JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

HYDRAULIC AND WATER RESOURCES ENGINEERING

HYDRAULIC ENGINEERING MASTER OF SCIENCE

HYDRAULIC PERFORMANCE OF URBAN WATER SUPPLY DISTRIBUTION SYSTEM A CASE STUDY AT SEKOTA TOWN WATER SUPPLY PROJECT,

ETHIOPIA

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF JIMMA UNIVERSIY.JIMMA INSTITUTE OF TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN HYDRAULIC ENGINEERING STREAM.

By: ABIRHAM ASSEFA

NOVEMBER, 2016

JIMMA, ETHIOPIA

JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

HYDRAULIC AND WATER RESOURCES ENGINEERING

HYDRAULIC ENGINEERING MSC PROGRAM

HYDRAULIC PERFORMANCE OF URBAN WATER SUPPLY DISTRIBUTION SYSTEM A CASE STUDY AT SEKOTA TOWN WATER SUPPLY PROJECT,

ETHIOPIA

A THESIS SUBMITTED TO SCHOOL OF GRADUATE STUDIES OF JIMMA UNIVERSIY, JIMMA INSTITUTE OF TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN HYDRAULIC ENGINEERING STREAM.

By: ABIRHAM ASSEFA

ADVISOR: Dr.-Ing FEKADU FUFA (PhD)

CO-ADVISOR: Mr. MEGERSA KEBEDE (MSc)

OCTOBER, 2016

JIMMA, ETHIOPIA

DECLARATION

I, the undersigned, declare that this thesis: entitled as Hydraulic performance of urban water supply distribution systems a case study at Sekota town is my original work, and it has not been presented for a degree in Jimma University or any other University and that all sources of materials used for the thesis have been fully acknowledged.

Name	Signature	Date

Abirham Assefa____

This thesis has been submitted for examination with my approval as University Supervisor

Name	Signature	Date

1. Chair man

____

2. Principal advisor

Dr.-ing. Fekadu Fufa____

3. Co-advisor

Mr. Megersa Kebede____

4. Internal examiner

____

5. External examiner

____

ABSTRACT

The life of an individual is directly related to water. Inadequate water supply, unsafe water resources and inequitable access of water consume time, increase disease and costs of health facilities. This will finally lead to poverty in the area. The water distribution system is an essential component of every water utility. Its main function is to provide a safe, reliable water supply at an acceptable level of service and water distribution networks. This research focuses on evaluating the hydraulic performance of urban water supply distribution system of Sekota Town which was designed by the two consultants of Amhara Water Works Construction Enterprise (AWWCE) and Amhara Design and Supervision Works Enterprise. To assess the water supply distribution coverage of Sekota Town, to evaluate the water demand in Sekota Town and to evaluated the hydraulic performance of the existing design of the distribution system network using Water CAD v8i model This research findings and to make the workload easy materials are play vital role. The materials are used Computer, Flow meter, Stationary, Topographic map - to determine geographic location, elevation etc. Were set. The scope of this study was on confined the factors which affect the hydraulic performance of the pressure line and distribution system when water flows from source to customer. Generally the outputs showed that the network is exposed to relatively low values of pressure and velocity, which has negative effect on the performance of the network. In assessing the water supply distribution coverage and the distribution network for the Town and determining its hydraulic performance, WATER CAD v8i software has to be used. The study resulted that an increase in loss of hydraulic reliability during water flow directly affects water quantity, the existing design of water distribution network of the Town should be redesigned and hence this deduction gives room for developing the town in all directions, as the municipality is not clear about the future industrial zone and development area of the town. The water supply distribution coverage was 11.39 l/p/d. the Sekota Town Water consumption is found much lower compared with other developing towns. Therefore additional water supply should be constructed in order to increase water supply coverage of the Town. In addition, during the implementation of the distribution system the reservoir has to be increased at list to one third of the maximum day demand of the Town and proper sized pipes be used. Besides discussion with the concerned administrative and executive bodies is found necessary for the present and future development target areas of the Town.

Key words. *Sekota Town water supply, WaterCADv8i, Evaluation of hydraulic performance, Water Supply, Demand and Distribution system and Population for cast*

ACKNOWLEDGEMENTS

First and foremost, thanks to the Almighty God for granting me his limitless care, love and blessings all along the way. I would like to thank my advisor Dr.-Ing Fekadu Fufa and my co-advisor Mr. Megersa Kebede (MSc) for their kind academic advice, continuous support, unreserved assistance, constructive and timely comments at all stages of my work and also for supplying me relevant materials to carry out the research. I should strongly appreciate their patience full guidance in a lot of discussions we made on various problems I faced during the data preparation and proposal writing and provided me to had fruitful knowledge about research writing methods.

Last but not least; I am especially thankful to my family for their continuous support.

TABLE OF CONTENTTS Page

Contents

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ADSWE	Amhara Design Supervise and Water Work Enterprise
ASOCE	American Society of Civil Engineers
AWRDB	Amhara Water Resource and Development Biro
AWWA	American Water Works Association
AWWCE	Amhara Water Works Contraction Enterprise
C	Hazen Williams Coefficient
CSA	Central Statistics Agency
D	Diameter
DCI	Ductile Iron
DMA	District Meter Area
DUOT	Delft University of Technology
EC	Ethiopian Calendar
ECSCIOUD	Ethiopian Civil Service College Institute of Urban Development
GC	Gregorian calendar
GI	Galvanized Iron
GIS	Geographical Information System
GPS	Global positioning System
GTP	Growth and Transformation Plan
GWP	Global Water Partnership
HCU	House Connection Users

HDPE	High Density Polyvinyl Etoile
Jilt	Jimma Institute of Technology
Km	Kilometer
L	Length
L/c/d	litter per capita per day
L/p/d	litter per person per day
L/s	litter per second
M	meter
m/s	meter per second
m^3	cubic meter
MDGR	Millennium Development Goal Report
MDGs	Millennium Development Goals
mm	Millimeter
MNF	Minimum Night Flow
MOWR	Ministry of Water Resources
Ps	pump station
PTU	Public Tap Users
ROUMOWAE	Republic of Uganda Ministry of Water and Environment
SI	System International
SSA	Sub Saharan Africa
SWNDSS	Smart Water Network Decision Support System

UPVC	UN plasticized polyvinyl chloride
WBCSD	World Business Council for Sustainable Development
WDR	World Bank World Development Report
WDS	Water Distribution System
WHO	World Health Organization
WSP	World Bank administered Water and Sanitation Program
YCO	Yard Connection Own Users
YCS	Yard connection shared

1. INTRODUCTION

1.1 Background

Most of the world's population now lives in urban areas, and in developing regions the proportion living in cities and Towns has risen from 35 percent in 1990 to 45 percent in 2010 from 1.4 billion to 2.5 billion people (Abdel, 2012) For the first time in history, over half of the world's populations were record to be living in urban areas. This equates to approximately 3.3 billion people, but by 2015, the urban population will expect to reach 60% (UN-Habitat, 2005) and will continue to grow to an estimated 4.9 billion by 2030.Yet the benefits of city life are not available to all. In places, rapid population influx, inadequate public services, and out-of-date urban planning models have marginalized vast numbers of new arrivals into informal settlements, exacerbating inequality and urban poverty, and compromising efforts to achieve and sustain water security (GWP, 2012). According to the millennium goal targets, the Africa urban areas will be accessed for improved water within 15 years from the years 2000.On the other hand, in Africa largest cities, only 43% inhabitants have house connection water supply services (Wolday, 2005).

The main problem that developing countries are faced to provide access to safe water for their citizens is shortage of resources. Moreover, the capacity of the citizens to play for water that fully recovers the cost is very limited for this reason, many developing cities are faced great difficulty to expand the service and rehabilitating the existing water supply, generally. Tariffs in developing countries are set well below the level needed to cover even operation and maintenance costs. Losses from a water distribution network can be determined by adopting several approaches. By using a field studies concept of yearly balance and minimum night flow (MNF) assessment, possibly in combination with "burst and background losses estimation", the total value of leakage in water supply networks (at district meter area, DMA, level) can be evaluated and it's component was determined (Tabesh et al., 2008).

Research has shown that low, tariffs are set largely for political, rather practical, purposes. Limited institutional capacity is also one of the bottlenecks that hinder cities of developing countries for managing the infrastructure asset in general and water supply in practical.

In sub-Saharan Africa, 748 million people were still relying on unsafe drinking water sources in 2012, of which 173 million obtained their drinking water straight from rivers, streams and ponds. The remaining population relied on unprotected, open wells or poorly protected natural springs (ACC, 2008).

In comparison to other Sub-Saharan African (SSA) countries, Ethiopia's urbanization growth rate is highly increasing time to time 18% of the population is urbanizing according to data published by the country's Central Statistical Agency. This is far less than the average for all SSA, at approximately 30 % (WDR, 2009) the delivery of basic services through a highly decentralized system in a large, heavily populated, and predominantly rural country like Ethiopia is not without its challenges. Since 2012, access an improved water source was 52% (JMP, 2014). Generally Water demands in developing countries are rapidly increasing due not only to growing populations, but also as a result of the higher standards of living leading to increase per capital use, rapid industrialization, and the expansion of irrigation to supply the agricultural needs of the population growth. Urban populations typically rely on WDS to provide reliable, clean, potable and non-potable water (Mahdi, 2008) this research was conducted to evaluating of hydraulic performance of urban water supply distribution system case study in Sekota Town.

It has shown a rapid growth. Regarding the infrastructure and social services, the Town has connected to the national greed of electric supply, it has digital telecommunication and water supply and sanitation system however compared to the Town and population size, the coverage is not satisfactory. Further, the Town has postal office, banking system, hospital, primary schools, kindergarten, high school, vocational training school, health Centre, collage, few private clinics fuel station, Industry and other basic facilities. As described by the head of the Town economic development office, Sekota is consider one of the rapidly grown commercial Towns and has good prospect for development. Hence, to assure its progress a potable, reliable and adequate water supply system must be established (ADSWE, 2010) Water distribution system is the systems of urban water supply networks that transport potable water over vast geographical areas from treatment plant to millions of consumers within the right quantity and quality of water conveniently to the demand areas based on hydraulic integrity. The hydraulic integrity of a water distribution system represents the capacity to provide reliable quantities of water at acceptable pressures. In many developing countries water, quantity available for supply generally is not sufficient to meet the demands and one of the most common methods of controlling demand is the use of intermittent supplies where water supplied only a few hours a day here are many different types of demands placed on a water distribution network. In many hydraulic network models, these demand values are fixing a priori at any point in time, although more recently models have incorporated pressure dependent demands that can provide a more realistic prediction of the hydraulic system behavior with respect to pressure variability (ASOCE, 2012).

This research don support with hydraulic network analysis software Water CAD v8i. However, most a computer program performs extending period simulation of hydraulic and water quality behavior within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves and storage tanks or reservoirs. Water CADV8i is an extremely efficient tool for laying out a water distribution networks. It was easy to prepare a schematic or scaled model and let Water CADv8i takes care of the link-node connectivity. In constructing distribution networks for this study, no labels to nodes, because Water CADv8i would assign labels automatically. When creating a schematic drawing, pipe lengths are entered manually. In a scaled drawing, pipe length automatically calculated from the position of the pipes' bends, start and stop nodes on the drawing pane. The Ethiopian water sector strategy provision of sustainable, efficient, reliable and affordable and user's acceptable water supply and sanitation services to the urban population are a major concern in Ethiopia in general and in Amhara region in particular. As the demand on water increases due to the population growth rate, and the increase in per capita consumption, low supply performance of the water network lead to the negative influence in most of the socio-economic sectors.

This occurs because of the poor workmanship or poor pipe installation, poor material quality and hydraulic failure of pipe network system due to poor design of water distribution system. In the case of Sekota Town water supply project the design which is designed by the consultant has the hydraulic problem due to poor design. Samuel Martin (2004) in the book of hydraulic transit design for pipe line system, a hydraulic transient/hammering is a flow condition where the velocity and pressure change rapidly with time. The occurrence of transients can introduce large pressure forces and rapid fluid accelerations into a water distribution system When flow velocity changes rapidly because a flow control component changes status (for example, a valve closing or pump stop), it causes the change to move through the system as a pressure wave. Hydraulic transient can cause hydraulic equipment's in a pipe network to fail, if adequate transient control measures are not in place to overcome the transient (if the pressure wave is strong enough).This study is to investigate the state of the existing and new design of water distribution systems (Sekota Town water distribution system as a case study) and to evaluate the hydraulic performance of water supply network under varying conditions of supply and the design parameters such as water pressure, flow velocity and the time which contributes for the water hammering of pipes and fittings. This study is prepared for the researches which were don desires to review the capacity of reservoir; water source and the total water demand and supply of Waghimra Sekota water supply project. Which was designed by Amhara water works contraction Enterprise (AWWCE) and reviewed by Amhara design and supervision works enterprise and evaluate the hydraulic performance of distribution system parameters (pressure, velocity, flow rate).

1.2 Statement of the Problem

The life of an individual is directly related to water. Inadequate water supply, unsafe water resources and inequitable access of water consume time, increase disease and costs of health facilities. This will finally lead to poverty in the area. The intermittent of pump or breakage of pipe system due to pressure and velocity change in the water distribution system leads to water supply system interruption and the households of the Town go to fetch water from the unprotected water sources The households of the Sekota Town and surrounding rural villages have access to improved water supply in good quality and sufficient quantity of water with an affordable price that is available to cover the operation and maintenance cost but also recovers project investment cost at the end of the project design period.

As explained earlier it is clear that lack of basic public health services, such as adequate housing, safe water and sanitation, are major causes of poor health environment and underdevelopment. In urban poor areas, people suffer from diseases related to poor water supplies and sanitation. The impact is felt mainly by women and children, who are the ones that have to walk the long distances to fetch water. The problems of water distribution system as the case of study of Sekota water supply project is pipe and pipe fitting or appurtenant breakage due to hydraulic water hammer, network of the distribution systems is not cover the whole villages of the Town, capacities of reservoir and size of pipe in distribution system is inadequate to satisfy the demand of population of the Town, the water supply discharge cannot reach last dead end nodes due to hydraulic head problem and capacity of Town water supply organizational structure is low to manage the water supply schemes of the Town to reduce the leakage at the low areas of the Town. Therefore, there is a need to investigate and evaluate the hydraulic performance of water supply system situation in the urban area of Sekota Town and surrounding rural/poor village and develop strategy to improve the water supply situations in these areas in order to increase the water coverage of urban potable water supply of the Town.

1.3 Objectives of the study

1.3.1 General objective

The main objective of this study was to evaluate the hydraulic performance of Sekota Town water Supply distribution systems.

1.3.2 Specific objectives

The specific objectives of this studies were.

- To assess the water supply distribution coverage of the Town
- To evaluate the water demand of Sekota Town
- To evaluate the hydraulic performance of the existing design of the distribution system network using WaterCADv8i model

1.4 Research questions

The research questions were:

- How did we evaluate the water supply distribution coverage of the Town?
- Is the existing water supply satisfied the current demand?

- How was the hydraulic performance of existing design of the distribution system network evaluated?

1.5 Expected outcomes

A municipality would benefit through reduced water loss and reduced costs to the utility. The importance of prioritizing active leak control practices and procedures in the identification of water loss and the corresponding strategies to reduce leakage cannot be understated. The municipality would also benefit through the extension of sustainable water supplies, reduce operating costs, improved the system of hydraulics performance and utility efficiency and this methodology would allow more rational performance of water distribution systems measures to be calculated for sub-systems, and to know the main problems of in the pressure line and distribution system.

1.6 Justifications

In Sekota Town, reforms had taken place in the water sector to address irregularities that exist in water resources management which affect water supply coverage and equity in water supply and water loss in distribution system the Keble. Among some of the reforms which include access to water for primary use for all, all water to be beneficially used, water to be treated as an economic good and consideration to be taken for those unable to pay full price during water tariffing. Constraints to sustainability aggravated by the macro-economic challenges face by Sekota Town during the period 2004-2008 the water not sufficient in the hole Towns. Capacity of local authorities to operate efficiently. Among some of the water problem associated with service delivery in Sekota, which include insufficient coverage of services, water losses, and financial problem. Little has been done to review and analyze the performance of the urban water supply utilities.

1.7 Limitations

The limitations of data collection completely depend on the municipality and water supply and sanitation office, there were some Sorts of limitation while this document was prepared.

Shortage of relevant data for the compilation of literature review, data would not organized in computerized system. A municipality must consider how it would collect, store and evaluate the data to allow it to make the most informed decisions. And also the data not prepared or document in hard copy.

1.8 Significance of the study

The significance of this study identifies the hydraulic performance of Sekota Town water demand and supply allocations that system is identified from the economic point of view and hydraulic design of water distribution system.

The study of the hydraulic performance of the water distribution system also contributes to examine the water hammering impacts of the water distribution system and the preventive measure of water hammer but also identify the hydraulic parameters for the design of water supply distribution systems. The design made by the consultant is reviewed and redesigned.

1.9 Scope of the study

The scope of this research include, Water demand, produce and consumption of existing water supply, flow pattern/velocity, flow rate and pressure/,population projection, hydraulic analysis of water supply networks and those factors affect water flow in distribution system. Forecast population with acceptable formula that CSA use. In this study, the water that delivers to community has assumed quality water and all population use only from existing Sekota water supply distribution system. The demand of livestock assumes river or other source. Un-meter water loss and illegal water connection are considering water loss and finance analysis of water supply system not part of this study. This research also uses hydraulic network analysis software WaterCADv8i.

