ASSESSMENTS OF URBAN WATER SUPPLY AND LOSS MANAGEMENT (THE CASE OF ADAMA TOWN)

A THESIS WHICH SUBMITTED TOSCHOOL OF GRADUATE STUDIES OF ADDISABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCEIN CIVIL ENGINEERING (WATER SUPPLY AND ENVIRONMENTAL ENGINEERING PROGRAM)

BY

SIRAJ ABDURO

ADVISOR: DR. GEREMEW SAHILU

DECEMBER, 2015

ADDIS ABABA, ETHIOPIA

ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

ADDIS ABABA UNIVERSITY INISTITUTE OF TECHNOLOGY

ASSESSMENTS OF URBAN WATER SUPPLY AND LOSS MANAGEMENT

(THE CASE OF ADAMA TOWN)

A THESIS WHICH SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDISABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CIVIL ENGINEERING (WATER SUPPLY AND ENVIRONMENTAL ENGINEERING)

By
Siraj Abduro

Approved by Board of Examiners

Dr. Ing. Geremew Sahilu	--------------------
Advisor	Signature
Dr. Mebrate Tafesse	---------------------
Internal Examiner	Signature
Dr. Ing. Gashaw Yayehyirad	---------------------
External Examiner	Signature
Dr. Esayas G/youhannes	------------------
Chairman (Department of graduate committee)	Signature

DECLARATION AND COPY RIGHT

I, Siraj Abduro, declare that this thesis is my own original work and that it has not been presented and will not be presented by me to any other university for similar or any other degree award.

Signature____________

Date________________

ABSTRACT

The aims of this research is to assess the situation of the urban water supply and demand, total water loss in distribution system and build a model to provide possible scenario in order to meet water supply with demand by reducing pressure effect in the system to minimize water loss in the town. Whereas, the significance of the study is to make responsible body to be aware in order to satisfying the water demand in Adama town water supply scheme.

Water production and consumption, the pressure zones or topography and customers' meter reading (water billed) approaches was used to evaluate the water loss. The distribution of water connection per family, per capital consumption and the level of mode of services have been used in assessment of water supply coverage in study area. In process of evaluating, model building and analysis; tools such as Microsoft excel, Auto CAD and Water CAD v6.5 was used.

The existing water supplying situation; the distribution of mode of service in the town house connection, yard connection and public taps were 5%, 60% and 35% respectively. Also average per capital consumption is 34.5L/c/d, whereas the average of water connection per family was 0.527 (52.7%) connection/family. On the other hand, water loss is analyzed in sampled kebeles and town levels, by using different methods like, percentage of loss and loss per number of connections. So at town level, currently in average, 34.05% of produced water is lost from the system due to many reason, effect of pressure, aged pipe, lack of good maintenance etc. In the modeling, the system has been modified using the design criteria of velocity and pressure. Areas with high pressures in the existing system have been identified and solution was established using pressure-reducing valves, which used to reduce effect of pressure and minimize water loss.

In Adama town, due to different reason; water supply is not satisfying the demand of the town, currently, Adama Town Water Supply and Sewerage Enterprise produce treated water only 233*L*/s whereas the water demand is 364*L*/s, from this result, a gap between supply- demand is 131*L*/s. The impact of leakage in distribution system is high; to minimize the breakage of pipe lines and physical loss, the old aged water pipe lines should be replaced in order to improve the adequacy of urban water supply of the town.

Key words: Water Supply, water consumption, demand, losses, distribution modeling

AKNOWLEDGMENT

First of all thanks to Allah. Next to that, I would like to express my gratitude to my advisor, Dr. Ing. Geremew Sahilu (Associate PG Director at Addis Ababa University Institute of Technology) for his efforts, useful suggestions, encouragement and valuable guidance.

I am thankful to my family for their great support at all the time from my childhood and for appreciating me, especially my wife Dursitu Abdurke for her encouraging me every time in my work.

I am also forward special thanks to Mr. Gezehagn Ragasa (official and supervise Engineer at Adama Town Water and Sewerage Enterprise) for providing all the necessary and required data. Also, Specific gratitude is given to Mr. Addisuu Tafari (senior staff at loss control case team, ATWSSE), for his valuable assistance in providing important data.

I would like to thank IT staffs of ATWSSE, especially Ms. Rukiya, for their supporting me in providing water billing records.

Finally, I wish to thank all, those have helped me directly or indirectly during this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXS

LIST OF ABBREVIATION

ATWSSE	Adama Town Water Supply and Sewerage Enterprise
AAWSA	Addis Ababa Water Supply and Sewerage Authority
AWWA	American Water Works Association
IWA	International Water Association
CSA	Central Statistical Agency
DCI	Ductile cast iron
DN	Nominal Diameter
DMA	District Meter Area
HGL	Hydraulic grade line
IWA	International Water Association
LPS	Liter per second
EPS	Extended period simulation
LCD	Liter per capital per day
mH_2O	pressure head in meter
MDG	Millennium Development Goals
MoWR	Ministry of Water Resource
MoH	Ministry of Health
NRW	Non-Revenue Water
PVC	Polyvinyl chloride
UAP	Universal Access Program
UFW	Uncounted for Water
UN	United Nations
UNDP	United Nations Development Program
WHO	World Health Organization
WDSP	Water Development Sector Program

1. INTRODUCTION

1.1. Background of the Study

The health of the community entirely depends on the availability of adequate and safe water. Hence, water is primarily essential for life, health and for human dignity. However, the access coverage of safe water provision and utilization in the country is not yet ensured to address the increasing water demands from a growing population, economic expansion and increasing mean water required per capital (MoH, 2011).

Water is a precious natural resource and management of water is a challenging task in developing countries. Increase in population is causing an ever increasing demand on water supply system. Water resources are limited and this requires better management of water resources and supply. The supply of water is not able to meet the demand due to several reasons like shortage of source water, high amount of leakage, poor maintenance of the system etc. An urban water distribution pipe network consists of huge capacity of pumps, pipes, valves, reservoirs and tanks. It is a challenging task for the water supply board to operate the system to deliver drinking water of required quantity and quality.

Water shortage and frequent service interruption is not only as a consequence of the shortfall between demand and supply but also as result of unidentified leakage and complicated network systems. The existing situation of water supply system in Adama and other of the different developing countries, not meet the demand. And it is becoming the adverse effect on urban development and public health.

Water supply system is one of the infrastructures, where developing countries are working hard to expand. Still so many people both in rural and urban areas are suffering with the provision of adequate potable water supply and sanitation. The actual water supply coverage in towns of developing countries in general and African towns in particular is very low while compared to the demand (WHO, 2001).

According to the millennium development goal targets, the African urban areas will be accessed for improved water with 15 years from the year 2000. On the other hand, in Africa largest cities, only 43% habitants have house connection water supply services. The main problem that developing countries are faced to provide access to safe water for their citizen's is shortage of resource. Moreover, the capacity of the citizen's to pay for water that fully recovers the cost is very limited. For this reason many developing citiesand towns are faced great difficulty to expand the service and rehabilitation of the exiting aged pipes. Generally the United Nation (UN-HABITAT, 2002) report, tariffs in developing countries is set well below the level needed to cover even operation and maintenance costs, and this situation cause for large amount of water leakage.

1.2. Statement of the Problems

In many developing countries on one hand, the level of water supply coverage is very low as water demand is increasing while compared to the developed countries. On the other hand, water loss is comparatively very high and difficult to manage both technically and financially. In the most of developing countries; to meet water supply with increasing demand, water suppliers have relied heavily on supply management, focusing on expansion of systems which is problematic and costly as water becomes scarce; this necessitates use of water conservation practices like water loss management (Park 2006).

As populations grew, the challenge to meet user demands also increased. In Ethiopia, both governmental and non-governmental development agents have been involved in order to enhance the coverage of potable water supply in different parts of the country. But, the coverage of the service in the country still lags.

The water loss in Adama town was increasing from time to time and highly affecting the water supply system. According to the previous study report, the water loss of the town was as high as 31% of total water supplied in the year 2009. The estimated water loss ratio dramatically increased from 14% to 31% in the past decade (Hussien A. 2010).

The problem of water supply in Adama town is not only the problem of adequacy but also distribution and reliability. According to ATWSSE, the distribution of piped water supply system covers mainly the central part of the town. The water supply is mostly interrupted due to burst in the transmission and the mainlines. The loss of a large amount of treated water in the supply system creates financial crises on Adama town water supply enterprise. Hence, this study is important to evaluate the water supply and demand as well as to improve the water loss management in the water distribution system of town.

1.4. Objectives of the Research

1.4.1. General Objective

The main objective of this research is to develop a model for forecasting water loss in Adama town.

1.4.2. Specific Objectives

The study would have the following specific objectives:

- Understand the scale and scope of water loss in Adama town
- To evaluate factors which cause water loss in Adama town
- Using non-linear regression techniques, develop multi useable water loss prediction tool for Adama town
- Demonstrate the developed model at different scale

1.5. Significance of the research

The significances of the research are to evaluate whether the existing system of water supply and loss management situation of Adama town is adequate or not and to model the distribution systems. In addition to that, the study aims to make responsible body to be aware to put policy in order to satisfy the water demand and reduction of water loss in urban water supply scheme. The paper is also important as an input to the future studies; as well as, help responsible organization to think of the future plan. It is therefore, necessary to investigate the status of water supply situation and water loss of the Adama town to provide the efficient loss management and adequate water supply system.

1.6. Scope and Limitations of the Study

An assessment of water supply situation in the urban area is a broad and vast issue. These are some of scope and limitations

The urban water supply situation issues links with various component such as availability of water sources, quality, quantity (supply-demand), demand management and reliability of water. Nevertheless, the current research would deal with the water supply coverage (quantity), demand and urban physical water loss in distribution system.

On the other hand, quantifying and characterizing urban water supply situation of the town is by its nature a complex task. For instance, Leakage identification needs detailed field investigation using sophisticated equipment. But, in this paper, an attempt was made to evaluate the water supply coverage (level of connection per family and per capital consumption), water loss analysis, demand forecast by mode of services and modelling distribution network using Water CAD software. The unavailability of important data and financial limitation was issues limited the study to concentrate only on water quantity and physical water loss in distribution system.

2. LITERATURE REVIEW

2.1. Introduction

Problems in providing satisfactory water supply to the rapidly growing population especially that of the developing countries is increasing from time to time (WSDP, 2005). Water supply system in urban areas are often unable to meet existing demands and are not available to everyone rather some consumers take disproportionate amounts of water and the poor is the first victim. develop and expand water supply projects and one of the difficulties among the other is managing and reducing losses of water at all levels of a distribution system. As a result of the overall shortage of water, many cities and towns are faced a problem in distributing the available water impartially among the residents. Besides the poor management of existing infrastructure asset increases the level of water losses in water supply (Wallingford, 2003). As this research deals with the water supply situation and water loss management in distribution networks' well-maintained water distribution system is a major asset for any town or community.

Continuous monitoring and maintenance of the distribution network is the key step in meeting pressure and flow requirements, and water quality standards. A recent drinking water infrastructure needs survey (USEPA 2001) estimates an investment of 151 billion dollars over a period of 20 years to provide safe drinking water for US customers. Reducing water losses in pipe networks can minimize the maintenance costs and improve the performance of pipe networks.

2.2. Urban Water Supply Coverage in Ethiopia

Water supply coverage provides a picture of water supply situation of one specific country and helps to compare one country with others. The percentage of population with or without piped water connection is a relevant indicator to compare the coverage of water supply in urban areas. Although the water supply coverage is better in urban areas while compared to the rural, the actual water supply coverage in cities and towns of developing countries like African cities in particular is very low while compared to the demand. According to the Global Water Supply and Sanitation assessment 2000 report, the African largest cities are having 43% house connection or yard tap, 21% served by public tap when 31% of population are un-served (WHO, 2001).

Like the others developing countries, in Ethiopia, the coverage of water supply in the country still lags. According to the Oromia Water resource Bureau (2008) report, at the base year of the Universal Access Program (UAP, 2006), the national water supply coverage is about 35% and sanitation coverage is only 17%. At the end of the planned year (in 2012), the total of 50.9 million new people are expected to get safe drinking water and 66.9 million new people to get sanitation facility in both rural and urban areas of the country (WSDP, 2005).

Accordingly, the minimum service standard for rural water supply that is to facilitate availability of 15 liter per person per day (l/c/day) safe water supply from a water point within a maximum conceptual radius of 1.5 km from the residence of the beneficiary to the water point. The minimum service standard for urban water supply is to facilitate availability of 20 l/c/day safe water supply from a water point within a maximum radius of 0.5 km from the residence of the beneficiary to the water point (Solomon B., 2011).

Along with the Water Sector Development Program (WSDP) plan for 15 years (2001 - 2015); the overall Universal Access Program (UAP) plan for 7 years (2006 - 2012) is found a more ambitious plan as the achievement in rural water supply and sanitation coverage is lagging. This indicated that it will be challenging to the sector to achieve the water supply targets of the UAP by the end of programs period in 2015 (WSDP, 2005).

2.3. Millennium Development Goals

The MDGs are drawn from the actions and targets contained in the Millennium Declaration that was adopted by 189 nations and signed by 147 heads of state and governments during the UN Millennium Summit in September 2000. The goals and targets represent a partnership between developed and developing countries to create an environment at the national and global levels alike which is conductive development and elimination of poverty (UNDP, 2008).

The Millennium Development Goals (MDGs) have 8 goals to be achieved by 2015 that respond to the world's main development challenges. The direct link of this study to MDGs is to the goal 7, target 10. “Have by 2015 the Proportion of population without sustainable access to an improved water source” urban and rural with special focus of the study in urban water supply situation and loss management. Also it demonstrates that reduction of water losses in the urban areas will directly constitute to achieving MDGs and therefore should be given a higher priority by all agencies involved in water supply sector (Solomon B., 2011). Ethiopia is working hard on water sector to achieve the MDG as shown below.

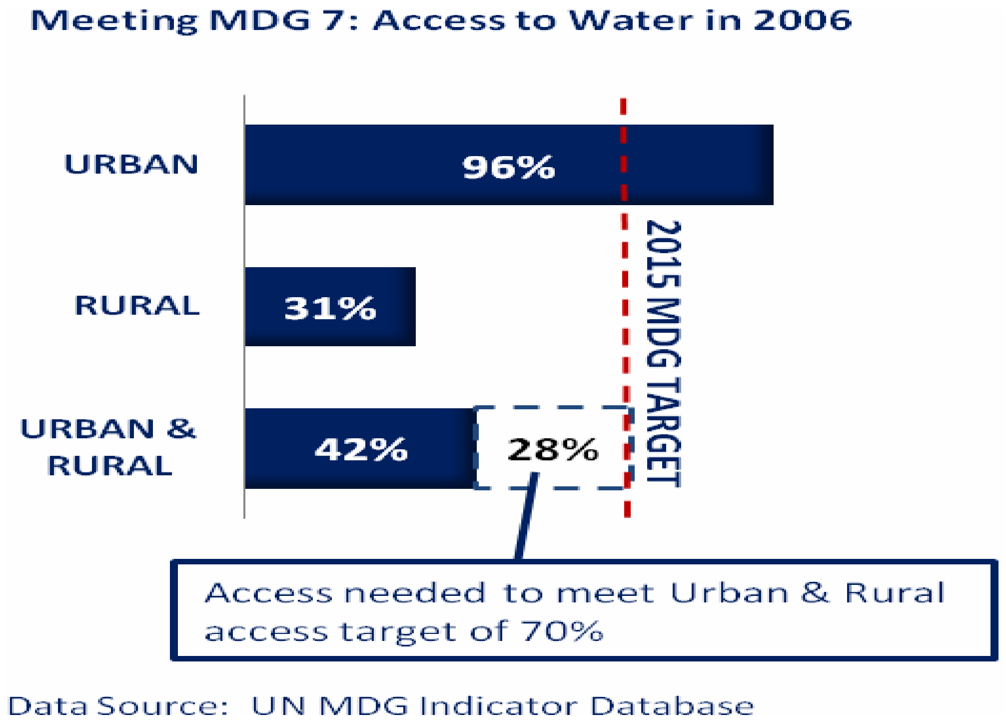

Figure 2.1: MDG Goals of Ethiopia in Water supply

2.4. Urban Water Demand

Water demand is defined as the volume of water quested by users to satisfy their needs. In a simplified way it is often considered equal to water consumption, although conceptually the two terms do not have the same meaning (Wallingford, 2003). In most developing countries, the theoretical water demand considerably exceeds the actual consumptive water use. Urban water demand is classified in to different categories: the domestic water demand that includes in house use and out of house use is among the others. Urban water demand is usually quoted in terms of liter per capital per day (Jeffrey A, 2012).

One of the difficulties faced by the water authority is determining the accurate water demand of the city as the consumption during the past years that should have been used as a base is far below the actual demand due to the shortage of water. Consumption of water for the city and/or town is therefore estimated based on the amount supplied rather thanthe actual demand. For these reason estimate of the future demand by the water authority is found to be uncertain (AAWSA, 2011)

2.4.1. Water Demand management and its tools

Demand management is a term that describes the methods used to modify the level and/or timing of demand for a particular resource. Demand management programs are designed to promote conservation either through changes in consumer behavior or changes to the stock of resource using equipment (Greenburg and Harshbarger, 1993). Behaviour change by urban water consumers can be promoted via communication strategies, through economic instruments such as pricing and financial incentives or through regulatory instruments such as water use conditions or restrictions. In the urban water industry, demand can also be reduced through the use of source substitution, such as rainwater storage tanks or wastewater reuse.

Increasing resource use efficiency remains the key strategy for water conservation and can involve either replacing water using equipment with more efficient types or finding and repairing leaks in the distribution system (Wallingford, 2003). In general, the demand of water for domestic consumption can be controlled by measures such as Installation of water meters (if not done already), and charging a water fee, applying different tariffs for different housing areas, Generation of awareness about prudent use of water, rationing of water (Tue Kell Nielsen, 2002).

2.4.2. Factors influencing water demand

Numerous factors can directly or indirectly influence water demand. Some of these factors are direct and perhaps more significant than others. Both the current level of influence of these factors on water demand and the specific trends in these factors are of great interest in forecasting demand and developing a demand management program. These factors include; Climate, Water supply system and Water usage practices which including pricing, regulation restrictions, income levels, socio-cultural factors, knowledge and awareness, technical innovation and presence of water service companies.

Different factors motivate different consumers to change their water usage practices. Some people will be motivated primarily by financial considerations, some by information provision and some by social factors. An effective demand management program will integrate a comprehensive range of strategies. It should also be noted that these factors might indirectly influence both water using equipment and source substitution, which, in turn, influence water demand (Wallingford, 2003).

2.5. Water Loss and Leakage in Distribution system

Leakage can be defined as unintentional or accidental loss of water from the pipe distribution network (Farley and Trow, 2003). The amount of water loss differs from country to country, city to city and even from network to another network in the same city or town. Different countries uses different indicators to evaluate their states in comparison with others and to compare the distribution of water loss from one location to other location of a distribution system in order to take action based on the level of loss. Using unaccounted for water (UFW) expressed as percentage has limitation when used for comparison as it highly depends with the volume of water produced.

The traditional the performance indicators of water losses are frequently expressed as a percentage of input volume. However, this indicator fails to take account of any of main local influences. Consequently, it cannot be an appropriate Performance indicator for comparison (WHO, 2001).

Depending upon the consumption per service connection, the same volume of real losses/service connection/day, in percentage terms, is anything from 5% to 30%. Thus developing countries with relatively low consumption, can appear to have high losses when expressed in percentage terms, percentage loses for urban areas in developed countries with high consumption can be equally misleading (Farley and Trow, 2003).

There are different formats of water loss in distribution system. To avoid for the wide diversity of format and definitions related to water loss, many practitioner have identified an urgent need for a common international terminology that among them task forces from the international water association (IWA) recently produced a standard approach for water balance calculation with a definition of all terms involved as indicated in the table below.

Table 2.1: IWA standard international terminologies

<table>
<tr><td rowspan="9">System Input Volume (corrected for known errors)</td><td rowspan="4">Authorised Consumption</td><td rowspan="2">Billed Authorised Consumption</td><td>Billed Metered Consumption (including water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorised Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer metering</td></tr>
</table>

(Source: IWA, 2000)

2.6. Water loss status around the Globe and in Ethiopia

2.6.1. Water loss status around Globe

Leaking pipes are a major concern for water utilities around the globe as they constitute a major portion of water losses. The condition of existing old networks can only worsen and further increase water losses. In the globe alone, 50% of supplied water is lost as leakage in some of the older networks (Sensus-Water 2020). Leakage rates are also related to potential pressure, length of pipes and number of connections. Improper connections can sometimes result in continuous escape of water from the distribution pipes. Water leakage in the distribution network is difficult to detect and is an important issue that will draw increased attention in the coming decades. Globally, one-third of all reporting countries face leakage levels of more than 40 percent of the clean water treated and pumped into the distribution system. Figure 2.2 below outlines leakage rates of different countries in the globe.

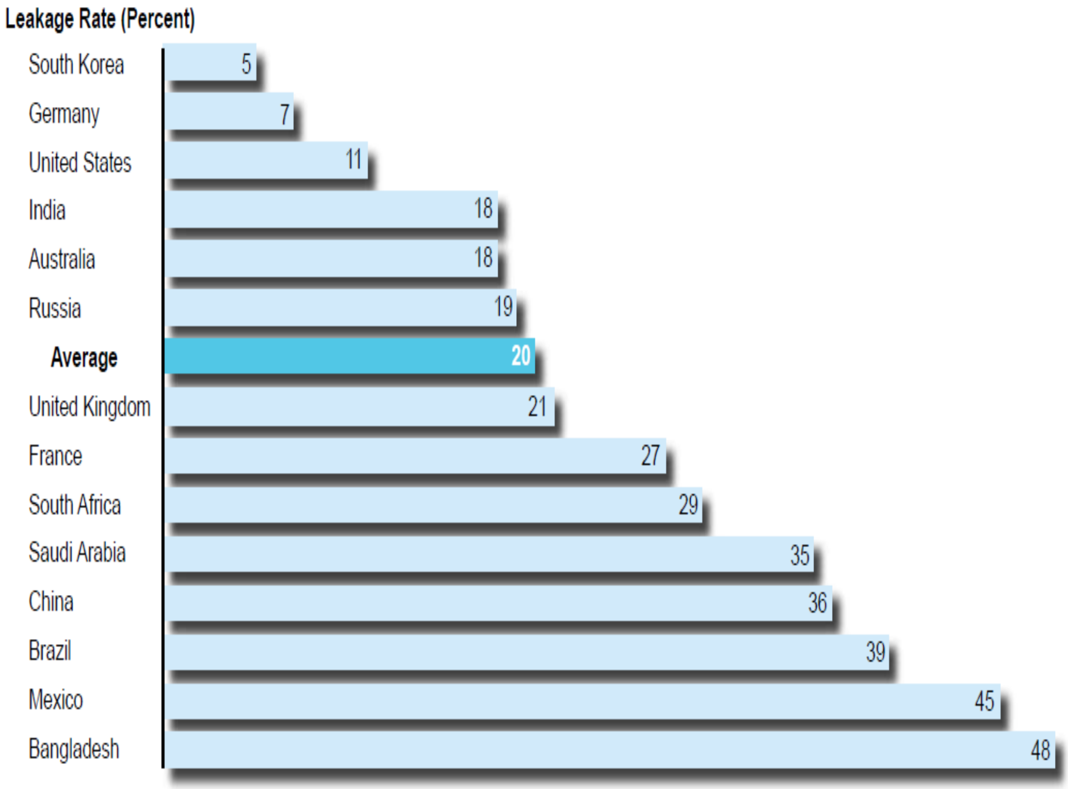

Figure 2.2: Leakage rates of different countries in the globe.

(Adopted from, Sensus-Water 2020-USWeb, bringing smart water networks in to Focus).

2.6.2. Water loss status in Ethiopia

In consider to water loss status in Ethiopia, the availability of data that cover many towns in Ethiopia a great constraints to know the status of water loss of the towns. However, there is some study in the case of the city of Addis Ababa which can tell the overall situation. In order to minimize the problem of water loss due to leakage, a number of the study should carried out on different of water supply components such as transmission line, service reservoirs, distribution systems, water meters etc. in different towns with the objective of finding out the level of loss or the amount of water wasted and find out a solution to reduce the problem. Accordingly, more than 40% water produced by the Addis Ababa Water Supply and Sewerage Authority was lost and wasted due to mainly leakages (AAWSA, 2011).

2.7. Types and Cause of water losses

Pipe leakages occurring as a result of aging of pipe material, poor installation and quality of workmanship, poor quality of material, material corrosion, high pressures, water hammers incorrect of backfill, vibration and traffic load, etc. contribute to Loss of water, i.e. loss of precious resource. The points of leakage not only allow water to be lost, but may also allow contaminants to enter the system (Allan Lambert, 2010).

Leakage is usually the major component of water loss in developing countries, but this is not always the case in developed or partially developed countries, where illegal connections or meter error are often more significant (Farly and Trow, 2003) the other component of total water loss are non-physical losses, e.g. Meter under registration, illegal connections and illegal unknown use. Generally, water losses in the system categorized in to real losses and apparent losses.

I) Physical Losses or Real Losses

Real loss is the water leak from water distribution system through joints and fitting, leakage from reservoir or water tank and reservoir over flow. Factors caused and affect the real losses from distribution system are as follows (Twort and et al, 1994):

a) **Poor quality of fittings, materials and construction:-** Leakage caused from poor quality of fittings, materials and construction have large magnitude in water loss and can occur in long distance from the water mains up to the meter and the private pipe work after the meter.

b) **Age of pipe-** age of a pipeline can appear to be the most significant factor affecting the amount of leakage. Reports from undertakings collected by the Research Consultant of water suggest that leakage rates from mains are of the order of 100 to 200lit/hr per km for newer mains and 150 to 300 lit/hr per km for older mains. In addition, assuming an average of 100 connections per km these figures would represent 1.0 to 3.0 lit/hr per connection. Also,theamount of leakage of newer systems has as little as 5% leakages, while older systems have 40% leakage or higher (Twort et al, 1994).

c) **Deterioration of water mains and pipes:-**The most serious problems are the corrosion of metallic pipes. Internal corrosion is generally more severe in soft waters from upland sources in the case of iron water mains.

d) **Pressure:-**Pressure has much greater impact on leakage and can affect the losses from a system in number of ways. These are; rate of leakage, frequency of bursts, and location of leaks, pressure surges and pressure cycling. Generally 45 to 75 meters static pressure is that which best suits the domestic distribution systems. System designer should take in to account maximum pressure as well as minimum ones. The effect of pressure on leakage is detailed in other elsewhere.

e) **Traffic loading:-**Due to the lack of standard backfill,the effects of vibration caused by heavy vehicles and other traffic are thought to be a major factor affecting the failure of buried or exposed pipelines.

II) Apparent or Commercial Losses

According to the Queensland Environmental Protection Agency Managing and Reducing Losses from Water Distribution Systems, Manual 7, 2005, apparent Losses are caused by:

a) **Illegal or unauthorized consumption**-It is water used that is not registered or paid for. This type of water loss can occur in various forms such as illegal access to water hydrant, illegal use of un-metered, illegal water connections etc.

b) **Inaccuracy of metering:-**Some of the key factors influencing meter accuracy are: meter age, incorrect meter installation, class or type of meter, inappropriate meter size and pressure.It is important to remember that; Under-registration of production meters and over-registration of customer meters leads to under-estimation of real losses and apparent losses. On the other hand, Over-registration of production meters and under-registration of customer meters,results in over-estimation of real losses; leads to over-estimation of apparent losses.

c) **Data transfer and data management errors-** Data handling errors are usually simple human errors- a wrong keystroke, miss reading a meter, or even reading the wrong meter. Data management errors can occur when; a new service connection and meter is supplied, and is not added to billing system, Unbilled users are metered, and are not added to the billing system and a property changes ownership and new owners are not added to the billing system.

2.8. Effect of Pressure on Leakage and Its Management

According to the different experiences and information on the possible influence of pressure; the Pressure in distribution system cause for increasing of leakage when it is more. On the one hand, pressure contributes to the shortage of water that as a result causes for unequal distribution of water among residents. To alleviate such problems, some water authorities develop a zoning scheme whereby the complete water distribution network is broken down in to manageable segments that can be easily metered and monitored. The leakage from water distribution system has been shown to be directly proportional to the square root of the distribution system pressure.

Burst rate are also a function of pressure. Frequent start and stop of pumps, closing and opening of control valves that induce water hammer are also some of the causes to be mentioned for pipe breakage and water loss through leakage (Wallingford HR, 2003).

The position of reservoir also has a great impact on the pressure distribution. Generally, distribution loss is the sum of losses from different distribution system such as trunk main, service reservoir, distribution main and communication pipes. The combination of these asset in individual companies and supply areas are wildly variable, the variation of pressure is significantly affect leakage (Lambert and Wallace, 1993).

The elevation which is desirable to position of a service reservoir depends up on the distance of reservoir from the distribution area and the elevation of the highest buildings to be supplied. If the distribution area varies widely in elevation it may be necessary to use two or more service reservoir at different levels so that the lower areas do not receive an excessive high pressure. Excessive pressure and effect of leakage can be reduced by adjusting the speed of pump, installing a pressure reducing valves and dividing the system in to different pressure zones. PRVs are sometimes installed in out let main from service reservoir in order to reduce the pressure of low laying zones, or to limit increases of pressure at night to reduce leakage. Reducing pressure, on the other hand, may make leak more difficult to find, because they make less noise or do not come up to the surface. Therefore, pressure reduction should be coordinated with leakage detection and repair operations (Farley and Throw, 2003).

2.9. Analysis Real Loss Performance Indicators

The serious problems with this indicator were highlighted in many conferences around the world, most recently at the IWA Leakage Conference in Cyprus (Liemberger, 2002). The new and most advanced real loss indicator (recommended by the IWA and the AWWA) is, the Infrastructure Leakage Index (ILI). The ILI is a measure of how well a distribution network is managed for the control of real losses, at the current operating pressure. It is the ratio of Current Annual volume of Real Losses (CARL) to Unavoidable Annual Real Losses (UARL).

ILI = CARL / UARL

Being a ratio, the ILI has no units and thus facilitates comparisons between countries that use different measurement units (U.S metric or imperial). But what are unavoidable losses and how are they calculated? Leakage management practitioners around the world are well aware that Real Losses will always exist even in new and well managed systems. It is just a question of how high these unavoidable losses will be. The first IWA Water Loss Task Force developed and published, in 1999, the following equation for predicting the UARL for well-maintained systems with infrastructure in good condition.

UARL (liters/day) = (18 x Lm + 0.8 x Nc + 25 x Lp) x P

Where Lm = mains length (km); Nc = number of service connections; Lp = total length of private pipe, property boundary to customer meter (km); P is the average pressure in (m).

The UARL is used to calculate the Infrastructure Leakage Index (ILI), a non-dimensional performance indicator for operational management of Real Losses. The ILI is the ratio of the Current Annual Real Losses (calculated from the standard Water Balance) to the system-specific Unavoidable Annual Real Losses. Since 1999, ILIs have been calculated for many hundreds of water supply systems internationally, with values ranging from close to 1, to over 100.

The ILI is clearly superior for Metric benchmarking (comparisons between systems) for Real Losses. However, the reason it is not usually recommended for Process benchmarking (progress towards targets for reduction of Real Losses) is that pressure management will normally be an important part of any real loss reduction strategy. When excess pressures are reduced, both the CARL and the UARL volumes will reduce, so the ILI may not change to any significant extent.

2.10. Water loss Management

The options available to reduce the leakage as represented diagrammatically in Figure 2.3. This shows that leakage can be reduced by reducing pressure on the system, improving the speed of detection, location and repair of leaks and also by infrastructure improvements. Water companies undertake a mixture of these complimentary actions. General pipe rehabilitation is the most costly and long term action, but is undertaken to improve a number of different factors including leakage. Operational pressure management is a cost-effective means of reducing leakage over whole or sub-networks, and for reducing the risk of further leaks by smoothing pressure variations. The options available to reduce leakage represented in below Figure (Lambert, 2005)

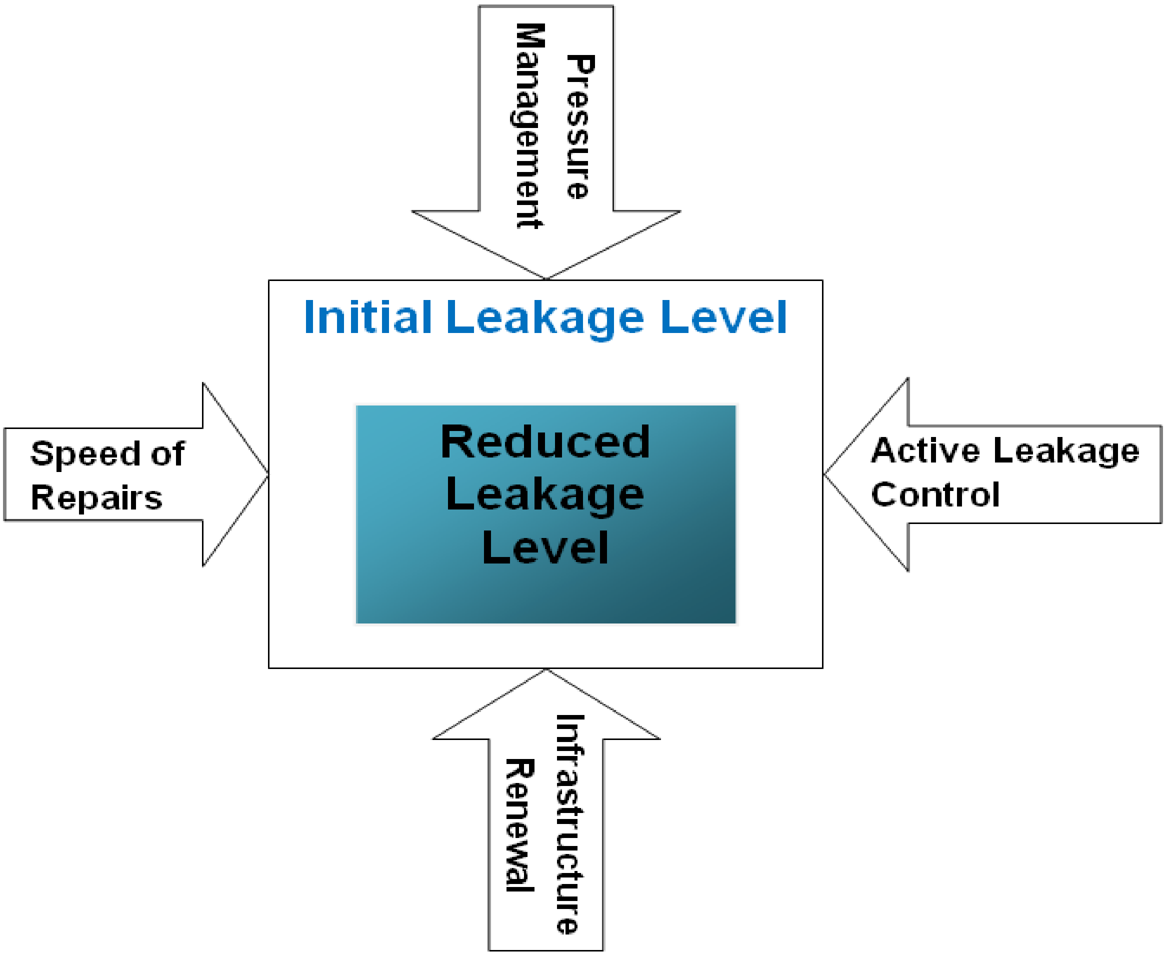

Figure 2.3: Schematic representation of leakage reducing options

2.11. Leakage Detection Using Detection Equipment

Most of water is lost through numerous holes, which are very difficult to locate, as pipes are located underground that usually need special equipment to locate the leak and repair. As water under pressure small holes, the pipe wall and the surrounding soil emit sound waves in the audible range. Water impacting the soil and cavity creates lower frequency waves that have limited transmission through the ground (Wallingford HR, 2003).

The step in leakage control involves location of leaks across the distribution network. Acoustic equipment combined with correlation methods are generally used to locate leaks. Acoustic methods are based on changes in sound of the escaping water (Smith et al., 2000). Acoustic sound transducers are placed in contact with ground surface to listen to any abnormalities in the underlying pipes. In acoustic equipment accompanied by noise correlates, the acoustic signals from transducers are transmitted to a receiving unit, where the signals are processed automatically. The use of different types of smart sensors to gather data and apply advanced analytics such as pattern detection could provide real-time information on the location of a leak in the network. (Sensus-Water 2020-USWeb).

2.12. Challenges of Water loss Management

Water loss reduction and control is difficult and not a simple matter to implement (Liemberger, et al. 2006).Understanding of the problem, lack of capacity, missing management focus, importance of enabling environment and incentives are the main causes for delay implementation of water loss reduction management. Understanding of the problem but not understanding the magnitude, sources and cost of Water loss are the main reasons for insufficient water loss reduction efforts around the world. Missing management focus: establishing and maintaining an effective water loss management program is, besides all other difficulties, a managerial problem, because managing Water loss calls for effective institutional management systems that are comprehensive and operational. Day to day operations and future planning should have this important factor in their perspective (Malcolm Farley, 2001).

2.13. Water Distribution Network Modeling

The main purpose of modeling is to improve the efficiency of distribution network of the existing system and to regulate minimum and maximum levels of pressures at critical points within the system and to develop a simplified model (Walski et. al, 2003).

A water distribution model is created by using a link-node formulation that is governed by two conservation laws, namely mass balance at nodes and energy conservation around hydraulic loops. The node is a point where water consumption is allocated and defined as demand (Cincinnati Ohio, 2006). In conservation of energy, the Bernoulli equation states that the sum of the elevation, pressure and velocity heads between two points must be constant. Whereas, in mass balance, the total in and out flow of nodes are the same. Frictional head loss is accounted for with head loss factors typically based on the Hazen-Williams, Manning and Darcy-Weisbach equations as stated in below table.

2.13.1. Conservation of Mass

Mass in = Mass out

$$\Sigma Q_{in}\Delta t=\Sigma(Q_{out}\Delta t + \Delta V_s) \quad (*)$$

Where: Qin = Total flow into the node (m3/s, cfs)

Qout = Total demand at the node (m3/s, cfs)

ΔVs = Change in storage volume (m3, ft3)

Δt = Change in time (s)

2.13.2. Conservation of Energy

The Energy equation is known as Bernoulli's equation. It consists the pressure head, elevation head, and velocity head. There may be also energy added to the system (such as by a pump), and energy removed from the system due to friction. The changes in energy are referred to as head gains and head losses (Shaher Hussni, 2003). In balancing the energy across any two points in the system, the energy equation will be as follow:

$$P1 / \gamma + z1 + V_1^2 / 2g + = P2 / \gamma + z2 + V_2^2 / 2g + hl \quad (**)$$

Where: P = the pressure (Ib/ft2 or N/m2); γ = specific weight of fluid (Ib/ft3 or N/m3)

z = the elevation at the centroid (ft or m); V = the fluid velocity (ft/s or m/ s)

g = gravitational acceleration (ft/s2 or m/ s2); hl = the combined head loss (ft or m)

2.13.3. Head Loss Equations

There are three main head loss equations. These equations and their application area are shown in table 2.4. The Hazen-Williams Formula is frequently used in the analysis of pressure pipe systems (such as water distribution networks). The formulas are as follows (Walski et. al, 2003).

