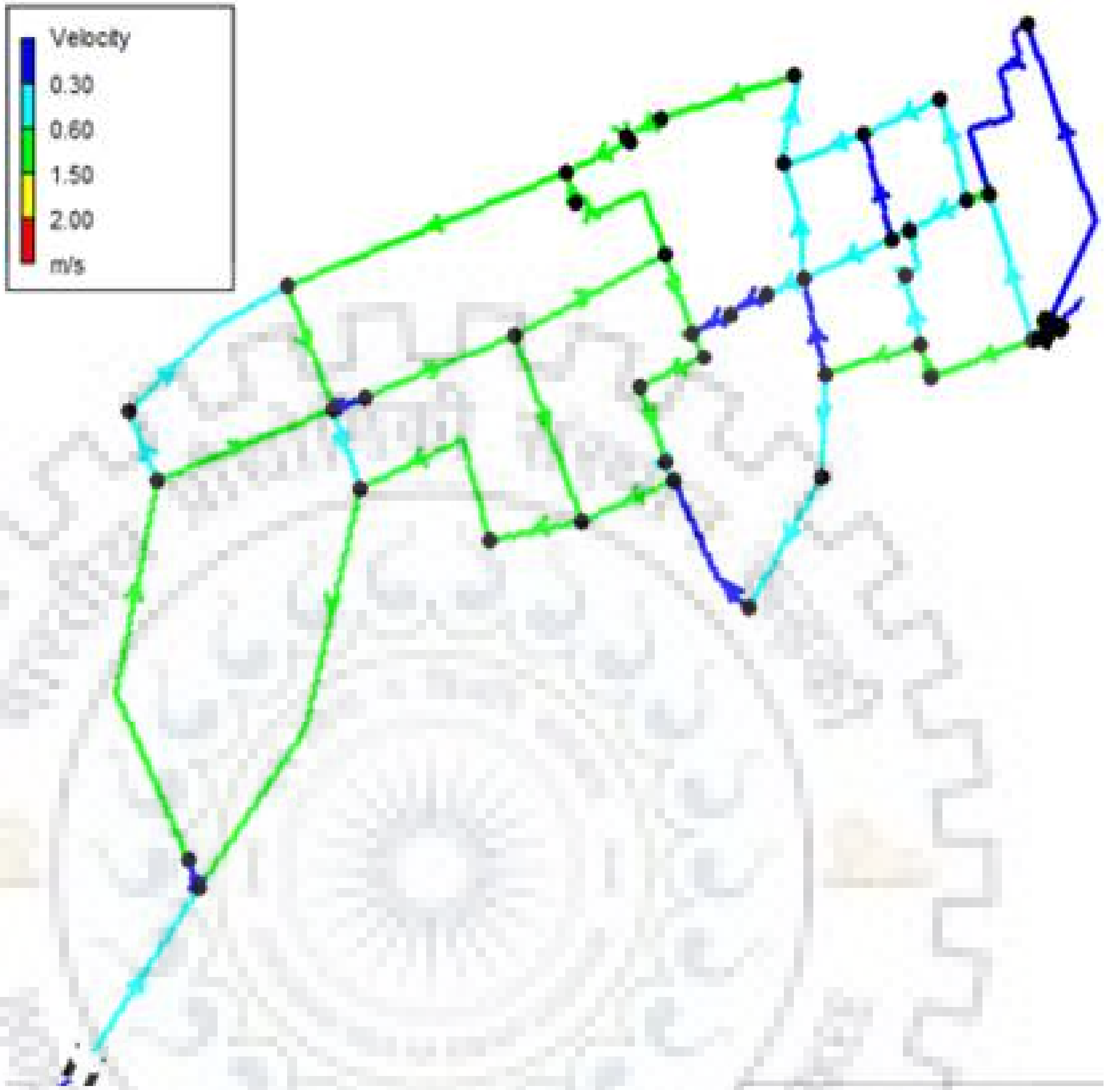


Figure 17. The low velocity area of distribution pipes after running EPANET at 7:00hr

In the above figure shows that compared with the standard MOWR standard some of pipes have velocity below the standard and some are above the standard depending the elevation of the areas and pumping time at pressurized pipes.

Table16.Result of EPANET at the time of high demand time scenario

	Velocity m/s		Velocity m/s		Velocity m/s		Velocity m/s
Pipe P1	0.38	Pipe P15	0.21	Pipe P33	0.51	Pipe P4A	0.46
Pipe P2	0.47	Pipe P16	0.26	Pipe 42	1.03	Pipe 47	0.26
Pipe P3	0.45	Pipe P19	0.63	Pipe 43	1.35	Pipe P20	0.77
Pipe P4	0.27	Pipe P21	1.02	Pipe 44	1.44	Pipe P17	0.87
Pipe P5	0.24	Pipe P22	1.18	Pipe 49	0.28	Pipe P18	0.66
Pipe P6	0.24	Pipe P23	0.07	Pipe 46	1.06	Pipe P30	0.37
Pipe P7	0.40	Pipe P24	0.04	Pipe 48	0.99	Pipe 80	0.42
Pipe P8	0.17	Pipe P25	0.66	Pipe 45	0.27	Pipe P51	1.36
Pipe P9	0.37	Pipe P26	0.64	Pipe 35	0.11	Pipe P52	0.85
Pipe P10	0.35	Pipe P27	0.59	Pipe P46	0.00	Pipe P32	0.15
Pipe P11	0.16	Pipe P28	0.67	Pipe P34	0.37	Pipe P4A	0.46
Pipe P12	0.38	Pipe P29	0.62	Pipe P35	2.39	Pipe 47	0.26
Pipe P13	0.23	Pipe P31	0.28	Pipe P45	0.99	Pipe P20	0.77
Pipe P14	0.24	Pipe HH	0.88	Pipe 50	1.07	Pipe P37	1.00

There are oversized pipes in the system these are changed in the reduced pipe system to improve velocity and the changed pipes are P4, P5, P8, P11, P13, P14, P15, P16, P23, P24, P35 and P32.

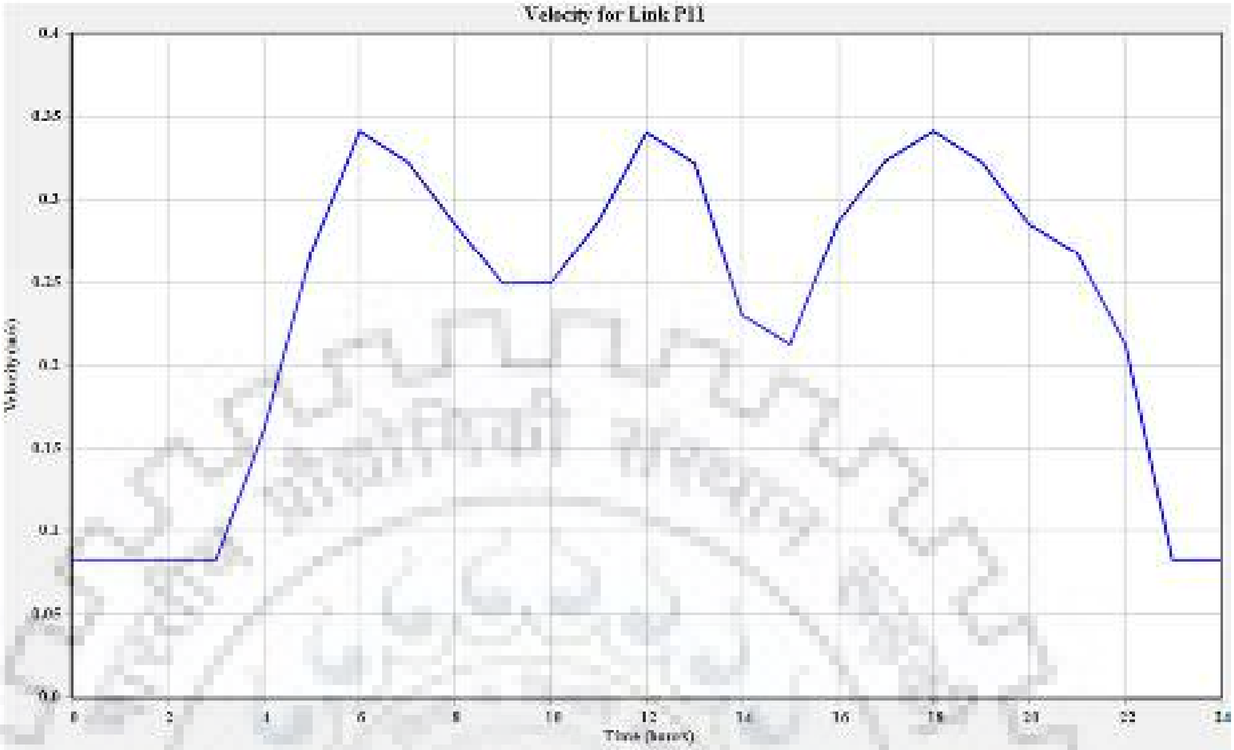


Figure 18 Velocity at sample link P11.