2. LITRATURE REVIEW

2.1 General concept of water distribution system

Water distribution system is the systems of urban water supply networks that transport potable water over vast geographical areas from treatment plant to millions of consumers to the demand areas. Water utilities worldwide face increasing challenges to preserve the hydraulic and water quality integrity of their water distribution networks. These challenges stem from burgeoning populations and migration to urban cities that continue to increase the load on aging, inefficient, and already strained infrastructures (AWWA, 2014).

The distributions system is classified transmission main and the distribution. Transmission mains convey water from the source, treatment, or storage facilities to the distribution system normally via a storage reservoir. There maybe a few service connections on the transmission main, but the purpose of this larger diameter pipe is to deliver water to the distribution mains where most of the service connections. Distribution mains deliver water to individual customer service lines and provide water for fire protection through fire hydrants, if applicable. The distribution mains normally deliver water from a storage reservoir to the consumers. The extend and routing of the transmission and distribution network depends largely on the location and characteristics of the demand areas to be served, the topography of the service area and the source of water, the quantities of water to be transmitted and the available infrastructure in the area such as roads, underground facilities and infrastructures etc.(ROUMWE, 2013).

The purpose of a system of pipes is to supply water at adequate pressure and flow. However, pressure is lost by the action of friction at the pipe wall. The pressure loss is also dependent on the water demand, pipe length, gradient and diameter. A low flow rate lead to ineffective to meet demand and high sedimentation in distribution system due to low velocity. Too large pressure values increase water losses (due to pipe waste) and incur a larger blowout probability. Additionally water supply networks regularly experience pressure drops and interruptions of water supply when there is an unexpected increase in water demand Therefore, safe and efficient operation of these large-scale networks is crucial for the survival of urban life (Duot, 2010).

Several researches and authors have been made to study the behavior of water distribution systems, and to reach an optimal solutions and assumptions in order to improve the hydraulic performance, cost effective, and to increase the efficiencies of the water supply networks.

Prabhata K. Swamee (2008) in his study houses are connected through service connections to water distribution network pipe-lines for water supply. From these connections, water is drawn as any of the water taps in a house opens, and the withdrawal stops as the tap closes. Generally there are many taps in a house, thus the withdrawal rate varies in an arbitrary manner. The maximum withdrawal rates occur in morning and evening hours. The maximum discharge (withdrawal rate) in a pipe is a function of the number of houses (persons) served by the service connections. In the analysis and design of a pipe network, this maximum withdrawal rate is considered. Therefore the hydraulic performance and its parameters determined maximum hourly and daily demand of water discharge.

Nemanja and Trifunovic (2006) in the books of the urban water distribution system, is elaborating general principles and practices in water transport and distribution in a practical and straight forward way. Water distribution systems consist of a network of smaller to larger pipes with numerous connections that supply water directly to the users. The flow variations in such systems are much wider than in cases of water transport systems. In order to achieve optimal operation, different types of reservoirs, pumping stations, water towers, as well as various appurtenances (valves, hydrants, measuring equipment, etc.) can be installed in the system.

Nemanja and Trifunovic (2006) analysis of a pipe network is essential to understand or evaluate a physical systems. In case of a single-input system, the input discharge is equal to the sum of withdrawals. The known parameters in a system are the Input pressure heads and the nodal withdrawals discharge. In the case of a multi-input network system, the system has to be analyzed to obtain input point discharge pipe discharges and nodal pressure heads.

(Masri, 1997) Studied the optimum design of water distribution networks. A computerized technique was developed for the analysis and optimal design of water distribution networks. The results show that the selection of the hydraulic restrictions should be reasonable and reflects the real capacity of the water distribution system.

(Jon Røstum, 2000) studied the cause of pipe failure of the distribution system. Static water pressure and pressure surges in a distribution system can affect pipe failure. Pressure surges can occur when water and air valves open and close during network operations. These surges can be one of the factors in failure clustering, as valves are closed and opened during repair activities. This cause of the pipe in the distribution system network is termed as the hydraulic failure of the pipe in water supply distribution system network. The pipe failure in the distribution system other than hydraulic impact is due to poor installation, material quality of pipe and age the pipe.

The most cause of hydraulic impact of pipe failure is termed as water hammer. Water hammer is the result of an event which is associated with a rapid velocity (or pressure) change, the result of an accident or a normal operational matter in a pipeline system.

Trondheim (2010) state that the water hammer transient is a non-uniform flow which is a change in the pressure resulting from a sudden change in the flow. This wave of altered pressure is propagating with the speed of sound through the pipe, and accompanying this pressure wave is the change of the flow which was the cause of the pressure change in the first place. At boundaries the pressure can be reflected and propagate back to the origin of the pressure change, and the flow behaves thereafter. This pressure- and flow variation continues to travel between boundaries, and the friction present in this flow is damping the value of these variations, finally giving a new steady state value for the flow under consideration.

Naeeni S (1996) developed a computer program, which enables to obtain the optimum design of various kinds of water distribution networks so that all constraints such as pipe diameters, flow, velocities, and nodal pressures are satisfied.

James, et.al (1994) made a study about distribution systems. Data about pressure and flow rate were obtained by continuous monitoring of their system. Transient analysis, time lagged calculations and inverse calculations were applied as a tool for calibration and leak detection.

James E. Funk (1994) studied the behavior of water distribution systems during transient operations. He concluded that during transient operations, pressure much higher than steady state values could develop. The causes of transient operation can be a result of pumps stopping or starting, valves opening or closing, and system startup or shut down, Perez, Martinez and Vela (1993) suggested a method for optimal design by considering factors other than pipe size. Pressure reducing valves were suggested to reduce the pressure in the downstream pipes, Vairavamoorthy, et.al (2000) suggested a new method of design sustainable water distribution systems in developing countries. They developed a modified mathematical modeling tool specifically developed for intermittent water distribution systems. This modified tool combined with optimal design algorithms with the objective of providing an equitable distribution of water at the least cost forms the basis of this new approach. They also develop guidelines for the effective monitoring and management of water quality in intermittent water distribution systems. A modified network analysis program has been developed that incorporates pressure dependent outflow functions to model the demand.

Vairavamoorthy and Lumbrs (1998) studied the leakage reduction in water distribution systems depending on optimal valve control. The inclusion of pressure- dependent leakage terms in network analysis allows the application of formal optimization techniques to identify the most effective means of reducing water losses in distribution systems. They describe the development of an optimization method to minimize leakage in water distribution systems through the most effective settings of flow reduction valves.

The following Joukowsky (Water hammer) equation may be developed hydraulic transient design for pipeline systems which is applicable for a wave propagating in the upstream direction:

$$\Delta P = -Pa\ \Delta v \text{ or } = \frac{-\mathbf{a}}{\mathbf{g}\ \Delta \mathbf{v}} \quad (1)$$

Where Δ p = change in pressure, ρ= fluid density, kg/m^3, a= characteristic wave celerity of the fluid, m/s, ΔV = change in fluid velocity, m/s,

$$\mathbf{a} = \sqrt{\frac{\frac{\mathbf{EP}}{\mathbf{PV}}}{1+\frac{\mathbf{Ev}}{\frac{\mathbf{EP}\times\mathbf{D}}{\mathbf{e}\times\mathbf{C}}}}} \quad (2)$$

Where V_E and P_E are the volumetric modulus of elasticity of the fluid and the pipe material (Pa) respectively, ρ_V is the density of the liquid (Kg/m3), D and e are the internal diameter and the wall thickness (m) of the pipe respectively, and C = constant, which depends on the axial movement of the pipe. In practical calculations, C $\approx$ 1.

The water hammer is reduced or controlled by the surge control. The purpose of surge control is to stop kinetic energy from being converted into elastic deformation energy. This can be done by the following basic methods are Energy storage, One-way surge and venting facilities, Optimizations of valve closing characteristics ,Optimizations of the strategy designed to control the piping system

Tan Wee Choon (1213) in international journal states the preventive methods of water hammer effect.

As his study some preventive measures are:

By decreasing the flow velocity, the effect of the water hammer should be minimized. increasing the moment of inertia of the pump can reduce the water hammer effect install a by-pass pipe with a non-return valve install air chambers adding the pressure control valves in pipe system install the vacuum valves to the piping system.

2.2 Head losses in the water distribution system

When a real fluid flows through a pipe, part of the total energy of the fluid is spent in maintaining the flow. This used up energy is converted to thermal energy due to internal friction and turbulence. Such a conversion, which is the loss of energy as far as its utility is concerned, is usually expressed in the form of head of liquids and therefore termed as head loss.

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),

The frictional head loss in a pipe is due to the viscosity of the fluid and the turbulence of the flow and is present throughout the length of the pipe. As 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.

When there is a sudden or gradual change in the boundaries of the fluid or when there is a local obstruction to flow, the flow pattern changes. This results in a change in the magnitude, direction or distribution of the velocity of flow. Such a change introduces additional head loss which is of a local nature and is usually much less than the frictional head loss in a long pipe. It is therefore termed as minor head loss.

Trifunovic (2006) in the books of the urban water distribution system, the most popular

Equations used for the determination of friction losses are:

The Darcy-Weisbach Equation, the Hazen-Williams Equation, the Manning Equation.

The Darcy-Weisbach Equation is:

$$Hf = \frac{\lambda \text{ L}}{12.1\text{D}^5 \text{ x Q}^2} \tag{3}$$

The Hazen-Williams Equation is:

$$H\ f = \frac{10.68\text{LQ}^{1.852}}{\text{C}^{1.852} D^{4.87}} \tag{4}$$

The Manning Equation is:

$$H\ f = \frac{10.29 N^2 \text{L}}{D^{16/3} * \text{Q}} \tag{5}$$

In all three cases, the friction loss h_f should be calculated in meters of water column (mwc) for the flow Q expressed in m^3/s and length L and diameter D expressed in m. The use of prescribed parameter units in Equations 3-5 is to be strictly obeyed as the constants was need to be readjusted depending on the alternative units used.

In the above equationsλ, C and N are experiment tally-determined factors that describe the impact of the pipe wall roughness on the friction loss.

Nemanja and Trifunovic (2006) in the books of the urban water distribution system, minor (in various literature local or turbulence) losses are usually caused by installed valves, bends, elbows, reducers, etc. Although the effect of the disturbance is spread over a short distance, the minor losses are for the sake of simplicity attributed to a cross-section of the pipe. As a result, an instant drop in the hydraulic grade line should be registered at the place of obstruction.

Pramod R. Bhave (1991) in the book of analysis of flow in water distribution networks, the resulting minor head loss is computed from the following equation:

$$H\ m = \frac{\text{k}v^2}{2\text{g}} \tag{6}$$

Where: $h_{m=}$ minor loss (m), K= minor loss coefficient for the specific fitting, V= velocity (m/s) and G= gravitational acceleration (m/s^2)

2.3 The effects of head loss in water distribution system

(Sodiki, 2013) in his study the available pressure at any point in a fluid flow conduit is progressively reduced away from the pressure source (such as the elevated storage in water distribution systems) due to frictional losses and losses through fittings such as elbows, tees, reducers and valves. The latter loss is sometimes called separation loss. Thus, extensive runs of conduit would result in increased frictional loss while multiplicity of fittings would result in increased separation loss.

The effects of head loss in the distribution systems are:

The capacity of the pump was increase due to high head of pressure line and as result the investment cost and operation and maintenance cost of pump is high.

The flow rate of the water in the distribution system is not uniformly reach each nodes or the junctions of the tap.

To prevent high head losses in water distribution system optimum an engineering design is required which is all hydraulic parameters like pressure, velocity and optimum pipe diameters should be in the design criteria of water system design.

2.4 Types of water distribution systems

2.4.1 Branching systems

This type of distribution network is the most economical system and common in the developing countries due to its low cost. In this system, when there is need for developing the network, new branches follow that development and new dead ends should be constructed. The branching systems have some disadvantages such as the following.

-The dead ends cause accumulation of sediments, which result in increasing contamination and health risks.

-The maintenance operation upstream of the network was prevent water to reach the downstream due to the interruption of the whole area of maintenance.

-The fluctuating demand causes high-pressure oscillations.

2.4.2 Grid systems

There are no dead ends in this type of distribution networks. The maintenance operation did not affect the interruption on the whole area as in the branching system, this type of layout is highly desirable because, for any given area on the grid, water can be supplied from more than one direction. This results in substantially lower head losses than would otherwise occur and, with valves located properly, allows for minimum in convenience when repairs or maintenance activities are required the whole area is covered with mains that form the grid system.

2.4.3 Ring Systems

The mains form a ring around the area under service, secondary pipes connecting the mains and delivering the water to the consumers.

2.4.4 Radial Systems

The area under service in the radial system is divided into sub areas, and a storage tank is placed in the center of each subarea to supply water to the consumer.

2.4.5 Water distribution system modeling

Analysis of water distribution network provides the basis for the design of new systems, the extensions, and control of existing systems. The flow and pressure distributions across a network are affected by the arrangement and sizes of the pipes and the distribution of the demand flows.WaterCADv8i could show pressure, demand, and hydraulic grade in different nodes as well as flows, velocities, gradient and pressure different pipes throughout the distribution system.

2.5 Water supply mode in distribution system

2.5.1 Continuous system

This is the best system and water is supply for all 24 hours. This system is possible when there is adequate quantity of water for supply. In this system sample of water is always available for firefighting and due to continuous circulation, water always remains fresh. In this system less diameter of pipes are required and rusting of pipes would be less. Losses was more if there are leakages in the system.

2.5.2 Intermittent system

If plenty of water is not available, the supply of water is dividing into zones and each zone is supply with water for fixed hours in a day or on alternate days. As the water is supply after intervals, it is call intermittent system. The system has disadvantages such as Pipelines are likely to rust faster due to alternate wetting and drying, increases the maintenance cost, polluted water through leaks during non-flow periods and more wastage excess to collect fresh water each time. In this water supply system the high-elevated area, get adequate pressure by dividing the city in zones. The repair work can easily do in the non-supply hours. Depending upon the level of the source of water and the city, topography of the area, and other local conditions and considerations, the water forced in to the distribution system in the following three ways:

- Gravitational system: This method is the most economical and reliable since no pumping is involved at any stage. However, it needs a lake or a reservoir as a source of supply. Such a system can adopt for cities, which are situating at the foothills, and the source of supply is available somewhere in the hill at sufficient elevation of the city. High pressure for firefighting may require use of motor pumping trucks, and low-lying areas may need to be isolated to prevent excessive pressure.
- Pumping without storage system: the treated water is directly pumping into the distribution mains without storing it anywhere. High lift pumps are required in this system, which have to operate at variable speeds to meet the variable demand of water. Therefore, generally not use as a distribution system. It is the least desirable method of distribution, since it provides no reserve flow in the event of power failure and pressures was fluctuate substantially with variations in flow. Since the flow must be constantly, vary to match an unpredictable demand, sophisticated control systems are required. Systems of this kind have the advantage of permitting increased pressure for firefighting,
- Combined gravity and pumping system: The treated water is pumping at a constant rate and stored into an elevated distribution tank, to distribute with action of gravity to customer. Sometimes the entire water is first pump into the distribution reservoir and then distributed among the consumers. Many times it is pump into the distribution mains and tanks simultaneously. The excess water during low demand period gets stored in the reservoir and is supply during high demand periods. The pumps work at a constant rate, which is adjusting in such a way that the excess

quantity of water stored in the reservoir during low consumption nearly equals the extra demand during high consumption (Shimelis and Tamirat 2012).

2.6 Pump

The most common input of energy into a system was through pumping. Pumps are crucial to any distribution system that cannot supply acceptable pressure to consumer through the sole use of gravity flow. A pump is an element that adds a head to the system as water passes through it. Pump is an integral of much pressure system and add energy to head gains to the flow to counteract head losses and hydraulic grade differences within the system.

2.7 Water demand

When designing the water supply scheme for a Town or city, it is necessary to determine the total quantity of water required for various purposes by the Town. In fact, the first duty of the engineer is to determine the water demand of the town and then to find suitable water sources from where the demand can be meet. However, as there are so many factors involved in demand of water, it is not possible to accurately determine the actual demand. Certain empirical formulae and thumb rules are employing in determining the water demand, which is very near to the actual demand (Rao, 2005).

The various types of water demands are domestic water demand, industrial water demand, commercial water demand, demand for public uses, fire demand, and demand for Losses. For a well design of a supply scheme, the above demands must evaluate to the at most accuracy formula.

$$\left\{\begin{matrix} Actual \\ water\ supply \end{matrix}\right\} = \left\{\begin{matrix} Actual \\ demand \end{matrix}\right\} = \left\{\begin{matrix} total \\ potential\ demand \end{matrix}\right\} + \{consume\ rwastage\} + \left\{\begin{matrix} distribution \\ loss \end{matrix}\right\} + \{unsatisfied\ demand\}$$ (Shimelis and Tilahun, 2012).

2.7.1 per capital demand.

When to find out not only the total yearly water demand but also to assess the required average rates of flow and the variation in rates. Then to calculate it

Total annual volume (V), Annual average rates in liters per day (V/365) and Annual average demand per person (per capita demand)

Fluctuating rates of demand in flows is expresses with percentage ratios of maximum or minimum yearly, monthly, daily or hourly rates average values.