Table 2.4: Head loss equations

Equations	Formula	Remarks
Darcy-Weisbach	$\mathbf{V} = \sqrt{\frac{\mathbf{8g}}{\mathbf{f}}\mathbf{RS}}$ V = Flow velocity (m/s, ft/sec) f = Darcy-Weisbach friction factor (unitless) g = Gravitational acceleration constant (m/s2) R = Hydraulic radius (m) S = Friction slope (m/m)	Darcy-Weisbach equation commonly used for pressurized pipe and open channel flow
Hazen-Williams	$\boldsymbol{V = 0.85CR^{0.63}S^{0.54}}$ V= Flow Velocity (m/s, ft/s) C = Hazen-Williams roughness coefficient R = Hydraulic radius (m) S = Friction slope (m/m)	This equation commonly used in the design and analysis of pressure pipe system
Manning's	$\boldsymbol{V = \frac{1}{n}R^{2/3}S^{1/2}}$ V= Flow Velocity(m/s) n = Manning's roughness (unitless) R = Hydraulic radius (m) S = Friction slope (m/m)	This equation commonly use for open channel flows.

(**Source:** Haestad Method, (2003) Water distribution modeling user's guide)

On the other hand, there are different friction factors in applying head loss equations. Among those, Hazen-Williams coefficientwhich internationally recognized in computing hydraulic networkused.Roughness (C-value) depends on age and pipe material. The commonly used pipe material and different valuesfor different pipe materials described as in table below (MoWR, 2006).

Table 2.5: Hazen-Williams C-values

Type of Pipes	**C-values**	
	New	Existing
uPVC	130	100-110
Steel	110	90-110
DCI/GI	120	100-110

(**Source:** Water Supply design criteria, MoWR, 2006)

2.13.4. Spatial Allocation of Demands

Although water utilities make a large number of flow measurements, such as those at customer meters for billing and at treatment plants and wells for production monitoring, data are usually not compiled on the node-by-node basis needed for modeling.

The most common method of allocating baseline demands is a simple unit loading method. This method involves counting the number of customers (hectares of a given land use, number of fixture units, or number of equivalent dwelling units) that contribute to the demand at a certain node, and then multiplying that number by the unit demand (for instance, number of lit/c/d for the applicable load classification(Walski, et al. 2003).

There are two basic approaches exist for filling in the data gaps between water production and computed customer usage: top-down and bottom-up. Both of these methods are based on general mass-balance concepts.

Top-down demand determination involves starting from the water sources and working down to the nodal demands. With knowledge about the production of water and any large individual water customers, the remainder of the demand is disaggregated among the rest of the customers. Bottom-up demand determination is exactly the opposite, starting with individual customer billing records and summing their influences using meter routes as an intermediate level of aggregation to determine the nodal demands(Walski,et al. 2003).

2.13.5. Model Calibration

A conventional network simulation model calculates a hydraulic solution under a set of constraints. Calibration is the process of comparing the model results to field observations, and allows for accurate and reliable hydraulic analysis results. Model calibration is usually to averaged pressure data of distribution system from a relatively short period and with limited coverage (S.Takahashi, 2010).

There are two type of calibrations Darwin and manual calibration (Walski, et al. 2003).

The Darwin Calibrator: is the power of Genetic Algorithms to automatically calibrate pipe roughness, demands, and pipe status. An unlimited number of calibration scenarios can be automatically generated and ranked by their proximity to observed data using a fitness value and the adjustments suggested by the calibrator can be automatically applied to the model.

Manual Calibration: is a process of trial-and-error generally involves the modeler's supplying estimates of pipe roughness values and nodal demands, conducting the simulation, and comparing predicted performance to observed performance. If the agreement is unacceptable, then a hypothesis explaining the cause of the problem should be developed, modifications made to the model, and the process repeated.

The calibration process is necessary for the following reasons (Walski, et al. 2003):

Confidence: Results provided by a computer model are frequently used to aid in making decisions regarding the operation or improvement of a hydraulic system. Calibration demonstrates the model's capability to reproduce existing conditions, thereby increasing the confidence and will have in the model to predict system behavior.

Understanding: The process of calibrating a hydraulic model provides excellent insight into the behavior and performance of the hydraulic system. In particular, it can show which input values the model is most sensitive to, so it need to be more careful in determining those values. With a better understanding of the system, the modeler will have an idea of the possible impact of various items or operational changes

Troubleshooting:increase the capability to observe incorrect data like incorrect pipe diameters, or missing pipes. Thus, another benefit of calibration is that it will help in identifying errors caused by mistakes made during the model-building process.

3. RESEARCH METHODOLOGY

3.1. Description of Study Area

Adama is located in East Shoa Zone of Oromia National Regional State. The town is about 100km to south east of Addis Ababa. Geographically, it is located at $8^0$27'N to $8^0$36'N and $39^0$12'E to $39^0$20'E. Adama is one of the fast growing towns in the region and has about 20 kabeles (Adama Town Municipality, 2010).

The total area of the town is around 13,467ha. The average annual temperature of the town is 21^0C having a hot temperate and dry climate. Average annual rainfall amounts 760mm. The town is located at an altitude between 1600-1700m above sea level (Adama Town Municipality, 2010).The map which describes the location of the study area shown in figure below.

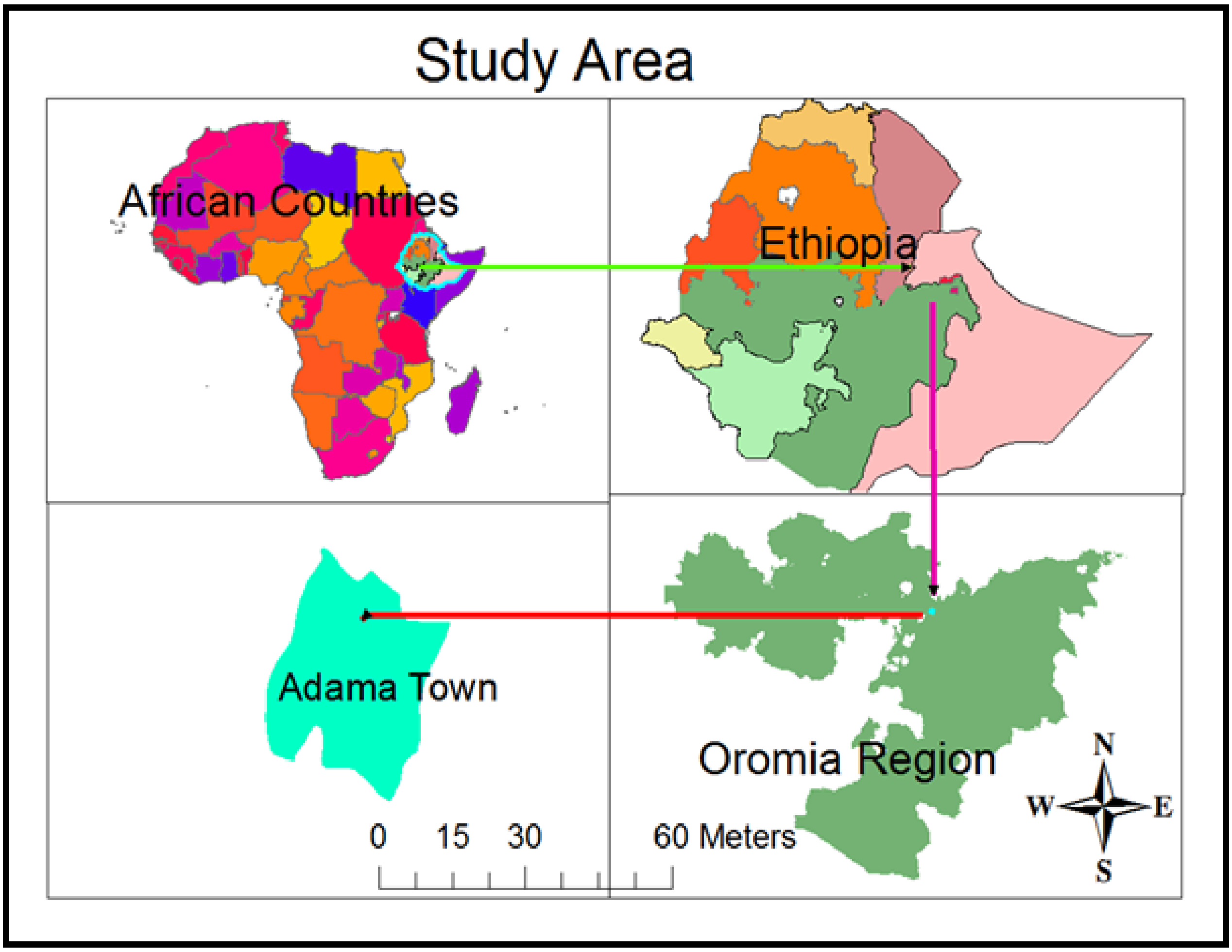

Figure 3.1: Location map of study area

3.2. Existing Water Supply Situation in Adama Town

Adama town was started to get water supply before seventy years ago. Groundwater has been used as the source of water over a longer period of time. The groundwater source near the town has been abandoned since 2003. Due to the intrusion of florid, instead, Awash River (minimum flow is about 15m3/s) which is regulated by Koka hydropower reservoir and transported from about 15km distance became the potential source of water supply for Adama Town. According to the utility report, the Water quality of treated water (Awash) is almost satisfactory except for its silty-like taste. In transporting raw water to the treatment plant, there are six pumps each with capacity of discharging 92 L/s water using a 1000KW electric generator (ATWSSE, 2014).

According to the draft document of AWSSE 2014, currently the volume of daily water production by the treatment plant is 20,000m^3 on the average. The water transmission line is 600mm diameter pipe which feeds five service reservoirs constructed at different locations in the town. The capacities of these reservoirs are ranging from 1000 to 4000m^3.

Boreholes were also other sources of water for the town. There are about 20 boreholes which are located around malka hidda and Tikur Abay areas. Among those boreholes, only three of them are under function. However, they are not using for drinking purpose rather than using for construction (ATWSSE, 2014).

3.2.1. Population Growth

According to the Adama town Municipality (2014) report, in the last seven years the population number of the town is increasing rapidly from time to time. The table below shows the increasing number of population of the Adama town.

Table 3.1: Population number of the town (2008 to 2014)

Years	2008	2009	2010	2011	2012	2013	2014
Population	238,688	249,508	260,653	272,122	283,986	296,254	308,934

(**Source:** Adama town Municipality, 2014)

3.3. Data Collections

The sources of data were decided to being from different bodies and organization such as; the ATWSSE, Oromia Water Resources and Energy Bureau, Adama Town Municipality, Oromia water work and design supervision, Adama town land use, internet and other relevant published and unpublished documents. Data collected were annually and monthly water production and consumption, population of each kebeles and number of water meter. Data from customer's water meters (billing record) provide the information on their current daily consumption whereas, monthly and annually water produced and consumed data which collected from water utility and other different offices was help in providing the basic information on the status of water supply, water loss and gap between supply and demand, challenges to satisfy the demand and input to develop modeling the distribution network of the town.

3.3.1. Primary and Secondary Data

Primary data collected in the from interviews with the management officials and experts of Adama Town Water Supply and Sanitation Enterprise, Whereas Secondary data such as water production, consumption and town water network were collected

3.3.1.1. Water Production

As discussed in the above section, currently the main source of water supply of the Adama town Awash River which regulated by Koka dam. According to the draft report of ATWSSE 2014, currently around 20,000m3/d produced and distributed to the system. Beside to water production of the entire town, monthly water distributed and consumed to the sampled kebeles were collected for the duration of twelve months.

3.3.1.2. Water Consumption

In order to evaluate water supply coverage and losses in the town; annual production, consumption data of six years of the entire town and monthly consumption of each kebeles for one year were collected from IT and information department of ATWSSE. For evaluating per capital water consumption of kebeles, monthly water consumptions of each kebeles was converted to the daily consumption using population data of that kebele, in the same way, the annual water consumption was converted to average daily per capital consumption using the total population data of the town. The number of domestic connection per family has been also used for analyzing the level of connection. There are around 36,226 numbers of water meters or customers within the town.

3.3.1.3. Town Water Network

Water network of the town with their attributes like size and material type of transmission mains and distribution lines, junctions, reservoirs, pumps and valves locations and elevations are available. Beside to this, the network which collected from ATWSSE has also the contour map of the town as shown in figure 3.2 which used to identify the elevation of different points on the network. On the other hand, before exporting Auto CAD format of network to water CAD, it was revised for all pipe diameters, node elevation and location which found in written form as annotation. Then after, network has been imported to Water CAD for the modeling purpose.

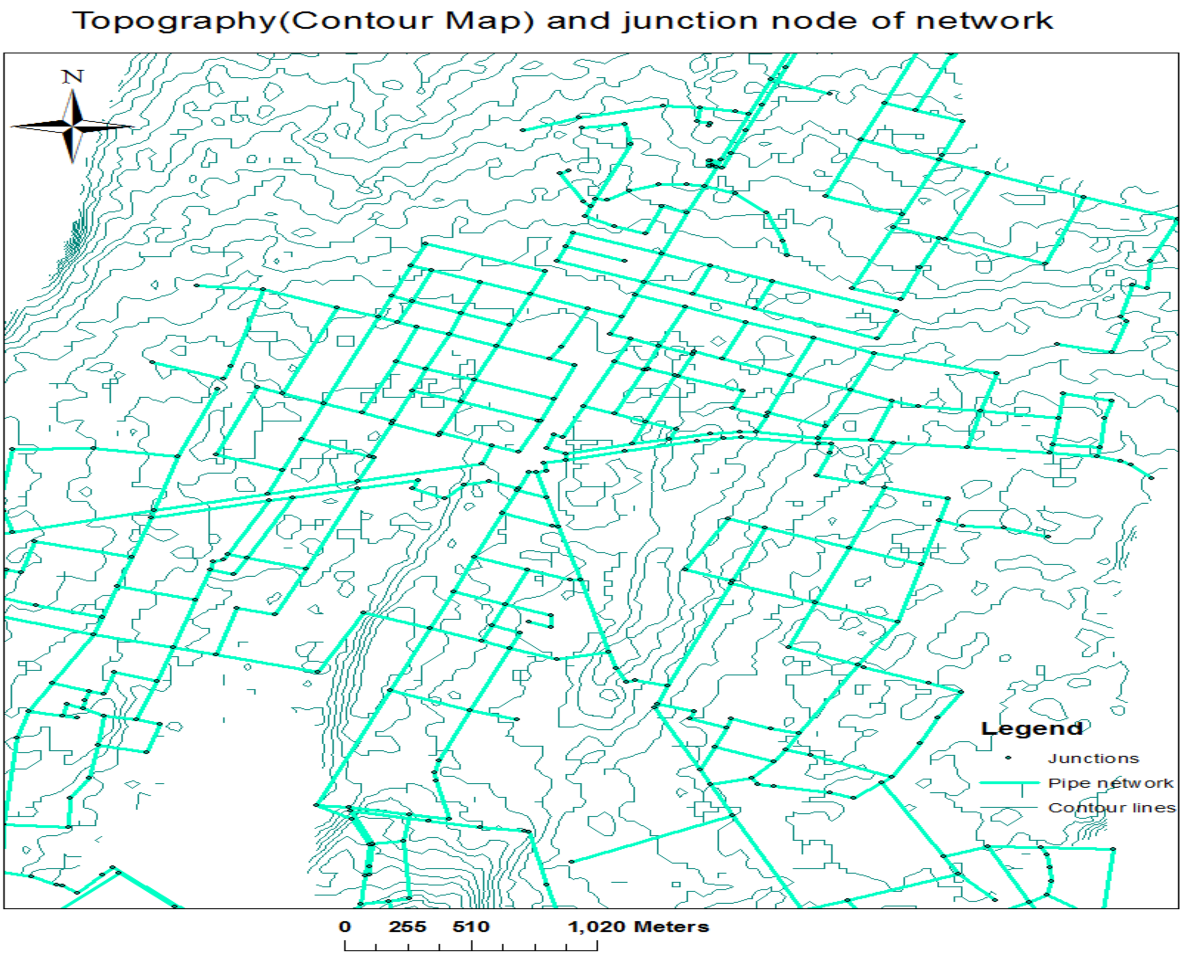

Figure 3.2: Contour map with junctions and Pipe network

3.4. Research Process (Data Analyze)

Water supply status of the town was first evaluated before analyzing the water loss. In this the focus was on; the level of connection and the volume of water consumption as these are highly related to the issue of water loss. After evaluating water supply coverage, the total water loss was analyzed for sample kabales and for the entire town. Then, water demand for present and future was estimated, lastly, performance of water distribution network and status of pressure was evaluated, then simple distribution network was modeled. The working methodology and tool used in this study are as followed.

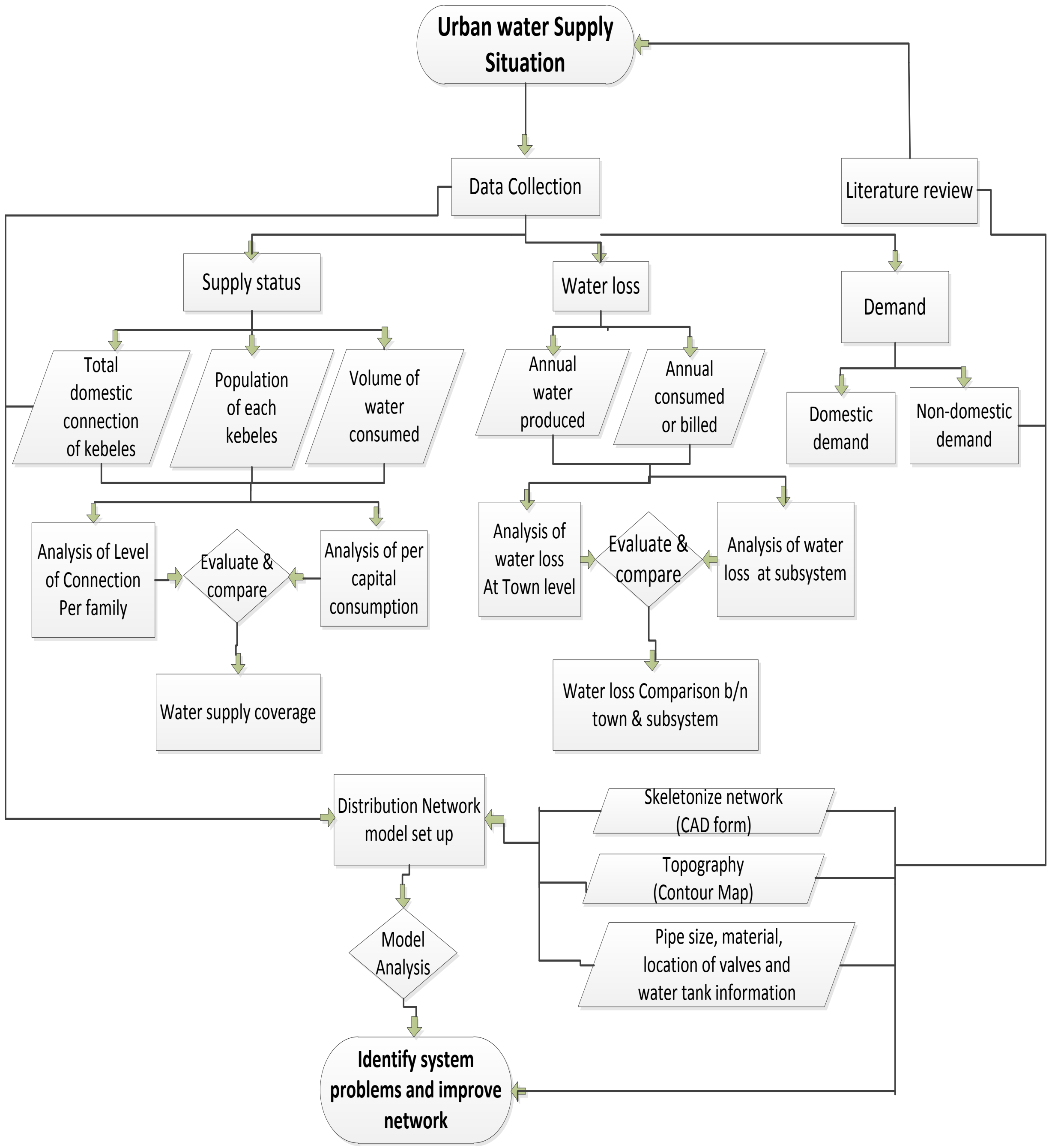

Figure 3.2: Research process flow diagram

3.5. Water Supply Coverage

Water supply status and coverage was evaluated by considering level of connections per family, average per capital water consumptions and mode of services. Average per capital consumption has been derived from the annual and monthly consumption of each kebeles which aggregated from customers' water meters. Also distribution of domestic connection per family has been evaluated by using number of connections and population of each kebeles. In this, statistical analysis was considered by using the following equations (expressions).

1. Level of connection per family

$$\text{Connection per family(no)} = \frac{\text{No. of connections of each kebeles}}{\text{Population of each kebeles / mean family size}}$$

2. Per capital water consumption

Per Capital consump (l/c/d) = [Annual consump (m3)*1000L/m3]/(Population*365)

3.6. Analysis of Water Losses

The magnitude of water losses is analyzed by using percentage of none revenue for water which requires knowing total water produced and billed to generate revenue for utility and total water loss as per number of connection per day at town level and sampled kebels. Lastly, water losses were compared among sampled kebeles and entire town. The following expression used in determining water losses from the system.

3. Total percentage of water loss

$$\text{Total water Loss (\%)} = \frac{unbilledvolume}{systemin\ putvolumes} * 100$$

4. Water losses as per connection per day

$$\text{Total water Loss (liter/connect/day)} = \frac{unbilledvolume(m3) * 1000L/m3}{Totalno.\ ofconnections * 365}$$

3.7. Water Demand Projection

The amount of water used for domestic purposes greatly depends on the lifestyle, living standard, climate condition, mode of service and affordability of the users. In projecting the domestic water demand the following procedures were followed (AAWSA, 2011).

a) Determining population percentage distribution by mode of service and corresponding consumer category and its future projection

b) Establishment of per capitaldemand for each mode of service or customer category.

3.7.1. Peak Factors

In communities there are different factors for water demand. Some of them are seasonal, daily and hourly peak factors. Water demand varies greatly during the day. The distribution system must be designed to cope with the peak demand, which is taken into account by the use of a peak hour factor (MoWR, 2006). The peak hour factor varies inversely with the size of the consumer base as stated in table 3.3.

Table 3.3: Peak factor distribution with population range

Population Range	Peak hour factors
< 20000	2
20001 to 50000	1.9
50001 to 100000	1.8
> 100000	1.6

(Adopted from Water Supply design criteria, MoWR, 2006)

Peaking factors can be determined by dividing the maximum daily usage rate by the average daily usage rate as below (MoWR, 2006)

$$Pf = Q_{max} / Q_{avg}$$

Where Pf = peaking factor

Q_{max} = maximum daily demand

Q_{avg} = average daily demand

3.7.2. Population Forecast

Number of population of the town is increasing from time to time. According to the CSA 2007, the population growth rate of towns was estimated for different subdivision of years from 1995 to 2030 was fixed as below and the growth rate of population from 2015 to 2035 is 3.69% and 3.35% respectively adopted which is gradually decreasing (MoWR, 2006). According to the report, the growth rates established by CSA at national level for every 5 years interval will be used during population forecast as in the table 3.4 below.

Table 3.4: Distribution of population growth rate

CSA's Country Level Population Growth Rates	
Years	Urban Growth rate %
1995-2000	4.3
2000-2005	4.1
2005-2010	4.06
2010-2015	3.88
2015-2020	3.69
2020-2025	3.51
2025-2030	3.35

(Adopted: Water Supply design criteria, MoWR, 2006)

Therefore, the geometric increase method was used in forecasting population numbers for twenty years of design period by using base or initial population number of 2014. The following equation used in population projection.

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

Where: P_n -population number at year 'n'

P_O- initial population,

K–Population growth rate (%)

n- Number of years

3.8. Model Setup and Data Entering Procedures

The main purpose of modeling is to assessing the existing system and to evaluate the levels of pressures at critical points within the system and to develop a simplified model. Due to the limitation of data, resource and time, this study does not consider water quality. The existing data, procedure of evaluating and model building ware as follow.

First step skeletonizing the distribution network system by conversion of the original existing water network of the town which available in Auto CAD software format to Water CAD V6.5; this was required so that the various background layers (CAD and GIS) can be used directly within the Water CAD software. Second, the other important elements such as junctions or nodes, pipe, tanks and reservoirs, pumps, etc. were located.

Data entering procedure:

Most of the data have been entered into the skeletonized water distribution network using both import tools and dialog box type of data entering of the water CAD. The ground elevations of reservoirs, tanks, nodes, pumps, valves and coordinate locations have been imported to the network whereas different demands such as average day demand and demand pattern were entered using dialog box entering. In the process of entering demands, every node demand has been identified and the distribution of all nodal demand was allocated. Also Per capita demand or base line demand of Adama town in the present year has been adopted from water demand projection which collected by AWSP-II and (CG Consulting Engineers Ltd) has been considered for modeling the system.

In modeling procedure the below step were considered;

- all the existing data have been collected
- Some missed data for modeling of the system have been generated
- All the existing and generated data have been entered into the built model
- The system has been simulated for single period (steady state) and extended period simulation

3.9. Model Calibration Approach

The trial and error process that usually goes into model calibration or manual approach was used for calibration. This generally carried out by supplying to the model estimated of pipe diameter, length, roughness as well as nodal demands and elevation, conducting the simulation, and comparing predicted performance to observed performance. If the agreement is unacceptable, then the cause of the problem must be hypothesized and modifications to the different model parameter must be made. The process is repeated again until the predicted and observed values are within a reason (David, et al. 1988).

There are two types of data collection (Walski, et al. 2003), which can be classified as either point reading or continuous monitoring. Point reading involves collecting data for a single location at a specific point in time, whereas, continuous monitoring involves collecting data at a single location over time. In this study, sample points readings (19 nodes) selected, where the parameters being measured are representative of the location.

Calibration data - Field test data taken were the flow, static pressure gauges, elevation and X and Y coordinate location of sampled points. The hydraulic model was calibrated by adjusting H-W coefficients (C) to the minimum and maximum of roughness value.

Nineteen junctions from different pressure zones distributed on the network of town were selected. Then the pressure and other parameters were measured to give a good representation of the pressure in the network. The entire fields measured were taken at the average and maximum hourly demand hours during the period of July 20, to 24, 2015.

The summary of modeling and model simulation was described in the below flow chart.

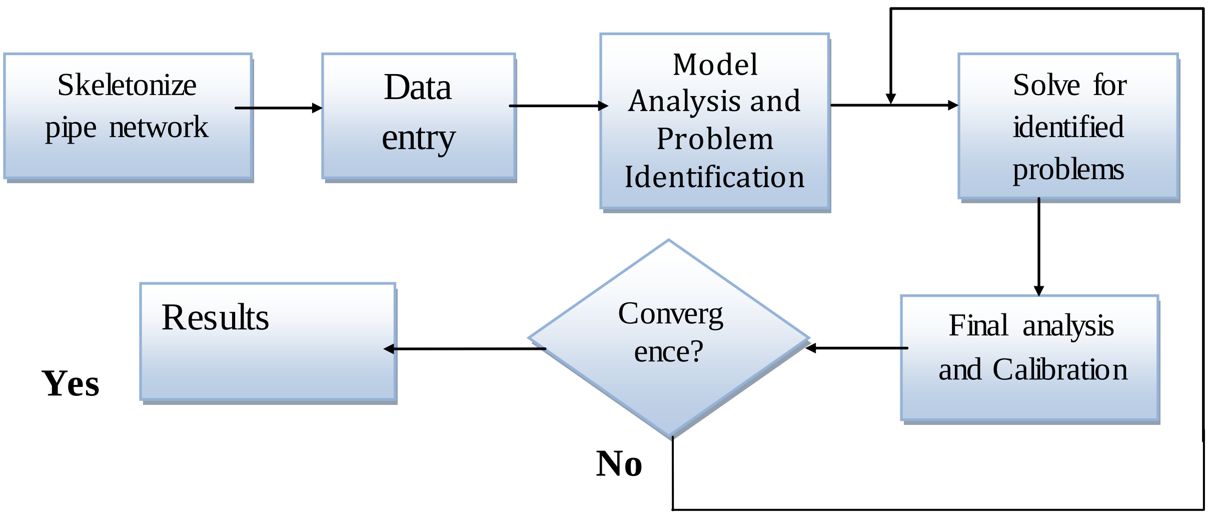

Figure 3.3: Flow chart for Model Simulation

3.10. Tools of the Study

The following tools are used in the analysis and modeling process of the study.

1. **Microsoft Excel 2007**; a product of Microsoft Corporation, is used to analysis different parameter such as average, mean, median and to put different describing tables and figures. Also it converts data files exported from WaterCAD into database files. There are different options of converting MS Excel files into different file formats such as database files, text files (tab delimited).

2. **Auto CAD 2007;** this is widely used commercial software for drawing the maps. The layers concept is also exported to WaterCAD v6.5 which is used to skeletonized and hydraulic analysis. The other function is used to see and view the details of the drawing of network with map (contour map) that is imported in AutoCAD 2007 from WaterCAD.

3. **Water CAD (v6.5);**with today's technology and software packages, we are able to model a system relatively quickly. This saves us from the repetitive iterations that determine the flows and pressures during model. Therefore, this is a software package used for the hydraulic analysis and design of the water distribution system. Water CAD was designed, developed and programmed by Haestad Methods Inc. (USA) staff of Software and Civil Engineers. Also WaterCAD has an option of converting the Water CAD files (extension .wcd files) into shape files, DXF files which can be imported into other software for different purposes. The advanced of this software is that it provides different analysis like Steady-state and Extended-period simulation, efficiently manage large data sets and different "what if" situations with database query and edit tools. In addition to the above mentioned, the software has different methods in result presentation like using thematic mapping, advance profiling and tabular reporting with Flex tables. Different scenario and element comparison is the most advantageous points of WaterCAD in managing model (Haestad Method Inc. 2003).

RESULTS AND DISCUSSIONS

4. WATER SUPPLY SITUATION AND COVERAGE

4.1. Introduction

In developing countries, Problem in provision of adequate water supply to the rapidly growing urban population is increasing dramatically. Water demand in the cities of developing countries including Adama town increases through time that as a result demand for additional water sources and infrastructure. Financial constrain is one of the major factors for the low water supply coverage and poor management of the existing water supply also has a great impact. Beside to the overall low supply coverage, there is high percentage of loss from existing system among different localities(Shimeles K. 2011). Therefore, evaluating the water supply distribution of the town is important in order to identify the problematic areas and intervene accordingly.

Water supply coverage is usually evaluated based on the quality, quantity, reliability, paying capacity of the people, distance of the source, etc. but the intention of this research is not to evaluate the quality or paying capacity, but the focus was related to the quantity of the supply and level of connection that are related to the water loss. In this part of the analysis, the number of domestic connection per family and the average daily per capital consumption is used to analysis the domestic water supply coverage for the Adama town.

4.2. Domestic Water Supply Status in the town

The water supply coverage of the town has been evaluated based on the level of connection per family, distribution of mode of service and average per capital consumption. beside to the level of connection per family, the average per capital consumption which has been derived from the yearly consumption of each kebeles as that has been aggregated from the individual domestic water meters as well as mode of services were statistically analyzed. In this there are numbers of population of each kebeles and total population (308,934) as forecasted to the year 2014 and number of water connections was considered as briefly discussed in this section.

4.2.1. Incremental of Customers Water Connections

To assess the access of urban water supply system, level of water supply coverage as well as the impact of water loss in the components which depends on the level of connections is important to identify different types and level of it. As the data from Adama Water Supply and Sewerage Enterprise describes, currently number of connection of water meter within the town are 36,226 (November 2014). Among those, 34,171 were water meters that used for domestic purpose. Even though the water demand of the town is highly increasing, there was a limited amount of customer water meter added within the last six years. As described in below graph, the limited amount of water connection was added from time to time, with low percentage. The average of increment of connection per year during the last six years was only 6.48% and only about 10,528 numbers of new customers' connection were added.

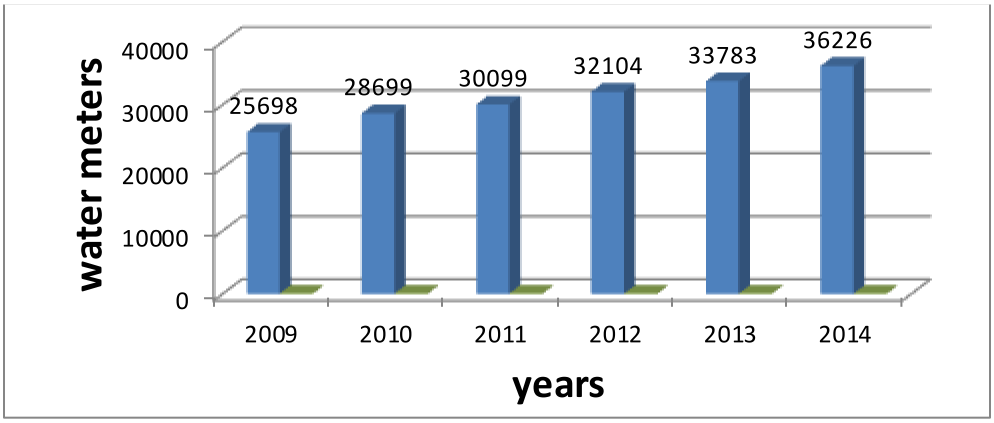

Figure 4.1: Level of increments of connections (customer water meter)

(Source: ATWSSE, 2014)

4.2.2. Level of Connection Per Family

The distribution of the water connection varied among kebeles in Adama town. More or less the variation was observed in among different kebeles; but particularly in kebele of 01 high level of connection 0.9 connection/family, while less value considered in kebele 08, was only 0.15connection/family. Therefore, for all kebeles the level of water connection per family has been evaluated and shown using graph 4.2 below. On the other hand, about 11 kebeles have high level of connection which is greater than 0.5 Connection/family, while 9 kebeles have lower level of connection which less than 0.5 Connection/family. The reason for the higher and lower level of connections per family in these kebeles is affordability of the households to install private water meter, accessibility of distribution lines, and while for lower level of connection per family; relatively lower income inhabitants, fastly expansion of the town and low accessibility of main lines.

According to the finding of this study, the average level of connection per family of the Adama town is 0.52connection per family. This implies that, 52% or about 1.97 families shared one connection. However, according to Ministry of Water Resources (2005), a maximum level of domestic water supply connection per family is 1 or 100% (as best practice), which means one connection for one family. Therefore, the average level of connection per family of the Adama town is lower. The distributions of level of connections per family for twenty kebeles in the town were shown in figure below.

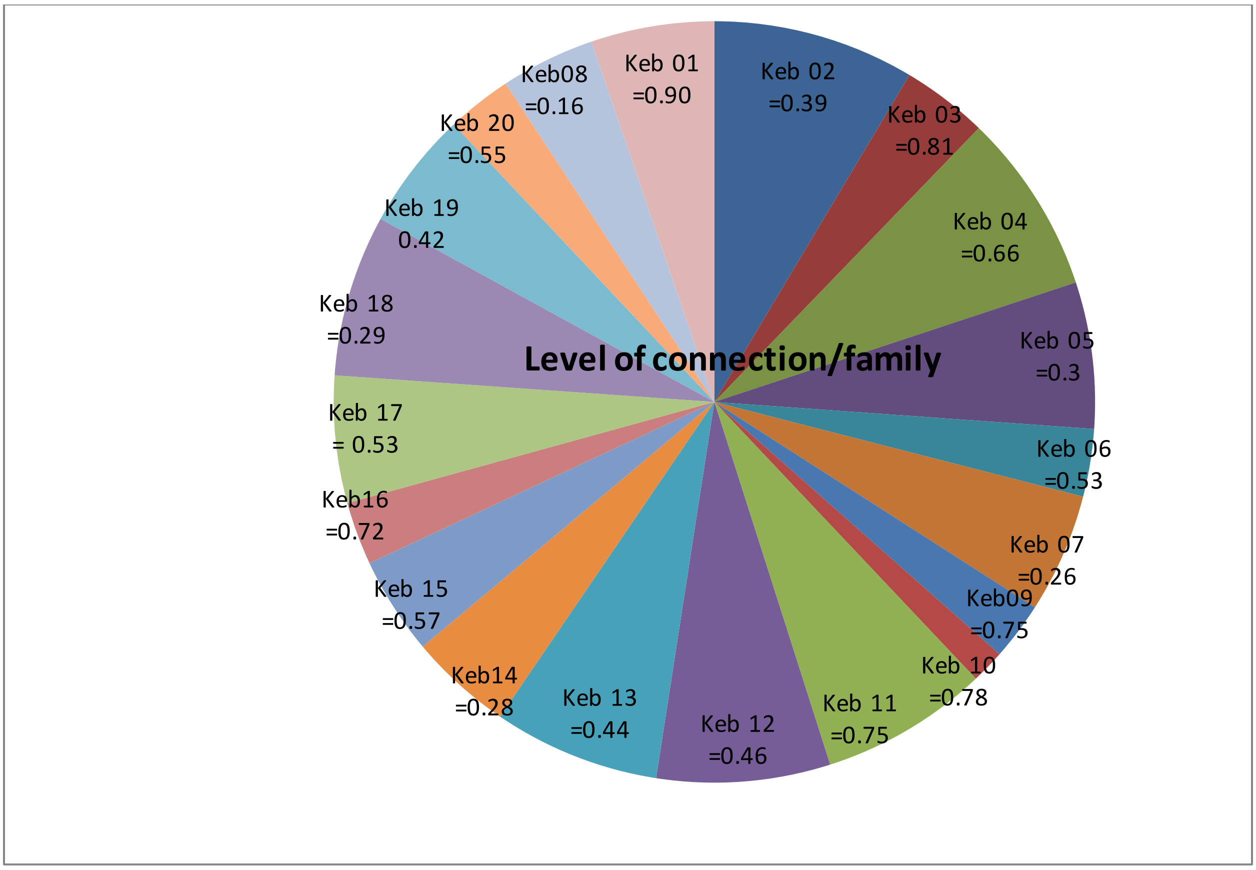

Figure 4.2: Distribution of connection per family.

4.3. Per Capital Water Consumption

According to some literature (Wallingford 2003), a minimum quantity of 25 l/c/day domestic water supply was categorized as basic level of service. On the other hand, according to the (UN-Habitat, 2003) and UAP, 20 l/c/day taken as a basic need to be provided. Unlike the level of domestic connections, there were variations of per capital consumption among kebeles. Out of the total 20 kabeles of the town, 8 kabeles were getting water less than this basic service (20 L/c/d), whereas about 12 kebeles use per capital consumption greater than the basic. However, as described in the figure 4.3 below, the mean average domestic consumption of the Adama town is greater than that of basic need 20 l/c/d, Therefore, the average daily per capita consumption of Adama town in 2014 is 34.5 l/c/d which was also lower than the standard as per the guideline of the water supply coverage of Ministry of Water Resources report (2009), for urban centers with population more than 30,000, the prescribed daily per-capita consumption was 37.5 l/c/day. Figure below shows, per capital consumption of different kebeles in the town.