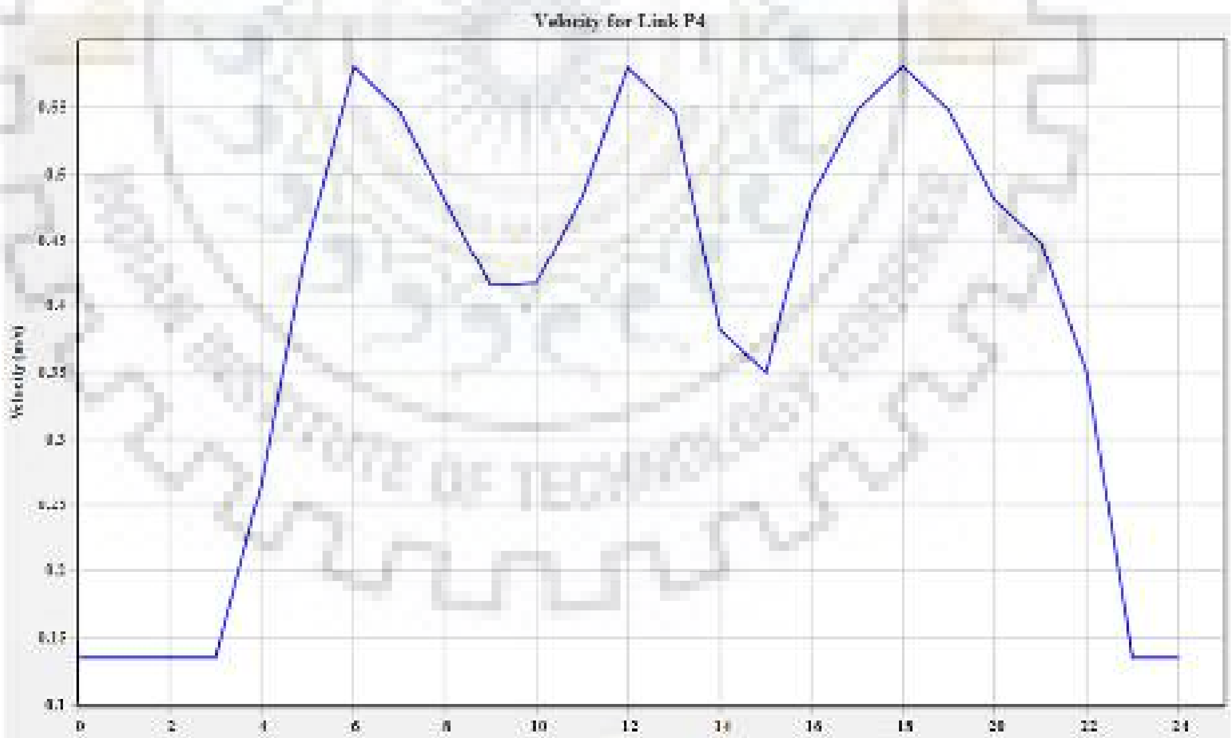


Figure 19 Velocity at sample link P4.

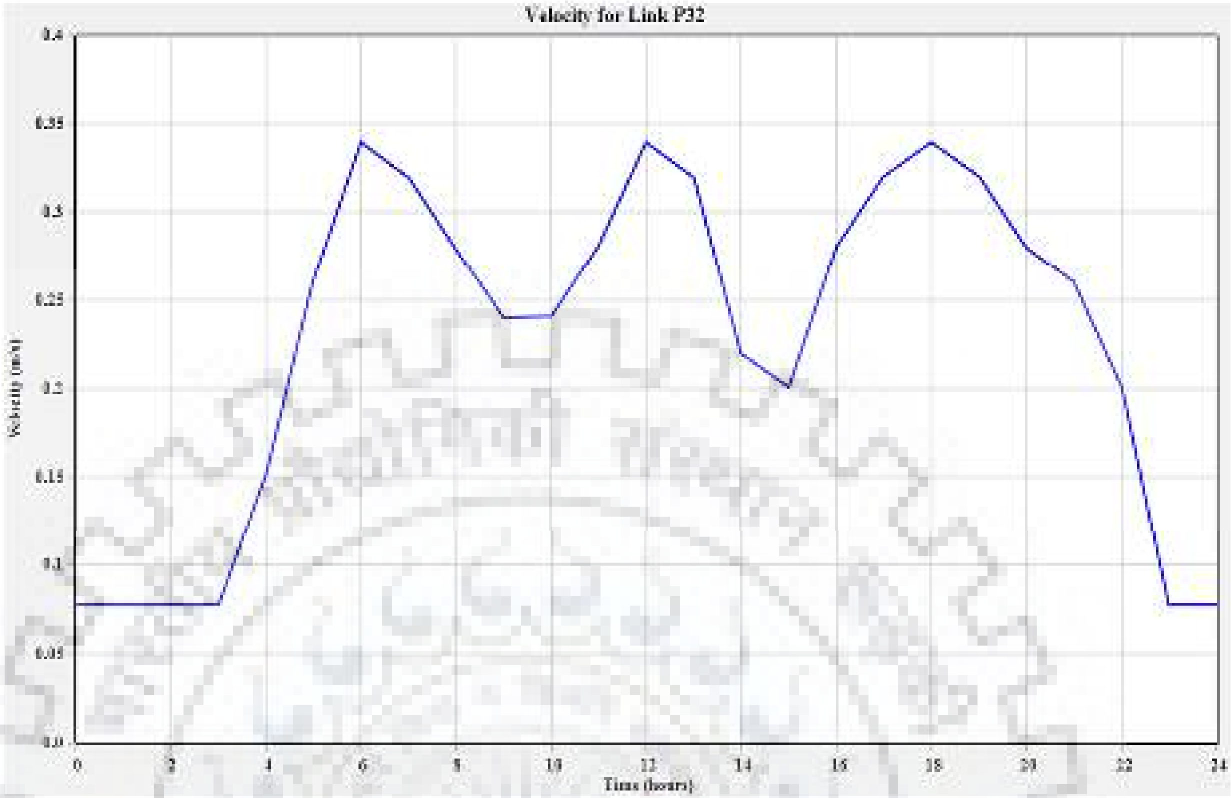


Figure 20 Velocity at sample link P32.

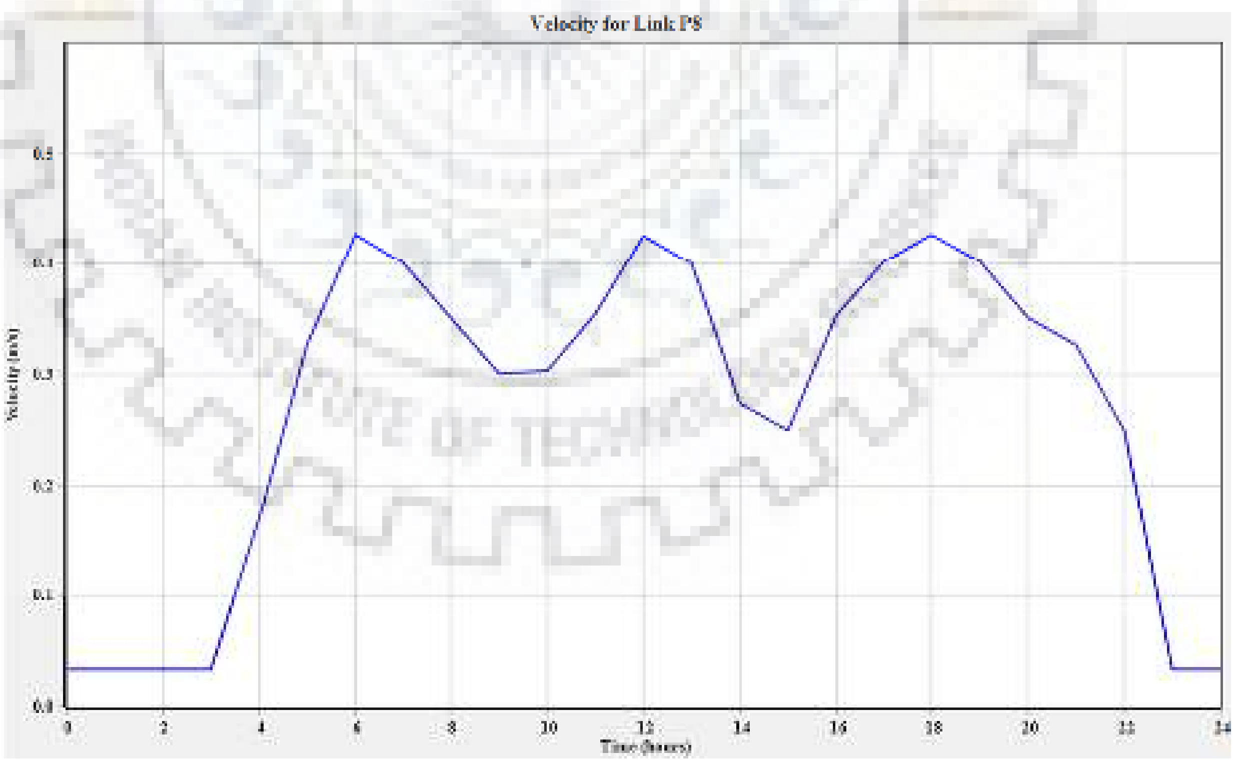


Figure 21 Velocity at sample link P8.