The total quantity of water required by various purposes by a Town per year and 'p' is population of Town, then per capita demand should be Per capita demand = Q/(P x 365) litters/day. Per capita demand of the Town depends on various factors like standard of living, numbers and type of commercial places in a Town etc. (Rao, 2005).

2.8 Population forecasting methods

The water distribution systems design for a predefined time horizon generally called design period. When the design period is fixed the next step is to determine the growing of population or water demand of a Town depends upon the factors like births, deaths, migration and annexation. The future development of the Town mostly depends upon trade expansion, development industries, and surrounding country, discoveries of mines, construction of railway stations etc. may produce sharp rises, slow growth, and stationary conditions or even decrease the population. For a static population, the system can be designed either for a design period equal to the life of the pipes sharing the maximum cost of the system. On the other hand, for a growing population or water demand, it is always economic to design the system in stages and strengthen the system after the end of every staging period. (Rao, 2005). The Ethiopian statistic authority uses the formula p n=p o x (1+r) ^n for most water supply project in the country to project population at the end of required decade/year. Where: P n= population at the target year or design period

Pp = present population, r = Annual growth rate, n= design period, in year (ADSWE, 2036

3. MATERIALS AND METHODS

3.1 Descriptions of the study area

Sekota Town was founded in 417 during the reign of Emperor Kalieb. Some sources show that the Town has similar age with Axum and Harar Towns. The Town was founded around the area where Wikir Meskele Kirstos Church was located in the 5^{th} century AD. In other time the Town was relocated from Meskele Kirstos Church area to a higher area called Fatizgi located west of the current location of the Town .However. This location was not found to be comfortable as it was thought to be, thus the Town was relocated to the current location. The name Sekota came from the word called Shigutan meaning shegutew. Sekota is one of the reform Towns in the region and has a city administration.

Sekota is located in the northern part of Ethiopia in Waghimra Sekota Administrative Zone of the Amhara National Regional State and it is 720km north of Addis Ababa and 430km north of Bahir Dar. Geographically the town is located at 12^0 38′, 11.18″, N latitude and 39^0 2′, 21.31″, E longitude With an altitude of 2272 m. a. s. l Sekota Town divided in to three administrative kebeles, and the current population of the Town is about 32,800 inhabitants in 2015 as reports of Town municipality and Covering a total area of the Town is 92.4 s q km.

3.2 Climatic conditions

The Town is situated in Weyna Dega. The mean annual rain fall is 760 mm. The monthly minimum and maximum temperature is 22^0 c and 26^0c respectively. On the other hand, the mean monthly minimum temperature reaches 18^oc according to the design reports of Amhara Design and Supervision Works Enterprise.

The infrastructure of the Sekota Town has road connections Bahir Dar. Desie and Mekelie and is accessible all year for transporting system Sekota enjoys the benefits of a digital automatic telephone system. Mobile telephone and postal service are also available. Sekota receives a 24 hour electric supply from the country's hydroelectric grid system.

There is a growing demand for water and sanitation services in the Town due to growing populations, rising standards of living and per capita incomes, and rising awareness of health benefits of improved water and sanitation. However, the demand for water in the Town is growing much faster than the supply.

A considerable portion of Sekota Town is inhabited by urban poor living in low and small housing where water supply facility is not adequate. Furthermore some of the rural areas around the Town also have limited water supply access.

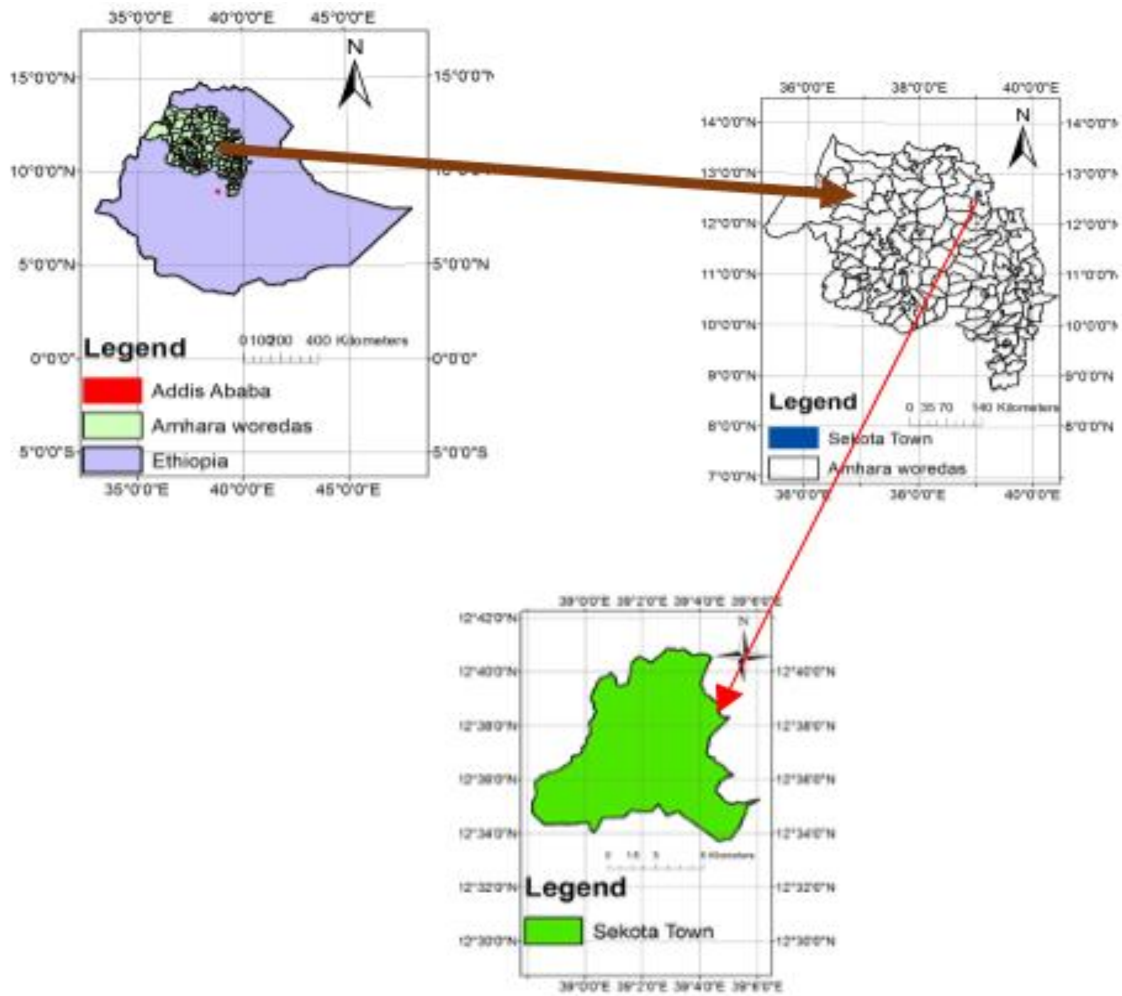

Figure 3.1 Map of Sekota Town

3.3 Materials

This research was study on evaluating hydraulic performance in water distribution system. To conduct the goal of the research it is require review of applicable practices, research Findings, information on impact and cause of hydraulic performance loss in water distribution system. Additionally to analyzing and interpreting information to provide a recommendation to the research findings and to make the workload easy materials are play vital role. The materials, which was used for this research, are list below:

Computer, Flow meter, Stationary, Topographic map - to determine geographic location, elevation etc. of the area, GPS - to take coordinates of points, Water meter: to measure the flow of water in the pipe, Pressure gage: to measure the pressure at the nodes and pump outlet and WaterCADv8i Software.

3.4 Study Period

The study period was done from February –October 2016 Within the specify period of time the required research planning, preparation of ground work, building of scaffolding, data collection, sampling and analysis, writing up and finally dissemination was executed.

3.4.1 Study design

A study design/frame is the process that guides researchers how to collect, analyze and interpret and observation data. This study was designed in how important and exact information was getting to evaluate hydraulic performance of water distribution system. Therefore, the objective of the research was achieve in accordance with the methodology of study.

- Questionnaires: Information was collected from Sekota water supply customers. This is the more the better. The data can be all kinds. The information that was collected from customers used to get relevant data and perhaps it used to find out about their attitudes the effect of hydraulic performance on the water supply delivery system.
- Survey: Site visit shall be conduct to collected data on impact of loss of hydraulic performance on Sekota water supply distribution system. Example, breakage of pipe, linkage of pipe, water loss due to back flow, burst of pipe, intermittent supply, etc.
- Literature review: Published literatures and written articles addressing causes and effect of hydraulic performance on water distribution system are review. Moreover, the volume and severity of hydraulic loss was notice. Finally, the possible solutions for the problems recommends.

3.5 Sample size and sampling procedures

The sample size that was from of the study area is just the representative sample size within the systematic sampling. This was conducted, and measure on peoples and existing water supply customers, consultants, Sekota water supply and sanitation office and other stakeholders. This sampling is giving the exact information without any doubt.

3.5.1 Sampling Procedures

Target Population: the target population is the user of Sekota water supply. That is register by Ethiopian central statistical Authority (CSA) in 2007 and other stakeholders.

Specifying sampling frame**:** The Sampling was designed from the list of participants in Sekota water supply distribution system. All parties become a sampling unit. Two types of sampling procedures would be implemented. Initially stratified sampling was taken by dividing the population into various strata. Then random sampling was apply to provide adequate data for the analysis. The population that was data collected with interview and questioner by sample size and procedure of sampling are tabulate as below.

The stratified sapling is to known in different way of angles or views of for water uses in different labels so that we stratified the Town of the population.

Random sampling we selected from different customers of the Town so that we can pick a random sample any customers for water supply.

Table 3.1 Sample size data

Item No.	Population	Number of data	Sampling procedure	Sample size
1	Customer of Sekota water supply			
1.1	Sekota head officials	8	Systematic	3
1.2	Sekota water supply stuffs	8	Random	3
1.3	Deferent socio-economic Costumer	15	Random	10
2	Consultant			
2.1	Amhara water design and supervise enterprise.	6	Systematic	3
2.2	Resident Engineers	4	Systematic	2
2.3	Site Supervisors	3	Systematic	2
3	Commercial area			
3.1	Pensions	12	Random	6
3.2	Super markets	11	Random	8
3.3	Hotels	15	Random	9
3.4	Health sectors	10	Systematic	6
4	Schools	8	Random	3
4.1	Teachers	20	Random	12
4.2	Student	15	Random	5
Total Sample size				67

3.6 Study Variables

The study variables assessed in this research are both independent and dependent variables. Which variables express about impact of water distribution system of hydraulic performance in water supply.

3.6.1 Independent variables

These independent variables are more relating with specific objectives but each specific objective is affecting one another. The independent variables that are to be measure and manipulate to determine its relationship to observe phenomena are select and list below.

Intermittent water supply, High water demand and Population for Water use in distribution system

3.6.2 Dependent variables

In other case, the dependent variable, which is the output and its result, depend on the independent variables, which directly related to the general objectives. On the other hand, dependent variable is measure to determine the effect of the independent variables is list below.

- Hydraulic integrity the distribution system
- The Scarcity of Water source

3.7 Desk study and data collection instrument development

During desk study, the literature review where be done on the topics related to Town water supply systems. In this phase of methodology the data collection instruments and data collection indicators was ready. The characteristics of water supply systems in different village of the Town would be also studied. The standards of the water supply services, water supply arrangements, and relation to hydraulic performance of water supply was examined; water sector and the constraints of the water supply systems at the lower elevations and end node areas of the water supply services have also been studied and discussed. Additionally literature reviews on evaluation techniques and procedures of water supply systems would be done. The hydraulic performance of water supply systems based on the perceptions of the users of the study area was evaluated and discussed at water supply office by the following indicators of the water system. Water quantity supplied to users, Water quality supplied to users, reliability for continuity supply of the water supply system, Convenience of the water points, the managements of the water distribution system, the coverage of the distribution system and percentage of water losses, the time schedule of pump on and shut off.

3.8 Data collection

To study this research two ways of data collection methods were used. The two major categories of data gathering techniques. Collected of primary data from field Survey, Gathering secondary data from legal agencies and organizations

3.8.1 Methods of primary data collection

The field data collection consisting of data gathering from different nodes/junctions, reservoir, sources and pipe layout related to the water distribution system in the study was investigated using different data collection instruments. Field observations would the other method which was help in this study. During the field visit different users such as private tap and public fountain users including the sites and infrastructures was visited to collect different information's and data should be recorded

The study was focus on the following key considerations of the Town areas: very poor Town settlements ,Remote areas in the Town most residents living in rented houses very suppressed water supply service areas Commercial centers of the Town proportion of the household using different types of facilities. The lowest or depression and peak points/areas of Town at field level the data hydraulic parameters of pressure, flow rate and velocity was measured and conducted with the data collecting instruments. The elevations and directions of existing nodes, water sources and service reservoir and length of pipe links would be collected that was used for analysis of pressure at nodes and velocity of links. The type and diameter of pipe the capacity of reservoir and its shape.

3.8.2 Methods of secondary data collection

The secondary data was collected from the recognized or legal organizations, agencies and literatures for its steadfastness. The secondary data which was collected, were the water supply and pumping data, Daily Monthly Water production and Consumption Data, Town water supply network data, Existing water distribution system pipe length and size of pipe data ,The elevation of each node. Base demand of node, Number of users at each mode of service (house, tap, yard and shared connection users), Pump data and its type

3.8.3. Data analysis

The data collected on the functionality and utilization of the water supply distribution system at Town level of the study areas was analyzed by using Water CAD v8i and model fordetermination hydraulic parameters of existing design water distribution system. The hydraulic performance of the water supply system and the Town water supply design was also analyzed for the present situation. During data analysis, the nodal pressure and pipe link velocity was 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 system network. These findings of hydraulic performances of the water supply system of the town was bring the suggestion and recommendations that was help to improve the water supply system of the Sekota Town. The water hammer or surge analysis of water distribution system would be determined and the pressure measures of pipe and pipe fittings damage would be provided at wall head of water pump and the pump impeller and pump shaft.

3.9 Water distribution system networks

The water distribution system is a pipe network that delivers water from single or multiple supply source to consumers. There is a general belief arising out of negligence on behalf of service providers, that water supply networks can be expanded indefinitely. Many water supply providers, in a drive to provide wide water supply coverage increase the number of customer connection through a massive network expansion. Because of rapid population growth and high water losses from the distribution network, the total water demand of the system in Sekota exceeds available production capacity.

The flow and pressure distributions across a network are affected by the arrangement, sizes of the pipes and the distribution of the demand flows. Since a change of diameter in one pipe length affected the flow and pressure distribution everywhere, network simulation is not an explicit process. Pipe network analysis involves the determination of the pipe flows and pressure heads that satisfy the continuity and energy conservation equations. According to this study, Hazen-Williams equation was used as it is commonly used in the design, modeling of water distribution network and water distribution systems because of its simple form, and analyzing an entire network in steady state flow.

The water distribution networks should meet demands for potable water. If designed correctly, the network of interconnected pipes, storage tanks, pumps, and regulating valves provides adequate pressures, adequate supply, and good water quality throughout the system. If incorrectly designed, some areas may have low pressures, poor fire protection, and even health risks

Table 3.2 Pipe head loss formula for full flow

	Resistance Coefficient(A)	Flow Exponent (B)
Hazen-Williams	$4.727\ C^{-1.852}\ d^{-4.871}\ L$	1.852
Darcy-Weisbach	$0.0252\ f(\varepsilon, d, q) d^{-5} L$	2
Chezy-Manning	$4.66^{2}\ d^{-5.33}\ L$	2

C = Hazen-Williams roughness coefficient, ε = Darcy-Weisbach roughness coefficient (ft.), f = friction factor (dependent on ε, d, and q), n = Manning roughness coefficient, d = pipe diameter (ft.), L = pipe length (ft.)

3.9.1 Initial setup

Throughout the process, International System Unit (SI) has been used. To request the use of these units in WaterCADV8i, the user chooses SI flow unit under the hydraulics option. In this study, liter per second unit was selected for flow, which also defines all other units using the 33SI system. Hence, lengths, pressure, head, elevations are taken in meters, and diameters of pipes are defined as millimeters. The network elements are: source, reservoir, pipes, nodes, pumps, and tanks

3.9.2 WaterCADv8i

WaterCADv8i is a powerful, easy-to-use program that helps hydraulic engineers design and analyzes water distribution systems. WaterCADv8i provides intuitive access to the tools used to model complex hydraulic situations. It can be used for many different kinds of applications in distribution system analysis. In this study, it is used to carry out the hydraulic analysis of the distribution networks in the study area.

3.9.3 Source

Untreated water (also called raw water) may come from ground water source or surface waters such as lakes and rivers and the raw water is usually transported to a water treatment plant where it is processed to produce treated water and stored in to the Service Reservoir Station the water is chemically treated and fed into the distribution system by gravity,

Water distribution systems are designed to adequately satisfy the water requirements for a combination of domestic, commercial, industrial, and firefighting purposes.

3.9.4 Reservoir

The term reservoir has a specific meaning with regard to water distribution systems modeling that may differ slightly from the use of the word in normal water distribution construction and operation. Reservoirs are a type of storage node. A storage node is a special type of node where a free water surface exists, and the hydraulic head is the elevation of the water surface above sea level. The water surface elevation of a reservoir does not change as water flows into or out of it during an extended period simulation.