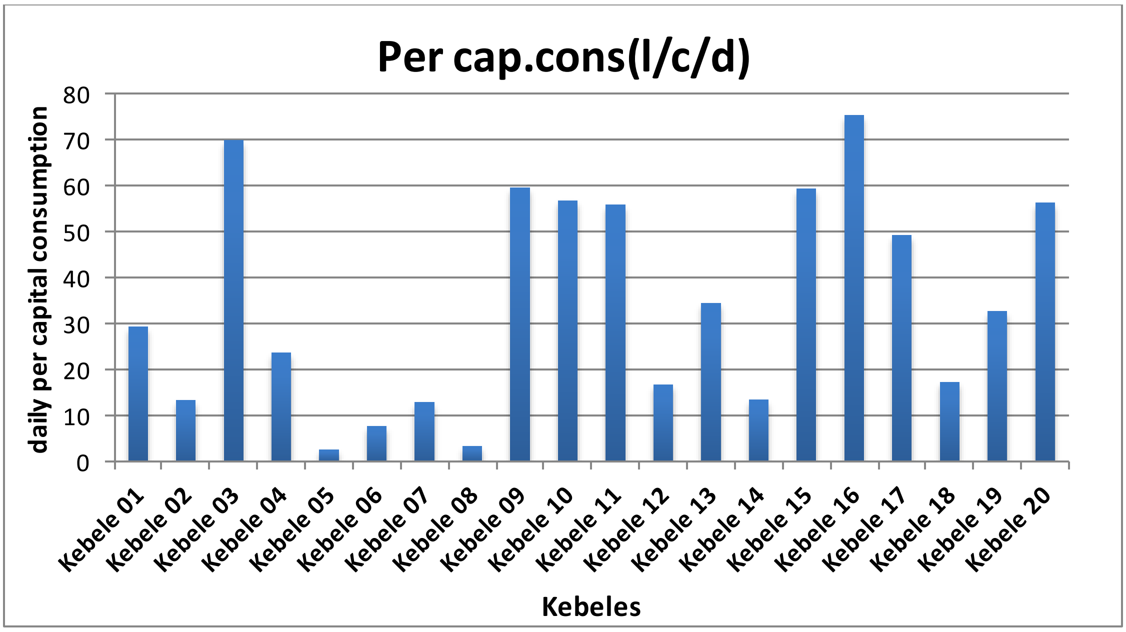

Figure 4.3: Distribution of per capital water consumption of each kebeles (l/c/d)

In addition to that, during the analysis of per capital water consumption at town level, the total water annually produced and consumed by the community for the last six years was as in below table. In order to evaluate water supplied and consumed as well as per capital consumption of the entire of the town in the last 6 years [2009 to 2014] was used. Therefore, according to this analysis, the average of per capital consumption for the entire town was 38.5(l/c/d) which is greater than the average of the individual kebeles. This implies that, there are numbers of kebeles those have per capital consumption greater than the average of individual kebeles. On the other hand, according to the discussion and key informant interview, in the country for the central towns, per capital water consumption standard is (80 -100lit/cap/day) which is greater than the double of Adama town.

Table 4.1: Annually water production, consumption and daily per capital consumption

Years	Annual production(m^3)	Total consumption (Total billed m^3)	Number of population	Daily per capital consumption(l/c/d)
2009	4780619	3767563	249,508	41.4
2010	4996584	3423907	260,653	36
2011	5341928	3514239	272,122	35
2012	6411436	4189881	283,986	40.4
2013	6422648	4251184	296,254	39.3
2014	6751362	4450983	308,934	39.4

On the other hand, there is linear relationship between per capital consumption and level of connections with correlation coefficient (0.6118), as the indication of this analysis, the areas (kebeles) where the level of connection per family is better, volume of per capital water consumption is also higher and/or there was direct relation of water consumption to the level of connection. In other word, kebeles having high level of connection (01, 03, 09, 10, 11, 15, 16, and 20) consumed more water as they can easily get it within their compound. Whereas in the rest kebeles, the less value of both per capital water consumption and percent of level of connection per family observed. The plot of relationship of percentage of connection per family and per capital water consumption of different kebeles is shown as in the figure below.

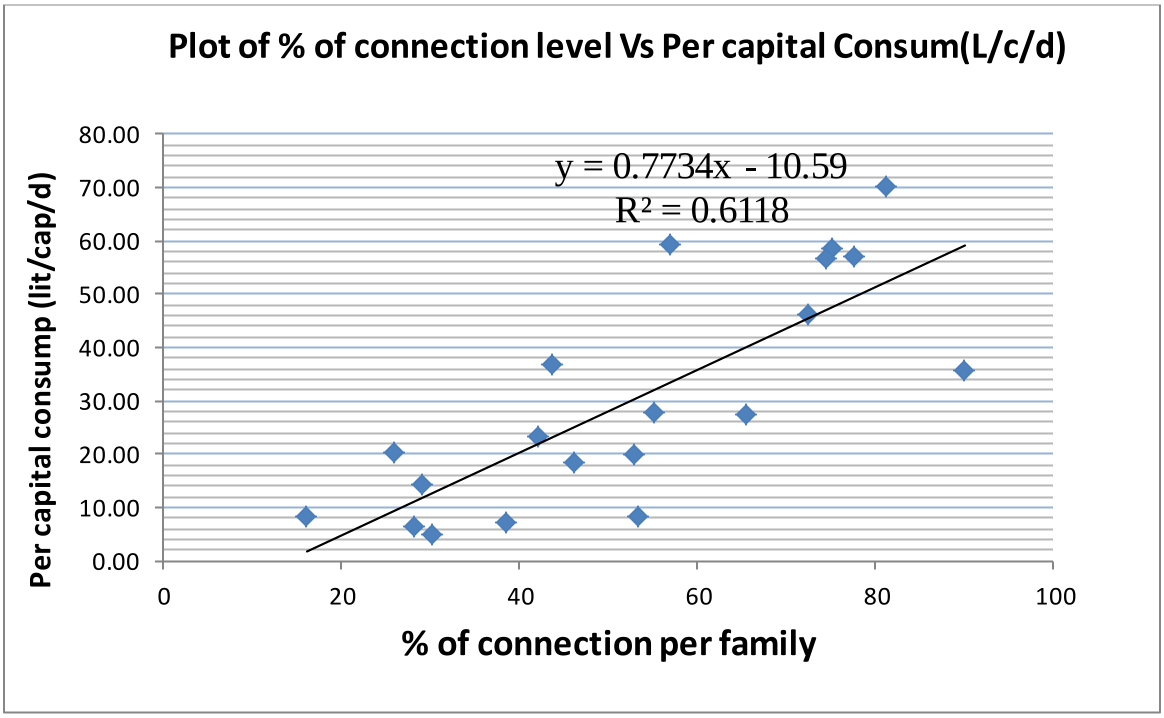

Figure 4.4: Comparison of percentage of connection Vs Per capital consumption

4.4. Mode of Services in the Town

As obviously known at everywhere of the cities and towns, there are different types of mode of services in Adama town. Those are house connection (HC), yard connection (YC) and public fountain (PT). Table below categorize types of mode of service, number of connections (HC=3089, YC= 30894 and PT= 188), population served by each mode and percent percentage of the modes. In this analysis, according to the (CSA, 2007), the average family size of the Adama town is 5. Also according to the ATWSSE key informant interview, about 575 persons used per a public fountain and in case of yard connection 6 persons per connection.

People having in-house services that are estimated about 5% of the total population use water on average between 35 to 42 liters per capital per day, while the remaining populations with access to safe drinking water (60%) with served by yard connection use 15 to 30 liters per capital per day and population those use public fountain (35%) consume less than 20 lit/c/ day.

Table 4.2: Mode of services in the town

Mode of services	Number of connection	Person per connections	No.of population served	(%) of these connection
HC	3089	5	15445	5
YC	30,894	6	185364	60
PT	188	575	108100	35

4.5. Domestic Water Supply Coverage

Traditionally, domestic water supply coverage is expressed in the percentage access of the population to save water supply services. According to the finding of this research, the percentage domestic water supply coverage of Adama town is 64% which was less than the Oromia Urban Water Supply Coverage achievement planed in 2015 to be 96% as well as when compared to the MDG targets of urban Water Supply Coverage.

Currently water supply coverage of the town is not increasing from year to year rather than it is decreasing [according to the utility annual report, 2009 to 2014, the coverage was 88% and 71% respectively]. The reason for decreasing is that during some years ago, there was no any expansion for water supply sources and components, whereas population growth and water demand were rapidly increasing.

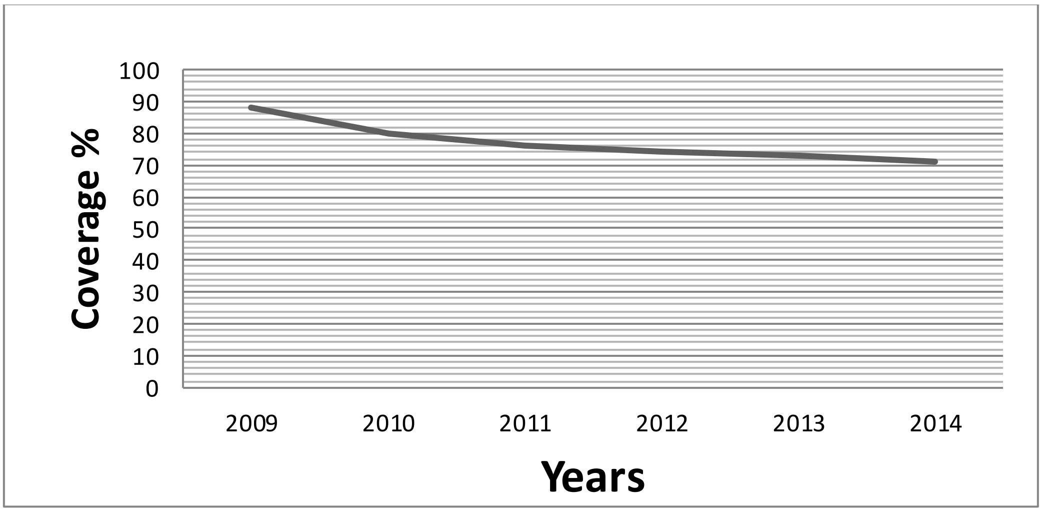

Figure 3.4: Decreasing water supply coverage of Adama town

(Source: ATWSSE, 2014)

5. WATER LOSS ANALYSIS

5.1. Introduction

Water loss occurs in all distribution systems only the volume of loss varies, depending on the characteristics of the pipe network and other local factors, the water company's operational practice, and the level of technology to controlling it (Jeffrey A, 2012). Total water loss is the difference between the amount of water produced and the amount which is billed or consumed. Leakage is one of the components of water loss, comprises apparent and the physical losses from pipes, joints and fittings, and also overflows from service reservoirs. These losses can be severe, and may go undetected for months or even years. The larger losses are usually from burst pipes, or from the sudden rupture of a joint, while smaller losses are from leaking joints, fittings, service pipes, and connections. The volume lost will depend largely on the characteristics of the pipe network and the leak detection and repair policy practiced by the company, such as:

- The pressure in the network
- Whether the soil type allows water to be visible at the surface
- The "awareness" time (how quickly the loss is noticed)
- The repair time (how quickly the loss is corrected).

Leakage is the major component of water loss in developing countries, but this is not always the case in developed or partially developed countries, where illegal connections, meter errors, or accounting errors are often major contributors (Allen Lambert, 2001).

5.2. Water Loss Expressed as Percentage of Production (%)

Total Water loss expressed as a percentage can be an appropriate means to show the extent of the loss within a given network, but for comparing the losses from one area to other areas, it is not a good indicator (Allen Lambert, 2001). Adama town cumulative annual water production, consumption and loss for the last 9 years (2005 to 2014) are shown in the figure 5.1 below. The total volume of water annually produced and distributed to the system in the fiscal year 2014 had been 6,751362m^3, the consumed was 4,450983m3 and the annual total water loss was 2,300379 m^3 which accounted to 34.07% of the total water production.

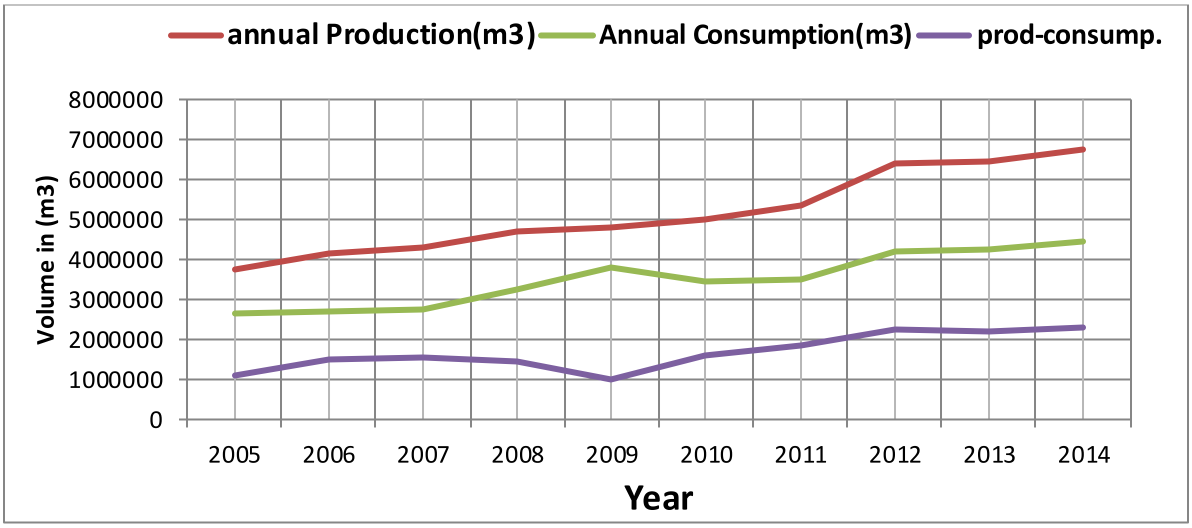

Figure 5.1: annually water production, consumption and percentage of loss (% loss)

5.3. Water Losses Expressed as Per Number of Connections

The amount of water losses in a given system is the effect of different water loss components. Water loss per connection (litters/service connection/day) was a basic performance indicator for areas with dense connections and good indicator when we went to compare the loss of one area with another area (Jason B. et al., 2011). To express the amount of water lost due to service connection in Adama town, taking total number of connection (36,226) in the town, then daily water loss per connection is, yearly unconsumed water (2300379m3) to the total connections.

Water loss = (2300379m3 * 1000l/m3)/(36226 *365) =174 lit/connection/day.

Even though per capital consumption of Adama town was low, According to performance indicators of water losses in distribution system by (Saroj Sharma, 2008), which state, 'comparison of water loss between different areas is recommended to be done using the water loss per service connection per day'. This value falls in a Good condition of system, which is '<250 Lit/service connection /day for water loss in water supply systems with per capita consumption of less than 150 l/day'.

5.4. Water Loss Expressed as per Length of pipes

Among the different types of physical water loss indicators, water losses expressed as per kilometers length of main pipes is used as indicator to compare the water loss of the town. The total length of pipes which have a size greater than 80mm and above within the entire town in the fiscal year is 410km. among this, nearly about 108km were categorized as main pipe where the rest 302km were secondary pipes as classification of the utility. Even though there are a pipelines that their diameter was not clearly identified, the pipe which have diameter ≥ 80mm have been used to evaluate water losses as per kilometer length of pipes. The summary of pipe length with their ages shown in table 5.1below

Table 5.1: Summary of town water pipes by categories of ages

Ages	All-pipes-category	Main-pipes category	Secondary-pipes-category
	Total- length(m)	pipe- length(m)	pipe- length(m)
<10 years	89710	37710	52000
10_20 years	179810	29512	150298
20-30 years	98960	22660	76300
30-40 years	31588	9888	21700
>40 years	9030	8230	800
Not-specified	902	-	902
Total	410,000	108000	302000

Then, using the total pipe length within town, the water losses as per kilometer length was analyzed as, total volume of water loss in the system to the length of main pipe.

Water loss = (2300379m3 *1000l/m3)/ (410 km*365day) = 15,400lit/km/day.

According to (Saroj Sharma, 2008), guideline for the water loss level is the "Benchmark", Average condition between 10,000 – 18,000 liter/km/day and Bad condition of system >18,000 liter/km/day'. Therefore, from this analysis the Adama town water loss level as per length of pipes was in average condition.

5.5. Water Loss Analysis in Sub-system

Adama town generally subdivided in to twenty kebeles. Among those, four sample kebeles (03, 09, 11, and 15) was selected to evaluate water loss in subsystem. The criteria of selecting these kebeles was that, they have the important data such as water supplied, consumed (as detailed in Appendix A) and number of connections as well as significant different topography (elevation of customers water tap and serving reservoir). In this, the focus was to evaluate which kebeles was high magnitude of loss, the impact of pressure on water loss and to compare water loss of these subsystems with entire town. The following graphs used to show analyzed cumulative of monthly water produced, consumed and the cumulative of water loss from system.

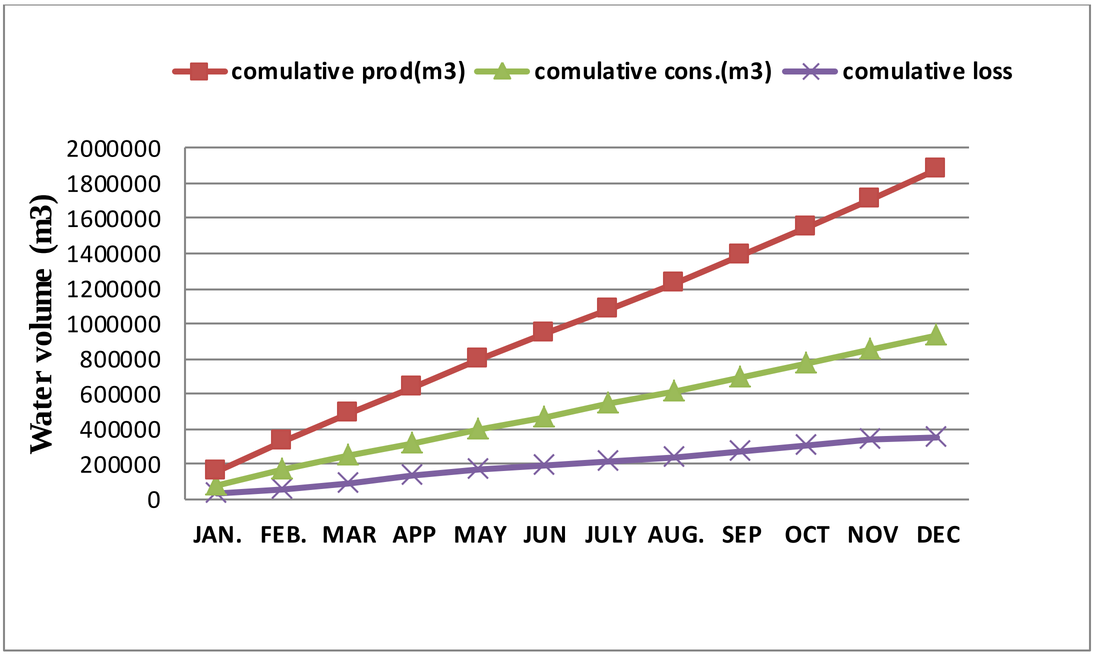

Figure 5.2: Cumulative production, consumption and losses of kebele 03

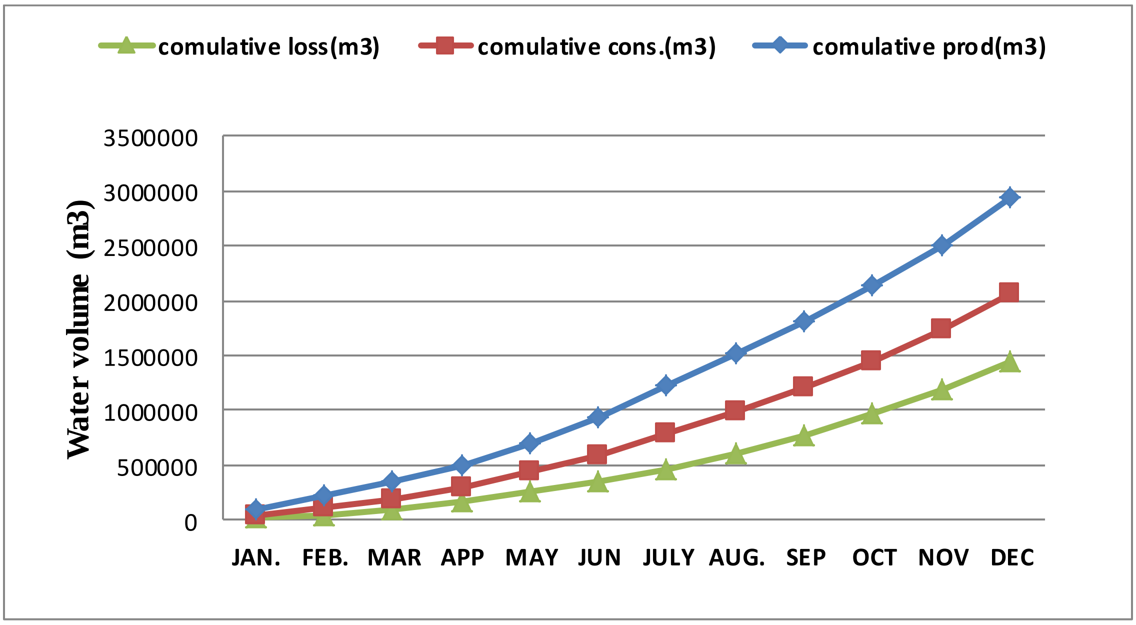

Figure 5.3: Cumulative production, consumption and losses of kebele 09

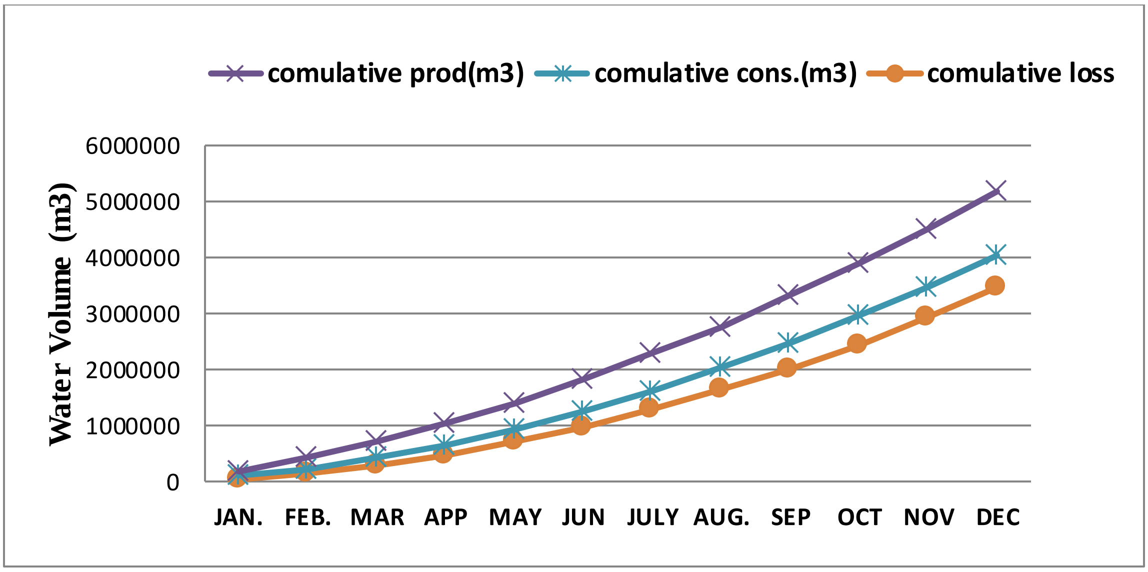

Figure 5.4: Cumulative production, consumption and losses of kebele 11

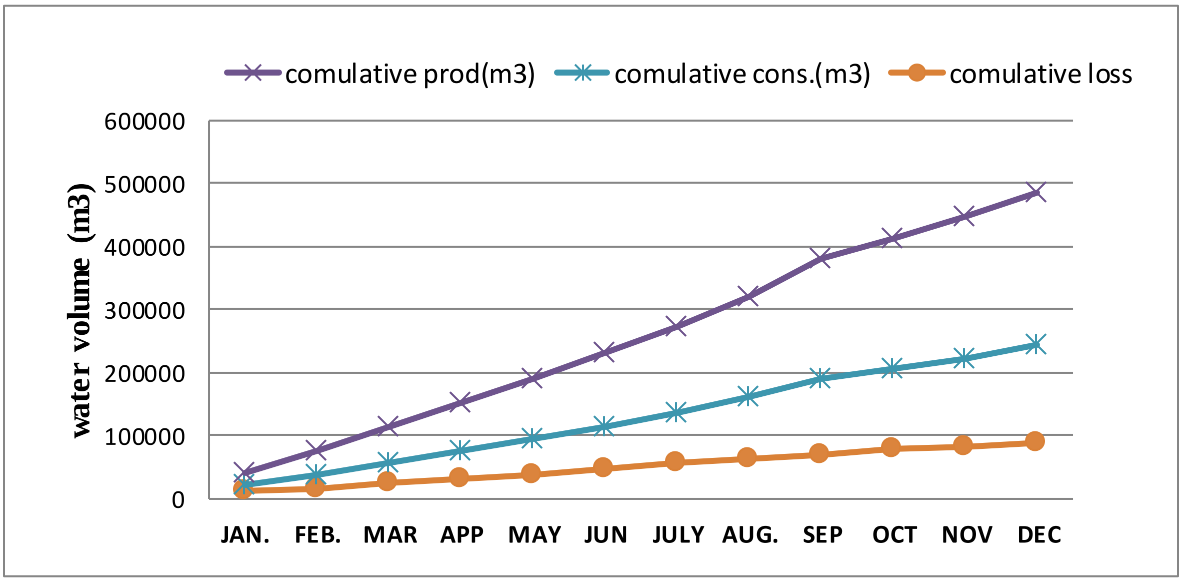

Figure 5.5: Cumulative production, consumption and losses of kebele 15

As it analyzed in these above four graphs for each individual kebeles or sub-system, volume of water in flowed, consumed and the average water losses as percentage of the produced water of these kebeles (03, 09, 11 & 15) have been summarized in table 5.2 below. In this, there is highest value of percentage of water loss in kebele 11, which also have large volume of in flow and consumption with related to the rest of kebeles.

Table 5.2: Percentage Water loss from subsystem

Sample kebeles	Total water produced(m3)	Total water Consumed (m3)	Total Water loss(m3)	%loss
03	9,36754	5,80457	3,56297	38
09	8,73209	6,26129	2,47080	28
11	1,126,289	5,89946	5,36343	**47**
15	2,41825	1,54124	8,7701	36

5.6. Water losses Comparison between subsystem and the town

A comparison was made among the whole system and subsystem (sampled kebeles) based on the approaches of percentage of total water loss and loss per number of connections. As evaluated and can be seen from the loss analysis at town level and sample kebeles in the above section, there are different percentage figures in both systems. The comparison of these losses at town level and at sub-system is as below.

5.6.1. Comparison among sub-systems

According to the analysis in the table 5.2 above, the average water loss expressed as the percentage of total volume supplied to the system was used to compare the losses in which kebele had large percent. As it can be seen from the loss table, higher percentage of losses 47%, and 38% were rerecorded in kebeles 11 and 03, respectively.

The other comparison was based on water losses as per number connection; in this case customer meter or number of connection of each kebele has been used. Similar to that of entire town system, the number of connections of each kebeles was identified and used to evaluate the water losses as per number of connections as shown in table 5.3 below.

Table 5.3: Water loss from sub-system as per number of connection

Sample kebeles	Volume of water losses(m3)	Number of connections	Losses as per numbers of connection(l/connection/day)
03	356297	4179	234
09	247080	4032	168
11	536343	3524	**417**
15	87701	1219	197

In case of water losses as per number of connection, in the same way to that of percentage losses, the amount of water loss as per number of connection in sample kebeles was large in the kebeles 11(417liter/connection/day) and in kebele 03(234 liter/connection/day).

Therefore, among those kebeles, kebele 11 has high magnitude of losses which expressed as per number of connections.

5.6.2. Comparison between sub-system and entire town

As the comparison was conducted among the sample kebeles above, comparing a water losses that was analyzed in both town level and sub-system is evaluated based on the approaches of percentage of unaccounted for water and water losses as per number of connections. As it clearly analyzed separately above, the percentage of losses and losses as per number of connection of both system are compared as shown in the table below.

Table 5.4: Summary of water loss comparison between sample kebeles and town level

Systems	Percentage of losses (%loss)	Losses as per number of connection(lit/conn/day)
03	38	234
09	28	168
11	**47**	**417**
15	36	197
Town level	34	174

As it can understand from the table 5.4 above, the water losses evaluated based on both the percentage of losses and losses as per number of connections approaches is greater in the sub-system (i.e. kebele 11). When the analysis based on percentage losses is considered, less percentage of losses observed at town level. The results indicate that there were other kebeles those have less percentage of losses than sampled kebeles or it affected by volume of water produced at town level. In addition, the second comparison was based on loss as per number of connections, so as it seen from table, the losses in the three sub-systems (kebeles 03, 11 & 15) is found to be greater than the town level; this situation gives an indication that there are other kebeles in the town those their magnitude of loss is less than these sampled kebeles and it depend on density of water connections.

On the other hand, according to the some literature (Farley and Trow 2003); it is recommended using a performance indicator of loss per service connection per day for real losses and densely connections. Therefore, water loss as per number of connection per day, in kebele 11 was high and used to conclude that there is large magnitude of water loss in kebele 11.

5.7. Major Factors Contributing to High Levels of Water Loss

The analysis of water loss for both town level and sampled kebeles was carried out so far as described in the above sections. Due to the limitation of data, it is difficult to identify and characterize directly all causes of the water losses from the system. Among the most obvious and visible possible causes or contributing factors of water losses, effect of high pressure (elevation difference), age of pipe network, maintenance situation of network are used to evaluate the distribution of water loss in the systems.

5.7.1. Ground Elevation difference from service reservoir

In analyzing water loss to evaluate the effect of potential pressure or ground elevation difference, identifying the ground elevation between survice reservoirs and consuming points of that pressure zone is important. Due to the topographic nature of Adama town, significant elevation differences between supplying water tank and customer tap were observed among different settlement areas in the town. The elevation differences have found a great impact on the magnitude of loss through leakage.

From those sampled kebeles, (03, 09 & 11), almost all the elevation of customer water meter with respective x and y coordinates as well as the elevation of survice reservoirs were collected and imported to Microsoft excel. As it shown from the table 5.5 below, the statistical analysis of mean, median and standard deviation of elevation for three sampled kebeles is identified and used to evaluate the average difference in ground elevation between supplying survice reservoirs and customers water meter.

Table 5.5: Ground elevation differences between sampled kebeles and reservoirs

Sample Kebeles	Customer tap Elevation(m)	Name of supplying reservoirs	Ground Elevation of Reservoirs(m)	Elevation difference(m)
03	Mean =1667.97 Median=1669.08 STDEV=20.22	Adama university reservoir (RAU)	1720	52
09	Mean =1617.58 Median=1617.98 STDEV=16.64	Galma Abba Geda reservoir (RGA)	1640	23
11	Mean =1601.98 Median=1599.35 STDEV=14.04	Lugo reservoir(RLU)	1685	83

As shown from table 5.5, the elevation difference among the sampled kebeles and their respective survice reservoirs is higher in kebele 11. The average elevation difference of kebele 11 is 83m, while that of kebele 03 and 09 are 52m and 23 m, respectively. On the other hand, as described in the above section 5.5, the large amount of total water losses found in kebele 11. Therefore, this gives an indication that pressure caused due to ground elevation difference has impact on the total water losses. Therefore, higher loss was found in lower settlement areas than settlements located in elevated areas.

5.7.1.1. Pressure and leakage relationships

Due to the topographic nature of Adama town, significant elevation differences were observed among different settlement areas that were getting water from the same service reservoir. The elevation differences have found a great impact on the magnitude of loss through leakage. In order to know the relationship between pressure and leakage in distribution system, they are necessary to conduct the field test data. In the short tests of pressure and leakage relationships on 20 small sectors Japanese distribution systems (Ogura, 1979), analyzed and presented in the form of a simple Power Law (Leakage L varies with Pressure P).

Leakage rate relationships, in its simplest form this is also a power law. Empirical quadratic and exponential relationship were also used (or rather, misused) in the UK and elsewhere from 1994 to 2003 to analyze test data and predict the effects of pressure management. However, it is now recommended by the Water Losses Task Force (Thornton 2003) and in the UK (UKWIR, 2003), that the most physically meaningful and 'Best Practice' form of equation for representing pressure and leakage rate relationships is a simple power law.

There is no international convention for characters used for the exponent and the water Losses task Force uses the alpha-numeric 'N1', resulting in the equations:

L varies with P^{N1} and, $\mathbf{L_1/L_0 = (P_1/P_0)^{N1}}$

So, if pressure is reduced from P_0 to P_1, flow rates through existing leaks change from L_0 to L_1, and the extent of the change depends on the exponent ^{N1}. When N1 is calculate from the non-dimensional Reynolds Number (Re), for Circular holes:

N1 near 0.5 for metal & PVC pipes for Reynolds Number Re > 4000

N1 likely to be near 0.5 for polyethylene and other, and Re >4000, but N1 can be in range 0.5 to 1.0 for small leaks and N1 for corrosion hole clusters may be even higher

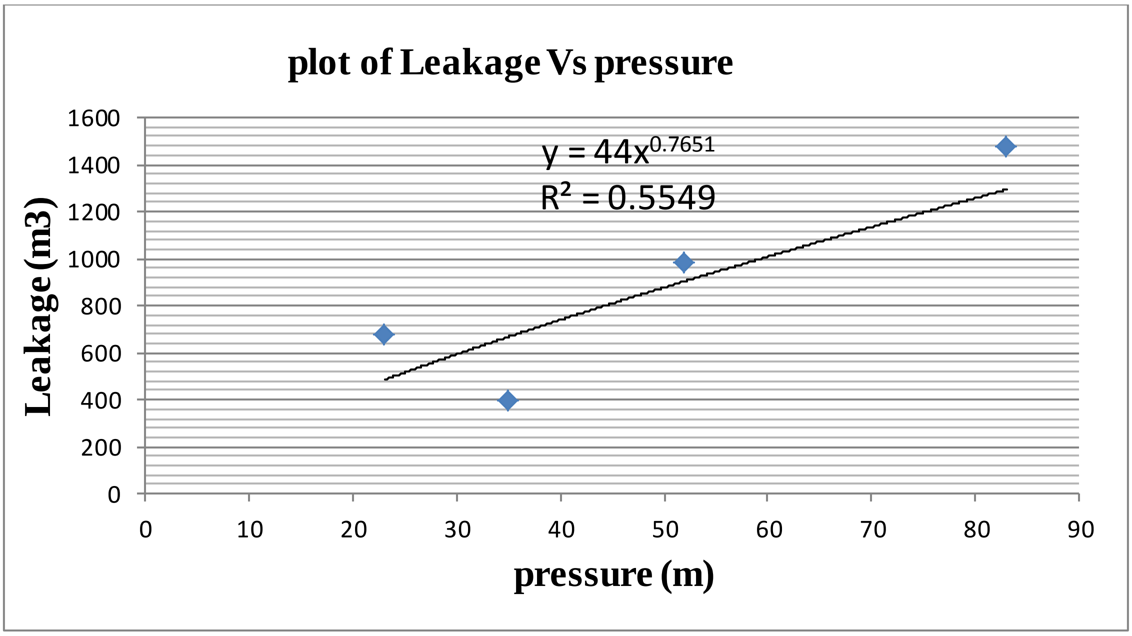

Figure 5.6: Pressure and leakage relation in distribution system

The above numerical equation generated from daily water loss of sampled kebeleswith the average pressure in the distribution system. Since pressure was varies within the system, the loss in the system also varied.The relationship of water loss (leakage) and pressure as you can see from the above graph, the graph is linear function.

X: - is from the graph represent the average pressure (m)

Y: - is represent the Leakage (Water loss) (m3)

From expression in the above graph function;Y=44 X $^{0.7651}$and the factor (correlation coefficient)R^2= 0.5549, that means L=44 (P) $^{0.670}$which is the pressure and the water loss (leakage) is directly proportional. When the pressure in the system is high the leakage or water loss is also high.

On the other hand, pressure distribution varies with the length of pipe from the service reservoir. Figure below is the plot the profile of pressure versus pipe length which shows that the pressureincreasing as node far away from the sources. So this may affect the leakage magnitudein the distribution system.

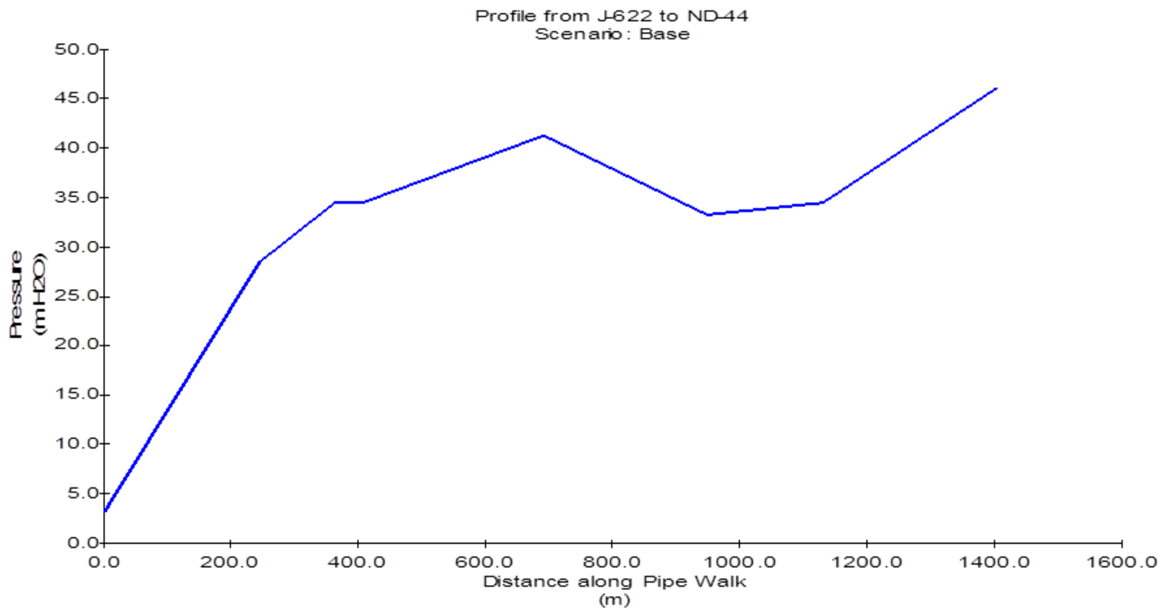

Figure 5.7: plot of pressure Vs distance of nodes from reservoirs

5.7.2. Age of Pipes Network

As the Adama town had long ages after gated modern water supply. It is estimated that nearly more than 25% of the pipe network was laid before 30 years ago. Aged pipes are more likely having more water loss through leakage than newly installed pipes. Therefore, Pipe age is one of the factors that affect the magnitude of losses in the distribution system especially that of physical losses. Because all pipe materials suffer from degradation over time due to operational measures, environmental conditions and general wear and tear and result in increased leakage in the network. As observed during key interview, with utility officials, there was only 18km pipe replacement during last few years ago. On the other hand, due to the limitations of data which clearly identify the distribution of age category of all pipes for individual kebeles, it was difficult to compare and evaluate the impact of aged pipe in sampled kebele rather than putting pipe age effect at town level. So, more pipes aged is considered in early settled kebeles than recent.