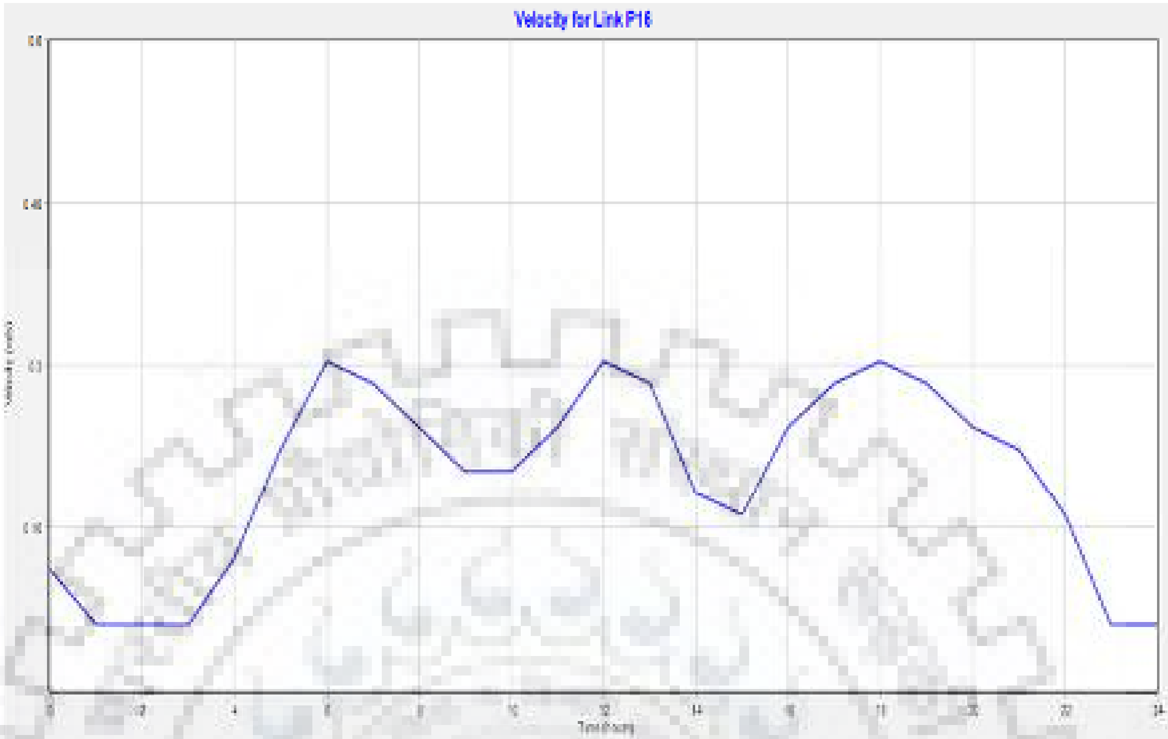


Figure 22. Velocity at sample link P16.

Figure 16, 17 and 18 at pipe P16 and P47 respectively shows that velocity it between 0.0 and 0.2 that is below the standard of velocity in water supply distribution system. Consistent low-pressure problem is happened by pushing water to serve customers at high an elevation, to resolve this dividing distribution system to average and common different pressure zone. High pressures are sometimes caused by delivering water to customers in a distant press zone. High pressure is usually considered best when the models have low requirements. This deviation corresponds to the minimum night time requirements for a typical system.

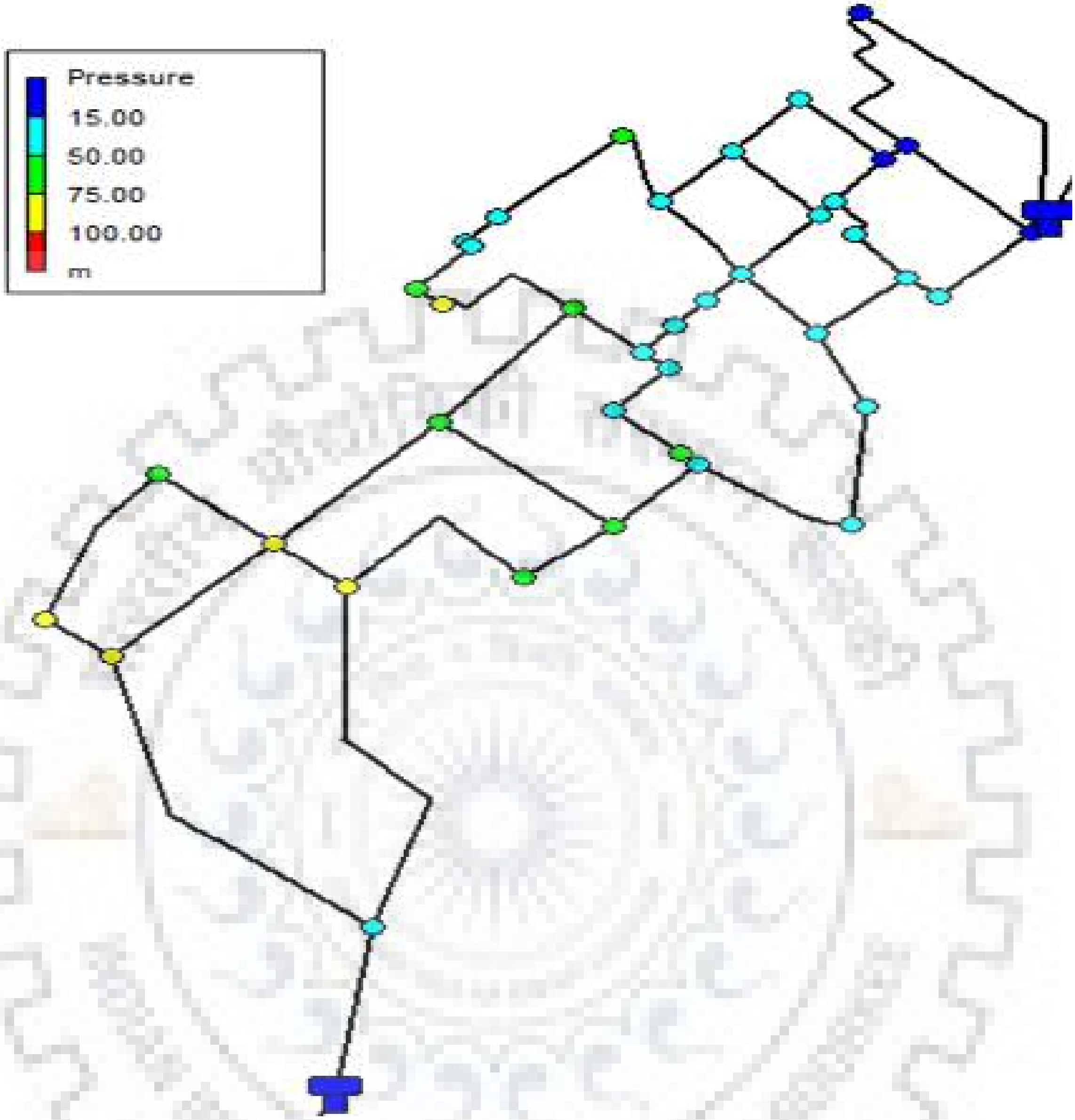


Figure 23. The low-pressure nodes at distribution pipes.

There are low pressure problems in the previous system the improved system increases the pressure by using booster pump and the improved junctions as figure shown are J51, J8, J67, J52, J25, J29, J27, J26, J25, J22 and J24. There are also high-pressure problems at critical areas like J41, J63, J8 and J67 are some of pipes and the solutions have been done by providing pressure release, control valves and arranging the necessary pressure zones.