3. 9.5 Pipes

Every pipe is connected to two nodes at its ends. In a pipe network system, pipes are the channels used to convey water from one location to another. The physical characteristics of a pipe include the length, inside diameter, roughness coefficient, and miner loss coefficient. The pipe roughness coefficient was associated with the pipe material and age. The miner loss coefficient is due to the fitting along the pipe. Pipe length and diameters are then inputted as well as roughness. A roughness of 150 was selected for the PVC pipes

3.9.6 Nodes

Nodes are the locations where pipe connected. Two types of nodes exist in a pipe networks system. All nodes should have their elevation specified above sea level. Nodes, besides representing the connection point between pipes, can represent the following components in a network: demand nodes, Source nodes and Storage nodes.

3.9.7 Pumps

A pump is an element that adds energy to the system in the form of an increased hydraulic grade. Since water flows to downhill (that is from higher energy to lower energy) pumps are used to boost the head at desired locations to overcome piping head losses and physical elevations differences unless a system is entirely operated by gravity. Pumps an integrated part of the distribution system.

3.9.8 Tanks

A storage tank is also a boundary node. But unlike a reservoir the hydraulic grade line of a tank fluctuates according to the inflow and out flow of water. The tanks have a finite storage volume and it is possible to completely fill or completely exhaust that storage (although most real systems are designed and operated to avoid such occurrences) storage tanks are presented in most real-world distribution systems and the relationship between an actual tank and its model counterpart is typically straight forward.

3.10 Data quality management

In order to increase the quality of the data, the research prepared a fieldwork manual to check every day progress and assistant was selected and trained to make the data handling good. The researcher has checked the reliability and the accuracy of the data as well as The Questionnaire was structured and standardized. Translation of questionnaire from English into Amharic and back to English was made by people who are able to do and checked by the principal investigator. Training guidelines was prepared on households" questionnaire, observation checklist, and focus group discussion. Training was conducted for supervisors and interviewers. Pre-test was conducted on respondents.

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

1. Develop water distribution network scenarios.

The water distribution system layout would be prepared using the surveyed data of base demand, Elevation and directions of Northing and Easting of Junction, Source and Tanker but also pipe data at links using Water CADv8i software.

The existing water supply design network was evaluated in reality depending on the existing situation of operating the different parts of the network.

2. Determine head loss, velocity of the flow and pressure in water distribution using Water

CADv8isoftware.

3. Estimation of distribution parameters/pressure, velocity, discharge, time variation/ and

Procedure.

4. Check the nodal pressure at the point of lower and higher elevation areas of the

Distribution system.

5. The water supply system of Sekota will be redesigned as continuous supply depending

On fixed and extended pattern, assuming the availability of water sources, and the using of pressure reducing valves to reduce the high pressures in the system if the pressure of the distribution system is above from the permissible limit or if these design parameters may be above the design criteria.

6. Provide the solution of the hydraulic water hammer or develop scenario to reduce pipe

System failure by providing the design of surge tank at the outlet of the pump and

Installation of pressure breaks tank or pressure reducing valve in the distribution system.

7. Finally, the recommendation and conclusion was done based on the results and

Discussions of this study researches.

4 RESULTS AND DISCUSSIONS

4.1 Water supply coverage and demand

Problem in provision of adequate water supply to the rapidly growing urban population were increasing dramatically. Water demand in the domestic sector of developing cities including Sekota Town increases through time as a result demand for additional water sources and infrastructure. Sekota Town has significant problem on the shortage of water supply. Thus after about ten years of exhaustive services, the water treatment and distribution system of the Town has been shortage of water where the system could not fully cater for all users in and around the Town. In order to restore the quality of water, The Sekota Town Water supply distribution system gets its source water from the three boreholes already drilled and constructed at Wellehe well field near St. Michael church. The total drinking water demand that required in the Town in the year 2015 was around 1,640 m^3/d (18.98 l/s). The designed production of the treatment plant was 15 l/s but now reduced to 3.98 l/s of the total production

4.2 Water distribution system in Sekota Town

The Sekota Town Water supply distribution system gets its water source from the three boreholes already drilled and constructed at Welleh well field near St. Michael church.

This is a presentation covering the overall work at borehole sites. Each three boreholes installed Submersible Pumps are located at three Bore Hole sites namely BH-1, BH-2 and BH-7.The first two boreholes namely BH-1 and BH-2 are powered by Electrical mains supplied by EEPCO and the third station which is BH-7 has a stand by Diesel generator in addition to the mains supply as a standby power when the main power failed.

Booster Pump Station -1 (BP-2)

The three boreholes pump water in to the wet well at (BP-2), from here water is pumped to BP3 by a stand by and duty booster pump arrangement. The system consists of suction piping from wet well to the suction flange of the booster water pumps and discharge piping connecting to the transmission system .the system includes a surge protection system, Booster Pump Station -2 (BP-3)

From (BP-3) pump station water is pumped to Service Reservoir (SSR) by a 1+1 booster pump arrangement. The system consists of suction piping from wet well to the suction flange of the booster water pumps and discharge piping connecting to the transmission system,

The total water supply of the yield was 34l/s or 2937.6m^3/d in the year 2008 from the three boreholes in the design period,

Table 4.1 The source of water (borehole) for Sekota town

Well	East	North	Elevation	Depth of well (m)	Pump position elevation (m	Q(L/S)
Borehole-1	505438	1388978	2074.781	138.5	1945	9
Borehole-2	505376	1389867	2060.178	151.25	1970	10
Borehole-7	505348	1388997	2046	128	1992	15
Total yield						34

Currently during the study period, borehole -1 and borehole -2 are not functional. only borehole -7 was functional producing1296m3/d or 15l/s .The source water is pumped to Buster Station-1(BP-2) by each bore-hole pump and from this site it is further pumped to Booster pump Station-2(BP-3) composed by surface centrifugal pumps. The station is powered by Mains supply as well as stand by Generator set.

From the second booster station the water is pumped to Service Reservoir site by surface centrifugal pumps. Here also the station is powered by Mains and Stand by Generator set. From the Service reservoir station the water is chemically treated and fed into the distribution system by gravity,

Figur (photo) 4.1 below taken 25/6/2016 shows that the uses in the town are waiting for the water tile the tankers are refilled (recovered) this is because the source could not solve the demand during field observation showing collecting water from public water point.

Figure 4.1 Photo taken during field observation showing collecting water from public water point or public tap (PT)

The existing water supply system of the town has the problem of water storage due to low yield from existing borehole .There are three borehole which was drilled before but there yield is not satisfy the population demand .The existing reservoir volume of the town is 300m^3 and the current population of the town is 32,800 which is not fair. As a result Sekota Town population need another additional borehole and new service reservoir to enhance their water demand for their necessity and sanitation systems.

4.3, Population for casting and water demand (phase-I)

4.3.1 General

In the design of any water work projects it is necessary to estimate the amount of water that is required In case of a water supply project, assessment starts by determining the number of people who would be served and their per capita water consumption together with an analysis of the factors that may affect the demand. Estimation of the quantity of water required for a Town generally depends on the design period, population and rate of demand.

4.3.2 Design period

The future period or the number of years for which a provision is made in designing the capacities of the various components of the water supply scheme is called Design period. The economic design period of the components of water supply depends on their life. Initial cost, rate of interest on loan, the ease with which they can be expanded of the likelihood that they will be reduced absolute by technological advances. In order to design the parts of water system, the flow at the end of design period must be estimated.

The design period should neither be too long that the financial burden is thrown on the future generation nor should be too small that the whole financial burden is thrown on the present generation and the design of water work becomes uneconomical. The design period is not only limited by general economic consideration but also the following factors.

- Funds available for the completion of the project if more funds are available design period may be more, but if small funds are available the design period shall be less,
- As far as possible the design period should be nearly equal to the materials used in the water supply work,
- Rate of interest on the loans taken to complete. If rate of interest is less it will be good to keep design period more. But if the interest rate is very high, the design should be small.

For design of water supply schemes for Towns, a design period of 15-25 years is considered appropriate. For Sekota town water supply scheme by considering the above factors adopt a design period of 20 years with two phases.

4.3.3 Population for casting

An estimate for the future population in Ethiopia is based on CSA projections CAS has made population projections up to the year 2036 and has considered three variants. Population projection provides information on the future size of the population in a given area. Knowledge of this information is fundamental for development plans whose target is to satisfy the future needs. The basic components of changes in the size of the population of a certain area include fertility, mortality, migration and urbanization (CSA 1994, Vol. II).

Three different (low, medium and high) variant population projections are made regarding fertility and only one assumption (medium variant) being employed with regard to mortality and urbanization. The three alternative assumptions were made to reduce the Total Fertility Rate (TFR) of 7.7 observed in the country (1993) to 4.0 by the year 2015, 2020 and 2030 for low, medium and high variants respectively.

Based on this the Central Statistical Authority (CSA) of Ethiopia has established the population growth rate for Amhara Region within five years interval (1995-2036). Current total population of Sekota Town is 32,800 (year 2015).

Table 4.2 Projected Annual Growth Rates based on country level CAS.s growth rate (Source, CSA 19994 vol. II analytical reports)

Year	Country level growth rate	
	Urban	Rural
1995-2000	4.9	2.75
2000-2005	4.4	2.57
2005-2010	4.5	2.33
2010-2015	4.3	2.15
2015-2020	4.1	1.98
2020-2025	4	1.69
2025-2030	3.8	1.41
2030-2036	3.35	1.34

In the design of a water supply scheme, after deciding the design period the next step is forecasting the population of the study area in various periods based on CSA,s country level population growth rates using different population for casting methods (arithmetic, geometric and Incremental), but for Sekota Town use Geometric Incremental Method (commonly usage method in Ethiopia).

$$Pn = Pp\,(1+r)^{no} \quad \text{.......} \quad (4.1)$$

Where, Pn=population at target year, Pp=Base (present) population, r = Annual growth rate in (%), and n = design period in (year)

Table 4.3 Population projection (for phase-I)

Year	2015	2016	2017	2021	2025	2026
Growth rate		4.1	4.1	4	3.8	3.8
Population	32,800	34,145	35,545	41,702	48,785	50,639

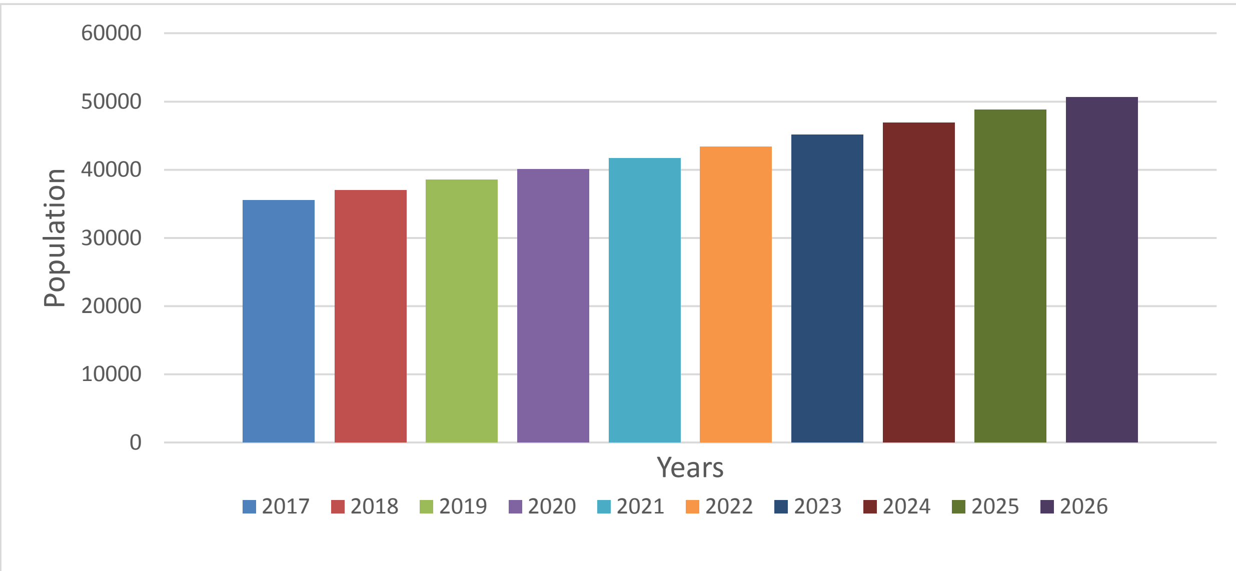

Figure 4.2 Population projection (phase-I)

Therefor the projected population of Sekota Town at the end of the target (design) year 2026 (phase-I) will be 50,639.

4.3.4, Water demand

The design and execution of any water supply scheme requires an estimate of the amount of water required by the community. The total amount of water is affected by expected development of city, presence of industries, quality of water and its cost. Generally.in designing the water supply scheme for Town or city, it is necessary to determine the total quantity of water required for various purposes.

The demand for various purposes is divided under the following categories. Domestic water demand, Non domestic water demand, Institutional water demand, Commercial water demand, Industrial water demand, firefighting water demand, Loss and waste

All these type of water demand depending on the following factors

Climate, Geographical location, Size, population, and economic condition of the community, Degree of industrialization, Water cost and water quality, Water policy and water resources regulatory bodies

4.3.5 Domestic water demand

Domestic water demand is the daily water requirement for use by human being for different domestic purposes like drinking, cooking, bathing, gardening, etc. the domestic water demand required by human being can be supplied or obtained through different modes of services depending on the economic level and facilities owned by the individual.

The use of water for domestic purposes may be subdivided in various categories

Drinking, Food preparation and cooking, Cleaning, washing and personal hygiene, Vegetable garden watering and other uses including waste disposal

Generally for Sekota Town piped system, the models and levels of services can be categorized as the following.

Public tap (PT), Yard connection own (YCO), Yard connection shared (YCS) and House connection (HC)

4.3.6 Growth of water demand

The implantation of the project was result in change of the per capital water demand through each mode of service to estimate the projected per capital demand using the initial demand of 20l/c/d, 30 l/c/d, 25 l/c/d, 50 l/c/d year for public tap/TP/ yard connection shared /YCS/ yard connection own /YCO/ house connection /HC/ users respectively for the first phase and assumed water demand to grew at growth rate of 1% per annum for public, 2% for YCS, YCO, and HC.

Table 4.4 Projected average per capital domestic water demand (phase-I) Sours, (MoWR Design Criteria)

Demand Category	Year			
	2016	2020	2025	2026
PTU	20	21	22	22
YCS	30	32	35	37
YCO	25	27	29	30
HC	50	53	59	61

4.3.7 Population distribution by mode of services

Based on the socio-economic survey carried out during study and the previous experiences, it is reasonable to assume and adopt that about 30, 35, 25 and 10 % of the population was public tap users, yard connection shared users, yard connection own users, house connection users respectively.

Table 4.5 Projected percentage of model of service (phase-I)

Demand category	Year			
	2016	2020	2025	2027
PTU (%)	30	25	23	20
YCS (%)	35	33	30	26
YCO (%)	25	32	35	40
HCU (%)	10	10	12	14
Total (%)	100	100	100	100

Table 4.6 Domestic water demand for Sekota Town

Year	2015	2016	2017	2020	2025	2026
Projected of population	32,800	34,145	35,545	40,098	48,785	50,639
Mode of services in %						
PTU (%)			30	25	23	20
YCS (%)			35	33	30	26
YCO (%)			25	32	35	40
HCU (%)			10	10	12	14
Population by mode of service						
PTU			10664	10025	11221	10128
YCS			12441	13232	14636	13166
YCO			8886	12831	17075	20256
HCU			3555	4010	5854	7089
Per capital demand(l/c/d			35545	40098	48786	50639
PTU			20	20.61	22	22
YCS			30	31.84	35.15	36.57
YCO			25	26.53	29	30
HCU			50	53.10	59	61
Demand by modes of services(m^3/d)						
PTU			213	207	247	223
YCS			373	421	515	482
YCO			222	340	495	608
HCU			178	213	345	432
Total domestic water demand(m^3/d)			986	1181	1602	1745
Climatic adjustment factors			1	1	1	1
Socioeconomic adjustment factor			1	1	1	1
Adjusted domestic water demand						
(m^3/d)			986.20	1181.02	1602.32	1745.04
(l/s)			11.41	13.67	18.54	20.19

Table 4.7 Adjusted water demand of Sekota Town (phase-I)

Description	Year			
	2017	2020	2025	2026
Population	34,145	40,098	48,785	50,639
Domestic water demand (m^3/d)	986.20	1181.02	1602.32	1745.04
Public water demand (m^3/d)(10% of DWD)	98.62	118.102	160.232	174.504
Losses (m^3/d)by 44%	44	38.5	33	30.25
Losses in%	433.93	454.69	528.76	527.87
Total average day demand (m^3/d)	1518.75	1754	2291	2448
l/s	17.58	20.30	26.52	28.33
Fire demand (FD)(10% of TADD) (m^3/d)	151.875	175.4	229.1	244.8
l/s	1.76	2.03	2.65	2.83
TADD +FD (m^3/d)	1670.62	1929.4	2520.1	2692.8
l/s	19.33	22.33	29.17	31.16
Maximum day factor	1.25	1.25	1.25	1.25
Maximum day demand (m^3/d)	2088.27	2411.75	3150.13	3366
l/s	24.17	29.91	36.46	38.96
Peak hour factor	1.9	1.9	1.9	1.9
Peak hour demand (m^3/d)	3174.18	3665.86	4788.19	5116.32
l/s	36.74	42.43	55.42	59.22

4.4 Water source description

Table 4.8 The source of water (boreholes) of Sekota Town

	East	North	Elevation	Pump position(m)	Depth of well (m)	Q(L/S
Borehole-1	505438	1388978	2074.78	1945	138.50	9
Borehole-2	505376	1389867	2060.18	1970	151.25	10
Borehole-7	505348	1388997	2046.00	1992	128.00	15
Total yield						34

In the design period the Sekota Town water supply was the total amount of yield from the whole boreholes was 34 l/s but at this time the water supply yield is 44.118% decreased that means the current time the yield is 15 l/s and the maximum day demand at the end of the design period (first phase) is 38.93l/s. so that the current source is not sufficient or enough to Town of the water demand and we should have to find additional source.