5.7.3. Poor Maintenance of Networks

As that of in some cities and towns of developing countries, including Ethiopia, a water authority has no performed a maintenance program for water distribution system. Maintenance of pipe network has also its own impact on physical (real) water losses. Even though, it is so difficult to find financial support to renew all the water distribution system, it needs regular schedule for maintenance of old network pipe which is very important part in reducing the leakage. In Adama town context, due to the lack of regular schedule and ability to rehabilitate the network system, poor maintenance practice resulted in increased leakage in the system which will be concern by Adama town water utility and other responsible bodies.

5.7.4. Illegal Connections

Illegal connections contribute significantly to apparent losses and revenue loss to the water authority (Farley and Trow, 2003). This connections is directly water theft from the system and also, the other consequence of these connections are often poorly laid just a few inches below the surface and will break easily resulting in real losses taking placed in the form of leakage from network. According to utility report, there are no a significant number of illegal users which clearly identified within distribution system in Adama town, however, the number of households who do not pay water rates but receive water from distribution is not focused and surveyed. Therefore, water utilities have concern on assessment to know and identify the effect of illegal connections in Adama town.

5.7.5. Customer Side Leakage

The customer side leakage is caused due to different reasons such as meter inaccuracy which highly affect water authority, in case of meter error, because the water is not used by the customer so the customer is not paid the rate, as well as there is a complain between the utility and customer. As per the feedback from the ATWSSE experts, until recently, the water enterprise is not checking the customer meters by itself unless the customers apply for checkup. However, customers apply most probably when the problem were over-registration rather than under registration.

Also when there is no regular tests of customer water meter and fittings or remain unrepaired for long periods there by contributing to significant loss. On the other hand, Since the Adama town water Utility only have central office, it is difficult to follow up and control efficiently the whole system of the town and to make test on customer water meter from time to time, also customers has no experience to quickly report for burst behind his meter, significant losses occur in the system. These types of leakage are mostly happened in the old settlement and under constructions area of the town.

5.8. Economical Dimension of Water Loss

As shown in figure 5.1 above, water loss rate was varied between 29 and 35% of production in the last ten years. The total annual water produced and distributed to the system within the year 2014 had been 6,751362 m3 and the annual total water loss was 2,300379m3 which accounted to 34% of the total water production. As observed from discussion with ATWSSE expert, it was found out that the cost of 5% of the billed volume of water annually was not paid back and hence the total percent water loss became 39%. This much of loss can serve for a year to 155,481 number of population taking 10% loss as a benchmark for UFW. In addition, taking the average tariff of 1m^3water in the Adama town as 2.0ETB and the utility loss income which estimated to 3,910,644ETB for 2014 year providing 10% loss as a benchmark for UFW.

On the other hand, ‘‘Acceptable water Loss by AWWA, a leak detection and accountability Committee (2000) recommended 10% as a benchmark for UFW levels and also action needed > 25% Matter ofconcern, reduction needed’’. Therefore, in Adama town water loss reduction is needed to minimize percentage of loss, in order to bring economic dimension of water loss at acceptable level of recommended.

5.9. Water Loss Management

Water loss management is the most important situation to satisfy the water demand of the community and this work represents a major step to define the best practice approach for assessing and presenting basic elements of water loss management program in towns, and it will focus on international water loss approach to promote and facilitate the application of IWA recommended methodology of leakage monitoring and loss management system (Malcolm Farley, 2011). As observed from interview with experts of the utility, the situation of water loss management in Adama town was not best practice, except they practice passive leakage control. Therefore, I suggest leakage monitoring/control strategies and pressure management in distribution system as below.

5.9.1. Leakage Monitoring and Control

Leakage monitoring and control is the serious case and first step in reducing water losses. Leakage management can be classified into passive and active leakage control.

Passive Leakage Control (PLC)-passive control is reacting to reported bursts or a drop in pressure, usually reported by customers or noted by the company's own staff while carrying out duties other than leak detection. Even though, it often practiced in less developed supply system or simple network, where the occurrence of underground leakage is less understood, it is difficult using this method in very aged and complex water network. In general, as described above, this method can describe the current practice of leakage control situation in Adama town.

Active Leakage control (ALC) - Active leakage control is when company staff is deployed or move to find leaks which have not been reported by customers (Malcolm Farley, 2011). The main focus of ALC methods are regular survey and leakage monitoring. Also, Leakage monitoring is flow monitoring into zones to measure leakage and to prioritize leak detection activities. This has now become one of the most cost effective activities for leakage management programs. However, the most appropriate leakage control policy will mainly be dictated by the characteristics of the network and local conditions, which may include financial constraints on equipment and other resources.

In some case, when leaks fail to appear at the surface, then, a more intensive policy of leakage monitoring is required (Malcolm Farley, 2011). A low activities method, such as repair of visible leaks only which now practicing by water utility in developing countries including Adama town may be cost-effective in supply areas where water is plentiful and cheap to produce. On the other hand, countries which have a high cost of production and supply, can justify a much higher level of activity, like continual flow monitoring, to warn of a burst or leakage occurring in town water network (Farley and Trow, 2003).

Therefore, as it was considered from the discussion and interview with official and expert of the Adama town water utility, the system of leakage monitoring and control which is currently practicable in Adama town water utility is passive leakage control method. So to manage water loss and increase the percentage of water supply coverage, the utility have to focus or upgrade leakage controlling system to active control.

5.9.2. Pressure Management through Distribution System

It was reported that many water utilities introduced pressure management to their water distribution systems. In most cases, large reductions in a new break frequency can be achieved over a wide range of pressures (Stuart Trow, 2003). Pressure management can be defined as the practice to manage system pressures to an optimum level of service ensuring sufficient and efficient supplying system to legal uses and consumers, while eliminating or reducing pressure transients or variations, all of which cause the distribution system to leak and break unnecessarily (Macolm Farley, 2003).

In case of Adama town, distribution main pipes and larger diameter pipes were laid under roads or alongside with 1 to 1.5 meter cover in depth. Smaller and secondary distribution pipes were sited at the edge of the roadway or alongside with 0.6 to 0.8 meter depth cover. These situations also indicated a potentially high background of leakage. Since the most supplying system in the town was continuous and intermittent, the network was subject to the variant types of pressure, which may cause to loss. Some of the pressure management benefits include(Stuart Trow, 2003):

♦ Reduction in annual repair costs

♦ Reduction of the repair backlog, shorter run times for bursts

♦ Fewer emergency repairs, more planned work

♦ Reduced inconvenience to customers

The practicing of pressure management can reduce break frequencies and extend the working life of parts of the distribution infrastructure by even a few years; the economic benefits would generally be even greater than the short term reduction in repair costs.

There are many different tools that can be used when implementing pressure management, including pump controls and sustaining valves (Lambert et al., 2006). Pressure management program was related to the establishment of zoning and district meter areas (DMA). On the other hand, while establishing zoning and district meter areas, the scope for pressure management should be evaluated in all cases and consider the following points.

- Identifying areas experiencing high and low pressures.
- Designing zones in these areas so that pressures not exceed the standards water supply design criteria.

- Introducing pressures reducing schemes such as sustaining valves in areas of high pressure to improve system management and breaking water tanks in areas of low pressure to reduce leakage

Generally, to conclude that there are different components of water loss in Adama town which caused from different reason like pipe age, customers' side leakage, lack of good maintenance etc. in other way, the ATWSSE is practicing to monitor and control leakage only passive controlling system. However, in order to minimize the water leaks from the system, active leakage control method is very important to ensure sustainability of adequate water supply system by saving large volume of water from damage and to reduce the cost of repair. Also pressure management by zoning and introducing number of DMAs strategies have to be given high consideration.

6. WATER DEMAND AND SYSTEMMODELLING

6.1. Estimation of Water Demand

Water demand estimation is one of the basic inputs to select sources of water supply and to find the amount of water required to fill the gap between the supply and water demand of the town. When we think about the consumption and demand, these questions must be answered; how much water is being used? Where are the points of consumption located? How does the usage changes as a function of time? These questions are addressed for each of the three basic demand types those described as:

Customer demand- this is the water required to meet the non-emergency or at normal time needs of users in the system. This type of demand is typically represents the metered portion of the total water consumption.

Unaccounted for water (UFW) – this is a portion of the total water that is lost due to the different factors which include system leakage, theft, unmetered service, etc.

Firefighting demand-these types of water demand is the portion which used for ensuring adequate protection of town and provided during fire emergencies.

To estimate the above categories of demand, some important data such as production and billing records are directly collected from water utility (ATWSSE). The collected information required to establish the present, past and future consumption rate (as it described in the consumption analysis section) and to study future usage trend. The total water supply of the customer demand categories of the town is distributing among the domestic and non-domestic demand. Before water demand projection, let me forecast population number in the future as below.

6.1.1. Population Forecast

Number of population of the town is increasing from time to time. According to the CSA 2007, the population growth rate of towns was estimated for different subdivision of years. Among these, there are years from 2015 up to 2035 and the growth rate 3.69% to 3.20% respectively which is gradually decreasing (MoWR, 2006). Therefore, the geometric increase method was used in forecasting population numbers for twenty years of design period by using base or initial population number of 2014 and a detail projection presented as shown in below table.

Table 6.1: Number of population projected

Years	2015	2020	2025	2030	2035
Populations	400,666	457,349	519,698	590,310	668,642

6.1.2. Domestic Water Demand Projection

Domestic water demand is the amount of water needed for drinking, food preparation, washing, cleaning, bathing and other miscellaneous domestic purposes. The amount of water used for domestic purposes greatly depends on the lifestyle, living standard, climate condition, mode of service and affordability of the users.

In projecting the domestic water demand the following procedures were followed:

1. Determining population percentage distribution by mode of service and corresponding consumer category and its future projection

2. Establishment of per capita water demand by purpose for each mode of services.

6.1.3. Population Distribution by Mode of Service

The percentage of population to be served by each mode of service will vary with time. The variation is caused by changes in living standards, improvement of the service level and capacity of the water supply service to expand(AAWSA, 2011). Therefore, in Adama town, the present and projected percentage of population served by each service category is estimated by taking the above stated conditions and by assuming that the percentage for the house connection and yard tap users will increase gradually during the future service period while the percentage of public tap users will dramatically reduce as more and more people will have private connections as the living standard of people increases. Table 6.2 shows the population distribution by different mode of service for projected design period of 2035.

Table 6.2: Population distribution by different mode of service

Description		Years				
		2015	2020	2025	2030	2035
Population Numbers	item	400,666	457,349	519,698	590,310	668,642
Coverage by service mode	HC	5%	10.1%	15.2%	20.1%	25%
	YC	60%	64.1%	68.2%	67.4%	66.5%
	PT	35%	26%	16.6%	13%	8.5%
Population served by each mode	HC	20,033	46,192	78,994	118,652	167,161
	YC	240,399	293,161	354,434	397,574	444,647
	PT	140,233	117,996	86,270	74,084	56,835

6.1.4. Per Capita Water Demand Projection

The per-capital domestic water demand for various demand categories varies depending on the size of the towns or cities and the level of development of the country. Per capita water demand for adequate supply level has to be determined based on the basic human water requirements for various activities of demand category (AAWSA, 2011).

It is difficult to estimate how exactly the per capita water demand will grow in between the planning horizons. Nevertheless, except for public fountain, the per capita demand of each mode of service has been assumed to grow gradually. Based on the base year 2014, the per capital demand between the years 2015 to 2035, the assumption has been made that there will be a linear growth in per capita demands. In table 6.3, per capital for domestic water demand of different mode of services was estimated for design period.

Table 6.3: Per capital water demand projection for different mode of services

Customer category (Mode of services)	Unit	**Per capital water demand (l/c/day)**					Annual increments
		2015	2020	2025	2030	2035	
HC	l/c/d	60	68	75	83	90	1.5
YCS	l/c/d	40	45	50	55	60	1
PT	l/c/d	20	23	25	27	30	0.5

As it summarized in table 6.3, the procedure that domestic water demand projected depending on per capital consumption fixed for different mode of service in the town. There is different customers' category which used different volume of water. As it showed from table 6.3 above, there will the increment per capital demand for all modes that the annual increment of 1.5, 1 and 0.5 for HC, YC and PT respectively. In similar way, the coverage of these modes will be increasing during the design period (2015-2035) whereas only the percentage of PT will decrease from 35% to 8.5%. on the other hand, since there will be the improvement of life standard of the community every time, water usage or per capital demand of all service modes linearly increasing from year to year. The detailed projection of domestic and non-domestic water demand which used for model building has been summarized in the table 6.4 below.

6.1.5. Non-Domestic Water Demand

The non-domestic demand includes demand for public, commercial, institutional and Industrial. Institutional and commercial demand refers to water required for different organization such as schools, hospitals, hotels, etc. where public demand refers water required for street flushing and public fountain and so on. This demand, for such town like Adama, normally accounts in the range of 20 to 40% of the average day water demand (MoWR, 2006). On the other hand, the existing trend in the number of non-domestic connections of Adama town has showed an overall increment indicating a higher demand. Unlike the towns in developing countries, considering the ongoing development activity in the town, the demand for non-domestic connection is assumed to increase by 40% within the planning horizon. The year 2014 number of non- domestic connection is also assumed to be around 2055. As it presented in table 6.4, currently more than 5152 cubic meter daily required for non-domestic purpose.

Table 6.4: Summary of domestic and non-domestic water demand projection

Description	unit	years				
		2015	2020	2025	2030	2035
Total population Served	No	**344,359**	**410,613**	**486,544**	**571,193**	**668,623**
HC	No	17,218	41472	73955	114810	167156
YC	No	206,615	263203	331823	384698	444634
PF	No	120,526	105938	80766	71685	56833
Domestic per capital demand						
HC	l/c/d	60	68	75	83	90
YC	l/c/d	40	45	50	55	60
PF	l/c/d	20	23	25	27	30
Domestic water demand						
HC	m3/d	1033	2799	5547	9471.825	15044
YC	m3/d	8265	11844	16591	21158	26678
PF	m3/d	2411	2384	2019	1971	1705
Adjustment factor	No	1.1	1.1	1.1	1.1	1.1
Average daily domestic demand	m3/d	12880	18730	26573	35861	47770
Public, Institutional& Commercial (30%)	m^3/d	3864	5619	7972	10758	14331
Industrial Demand (10%)	m^3/d	1,288	1,873	2,657	3,586	4,777
Total Water Demand (domestic + non-domestic)	m^3/d	18,032	26,222	37,202	50,205	66,878
	m3/yr	6581680	9571030	13578839	18324862	24410470
Un-accounted For Water (water loss)	%	34%	26%	23%	22%	20%
	m^3/yr	2,237,771	2,488,468	3,123,133	4,031,470	4,882094
Required production	m^3/yr	8,819,451	12,059,498	16,701,973	22,356331	29,292564
Average Day Demand	m^3/d	24,163	33,040	45,759	61,250	80,254
	l/s	280	382	530	709	929
daily peak factor	No	1.2	1.2	1.2	1.2	1.2
Hourly peak factor	No	1.6	1.6	1.6	1.6	1.6
Maximum daily demand(MDD)	l/s	336	459	636	851	1115
	m3/d	28,995	39648	54910	73500	96304
Maximum hourly demand(PHD)	l/s	537	734	1,017	1,361	1,783
	m3/d	46,393	63436	87857	117600	154087
Fire Demand (10%)	m3/d	2416	3304	4576	6125	8025
Total daily demand	m3/d	31412	42952	59486	79625	104330
	l/s	364	497	689	922	1,208
Existing Water Supply available in average from Awash	l/s	233				
	m3/d	20131				
Additional daily Water Required	l/s	131				
	m3/d	11281				

6.2. Water Distribution System Modeling

The main purpose of modeling is to assessing the carrying capacity of the existing system, to evaluate the levels of pressures distribution within the system and to develop a simplified model with optimum working pressure. Due the limitation of data, resource and time, this study does not consider water quality. The existing data of water network, procedure of evaluating and model building ware as follow.

6.2.1. Existing system

6.2.1.1. Transfer Main and Distribution Network

A transfer main is defined as a conduit for the conveyance of treated water from reservoir to reservoir or water tank at different location. This main line transmits water from Awash River (water treatment plant) to Lugo reservoir, then to the rest of water tanks. The size of transfer line was DN 300 to DN600 mm. Also the distribution main is a conduit which used to convey water from service reservoir to different point of consumption. In the town water network system, the distribution main ranged from DN 80 to DN 200 mm. as shown in figure below.

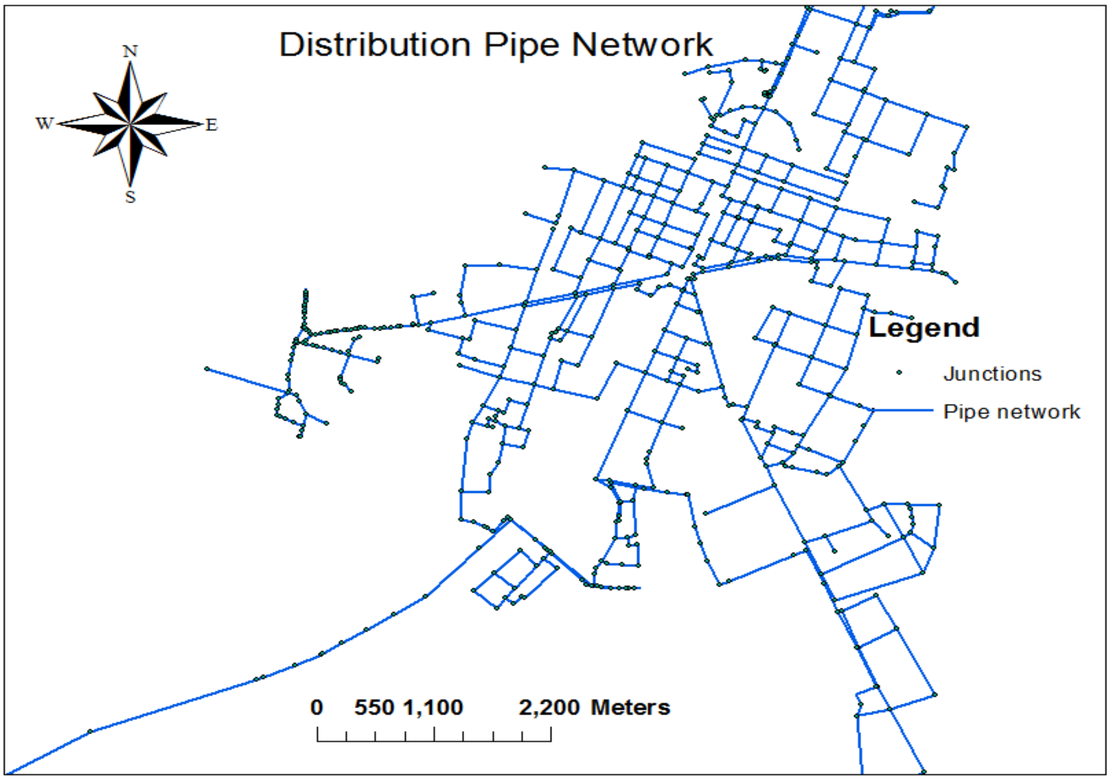

Figure 6.1: Pipe network of the town

6.2.1.2. Service reservoirs or tank

To overcome the variation demand in a town which varies from hour to hour, day to day and even season to season, frequently Service reservoirs are provided in order to achieve balance of supply and demand. Practically, water at low demand is collected in reservoirs and at time of maximum need water is continuously withdrawn. In town distribution system, more than eight service reservoirs are currently operational. Table 6.5 below provides information about the tanks such as reservoir names, location and base elevation.

Table 6.5: Servicereservoir or Tank locations and elevation

Tank names	Location		Base elevation (m)
	X	Y	
Lugo Reservoir	529025	940546	1685
Adama university	531885	946978	1721
Dhaka Adi	532321	947945	1746
Bokku 1	531083	937716	1716
Bokku 2	531048	939372	1632
Kebele 02	530205	945920	1658
Abba Gada	526898	943404	1640
GalmaAbba Gada	525885	943783	1757

6.2.1.3. Pumps

When gravity is insufficient to supply water at an adequate pressure, then pumps needed. A pump is a device to which mechanical energy is applied and imparts energy to water thereby raising its hydraulic head for conveying water to points of desire. Since, energy needs to be added to a hydraulic system to overcome elevation differences, friction losses, and minor losses. Frequently, pumping is required to raise water to service reservoirs likely located on higher elevations. In Adama town water supply system network, Pumps location, head and discharge presented in table 6.6 below.

Table 6.6: Network system pumping stations description

Pumping Station	Pump Number	Location			Design Q (l/s)	Pump Head(M)	Pumping to stations	Current Status
		X	Y	Z				
Awash treatment Plant	1	519787	937307	1559	41	146	Lugo Tank	On
	2	519789	937308	1559	41	146	>>	On
	3	519791	937309	1559	41	146	>>	On
	4	519792	937310	1559	41	146	>>	On
	5	519794	937311	1559	41	146	>>	On
	6	519796	937311	1559	41	146	>>	On
	7	519798	937312	1559	41	146	>>	On
	8	519800	937313	1559	41	146	>>	On
Abba Gada	1	526896	943401	1640	6	121	G/Abbagada	On
	2	526894	943404	1640	0	0	>>	Off
Bokku	1	531049	939369	1632	18	96	Bokku 2	On
Kebele Zero hulet	1	530194	945920	1657	25	91	DHAdi &AU	On
	2	530194	945919	1657	0	0	>>	Off
	3	530200	945919	1657	25	65	>>	On
	4	530200	945918	1657	25	65	>>	On
	4	530200	945917	1657	0	0	>>	Off

6.2.1.4. Control Valves

In water distribution system regulation and control of either discharge or pressure is frequently achieved through use of valves. There are different types of valves, such as pressure reducing valves, non-return valves and flow control valves. However the most common type of valve in water distribution systems is the isolation valve, which can be manually closed to block the flow of water and used to optimize the operation of a network with respect to pressure and flow. In Adama town, the existing valves have several status conditions, that is valves used for the intermittent supply and for throttling. Some valves data are presented in the following tables.

Table 6.7: Flow control valve in the network system

NAME	Location			DN(mm)	Discharge l/s	Status
	X	Y	Z			
FCV-BAG	526900	943403	1640	100	7	Throttling
FCV-BOK	531051	939373	1632	150	20.1	Throttling
FCV-GAG	525884	943780	1755	150	0	Inactive
FCV-K02	530205	945918	1657	300	75	Throttling

6.2.2. Model Analysis

Water CAD gives the choice between performing a steady-state analysis of the system and performing an extended-period simulation over any time period.Analysis of the model of existing system has been made by running the model at current year daily average, at peaking and temporal variations of demand with steady state and extended period simulation (Haestad Method Inc. 2003)

6.2.2.1. Steady State Simulation

Steady-state analyses determine the operating behavior of the system at a specific point or node in time or under steady-state conditions (flow rates and hydraulic grades remain constant over time). The water CAD software simulates Steady-State hydraulic calculation based on mass and energy conservation equations principle. The results that are obtained from this type of analysis are instantaneous values and may be representative of the values of the system at constant condition. Steady state simulation results of nodes and links ofmodel was illustrated in appendix B

6.2.2.2. Extended Period Simulation (EPS)

When the variation of the demand pattern in the system attributes over time is important, EPS is appropriate. The system conditions have been computed over twenty-four hours with a specified time increment and starting model run time at 12:00 PM. This type of analysis allows you to model tanks filling and draining, regulating valves opening and closing, pressures and flow rates changing throughout the system. The software simulates non-steady-State hydraulic calculation based on mass and energy conservation principle. Also an extended period simulation indicates whether the system has the ability to provide acceptable levels of service over a period of minutes, or hours. In EPS analysis, the peak and minimum hours, demand has been simulated to identify the current problems of the system and then to redesign the model based on the design criteria of the water distribution system, parameters like pressure and velocity for both minimum and peak hour consumption was evaluated. Minimum hour model run has been made at 1:00AM and Peak hour model has been made at 7:00AM from the starting. The result of simulation at minimum and maximum consumption hours illustrated in appendix D and E respectively.

6.2.3. Calibrating Hydraulic Network Model

It was difficult to take field measurement at each connection in the water supply network. However, nineteen sample points those represent pressure zones which spread throughout the study area have been selected for model calibration. During calibration, the head loss between the supply main nodes and the sample point where pressure is measured had been considered. The total head loss which includes elevation head and pipe friction loss between the two corresponding locations were illustrated and shown in table 6.8 below.

Acceptable levels of Calibrating

Pressure Criteria (Thomas M. et.al, 2003)

- 85% of field test measurements should be within ± 0.5 m or ± 5% of the maximum head loss across the system, whichever is greater.
- 95% of field test measurements should be within ± 0.75 m or ± 7.5% of the maximum head loss across the system, whichever is greater.
- 100% of field test measurements should be within ± 2 m or ± 15% of the maximum head loss across the system, whichever is greater

Table 6.8: Locations of samples of a supply main nodes and the corresponding field test

Sample Nodes					Corresponding Field test Measurement location			Head loss b/n Sample Nodes and Field test Location		
No	Junction	X(m)	Y(m)	Z(m)	X(m)	Y(m)	Z(m)	Elevation Head (m)	Friction loss(m)	TotalHead Loss(m)
1	NG-16	526,286	943,073	1,694	526,294	943,094	1,696	2	1.09	3.09
2	NG-49	525,822	942,571	1,717	525,834	942,579	1,716	1	0.91	1.91
3	NG-02	525,801	942,624	1,716	525,817	942,629	1,719	3	0.14	3.14
4	NG-31	525,623	942,413	1,706	525,641	942,428	1,708	2	0.11	2.11
5	N10A	529,581	942,668	1,617	529,656	942,685	1,622	5	0.67	5.67
6	ND-31	532,283	947,681	1,720	532,239	947,694	1,722	4	0.85	4.85
7	ND-43	531,844	947,072	1,711	531,830	947,025	1,713	2	0.47	2.47
8	N36A	528,208	942,698	1,613	528,227	942,683	1,614	1	0.88	1.88
9	ND-40	532,035	948,454	1,707	532,024	948,383	1,711	4	0.63	4.63
10	ND-45	532,826	947,227	1,716	532,804	947,243	1,717	1	0.49	1.49
11	N111A	530,975	945,569	1,651	530,972	945,560	1,654	3	0.64	3.64
12	N71	531,322	945,834	1,657	531,318	945,862	1,661	4	0.52	4.52
13	N70	531,150	945,405	1,652	531,161	945,419	1,649	3	0.15	3.15
14	N14B3	529,468	942,911	1,620	529,459	942,936	1,623	3	0.38	3.38
15	N48	528,266	944,578	1,626	528,275	944,584	1,624	2	0.34	2.34
16	BO-04	531,057	939,881	1,625	531,030	939,864	1,633	1	0.74	1.74
17	BO-01	531,239	939,461	1,632	531,268	939,488	1,637	5	0.65	5.65
18	BO-03	531,128	938,270	1,691	531,131	938,283	1,713	1	0.24	1.24
19	BO-13	531,682	939,531	1,679	531,619	939,574	1,648	3	0.67	3.67

The comparisons of model simulated and field test are described below in table 6.9 and figure 6.2. Calibrations have been carried on the base scenarios within the acceptable level of pressure mentioned above. As a result, 100% of the field test measurements were within ±2m, showing an acceptable level of pressure calibration criteria as stated by (Walski, et al 2003). Hence, the model is valid.

Table 6.9: Comparison of simulated pressure results with field-measured data

S/N	Sample Nodes	Simulated model pressure	Field measured pressure at Customers tap (mH2O)	Total Head Loss between the two locations (m)	The likely Simulated pressure at supply main node(m)	Error (m)	Time from start (hr)	Scenario
1	NG-16	54.39	50	3.09	51.3	-1.3	10:00	Base Scenario
2	NG-49	33.07	31	1.91	31.16	-0.16	10:00	
3	NG-02	34.27	30	3.14	31.13	-1.13	10:00	
4	NG-31	43.78	41	2.11	41.67	-0.67	10:00	
5	N10A	61.16	57	5.67	55.49	1.51	11:00	
6	ND-31	26.36	23	4.85	21.51	1.49	11:00	
7	ND-43	35.38	33	2.47	32.91	0.09	11:00	
8	N36A	66.09	65	1.88	64.21	0.79	11:00	
9	ND-40	40.46	37	4.63	35.83	1.17	12:00	
10	ND-45	28.68	26	1.49	27.19	-1.19	12:00	
11	N111A	63.76	61	3.64	60.12	0.88	12:00	
12	N71	57.62	55	4.52	53.10	1.90	12:00	
13	N70	62.55	61	3.15	59.40	1.60	12:00	
14	N14B3	58.13	56	3.38	54.75	1.25	14:00	
15	N48	28.5	27	2.34	26.16	0.84	14:00	
16	BO-04	56.75	54	1.74	55.01	-1.01	14:00	
17	BO-01	49.76	46	5.65	44.11	1.89	14:00	
18	BO-03	25.64	23	1.24	24.40	-1.40	14:00	
19	BO-13	37.36	34	3.67	33.69	0.31	14:00	

Also to test the fitness value, illustrating pressure plots of observed versus simulated a value which shows the regression relation and model accounts for 96% of the variance and this shows that there is a strong correlation between observed and simulated values.

The following figure shows the relationship between simulated and field measured pressure during calibration.

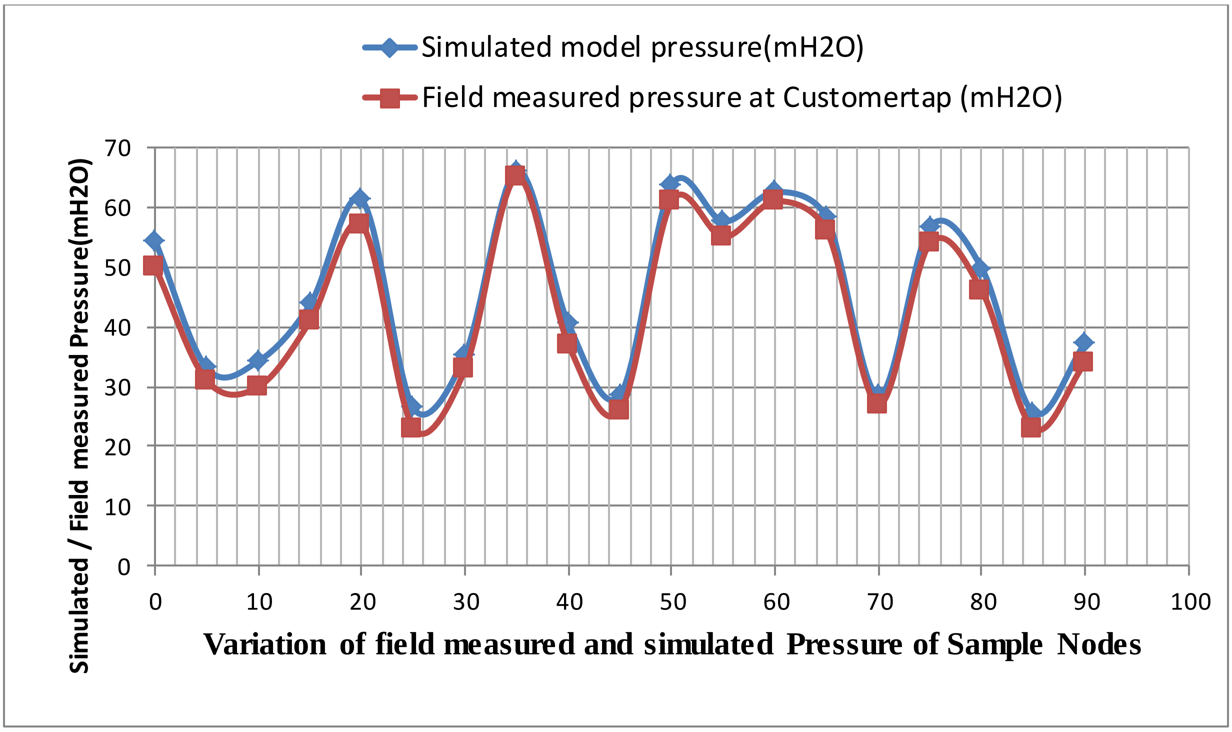

Figure 6.2: Comparison between simulated pressures with field-measured data results

6.2.4. Identified Problems in the Distribution Network System

There are different problems those visible in town water supply network. These are:

Firstly, age of pipe; as described in the above section there are old enough aged pipes in the system which are greater than expected lifetime, especially, ductile cast iron and Steel pipes serving for more than 40 year. According to the (MoWR, 2006) water supply design criteria the expected life time for Ductile cast iron and Steel pipe is 40 and 30 years respectively. Accordingly, most of the total distribution mains are old enough and it needs rehabilitation especiallyin kebeles of old settlement areas.

Secondly, pipe size, when a pipe size is too small or undersize, it may become a problem during high flow conditions such as fire flow. Undersized pipes can usually be found by looking for pipes with high velocities.

Thirdly, Pressure distribution problem; in the system of water supply network, the other problems considered were high and low pressures occurred during different consumption hours. Consistent low pressure problem is due to trying to serve customers at too high an elevation for that pressure zone, whereas high pressures are usually caused by serving customers at too low elevation for the pressure zone.

In evaluating the effect of pressure in the distribution system, there are number of supplying service reservoirs or pressure zones which located at different point of the town. The output result of WaterCAD software used to assess the pressure distribution throughout the network using pressure contours as illustrated in below figures. In these different contour colors used to describe pressure distribution in the network at minimum and maximum consumption hours.

Usually, high pressures are easily observed with simulation runs at low demands while low pressure occurred at high demand time. In case of Adama town water distribution network, at minimum day demand (at 1:00 AM) and maximum day demand (at 7:00 AM), there is a range of pressure distribution which is analyzed by Water CAD and shows above and lower acceptable level of pressure to areas with of different pressure zones. In evaluating pressure distribution, the output result of simulation displayed in the form of contour map as shown from figure 6.3 and 6.4 below for both maximum and minimum consumption respectively.

On the other hand, as it can observed from the below figure, during low consumption the pressures are too high, at different points in the distribution network. So in this case, the usual solution is to establish a new pressure zone for the lower elevation. During that, in these areas the pressures should regulate or not exceed the standards of a minimum of 10m and a maximum of 70m. Also, introducing PRVs and schemes in areas of high pressure used to improve system management and has advantage in reducing water loss, especially pipe leakage.

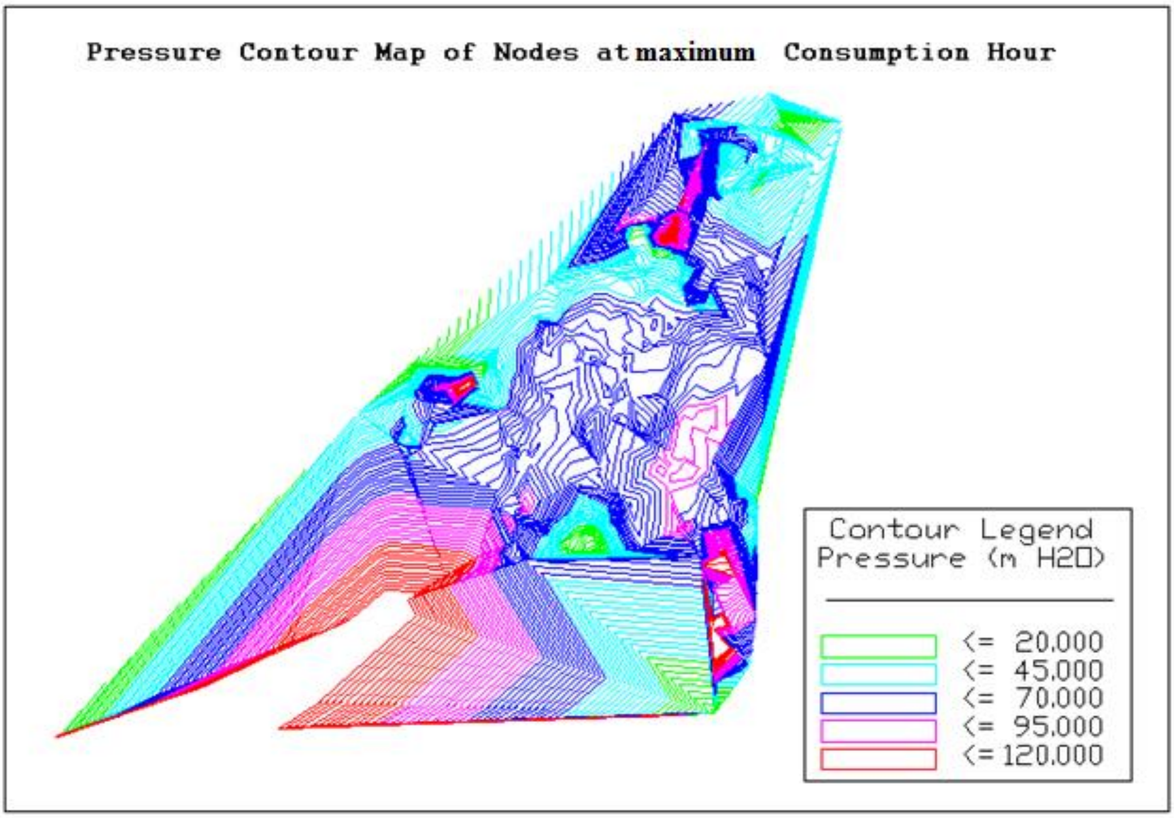

Figure 6.3: Contour map of pressure distribution at maximum consumption hour

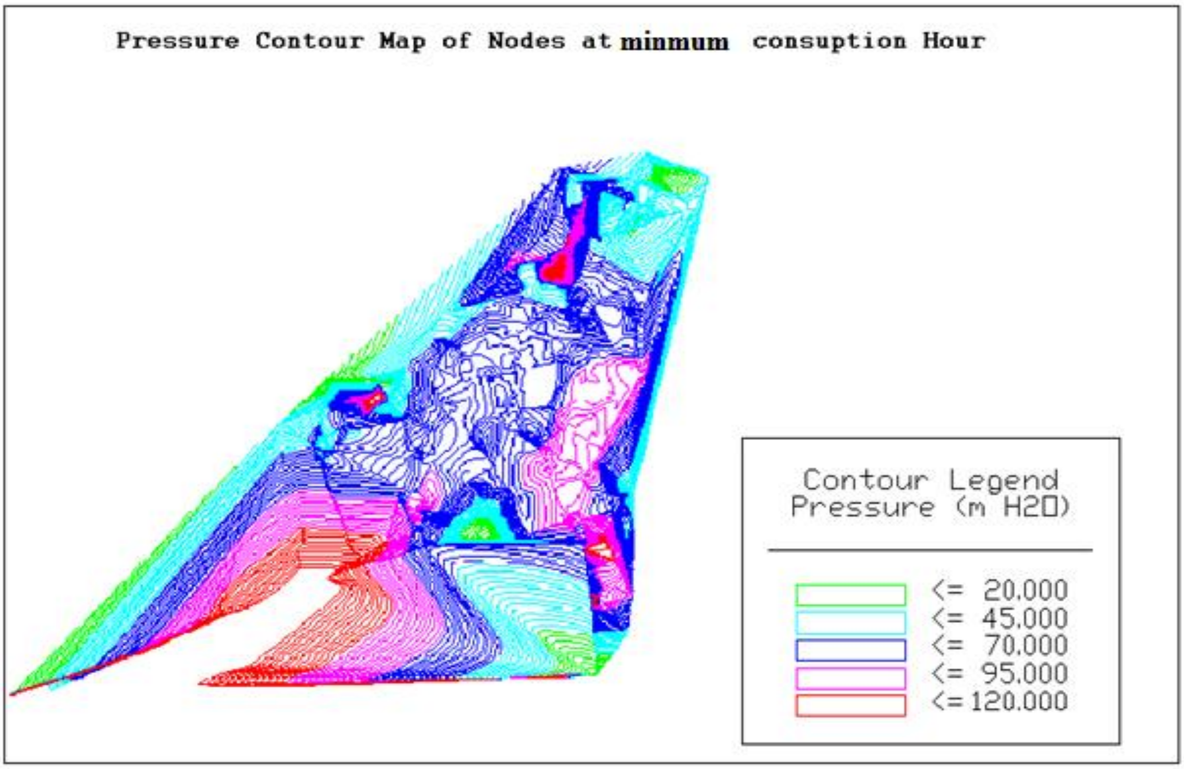

Figure 6.4: Contour map of pressure distribution at minimum consumption hour

6.2.5. System Model Improvements

In designing or improving a system there are sets of design criteria to be considered are pressure and velocity. The design criteria used in the modelling of water supply distribution system components, nodal pressure during the period of peak demand, and optimum velocities of the transfer and distribution mains are as follows (MoWR, 2006):

- Maximum velocities of major transfer mains $\leq$ 2.5 m/s.
- Maximum velocities of distribution mains $\leq$ 2 m/s.
- Minimum static head within a pressure zone was limited to 10m whereas maximum pressure limited to 60-70m.