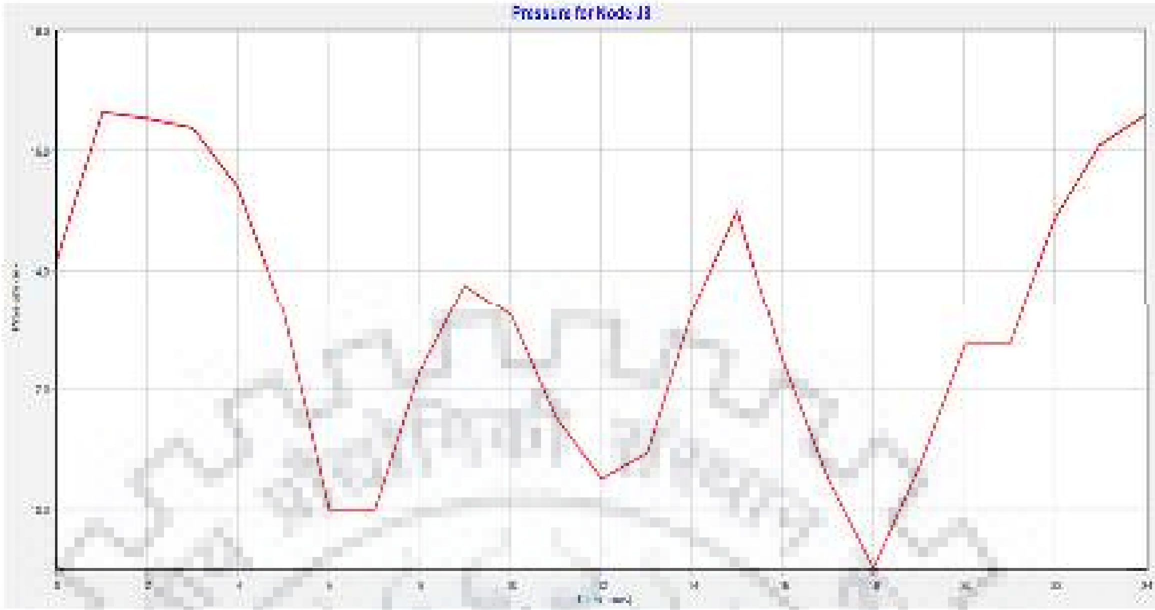


Figure 24.Pressure at sample nodes J8

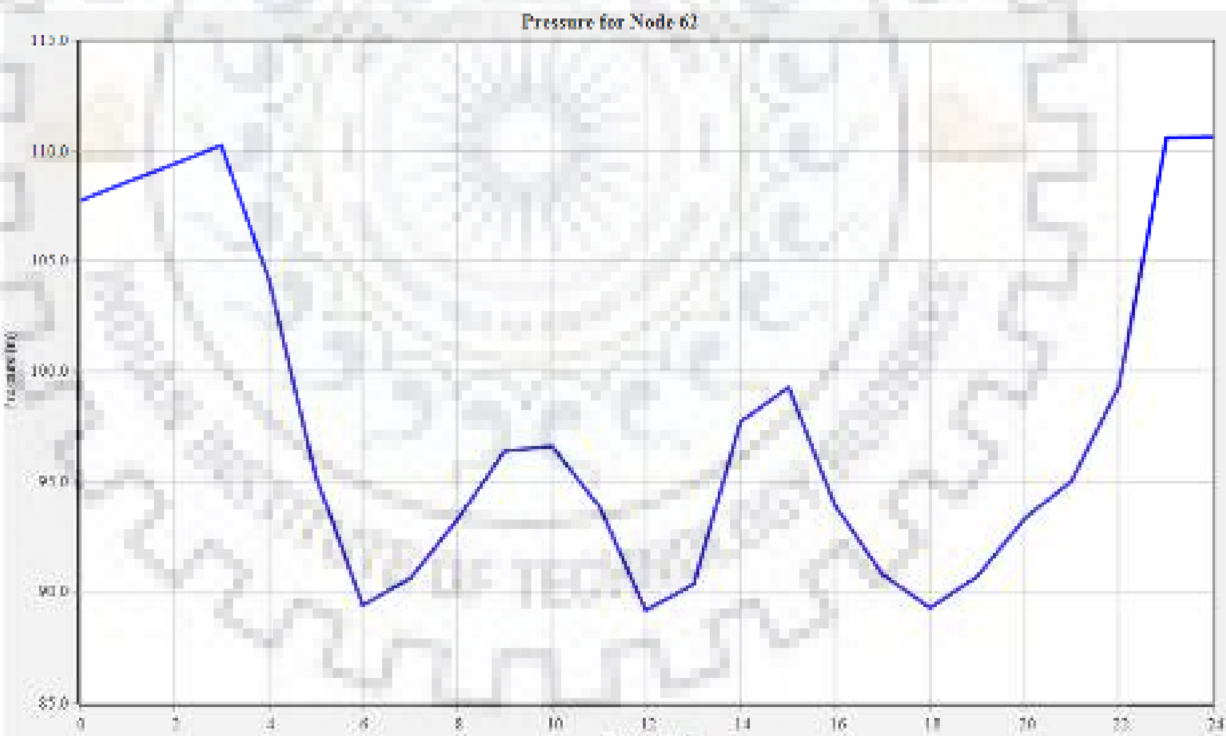


Figure 25 Pressure at sample nodes 62

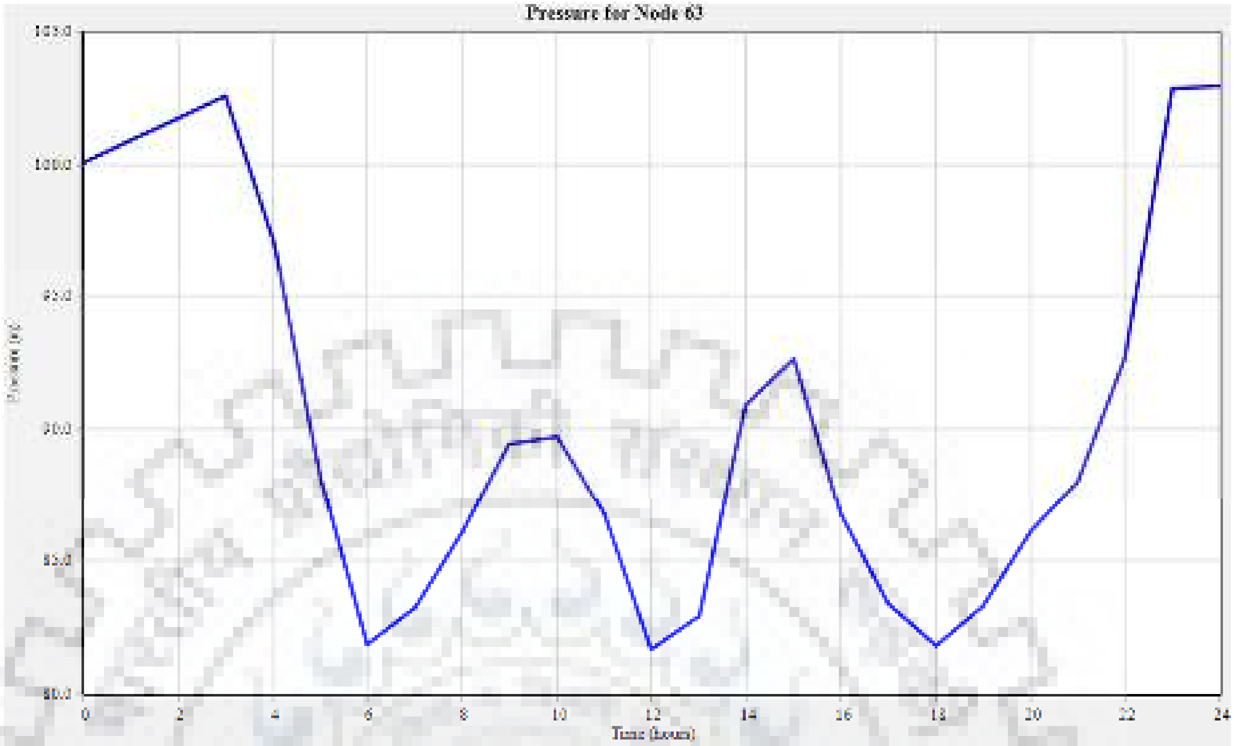


Figure 26 Pressure at sample nodes 63

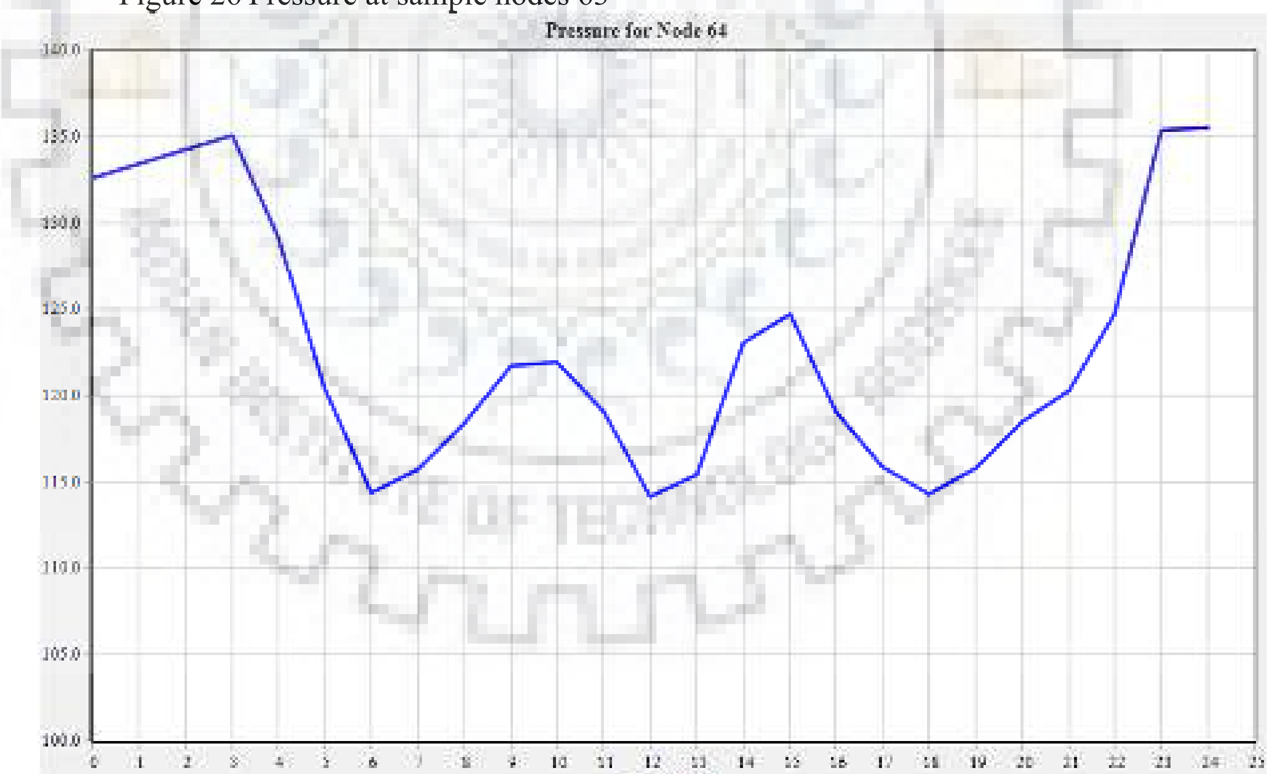


Figure 27. Pressure at sample nodes 64

In figure above shows that the pressure at node 8 and 67 below 10m in some points that is below the standard of pressure at the node.