4.5 Service reservoir (phase -I)

The standard of service reservoir is the volume of one third of the maximum day demand biased on this the size of service reservoir for Sekota Town water supply is currently300 m^3 only so this is very low biased on the standards, the current time the maximum day demand of Sekota Town is 3366 m^3.

The new size of service reservoir for Sekota Town water supply scheme is fixed using simplified empirical method commonly practiced in many water supply projects. This is just taking one third of the maximum day demand of Sekota Town population at the end of design period of (phase -I) the current time the new service reservoir will be 1100 m^3 after subtracting the existing reservoir volume at the**.** (Phase -I)

4.6 Population forecasting and water demand (phase-II)

Table 4.9 Population projection (for phase-II)

population projection		
Year	Growth rate	Projected population
2026		50,639
2030	3.8	58,785
2035	3.51	69,852
2036	3.35	72,192

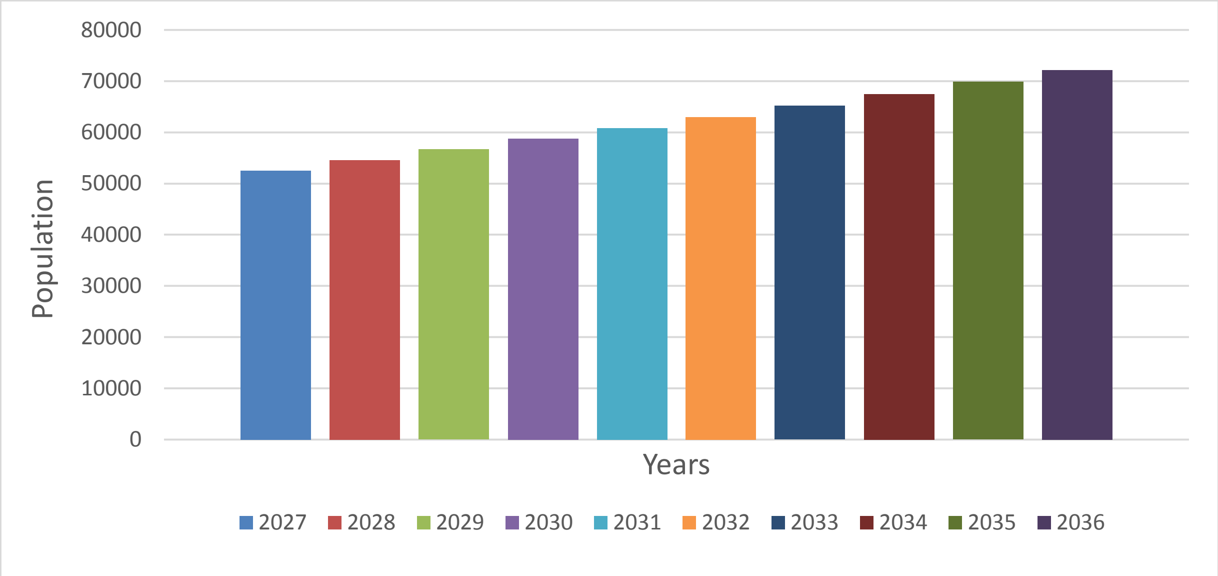

Figure 4.3 Population projection (phase-II)

Table 4.10 Projected per capita water demand by mode of Services (l/c/d) (phase-II)

Demand category	Year			
	2027	2030	2035	2036
PTU	25	26.02	27.43	27.62
YCS	40	43.29	47.80	48.76
YCO	30	32.47	35.85	36.57
HCU	70	75.77	83.66	85.33

Table 4.11 Percentage of population served by each demand category.

Demand category	Year			
	2027	2030	2035	2036
PTU (%)	20	18	15	12
YCS (%)	26	22	20	18
YCO (%)	40	44	47	50
HCU (%)	14	16	18	20
Total (%)	100	100	100	100

Table 4.12 Adjusted water demand of Sekota Town (phase-II)

Description	Year			
	2027	2030	3035	2036
Population	52,563	58,785	69,852	72,192
Domestic water demand (m^3/d)	1961.04	2374.05	3192.06	3443.07
Public water demand (m^3/d)(10% of DWD)	196.104	237.41	319.21	344.31
Losses coefficient	44%	35%	30%	28%
Losses (m3/d)	862.86	830.92	957.62	964.06
Total average day demand (m^3/d)	3,020.00	3,442.38	4,468.89	4,751.44
l/s	34.95	39.84	51.72	54.99
Fire demand (10% of TADD) in (m^3/d)	302.00	344.238	446.889	475.144
l/s	3.49	3.98	5.17	5.50
TADD +FD (m^3/d)	3,322	3,786.62	4,915.78	5,226.58
l/s	38.45	43.83	56.89	60.49
Maximum day factor	1.25	1.25	1.25	1.25
Maximum day demand x (TADD +FD) (m^3/d)	4,152.5	4,733.28	6,144.73	6,533.23
l/s	48.06	54.78	71.12	75.62
Peak hour factor	1.9	1.9	1.9	1.9
Peak hour demand (TADD +FD) (m^3/d)	6,311.80	7,194.58	9,339.98	9,930.50
l/s	73.05	83.27	108.10	114.94

4.7 Service Reservoir (phase-II)

Size of reservoir for Sekota Town water supply scheme in phase two is fixed using simplified empirical method commonly practiced in many water supply projects. This is just taking one third of the maximum day demand of Sekota Town at the end of design period. So .the service reservoir volume should be 2000m^3 in the second phase,

4.8 Pressure in pipe line

As the design criteria the maximum and minimum pressure in the distribution network shall be 135m and 15m manometer head respectively except where local topography and other condition dictate. Average day demand shall be used for minimum pressure computation. The pressure needed to supply water through the pipe network itself cause water loss in several ways through increased leakage because of increased pressure. increased burst frequency as a consequence of increased pressure; pressure cycling from frequent on/off switching by pumps of faulty pressure reducing valves can cause fatigue in plastic pipes. On the other hand, higher pressure will result in more water leaking from holes in the pipeline. All pipes have specific pressure within which they should serve; once the pressure is exceeded,

4.9 Flow

The flow arrow symbol on the pipe in the plan view always indicates the direction of flow, and the “Start node” and “Stop node” fields in the pipe properties indicate the orientation of the pipe itself. If water is flowing from the “start node” to the “stop node”, the flow arrow was point that way and the flow result value should be positive. If water is flowing from the “stop node” to the “start node”, the flow arrow was point that way and the flow result value was negative. A negative flow indicates orientation of flow with regard to the orientation of the pipe itself. The reason why this behavior occur is because in some system (mainly water distribution), flow can often reverse direction over the course of a day. Showing the negative sign in front of the calculated flow value is one way for the user to distinguish the current direction of flow.

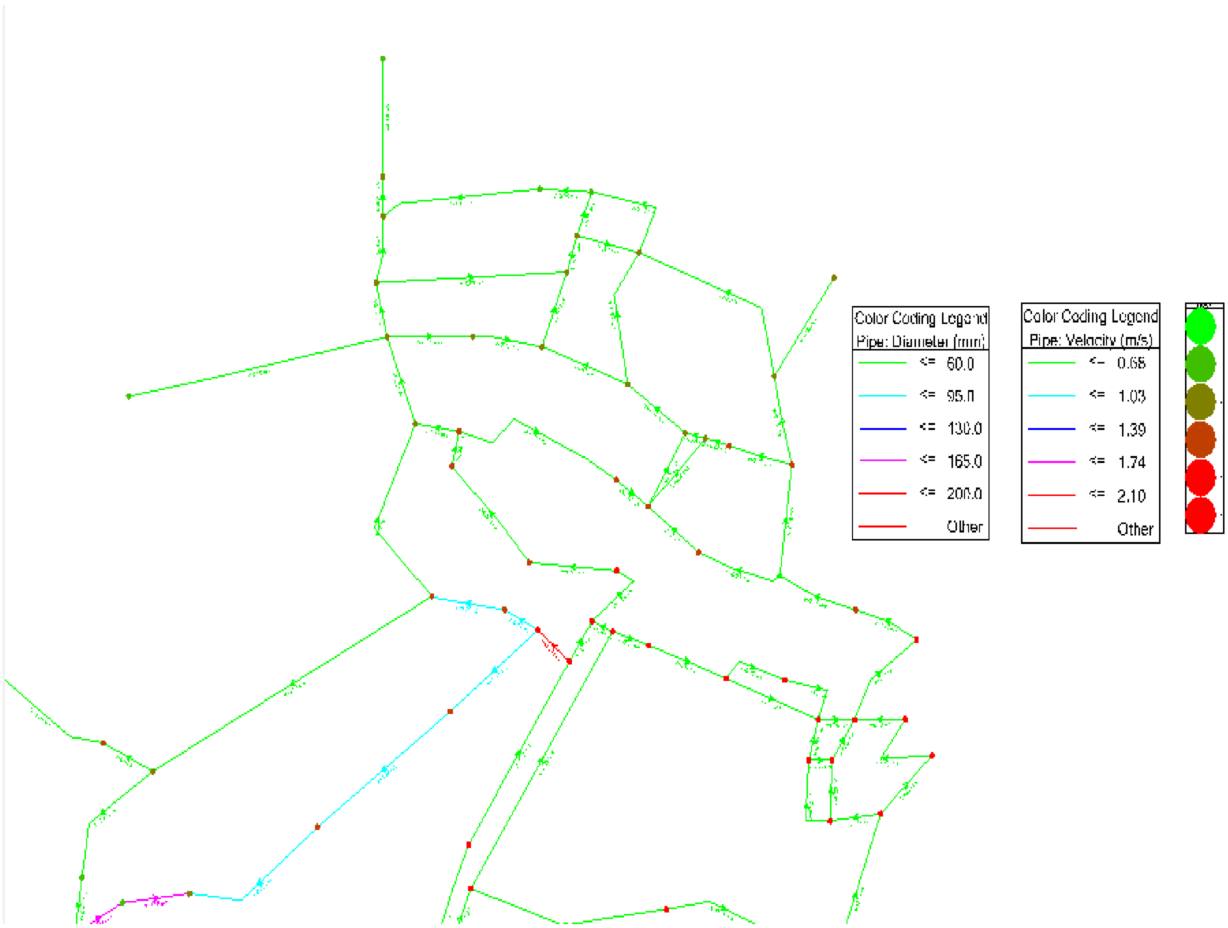

Figure 4.4 Water distribution network analysis of nod, junction and pipe

4.10 Pump capacity curve

A pump curve represents the relationship between the head and flow rate that a pump can deliver at it nominal speed setting. Pump head is the head gain imparted to the water by the pump and plotted on the vertical of the curve in meter. Flow rate is plotted on the horizontal in litter per second. A valid pump curve must have decreasing head with increasing flow. An efficiency curve determines pump efficiency in vertical percent as a function of pump flow rate in horizontal flow. Based on this BH-7pump is the total capacity of the pump head 190m and the total discharge is 15l/s

The submersible pump BH-7pump is have the following types.

Description=Electrical submersible pump, type=grandiose pump, model=sp 60-22, manufactures=mms6000, Rating=45kw, phase/Freg/volts=3/50/380, speed=2860 rpm

Design parameters the pump

Main switch gear=wall mounted type, Ingress protection=IP54, cable entry=bottom cable entry, 125 amp isolator with door interlock, 125 amp triple pole moulded case circuit breaker with over current and short circuit protection ,set of current trans formers for metering.

The diesel engines include low fuel consumption, high operational reliability, and high torque performance, easy ignition, low emission, small footprint, high power output and low maintenance.

The diesel engines are ideal for operating various type of machinery and equipment in the power generator,

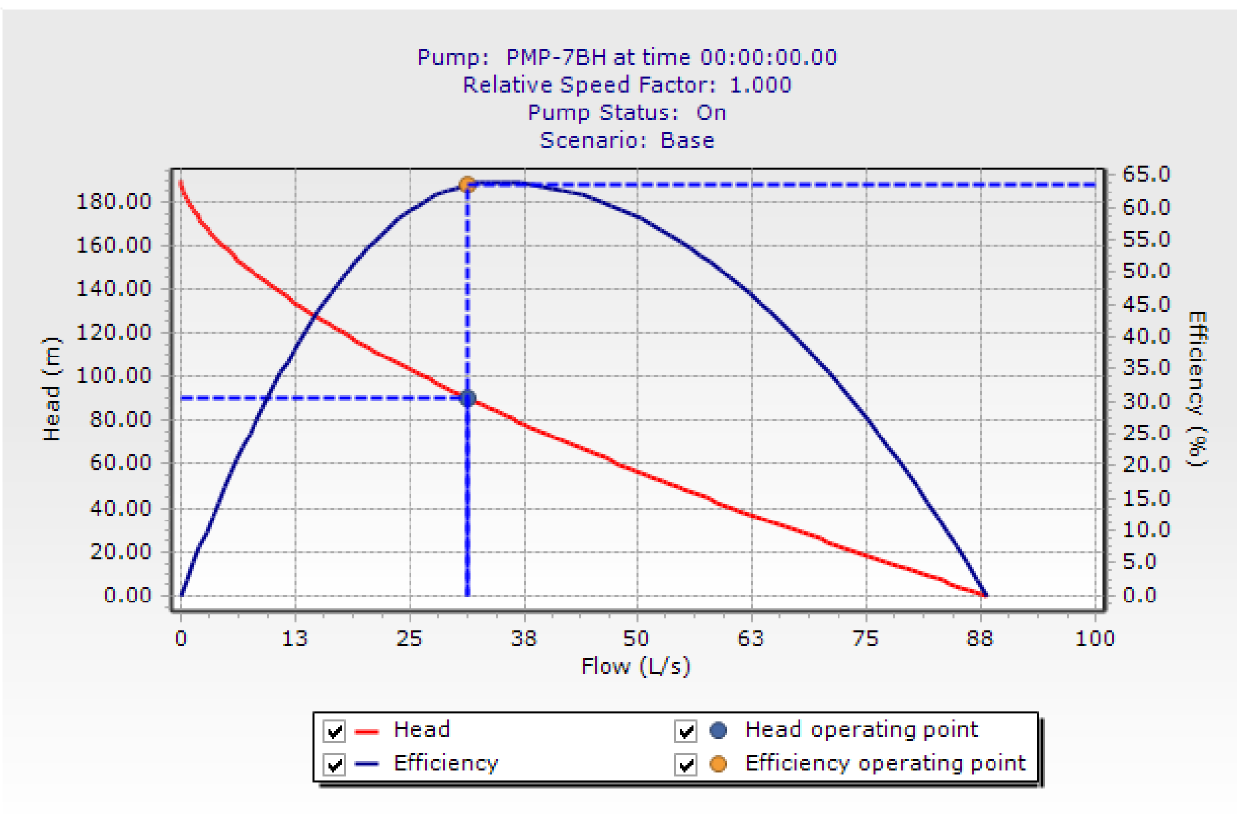

Figure 4.5 Pump head flow curve of the source

Booster pump Station one (BP1)

The boreholes pump water in to the wet well at BP1, from here water is pumped to BP2 by a stand by and duty booster pump arrangement. The system consists of suction piping from wet well to the suction flange of the booster water pumps and discharge piping connecting to the transmission system .the system includes a surge protection system,