A water distribution system is designed at peak hour demand. By examine what is going on the system as result of peak hour, solutions have been given to the problems faced (pressures and velocities out of the design limit) within the network.

The model modified by followingthese procedures:

- At minimum hour demand, 1:00 AM pressures at junction of low elevation were high, reduction to the desired pressure has been made by using pressure reducing valves
- At peak hour demand, 7:00 AM the velocities out of the design range are modified by resizing pipe diameters.

According to the above procedures, the distribution mains are modified to maintain acceptable pressure and velocities in network. The result of steady state model simulation for pressures at nodes presented in(appendix B) and velocities at links (appendix C).

6.2.6. Model Results

Both steady state and extended period simulation were performed. It was required to run single period simulation at the beginning of the simulation as to observe the model behavior. In addition to that, only extended period simulation was carried with different demand pattern throughout the 24 hours which used for assessment of entire model.

i) **Pressure:-**Pressure in water distribution system has to be maintained the design criteria minimum and maximum (10m to 70m) which stated by MoWR, 2006; to efficiently make water available to each demand category and as to reduce leakage as well as pipe breakage across the system. With regard to current model simulation, results of pressure at peak flow is summarized in table 6.10, and detailed in appendix E.

Table 6.10: Distribution of pressure at maximum consumption

Pressure(mH_2O)	Nodes number	Percentage (%)
≤10	22	3.54
10-15	17	2.73
16-30	48	7.72
31-45	154	24.79
46-60	269	43.31
61-75	76	12.23
76- 80	19	3.05
≥80	14	2.25

As shown in table above, during the maximum consumption more than 93.85% are in permissible pressure range (10m to 80m) whereas 2.25% and 3.54% of nodes exceed maximum and minimum allowable pressure respectively.

On the other hand, there are high pressure throughout the system mainly due to the topography of the area and the elevation of the distribution service reservoir. Hence, in town areas supplied by booster pump considered with high pressure whereas majority of nodes located in central parts of networks are relatively maintain average allowable pressure range that prescribed by MoWR 2006, water supply design criteria.The figure 6.5, below shows contours of pressure distribution of simulated model.

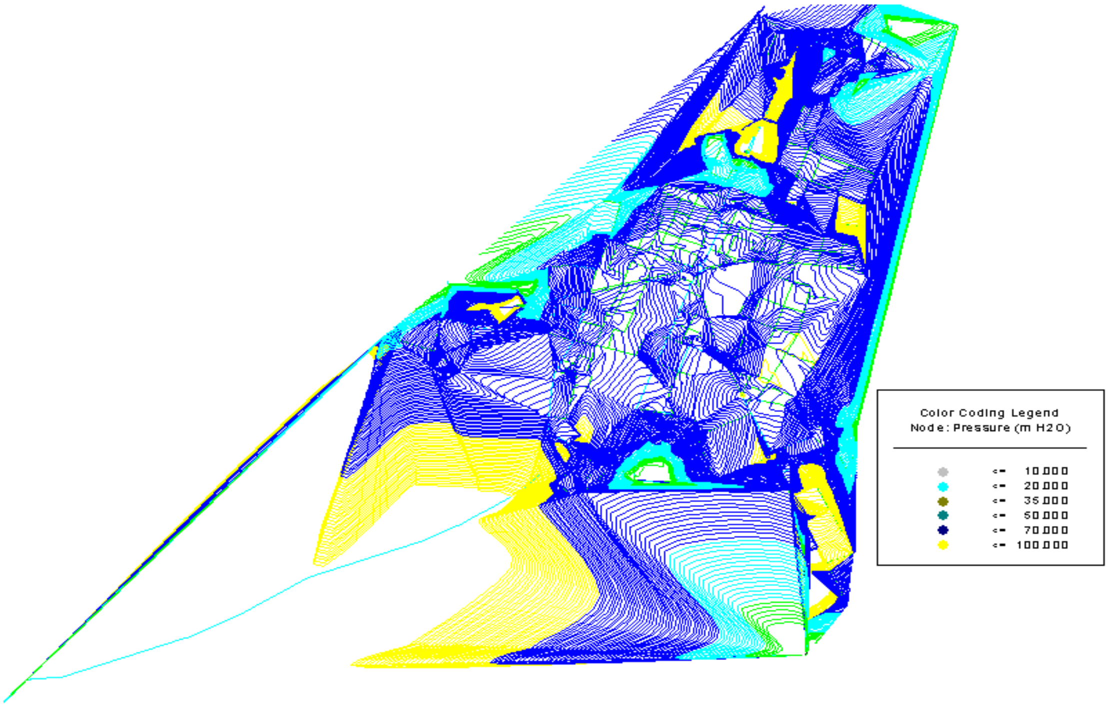

Figure 6.5: Contour of node pressure distribution at max. Consumption result

Also pressure distribution at steady state simulation at different nodes shown in figure 6.6 below.

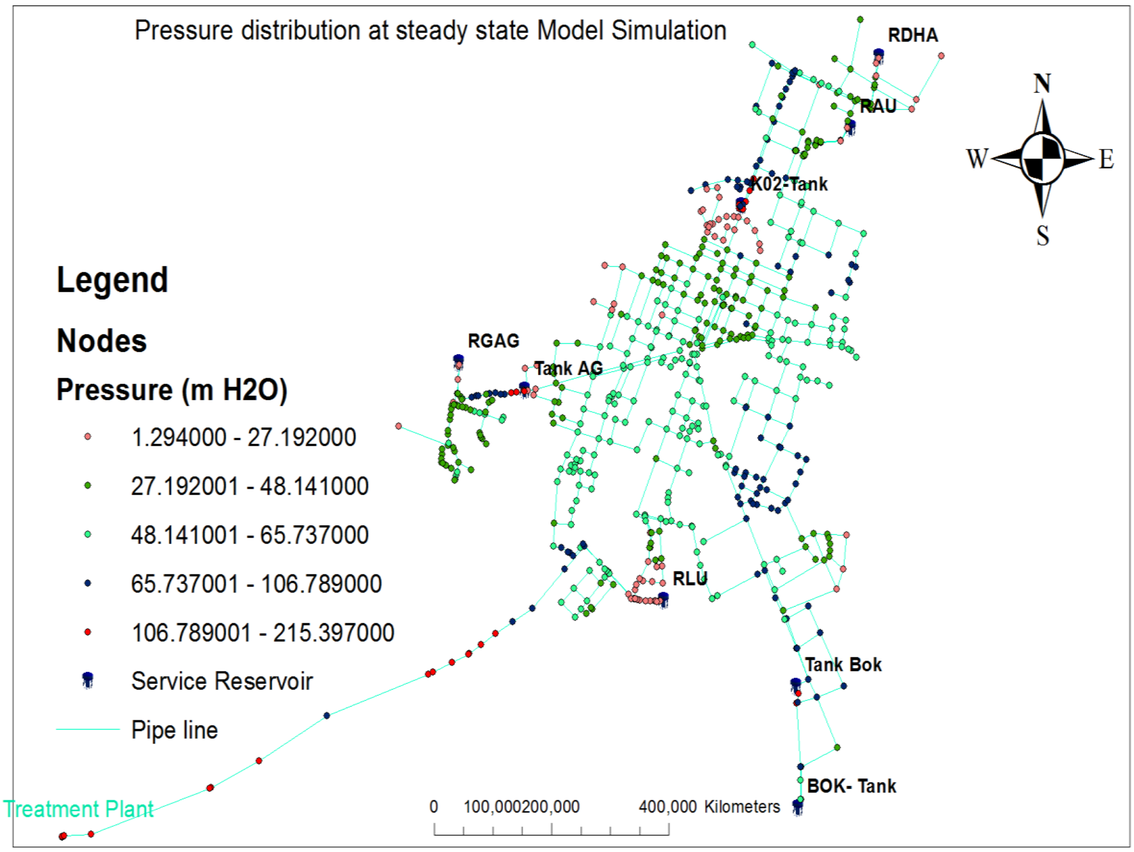

Figure 6.6: Nodes pressure distribution of simulated model at steady state.

ii) Velocity:-Increasing the diameter of the pipes in the model should result in a corresponding decrease in velocity and increase in pressure. According to the (MoWR, 2006), the optimal velocity in pumped pipe lines can range from 1 to 3 m/s, depending on the relative size of the peak and average flow rates. The absolute minimum velocity of flow in a pipeline is in the range 0.1m/s to 0.3m/s, in order to avoid stagnation and water quality problems in the water system (Shaher Hussn, 2003).

Also ranges of velocity as of Bentley Water CAD/GEMs (2008) are given by

- Typical - 0.6-1.2 m/s
- High - 1.5-2.5 m/s
- Very high greater than 3 m/s.

And the network simulated shows the range of mentioned velocity. Figure below shows velocity distribution of model result in pipe line network.

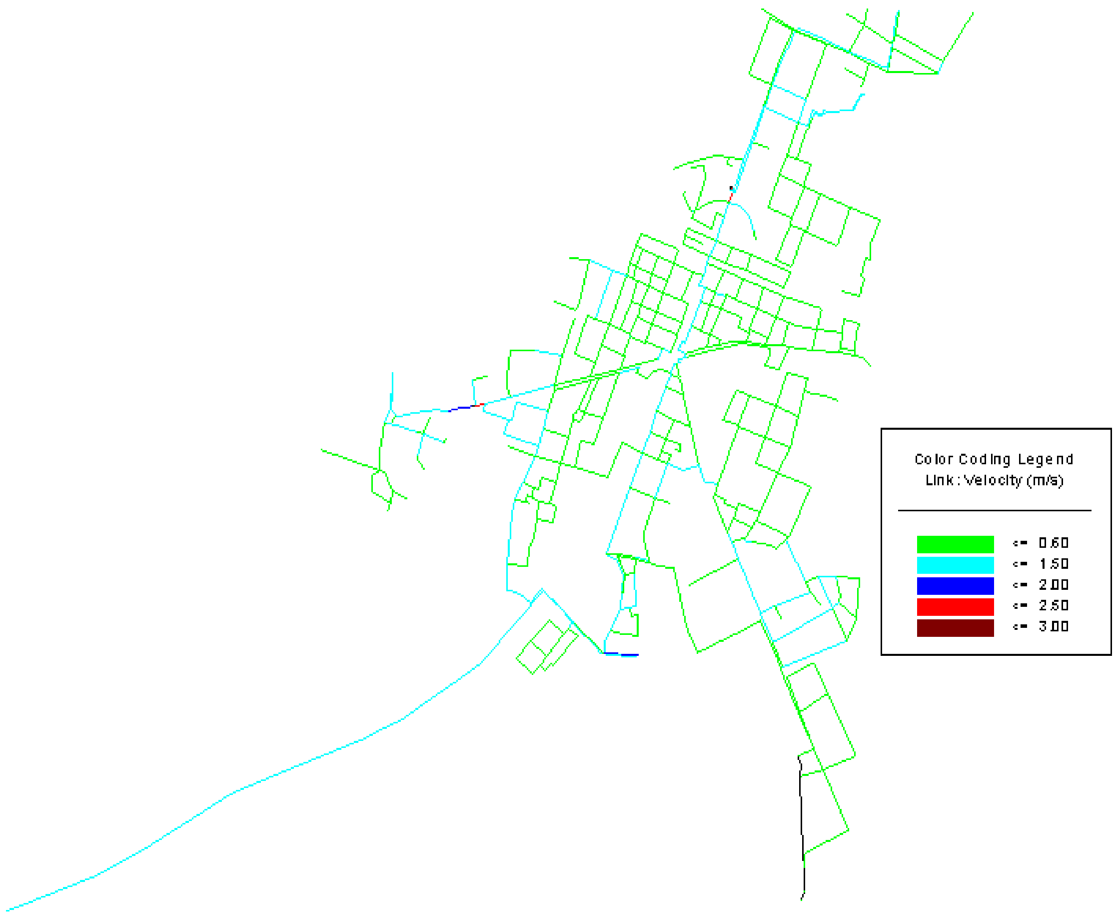

Figure 6.7: Velocity distribution in system pipe network

7. CONCLUSION AND RECOMMENDATION

7.1 Conclusion

Based on data of, number of connection, annual water production and consumption as well as distribution network; the results of this research conclusion as following:

- There was 36,226 number of connection, when 34,171 are domestic, 2055 are non-domestic water connections. The average domestic level of water connection per family in Adama town (0.52 connections per family) was much less than the UAP target (one connection for one family in year 2012).
- The average per capita consumption of Adama town was calculated as 34.5 l/c/d. This value is still less than the daily per-capita consumption 37.5 l/c/day set by the (MoWR, 2008) for urban centers of population more than 30,000.
- On the other hand, currently total water loss (NRW) entire the town 34.07% is considered which to be reduced to less than 20 %. From the water loss analysis of the sampled kebeles, higher water loss was found in kebele 11 which had relatively higher pressure and having older pipe systems in comparison to the other kebeles. From this, it can be concluded that pressure resulted due to significant ground elevation differences has an impact on water losses that as a result needs proper management. The other issue addressed was the major factor contributing to high levels of water loss in town are; Aged of pipe network, Poor maintenance of networks, Customer side leakage and illegal connections.
- Due to different reason currently water supply was not satisfy the demand of the town, in this fiscal year, ATWSSE produce treated water only 233 l/s whereas currently water demand is 364 l/s, from this result, a gap between supply- demand is 131 l/s in the present year 2015.
- The other focus of this paper was to develop a model that would represent the significantly manage effect of pressure in the distribution system of the town. It would serve as an analysis tool to increase understanding of the complexities of the system and to plan improvements of pressure reduction.

7.2. Recommendation

- There is rapid growing of population and expansion of Adama town, therefore, Water supply and demand in town has a gap presently, in order to meet the demand in future, water sector should expand Awash water treatment plant or investigate another water sources. Although, implementing water loss reduction for water sustainability is not an easy task for Adama town water utility, loss control programs are important to create acceptable level of water loss to satisfy water demand of the town.
- Currently ATWSSE have no leakage detection/ locating/ equipment, the method was only when it reported by community after days, Due to these reasons, the impact of leakage on water loss is high, to minimize the breakage of pipe lines, the old aged water lines should be changed or replaced. Also, ATWSSE should work with another service provider like road office, so as to avoid damage of water lines. In addition, the office should develop further rules and regulations (for instance, schemes to test customer`s water meter especially, those above 15 years aged) which can improve provision of water management and should create awareness for the community to save water. On the other hand, the office should practice different DMAs which used to manage pressure of discrete areas and to control water losses from the system due to leakage.
- Lastly, I recommend, future work, Due to the limited time and resources, this study is not adequately addressing all issues despite their significance. And it could be considered as a preliminary assessment of the situation in Adama town regarding water supply, demand and loss management. Therefore, further research will need to go deeper by gathering important data for sophisticated tools such as GIS, RS, to model the network and provide in to several DMAs. In addition, further studies needs to increase technological facilities in water loss management point of views (Urban water loss management from the point of environmental aspect, water demand management in urban areas, comprehensive and standardized urban water audit)

References

Adama Town Water Supply and Sewerage Enterprise, 2014, draft report of town infrastructure for last five years Adama Town.

Addis Ababa Water and Sewerage authority, (2011), water and sanitation development and rehabilitation project office, business plane draft report.

Allan Lambert and Richard Taylor (2010), water loss guidelines, the New Zealand water and wastewater Association.

Amdework Belay (2012),Hydraulic network modeling and upgrading of Legedadi subsystem water supply Addis Ababa, Msc thesis Addis Ababa University

Central Statistical Agency of Ethiopia (2008).Summary and Statistical Report of the 2007 Population and Housing Census, Population size by Age and Sex, Addis Ababa, Ethiopia, United Nations Population Fund.

Desalegn W. d. B. (2005), "Water supply coverage and water loss in distribution systems the case of Addis Ababa," Msc thesis, International Institute for Geo-Information Science and Earth Observation, Enschede, Netherlands.

Farley M. and Trow (2003). Losses in Water Distribution Networks: A Practitioner's Guide to Assessment, Monitoring and Control. IWA Publishing, Alliance House, 12 Caxton St., London, UK.

Federal Water Works Design & Super vision Enterprise. (2015), "Legedadi Phase II Water Supply Project", Addis Ababa Water Supply and Sewerage Authority, conceptual design report

Haestad Methods Solution Center, Bentley Systems Incorporated, 8th Annual International Symposium on Water Distribution System Analysis, Cincinnati, Ohio, August 27-30, 2006.

Hossam Saadeldin, (2011), Pressure, leakage and energy management in water distribution systems; PhD thesis, De Montfort University.

Hussien Aman (2010), Water Loss Management; Msc thesis, College of Development Studies, Addis Ababa University.

James G. H. & Rabi H. Mohtar (2002) "Water Distribution Model Calibration for the Design of the Ortley Beach and Seaside Heights", Water System Computer

Models in Environmental and Natural Resources Engineering, Purdue University.

Janet M. Wagner, David H. Marks(1988), "water distribution reliability simulation methods" Journal of Water Resources Planning Management, Vol. 114, No. 3

Jeffrey A. Gilbert, P.E. (2012), “Practical Design of Water Distribution Systems,” PDHonline course C-182.

Malcolm Farley, 2001, Leakage management and control, a best practice training manual, WHO, 2001, Geneva, Switzerland.

Ministry of Health, National Drinking Water Quality Monitoring and Surveillance, Strategy, May 2011,Addis Ababa

Ministry of Water Resources (MoWR, 2000), the Federal Democratic Republic of Ethiopia: Ethiopian Water Resource Management Policy, Addis Ababa.

Ministry of Water Resources (MoWR, 2006) urban water Supply Design criteria water resource management, urban water supply and sanitation department, Addis Ababa, Ethiopia.

Ministry of Water Resources, Universal Access Program (UAP, 2005) for Water Supply and Sanitation, Addis Ababa.

Sensus-Water 2020-USWeb, bringing smart water networks in to Focus, global water loss effect paper, 2012, North American and Europe.

Shaher Hussni Abdul Razaq Zyroud (2003), “Hdrualic Performance of Palastinian Water Distribution Systems”.

Shimeles Kabeto,(2011)Water Supply Coverage and Water Loss in Distribution System with Modeling ,The Case Study of Addis Ababa, Addis Ababa University.

Solomon B.T. (2011),"an assessment on the status of water supply and sanitation in Ethiopia, a case of Ambo town", Journal of Sustainable Development in Africa (Volume13) Clarion University of Pennsylvania, Clarion, Pennsylvania

Walski, T.M, D.V. Chase, D.A. Savic, W.M. Grayman, S. Beckwith and E.Koelle (2003), Advanced Water Distribution Modeling and Management.

APPENDIXES

Appendix A: water distributed and consumed at sampled kebeles

Water distributed to sub-systems					**Water Consumed from system**			
Month	Subsystem (kebeles)				Subsystems (kebeles)			
	3	**9**	**11**	**15**	**3**	**9**	**11**	**15**
JAN.	80000	50297	89625	19890	49131	34026	45070	9240
FEB.	83000	52886	95336	17254	61154	42925	49283	11715
MAR	81000	49898	96120	18668	49389	21259	48872	11282
APP	74000	48656	93256	19280	29852	24917	45145	12577
MAY	78000	57898	93812	19251	42240	49641	42570	11451
JUN	73000	72785	89343	20323	50312	62147	51499	11807
JULY	72000	98226	90520	21882	49846	87952	57926	13266
AUG.	72500	97858	93215	23745	43257	71831	54518	16958
SEP	78930	75210	98664	28950	44918	45596	61382	21964
OCT	79650	80675	97558	16562	48996	43415	54669	8961
NOV	81027	85964	92478	16820	48674	55695	40990	12668
DEC	83647	102856	96362	19200	62688	86725	38022	12235
TOTAL	936754	873209	1126289	241825	580457	626129	589946	154124

AppendixB: Steady State Analysis; Node results report

Nodes Label	Northing (m)	Easting (m)	Elevation (m)	Supply Zone	Demand (Calculated) (l/s)	Calculated Hydraulic Grade (m)	Pressure (mH2O)
N65C	945,005	528,996	1,630	RLU	2.06	1,671.57	41.487
N22	944,110	530,636	1,618	RLU	0.2	1,672.66	54.552
N29B'	944,363	529,568	1,622	RLU	0.67	1,671.46	49.36
N105A1	947,187	530,490	1,673	Rk02	0.15	1,729.21	56.102
N63B'	945,853	529,627	1,644	RLU	0.51	1,660.26	16.223
N53A	944,206	528,912	1,620	RLU	0.49	1,673.48	53.376
N3C	940,398	530,854	1,612	RLU	2.22	1,657.21	45.123
N3H1	941,391	531,558	1,594	RLU	1.27	1,632.96	38.884
N43	942,943	527,747	1,622	RLU	0.74	1,675.20	53.089
N82D	941,192	527,589	1,612	RLU	0.14	1,679.56	67.42
N15B2	941,464	528,839	1,638	RLU	0.22	1,678.56	40.479
N29	944,063	529,321	1,623	RLU	0.34	1,672.53	49.433
N30A5	943,779	529,427	1,622	RLU	0.48	1,674.32	52.214
ND-24	946,117	530,343	1,661	Rk02	0	1,780.14	118.904
N31D1	943,537	529,565	1,621	RLU	1.76	1,674.07	52.96
N44A1	943,591	527,941	1,620	RLU	0.88	1,674.17	54.057
J-1618	940,943	530,578	1,602	RLU	2.8	1,678.31	76.159
N53'	944,129	529,106	1,620	RLU	0.46	1,672.60	52.497
ND-06	947,310	532,115	1,715	Rk02	0	1,754.19	39.114
N8	942,376	529,985	1,612	RLU	0.59	1,672.87	60.748
ND-36	947,455	531,691	1,701	RDHA	0	1,746.47	45.378
NG-53	943,385	526,897	1,641	T.AG	0	1,788.64	147.347
NG-23	942,998	525,750	1,711	RGAG	0.62	1,750.95	39.873
N11	942,742	529,391	1,618	RLU	0.58	1,675.71	57.593
N81C2	940,445	527,918	1,633	RLU	0.3	1,678.04	44.953
N56	944,659	530,128	1,628	RLU	0.2	1,672.61	44.521
ND-01	947,279	532,192	1,709	Rk02	0	1,753.47	44.378
N58	944,665	530,863	1,629	RLU	1.03	1,672.39	43.301
ND-07	947,294	532,152	1,711	Rk02	0	1,753.84	42.754
N46B1	944,001	528,206	1,622	RLU	0.77	1,673.67	51.564
N22A	944,071	530,687	1,616	RLU	0.3	1,672.65	56.538
BA-02	940,457	531,240	1,614	R.BOK	0.62	1,714.41	100.203
N103C1	946,173	530,150	1,662	Rk02	0.44	1,736.70	74.548
N46	943,743	528,412	1,619	RLU	0.58	1,673.88	54.772
ND-46	947,359	532,898	1,715	RDHA	2.03	1,740.16	25.111
N103D	946,145	530,194	1,662	Rk02	0.28	1,736.69	74.543
N43A2	943,437	527,472	1,633	RLU	0.56	1,672.23	39.153
N39B6	942,398	527,674	1,619	RLU	0.17	1,676.42	57.308
J-1562	941,055	528,041	1,623	R.awash	0	1,688.87	65.737
N82C	941,144	527,645	1,613	RLU	1.45	1,679.67	66.54
N81C1	940,360	527,838	1,630	RLU	0.3	1,677.98	47.879
N45	943,394	526,944	1,645	RLU	0	1,657.43	12.408
N57A'	944,317	531,038	1,616	RLU	0.51	1,672.54	56.425

N22A2	944,113	530,325	1,623	RLU	0.5	1,672.77	49.668
N20A	943,573	531,123	1,605	RLU	0.92	1,666.49	61.364
N7C	942,097	530,219	1,604	RLU	1.25	1,671.75	67.61
N28A	944,168	530,064	1,626	RLU	0.33	1,672.72	46.623
ILWA-01	945,101	528,129	1,635	RLU	2.15	1,652.62	17.584
BO-07	938,090	531,119	1,700	RBOK	0	1,749.40	49.305
N39A5	942,059	527,926	1,614	RLU	0.67	1,677.26	63.129
N22E	943,787	530,905	1,608	RLU	0.81	1,667.81	59.69
NG-37	942,671	526,313	1,707	RGAG	0.45	1,745.07	37.989
N107'	946,201	529,671	1,654	Rk02	0.21	1,736.72	82.549
N42	942,828	527,713	1,624	RLU	1.87	1,675.47	51.369
N7B	942,223	530,266	1,603	RLU	0.6	1,672.12	68.976
ND-41	947,952	533,282	1,715	RDHA	1.14	1,729.76	14.727
N39A7	942,300	527,756	1,616	RLU	0.36	1,676.87	60.75
ND-45	947,227	532,826	1,716	RDHA	2.22	1,743.25	27.192
N103B	946,354	530,683	1,667	Rk02	0.24	1,734.62	67.481
N15D2	941,003	528,999	1,659	RLU	0.14	1,679.82	20.776
N47C	944,401	528,471	1,623	RLU	0.46	1,673.34	50.237
N35	943,354	528,256	1,617	RLU	0.58	1,676.18	59.062
N54E	944,558	529,934	1,625	RLU	0.48	1,671.25	46.152
N63B'1	945,837	529,595	1,644	RLU	0.51	1,660.38	16.344
N3H3	941,220	531,579	1,603	RLU	0.28	1,632.28	29.222
N7B1	942,280	530,117	1,606	RLU	0.59	1,672.42	66.286
N29A3	944,220	529,514	1,624	RLU	0.29	1,671.50	47.408
NG-89	943,754	525,897	1,748	T.AG	0	1,755.65	7.635
N105A4	947,854	530,683	1,685	Rk02	0.28	1,727.99	42.904
N109B	945,244	531,552	1,644	RAU	0.65	1,712.58	68.446
BA-01	940,290	530,910	1,616	R.BOK	0.28	1,714.42	98.219
N6B	941,901	530,932	1,597	RLU	0.11	1,667.36	70.217
N29A2	944,211	529,510	1,623	RLU	0.29	1,671.51	48.408
J-1565	940,248	526,717	1,590	R.awash	0	1,697.01	106.789
N65A	945,380	529,049	1,638	RLU	0.76	1,671.41	33.341
N29A"	944,117	529,608	1,623	RLU	0.16	1,672.40	49.296
N102A	945,926	531,127	1,657	RAU	0.34	1,713.13	56.016
N27A	944,148	530,386	1,623	RLU	0.17	1,672.70	49.601
N3F	941,449	531,318	1,597	RLU	1.27	1,640.09	43.007
N103C	946,263	530,162	1,667	Rk02	0.46	1,736.73	69.585
N100U1	946,806	531,736	1,702	Rk02	0	1,721.71	19.67
N24C	944,069	531,580	1,607	RLU	0.55	1,672.51	65.38
N22A5	944,026	529,853	1,624	RLU	0.55	1,672.99	48.893
J-1567	941,276	527,813	1,614	R.awash	0	1,690.28	76.129
NN-01	941,019	529,583	1,615	RLU	0.33	1,678.97	63.841
N54B1	945,046	529,898	1,635	RLU	0.52	1,669.68	34.612
N39A6	942,247	527,978	1,613	RLU	0.47	1,677.04	63.91
N81A1	940,754	528,252	1,641	RLU	0.25	1,679.31	38.23
ND-31	947,681	532,283	1,720	RDHA	2.46	1,746.92	26.864
N103A	946,449	530,448	1,667	Rk02	0	1,734.62	67.488

N111A	945,569	530,975	1,651	RAU	0.21	1,712.96	61.84
N3G	940,693	531,677	1,616	RLU	1.33	1,631.75	15.714
N32C	944,147	529,114	1,620	RLU	0.74	1,672.54	52.433
NG-77	943,319	525,913	1,717	T.AG	0	1,765.05	47.955
NG-46	943,034	526,570	1,691	RGAG	0.71	1,743.00	51.9
N82F	941,253	527,459	1,612	RLU	0.24	1,679.33	67.19
N44B1	943,631	527,350	1,636	RLU	2	1,665.77	29.713
N63B1	945,267	529,853	1,634	RLU	0.32	1,668.77	34.7
N10A	942,668	529,581	1,617	RLU	0.91	1,675.01	57.895
N69A2	945,397	530,495	1,642	RLU	2.8	1,660.35	18.316
N4	941,852	530,200	1,602	RLU	0.57	1,672.19	70.044
ND-28	947,060	530,715	1,684	Rk02	0	1,771.13	86.957
N22D	943,817	530,812	1,610	RLU	0.82	1,672.61	62.488
N105A	947,099	530,702	1,685	Rk02	0.39	1,730.73	45.639
NG-44	943,726	525,882	1,749	RGAG	0	1,754.67	5.661
N15B	941,623	528,752	1,628	RLU	0	1,678.74	50.641
NG-47	943,236	526,347	1,703	RGAG	0.37	1,746.87	43.785
N44B3	944,038	527,384	1,631	RLU	1.93	1,665.87	34.803
N47A4	944,837	529,018	1,626	RLU	0.28	1,671.83	45.742
N62	945,312	530,003	1,637	RLU	0.36	1,668.06	31.001
N3H	941,439	531,538	1,594	RLU	1.27	1,635.05	40.971
J-1609	941,547	529,453	1,618	RGAG	0	1,679.13	61.009
N12A	941,654	528,985	1,627	RLU	1.01	1,678.36	51.261
N35A	943,331	528,332	1,615	RLU	0.48	1,676.18	61.057
ND-39	947,732	531,013	1,693	RDHA	1.11	1,746.38	53.275
N30A	943,947	529,526	1,622	RLU	0.1	1,673.48	51.373
J-1564	940,084	526,455	1,588	R.awash	0	1,698.38	110.157
J-1560	940,536	528,747	1,677	R.awash	0	1,685.25	8.232
N15D1	940,992	528,920	1,660	RLU	0.41	1,679.73	19.693
N16A	943,188	529,675	1,622	RLU	2.24	1,674.00	51.897
J-1541	937,323	519,821	1,560	R.awash	0	1,730.58	170.235
N67A4	945,765	530,105	1,654	RLU	0.53	1,664.47	10.45
NG-17	942,821	526,211	1,698	RGAG	2.24	1,745.30	47.209
N18B	943,395	530,760	1,606	RLU	1.94	1,668.60	62.474
N21D	943,468	531,566	1,603	RLU	0.9	1,665.16	62.036
N103C2	946,166	530,202	1,663	Rk02	0.14	1,736.69	73.546
N14B	943,028	529,373	1,621	RLU	0.63	1,675.46	54.353
N30A2	943,888	529,470	1,622	RLU	0.96	1,673.92	51.812
J-1566	940,435	527,015	1,601	R.awash	0	1,695.44	94.25
N67C	946,136	529,684	1,650	RLU	0.63	1,663.61	13.581
N36A	942,698	528,208	1,613	RLU	1.39	1,675.95	62.823
N82	940,561	528,566	1,671	RLU	1.07	1,681.37	10.347
N106A"	945,956	531,138	1,656	RAU	0.87	1,713.14	57.026
N43B5	943,303	528,196	1,616	RLU	0.58	1,676.21	60.091
N61A	945,232	530,202	1,637	RLU	0.51	1,668.31	31.247
N111	945,687	530,663	1,648	RAU	0.56	1,712.98	64.844
N64A2	944,702	529,602	1,626	RLU	0.54	1,670.97	44.878

N12A3	941,931	529,089	1,624	RLU	1	1,677.51	53.405
J-1557	940,531	528,824	1,682	R.awash	0	1,684.91	2.9
N15F7	940,535	528,897	1,682	RLU	1.11	1,683.23	1.23
N57	944,422	530,765	1,621	RLU	0.86	1,672.57	51.47
N29A1	944,021	529,426	1,623	RLU	0.34	1,671.51	48.415
J-1555	940,620	528,484	1,675	R.awash	0	1,686.11	11.087
N10A1	942,607	529,822	1,629	RLU	0.19	1,673.94	44.847
N69	945,300	530,510	1,640	RLU	2.26	1,660.18	20.136
N52B	944,488	529,247	1,622	RLU	0.78	1,671.50	49.402
N7AB1	942,215	530,446	1,600	RLU	0.48	1,671.84	71.692
N11A	942,786	529,277	1,622	RLU	0.11	1,675.83	53.719
N43A7	943,022	527,479	1,630	RLU	0.63	1,673.15	43.062
NG-60	943,349	526,530	1,689	T.AG	0	1,778.69	89.51
N105C1	947,413	530,827	1,689	Rk02	0.11	1,729.34	40.254
N78	945,012	530,967	1,640	RAU	0.41	1,712.66	72.513
NG-01	943,199	525,784	1,720	RGAG	0.32	1,751.43	31.366
N81	940,928	528,189	1,632	RLU	0	1,680.97	48.874
N7D	941,998	530,460	1,602	RLU	0.59	1,671.29	69.148
ILWA-02	944,605	527,950	1,627	RLU	1.64	1,651.26	24.215
N7AB	942,278	530,285	1,604	RLU	0.59	1,672.04	67.902
ND-44	947,273	531,634	1,701	RDHA	0.42	1,744.65	43.563
BA-08	939,143	531,062	1,643	T.Bok	0	1,842.27	198.866
N7A1	942,043	530,606	1,602	RLU	0.12	1,670.30	68.167
ND-29	946,530	530,506	1,670	Rk02	0	1,776.20	105.984
N50	945,080	528,398	1,636	RLU	2.22	1,652.68	16.648
ND-33	947,522	532,250	1,714	RDHA	1.58	1,746.77	32.706
J-1559	939,563	525,487	1,573	R.awash	0	1,703.29	130.025
N58A2	944,935	530,952	1,638	RLU	1.24	1,668.42	30.363
N27A2	944,136	530,201	1,625	RLU	0.17	1,672.73	47.634
N3B	941,269	531,199	1,595	RLU	1.72	1,641.12	46.023
N100R5	946,752	531,352	1,684	Rk02	0	1,724.66	40.582
N53B	944,273	528,795	1,620	RLU	0.66	1,673.04	52.928
N31B	943,252	529,463	1,618	RLU	0.75	1,675.27	57.152
N21	943,523	530,423	1,612	RLU	1.11	1,670.80	58.686
ND-03	947,304	532,198	1,710	Rk02	0	1,753.24	43.156
N46B	943,899	528,472	1,618	RLU	0.79	1,673.77	55.653
ND-11	945,872	530,248	1,656	Rk02	0	1,782.48	126.225
IAU-01	945,223	531,049	1,646	RLU	0.9	1,712.66	66.528
NG-39	942,315	526,080	1,703	RGAG	0.16	1,749.75	46.654
N68A3	945,622	530,006	1,646	RLU	0.32	1,665.26	19.218
ND-42	947,171	531,885	1,713	RDHA	0.41	1,745.29	32.226
ND-08	947,678	530,998	1,695	Rk02	0	1,765.09	69.949
N10A2	942,519	529,860	1,626	RLU	0.14	1,673.63	47.534
N43A	943,142	527,806	1,622	RLU	0.74	1,674.84	52.734
N64E	944,927	529,197	1,628	RLU	0.88	1,671.54	43.451
N43B2	942,958	528,442	1,615	RLU	0.84	1,675.93	60.812
N24E2	944,352	531,820	1,617	RLU	0.21	1,672.42	55.307