5.3.4 System model improvements

In designing or improving a system there are sets of design criterion to be considered, pressure and velocity. The design criteria used in designing the water supply system components, node pressure during peak hours and optimum transmission and distribution grid speeds are as follows.

(MOWR, 2006).

- Minimum static head is 15 m.
- Maximum static head within a pressure zone was limited to 100 m.
- Maximum velocities of major transfer mains 0.6 to 2.2 m/s.
- Maximum velocities of distribution mains 0.5 to 1.5 m/s for looped system.

According to the above procedures, the distribution main pipes are modified and Pressure reducer valves are added to reduce the maximum pressure. As a result, 33% of the total distribution mains had been resized.

Table 17.Improved distribution mains in distribution system

No.	Description	Material	Existing Pipe Size (mm)	Existing Pipe length (m)	Modified Pipe Size (mm)	Modified Pipe length (m)
1	PIPE	HDPE	125	230	110	230
2	PIPE	HDPE	110	500	100	500
3	PIPE	HDPE	100	980	90	980
4	PIPE	HDPE	90	540	80	540
5	PIPE	HDPE	80	640	50	640

Table:9 Description of pipe material and length

5.4 Water quality modelling in EPANET

In addition to the essential hydraulic model inputs, the water quality models would like the supplementary information components to simulate the behavior in an exceedingly distribution system. A water quality model needs the standard of all external inflows to the network and in addition the water quality throughout the network be acquainted at the beginning of the simulation. Initial water quality values are assessed supported field information, then the model is run the associate adequately long amount of sometime below a repetition pattern of providing and demand inputs thus as that the initial conditions, notably in storage tanks, don't influence the water quality predictions among the distribution system. The water age and supply tracing selections alone wish input from the hydraulic model.

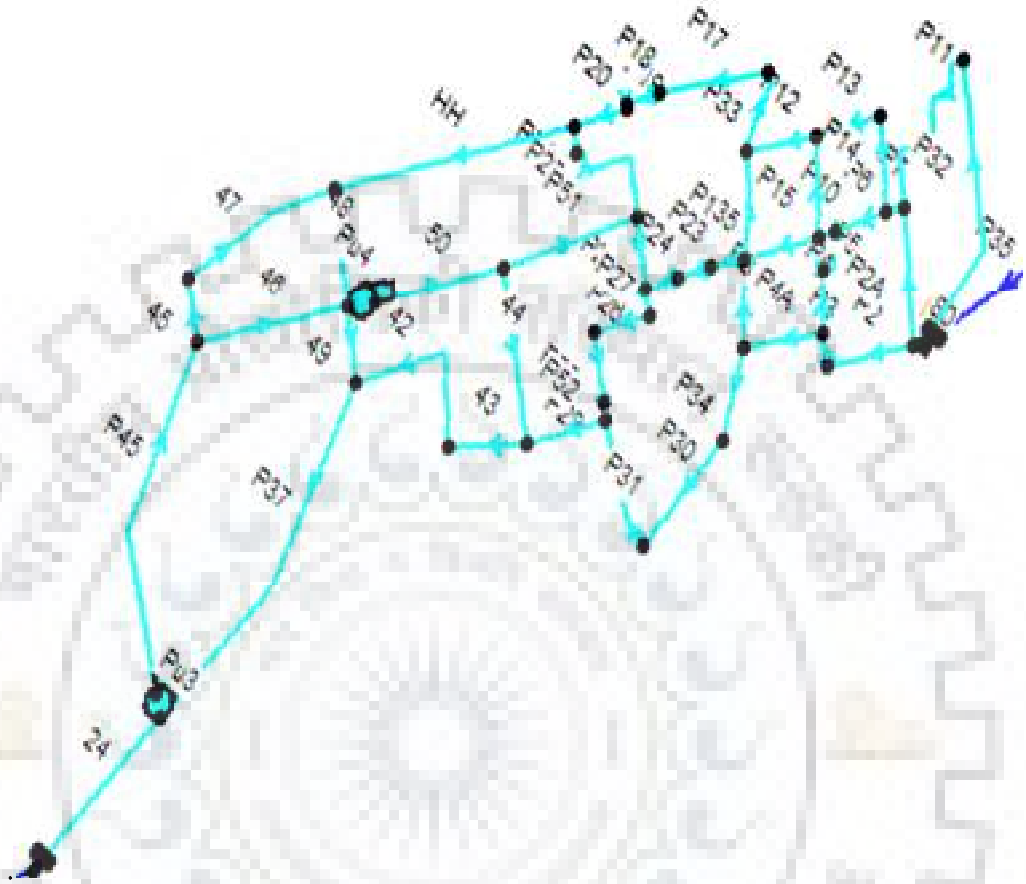


Figure 28.Water quality modeling distribution system

Calculation of water ages on the water distribution system to demonstrate the old and new water in the flow condition, predicting residential water distribution chlorine decay involvement of source in water quality, location and etc. used in water quality models.

In current years there is a growing interest in the multi types of quality water systems. The purified water which is obtained by refining may contain some harmful disease-causing bacteria in it. These bacteria must be killed in order to make the water harmless for drinking. The chemical substances used for killing this microorganism are acknowledged as disinfectants and technique is known as disinfection. This method of purification is the most vital due to the fact the contaminated water might also lead to the transfer of numerous diseases and their epidemics, thus source of disaster to public life. The disinfection can be achieved with the support of bromine, ultraviolet rays, potassium permanganate or treatment with excess lime, iodine, however chlorination is most regularly used approach of disinfection in community water supply schemes because it is low-priced, fantastic in killing the bacteria, easy to use and can be maintained as residual. Presence of residual chlorine in the detectable quantity at purchaser faucets assures water free from bacteriological uncleanness. The direct goal of the distribution community is to make on hand and sufficient quantity of water at required pressure and velocity. The satisfactory of water in the distribution network is the most essential standards to user must deliver quality and good pleasant water.

Chlorine decay

The mechanism of chlorine decay within the pipe has 2 special ways. The first thing is the response of chlorine with supplies current in water. This decay of chlorine is identified as bulk decay. The 2nd dimension is the reaction of chlorine with elements existing on the pipe wall. Pipe wall gets frequently coated with a variety of scales whose compositions rely on pipe type source water satisfactory and treatment technique. This decay of chlorine is identified as wall decay type. The wall decay within the distribution network is also predominant wherever far-famed corrosion is present.

Bulk decay rate constant

The loss of chlorine residual accumulation along the water distribution system is discussed in three divided mechanism the first one chlorine reactions in bulk fluid; chlorine reactions with pipe, natural evaporation and other system elements. If possible, the chlorinated water was clean and the material of the pipes was inactive, the only mechanism leading to the decay would be that of natural evaporation, principally in specific areas of the distribution system, specifically reservoirs and other free surface flows. Bulk decay coefficients for chlorine be dominated by the nature of the source water and the treatment it has actioned and values range from 0.1 to 1.0 (per day).

Wall decay rate constant

Wall decay of residual chlorine is related with disinfection of bio-film and reaction with corrosion results. Chlorine decay rate originated by bio-film is normally lesser than caused by corrosion by products. Wall decay rate constant is a function of pipe diameter, velocity, pipe distance, and viscosity. Wall decay rate constant can fluctuate significantly from pipe to pipe even in the same network system.

Water quality modeling opportunities

In addition to hydraulic modeling, EPANET provides the following water quality modeling skills:

- Models, the entire water network tracks the percentage of the flow of a given node that reaches all the other nodes over time.
- Patterns of reactions both in the mass flow and in the tube wall.
- Model the movement of reactive material in the network over time.
- Formulate the mobility and potential of the reactive material while increasing disintegration over time.

With the help of these functions, EPANET can study such water quality phenomena as follows:

- Loss of chlorine residuals in distribution.
- Growth of disinfection by-products.
- Blending water from different sources,
- Age of water throughout a system.