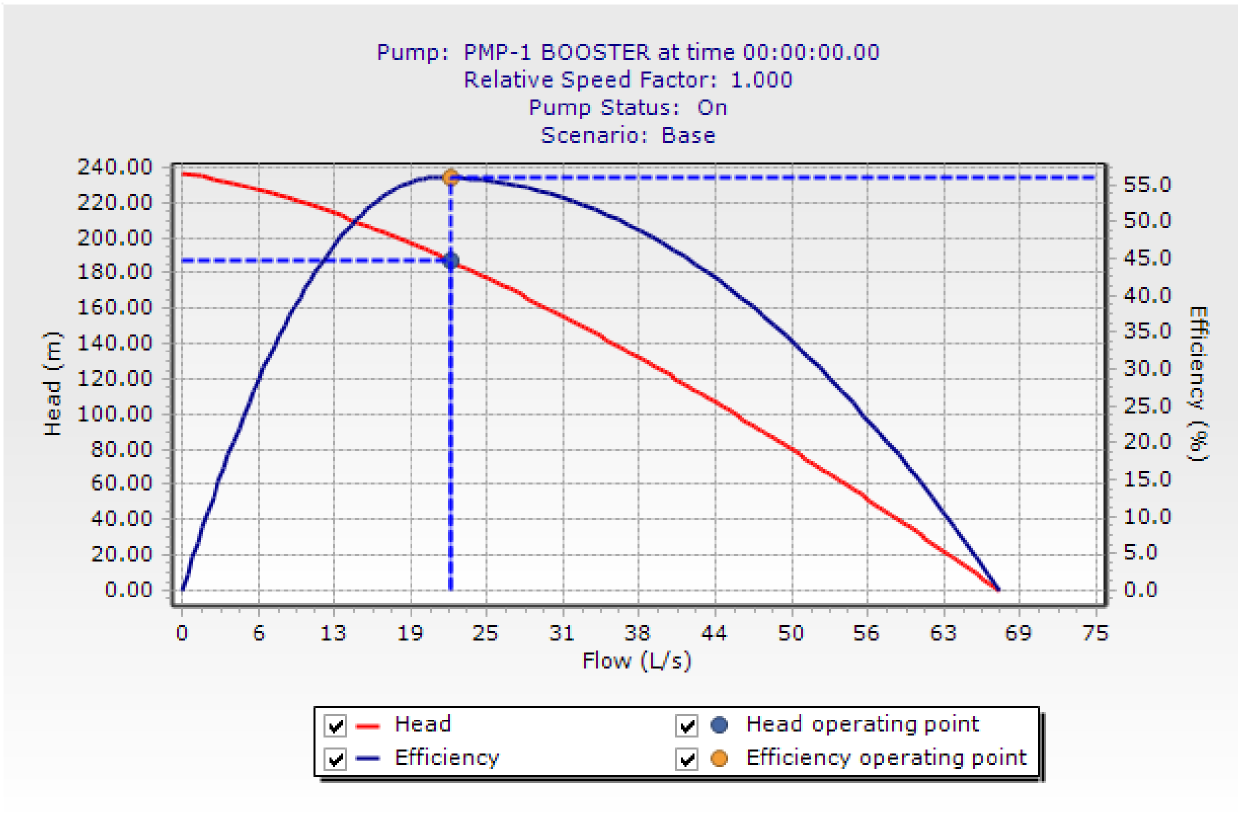

Figure 4.6 Booster pump station one pump curve

Booster pump station two (BP2)

From BP2 pump station water is pumped to Service Reservoir (SSR) by a 1+1 booster pump arrangement. The system consists of suction piping from wet well to the suction flange of the booster water pumps and discharge piping connecting to the transmission system,

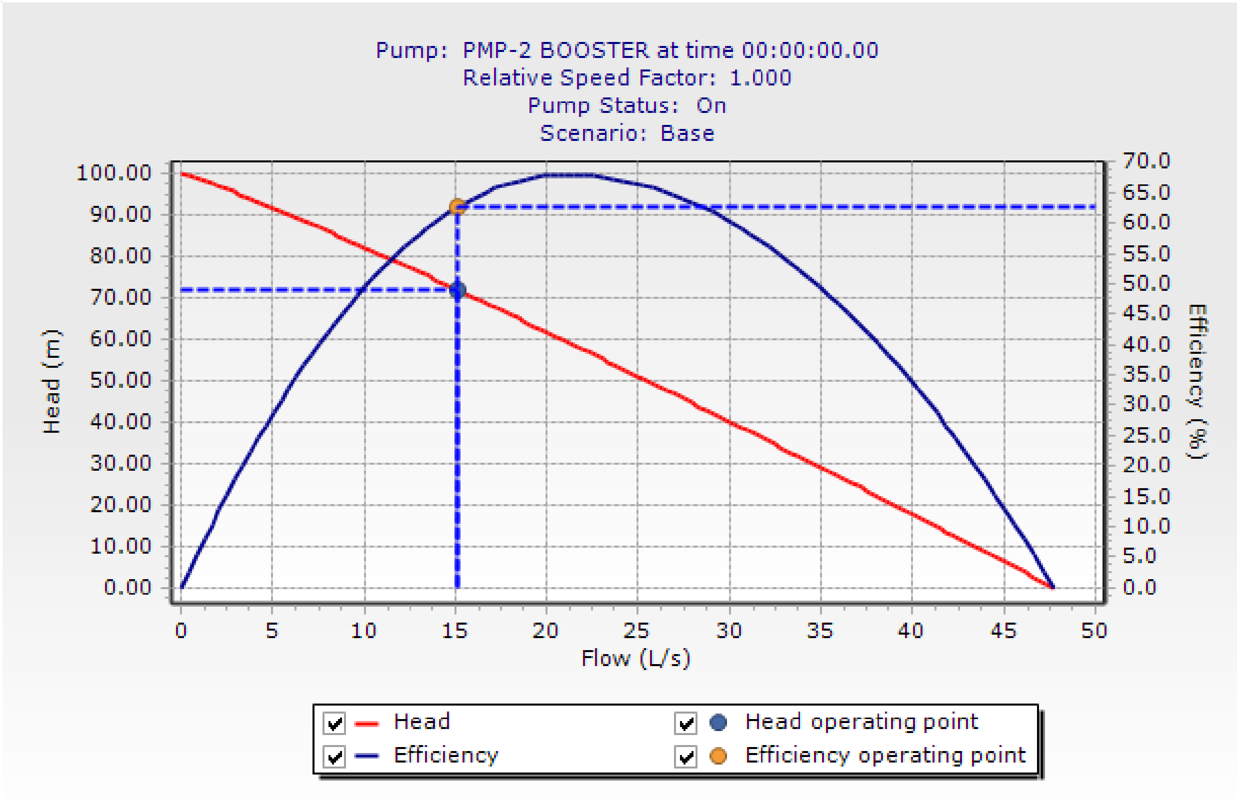

Figure 4.7 Booster pump station two pump curve

4.11 Nodal demand

Nodal distribution demand for towns with the order of magnitude of Sekota does not show appreciable difference amongst demand categories. The fact that the topographic situation has dictated the provision of only one pressure zone further strengthens the logic for using a uniform demand throughout the nodes. But as the demand is done differently the domestic and the non-domestic demand is considered differently therefore the node near the commercial institution and the other node are seen as per their own demand. Hence this deduction gives room for developing the town in all directions, as the municipality is not very clear about the future industrial zone and development area of the town at this moment.

4.12 Network lay out

The prevailing topography of Sekota Town has dictated the consideration of one distinct pressure zone, which is eventually feed by the gravity system. The elevation ranges from 2375m beginning of the new service reservoirs up to 2238 m above mean sea level at the north of the Town. The primary distribution network route has already constructed.

4.13 Network analysis

The revised distribution network is now redesigned in such a way that it economical and efficiently conveys the peak hour demand of year 2026. As the size, routs and conditions of pipes in the existing distribution network are inadequate to accommodate the pressure and flow magnitudes of the new system; no part of the existing distribution network is included in the analysis of the revised distribution network as mentioned above. However it is obvious that since all the existing house and yard connections cannot be switched overnight to the new distribution system, they are assumed to be in use for some time in the future. The water service is advised to gradually change house connections to the new distribution line and at the same time abandon old and leaking pipes.

The distribution network has been carried by using the water CAD v8i computer programming and the frictional head losses in the distribution network are computed using the Hazen-Williams formula. As expressed in the design parameter the frictional head losses should be less than 5m/km but in the design there are very few pipes, which have frictional head loss between 5 and 14m/km. The available head in the nodes ranges from 64 to135m. About 74% of the total nodes have ahead greater than 100m and the rest have less than 100m. However taking in to account that the house connections are usually of small diameter ½" there should be considerable head loss between the nodal and the actual house fixtures, thereby the resulting residual head at the point of fixtures would be within the 100m limit.

A minimum of 0.3m/sec is usually recommended where the topography of the area is moderately flat and hence it should not lead to silt deposition (ADSWE.2014) However for the Sekota Town the topography is not flat, it in fact has high slopes, which coupled with adequate residual pressure would not allow silt deposition. The analysis for peak hour's demand and maximum velocity is checked for nodes with minimum residual head and maximum velocity. As shown in the output of WaterCADv8i analysis table there is no node with minimum head of 15m. At the same time the maximum velocity is 1.4m/sec, which is acceptable (AWRDB, 2014)

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

This research reviews and reflects on the current state of Waghimra Sekota Town of water supply distribution system. the design and operation of water supply systems and how performance of water supply. The coverage of water supply population for cast and the yield and distribution systems should be assessed. The average water supply coverage and the distribution were evaluated based on the daily per capita consumption and level of connection using the population data of the town.

The average water supply coverage of the Town was 11.39l/p. This average per capita consumption is found much lower compared with other developing Towns and even if lower than that of the standard. Set by UN-Habitat, The minimum quantity of domestic water required in developing countries in urban areas 20l/c/d within a radius of 0.5km The average number of connections per family of the Town which is equivalent to 60 % in house or yard connection is also far below the same Towns.

The standard of service reservoir is the volume of one third of the maximum day demand based on this the size of service reservoir for Sekota Town water supply is currently300m^3 only so this is very low on the standards, the current time the maximum day demand of Sekota Town is very high biased on this the current time the new service reservoir will be 1100m^3 after subtracting the existing reservoir volume must be cube red domestic water supply coverage, nodal distribution demand for Towns with the order of magnitude of Sekota does not shows appreciable difference amongst demand categories. The fact that the topographic situation has dictated the provision of only one pressure zone further strengthens the logic for using a uniform demand throughout the nodes. But as the demand is done differently the domestic and the non-domestic demand is considered differently i.e. the node near the commercial institution and the other node are seen as per their own demand. Hence this deduction gives room for developing the Town in all directions, as the municipality is not very clear about the future industrial zone and development area of the Town at this moment from this and by discussing with the relevant administrative and executive bodies the present and future development target areas of the Town are considered in this design.

5.2 RECOMMENDATIONS

In order to improve the water supply services of the Town in terms of coverage, water demand and reducing water loss the following actions should be undertaken.

The first and actual information should be collected and assessed the problem. Because, this study work specifically investigated the water supply and demand, the existing water supply quantity, reducing water loss; the gap associated with water scarcity and suggested possible measurer.

The predominant approach towards meeting increasing water demand of the Town is towards supply augmentation schemes. This includes developing new sources or expanding existing sources. Therefore, the Town water supply and sanitation office have to be look seriously into water demand management. To satisfy continuous rising of water demand several measures should be taken and for the existing situation of Sekota Town water supply distribution system and the resources take a seriously such as the following.

- Construct additional borehole in order to increase water supply coverage of the town
- Increase reservoir at list one third of the maximum day demand of the town
- Proper sized pipes during the implementation of the distribution system.
- Awareness creation to the society

The Sekota Town futurity water distribution system network route should be determined through the reconnaissance work that involve surveying of the network areas in line with the new master plan of Town. Both the municipality and Sekota Town water and sewerage cervices are in all directions of the present and future industrial zone and development target areas of the Town considered in the design must be review were also reviewed through discussions with the relevant administrative and executive bodies of the Town

The water supply system of Sekota should be redesigned as continuous supply depending on fixed and extended pattern, assuming the availability of water sources, and the using of pressure reducing valves to reduce the high pressures in the system if the pressure of the distribution system is above from the permissible limit or if these design parameters may be above the design criteria. Following the determination of the route along with topographic data like elevation, the analysis of the revised distribution network has taken the recent available land-use and urban development master plans of the city into consideration as mentioned above.

REFERENCES

Abdel-Latif, M.Y (2001). “Water Distribution Modeling With Intermittent Supply: Sensitivity Analysis and Evaluation for Bani Suhila City .Palestine”.

ACC (2008) The Cape Urban Observation an introduction.acc.uct.ac.za, accessed

CSA (2007). Population and housing census of Ethiopian, central statistics Agency.

James F. (1994). Effects of Transient Operation on the Reliability of Hydraulic Systems Improving Efficiency and Reliability in Water distribution systems. Department of the Mechanical Engineering. University of Kentucky, Lexington, U.S.A.

JMP (2014) Meeting MDG water and sanitation urban and rural challenge of the decade

Jon R. (2000). Statistical Modeling of Pipe Failures in Water Networks, Ph.D. Thesis, Norwegian University of Science and Technology

Mahdi (2008) Performance Measurement of Water Distribution Systems (WDS).A critical and constructive appraisal of the state-of-the-art Master of Applied Science Civil Engineering Department University of Toronto

Masri M. (1997) Design of Optimal Water Distribution Networks, M.SC thesis in Najah National University.

Ministry of Water and Energy (2015). Urban Water Supply Universal Access Plan, Federal Democratic Republic of Ethiopia: Volume II

Naeeni S. (1996) “Optimizations of Water Distribution Networks” Journal of Hydraulic Research, Vol.34,

Nemanja Trifunovic (2006). Introduction to Urban Water Distribution, London, UK: Taylor & Francis Balkema

Perez, Martinez, and Vela. (Feb., 1993). “Improved Design of Branched Networks by Using Pressure Reducing Valves”. Journal of Hydraulic Engineering. ASCE, Vol. (119), No.2, Prabhata K. Swamee, (2008). Design of Water Supply Pipe Networks, Canada: John Wiley and Sons Inc., Hoboken, New Jersey.

Pramod R. B (1991). Analysis of Flow in Water Distribution Networks, United States of America: Techonomic Publishing Company, Inc.

Robert, G., et al. (2012). Water Audit Manual. Volume 4. Kenya: United Nations Human Settlements Program (UN-Habitat).

Samuel Martin (2004). Hydraulic Transient Design for Pipeline Systems, School of Civil and Environmental Engineering Georgia Institute of Technology Atlanta, Georgia: The McGraw-Hill Companies.

Shimelis, B. and Tamirat (2012). Water Supply and Sanitation for Urban Engineers & Planners. Addis Ababa, Ethiopia: Ethiopian Civil Service College Institute of Urban Development.

Sodiki I (2013). The Effect of System Pressure on Head Loss Components, International Journal of Scientific & Engineering Research,

Tabesh, E (2008). Performance Indicators of Water Losses in Distribution: Delft, the Netherlands.

Tabesh, M Asadiyani, M Yekta, &Burrows. R (2008). An Integrated Model to Evaluate Losses in Water Distribution Systems.

Tan Wee Choon, Lim Kheng Aik.(1213) Investigation of Water Hammer Effect through Pipeline System, International Journal Advanced Science Engineering Information Technology, 2, 3.

Trondheim. (2010).Transient Friction in Pressurized Pipes; the Water Hammer Phenomenon, Doctoral thesis Research, 135, 5.

Vairavamoorthy, K., Akinpelu, E., Lin, Z., and Ali, M. (2000). "An Appropriate Design Tool for Intermittent Water Supply Systems", Technical Report, South Bank University, London. Vairavamoorthy, K. and Lumbers, J. (1998). "Leakage Reduction in Water Distribution Systems: Optimal Valve Control". Journal of Hydraulic Engineering, Vol. (124), No.11,

Welday, B., (2005). Comprehensive asset management in water supply and sanitation.