N6B3	942,456	531,211	1,597	RLU	0.17	1,668.49	71.347
N43B1	943,001	528,289	1,614	RLU	0.84	1,675.94	61.812
N39A1	941,571	527,608	1,615	RLU	1.62	1,678.25	63.122
N22C	944,082	530,938	1,613	RLU	0.65	1,672.61	59.487
N69A1	945,580	530,428	1,645	RLU	0.17	1,661.91	16.878
N52A	944,346	529,193	1,621	RLU	0.78	1,671.51	50.404
NG-64	943,351	526,356	1,689	T.AG	0	1,774.79	85.613
N29A'	944,133	529,569	1,623	RLU	0.16	1,672.51	49.408
N2	941,481	528,962	1,633	RLU	1.19	1,678.63	45.536
N108A	946,118	529,446	1,656	Rk02	0.38	1,736.71	80.551
N15F1	940,803	528,713	1,670	RLU	0.5	1,680.48	10.456
N69A	945,704	530,300	1,651	RLU	0.17	1,663.43	12.406
N71	945,834	531,322	1,657	RAU	0.62	1,712.81	55.701
N22D2	944,011	530,682	1,615	RLU	0.92	1,672.64	57.526
N64A	945,128	529,273	1,633	RLU	0.56	1,671.46	38.386
J-1556	940,563	528,524	1,670	R.awash	0	1,685.80	15.768
N21C	943,523	531,384	1,604	RLU	0.9	1,665.35	61.222
N67A3	945,764	529,993	1,648	RLU	0.65	1,664.23	16.202
N47B	944,440	528,375	1,627	RLU	0.46	1,673.58	46.489
N24A	944,013	531,572	1,607	RLU	0.55	1,672.51	65.38
N44B2	943,716	527,339	1,635	RLU	0.24	1,665.78	30.717
N100U3	946,177	531,218	1,664	RAU	0.12	1,713.25	49.155
N36	942,744	528,035	1,615	RLU	1.07	1,676.50	61.378
N38B	942,522	527,965	1,616	RLU	0.71	1,676.67	60.549
J-1569	937,352	520,259	1,559	R.awash	0	1,728.62	169.282
N47A2	945,039	528,915	1,632	RLU	0.35	1,671.63	39.55
N18	943,165	530,285	1,613	RLU	2.06	1,671.52	58.399
N100R6	946,799	531,238	1,681	Rk02	0	1,725.51	44.423
N13	942,465	528,911	1,633	RLU	0.28	1,676.86	43.774
N24E1	944,238	531,794	1,614	RLU	0.17	1,672.42	58.299
N39A3	941,894	527,691	1,616	RLU	0.65	1,677.77	61.647
N39B	942,327	527,452	1,624	RLU	0.8	1,676.80	52.692
N3D	940,683	530,727	1,606	RLU	1.45	1,658.24	52.136
J-1616	940,604	529,852	1,615	RLU	0	1,678.69	63.56
N32A1	943,984	528,841	1,618	RLU	0.66	1,673.64	55.525
N56B	944,673	530,133	1,628	RLU	0.2	1,672.61	44.518
N36A2	942,973	528,800	1,620	RLU	1.62	1,676.02	55.907
N9B1	942,615	530,818	1,601	RLU	0.39	1,670.47	69.334
N54	944,609	529,811	1,626	RLU	4.4	1,671.03	44.937
N54F	944,759	529,877	1,628	RLU	0.43	1,670.63	42.548
NG-10	943,188	525,889	1,710	RGAG	0.32	1,750.75	40.663
N30A3	943,832	529,310	1,621	RLU	0.53	1,674.34	53.229
N102	946,057	530,810	1,659	RAU	0.36	1,713.30	54.187
NG-75	943,284	525,942	1,706	T.AG	0	1,766.00	59.881
N43B3	943,219	528,280	1,617	RLU	0.48	1,676.21	59.095
ILWBO1	942,948	527,339	1,632	RLU	1.29	1,675.22	43.134
N3E	941,084	531,489	1,600	RLU	2.77	1,634.89	34.82

N64B	944,952	529,707	1,630	RLU	0.6	1,670.21	40.13
NG-36	942,238	525,849	1,700	RGAG	0.22	1,749.52	49.421
N3J1	941,426	531,828	1,623	RLU	1.03	1,634.10	11.078
N54A1	944,585	529,656	1,625	RLU	5.32	1,671.33	46.235
N6A4	941,852	530,391	1,603	RLU	0.31	1,670.89	67.754
N43B6	943,316	528,238	1,616	RLU	0.59	1,676.19	60.072
N56A1	944,953	530,379	1,633	RLU	0.83	1,668.94	35.87
N44	943,638	527,955	1,621	RLU	1.52	1,674.11	52.999
NG-52	942,178	525,829	1,709	RGAG	0.35	1,749.48	40.399
N55B	944,762	530,616	1,631	RLU	0.71	1,672.39	41.309
N4A	941,647	530,289	1,602	RLU	0	1,669.79	67.658
N24D	944,049	531,771	1,607	RLU	0.42	1,672.42	65.287
N32	943,828	528,780	1,619	RLU	0.55	1,673.77	54.661
N27A1	944,150	530,318	1,624	RLU	0.17	1,672.71	48.614
N105	946,836	530,599	1,676	Rk02	0	1,731.05	54.937
ND-18	947,501	530,904	1,690	Rk02	0	1,766.86	76.71
ND-22	947,267	530,797	1,688	Rk02	0	1,769.15	80.991
N32B	943,940	529,278	1,621	RLU	0.49	1,673.75	52.641
N81F	940,701	527,654	1,618	RLU	1.24	1,678.16	60.04
NG-35	942,290	525,861	1,701	RGAG	0.34	1,749.58	48.482
N65B	945,205	529,076	1,635	RLU	0.4	1,671.49	36.42
NG-61	943,367	526,446	1,692	T.AG	1.41	1,776.70	84.527
BO-09	940,277	530,878	1,616	RLU	0	1,678.31	62.187
J-1007	945,892	530,218	1,658	RLU	0	1,660.73	2.727
N3B2	940,934	530,847	1,601	RLU	1.6	1,657.24	56.131
J-1016	941,256	528,807	1,645	RLU	0	1,679.48	34.411
N64A1	944,625	529,552	1,623	RLU	0.41	1,671.32	48.224
J-1624	941,572	529,274	1,624	RLU	0	1,679.18	55.074
N3I	941,133	531,561	1,603	RLU	1.27	1,632.26	29.199
NG-54	943,397	526,883	1,641	T.AG	0	1,789.20	148.4
N43A3	943,233	527,418	1,634	RLU	0.56	1,671.15	37.077
N106	946,663	531,049	1,672	Rk02	0	1,713.48	41.393
N15D	941,089	528,904	1,651	RLU	0.22	1,679.64	28.585
ILEBO23	941,093	531,350	1,596	RLU	1.91	1,640.81	44.718
N5A	941,946	530,158	1,601	RLU	0.22	1,672.61	71.463
N15F6	940,553	528,618	1,673	RLU	1.06	1,681.58	8.563
ND-27	947,664	532,271	1,720	Rk02	0	1,750.03	29.968
N21B	943,535	531,221	1,606	RLU	0.49	1,665.92	59.794
N106B	946,920	531,151	1,678	Rk02	0.78	1,721.99	43.899
N3J	940,966	531,781	1,612	RLU	1.6	1,631.25	19.212
N43A6	943,076	527,314	1,636	RLU	0.58	1,671.98	35.908
NG-13	943,139	526,064	1,702	RGAG	1.39	1,749.29	47.192
N22A3	944,111	530,255	1,624	RLU	0.41	1,672.80	48.698
NG-51	943,203	525,798	1,718	RGAG	1.11	1,751.56	33.497
NG-33	942,376	525,694	1,712	RGAG	0.32	1,749.53	37.455
N45'	943,742	527,089	1,642	RLU	0.7	1,649.54	7.526
N81A	940,852	528,124	1,631	RLU	0.32	1,679.88	48.782

N3H2	941,307	531,571	1,597	RLU	0.28	1,632.47	35.402
J-1558	939,537	525,422	1,576	R.awash	0	1,703.60	127.343
N18C	942,747	530,515	1,599	RLU	1	1,669.68	70.535
N7A	942,077	530,502	1,601	RLU	0.58	1,671.28	70.14
N59	944,531	531,354	1,622	RLU	1.03	1,672.37	50.267
N63B'2	945,649	529,687	1,642	RLU	0.26	1,662.92	20.878
N61	945,135	530,450	1,636	RLU	2.23	1,668.37	32.304
BA-09	938,272	531,118	1,691	T.Bok	0	1,765.42	74.273
NG-59	943,348	526,587	1,687	T.AG	1.07	1,780.01	92.825
N29B	944,315	529,690	1,623	RLU	0.5	1,671.82	48.725
NG-27	942,654	525,728	1,708	RGAG	0	1,750.37	42.29
N25A2	943,938	531,898	1,606	RLU	0	1,672.50	66.363
N6A	941,862	530,891	1,598	RLU	0.41	1,667.32	69.183
N45'A	943,704	526,900	1,642	RLU	0.7	1,650.69	8.673
N11A1	942,886	529,317	1,621	RLU	0.58	1,675.64	54.527
N100R1	946,981	531,840	1,714	Rk02	0	1,720.31	6.3
J-1553	939,941	526,225	1,583	R.awash	0	1,699.59	116.35
J-1549	940,525	528,924	1,682	R.awash	0	1,684.46	2.456
BO-01	939,461	531,239	1,632	RLU	0	1,678.31	46.22
N15A	941,703	528,740	1,628	RLU	0.71	1,678.43	50.325
N103'	946,243	530,301	1,664	Rk02	0.38	1,736.73	72.587
N71B	945,083	531,966	1,639	RAU	0.72	1,708.69	69.545
N14B1	942,955	529,556	1,620	RLU	0.4	1,675.14	55.027
N12A2	941,878	529,091	1,623	RLU	0.64	1,677.61	54.495
N47A	944,102	528,550	1,617	RLU	0.8	1,673.65	56.534
NG-31	942,413	525,623	1,706	RGAG	0.28	1,749.54	43.456
ILEBO1	940,823	529,653	1,617	RLU	1.14	1,678.92	61.791
N30A6	943,768	529,422	1,622	RLU	0.46	1,674.36	52.253
N28A'	944,218	529,938	1,626	RLU	0.46	1,672.75	46.658
N71C	945,263	531,973	1,645	RAU	0.31	1,709.90	64.767
N68	945,558	529,697	1,639	RLU	1.19	1,663.71	24.665
J-1563	939,696	525,781	1,580	R.awash	0	1,701.85	121.607
N15F4	940,681	528,590	1,670	RLU	1.24	1,681.04	11.017
ILu-01	942,275	529,419	1,619	RLU	1.08	1,676.80	57.686
NNL-03	940,890	530,464	1,604	RLU	0.44	1,678.36	74.21
ND-02	947,282	532,193	1,709	Rk02	0	1,753.44	44.351
N30A8	943,717	529,130	1,624	RLU	0.55	1,674.37	50.268
N54C	944,965	530,099	1,628	RLU	0.07	1,670.99	42.901
N39A4	942,106	527,731	1,614	RLU	0.65	1,677.49	63.361
ND-10	947,750	531,043	1,693	Rk02	0	1,764.34	71.199
N38A3	942,584	527,797	1,619	RLU	0.44	1,676.51	57.393
BO-05	939,270	531,095	1,638	T.Bok	0	1,853.83	215.397
N48	944,578	528,266	1,626	RLU	0.56	1,651.33	25.275
BA-03	940,095	531,427	1,620	R.BOK	0.35	1,714.53	94.337
N68A2	945,444	529,939	1,641	RLU	1.11	1,664.26	23.218
N81C3	940,424	527,933	1,633	RLU	0.58	1,678.07	44.982
ND-43	947,072	531,844	1,711	RDHA	1.68	1,744.96	33.892

N37	942,274	527,887	1,616	RLU	0.47	1,676.94	60.813
N10A3	942,529	529,899	1,625	RLU	0.92	1,673.50	48.403
N17B	943,583	530,272	1,621	RLU	1.48	1,670.82	49.723
N82A	941,308	527,790	1,613	RLU	1.54	1,680.04	66.9
N9B	942,634	530,795	1,599	RLU	0	1,670.68	71.536
N52C	944,421	528,999	1,622	RLU	0.5	1,671.75	49.648
J-1629	941,613	529,063	1,627	RLU	0	1,679.25	52.142
N64D	944,850	529,391	1,627	RLU	0.59	1,670.59	43.498
N52D	944,612	528,931	1,622	RLU	0.64	1,671.89	49.787
BO-08	940,575	530,742	1,609	RLU	0	1,678.31	69.173
ND-21	947,393	530,848	1,690	Rk02	0	1,767.95	77.789
NG-42	943,236	525,806	1,725	RGAG	0.54	1,751.75	26.698
ND-47	947,778	531,887	1,713	RDHA	0.1	1,746.47	33.402
N54B1'	945,127	529,930	1,634	RLU	0.33	1,669.44	35.371
N39B2	942,300	527,585	1,624	RLU	1.72	1,676.41	52.304
N20B	943,717	531,159	1,607	RLU	0.92	1,667.14	60.019
N55A	944,518	530,059	1,625	RLU	0.36	1,672.69	47.597
NG-02	942,624	525,801	1,716	RGAG	0.42	1,750.02	33.95
N106A	946,292	530,904	1,663	RAU	0.95	1,713.35	50.245
N103	946,222	530,357	1,665	Rk02	0.77	1,736.74	71.594
N8A	942,355	529,977	1,612	RLU	0.44	1,672.86	60.735
N74	944,668	531,820	1,624	RAU	0.15	1,708.65	84.479
N10	942,715	529,789	1,627	RLU	0.17	1,674.30	47.208
ND-35	947,341	531,954	1,715	RDHA	1.07	1,746.48	31.415
N111C	945,088	530,775	1,642	RAU	0.37	1,712.85	70.711
N109	945,538	532,088	1,657	RAU	0.24	1,712.38	55.265
N14B2	942,875	529,558	1,620	RLU	0.4	1,675.08	54.965
N36A1	942,586	528,619	1,616	RLU	2.01	1,675.96	59.842
N22D1	943,866	530,632	1,614	RLU	0.98	1,672.63	58.507
BA-07	938,531	531,682	1,679	R.BOK	0.63	1,715.47	36.395
BO-04	939,881	531,057	1,625	RLU	0	1,678.31	53.206
N15F	940,832	528,662	1,666	RLU	0.5	1,680.57	14.544
N14A	943,111	529,162	1,623	RLU	0.94	1,675.69	52.588
N44B4	944,044	527,710	1,625	RLU	1.93	1,667.81	42.728
NG-49	942,571	525,822	1,717	RGAG	0.59	1,749.81	32.747
N39	941,279	527,341	1,617	RLU	1.83	1,679.13	62.009
N24E	944,242	531,608	1,614	RLU	0	1,672.51	58.394
N15A1	941,071	528,792	1,657	RLU	0.49	1,679.85	22.807
J-1570	938,353	522,826	1,575	R.awash	0	1,716.35	141.062
NG-57	943,365	526,694	1,672	T. AG	0.84	1,782.71	110.491
N22A1	944,076	530,634	1,616	RLU	0	1,672.66	56.549
N49	944,430	528,211	1,622	RLU	0.96	1,673.92	51.82
N105A2	947,228	530,435	1,674	Rk02	0.38	1,728.81	54.7
N20	943,286	531,051	1,606	RLU	1.81	1,668.56	62.436
ND-26	946,286	530,409	1,666	Rk02	0	1,778.53	112.304
N30A1	943,895	529,539	1,620	RLU	0.66	1,673.67	53.563
ND-40	948,454	532,035	1,707	RDHA	1.26	1,746.05	38.968

NN-02	940,565	529,771	1,620	RLU	0.54	1,678.73	58.614
N3	941,027	530,571	1,601	RLU	1.62	1,662.60	61.475
N81B1	940,944	527,897	1,621	RLU	0.3	1,678.77	57.655
N52B'	944,563	529,054	1,622	RLU	0.48	1,671.68	49.578
NG-20	943,200	525,811	1,713	RGAG	0.18	1,751.50	38.419
N54D	944,712	529,995	1,629	RLU	0.44	1,671.01	41.922
N54E1	944,554	529,945	1,625	RLU	0.29	1,671.26	46.168
ND-34	947,244	532,192	1,707	RDHA	2.43	1,746.55	39.472
N6B2	942,289	531,117	1,599	RLU	0.62	1,667.89	68.749
NG-79	943,358	525,878	1,725	T.AG	0	1,763.96	38.877
N68C1	945,451	529,649	1,639	RLU	0.67	1,668.97	29.91
N72	945,925	530,241	1,658	Rk02	0	1,739.69	81.525
BA-04	939,887	531,075	1,624	R.BOK	0.47	1,714.52	90.339
N58A1	944,760	530,875	1,633	RLU	2.01	1,668.44	35.367
J-1610	941,542	529,471	1,618	RLU	0	1,679.13	61.003
N39A2	941,763	527,619	1,617	RLU	1.06	1,677.97	60.852
N81B	940,774	528,061	1,634	RLU	0.55	1,679.40	45.305
N65	945,237	528,993	1,636	RLU	0.35	1,671.49	35.42
N81D1	940,507	527,460	1,614	RLU	0.4	1,677.99	63.858
NG-29	942,528	525,630	1,702	RGAG	0.62	1,749.67	47.578
N27B1	944,304	530,289	1,629	RLU	0.66	1,672.65	43.565
N32A	943,989	528,828	1,619	RLU	0.79	1,673.63	54.517
N29A	944,045	529,537	1,621	RLU	0.17	1,672.76	51.654
N15F2	940,791	528,855	1,675	RLU	0.33	1,680.28	5.265
N6B4	942,513	531,084	1,598	RLU	0.34	1,669.01	70.871
N81E	940,531	527,849	1,630	RLU	0.59	1,678.32	48.227
N81D	940,314	527,676	1,623	RLU	0.78	1,677.58	54.474
N105A3	947,275	530,446	1,675	Rk02	1.1	1,728.60	53.496
N24	944,049	531,237	1,611	RLU	1.39	1,672.54	61.419
N7	942,187	530,560	1,600	RLU	0.41	1,671.71	71.565
NG-68	943,330	526,184	1,697	T.AG	0	1,771.16	74.009
N28B1'	944,008	529,615	1,622	RLU	0.25	1,672.99	50.887
N34	943,260	528,567	1,615	RLU	1.66	1,675.93	60.811
N54A	944,899	529,841	1,630	RLU	0.43	1,670.11	40.026
N24A1	943,988	531,761	1,606	RLU	0.42	1,672.50	66.37
N39A	941,590	527,350	1,621	RLU	1.29	1,678.65	57.533
N19	942,913	530,958	1,599	RLU	1.24	1,670.46	71.313
N46A2	943,723	528,515	1,620	RLU	0.39	1,676.16	56.05
NG-18	942,761	526,231	1,700	RGAG	2.38	1,745.08	44.986
ND-19	947,402	531,888	1,714	Rk02	0	1,756.33	42.25
N6A3	941,841	530,455	1,602	RLU	0.16	1,670.41	68.277
N6B1	942,121	531,047	1,599	RLU	0.1	1,667.64	68.502
N28C	944,268	529,812	1,624	RLU	0.58	1,671.78	47.68
N54B	944,789	529,798	1,627	RLU	0	1,670.41	43.327
N15C	941,105	528,988	1,650	RLU	0.21	1,679.45	29.394
J-1626	941,198	529,542	1,615	RLU	0	1,679.02	63.895
N30A4	943,808	529,206	1,623	RLU	0.4	1,674.35	51.248

J-1554	940,902	528,196	1,633	R.awash	0	1,687.90	54.791
N64B1	945,049	529,472	1,631	RLU	0.64	1,670.22	39.141
N39B1	942,156	527,401	1,624	RLU	2.01	1,677.23	53.122
N47A1	944,899	528,860	1,630	RLU	0.14	1,672.08	41.997
N31	943,837	529,021	1,616	RLU	0.58	1,674.41	58.287
NG-71	943,310	526,091	1,702	T.AG	0	1,769.16	67.028
J-1725	945,886	530,199	1,658	Rk02	0	1,740.36	82.192
N17	943,251	530,098	1,621	RLU	2.06	1,671.36	50.258
J-1568	940,970	527,512	1,613	R.awash	0	1,692.19	79.032
N6C	941,382	531,141	1,598	RLU	0.21	1,640.82	42.733
ND-16	947,581	531,449	1,700	Rk02	0	1,760.48	60.361
NG-48	943,104	526,295	1,701	RGAG	0.65	1,747.58	46.488
N43A4	943,249	527,360	1,635	RLU	0.58	1,670.87	35.799
J-1544	939,808	526,032	1,580	R.awash	0	1,700.63	120.386
N56A	944,867	530,342	1,631	RLU	0.71	1,672.40	41.312
N43B4	943,252	528,181	1,617	RLU	0.58	1,676.24	59.125
NG-11	943,177	525,951	1,708	RGAG	0.42	1,750.18	42.093
BO-03	938,271	531,128	1,691	R.BOK	0.32	1,715.73	24.677
N3B1	941,097	530,754	1,599	RLU	1.45	1,657.77	58.653
N38A	942,515	527,546	1,621	RLU	1.37	1,676.31	55.202
N44A	943,496	527,383	1,634	RLU	1.5	1,666.25	32.181
N82B	941,262	527,749	1,615	RLU	1.45	1,679.93	64.801
NG-50	942,421	525,884	1,716	RGAG	0.62	1,749.76	33.689
NG-16	943,073	526,286	1,694	RGAG	1.6	1,748.18	54.068
N22A4	944,091	530,147	1,625	RLU	0.4	1,672.84	47.748
N6	941,892	530,367	1,602	RLU	0.2	1,671.27	69.135
N53A1	944,221	528,918	1,620	RLU	0.53	1,673.21	53.107
N77	944,725	531,598	1,625	RAU	0.35	1,708.65	83.479
N12A1	941,623	529,144	1,626	RLU	0.4	1,678.07	51.965
N9	942,497	530,031	1,614	RLU	0.84	1,673.08	58.96
ND-14	947,857	532,285	1,737	Rk02	0	1,748.34	11.315
N31D	943,531	529,590	1,622	RLU	1.76	1,674.00	51.897
NG-19	942,742	526,249	1,700	RGAG	0	1,745.07	44.984
N52'	944,711	529,335	1,626	RLU	0.62	1,671.49	45.399
NG-34	942,333	525,774	1,705	RGAG	0.47	1,749.53	44.444
N63A	945,198	529,531	1,630	RLU	0.9	1,670.20	40.123
N11A2	942,842	529,430	1,618	RLU	0.32	1,675.65	57.538
ND-12	947,720	531,109	1,701	Rk02	0	1,763.71	62.579
N105C	947,726	530,998	1,693	Rk02	0.98	1,727.95	34.876
N30	943,889	529,500	1,621	RLU	0.44	1,673.81	52.708
N30A7	943,724	529,541	1,620	RLU	0.83	1,673.93	53.82
NG-25	942,800	525,726	1,705	RGAG	0.24	1,750.60	45.513
N70	945,405	531,150	1,652	RAU	0.25	1,712.75	60.631
N54D'	945,049	530,131	1,631	RLU	0.5	1,669.13	38.052
NG-41	942,909	524,969	1,728	RGAG	0.24	1,750.31	22.263
BO-06	937,829	531,119	1,713	T.Bok	0	1,726.44	13.41
J 2	937,320	519,815	1,559	R.awash	0	1,730.61	171.26

N24B	944,402	531,627	1,617	RLU	0.71	1,672.45	55.334
N67E1	946,027	529,878	1,647	RLU	1.06	1,663.64	16.606
N7B2	942,327	530,135	1,605	RLU	0.59	1,672.52	67.387
N22B	944,095	530,849	1,615	RLU	0.65	1,672.62	57.504
NG-30	942,470	525,626	1,702	RGAG	0.18	1,749.60	47.501
N15E	940,771	529,008	1,677	RLU	0.32	1,680.08	3.075
ND-23	947,635	531,321	1,709	Rk02	0.21	1,761.70	52.593
N12	942,335	529,233	1,621	RLU	0.16	1,676.81	55.693
NG-26	942,684	525,730	1,702	RGAG	0.13	1,750.42	48.323
NG-65	943,344	526,313	1,690	T. AG	0	1,773.87	83.705
NG-69	943,321	526,157	1,698	T.AG	0	1,770.57	72.42
NG-21	943,143	525,771	1,712	RGAG	0.25	1,751.28	39.204
BA-06	939,373	531,790	1,645	R.BOK	0.47	1,714.85	69.705
NG-40	943,262	526,396	1,706	RGAG	0.26	1,746.82	40.736
N14B3	942,911	529,468	1,620	RLU	0.4	1,675.05	54.944
ND-13	947,607	530,959	1,692	RDHA	0.61	1,765.80	73.654
J-1546	937,983	522,072	1,563	R.awash	0	1,720.08	156.768
N68A1	945,493	529,814	1,640	RLU	1.06	1,663.88	23.832
J-1561	940,543	528,656	1,673	R.awash	0	1,685.65	12.628
N27C	944,185	530,668	1,618	RLU	0.55	1,672.61	54.495
N25A	943,848	531,979	1,606	RLU	0.29	1,672.50	66.362
J-1551	940,945	528,152	1,631	R.awash	0	1,688.18	57.06
ND-09	947,713	531,019	1,694	Rk02	0	1,764.73	70.589
NG-90	942,184	525,835	1,698	RGAG	0.4	1,749.48	51.379
N43A1	943,337	527,864	1,624	RLU	1.39	1,674.49	50.392
N12A4	942,008	529,105	1,623	RLU	0.21	1,677.38	54.273
J-1542	937,326	519,830	1,561	R.awash	0	1,730.53	169.691
N63A1	945,264	529,580	1,634	RLU	0.58	1,669.39	35.323
N71D	944,899	531,855	1,632	RAU	0.52	1,708.65	76.5
ND-20	947,356	531,999	1,718	Rk02	0	1,755.28	37.209
N30A9	943,781	528,997	1,618	RLU	0.66	1,674.39	56.28
N71'	945,680	531,709	1,657	RLU	0.9	1,712.56	55.447
N101	946,619	531,173	1,674	Rk02	0	1,726.83	52.722
N51B	944,962	528,692	1,631	RLU	0.4	1,666.91	35.839
N31A	943,334	529,248	1,626	RLU	1.03	1,675.33	49.232
N107	946,276	530,013	1,656	Rk02	0.46	1,736.72	80.561
N15F3	940,750	528,612	1,668	RLU	0.45	1,680.84	12.812
N71BC	945,107	531,906	1,641	RAU	0.51	1,708.67	67.538
N82E	941,199	527,565	1,612	RLU	0.45	1,679.52	67.38
N38A1	942,460	527,696	1,620	RLU	0.44	1,676.38	56.263
N27B2	944,416	530,333	1,630	RLU	0.88	1,672.66	42.575
NG-09	943,197	525,865	1,711	RGAG	0	1,750.98	39.904
BO-02	937,829	531,127	1,712	R.BOK	0.82	1,715.93	3.923
N67	945,670	529,739	1,639	RLU	0.74	1,663.81	24.756
N111A'	945,486	530,942	1,649	RAU	0.88	1,712.93	63.797
J-1550	940,969	528,128	1,628	R.awash	0	1,688.33	60.205
N14	942,868	529,069	1,628	RLU	0	1,676.10	48

N55A'	944,518	530,525	1,627	RLU	0.86	1,672.59	45.495
N33	943,784	528,778	1,619	RLU	1.17	1,675.88	56.765
ND-17	947,541	531,551	1,703	Rk02	0	1,759.53	56.411
N39B3	942,288	527,644	1,623	RLU	0.21	1,676.41	53.298
N43B	943,052	528,124	1,619	RLU	1	1,676.34	57.222
N43A5	943,337	527,039	1,644	RLU	0.71	1,664.66	20.619
N68C	945,583	530,108	1,646	RLU	1.11	1,665.91	19.873
N68D	945,752	530,175	1,650	RLU	1.56	1,664.64	14.613
J-1608	941,260	528,825	1,644	RLU	0	1,679.47	35.403
NG-15	943,094	526,210	1,697	RGAG	1.15	1,748.49	51.389
N67A	945,624	529,721	1,638	RLU	0.74	1,663.70	25.65
N47A3	944,867	528,941	1,628	RLU	0.28	1,671.84	43.75
N15	941,712	528,611	1,625	RLU	0.92	1,678.42	53.316
J-1620	941,458	528,840	1,638	RLU	0	1,679.41	41.329
N28A"	944,073	529,886	1,622	RLU	0.3	1,672.79	50.684
N44B	943,989	528,050	1,620	RLU	1.93	1,673.93	53.821
ND-25	947,472	531,716	1,704	Rk02	0	1,757.96	53.85
N39B5	942,345	527,671	1,619	RLU	0.21	1,676.48	57.363
N48B	944,498	528,237	1,624	RLU	0.56	1,651.31	27.251
N100R4	946,810	531,374	1,686	Rk02	0	1,724.24	38.159
N67A1	945,665	529,784	1,640	RLU	0.66	1,663.86	23.81
NG-32	942,403	525,645	1,711	RGAG	0.43	1,749.53	38.455
NG-28	942,596	525,634	1,702	RGAG	0.36	1,749.89	47.789
NG-43	943,359	525,870	1,734	RGAG	0.12	1,752.55	18.509
J-1631	941,678	528,745	1,627	RLU	0	1,679.34	52.237
N106A'	946,247	531,028	1,665	RAU	0.32	1,713.35	48.248
N18A	943,037	530,626	1,603	RLU	1.77	1,670.66	67.526
N28B1	943,968	529,620	1,622	RLU	0	1,673.13	51.024
N63B	945,358	529,616	1,636	RLU	0.32	1,669.13	33.063
N47	944,336	528,641	1,623	RLU	0.18	1,673.51	50.412
N55	944,514	530,069	1,625	RLU	0.36	1,672.69	47.595
N31C	943,622	529,364	1,624	RLU	0.95	1,674.87	50.771
N59A	944,290	531,293	1,616	RLU	1.21	1,672.52	56.406
NG-38	942,989	526,554	1,692	RGAG	0.53	1,743.30	51.199
N71E	944,872	531,882	1,633	RAU	0.31	1,708.65	75.501
N25A1	943,960	531,858	1,607	RLU	0.82	1,672.50	65.365
N15F5	940,558	528,585	1,672	RLU	0.29	1,681.38	9.364
J-1548	940,527	528,892	1,681	R.awash	0	1,684.60	3.596
N16A1	943,185	529,635	1,620	RLU	0.84	1,674.12	54.008
N38A2	942,439	527,752	1,618	RLU	1.53	1,676.40	58.277
N4B	941,343	529,642	1,615	RLU	0.12	1,669.79	54.683
NG-83	943,543	525,880	1,736	T.AG	0	1,760.09	24.038
N70'	945,415	531,124	1,651	RAU	0.84	1,712.75	61.628
ND-32	947,564	532,258	1,714	RDHA	1.36	1,746.84	32.77
ND-37	948,110	530,388	1,692	RDHA	0.41	1,746.33	54.217
N39B4	942,378	527,607	1,621	RLU	0.5	1,676.42	55.309
N56B1	944,627	530,246	1,628	RLU	0.66	1,672.53	44.443

NG-24	942,848	525,728	1,711	T.AG	0.12	1,750.69	39.806
J-1613	941,318	528,827	1,643	RLU	0.49	1,679.45	36.38
N67A2	945,724	529,875	1,644	RLU	0.7	1,664.01	19.973
NG-45	942,792	526,218	1,706	RGAG	0.91	1,745.17	39.089
N81C	940,421	527,759	1,622	RLU	0.36	1,677.96	55.844
N6A1	941,760	530,777	1,598	RLU	0.32	1,668.17	70.032
N57A	944,355	530,934	1,619	RLU	0.51	1,672.55	53.442
N46A1	943,703	528,422	1,620	RLU	0.68	1,676.16	56.049
NG-14	943,117	526,131	1,700	RGAG	0.84	1,748.89	48.796
N27B3	944,275	530,434	1,626	RLU	0.88	1,672.63	46.539
N100U2	946,785	531,436	1,687	Rk02	0	1,723.78	36.703
N17A	943,178	530,290	1,613	RLU	1.28	1,671.51	58.394
N51A	944,788	529,144	1,625	RLU	0.47	1,671.61	46.52
BA-10	939,462	531,246	1,632	R.BOK	1.74	1,714.62	82.456
NG-22	943,063	525,760	1,710	RGAG	0.53	1,751.09	41.008
N15B1	941,461	528,824	1,639	RLU	0.29	1,679.08	40.004
ND-38	947,915	531,648	1,711	RDHA	0.21	1,746.46	35.392
N27B	944,252	530,425	1,626	RLU	0.53	1,672.65	46.554
N67E	946,160	529,854	1,651	RLU	1.36	1,663.61	12.587
N105C'	947,558	531,414	1,702	Rk02	0	1,725.60	23.551
N28AA	944,106	530,037	1,626	RLU	0.33	1,672.76	46.663
N45A'	943,421	527,062	1,642	RLU	0.35	1,663.12	21.082
J 1	937,317	519,809	1,559	R.awash	-110	1,730.64	171.291
J-1013	945,899	530,198	1,657	Rk02	0	1,742.42	85.253
J-1011	945,921	530,208	1,657	Rk02	0	1,659.33	2.324
J-1012	945,913	530,198	1,657	Rk02	0	1,742.82	85.642
J-1015	945,919	530,198	1,657	Rk02	0	1,743.24	86.069
J-1724	945,907	530,198	1,657	Rk02	0	1,742.43	85.257
ND-04	945,924	530,187	1,657	Rk02	0	1,785.80	128.541
ND-48	945,905	530,186	1,657	Rk02	0	1,784.63	127.371
J-1010	945,881	530,227	1,659	RLU	0	1,661.29	2.287
J-609	946,771	531,242	1,679	RAU	0	1,713.98	34.907
J-610	946,740	531,352	1,681	RAU	1.58	1,714.69	33.824
J-611	946,776	531,437	1,682	RAU	0	1,715.40	33.329
J-612	946,796	531,741	1,701	RAU	1.64	1,717.71	16.68
J-613	946,966	531,848	1,713	RAU	1.6	1,719.57	6.559
J-614	946,708	531,230	1,674	RAU	1.65	1,713.58	39.501
J-615	946,614	531,187	1,673	RAU	1.28	1,713.56	40.78
J-616	946,597	531,165	1,673	RAU	2.49	1,713.53	40.244
J-617	946,593	531,179	1,674	RAU	1.15	1,713.54	39.758
J-618	946,669	531,043	1,671	Rk02	0	1,727.79	56.374
J-619	946,664	531,057	1,673	Rk02	0	1,727.68	54.371
NG-67	943,275	525,934	1,714	RGAG	0.15	1,750.98	36.91

Appendix C: Steady State Analysis; Link reports

Pipe Label	From Node	To Node	Length (m)	Diameter (mm)	Pipe Material	Discharge (l/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)	Velocity (m/s)
PE-91	N30A1	N30A	54	500	DCI	227.48	0.19	3.63	1.16
PE-55	N9B1	N9B	30	80	DCI	-2.6	0.21	6.92	0.52
PE-511	N67A4	N67A3	112	150	DCI	7.15	0.24	2.11	0.4
PE-392	N27A	N22	253	200	PVC	3.89	0.04	0.15	0.12
PE-512	N67A3	N67A2	125	150	DCI	6.51	0.22	1.77	0.37
EG-46	NG-13	NG-14	70	150	DCI	12.09	0.39	5.58	0.68
PE-59	N18A	N19	354	100	DCI	1.22	0.2	0.58	0.16
PE-133	N12A	N12A1	162	300	PVC	42.78	0.29	1.82	0.61
PE-382	N27A	N27B	111	200	PVC	7.15	0.05	0.48	0.23
P-1783	J-1546	J-1547	21	600	DCI	409.95	0.09	4.45	1.45
P-1846	ILEBO1	NN-02	284	150	DCI	3.78	0.18	0.65	0.21
PE-152	N15D2	N15D1	80	150	DCI	4.96	0.09	1.07	0.28
PE-332	N64B1	N63A	160	100	DCI	0.48	0.02	0.1	0.06
PE-442	N71'	N109B	463	100	DCI	-0.34	0.03	0.06	0.04
PE-145	N15B2	N2	124	200	DCI	-7.36	0.07	0.55	0.23
PE-113	N14A	N14	260	600	DCI	-231.94	0.4	1.55	0.82
PE-112	N14B2	N14B3	97	80	DCI	0.4	0.02	0.22	0.08
PE-246	N43A6	N43A7	174	150	DCI	-13.37	1.17	6.73	0.76
PE-292	N29	N32C	223	100	DCI	-0.24	0.01	0.03	0.03
PE-398	N24A	N24A1	191	200	DCI	1.85	0.01	0.04	0.06
PE-298	N52A	N32C	214	80	DCI	-2.14	1.03	4.83	0.43
PE-331	N47A2	N65	213	100	DCI	1.3	0.14	0.65	0.17
PE-70	N18B	N18A	382	100	DCI	-4.09	2.06	5.39	0.52
PE-465	N100R4	N100R5	62	300	DCI	-83.76	0.43	6.87	1.18
P-1774	J-1553	J-1564	271	600	DCI	409.95	1.21	4.45	1.45
P-1776	J-1544	J-1545	20	600	DCI	409.95	0.09	4.45	1.45
PE-440	N71'	N109	405	150	DCI	3.11	0.18	0.45	0.18
PE-116	N11A1	N14B	153	80	DCI	0.98	0.17	1.14	0.2
PE-384	N27B3	N55A'	259	200	PVC	4.18	0.05	0.18	0.13
PE-283	N32A1	N32A	14	200	PVC	8.81	0.01	0.71	0.28
P-1841	NN-01	ILEBO1	208	200	DCI	4.91	0.05	0.26	0.16
PE-349	N54B1	N54B1'	87	500	DCI	195.56	0.24	2.75	1
PE-372	N56A	N54C	262	80	DCI	2.27	1.41	5.37	0.45
PE-466	N100U2	N100R4	67	300	DCI	-83.76	0.46	6.87	1.18
PE-432	N63B	N63B1	254	50	DCI	0.32	0.36	1.42	0.16
PE-443	N70	N109B	433	100	DCI	0.99	0.17	0.39	0.13
PE-281	N46	N32	378	300	PVC	16.01	0.11	0.29	0.23
PE-260	N44B2	N44B3	325	80	DCI	-0.47	0.09	0.29	0.09
EG-95	NG-42	NG-43	139	200	DCI	-26.14	0.8	5.73	0.83
PE-50	N6B	N6B1	248	80	DCI	-0.98	0.28	1.13	0.19
PE-100	N31D1	N31D	26	150	DCI	7.92	0.07	2.55	0.45
PE-271	N47	N47C	182	150	PVC	4.91	0.18	0.96	0.28