5.4.1 Water quality examination by EPANET

EPANET's water simulation software uses a time-based method to track the ability to separate the amount of water as the tubes pass and mix between fixed lengths of time. These best water time steps are generally much shorter than the hydraulic time phase (e.g., Minutes instead of hours) to take into account the small flow paths that may occur in the pipes. On the other hand, as with hydraulics, effects are solely reported at the end of of each user- specified reporting time step.

After simulation of the simulation of water quality distribution system the followings ideas are used as a discussion point. When running of EPANET to simulate the system in the first of 32 hrs. all pipes are no problem that means chlorine is not less than 0.2 as below understood in the diagram.

According to the simulation of chlorine from the water treatment plant which the necessary amount added and after 32 hours the concentration of about half of nodes dropped mentioned in table below.

Table 18. The concentration of chlorine in nodes at 32 hr.

Node ID	chlorine mg/L	Node ID	chlorine mg/L	Node ID	chlorine mg/L	Node ID	chlorine mg/L
Junc J1	0.16	Junc J15	0.18	Junc J26	0.22	Junc J60	0.26
Junc J2	0.16	Junc J16	0.18	Junc J27	0.22	Junc J26	0.22
Junc J3	0.16	Junc J17	0.18	Junc J28	0.22	Junc J27	0.22
Junc J4	0.17	Junc J18	0.18	Junc J29	0.21	Junc J28	0.22
Junc J5	0.17	Junc J19	0.19	Junc J30	0.17	Junc J29	0.21
Junc J6	0.17	Junc J20	0.21	Junc J31	0.18	Junc J30	0.17
Junc J7	0.17	Junc J21	0.26	Junc 61	0.25	Junc J60	0.26
Junc J8	0.17	Junc J22	0.26	Junc 62	0.23		
Junc J9	0.17	Junc J23	0.17	Junc 63	0.23		
Junc J10	0.17	Junc J24	0.18	Junc 64	0.26		
Junc J11	0.17	Junc J25	0.22	Junc 65	0.25		
Junc J12	0.17	Junc J15	0.18	Junc 68	0.23		
Junc J13	0.18	Junc J16	0.18	Junc 67	0.27		
Junc J14	0.18	Junc J17	0.18	Junc 66	0.26		

According to the simulation of chlorine from the water treatment plant which the necessary amount added and after 32 hours the concentration of most pipes dropped below table 17 mentioned.

Table 19. The concentration of chlorine in nodes after 32 hr.

Link ID	chlorine mg/L	Link ID	chlorine mg/L	Link ID	chlorine mg/L	Link ID	chlorine mg/L
Pipe P1	0.13	Pipe P15	0.13	Pipe 42	0.18	Pipe P30	0.14
Pipe P2	0.13	Pipe P16	0.13	Pipe 43	0.18	Pipe 80	0.13
Pipe P3	0.13	Pipe P19	0.14	Pipe 44	0.20	Pipe P51	0.20
Pipe P4	0.13	Pipe P21	0.21	Pipe 49	0.20	Pipe P52	0.16
Pipe P5	0.13	Pipe P22	0.20	Pipe 46	0.22	Pipe P32	0.14
Pipe P6	0.13	Pipe P23	0.13	Pipe 48	0.18	Pipe HH	0.16
Pipe P7	0.13	Pipe P24	0.13	Pipe 45	0.22	Pipe P45	0.22
Pipe P8	0.13	Pipe P25	0.21	Pipe P2A	0.13	Pipe P37	0.20
Pipe P9	0.13	Pipe P26	0.17	Pipe P4A	0.13	Pipe 50	0.20
Pipe P10	0.13	Pipe P28	0.17	Pipe 47	0.22	Pipe P2A	0.13
Pipe P11	0.14	Pipe P29	0.17	Pipe P20	0.14	Pipe P4A	0.13
Pipe P12	0.13	Pipe P22	0.20	Pipe P17	0.13	Pipe 47	0.22
Pipe P13	0.13	Pipe P31	0.14	Pipe P18	0.13		
Pipe P14	0.13	Pipe P33	0.13				

The sufficient amount of chlorine also added in tank but after 32 hours most of the pipes are less than minimum standard of chlorine (0.2mg/l) in the distribution system of pipes simulation, there are also after 50hrs total pipes are less than that expected in WHO or other worldwide standards of acceptable amount.

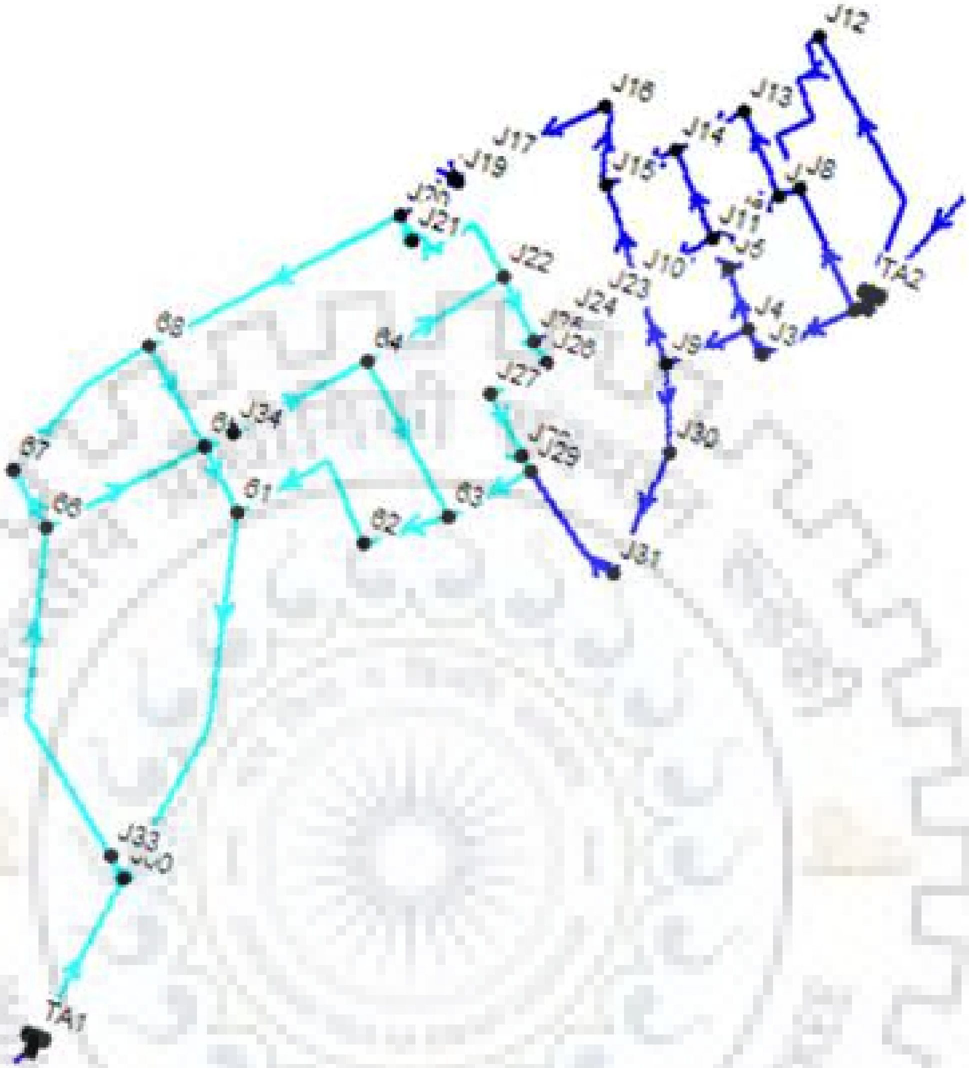


Figure 29. Chlorine at 32hrs in the distribution system

The above diagram shows that blue color indicates residual chlorine is less than 0.2.mg/l and the green color is 0.2mg/l in the system. After 75 hours of simulation, there are 12 pipes that have a chlorine concentration less than 0.2mg/l.

Figure 30 Sample node J29 with chlorine amount less than 0.2mg/l after 32 hours.