APPENDICES

Flex Table: Pipe Table

ID	Label	Start Node	Stop Node	Diameter (mm)	Material
828	P-1	J-161	J-152	75.0	PVC
450	P-2	J-203	J-200	75.0	PVC
607	P-3	J-13	J-14	25.0	PVC
665	P-4	J-101	J-102	75.0	PVC
680	P-5	J-113	J-136	75.0	PVC
489	P-6	J-2	J-80	25.0	PVC
726	P-7	J-108	J-90	75.0	PVC
495	P-8	J-79	J-66	25.0	PVC
464	P-9	J-60	J-68	75.0	PVC
462	P-10	J-52	J-56	75.0	PVC
563	P-11	J-57	J-112	25.0	PVC
576	P-12	J-104	J-122	25.0	PVC
671	P-13	J-103	J-110	75.0	PVC
730	P-14	J-88	J-102	75.0	PVC
598	P-15	J-13	J-26	25.0	PVC
731	P-16	J-102	J-100	75.0	PVC
530	P-17	J-148	J-132	25.0	PVC
472	P-18	J-198	J-157	25.0	PVC
593	P-19	J-11	J-23	75.0	PVC
612	P-20	J-15	J-3	25.0	PVC
655	P-21	J-91	J-92	75.0	PVC
626	P-22	J-184	J-185	75.0	PVC
582	P-23	J-36	J-37	25.0	PVC
527	P-24	J-139	J-67	25.0	PVC
561	P-25	J-70	J-58	25.0	PVC
749	P-26	J-10	J-16	25.0	PVC
664	P-27	J-168	J-169	75.0	PVC
546	P-28	J-147	J-140	25.0	PVC
689	P-29	J-146	J-154	75.0	PVC
708	P-30	J-108	J-120	75.0	PVC
682	P-31	J-92	J-114	75.0	PVC
684	P-32	J-137	J-146	75.0	PVC
829	P-33	J-152	J-121	75.0	Ductile Iron
656	P-34	J-113	J-114	75.0	PVC
602	P-35	J-11	J-29	25.0	PVC
580	P-36	J-122	J-149	75.0	PVC
532	P-37	J-159	J-144	25.0	PVC
467	P-38	J-172	J-190	75.0	PVC
592	P-39	J-9	J-11	25.0	PVC
562	P-40	J-58	J-57	25.0	PVC
558	P-41	J-112	J-127	25.0	PVC
692	P-42	J-153	J-168	75.0	PVC
773	P-43	J-78	J-49	75.0	PVC
783	P-44	J-84	J-75	75.0	Ductile Iron

782	P-45	J-85	J-84	75.0	Ductile Iron
758	P-46	J-59	J-31	25.0	PVC
711	P-47	J-37	J-53	25.0	PVC
406	P-48	J-21	J-39	25.0	PVC
706	P-49	J-115	J-116	75.0	PVC
662	P-50	J-143	J-146	75.0	PVC
713	P-51	J-64	J-53	25.0	PVC
694	P-52	J-169	J-174	75.0	PVC
761	P-53	J-94	J-55	25.0	PVC
678	P-54	J-140	J-141	25.0	PVC
632	P-55	J-183	J-184	75.0	PVC
736	P-56	J-77	J-78	75.0	PVC
729	P-57	J-86	J-101	75.0	PVC
529	P-58	J-133	J-148	25.0	PVC
705	P-59	J-85	J-97	75.0	PVC
516	P-60	J-139	J-138	25.0	PVC
801	P-61	J-174	J-189	75.0	PVC
790	P-62	J-56	J-74	75.0	PVC
442	P-63	J-193	J-190	75.0	PVC
436	P-64	J-172	J-180	75.0	PVC
698	P-65	J-174	J-165	75.0	PVC
471	P-66	J-160	J-198	25.0	PVC
707	P-67	J-91	J-108	75.0	PVC
579	P-68	J-106	J-122	75.0	PVC
755	P-69	J-55	J-19	25.0	PVC
683	P-70	J-114	J-137	75.0	PVC
557	P-71	J-118	J-112	25.0	PVC
457	P-72	J-142	J-105	75.0	PVC
704	P-73	J-84	J-96	75.0	PVC
433	P-74	J-87	J-142	75.0	PVC
657	P-75	J-136	J-137	75.0	PVC
679	P-76	J-91	J-113	75.0	PVC
818	P-77	J-185	J-177	75.0	PVC
733	P-78	J-99	J-77	75.0	PVC
787	P-79	J-65	J-89	75.0	PVC
821	P-80	J-152	J-129	75.0	PVC
750	P-81	J-16	J-20	25.0	Ductile Iron
748	P-82	J-3	J-10	25.0	Ductile Iron
744	P-83	J-156	J-150	25.0	Ductile Iron
732	P-84	J-101	J-99	75.0	Ductile Iron
728	P-85	J-90	J-88	75.0	Ductile Iron
850	P-86	J-166	J-164	25.0	PVC
848	P-87	J-182	J-191	75.0	PVC
838	P-88	J-170	J-171	75.0	PVC
690	P-89	J-154	J-169	75.0	PVC
668	P-90	J-93	J-92	75.0	PVC
772	P-91	J-77	J-47	75.0	PVC
606	P-92	J-32	J-29	25.0	PVC
798	P-93	J-173	J-188	75.0	PVC
793	P-94	J-34	J-38	25.0	PVC
809	P-95	J-177	J-176	75.0	PVC
804	P-96	J-179	J-164	25.0	PVC
788	P-97	J-81	J-68	75.0	PVC
785	P-98	J-60	J-52	75.0	PVC
717	P-99	J-51	J-123	25.0	PVC

837	P-100	J-182	J-181	75.0	Ductile Iron
784	P-101	J-75	J-60	75.0	Ductile Iron
822	P-102	J-129	J-131	75.0	PVC
496	P-103	J-66	J-67	25.0	Ductile Iron
681	P-104	J-136	J-143	75.0	Ductile Iron
599	P-105	J-26	J-22	25.0	Ductile Iron
559	P-106	J-127	J-156	25.0	PVC
786	P-107	J-52	J-65	75.0	PVC
521	P-108	J-76	J-83	25.0	PVC
524	P-109	J-95	J-134	25.0	PVC
824	P-110	J-78	J-121	75.0	PVC
734	P-111	J-100	J-78	75.0	PVC
660	P-112	J-63	J-64	25.0	PVC
746	P-113	J-15	J-20	25.0	PVC
552	P-114	J-72	J-50	25.0	PVC
578	P-115	J-93	J-106	75.0	PVC
691	P-116	J-143	J-153	75.0	PVC
624	P-117	J-183	J-176	75.0	PVC
652	P-118	J-173	J-174	75.0	PVC
591	P-119	J-23	J-9	75.0	PVC
531	P-120	J-148	J-159	25.0	PVC
466	P-121	J-75	J-81	75.0	PVC
386	P-122	J-188	J-189	75.0	PVC
473	P-123	J-157	J-132	25.0	PVC
553	P-124	J-72	J-76	25.0	PVC
423	P-125	J-43	J-28	25.0	PVC
574	P-126	J-70	J-93	25.0	PVC
853	P-127	J-156	J-204	25.0	PVC
795	P-128	J-38	J-32	25.0	PVC
498	P-129	J-35	J-62	25.0	PVC
777	P-130	J-97	J-96	75.0	Ductile Iron
812	P-131	J-167	J-161	75.0	PVC
791	P-132	J-74	J-105	75.0	PVC
756	P-133	J-19	J-31	25.0	PVC
842	P-134	J-170	J-193	75.0	Galvanized iron
840	P-135	J-68	J-130	75.0	Galvanized iron
846	P-136	J-170	J-181	75.0	Galvanized iron
548	P-137	J-140	J-126	25.0	Galvanized iron
468	P-138	J-180	J-193	75.0	Galvanized iron
594	P-139	J-9	J-12	25.0	Galvanized iron
575	P-140	J-73	J-106	25.0	Ductile Iron
539	P-141	J-144	J-133	25.0	Ductile Iron
666	P-142	J-99	J-100	75.0	PVC
526	P-143	J-66	J-139	25.0	PVC
509	P-144	J-50	J-44	25.0	PVC
451	P-145	J-200	J-201	25.0	PVC
497	P-146	J-67	J-54	25.0	Ductile Iron
478	P-147	J-162	J-159	25.0	Ductile Iron
460	P-148	J-65	J-74	75.0	Ductile Iron
415	P-149	J-40	J-45	25.0	Ductile Iron
545	P-150	J-125	J-147	25.0	PVC
855	P-151	J-88	J-129	75.0	Ductile Iron
816	P-152	J-82	J-61	75.0	Ductile Iron
456	P-153	J-202	J-204	25.0	PVC
778	P-154	J-96	J-81	75.0	Ductile Iron

776	P-155	J-115	J-97	75.0	Ductile Iron
426	P-156	J-43	J-42	25.0	PVC
475	P-157	J-157	J-163	25.0	PVC
515	P-158	J-107	J-139	25.0	PVC
445	P-159	J-197	J-199	37.0	PVC
802	P-160	J-189	J-178	75.0	PVC
663	P-161	J-153	J-154	75.0	PVC
789	P-162	J-68	J-56	75.0	PVC
458	P-163	J-105	J-89	75.0	PVC
830	P-164	J-87	J-89	75.0	Ductile Iron
573	P-165	J-160	J-118	25.0	PVC
441	P-166	J-175	J-193	75.0	PVC
844	P-167	J-171	J-176	75.0	Galvanized iron
715	P-168	J-37	J-51	25.0	Galvanized iron
693	P-169	J-168	J-173	75.0	Ductile Iron
754	P-170	J-59	J-55	25.0	PVC
514	P-171	J-25	J-28	25.0	PVC
568	P-172	J-198	J-194	25.0	PVC
858	P-173	J-25	J-45	25.0	PVC
867	P-174	BOREHOLE-7	PMP-7BH	150.0	Ductile Iron
888	P-175	PMP-2 BOOSTER	T-3	150.0	Ductile Iron
913	P-176	J-59	J-94	25.0	PVC
918	P-177	J-64	J-110	25.0	PVC
922	P-178	J-109	J-86	75.0	PVC
923	P-179	J-146	J-58	75.0	PVC
926	P-180	J-144	J-124	25.0	GS
927	P-181	J-159	J-158	25.0	PVC
928	P-182	J-142	J-172	75.0	PVC
929	P-183	J-81	J-171	75.0	Galvanized iron
932	P-184	J-130	J-182	75.0	Galvanized iron
933	P-185	J-186	J-183	75.0	PVC
935	P-186	J-204	J-160	25.0	PVC
938	P-187	J-80	J-35	25.0	PVC
940	P-188	J-41	J-23	75.0	PVC
941	P-189	J-54	J-42	25.0	PVC
942	P-190	J-14	J-18	25.0	PVC
947	P-191	J-119	J-85	75.0	PVC
948	P-192	J-117	J-115	75.0	PVC
952	P-193	J-165	J-112	25.0	PVC
954	P-194	J-3	J-14	25.0	PVC
957	P-195	J-20	J-31	25.0	PVC
961	P-196	J-177	J-184	75.0	Ductile Iron
962	P-197	J-39	J-36	25.0	PVC
963	P-198	J-47	J-69	152.5	Ductile Iron
964	P-199	J-49	J-71	75.0	PVC
965	P-200	J-71	J-117	75.0	PVC
966	P-201	J-69	J-119	75.0	PVC
967	P-202	J-87	J-41	75.0	PVC
968	P-203	J-117	J-82	75.0	PVC
969	P-204	J-154	J-57	75.0	PVC
970	P-205	J-109	J-98	75.0	PVC
971	P-206	J-98	J-103	75.0	PVC
972	P-207	J-131	J-90	98.1	PVC
973	P-208	J-137	J-70	75.0	PVC
974	P-209	J-121	J-161	95.6	PVC

975	P-210	J-147	J-155	75.0	PVC
976	P-211	J-175	J-130	75.0	PVC
977	P-212	J-155	J-110	106.6	Galvanized iron
979	P-213	J-178	J-179	75.0	PVC
980	P-214	J-185	J-167	75.0	PVC
981	P-215	J-189	J-164	75.0	Ductile Iron
982	P-216	J-180	J-175	75.0	PVC
983	P-217	J-188	J-187	75.0	PVC
984	P-218	J-186	J-185	75.0	PVC
985	P-219	J-186	J-187	75.0	PVC
986	P-220	J-181	J-191	75.0	PVC
987	P-221	J-191	J-192	75.0	PVC
988	P-222	J-190	J-197	75.0	PVC
989	P-223	J-199	J-193	75.0	Ductile Iron
990	P-224	J-197	J-203	75.0	PVC
991	P-225	J-73	J-118	25.0	PVC
992	P-226	J-104	J-198	25.0	PVC
993	P-227	J-12	J-13	25.0	PVC
994	P-228	J-128	J-149	25.0	PVC
995	P-229	J-127	J-165	25.0	PVC
996	P-230	J-150	J-164	79.5	PVC
997	P-231	J-194	J-128	25.0	PVC
998	P-232	J-166	J-196	25.0	PVC
999	P-233	J-179	J-166	79.2	PVC
1000	P-234	J-201	J-202	25.0	PVC
1001	P-235	J-195	J-196	25.0	PVC
1002	P-236	J-200	J-195	25.0	PVC
1003	P-237	J-22	J-11	76.4	PVC
1004	P-238	J-24	J-34	25.0	PVC
1005	P-239	J-26	J-33	25.0	PVC
1006	P-240	J-33	J-24	25.0	PVC
1008	P-241	J-48	J-50	25.0	PVC
1010	P-242	J-86	J-46	51.6	Ductile Iron
1012	P-243	J-83	J-95	25.0	PVC
1014	P-244	J-63	J-103	25.0	PVC
1015	P-245	J-138	J-76	25.0	PVC
1018	P-246	J-80	J-79	50.5	Ductile Iron
1019	P-247	J-63	J-17	48.4	PVC
1020	P-248	J-1	J-21	25.0	PVC
1021	P-249	J-2	J-107	48.7	PVC
1022	P-250	J-94	J-99	25.0	PVC
1023	P-251	J-111	J-2	25.0	PVC
1025	P-252	J-123	J-151	25.0	PVC
1026	P-253	J-124	J-145	52.6	Ductile Iron
1027	P-254	J-158	J-111	49.0	PVC
1029	P-255	J-134	J-125	25.0	PVC
1030	P-256	J-145	J-144	25.0	PVC
1031	P-257	J-145	J-135	25.0	PVC
1033	P-258	J-132	J-133	25.0	PVC
1034	P-259	J-163	J-162	25.0	PVC
1038	P-260	J-18	J-15	25.0	PVC
1039	P-261	J-77	J-19	50.5	Ductile Iron
1041	P-262	J-42	J-28	25.0	PVC
1043	P-263	J-35	J-42	25.0	PVC
1044	P-264	J-50	J-27	25.0	PVC

1045	P-265	J-46	J-17	51.6	Ductile Iron
1046	P-266	J-30	J-40	25.0	PVC
1048	P-267	J-45	J-44	25.0	PVC
1051	P-268	T-1	PMP-1 BOOSTER	150.0	Ductile Iron
1054	P-269	T-2	PMP-2 BOOSTER	150.0	Ductile Iron
1059	P-270	PMP-7BH	T-1	150.0	Ductile Iron
1067	P-271	PMP-1 BOOSTER	J-4	150.0	Ductile Iron
1068	P-272	J-4	T-2	250.0	Ductile Iron
1071	P-273	J-135	J-5	25.0	Ductile Iron
1072	P-274	J-5	J-125	25.0	Ductile Iron
1073	P-275	J-149	J-5	152.4	Ductile Iron
1074	P-276	J-33	J-19	152.4	Ductile Iron
1075	P-277	J-141	J-151	25.0	Ductile Iron
1077	P-278	J-126	J-6	25.0	Ductile Iron
1078	P-279	J-6	J-72	25.0	Ductile Iron
1079	P-280	J-6	J-39	152.4	Ductile Iron
1081	P-281	J-54	J-7	25.0	Ductile Iron
1082	P-282	J-7	J-48	25.0	Ductile Iron
1085	P-283	J-43	J-8	152.4	Ductile Iron
1086	P-284	J-8	J-7	152.4	Ductile Iron
1087	P-285	J-8	J-44	152.4	Ductile Iron
1088	P-286	T-3	J-87	152.4	Ductile Iron

Flex Table: Junction Table

ID	Label	X (m)	Y (m)	Elevation (m)	Zone
30	J-1	503,125.26	1,396,134.07	2,300.00	Zone – 1
484	J-2	504,136.52	1,396,229.55	2,366.00	Zone – 1
31	J-3	503,603.49	1,395,076.98	2,339.00	Zone – 1
1066	J-4	505,425.32	1,393,832.03	2,183.02	Zone – 1
1070	J-5	503,922.84	1,396,171.13	2,301.63	Zone – 1
1076	J-6	503,691.60	1,396,208.11	2,304.36	Zone – 1
1080	J-7	503,832.50	1,396,471.65	2,313.13	Zone – 1
1084	J-8	503,864.02	1,396,550.68	2,314.39	Zone – 1
130	J-9	504,288.22	1,395,032.62	2,333.00	Zone – 1
153	J-10	503,530.30	1,395,065.54	2,333.00	Zone – 1
186	J-11	504,217.54	1,395,088.59	2,331.00	Zone – 1
197	J-12	504,154.34	1,395,030.07	2,331.00	Zone – 1
264	J-13	503,920.08	1,394,990.79	2,329.00	Zone – 1
275	J-14	503,758.44	1,394,961.85	2,329.00	Zone – 1
286	J-15	503,667.50	1,395,142.89	2,328.00	Zone – 1
314	J-16	503,564.18	1,395,099.21	2,327.00	Zone – 1
320	J-17	503,187.95	1,395,550.06	2,326.00	Zone - 1
324	J-18	503,720.89	1,395,089.30	2,325.00	Zone - 1
326	J-19	503,635.56	1,395,262.51	2,325.00	Zone - 1
327	J-20	503,643.46	1,395,168.62	2,324.00	Zone - 1
330	J-21	503,271.17	1,396,053.27	2,305.00	Zone - 1
332	J-22	503,969.89	1,395,064.40	2,323.00	Zone - 1
333	J-23	504,290.51	1,395,094.75	2,322.00	Zone - 1
335	J-24	504,001.20	1,395,141.83	2,322.00	Zone - 1