PE-477	N105A	N105A1	230	80	DCI	2.53	1.52	6.61	0.50
P-806	N100U3	N106A"	235	200	DCI	6.85	0.11	0.48	0.22
PE-276	N47A1	N51B	180	50	DCI	1.63	5.17	28.8	0.83
PE-32	N6B	N6A	57	150	DCI	3.73	0.04	0.63	0.21
PE-242	N43A3	N43A4	60	150	DCI	10.98	0.28	4.67	0.62
PE-322	N64B1	N64D	215	100	DCI	-2.19	0.37	1.7	0.28
PE-135	N12A2	N12A3	53	300	PVC	41.74	0.09	1.74	0.59
PE-488	N103'	N103C	141	200	PVC	2.37	0.01	0.06	0.08
PE-146	N2	N12A	175	300	PVC	38.75	0.26	1.51	0.55
PE-49	N8A	N5A	447	300	PVC	22.67	0.25	0.56	0.32
PE-394	N22	N22B	214	200	PVC	4.41	0.04	0.2	0.14
PE-35	N4A	N3	681	150	DCI	17.06	7.2	10.56	0.97
PE-301	N52C	N52B'	152	100	DCI	1.08	0.07	0.46	0.14
PE-319	N64A1	N64A2	92	100	DCI	3.4	0.35	3.84	0.43
PE-472	N106B	N105A	483	80	DCI	-4.37	8.74	18.09	0.87
ED-15	ND-18	ND-13	119	300	DCI	96.25	1.06	8.89	1.36
PE-68	N21	N17A	370	80	DCI	-1.3	0.71	1.91	0.26
P-1799	J-1557	J-1548	68	600	DCI	409.95	0.3	4.45	1.45
PE-43	N7AB	N7B	58	200	DCI	-11.7	0.08	1.3	0.37
PE-357	N28A'	N55A	323	300	PVC	12.4	0.06	0.18	0.18
PE-476	N105C1	N105A	338	100	DCI	-3.54	1.4	4.13	0.45
PE-430	N63B	N63A1	101	100	DCI	-2.77	0.26	2.63	0.35
PE-417	N24E1	N24E2	117	80	DCI	-0.1	0	0.02	0.02
PE-299	N52A	N52C	208	80	DCI	-0.99	0.24	1.16	0.20
EG-81	NG-49	NG-50	162	150	DCI	2.7	0.06	0.35	0.15
PE-364	N55	N56	157	200	PVC	7.46	0.08	0.51	0.24
PE-184	N81C	N81D	135	50	DCI	0.46	0.37	2.75	0.23
PE-329	N65C	N65B	215	100	DCI	0.95	0.08	0.36	0.12
ED-13	ND-22	ND-21	136	300	DCI	96.25	1.21	8.89	1.36
PE-75	N20A	N21B	105	80	DCI	2.28	0.57	5.45	0.45
PE-446	N111A	N102A	388	150	DCI	-3.01	0.16	0.42	0.17
PE-247	N43A7	N43	280	150	DCI	-14	2.05	7.32	0.79
PE-379	N28AA	N27A2	167	300	PVC	11.56	0.03	0.16	0.16
PE-93	N30A2	N30	30	500	DCI	219.99	0.1	3.41	1.12
PE-422	N56A1	N54D'	266	200	DCI	-8.41	0.19	0.7	0.27
PE-08	N3J	N3J1	462	50	DCI	-0.71	2.85	6.16	0.36
PE-56	N9B	N7	505	150	DCI	-7.02	1.03	2.04	0.4
PE-304	N52D	N47A4	241	150	DCI	2.1	0.05	0.22	0.12
PE-395	N22B	N22C	90	200	DCI	3.64	0.01	0.15	0.12
PE-44	N7B	N7C	134	100	DCI	2.83	0.37	2.74	0.36
PE-196	N39A2	N39A3	149	300	PVC	36.53	0.2	1.36	0.52
PE-103	N31A	N31B	230	150	DCI	2.39	0.06	0.28	0.14
PE-95	N30A5	N30A6	12	500	DCI	-211.66	0.04	3.17	1.08
PE-266	N44A1	N44	49	400	DCI	70.31	0.06	1.23	0.56
PE-403	N57	N57A	182	200	DCI	3.4	0.02	0.13	0.11
P-1782	J-1547	J-1570	819	600	DCI	409.95	3.64	4.45	1.45
PE-483	N105A	N105	283	200	DCI	-10.83	0.32	1.12	0.34

PE-30	N7A	N7A1	109	80	DCI	2.98	0.98	8.93	0.59
PE-222	N36	N43B	321	300	PVC	21.64	0.16	0.51	0.31
PE-445	N102A	N71	215	150	DCI	5.87	0.32	1.46	0.33
PE-467	N100U1	N100U2	301	300	DCI	-83.76	2.07	6.87	1.18
PE-219	N36A1	N36A2	427	200	PVC	-3.62	0.06	0.13	0.12
PE-137	N12A4	N12	351	300	PVC	40.53	0.58	1.64	0.57
PE-211	N38A1	N38A2	60	150	DCI	-2.56	0.02	0.31	0.14
PE-312	N52'	N51A	206	80	DCI	-0.69	0.12	0.6	0.14
PE-373	N54C	N54B1	217	80	DCI	2.41	1.31	6.03	0.48
PE-149	N15F1	N15F2	143	150	DCI	5.75	0.2	1.41	0.33
PE-478	N105A1	N105A2	69	80	DCI	2.38	0.4	5.9	0.47
PE-369	N56B	N56B1	122	150	DCI	3.69	0.08	0.62	0.21
ED-42	ND-36	ND-39	732	150	DCI	1.52	0.09	0.12	0.09
PE-97	N30	N30A7	170	200	PVC	-8.58	0.11	0.67	0.27
PE-85	N22A1	N22A2	311	200	PVC	-5.94	0.11	0.34	0.19
PE-248	N30A5	N30A3	128	300	DCI	-9.78	0.02	0.13	0.14
PE-40	N7A	N7	124	100	DCI	-3.2	0.43	3.44	0.41
PE-34	N4	N4A	223	150	DCI	17.18	2.39	10.7	0.97
EG-59	NG-01	NG-21	58	150	DCI	7.89	0.15	2.53	0.45
PE-17	N6C	N3B	127	100	DCI	-2.6	0.3	2.33	0.33
PE-198	N39A4	N39A5	201	300	PVC	33.53	0.23	1.16	0.47
PE-228	N35A	N43B3	123	300	PVC	-15.36	0.03	0.27	0.22
P-1838	J-1624	J-1609	181	200	DCI	5.24	0.05	0.29	0.17
P-1789	J-1562	J-1550	122	600	DCI	409.95	0.54	4.45	1.45
PE-239	N35	N46A1	386	150	DCI	0.95	0.02	0.05	0.05
PE-303	N52D	N53B	365	150	DCI	-8.87	1.15	3.14	0.5
PE-241	N43A2	N43A3	211	150	DCI	11.54	1.08	5.12	0.65
PE-498	N67	N67A	49	80	DCI	1.37	0.1	2.1	0.27
ED-53	ND-31	ND-46	694	65	DCI	1.81	6.76	9.73	0.55
EG-72	NG-33	NG-34	91	80	DCI	-0.14	0	0.03	0.03
EG-08	NG-60	NG-61	86	150	DCI	26.08	1.99	23.18	1.48
PE-462	N106	N106A	399	200	PVC	5.82	0.13	0.33	0.19
PE-436	N71BC	N71D	214	150	DCI	1.33	0.02	0.09	0.08
PE-220	N36A2	N14	289	200	PVC	-5.24	0.08	0.27	0.17
PE-505	N68A2	N68A3	190	100	DCI	-4.01	0.99	5.22	0.51
ED-26	ND-20	ND-06	125	300	DCI	95.43	1.09	8.75	1.35
PE-306	N47A3	N47A1	87	100	DCI	-2.86	0.24	2.79	0.36
ED-51	ND-34	ND-45	634	65	DCI	1.29	3.31	5.21	0.39
EG-80	NG-02	NG-49	57	100	DCI	3.29	0.21	3.61	0.42
PE-447	N111A	N111A'	89	150	DCI	3.05	0.04	0.43	0.17
PE-65	N17A	N17	205	150	DCI	4.05	0.15	0.74	0.23
ED-25	ND-19	ND-20	120	300	DCI	95.43	1.05	8.75	1.35
PE-186	N39A	N39B1	568	400	DCI	103.4	1.42	2.5	0.82
PE-360	N55A	N54E2	119	50	DCI	1	1.38	11.61	0.51
EG-67	NG-28	NG-29	68	80	DCI	1.68	0.21	3.1	0.34
PE-231	N43B5	N43B6	44	150	DCI	3.04	0.02	0.43	0.17
ED-43	ND-39	ND-37	730	100	DCI	0.41	0.06	0.08	0.05

PE-147	N15A1	N15F	271	600	DCI	-310.16	0.72	2.65	1.1
ED-08	ND-24	ND-26	181	300	DCI	96.25	1.61	8.89	1.36
PE-26	N6A3	N6A4	65	100	DCI	-4.82	0.48	7.34	0.61
PE-160	N15F8	RLU	52	600	DCI	-479.13	0.31	5.94	1.69
PE-157	N15F5	N15F6	34	600	DCI	-476.96	0.2	5.89	1.69
PE-132	N15A	N12A	250	200	PVC	5.04	0.06	0.25	0.16
ED-24	ND-25	ND-19	186	300	DCI	95.43	1.62	8.75	1.35
PB-09	BA-04	BA-01	436	80	DCI	0.42	0.1	0.24	0.08
PE-263	N44A	N44	589	150	DCI	-19.35	7.86	13.33	1.09
PE-150	N15F2	N15E	154	150	DCI	5.42	0.2	1.27	0.31
PB-23	BA-08	BA-09	873	150	DCI	53.61	76.84	88.03	3.03
PE-125	N10A2	N10A3	40	300	PVC	58.07	0.13	3.2	0.82
PE-191	N43	N43A	208	400	DCI	84.25	0.36	1.71	0.67
PE-500	N63B'2	N63B'1	209	50	DCI	1.02	2.54	12.15	0.52
P-1952	J-1725	N68D1	24	300	DCI	98.34	0.22	9.25	1.39
PE-227	N43B4	N43B3	104	300	PVC	15.84	0.03	0.29	0.22
PE-92	N30	N30A1	39	500	DCI	228.14	0.14	3.65	1.16
PE-141	N15A1	N15D	114	300	PVC	43.18	0.21	1.85	0.61
EG-58	NG-20	NG-01	27	150	DCI	8.2	0.07	2.5	0.46
EG-02	NG-54	NG-53	18	150	DCI	30.45	0.56	30.89	1.72
PE-104	N31B	N16A1	185	80	DCI	2.46	1.15	6.23	0.49
PE-33	N6	N4	172	100	DCI	-4.05	0.91	5.3	0.52
PE-509	N103	N72	319	300	DCI	-98.34	2.95	9.25	1.39
EG-56	NG-48	NG-47	142	50	DCI	0.63	0.71	5	0.32
PE-185	N39	N39A	311	500	DCI	143.9	0.48	1.56	0.73
PE-264	N44	N44B	364	200	PVC	7.22	0.18	0.48	0.23
PE-491	N103C2	N103D	23	100	DCI	0.28	0	0.03	0.04
PE-221	N36A	N43B1	314	200	PVC	1.9	0.01	0.04	0.06
PE-345	N54	N54F	164	500	DCI	181.97	0.39	2.4	0.93
PE-181	N81F	N81E	259	80	DCI	-0.71	0.16	0.63	0.14
PE-69	N21	N18B	361	50	DCI	0.71	2.2	6.11	0.36
PE-14	N3H	N3F	220	80	DCI	-4.96	5.04	22.87	0.99
PE-206	N39B4	N39B5	72	80	DCI	-0.81	0.06	0.8	0.16
PE-124	N10A1	N10A2	96	300	PVC	58.21	0.31	3.21	0.82
PE-58	N18C	N18A	311	50	DCI	-0.5	0.98	3.17	0.25
PE-09	N3J1	N3H	290	80	DCI	-1.74	0.95	3.29	0.35
PE-02	N3C	N3G	874	40	DCI	0.91	25.47	29.13	0.73
PE-54	N6B4	N9B1	285	80	DCI	-2.21	1.46	5.12	0.44
EG-90	NG-47	NG-40	55	50	DCI	0.26	0.05	0.99	0.13
PE-282	N32	N32A1	168	200	PVC	9.47	0.13	0.8	0.3
PE-339	N28B1	N28B1'	40	500	DCI	219.57	0.14	3.4	1.12
PE-424	N61A	N54D'	196	100	DCI	-3.56	0.82	4.17	0.45
PE-284	N32A	N53A	233	200	PVC	8.24	0.14	0.62	0.26
PE-99	N31C	N31D1	218	150	DCI	9.67	0.81	3.69	0.55
PE-39	N7C	N7D	261	100	DCI	2.23	0.46	1.76	0.28
ED-30	ND-01	ND-02	3	300	DCI	95.43	0.03	8.74	1.35
ED-49	ND-47	ND-40	692	100	DCI	1.26	0.42	0.61	0.16

EG-15	NG-65	NG-68	130	150	DCI	24.67	2.72	20.91	1.4
PE-203	N39B	N39B2	136	80	DCI	1.62	0.39	2.87	0.32
PE-197	N39A3	N39A4	216	300	PVC	35.88	0.28	1.31	0.51
PE-269	N46B	N47A	217	300	PVC	22.17	0.12	0.54	0.31
EG-75	NG-36	NG-90	56	80	DCI	0.75	0.04	0.69	0.15
PE-277	N51B	N47C	603	100	DCI	-5.9	6.43	10.66	0.75
P-1834	J-1613	J-1620	141	200	DCI	5.24	0.04	0.29	0.17
PB-11	BA-07	BA-05	753	200	DCI	5.76	0.26	0.35	0.18
P-1840	J-1609	J-1610	19	200	DCI	5.24	0.01	0.29	0.17
PE-189	N38A	N42	355	400	DCI	100.48	0.84	2.37	0.8
EG-77	NG-35	NG-50	133	100	DCI	-1.92	0.18	1.33	0.24
PE-79	N22E	N18B	418	100	DCI	-2.32	0.79	1.89	0.3
PE-278	N51B	N50	317	80	DCI	7.14	14.23	44.93	1.42
ED-05	ND-05	ND-11	62	300	DCI	96.25	0.55	8.89	1.36
PE-517	N69A1	N69A2	195	100	DCI	5.06	1.56	8	0.64
PE-267	N44	N46	469	400	DCI	42.23	0.22	0.48	0.34
PE-12	N3H2	N3H3	87	50	DCI	0.41	0.19	2.19	0.21
PE-72	N20	N19	384	100	DCI	-3.89	1.9	4.93	0.5
P-1773	J-1541	J-1542	10	600	DCI	409.95	0.04	4.45	1.45
PE-129	N12	N11	436	300	PVC	50.94	1.1	2.51	0.72
PE-458	N106A	N102	253	200	PVC	4.42	0.05	0.2	0.14
PE-182	N81D1	N81F	274	80	DCI	-0.72	0.18	0.64	0.14
PE-513	N67A2	N67A1	109	150	DCI	5.81	0.16	1.44	0.33
PE-344	N29B	N54	318	500	DCI	186.02	0.8	2.5	0.95
PE-441	N71	N71'	417	150	DCI	3.66	0.25	0.61	0.21
PE-101	N31D	N30A7	199	200	PVC	6.23	0.07	0.37	0.2
PE-272	N47C	N47B	104	80	DCI	-1.45	0.24	2.36	0.29
EG-05	NG-57	NG-59	108	150	DCI	27.15	2.7	24.97	1.54
PE-183	N81D	N81D1	290	50	DCI	-0.32	0.4	1.39	0.16
ED-54	ND-45	ND-46	150	50	DCI	1.36	3.09	20.53	0.69
P-811	N3B	ILEBO-23	232	100	DCI	1.91	0.31	1.32	0.24
PE-326	N65C	N47A3	148	100	DCI	-2.26	0.27	1.8	0.29
PE-179	N81B	N81B1	236	80	DCI	1.55	0.62	2.65	0.31
PE-249	N30A3	N30A4	107	300	DCI	-10.3	0.02	0.14	0.15
PE-409	N24E	N24C	175	200	DCI	0.34	0	0	0.01
PE-218	N36A	N36A1	426	200	PVC	-1.61	0.01	0.03	0.05
PE-314	N51A	N47A4	135	100	DCI	-2.14	0.22	1.63	0.27
ED-46	ND-42	ND-44	271	50	DCI	0.42	0.64	2.36	0.22
PE-431	N63A1	N54B1'	376	200	DCI	-3.35	0.05	0.13	0.11
PE-258	N44A	N44B1	139	80	DCI	1.77	0.47	3.4	0.35
PE-317	N64A1	N52'	233	100	DCI	-1.38	0.17	0.73	0.18
EG-94	NG-51	NG-42	34	200	DCI	-25.6	0.19	5.52	0.81
PB-13	BA-05	BA-06	447	100	DCI	1.46	0.36	0.81	0.19
PE-52	N6B2	N6B3	192	80	DCI	-1.7	0.6	3.15	0.34
PE-53	N6B3	N6B4	139	80	DCI	-1.87	0.52	3.76	0.37
PE-193	N43A1	N44A1	265	400	DCI	70.63	0.33	1.23	0.56
PE-365	N54E	N54D	166	150	DCI	5.82	0.24	1.44	0.33

PE-459	N102	N102A	343	150	DCI	3.24	0.17	0.49	0.18
EG-03	NG-55	NG-57	83	150	DCI	28	2.18	26.43	1.58
PE-15	N3F	N3E	403	80	DCI	3.64	5.2	12.92	0.72
PB-21	BO-07	BO-06	261	250	DCI	53.61	22.97	88.03	2.03
ED-45	ND-42	ND-43	107	80	DCI	1.68	0.33	3.07	0.33
PE-66	N17	N17B	375	100	DCI	2	0.54	1.43	0.25
P-1837	J-1629	J-1624	215	200	DCI	5.24	0.06	0.29	0.17
PE-300	N52C	N53A1	216	80	DCI	-2.57	1.47	6.8	0.51
PE-494	N107'	N108A	240	150	DCI	0.38	0	0.01	0.02
ED-37	ND-31	ND-32	120	250	PVC	15.62	0.08	0.68	0.32
PE-376	N55	N27B2	282	200	PVC	3.23	0.03	0.11	0.1
PE-333	N64B1	N64A	214	50	DCI	-0.69	1.24	5.81	0.35
PE-217	N36	N36A	179	80	DCI	1.68	0.55	3.09	0.33
EG-21	NG-71	NG-75	151	150	DCI	24.67	3.16	20.91	1.4
PE-04	N3E	N3D	861	50	DCI	-1.58	23.35	27.12	0.8
P-1819	N50	ILWA-01	270	150	DCI	2.15	0.06	0.23	0.12
PE-343	N29A"	N29B	214	500	DCI	192.66	0.57	2.67	0.98
PE-290	N32B	N29	130	100	DCI	5.5	1.22	9.34	0.7
PE-457	N106A	N106A'	132	200	PVC	0.45	0	0	0.01
PE-254	N45'	N45'A	193	50	DCI	-0.7	1.15	5.97	0.35
PE-389	N57	N27C	256	200	PVC	-3.45	0.03	0.12	0.11
PE1-450	IAU-01	N78	226	100	DCI	0.15	0	0.01	0.02
EG-35	NG-83	NG-89	212	150	DCI	24.67	4.44	20.91	1.4
PE-114	N14	N11A	224	200	PVC	11.81	0.27	1.21	0.38
PE-501	N63B'1	N63B'	36	50	DCI	0.51	0.12	3.4	0.26
PE-42	N7AB1	N7AB	173	200	DCI	-11.11	0.2	1.18	0.35
PE-391	N27C	N22	82	80	DCI	-0.76	0.06	0.7	0.15
PE-144	N15A	N15B2	259	200	DCI	-7.14	0.13	0.52	0.23
PE-28	N6	N7D	141	150	DCI	-1.28	0.01	0.09	0.07
PE-210	N38A	N38A1	160	150	DCI	-2.88	0.06	0.39	0.16
PE-41	N7	N7AB1	117	200	DCI	-10.63	0.13	1.08	0.34
PE-45	N7B	N7B1	159	200	PVC	-15.14	0.3	1.91	0.48
PE-385	N55A'	N55B	260	80	DCI	0.78	0.19	0.75	0.16
ED-31	ND-03	ND-27	367	300	DCI	95.43	3.21	8.75	1.35
PE-175	N81C2	N81C1	117	80	DCI	0.68	0.07	0.58	0.14
EG-96	NG-43	NG-44	368	200	DCI	-26.26	2.13	5.78	0.84
PE-474	N105C	N105C'	449	80	DCI	2.24	2.35	5.23	0.44
P-1772	J-1542	J-1543	11	600	DCI	409.95	0.05	4.45	1.45
PE-421	N61	N56A1	195	100	DCI	-2.94	0.57	2.94	0.37
PE-76	N21B	N21C	163	80	DCI	1.8	0.57	3.49	0.36
P-1771	J-1543	J-1569	418	600	DCI	409.95	1.86	4.45	1.45
PE-118	N11A2	N11	107	80	DCI	-0.64	0.06	0.51	0.13
PE-481	N105A4	N105D	103	80	DCI	0.62	0.05	0.49	0.12
PE-279	N50	N48	519	100	DCI	2.76	1.36	2.61	0.35
PE-166	N82C	N82D	74	500	DCI	146.57	0.12	1.61	0.75
P-1835	J-1620	J-1631	240	200	DCI	5.24	0.07	0.29	0.17
EG-66	NG-27	NG-28	110	80	DCI	2.04	0.49	4.44	0.41

PE-174	N81C3	N81C2	26	80	DCI	0.98	0.03	1.14	0.2
PE-510	N68D	N67A4	71	150	DCI	7.68	0.17	2.41	0.43
PE-327	N47A1	N47A2	150	100	DCI	2.98	0.45	3.01	0.38
P-1209	J-1007	FCV-K02	24	350	DCI	165.58	0.58	24.28	2.34
PE-397	N24	N24A	337	200	DCI	2.8	0.03	0.09	0.09
PE-127	N14	N13	433	600	DCI	-248.99	0.76	1.77	0.88
PE-516	N69A	N69A1	178	100	DCI	5.23	1.52	8.52	0.67
PB-10	BA-03	BA-06	808	100	DCI	-0.99	0.32	0.39	0.13
PE-136	N12A3	N12A4	79	300	PVC	40.74	0.13	1.66	0.58
P-1833	J-1608	J-1613	58	200	DCI	5.73	0.02	0.35	0.18
EG-27	NG-77	NG-79	52	150	DCI	24.67	1.1	20.91	1.4
PE-178	N81E	N81B	322	80	DCI	-1.75	1.07	3.32	0.35
PE-315	N29B'	N54A1	239	200	PVC	7.75	0.13	0.55	0.25
PE-173	N81A1	N81C3	459	80	DCI	1.56	1.23	2.69	0.31
PE-142	N15D	N15C	86	300	PVC	47.51	0.19	2.21	0.67
PE-305	N47A4	N47A3	83	100	DCI	-0.32	0	0.05	0.04
PE-139	N15B	N15B1	177	600	DCI	-260.47	0.34	1.92	0.92
PE-243	N43A4	N43A5	333	150	DCI	23.2	6.21	18.66	1.31
PE-366	N56	N56B	15	200	PVC	3.89	0	0.15	0.12
PE-468	N100R1	N100U1	203	300	DCI	-83.76	1.4	6.87	1.18
PE-148	N15F	N15F1	59	150	DCI	6.25	0.1	1.65	0.35
EG-07	NG-59	NG-60	57	150	DCI	26.08	1.32	23.18	1.48
P-1791	J-1551	J-1554	62	600	DCI	409.95	0.27	4.45	1.45
PE-381	N27A1	N27A	68	300	PVC	11.21	0.01	0.15	0.16
P-1787	J-1568	J-1567	429	600	DCI	409.95	1.91	4.45	1.45
EG-64	NG-25	NG-26	116	150	DCI	6.13	0.18	1.58	0.35
EG-18	NG-68	NG-69	28	150	DCI	24.67	0.59	20.91	1.4
PE-420	N58A2	N61	540	150	DCI	1.39	0.06	0.1	0.08
PE-348	N54A	N54B1	158	500	DCI	193.67	0.42	2.7	0.99
PE-115	N11A	N11A1	108	80	DCI	1.24	0.19	1.77	0.25
PE-519	N62	N68C	291	400	DCI	185.67	2.15	7.39	1.48
PE-171	N81A	N81B	100	100	DCI	3.85	0.48	4.83	0.49
PE-117	N11A1	N11A2	121	80	DCI	-0.32	0.02	0.14	0.06
PB-05	BA-05	BA-10	275	100	DCI	2.47	0.58	2.12	0.31
PE-168	N82E	N82F	119	500	DCI	145.98	0.19	1.6	0.74
PE-252	N30A9	N31	61	300	DCI	-11.91	0.01	0.19	0.17
PE-255	N45'A	N45	313	50	DCI	-1.39	6.74	21.54	0.71
PE-464	N100R6	N100R5	123	300	DCI	83.76	0.85	6.87	1.18
PE-162	N82	N81	526	600	DCI	157	0.4	0.75	0.56
PE-123	N10	N10A1	113	300	PVC	58.4	0.37	3.23	0.83
PE-396	N22C	N24	301	200	DCI	4.43	0.06	0.21	0.14
ED-09	ND-26	ND-29	262	300	DCI	96.25	2.33	8.89	1.36
ED-29	ND-02	ND-03	23	300	DCI	95.43	0.2	8.75	1.35
PE-463	N101	N100R6	191	300	DCI	83.76	1.32	6.87	1.18
PE-122	N10	N16A	486	80	DCI	0.71	0.3	0.62	0.14
ED-16	ND-13	ND-08	81	300	DCI	95.64	0.71	8.79	1.35
P-1792	J-1554	J-1555	403	600	DCI	409.95	1.79	4.45	1.45

P-1844	NN-02	J-1616	90	150	DCI	3.24	0.04	0.49	0.18
P-1786	J-1564	J-1565	309	600	DCI	409.95	1.37	4.45	1.45
PE-347	N54B	N54A	118	500	DCI	190.08	0.31	2.6	0.97
PE-187	N39B1	N39B	178	400	DCI	101.4	0.43	2.41	0.81
PE-48	N8	N8A	23	300	PVC	23.11	0.01	0.58	0.33
PE-335	N65B	N65	89	100	DCI	0.23	0	0.03	0.03
PE-11	N3H1	N3H2	85	50	DCI	0.68	0.49	5.75	0.35
PE-216	N42	N36	333	80	DCI	-1.68	1.03	3.09	0.33
PE-83	N22D2	N22A	60	200	PVC	-4.16	0.01	0.18	0.13
P-1780	J-1571	J-1558	1656	600	DCI	409.95	7.37	4.45	1.45
P-1775	J-1545	J-1553	215	600	DCI	409.95	0.95	4.45	1.45
PE-497	N67E1	N67	383	150	DCI	-3.05	0.17	0.43	0.17
P-1777	J-1563	J-1544	275	600	DCI	409.95	1.22	4.45	1.45
PE-507	N68C	N68D	182	400	DCI	180.22	1.27	7	1.43
PE-489	N103C	N103C1	91	100	DCI	0.85	0.03	0.3	0.11
EG-69	NG-30	NG-31	57	80	DCI	0.88	0.05	0.93	0.18
PE-492	N103C	N107	150	200	PVC	1.05	0	0.01	0.03
PE-235	N33	N46A2	270	150	DCI	-4.9	0.28	1.05	0.28
PE-486	N103A	N103	244	300	DCI	-94.83	2.11	8.65	1.34
PE-503	N68	N68A1	134	100	DCI	-1.85	0.17	1.24	0.24
PE-77	N21C	N21D	190	80	DCI	0.9	0.18	0.97	0.18
EG-31	NG-79	NG-83	185	150	DCI	24.67	3.87	20.91	1.4
PE-285	N53A	N53A1	16	80	DCI	4.17	0.27	16.64	0.83
PE-450	IAU-01	N70'	206	100	DCI	-1.05	0.09	0.44	0.13
PE-340	N28B1'	N29A	86	500	DCI	193.16	0.23	2.68	0.98
PE-427	N54B1'	N62	199	400	DCI	179.41	1.38	6.94	1.43
PE-90	N30A	N28B1	96	500	DCI	227.38	0.35	3.63	1.16
PE-84	N22A	N22A1	53	200	PVC	-4.47	0.01	0.2	0.14
PE-423	N61	N61A	266	150	DCI	2.11	0.06	0.22	0.12
PE-31	N7A1	N6B	356	80	DCI	2.86	2.95	8.28	0.57
PE-240	N43A1	N43A2	404	150	DCI	12.1	2.26	5.59	0.68
P-1210	FCV-K02	K02-Tank	6	400	DCI	165.58	0.15	24.29	2.34
EG-70	NG-31	NG-32	24	80	DCI	0.6	0.01	0.46	0.12
PE-128	N13	N12	347	300	PVC	11.65	0.06	0.16	0.16
ED-48	ND-47	ND-38	276	100	DCI	0.21	0.01	0.02	0.03
PE-323	N64D	N64E	209	80	DCI	-2.08	0.95	4.57	0.41
PE-199	N39A5	N39A6	195	300	PVC	32.87	0.22	1.11	0.46
PE-74	N20A	N20B	148	50	DCI	-0.59	0.65	4.39	0.3
PE-109	N14B	N31B	241	80	DCI	0.82	0.2	0.81	0.16
PE-229	N35	N35A	80	200	PVC	0.92	0	0.01	0.03
PE-86	N22A2	N22A3	70	200	PVC	-6.45	0.03	0.39	0.21
P-1832	J-1016	J-1608	18	200	DCI	5.73	0.01	0.34	0.18
PE-155	N15F3	N15F4	73	600	DCI	-317.36	0.2	2.77	1.12
PE-414	N24E2	N24B	199	80	DCI	-0.31	0.03	0.13	0.06
PE-412	N24C	N24D	192	50	DCI	0.18	0.09	0.48	0.09
EG-44	NG-11	NG-12	45	150	DCI	15.22	0.38	8.55	0.86
EG-50	NG-16	NG-17	263	100	DCI	5.98	2.87	10.92	0.76

PE-232	N43B4	N43B5	53	150	DCI	3.62	0.03	0.6	0.2
PE-251	N30A8	N30A9	148	300	DCI	-11.25	0.02	0.17	0.16
ED-52	ND-33	ND-45	647	80	DCI	2.28	3.53	5.45	0.45
PE-170	N81	N81A	100	100	DCI	5.98	1.09	10.93	0.76
PE-180	N81B1	N81F	344	80	DCI	1.25	0.61	1.77	0.25
PE-177	N81E	N81C	142	50	DCI	0.44	0.37	2.59	0.23
PE-169	N82F	N39	121	500	DCI	145.74	0.19	1.59	0.74
PE-126	N10A3	N9	136	300	PVC	57.14	0.42	3.11	0.81
PE-383	N27B	N27B3	25	200	PVC	8.3	0.02	0.63	0.26
PE-351	N28A"	N28AA	155	300	DCI	12.09	0.03	0.19	0.17
PE-167	N82D	N82E	25	500	DCI	146.43	0.04	1.6	0.75
PE-110	N14B	N14B1	197	80	DCI	1.2	0.32	1.65	0.24
ED-27	ND-06	ND-07	40	300	DCI	95.43	0.35	8.75	1.35
EG-73	NG-34	NG-35	97	80	DCI	-0.61	0.05	0.48	0.12
PE-515	N68D	N69A	134	100	DCI	5.4	1.21	9.05	0.69
PE-57	N9B	N18C	302	50	DCI	0.51	1	3.32	0.26
PE-506	N68A3	N68C	109	100	PVC	-4.33	0.66	6.02	0.55
PQS-15	J 1	J 2	7	600	PVC	409.95	0.03	4.46	1.45
PE-378	N27B1	N27B	146	200	PVC	1.68	0	0.03	0.05
PE-250	N30A4	N30A8	119	300	PVC	-10.7	0.02	0.15	0.15
PE-338	N64B	N54A	144	150	PVC	4.02	0.1	0.73	0.23
PE-428	N68C1	N62	380	80	DCI	1.46	0.91	2.38	0.29
P-1798	J-1548	J-1549	32	600	DCI	409.95	0.14	4.45	1.45
EG-52	NG-45	NG-18	34	100	DCI	2.82	0.09	2.73	0.36
PE-214	N38B	N37	260	300	PVC	-31.31	0.27	1.02	0.44
PE-194	N39A	N39A1	259	300	PVC	39.21	0.4	1.55	0.55
ED-14	ND-21	ND-18	122	300	DCI	96.25	1.08	8.89	1.36
PE-05	N3G	N3J	292	50	DCI	0.35	0.5	1.7	0.18
PE-10	N3H	N3H1	52	50	DCI	1.95	2.09	40.13	0.99
P-1793	J-1555	J-1556	69	600	DCI	409.95	0.31	4.45	1.45
PE-302	N52B'	N52D	132	150	DCI	-6.12	0.21	1.58	0.35
ED-40	ND-34	ND-35	257	200	DCI	5.15	0.07	0.28	0.16
PE-78	N20B	N22E	263	80	DCI	-1.51	0.67	2.55	0.3
PE-270	N47A	N47	251	300	DCI	21.15	0.13	0.54	0.3
ED-32	ND-27	ND-14	193	300	DCI	95.43	1.69	8.75	1.35
PE-188	N39B	N38A	210	400	DCI	98.98	0.48	2.31	0.79
PE-291	N29	N29A1	113	100	DCI	5.39	1.02	9.01	0.69
EG-51	NG-17	NG-45	30	100	DCI	3.74	0.14	4.57	0.48
PE-253	N31	N33	249	150	DCI	-12.49	1.47	5.93	0.71
PE-330	N65C	N47A2	88	100	PVC	-1.33	0.06	0.67	0.17
PE-297	N29A3	N52A	345	200	PVC	-0.72	0	0.01	0.02
P-1784	J-1566	J-1568	730	600	DCI	409.95	3.25	4.45	1.45
PE-201	N37	N39A7	134	80	DCI	0.61	0.06	0.48	0.12
PE-405	N59A	N59	249	50	DCI	0.2	0.15	0.61	0.1
PE-480	N105A3	N105A4	626	80	DCI	0.9	0.61	0.98	0.18
PE-163	N81	N82A	551	500	DCI	151.02	0.94	1.7	0.77
PE-13	N3H3	N3I	89	50	DCI	0.13	0.02	0.26	0.07

PE-406	N57A'	N59A	256	200	DCI	2.51	0.02	0.07	0.08
P-1785	J-1565	J-1566	352	600	DCI	409.95	1.56	4.45	1.45
P-1836	J-1631	J-1629	325	200	DCI	5.24	0.1	0.29	0.17
ED-39	ND-33	ND-34	284	200	DCI	8.87	0.22	0.78	0.28
PE-473	N105C'	N106B	690	80	DCI	2.24	3.61	5.23	0.44
PE-111	N14B1	N14B2	80	80	DCI	0.8	0.06	0.77	0.16
PE-451	N111C	N78	206	50	DCI	0.26	0.19	0.94	0.13
P-1800	J-1560	J-1557	77	600	DCI	409.95	0.34	4.45	1.45
PE-192	N43A	N43A1	203	400	DCI	84.12	0.35	1.71	0.67
P-1953	N68D1	N72	48	300	DCI	98.34	0.45	9.25	1.39
PE-342	N29A'	N29A"	42	500	DCI	192.82	0.11	2.67	0.98
PE-346	N54F	N54B	84	500	DCI	190.08	0.22	2.6	0.97
PE-259	N44B1	N44B2	86	80	DCI	-0.23	0.01	0.08	0.05
PE-121	N10A	N10	213	300	PVC	59.27	0.71	3.32	0.84
PE-499	N67A	N63B'2	42	50	DCI	1.29	0.78	18.58	0.66
PE-324	N64E	N51A	149	150	DCI	-3.31	0.08	0.51	0.19
ED-20	ND-12	ND-23	228	300	DCI	95.64	2.01	8.79	1.35
EG-79	NG-27	NG-02	79	100	DCI	3.71	0.36	4.51	0.47
PE-453	N111	N111A	333	100	DCI	0.25	0.01	0.03	0.03
PE-24	N6A1	N6A2	102	100	DCI	-4.47	0.65	6.38	0.57
P-1847	NNL-03	J-1618	126	150	DCI	2.8	0.05	0.37	0.16
PE-209	N39B6	N38A1	66	80	DCI	0.76	0.05	0.71	0.15
PB-02	BO-02	BO-03	442	200	DCI	6.71	0.2	0.46	0.21
EG-61	NG-22	NG-23	66	150	DCI	7.11	0.14	2.09	0.4
ED-19	ND-10	ND-12	73	300	DCI	95.64	0.64	8.79	1.35
P-812	N42	ILWBO1	393	100	DCI	1.29	0.25	0.64	0.16
EG-55	NG-16	NG-48	32	50	DCI	1.28	0.59	18.4	0.65
PE-208	N39B5	N39B6	53	80	PVC	0.93	0.06	1.04	0.19
PE-316	N54A1	N64A1	112	200	PVC	2.43	0.01	0.07	0.08
PE-94	N30A2	N30A5	117	500	PVC	-220.96	0.4	3.44	1.13
PE-120	N11	N10A	204	300	PVC	60.18	0.7	3.42	0.85
PE-06	N3J	N3I	276	50	DCI	-0.53	1.01	3.65	0.27
ED-38	ND-32	ND-33	43	200	DCI	12.74	0.06	1.51	0.41
P-1843	J-1616	NNL-03	675	150	DCI	3.24	0.33	0.49	0.18
P-1207	N15B1	J-1016	206	600	DCI	-260.76	0.4	1.92	0.92
PE-23	N6A	N6A1	153	100	DCI	-4.15	0.85	5.56	0.53
PE-138	N15	N15B	167	600	DCI	-260.47	0.32	1.92	0.92
P-1779	J-1558	J-1559	70	600	DCI	409.95	0.31	4.45	1.45
PE-238	N35A	N46A2	433	300	PVC	5.58	0.02	0.04	0.08
PE-337	N65A	N63A	515	50	DCI	0.42	1.2	2.34	0.21
PE-482	N105D	N105C	237	100	DCI	-0.22	0.01	0.02	0.03
EG-57	NG-09	NG-20	54	150	DCI	-16.11	0.51	9.5	0.91
PE-294	N53'	N53A	209	100	DCI	-3.58	0.88	4.22	0.46
PB-12	BA-04	BA-03	409	100	DCI	-0.17	0.01	0.01	0.02
PE-371	N54C	N54D	273	80	DCI	-0.21	0.02	0.07	0.04
PE-205	N39B2	N39B4	81	80	DCI	-0.31	0.01	0.14	0.06
PB-22	BA-09	BO-07	182	200	DCI	53.61	16.02	88.03	2.03