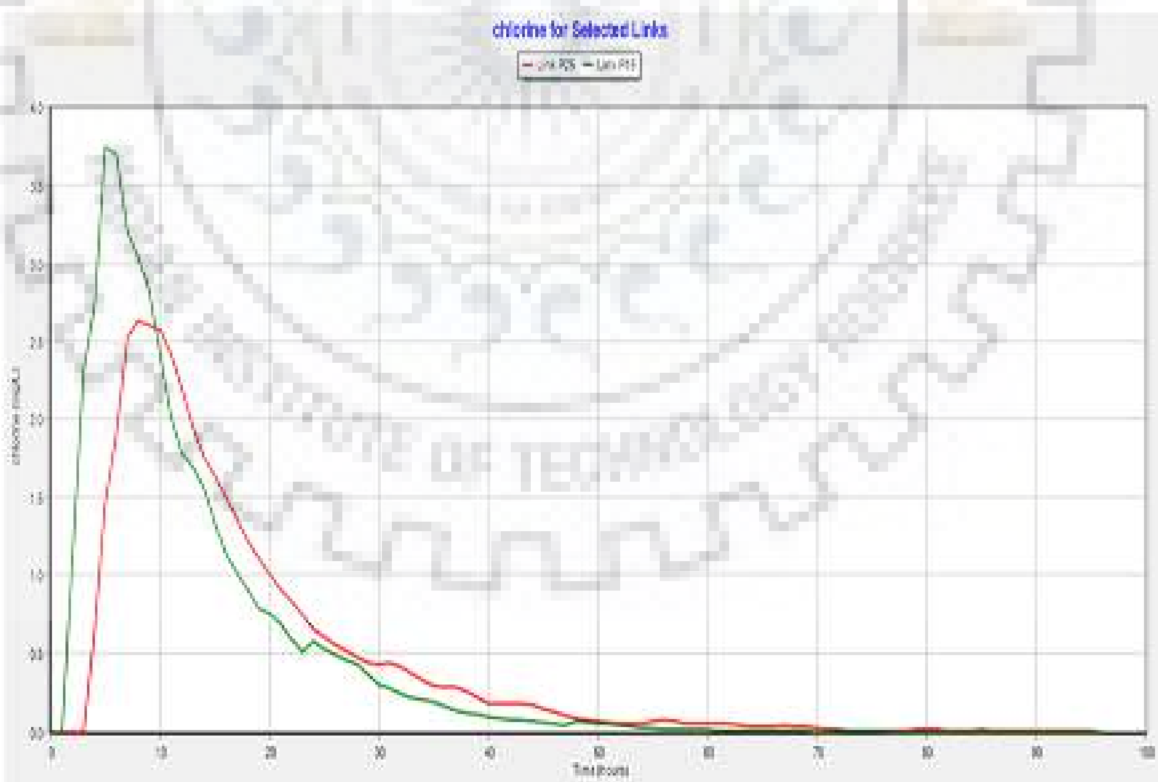


Figure 31 Sample links P25 and P15 with chlorine amount less than 0.2mg/l after 32 hours.

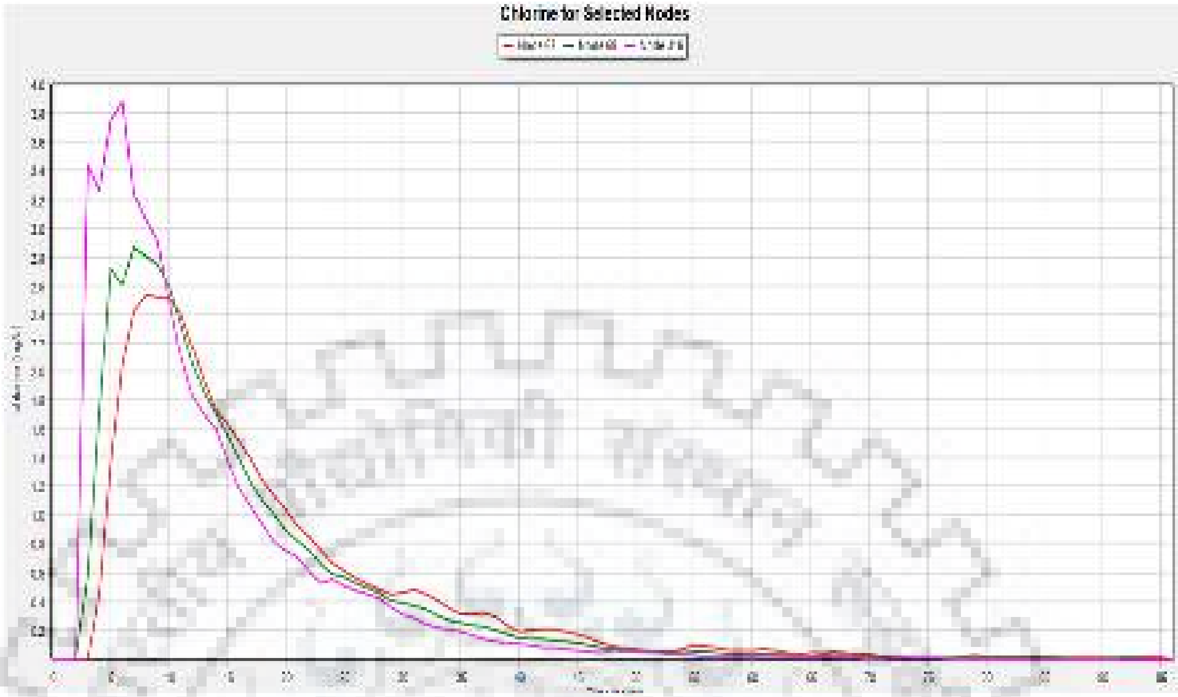


Figure 32. Sample nodes J16,J68 and J67 with chlorine amount less than 0.2mg/l after 32 hours.

There are two tanks which the chlorine chemical can be inserted the result of water quality shows in the time increment the chlorine residual will be decreasing in each time and at the time goes last chlorine will zero at end of 96hr (at the end of forth day) this clearly shown below.

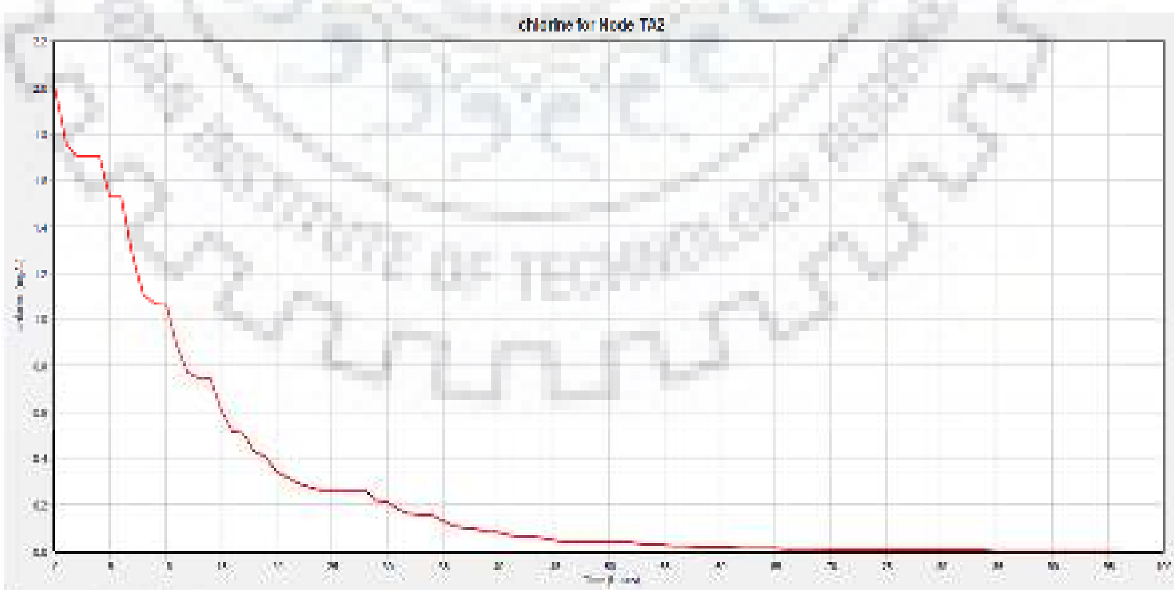


Figure 33 Chlorine condition in water tanks **2**

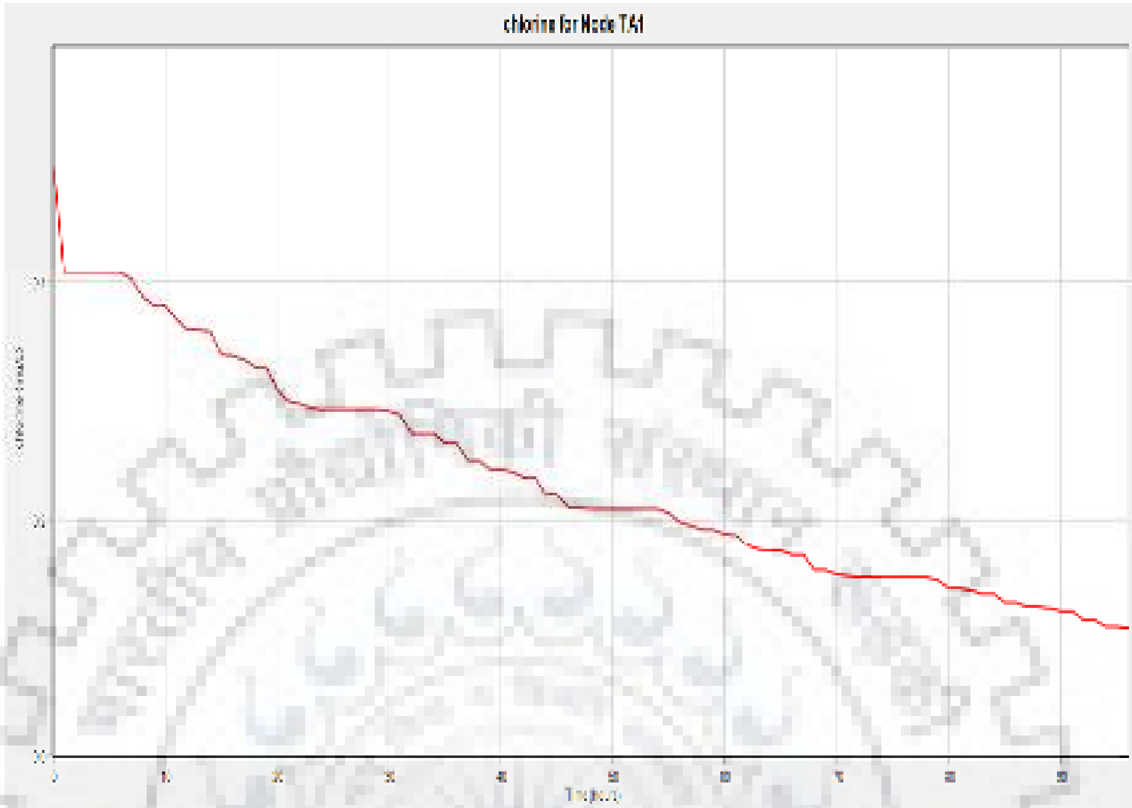


Figure 34. Chlorine condition in water tanks 1

When we consider that decreasing of chlorine with time in the water supply distribution system needs chlorine boosters for selected areas to raise the concentration of chlorine within the distribution system and in addition to this necessary amount of bleaching powder added to the system to enhance the standard.