336	J-25	503,829.91	1,396,638.43	2,324.00	Zone - 1
338	J-26	503,906.47	1,395,047.28	2,321.00	Zone - 1
339	J-27	503,303.63	1,396,419.46	2,324.00	Zone - 1
341	J-28	503,895.65	1,396,635.22	2,323.00	Zone - 1
342	J-29	504,223.95	1,395,125.48	2,320.00	Zone - 1
346	J-30	503,628.77	1,396,775.84	2,322.00	Zone - 1
350	J-31	503,598.79	1,395,230.99	2,318.00	Zone - 1
356	J-32	504,182.86	1,395,173.02	2,317.00	Zone - 1
359	J-33	503,908.74	1,395,105.58	2,316.00	Zone - 1
360	J-34	504,123.88	1,395,226.24	2,316.00	Zone - 1
363	J-35	504,129.54	1,396,440.75	2,318.00	Zone - 1
366	J-36	503,244.08	1,395,910.91	2,319.00	Zone - 1
367	J-37	503,234.90	1,395,851.50	2,319.00	Zone - 1
370	J-38	504,141.54	1,395,232.05	2,314.00	Zone - 1
371	J-39	503,334.62	1,396,023.25	2,317.00	Zone - 1
372	J-40	503,628.77	1,396,651.38	2,316.00	Zone - 1
376	J-41	504,367.48	1,395,090.17	2,312.00	Zone - 1
377	J-42	503,956.59	1,396,571.14	2,315.00	Zone - 1
378	J-43	503,877.19	1,396,589.19	2,315.00	Zone - 1
381	J-44	503,620.16	1,396,539.42	2,315.00	Zone - 1
382	J-45	503,628.93	1,396,609.51	2,314.00	Zone - 1
383	J-46	503,528.19	1,395,496.15	2,312.00	Zone - 1
33	J-47	503,828.03	1,395,280.72	2,312.00	Zone - 1
36	J-48	503,743.63	1,396,482.57	2,314.00	Zone - 1
37	J-49	503,839.61	1,395,292.06	2,312.00	Zone - 1
39	J-50	503,634.05	1,396,482.15	2,314.00	Zone - 1
40	J-51	503,295.68	1,395,884.33	2,314.00	Zone - 1
43	J-52	504,318.39	1,395,176.62	2,309.00	Zone - 1
45	J-53	503,286.94	1,395,837.82	2,313.00	Zone - 1
47	J-54	503,941.88	1,396,432.22	2,312.00	Zone - 1
50	J-55	503,603.98	1,395,283.72	2,309.00	Zone - 1
51	J-56	504,321.52	1,395,187.71	2,309.00	Zone - 1
52	J-57	503,949.30	1,395,746.21	2,310.00	Zone - 1
54	J-58	503,893.28	1,395,747.80	2,310.00	Zone - 1
55	J-59	503,557.11	1,395,286.31	2,309.00	Zone - 1
56	J-60	504,271.15	1,395,206.08	2,308.00	Zone - 1
58	J-61	503,880.69	1,395,325.35	2,309.00	Zone - 1
62	J-62	504,205.49	1,396,544.39	2,310.00	Zone - 1
63	J-63	503,348.94	1,395,808.09	2,311.00	Zone - 1
65	J-64	503,353.80	1,395,824.92	2,311.00	Zone - 1
66	J-65	504,370.21	1,395,159.86	2,307.00	Zone - 1
67	J-66	504,040.94	1,396,375.09	2,310.00	Zone - 1
68	J-67	504,015.65	1,396,380.77	2,310.00	Zone - 1
69	J-68	504,275.78	1,395,216.42	2,308.00	Zone - 1
70	J-69	503,942.33	1,395,262.30	2,308.00	Zone - 1
71	J-70	503,833.70	1,395,746.21	2,309.00	Zone - 1
74	J-71	503,945.30	1,395,277.72	2,308.00	Zone - 1
77	J-72	503,670.38	1,396,390.39	2,310.00	Zone - 1
79	J-73	503,832.54	1,395,763.30	2,309.00	Zone - 1
80	J-74	504,369.92	1,395,169.84	2,307.00	Zone - 1
83	J-75	504,227.46	1,395,230.98	2,306.00	Zone - 1
85	J-76	503,726.19	1,396,382.36	2,309.00	Zone - 1
87	J-77	503,744.21	1,395,355.65	2,307.00	Zone - 1
88	J-78	503,758.49	1,395,361.32	2,307.00	Zone - 1
95	J-79	504,071.79	1,396,367.18	2,308.00	Zone - 1

96	J-80	504,151.85	1,396,347.16	2,308.00	Zone - 1
100	J-81	504,234.20	1,395,240.77	2,306.00	Zone - 1
103	J-82	503,924.40	1,395,325.53	2,306.00	Zone - 1
104	J-83	503,717.30	1,396,345.84	2,308.00	Zone - 1
105	J-84	504,177.17	1,395,266.03	2,305.00	Zone - 1
106	J-85	504,152.13	1,395,272.27	2,305.00	Zone - 1
107	J-86	503,625.46	1,395,490.27	2,306.00	Zone - 1
109	J-87	504,478.87	1,395,136.51	2,368.00	Zone - 1
110	J-88	503,645.39	1,395,493.00	2,306.00	Zone - 1
111	J-89	504,424.15	1,395,148.68	2,304.00	Zone - 1
113	J-90	503,645.22	1,395,548.19	2,306.00	Zone - 1
117	J-91	503,670.42	1,395,686.13	2,306.00	Zone - 1
118	J-92	503,677.00	1,395,700.00	2,306.00	Zone - 1
120	J-93	503,692.40	1,395,747.73	2,306.00	Zone - 1
121	J-94	503,603.81	1,395,351.24	2,305.00	Zone - 1
122	J-95	503,816.09	1,396,243.68	2,307.00	Zone - 1
123	J-96	504,181.74	1,395,279.49	2,305.00	Zone - 1
124	J-97	504,151.24	1,395,287.07	2,305.00	Zone - 1
127	J-98	503,645.78	1,395,689.02	2,306.00	Zone - 1
128	J-99	503,687.69	1,395,416.61	2,305.00	Zone - 1
131	J-100	503,698.45	1,395,424.00	2,305.00	Zone - 1
132	J-101	503,656.58	1,395,450.90	2,305.00	Zone - 1
133	J-102	503,666.61	1,395,459.00	2,305.00	Zone - 1
134	J-103	503,663.82	1,395,752.80	2,306.00	Zone - 1
135	J-104	503,845.86	1,395,809.72	2,306.00	Zone - 1
136	J-105	504,422.88	1,395,158.58	2,301.00	Zone - 1
137	J-106	503,693.85	1,395,769.59	2,306.00	Zone - 1
139	J-107	504,032.71	1,396,254.60	2,306.00	Zone - 1
140	J-108	503,651.30	1,395,605.13	2,305.00	Zone - 1
143	J-109	503,629.27	1,395,609.01	2,305.00	Zone - 1
146	J-110	503,671.32	1,395,769.56	2,306.00	Zone - 1
149	J-111	504,233.34	1,396,193.84	2,305.00	Zone - 1
150	J-112	504,014.61	1,395,736.95	2,304.00	Zone - 1
151	J-113	503,714.56	1,395,675.86	2,304.00	Zone - 1
152	J-114	503,721.00	1,395,689.00	2,304.00	Zone - 1
155	J-115	504,095.41	1,395,286.56	2,303.00	Zone - 1
156	J-116	504,095.54	1,395,300.15	2,303.00	Zone - 1
157	J-117	504,021.90	1,395,284.74	2,303.00	Zone - 1
158	J-118	504,019.40	1,395,751.33	2,304.00	Zone - 1
159	J-119	504,076.31	1,395,272.46	2,302.00	Zone - 1
160	J-120	503,703.42	1,395,596.92	2,303.00	Zone - 1
165	J-121	503,779.43	1,395,407.27	2,302.00	Zone - 1
168	J-122	503,716.08	1,395,838.06	2,303.00	Zone - 1
172	J-123	503,381.40	1,395,894.10	2,303.00	Zone - 1
174	J-124	504,142.99	1,396,119.63	2,302.00	Zone - 1
177	J-125	503,896.56	1,396,182.08	2,302.00	Zone - 1
178	J-126	503,784.35	1,396,193.92	2,302.00	Zone - 1
179	J-127	504,082.29	1,395,720.78	2,301.00	Zone - 1
180	J-128	503,991.70	1,395,877.41	2,301.00	Zone - 1
181	J-129	503,755.74	1,395,511.01	2,300.00	Zone - 1
182	J-130	504,295.74	1,395,259.61	2,299.00	Zone - 1
183	J-131	503,757.88	1,395,539.96	2,300.00	Zone - 1
184	J-132	504,200.83	1,395,970.94	2,301.00	Zone - 1
187	J-133	504,173.55	1,396,035.09	2,301.00	Zone - 1
189	J-134	503,927.87	1,396,235.11	2,301.00	Zone - 1

190	J-135	503,969.03	1,396,156.20	2,301.00	Zone - 1
191	J-136	503,797.20	1,395,643.52	2,300.00	Zone - 1
192	J-137	503,804.00	1,395,656.00	2,300.00	Zone - 1
193	J-138	503,927.55	1,396,331.05	2,301.00	Zone - 1
194	J-139	503,968.26	1,396,303.03	2,300.00	Zone - 1
195	J-140	503,827.10	1,396,172.44	2,300.00	Zone - 1
196	J-141	503,714.92	1,396,086.37	2,300.00	Zone - 1
198	J-142	504,451.40	1,395,160.95	2,296.00	Zone - 1
202	J-143	503,848.71	1,395,632.14	2,298.00	Zone - 1
203	J-144	504,185.53	1,396,077.84	2,299.00	Zone - 1
205	J-145	504,067.83	1,396,121.22	2,299.00	Zone - 1
207	J-146	503,851.89	1,395,644.79	2,298.00	Zone - 1
210	J-147	503,867.28	1,396,139.13	2,299.00	Zone - 1
215	J-148	504,203.15	1,396,035.02	2,298.00	Zone - 1
216	J-149	503,741.25	1,395,899.37	2,298.00	Zone - 1
217	J-150	504,132.00	1,395,675.26	2,297.00	Zone - 1
220	J-151	503,545.41	1,395,964.30	2,298.00	Zone - 1
222	J-152	503,808.64	1,395,487.68	2,296.00	Zone - 1
223	J-153	503,897.22	1,395,626.15	2,296.00	Zone - 1
224	J-154	503,902.00	1,395,639.00	2,296.00	Zone - 1
226	J-155	503,738.58	1,395,945.68	2,297.00	Zone - 1
227	J-156	504,152.90	1,395,703.25	2,296.00	Zone - 1
229	J-157	504,265.46	1,395,978.24	2,296.00	Zone - 1
233	J-158	504,311.50	1,396,162.28	2,296.00	Zone - 1
234	J-159	504,231.76	1,396,077.55	2,296.00	Zone - 1
236	J-160	504,165.13	1,395,730.21	2,295.00	Zone - 1
239	J-161	503,880.38	1,395,456.74	2,294.00	Zone - 1
242	J-162	504,296.95	1,396,078.34	2,295.00	Zone - 1
243	J-163	504,330.96	1,396,039.92	2,294.00	Zone - 1
244	J-164	504,124.81	1,395,615.37	2,293.00	Zone - 1
245	J-165	504,011.31	1,395,637.69	2,293.00	Zone - 1
247	J-166	504,143.08	1,395,613.23	2,293.00	Zone - 1
250	J-167	503,932.61	1,395,439.33	2,292.00	Zone - 1
251	J-168	503,953.52	1,395,608.19	2,292.00	Zone - 1
254	J-169	503,959.00	1,395,624.00	2,292.00	Zone - 1
255	J-170	504,414.79	1,395,307.20	2,291.00	Zone - 1
256	J-171	504,274.97	1,395,311.87	2,291.00	Zone - 1
257	J-172	504,488.82	1,395,201.70	2,289.00	Zone - 1
259	J-173	503,979.87	1,395,590.22	2,291.00	Zone - 1
260	J-174	503,987.00	1,395,603.00	2,291.00	Zone - 1
262	J-175	504,461.67	1,395,241.84	2,290.00	Zone - 1
265	J-176	504,226.22	1,395,348.17	2,290.00	Zone - 1
266	J-177	504,080.32	1,395,359.26	2,290.00	Zone - 1
267	J-178	504,095.17	1,395,507.28	2,290.00	Zone - 1
269	J-179	504,124.81	1,395,558.48	2,290.00	Zone - 1
271	J-180	504,477.38	1,395,207.31	2,289.00	Zone - 1
272	J-181	504,367.70	1,395,357.65	2,289.00	Zone - 1
273	J-182	504,308.36	1,395,352.66	2,289.00	Zone - 1
274	J-183	504,206.28	1,395,374.58	2,289.00	Zone - 1
277	J-184	504,143.82	1,395,382.96	2,289.00	Zone - 1
278	J-185	504,120.80	1,395,402.69	2,289.00	Zone - 1
281	J-186	504,159.27	1,395,412.69	2,289.00	Zone - 1
283	J-187	504,113.02	1,395,489.51	2,289.00	Zone - 1
284	J-188	504,034.37	1,395,547.70	2,289.00	Zone - 1
285	J-189	504,043.70	1,395,560.05	2,289.00	Zone - 1

287	J-190	504,521.25	1,395,290.67	2,286.00	Zone - 1
290	J-191	504,296.96	1,395,414.59	2,287.00	Zone - 1
292	J-192	504,228.87	1,395,444.69	2,287.00	Zone - 1
293	J-193	504,511.68	1,395,294.52	2,286.00	Zone - 1
299	J-194	504,134.73	1,395,849.50	2,286.00	Zone - 1
300	J-195	504,333.87	1,395,526.14	2,285.00	Zone - 1
301	J-196	504,237.22	1,395,571.23	2,285.00	Zone - 1
303	J-197	504,552.85	1,395,392.54	2,282.00	Zone - 1
304	J-198	504,200.40	1,395,806.72	2,284.00	Zone - 1
305	J-199	504,543.31	1,395,393.73	2,282.00	Zone - 1
306	J-200	504,461.40	1,395,512.57	2,282.00	Zone - 1
307	J-201	504,411.79	1,395,550.80	2,282.00	Zone - 1
311	J-202	504,338.31	1,395,599.71	2,281.00	Zone - 1
312	J-203	504,510.01	1,395,512.75	2,280.00	Zone - 1
313	J-204	504,270.71	1,395,668.70	2,280.00	Zone - 1

Hydraulic Grade (m)	Pressure (m H2O)
2,357.65	58
2,357.00	-9
2,365.73	27
2,319.06	136
2,365.68	64
2,357.67	53
2,356.76	44
2,356.76	42
2,367.13	34
2,365.72	33
2,367.13	36
2,366.23	35
2,365.93	37
2,365.79	37
2,365.73	38
2,365.72	39
2,365.36	39
2,365.73	41
2,365.87	41
2,365.73	42
2,357.65	53
2,367.12	44
2,367.13	45
2,365.97	44
2,356.69	33
2,365.99	45
2,356.84	33
2,356.74	34
2,366.80	47
2,356.68	35
2,365.81	48
2,366.61	50
2,365.87	50
2,366.41	50
2,356.85	39

2,353.92	35
2,352.64	34
2,366.53	52
2,357.67	41
2,356.68	41
2,367.18	55
2,356.76	42
2,356.76	42
2,356.76	42
2,356.69	43
2,365.51	53
2,365.93	54
2,356.77	43
2,365.92	54
2,356.84	43
2,347.71	34
2,366.76	58
2,356.85	44
2,356.78	45
2,365.82	57
2,366.76	58
2,365.79	56
2,365.79	56
2,365.81	57
2,366.70	59
2,366.10	57
2,356.85	47
2,365.20	54
2,363.16	52
2,366.89	60
2,356.93	47
2,356.89	47
2,366.71	59
2,365.93	58
2,365.79	57
2,365.99	58
2,357.38	47
2,365.63	57
2,366.87	60
2,366.55	60
2,357.72	49
2,365.88	59
2,365.88	59
2,356.94	49
2,356.94	49
2,366.52	60
2,366.10	60
2,358.84	51
2,366.47	61
2,366.27	61
2,365.73	60
2,367.21	-1
2,365.82	60
2,367.01	63
2,365.82	60

2,365.79	60
2,365.78	60
2,365.77	60
2,365.81	61
2,360.93	54
2,366.48	61
2,366.27	61
2,365.42	59
2,365.85	61
2,365.85	61
2,365.80	61
2,365.82	61
2,365.26	59
2,365.46	59
2,366.91	66
2,365.70	60
2,356.99	51
2,365.80	61
2,365.63	61
2,365.18	59
2,358.96	54
2,365.74	62
2,365.79	62
2,365.79	62
2,366.17	63
2,366.17	63
2,366.10	63
2,365.55	61
2,366.06	64
2,365.80	63
2,365.88	64
2,365.69	63
2,342.40	39
2,363.27	61
2,365.03	63
2,359.35	57
2,365.74	65
2,365.13	64
2,365.83	66
2,366.70	68
2,365.82	66
2,363.21	62
2,363.09	62
2,362.86	62
2,364.82	64
2,365.79	66
2,365.79	66
2,357.04	56
2,356.98	57
2,360.74	61
2,358.06	58
2,366.92	71
2,365.79	68
2,363.09	64
2,363.28	64

2,365.79	68
2,365.05	66
2,363.06	65
2,365.68	68
2,365.80	69
2,346.78	49
2,365.87	70
2,365.79	70
2,365.79	70
2,365.16	68
2,365.74	70
2,363.53	67
2,359.07	63
2,362.84	67
2,365.46	70
2,365.88	72
2,362.90	68
2,363.30	69
2,365.80	73
2,365.80	73
2,365.80	73
2,365.90	74
2,365.80	74
2,365.80	74
2,366.62	75
2,366.51	75
2,366.73	78
2,365.80	75
2,365.80	75
2,366.70	77
2,366.10	76
2,366.06	76
2,365.80	76
2,365.80	76
2,366.71	78
2,366.63	77
2,366.64	77
2,366.06	77
2,366.05	77
2,366.04	77
2,366.03	77
2,365.86	77
2,365.81	77
2,365.80	77
2,366.71	81
2,366.64	79
2,366.64	79
2,366.70	81
2,365.05	79
2,366.10	81
2,365.85	81
2,366.70	85
2,365.01	81
2,366.70	85
2,366.69	85

2,366.23	84
2,365.85	85
2,366.69	87
2,365.73	86