CHAPTER 6 CONCLUSION AND RECOMMENDATION

6.1 Conclusions

In general, the major problem in Durame town water supply can be summarized as follows. Scarce sources of water supply and supply shortages due to population growth and the expansion of new areas as the city became the capital of the area. Network expansion needs due to population growth and the expansion of new areas. Even those who have access to water, the current water consumption is less than the demand required. According to the Ethiopian Water Resource Management policy, any water sector in medium town should provide 70l/d potable water with acceptable quality and adequate quantity. Production-consumption the analysis confirmed that daily production with the assumption of no interruption in the system was 2890m3/day. The per capita consumption pattern on the average precariat is 36.5 l/day which is far below the standard.

The present water source, the borehole has been constructed for not more than 35,000 population. Currently, the town has a population of 52, 000 the rapid increase in this figure might be a serious problem for future I no increase source.

Expand the existing system should be made by calculating the existing water production and comparing with consumption. If the existing production is greater than and sufficient quantity to supply the demand, the decision would be made to expand the existing system. Otherwise, simply elongation of the pipe at the request of the customer is a useless expansion simply to enjoy customer which leads most of the pipe to run dry.

The topography of the study area is characterized by the highest elevated Ambericho Mountain of 3028 meters above Durame town has been a challenge for many years to equally allocate water to the customers. To overcome the problem in water supply network it needs some consideration as follows

- The existing water supply design network was evaluated in actuality depending on the existing town water supply system by running the different parts of the network. From the total 33% distribution systems needs improvement, by resizing under and oversized distribution main pipes.

- Low pressure in some of the system and to increase pressure booster station should be installed.
- The nodal pressure in all distribution system, especially at the point of lower and higher elevation areas of the distribution system has been checked.
- For high-pressure area use pressure reducing valves as the pressure of the distribution system is above the permissible limit.

Organizational structure provides a useful frame to unite the similar type of workflow in the institution. However, to ensure the work objectives achieved, supportive processes like human resource development system need to be put in place. The institutional framework of the management and administrative structure of the town drinking water supply service enterprise are organized into layers. Durame town water sector has a vast problem of lack technical manpower and shortage of staff members to fulfill the sectorial goal to solve problems concerning water supply system of the town. So that in the office employees commonly ran two or more jobs and positions.

In general, the following major organizational arrangement and institution skilled manpower shortcoming are identified:

- Shortage of skilled and equipped manpower to perform every activity water distribution system.
- Lack of appropriate and specific manuals procedures designed for the operation/activities of the water supply sector and are governed by civil service.

Durame water distribution some pipes are old age that needs replacement with other proportional and gives serious attention on changing with appropriate standard pipe material, and new pipes is necessarily for healthy. In another hand consumer often play significant roles in the collection, treatment and storing properly unprotected water. Consumer actions can help ensure the safety of the water they drink and can also help increase or pollute the water used by others. Consumers are responsible for ensuring that their activities do not reduce water quality.

Keep in mind that installation and maintenance of home plumb installation systems should preferably be carried out by skilled and competent installers or by experienced people if everyone can try to service the system, dysfunctional. So that serious care water supply works can be must undertake by technical skill manpower.

Water quality in water supply distribution system is the main issue to consider potable water to the consumer therefore the water quality model can be used to support to accomplish a variety of quality-related studies. Study of chlorine residual in the system by sing EPANET software shows one of water aging. The results show as follows.

- Find by controlling the survey of the field and changing the operation of the system to reduce the age of water.
- Find the best pipe combinations, scroll wheel, pipe cleaning, storage time reduction and injection boost speed at the booster station to maintain the desired level of disinfection throughout the system.
- Water storage tanks of the town are not well covered by any material that is exposed to any tendency of pollutants so that protecting from external contamination is necessary.
- Using disinfectant bleaching powder by calculating the appropriate amount of water supply and demand and considering the standards of chlorine usage is better.

6.2 Recommendations

Expansion work from oversized pipe should be redesigned and replaced with adequate pipe size. Before the commencement of any activities concerning expansion, the following consideration should be taken in to account:

- As compared to consumption, production should be greater and adequate to service the demand.
- Pressure efficiency should be checked; if the pressure efficiency in the system was low booster station should be installed as per the specification recommended by design engineer.

Due to nature of the topography, distributing water from the same point has been difficult for many years; to avoid this, making a distribution by zoning will solve the problem to avoid this, making a distribution by zoning will solve the problem

- The first zone at KMG an elevation of 2186m----- existing
- The second zone at Danshe Mountain an elevation of 2114m---- existing
- The third zone at Kalehiwot an elevation of 2175 m proposed and
- The fourth zone at Teklehaimanot an elevation of 2120m ---- proposed

To decrease a substantial amount of loss in the system warn out and deteriorated pipe at the older and lower reach of the town should be replaced with the new one. Water supply and demand deficit mainly due to population increase, climatic changes, environmental factors, and urbanization lead towns to decrease water coverage below the standard that leads stress of water nowadays and series problem in future so that finding alternative water source solve the problem.

Durame town water sector has vast problem of lack technical manpower and shortage of staff members to fulfill the sectorial goal to solve problems concerning water supply system of the town. So that in the office employees commonly ran two or more jobs and positions. In general, the following major organizational structure and management shortcoming are identified:

- Shortage of skilled and equipped manpower to perform every activity water distribution system.
- Lack of appropriate and specific manuals procedures designed for the operation/activities of the water supply sector and are governed by a civil service regulation.

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APPENDIX A: PHOTOS TAKEN DURING FIELD VISIT

APPENDIX A1 KMG water tank

APPENDIX A2 Old masonry tank

APPENDIX A3 Nonfunctional water points

APPENDIX A4 Water tank with serious problem due to road construction

APPENDIX A5 Erosion effect on pipes

APPENDIX A6 Nonfunctional metal tank

APPENDIX A7 Aeration place for iron

APPENDIX A8 Generator

APPENDIX B: HAZEN-WILLIAMS COEFFICIENTS FOR SOME COMMON MATERIALS

Material	Hazen-Williams Coefficient
ABS - Acrylonite Butadiene Styrene	130
Aluminum	130 - 150
Asbestos Cement	140
Asphalt Lining	130 - 140
Brass	130 - 140
Brick sewer	90 - 100
Cast-Iron - new unlined (CIP)	130
Cast-Iron 10 years old	107 - 113
Cast-Iron 20 years old	89 - 100
Cast-Iron 30 years old	75 - 90
Cast-Iron 40 years old	64-83
Cast-Iron, asphalt coated	100
Cast-Iron, cement lined	140
Cast-Iron, bituminous lined	140
Cast-Iron, sea-coated	120
Cast-Iron, wrought plain	100
Cement lining	130 - 140
Concrete	100 - 140
Concrete lined, steel forms	140

Material	Hazen-Williams Coefficient
Concrete lined, wooden forms	120
Concrete, old	100 - 110
Copper	130 - 140
Corrugated Metal	60
Ductile Iron Pipe (DIP)	140
Ductile Iron, cement lined	120
Fiber	140
Fiber Glass Pipe - FRP	150
Galvanized iron	120
Glass	130
Lead	130 - 140
Metal Pipes - Very to extremely smooth	130 - 140
Plastic	130 - 150
Polyethylene, PE, PEH	140
Polyvinyl chloride, PVC, CPVC	150
Smooth Pipes	140
Steel new unlined	140 - 150
Steel, corrugated	60
Steel, welded and seamless	100
Steel, interior riveted, no projecting rivets	110

Material	Hazen-Williams Coefficient
Steel, vitrified, spiral-riveted	90 - 110
Steel, welded and seamless	100
Tin	130
Vitrified Clay	110
Wrought iron, plain	100
Wooden or Masonry Pipe - Smooth	120
Wood Stave	110 - 120
Steel, projecting girth and horizontal rivets	100

(Hazen-Williams)https://www.engineeringtoolbox.com/hazen-williams-coefficients-d_798.html