PE-62	N18	N9	715	200	PVC	-16.27	1.56	2.18	0.52
PE-213	N38A3	N38B	179	150	DCI	-4.53	0.16	0.91	0.26
PE-313	N51A	N52B'	242	150	DCI	-2.33	0.06	0.26	0.13
ED-18	ND-09	ND-10	44	300	DCI	95.64	0.39	8.79	1.35
PE-223	N43B	N43A	330	50	DCI	0.6	1.5	4.53	0.31
PE-19	N3B1	N3B2	188	80	DCI	1.6	0.53	2.81	0.32
P-1797	J-1549	J-1552	42	600	DCI	409.95	0.19	4.45	1.45
P-1839	J-1610	J-1626	351	200	DCI	5.24	0.1	0.29	0.17
EG-01	NG-55	NG-53	121	150	DCI	-30.45	3.75	30.88	1.72
PE-359	N55A	N55	11	300	PVC	11.04	0	0.15	0.16
PE-407	N59A	N24	248	80	DCI	-0.25	0.02	0.09	0.05
EG-49	NG-16	NG-38	281	50	DCI	1.24	4.87	17.36	0.63
PE-413	N24D	N24E1	191	80	DCI	0.07	0	0.01	0.01
PE-61	N18A	N18	364	150	DCI	-7.57	0.86	2.35	0.43
PE-475	N105C	N105C1	357	100	DCI	-3.43	1.39	3.89	0.44
PE-03	N3G	N3E	434	50	DCI	-0.77	3.14	7.25	0.39
PE-352	N28A	N28AA	68	50	DCI	-0.2	0.04	0.6	0.1
P-1173	J 2	J-1541	6	600	DCI	409.95	0.03	4.44	1.45
EG-88	NG-50	NG-39	223	80	DCI	0.16	0.01	0.04	0.03
PE-350	N28B1'	N28A"	279	300	PVC	26.16	0.2	0.73	0.37
PE-37	N4	N5A	103	200	PVC	-21.8	0.42	4.1	0.69
PE-51	N6B1	N6B2	182	80	PVC	-1.08	0.25	1.36	0.21
PE-234	N34	N33	565	300	PVC	8.77	0.05	0.1	0.12
PE-207	N39B5	N39A7	96	80	DCI	-1.96	0.39	4.09	0.39
PE-367	N56	N54D	143	100	DCI	3.37	1.6	11.2	0.67
PE-21	N3	N3D	378	100	DCI	6.16	4.36	11.54	0.78
PE-311	N52B	N52'	240	200	PVC	2.01	0.01	0.05	0.06
PE-308	N29B'	N52B	344	200	DCI	-3.24	0.04	0.12	0.1
ED-07	ND-15	ND-24	158	300	DCI	96.25	1.4	8.89	1.36
PE-411	N24D	N24A1	62	100	DCI	-0.32	0.08	1.37	0.16
PE-98	N30A6	N31C	157	500	DCI	-215.3	0.51	3.28	1.1
PE-143	N15C	N2	377	300	PVC	47.3	0.83	2.19	0.67
PE-07	N3I	N3E	87	100	DCI	-1.67	2.63	30.19	0.85
PE-18	N3B	N3B1	477	80	DCI	-6.23	16.66	34.92	1.24
EG-54	NG-38	NG-46	48	50	DCI	0.71	0.3	6.22	0.36
EG-14	NG-64	NG-65	44	150	DCI	24.67	0.91	20.91	1.4
PE-387	N58	N57	262	100	DCI	-1.36	0.19	0.71	0.17
P-1770	J-1569	J-1546	1920	600	DCI	409.95	8.54	4.45	1.45
EG-25	NG-75	NG-77	45	150	DCI	24.67	0.95	20.91	1.4
PE-437	N71B	N71BC	65	150	PVC	1.84	0.01	0.17	0.1
PE-195	N39A1	N39A2	192	300	PVC	37.58	0.28	1.43	0.53
PE-161	N15F5	N82	19	600	PVC	158.07	0.01	0.76	0.56
PE-82	N22D1	N22D2	153	200	PVC	-3.24	0.02	0.11	0.1
PE-370	N56B1	N56A	258	150	PVC	3.4	0.14	0.53	0.19
PE-286	N53A1	N53B	134	100	PVC	1.07	0.18	1.34	0.21
PE-262	N44B4	N44B	344	80	PVC	-4.32	6.12	17.76	0.86
PE-257	N45A'	N44A	330	150	PVC	-16.08	3.12	9.46	0.91

PE-87	N22A3	N22A4	110	200	PVC	-6.85	0.05	0.44	0.22
PE-268	N46	N46B	167	300	PVC	25.64	0.12	0.7	0.36
EG-74	NG-35	NG-36	53	80	DCI	0.97	0.06	1.11	0.19
EG-09	NG-61	NG-64	91	150	DCI	24.67	1.91	20.91	1.4
PE-202	N39A7	N39A4	196	80	DCI	-1.7	0.62	3.15	0.34
PE-261	N44B3	N44B4	326	80	DCI	-2.4	1.94	5.95	0.48
ED-17	ND-08	ND-09	41	300	DCI	95.64	0.36	8.79	1.35
PE-418	N58A1	N56A1	532	150	DCI	-4.64	0.5	0.95	0.26
PE-01	N3D	N3C	312	100	DCI	3.13	1.03	3.29	0.4
PE-96	N30A6	N30A7	127	100	DCI	3.18	0.43	3.39	0.4
PE-341	N29A	N29A'	94	500	DCI	192.98	0.25	2.68	0.98
PE-429	N68C1	N63B	99	100	DCI	-2.13	0.16	1.62	0.27
PE-233	N35A	N34	245	200	DCI	10.21	0.25	1.01	0.33
PE-425	N54D'	N54B1'	215	200	DCI	-12.46	0.31	1.45	0.4
PE-88	N22A4	N22A5	301	200	PVC	-7.26	0.15	0.49	0.23
ED-28	ND-07	ND-01	43	300	DCI	95.43	0.37	8.75	1.35
PE-275	N47	N47A1	604	150	DCI	7.61	1.43	2.37	0.43
PE-60	N19	N9B	323	150	DCI	-3.91	0.22	0.69	0.22
PE-172	N81A	N81A1	161	80	DCI	1.81	0.57	3.55	0.36
PE-358	N28C	N54E	315	200	DCI	6.34	0.53	1.69	0.36
ED-55	ND-46	ND-41	707	50	DCI	1.14	10.4	14.73	0.58
ED-11	ND-30	ND-28	267	300	DCI	96.25	2.37	8.89	1.36
PE-105	N16A1	N16A	40	80	DCI	1.61	0.11	2.85	0.32
ED-50	ND-47	ND-32	428	100	DCI	-1.51	0.37	0.86	0.19
PE-119	N11	N11A	122	200	PVC	-10.46	0.12	0.96	0.33
P-1794	J-1556	J-1561	134	800	PVC	409.95	0.15	1.1	0.82
PE-456	N106A'	N100U3	202	200	PVC	6.97	0.09	0.45	0.22
P-1795	J-1561	J-1560	91	600	DCI	409.95	0.41	4.45	1.45
PE-334	N64A	N65B	212	80	DCI	-0.32	0.03	0.14	0.06
PE-471	N106	N106B	276	80	DCI	-5.82	8.51	30.82	1.16
PE-362	N54E1	N54E	12	50	DCI	0.31	0.02	1.35	0.16
PE-336	N65	N65A	154	100	DCI	1.18	0.08	0.54	0.15
PE-328	N64E	N64A	215	100	DCI	0.93	0.08	0.35	0.12
EG-60	NG-21	NG-22	81	150	DCI	7.64	0.19	2.38	0.43
PE-449	N70'	N70	28	100	DCI	-0.35	0	0.06	0.04
PE-200	N39A6	N37	95	300	PVC	32.4	0.1	1.09	0.46
ED-22	ND-17	ND-25	179	300	DCI	95.43	1.57	8.75	1.35
EG-53	NG-18	NG-19	26	100	DCI	0.45	0	0.09	0.06
PE-22	N6C	N6A	541	80	DCI	-7.48	26.5	48.96	1.49
PE-399	N24A1	N25A1	101	150	DCI	1.11	0.01	0.07	0.06
PE-318	N52'	N64D	150	50	DCI	0.7	0.91	6.04	0.36
PB-16	BA-07	BO-03	612	200	DCI	-6.39	0.26	0.42	0.20
PE-215	N38B	N36	233	300	PVC	26.07	0.17	0.73	0.37
PE-354	N28A'	N28A"	154	300	PVC	-13.77	0.03	0.22	0.19
PE-102	N31C	N31A	311	600	DCI	-225.92	0.46	1.48	0.8
PE-280	N48	N48B	85	150	DCI	2.2	0.02	0.24	0.12
PE-158	N15F6	N15F7	280	600	DCI	-478.02	1.65	5.91	1.69

PE-296	N29A2	N29A3	9	250	PVC	4.75	0	0.22	0.15
PE-273	N47B	N46B1	470	150	DCI	-1.91	0.09	0.18	0.11
PE-415	N24B	N24E	161	100	DCI	-1.02	0.07	0.41	0.13
PE-386	N55B	N58	265	150	DCI	0.49	0	0.02	0.03
PE-380	N27A2	N27A1	118	300	PVC	11.38	0.02	0.16	0.16
PE-355	N28C	N28A'	136	100	DCI	-0.77	0.98	7.2	0.39
EG-68	NG-29	NG-30	58	80	DCI	1.06	0.08	1.32	0.21
PE-245	N43A4	N43A6	179	150	DCI	-12.8	1.11	6.2	0.72
EG-42	NG-09	NG-10	26	150	DCI	15.96	0.24	9.34	0.9
PE-108	N14A	N14B	227	100	DCI	1.66	0.23	1.02	0.21
PE-73	N20	N20A	296	80	DCI	2.62	2.07	7.01	0.52
P-808	N106A"	N102A	32	200	DCI	5.98	0.01	0.37	0.19
PE-390	N27C	N27B3	251	200	PVC	-3.24	0.03	0.11	0.1
PE-377	N27B2	N27B1	120	200	PVC	2.34	0.01	0.06	0.07
PE-484	N105	N103A	415	300	DCI	-94.59	3.58	8.61	1.34
PE-107	N31A	N14A	239	600	DCI	-229.34	0.36	1.52	0.81
PE-156	N15F4	N15F5	123	600	DCI	-318.6	0.34	2.79	1.13
ED-44	ND-35	ND-42	183	80	DCI	2.51	1.19	6.48	0.5
PE-454	N102	N111	398	80	DCI	0.81	0.32	0.81	0.16
PE-496	N67E	N67E1	135	150	DCI	-1.99	0.03	0.2	0.11
PE-363	N54E	N54	133	50	DCI	0.35	0.22	1.63	0.18
EG-19	NG-69	NG-71	67	150	DCI	24.67	1.4	20.91	1.4
PE-356	N29B	N28C	131	200	PVC	6.14	0.05	0.36	0.2
P-1796	J-1552	RLU	62	600	DCI	409.95	0.27	4.45	1.45
PE-274	N46B1	N46B	285	150	DCI	-2.67	0.1	0.34	0.15
PE-47	N7B2	N8	158	200	PVC	-16.33	0.35	2.2	0.52
PE-63	N9	N8	130	300	PVC	40.03	0.21	1.61	0.57
PE-287	N53B	N47	166	150	DCI	-8.45	0.48	2.87	0.48
PE-288	N47A	N32A	300	80	DCI	0.22	0.02	0.07	0.04
PB-20	BO-06	T.BOK	119	150	DCI	53.61	10.44	88.03	2.51
PE-438	N71C	N71B	180	80	DCI	2.56	1.21	6.73	0.51
EG-63	NG-24	NG-25	48	150	DCI	6.37	0.08	1.7	0.36
PE-439	N109	N71C	298	80	DCI	2.87	2.48	8.31	0.57
PE-244	N43A5	N45A'	87	150	DCI	22.49	1.54	17.62	1.27
PE-25	N6A2	N6A3	230	100	DCI	-4.66	1.59	6.89	0.59
PE-368	N54D	N54F	127	150	DCI	8.54	0.37	2.93	0.48
PE-27	N6A4	N6	47	100	DCI	-5.13	0.38	8.23	0.65
P-1778	J-1559	J-1563	323	600	DCI	409.95	1.44	4.45	1.45
ED-10	ND-29	ND-30	303	300	DCI	96.25	2.69	8.89	1.36
PE-237	N46A1	N44A1	494	50	DCI	0.56	2	4.04	0.29
ED-23	ND-16	ND-17	109	300	DCI	95.43	0.96	8.75	1.35
P-1842	J-1626	NN-01	183	200	DCI	5.24	0.05	0.29	0.17
PE-16	N3F	N6C	189	150	DCI	-9.86	0.72	3.83	0.56
PE-130	N13	N15	810	600	DCI	-260.93	1.56	1.93	0.92
PE-226	N43B	N43B4	208	300	PVC	20.04	0.09	0.45	0.28
EG-47	NG-14	NG-15	82	150	DCI	11.25	0.4	4.88	0.64
PE-190	N42	N43	120	400	DCI	99	0.28	2.31	0.79

P-1781	J-1570	J-1571	1210	600	DCI	409.95	5.38	4.45	1.45
P-1208	J-1016	N15A1	186	600	DCI	-266.49	0.37	2	0.94
PE-416	N57A	N57A'	111	200	PVC	3.02	0.01	0.1	0.1
EG-43	NG-10	NG-11	63	150	DCI	15.64	0.57	8.99	0.89
EG-45	NG-12	NG-13	74	150	DCI	13.48	0.51	6.83	0.76
PE-38	N5A	N7C	163	50	DCI	0.65	0.86	5.29	0.33
PE-310	N52B	N52B'	207	150	DCI	-4.39	0.18	0.85	0.25
PB-24	BO-05	BA-08	131	200	DCI	53.61	11.56	88.03	2.53
PE-448	N70'	N111A'	195	100	DCI	-1.54	0.17	0.89	0.2
PE-151	N15E	N15D2	232	150	DCI	5.1	0.26	1.13	0.29
PE-212	N38A2	N38A3	152	150	DCI	-4.09	0.11	0.75	0.23
PB-06	BA-10	BA-04	458	100	DCI	0.73	0.1	0.22	0.09
PE-165	N82B	N82C	157	500	DCI	148.02	0.26	1.64	0.75
P-1790	J-1550	J-1551	34	600	DCI	409.95	0.15	4.45	1.45
EG-48	NG-15	NG-16	79	150	DCI	10.1	0.32	4	0.57
EG-65	NG-26	NG-27	30	150	DCI	6	0.05	1.52	0.34
PE-71	N18B	N20	311	100	DCI	0.53	0.04	0.12	0.07
PE-504	N68A1	N68A2	134	100	DCI	-2.9	0.38	2.86	0.37
P-1788	J-1567	J-1562	318	600	DCI	409.95	1.41	4.45	1.45
ED-12	ND-28	ND-22	223	300	DCI	96.25	1.98	8.89	1.36
EG-62	NG-23	NG-24	151	150	DCI	6.49	0.27	1.76	0.37
PE-361	N54E2	N54E1	11	50	DCI	0.6	0.05	4.55	0.31
PE-479	N105A2	N105A3	48	80	DCI	2	0.21	4.28	0.4
PE-320	N64A2	N64B	271	100	DCI	2.86	0.76	2.79	0.36
PE-20	N3B1	N3	196	100	DCI	-9.28	4.83	24.63	1.18
ED-21	ND-23	ND-16	139	300	DCI	95.43	1.22	8.75	1.35
PE-230	N43B6	N35	42	150	DCI	2.45	0.01	0.29	0.14
PE-134	N12A1	N12A2	260	300	PVC	42.38	0.46	1.79	0.6
PE-153	N15D1	N15D	98	150	DCI	4.55	0.09	0.91	0.26
PE-46	N7B1	N7B2	50	200	PVC	-15.74	0.1	2.05	0.5
PE-426	N62	N61A	215	150	PVC	-5.15	0.25	1.15	0.29
PE-89	N22A5	N28B1	240	200	PVC	-7.81	0.13	0.56	0.25
PE-401	N25A2	N25A	121	150	DCI	0.29	0	0.01	0.02
PE-293	N32C	N53'	20	100	DCI	-3.11	0.06	3.26	0.4
PE-154	N15F	N15F3	96	600	DCI	-316.91	0.27	2.76	1.12
PE-159	N15F7	N15F8	77	600	DCI	-479.13	0.46	5.94	1.69
PE-307	N29A3	N29B'	153	200	DCI	5.18	0.04	0.29	0.16
PE-256	N45	N45A'	121	200	DCI	-38.22	5.69	47.04	2.16
PE-514	N67A1	N67	45	150	DCI	5.15	0.05	1.15	0.29
PE-164	N82A	N82B	62	500	DCI	149.47	0.1	1.67	0.76
ED-06	ND-11	ND-15	105	300	DCI	96.25	0.93	8.89	1.36
PE-518	N69A2	N69	98	100	DCI	2.26	0.18	1.8	0.29
P-1324	N45	FCV-GA	41	150	DCI	36.83	12.83	316.45	2.69
PE-64	N18	N17A	14	200	PVC	6.63	0.01	0.41	0.21
PB 26	P.BOK 1	BO-05	101	150	DCI	53.61	8.88	88.03	2.30
EG-83	T.AG	PMAG1	8	150	DCI	30.45	0.24	30.88	1.72
EG 84	PMAG1	NG-54	10	150	DCI	30.45	0.3	30.88	1.72

P-1958	J-1011	P.K02 -1	1	250	DCI	98.34	0.07	66.68	2.13
P-1205	P.K02 -1	J-1015	1	300	DCI	98.34	0.07	66.68	2.13
P-1198	J-1724	J-1013	1	350	DCI	98.34	0	4.46	1.02
ED-03	P.k02-4	ND-04	2	200	DCI	96.25	0.13	64.07	1.06
P-767	ND-48	ND-05	25	300	DCI	96.25	1.6	64.08	2.06
P-1199	J-1013	J-1725	31	300	DCI	98.34	2.07	66.69	2.13
PE 508	N68D	J-1010	138	350	DCI	165.58	3.35	24.28	2.34
P-1191	J-1007	J-1010	23	300	DCI	-165.58	0.56	24.28	2.34
P-1200	K02-T.	P.k02-4	22	250	DCI	96.25	1.41	64.07	1.56
P-744	J-1015	J-1012	6	250	DCI	98.34	0.43	66.71	2.13
EG 60	NG-51	NG-20	13	200	PVC	24.49	0.07	5.08	0.78
P-749	J-613	J-612	201	150	PVC	16.63	1.86	9.24	0.94
P-750	J-612	J-611	304	150	PVC	14.99	2.32	7.63	0.85
P-751	J-611	J-610	92	150	PVC	14.99	0.7	7.63	0.85
P-752	J-610	J-609	115	150	PVC	13.41	0.71	6.2	0.76
P-753	J-609	J-614	64	150	PVC	13.41	0.4	6.2	0.76
P-760	J-614	J-615	103	300	DCI	11.76	0.02	0.18	0.17
P-761	N106A'	J-616	376	200	DCI	-6.83	0.18	0.48	0.22
P-762	J-615	J-617	23	200	DCI	10.48	0.02	1.05	0.33
P-763	J-617	J-616	15	200	DCI	9.33	0.01	0.85	0.3
P-764	N105	J-618	474	300	DCI	83.76	3.26	6.87	1.18
P-768	J-619	N101	124	300	DCI	83.76	0.85	6.87	1.18
P-769	J-618	J-619	16	300	DCI	83.76	0.11	6.87	1.18
P-780	K02-T.	J-1011	10	250	DCI	98.34	0.67	66.69	3.13
P-781	N100R1	FCV-4	35	300	DCI	83.76	0.24	6.87	1.18
P-782	FCV-4	RAU	10	300	DCI	83.76	0.07	6.88	1.18
P-785	PMP-1	J 1	10	600	DCI	147.24	0.01	0.66	0.52
P-788	ND-14	FCV-6	79	300	DCI	95.43	0.69	8.75	1.35
P-789	FCV-6	RDHA	16	300	DCI	95.43	0.14	8.75	1.35
P-790	RGAG	FCV-7	8	150	DCI	-24.67	0.17	20.91	1.4
P-791	FCV-7	NG-89	23	150	DCI	-24.67	0.48	20.92	1.4
EG 93	RGAG	NG-44	57	200	DCI	26.26	0.33	5.78	0.84
P-792	BOK- T	FCV-8	15	200	DCI	7.53	0.01	0.58	0.24
P-793	FCV-8	BO-02	106	200	DCI	7.53	0.06	0.57	0.24
P-796	J-1012	J-1724	6	250	DCI	98.34	0.39	66.66	2.13
P-797	ND-04	ND-48	18	250	DCI	96.25	1.17	64.08	2.06
P-800	R.awash	PMP-3	9	600	DCI	152.72	0.01	0.71	0.54
P-801	PMP-3	PMP-4	12	600	DCI	152.72	0.01	0.72	0.54
P-802	PMP-4	J 1	16	600	DCI	152.72	0.01	0.71	0.54
P-804	RAU	J-613	39	150	PVC	18.23	0.43	10.95	1.03
P-807	J-622	ND-31	244	250	PVC	19.88	0.26	1.07	0.41
P-809	RDHA	J-622	23	150	DCI	19.88	0.32	14.02	1.13
P-810	R.awash	PMP-5	5	600	DCI	147.24	0	0.67	0.52
P-813	PMP-5	PMP-1	5	600	DCI	147.24	0	0.66	0.52

Appendix D: EPS;Nodes results at Minimum Consumption hours

Node Label	Easting (m)	Northing (m)	Elevation (m)	Supply Zones	Demand (Calculated) (l/s)	Calculated Hydraulic Grade (m)	Pressure (mH2O)
N65C	528,996	945,005	1,630	RLU	2.06	1,674.63	44.54
N22	530,636	944,110	1,618	RLU	0.2	1,675.49	57.37
N29B'	529,568	944,363	1,622	RLU	0.67	1,674.50	52.39
N105A1	530,490	947,187	1,673	Rk02	0.15	1,731.07	57.95
N63B'	529,627	945,853	1,644	RLU	0.51	1,661.66	17.62
N53A	528,912	944,206	1,620	RLU	0.49	1,676.74	56.63
N3C	530,854	940,398	1,612	RLU	2.22	1,660.48	48.38
N3H1	531,558	941,391	1,594	RLU	1.27	1,636.23	42.14
N43	527,747	942,943	1,622	RLU	0.74	1,678.57	56.45
N82D	527,589	941,192	1,612	RLU	0.14	1,683.18	71.03
N15B2	528,839	941,464	1,638	RLU	0.22	1,682.04	43.95
N29	529,321	944,063	1,623	RLU	0.34	1,675.70	52.59
N30A5	529,427	943,779	1,622	RLU	0.48	1,677.33	55.22
N31D1	529,565	943,537	1,621	RLU	1.76	1,677.07	55.96
N44A1	527,941	943,591	1,620	RLU	0.88	1,677.48	57.36
J-1618	530,578	940,943	1,602	RLU	2.8	1,681.87	79.71
N53'	529,106	944,129	1,620	RLU	0.46	1,675.78	55.67
N8	529,985	942,376	1,612	RLU	0.59	1,676.14	64.01
ND-36	531,691	947,455	1,701	RDHA	0	1,747.97	46.88
NG-23	525,750	942,998	1,711	RGAG	0.62	1,751.28	40.20
N11	529,391	942,742	1,618	RLU	0.58	1,678.99	60.87
N81C2	527,918	940,445	1,633	RLU	0.3	1,681.75	48.65
N56	530,128	944,659	1,628	RLU	0.2	1,675.42	47.32
N58	530,863	944,665	1,629	RLU	1.03	1,675.19	46.10
N46B1	528,206	944,001	1,622	RLU	0.77	1,676.95	54.84
N22A	530,687	944,071	1,616	RLU	0.3	1,675.48	59.36
N103C1	530,150	946,173	1,662	Rk02	0.44	1,738.50	76.35
N46	528,412	943,743	1,619	RLU	0.58	1,677.18	58.06
ND-46	532,898	947,359	1,715	RDHA	2.03	1,741.66	26.61
N103D	530,194	946,145	1,662	Rk02	0.28	1,738.49	76.34
N43A2	527,472	943,437	1,633	RLU	0.56	1,675.44	42.36
N39B6	527,674	942,398	1,619	RLU	0.17	1,679.86	60.73
J-1562	528,041	941,055	1,623	R.awash	0	1,692.63	69.49
N82C	527,645	941,144	1,613	RLU	1.45	1,683.30	70.16
N81C1	527,838	940,360	1,630	RLU	0.3	1,681.68	51.58
N45	526,944	943,394	1,645	RLU	0	1,659.70	14.67
N57A'	531,038	944,317	1,616	RLU	0.51	1,675.36	59.24
N22A2	530,325	944,113	1,623	RLU	0.5	1,675.60	52.49
N20A	531,123	943,573	1,605	RLU	0.92	1,669.75	64.62
N7C	530,219	942,097	1,604	RLU	1.25	1,675.01	70.87
N28A	530,064	944,168	1,626	RLU	0.33	1,675.54	49.44
ILWA-01	528,129	945,101	1,635	RLU	2.15	1,655.85	20.81

BO-07	531,119	938,090	1,700	RBOK	0	1,717.32	17.28
N39A5	527,926	942,059	1,614	RLU	0.67	1,680.71	66.58
N22E	530,905	943,787	1,608	RLU	0.81	1,671.08	62.95
NG-37	526,313	942,671	1,707	RGAG	0.45	1,745.40	38.32
N107'	529,671	946,201	1,654	Rk02	0.21	1,738.52	84.35
N42	527,713	942,828	1,624	RLU	1.87	1,678.86	54.75
N7B	530,266	942,223	1,603	RLU	0.6	1,675.38	72.24
ND-41	533,282	947,952	1,715	RDHA	1.14	1,731.26	16.22
N39A7	527,756	942,300	1,616	RLU	0.36	1,680.31	64.18
ND-45	532,826	947,227	1,716	RDHA	2.22	1,744.75	28.68
N103B	530,683	946,354	1,667	Rk02	0.24	1,736.44	69.30
N15D2	528,999	941,003	1,659	RLU	0.14	1,683.41	24.36
N47C	528,471	944,401	1,623	RLU	0.46	1,676.61	53.50
N35	528,256	943,354	1,617	RLU	0.58	1,679.52	62.39
N54E	529,934	944,558	1,625	RLU	0.48	1,673.81	48.71
N63B'1	529,595	945,837	1,644	RLU	0.51	1,661.78	17.75
N3H3	531,579	941,220	1,603	RLU	0.28	1,635.55	32.48
N7B1	530,117	942,280	1,606	RLU	0.59	1,675.69	69.55
N29A3	529,514	944,220	1,624	RLU	0.29	1,674.55	50.44
NG-89	525,897	943,754	1,748	Tank AG	0	1,755.99	7.98
N105A4	530,683	947,854	1,685	Rk02	0.28	1,729.85	44.76
N109B	531,552	945,244	1,644	RAU	0.65	1,714.52	70.38
N6B	530,932	941,901	1,597	RLU	0.11	1,670.63	73.48
N29A2	529,510	944,211	1,623	RLU	0.29	1,674.55	51.45
J-1565	526,717	940,248	1,590	R.awash	0	1,700.49	110.27
N65A	529,049	945,380	1,638	RLU	0.76	1,674.44	36.37
N29A"	529,608	944,117	1,623	RLU	0.16	1,675.13	52.03
N102A	531,127	945,926	1,657	RAU	0.34	1,715.07	57.95
N27A	530,386	944,148	1,623	RLU	0.17	1,675.52	52.42
N3F	531,318	941,449	1,597	RLU	1.27	1,643.36	46.27
N103C	530,162	946,263	1,667	Rk02	0.46	1,738.53	71.38
N100U1	531,736	946,806	1,702	Rk02	0	1,723.65	21.60
N24C	531,580	944,069	1,607	RLU	0.55	1,675.33	68.19
N22A5	529,853	944,026	1,624	RLU	0.55	1,675.83	51.73
J-1567	527,813	941,276	1,614	R.awash	0	1,694.00	79.84
NN-01	529,583	941,019	1,615	RLU	0.33	1,682.53	67.39
N54B1	529,898	945,046	1,635	RLU	0.52	1,671.97	36.90
N39A6	527,978	942,247	1,613	RLU	0.47	1,680.48	67.34
N81A1	528,252	940,754	1,641	RLU	0.25	1,683.01	41.93
ND-31	532,283	947,681	1,720	RDHA	2.46	1,748.42	28.36
N103A	530,448	946,449	1,667	Rk02	0	1,736.44	69.30
N111A	530,975	945,569	1,651	RAU	0.21	1,714.90	63.76
N3G	531,677	940,693	1,616	RLU	1.33	1,635.01	18.97
N32C	529,114	944,147	1,620	RLU	0.74	1,675.71	55.59
NG-77	525,913	943,319	1,717	Tank AG	0	1,765.58	48.48
NG-46	526,570	943,034	1,691	RGAG	0.71	1,743.33	52.23

N82F	527,459	941,253	1,612	RLU	0.24	1,682.93	70.79
N44B1	527,350	943,631	1,636	RLU	2	1,668.70	32.64
N63B1	529,853	945,267	1,634	RLU	0.32	1,670.99	36.91
N10A	529,581	942,668	1,617	RLU	0.91	1,678.28	61.16
N69A2	530,495	945,397	1,642	RLU	2.8	1,661.70	19.66
N4	530,200	941,852	1,602	RLU	0.57	1,675.45	73.30
N22D	530,812	943,817	1,610	RLU	0.82	1,675.44	65.31
N105A	530,702	947,099	1,685	Rk02	0.39	1,732.58	47.49
NG-44	525,882	943,726	1,749	RGAG	0	1,755.00	5.99
N15B	528,752	941,623	1,628	RLU	0	1,682.23	54.13
NG-47	526,347	943,236	1,703	RGAG	0.37	1,747.20	44.11
N44B3	527,384	944,038	1,631	RLU	1.93	1,668.84	37.76
N47A4	529,018	944,837	1,626	RLU	0.28	1,674.92	48.82
N62	530,003	945,312	1,637	RLU	0.36	1,670.06	32.99
N3H	531,538	941,439	1,594	RLU	1.27	1,638.32	44.23
J-1609	529,453	941,547	1,618	RGAG	0	1,682.69	64.56
N12A	528,985	941,654	1,627	RLU	1.01	1,681.82	54.71
N35A	528,332	943,331	1,615	RLU	0.48	1,679.52	64.39
ND-39	531,013	947,732	1,693	RDHA	1.11	1,747.88	54.77
N30A	529,526	943,947	1,622	RLU	0.1	1,676.37	54.26
J-1564	526,455	940,084	1,588	R.awash	0	1,701.82	113.59
J-1560	528,747	940,536	1,677	R.awash	0	1,689.13	12.11
N15D1	528,920	940,992	1,660	RLU	0.41	1,683.32	23.27
N16A	529,675	943,188	1,622	RLU	2.24	1,677.00	54.89
J-1541	519,821	937,323	1,560	R.awash	0	1,732.93	172.58
N67A4	530,105	945,765	1,654	RLU	0.53	1,665.82	11.80
NG-17	526,211	942,821	1,698	RGAG	2.24	1,745.63	47.54
N18B	530,760	943,395	1,606	RLU	1.94	1,671.87	65.73
N21D	531,566	943,468	1,603	RLU	0.9	1,668.43	65.30
N103C2	530,202	946,166	1,663	Rk02	0.14	1,738.50	75.34
N14B	529,373	943,028	1,621	RLU	0.63	1,678.66	57.54
N30A2	529,470	943,888	1,622	RLU	0.96	1,676.88	54.76
J-1566	527,015	940,435	1,601	R.awash	0	1,698.98	97.78
N67C	529,684	946,136	1,650	RLU	0.63	1,664.99	14.96
N36A	528,208	942,698	1,613	RLU	1.39	1,679.23	66.09
N82	528,566	940,561	1,671	RLU	1.07	1,685.09	14.07
N106A"	531,138	945,956	1,656	RAU	0.87	1,715.08	58.96
N43B5	528,196	943,303	1,616	RLU	0.58	1,679.55	63.43
N61A	530,202	945,232	1,637	RLU	0.51	1,670.38	33.32
N111	530,663	945,687	1,648	RAU	0.56	1,714.91	66.78
N64A2	529,602	944,702	1,626	RLU	0.54	1,673.83	47.73
N12A3	529,089	941,931	1,624	RLU	1	1,680.90	56.79
J-1557	528,824	940,531	1,682	R.awash	0	1,688.80	6.79
N15F7	528,897	940,535	1,681	RLU	1.11	1,687.10	5.69
N57	530,765	944,422	1,621	RLU	0.86	1,675.39	54.28
N29A1	529,426	944,021	1,623	RLU	0.34	1,674.56	51.45

J-1555	528,484	940,620	1,675	R.awash	0	1,689.97	14.94
N10A1	529,822	942,607	1,629	RLU	0.19	1,677.20	48.11
N69	530,510	945,300	1,640	RLU	2.26	1,661.52	21.48
N52B	529,247	944,488	1,622	RLU	0.78	1,674.54	52.44
N7AB1	530,446	942,215	1,600	RLU	0.48	1,675.10	74.95
N11A	529,277	942,786	1,622	RLU	0.11	1,679.09	56.98
N43A7	527,479	943,022	1,630	RLU	0.63	1,676.41	46.32
N105C1	530,827	947,413	1,689	Rk02	0.11	1,731.19	42.10
N78	530,967	945,012	1,640	RAU	0.41	1,714.60	74.45
NG-01	525,784	943,199	1,720	RGAG	0.32	1,751.76	31.70
N81	528,189	940,928	1,632	RLU	0	1,684.68	52.57
N7D	530,460	941,998	1,602	RLU	0.59	1,674.55	72.41
ILWA-02	527,950	944,605	1,627	RLU	1.64	1,654.50	27.44
N7AB	530,285	942,278	1,604	RLU	0.59	1,675.31	71.16
ND-44	531,634	947,273	1,701	RDHA	0.42	1,746.15	45.06
BA-08	531,062	939,143	1,643	T.Bok	0	1,717.32	74.17
N7A1	530,606	942,043	1,602	RLU	0.12	1,673.57	71.43
N50	528,398	945,080	1,636	RLU	2.22	1,655.91	19.87
ND-33	532,250	947,522	1,714	RDHA	1.58	1,748.27	34.20
J-1559	525,487	939,563	1,573	R.awash	0	1,706.56	133.29
N58A2	530,952	944,935	1,638	RLU	1.24	1,670.55	32.49
N27A2	530,201	944,136	1,625	RLU	0.17	1,675.55	50.45
N3B	531,199	941,269	1,595	RLU	1.72	1,644.38	49.28
N100R5	531,352	946,752	1,684	Rk02	0	1,726.57	42.49
N53B	528,795	944,273	1,620	RLU	0.66	1,676.25	56.14
N31B	529,463	943,252	1,618	RLU	0.75	1,678.41	60.29
N21	530,423	943,523	1,612	RLU	1.11	1,674.07	61.95
N46B	528,472	943,899	1,618	RLU	0.79	1,677.05	58.93
IAU-01	531,049	945,223	1,646	RLU	0.9	1,714.60	68.46
NG-39	526,080	942,315	1,703	RGAG	0.16	1,750.08	46.98
N68A3	530,006	945,622	1,646	RLU	0.32	1,666.80	20.76
ND-42	531,885	947,171	1,713	RDHA	0.41	1,746.79	33.72
N10A2	529,860	942,519	1,626	RLU	0.14	1,676.90	50.79
N43A	527,806	943,142	1,622	RLU	0.74	1,678.19	56.08
N64E	529,197	944,927	1,628	RLU	0.88	1,674.58	46.49
N43B2	528,442	942,958	1,615	RLU	0.84	1,679.22	64.09
N24E2	531,820	944,352	1,617	RLU	0.21	1,675.24	58.12
N6B3	531,211	942,456	1,597	RLU	0.17	1,671.76	74.61
N43B1	528,289	943,001	1,614	RLU	0.84	1,679.22	65.09
N39A1	527,608	941,571	1,615	RLU	1.62	1,681.79	66.65
N22C	530,938	944,082	1,613	RLU	0.65	1,675.43	62.30
N69A1	530,428	945,580	1,645	RLU	0.17	1,663.26	18.22
N52A	529,193	944,346	1,621	RLU	0.78	1,674.55	53.44
N29A'	529,569	944,133	1,623	RLU	0.16	1,675.26	52.16
N2	528,962	941,481	1,633	RLU	1.19	1,682.11	49.01
N108A	529,446	946,118	1,656	Rk02	0.38	1,738.51	82.35

N15F1	528,713	940,803	1,670	RLU	0.5	1,684.13	14.10
N69A	530,300	945,704	1,651	RLU	0.17	1,664.78	13.75
N71	531,322	945,834	1,657	RAU	0.62	1,714.75	57.62
N22D2	530,682	944,011	1,615	RLU	0.92	1,675.47	60.34
N64A	529,273	945,128	1,633	RLU	0.56	1,674.49	41.41
J-1556	528,524	940,563	1,670	R.awash	0	1,689.67	19.63
N21C	531,384	943,523	1,604	RLU	0.9	1,668.61	64.48
N67A3	529,993	945,764	1,648	RLU	0.65	1,665.60	17.56
N47B	528,375	944,440	1,627	RLU	0.46	1,676.86	49.76
N24A	531,572	944,013	1,607	RLU	0.55	1,675.33	68.19
N44B2	527,339	943,716	1,635	RLU	0.24	1,668.71	33.65
N100U3	531,218	946,177	1,664	RAU	0.12	1,715.19	51.09
N36	528,035	942,744	1,615	RLU	1.07	1,679.88	64.75
N38B	527,965	942,522	1,616	RLU	0.71	1,680.08	63.95
J-1569	520,259	937,352	1,559	R.awash	0	1,731.04	171.69
N47A2	528,915	945,039	1,632	RLU	0.35	1,674.70	42.61
N18	530,285	943,165	1,613	RLU	2.06	1,674.78	61.66
N100R6	531,238	946,799	1,681	Rk02	0	1,727.41	46.32
N13	528,911	942,465	1,633	RLU	0.28	1,680.18	47.08
N24E1	531,794	944,238	1,614	RLU	0.17	1,675.24	61.11
N39A3	527,691	941,894	1,616	RLU	0.65	1,681.27	65.14
N39B	527,452	942,327	1,624	RLU	0.8	1,680.26	56.15
N3D	530,727	940,683	1,606	RLU	1.45	1,661.51	55.40
J-1616	529,852	940,604	1,615	RLU	0	1,682.25	67.11
N32A1	528,841	943,984	1,618	RLU	0.66	1,676.91	58.79
N56B	530,133	944,673	1,628	RLU	0.2	1,675.42	47.32
N36A2	528,800	942,973	1,620	RLU	1.62	1,679.27	59.15
N9B1	530,818	942,615	1,601	RLU	0.39	1,673.74	72.59
N54	529,811	944,609	1,626	RLU	4.4	1,673.55	47.45
N54F	529,877	944,759	1,628	RLU	0.43	1,673.09	45.00
NG-10	525,889	943,188	1,710	RGAG	0.32	1,751.07	40.99
N30A3	529,310	943,832	1,621	RLU	0.53	1,677.35	56.24
N102	530,810	946,057	1,659	RAU	0.36	1,715.23	56.12
NG-75	525,942	943,284	1,706	Tank AG	0	1,766.54	60.42
N43B3	528,280	943,219	1,617	RLU	0.48	1,679.56	62.43
ILWBO01	527,339	942,948	1,632	RLU	1.29	1,678.61	46.51
N3E	531,489	941,084	1,600	RLU	2.77	1,638.16	38.08
N64B	529,707	944,952	1,630	RLU	0.6	1,672.67	42.58
NG-36	525,849	942,238	1,700	RGAG	0.22	1,749.85	49.75
N3J1	531,828	941,426	1,632	RLU	1.03	1,637.37	4.96
N54A1	529,656	944,585	1,625	RLU	5.32	1,674.34	49.25
N6A4	530,391	941,852	1,603	RLU	0.31	1,674.16	71.01
N43B6	528,238	943,316	1,616	RLU	0.59	1,679.53	63.40
N56A1	530,379	944,953	1,633	RLU	0.83	1,671.13	38.05
N44	527,955	943,638	1,621	RLU	1.52	1,677.42	56.30
NG-52	525,829	942,178	1,709	RGAG	0.35	1,749.81	40.73

N55B	530,616	944,762	1,631	RLU	0.71	1,675.19	44.10
N4A	530,289	941,647	1,602	RLU	0	1,673.06	70.92
N24D	531,771	944,049	1,607	RLU	0.42	1,675.24	68.10
N32	528,780	943,828	1,619	RLU	0.55	1,677.06	57.94
N27A1	530,318	944,150	1,624	RLU	0.17	1,675.53	51.43
N32B	529,278	943,940	1,621	RLU	0.49	1,677.03	55.92
N81F	527,654	940,701	1,618	RLU	1.24	1,681.87	63.74
NG-35	525,861	942,290	1,701	RGAG	0.34	1,749.91	48.81
N65B	529,076	945,205	1,635	RLU	0.4	1,674.54	39.46
BO-09	530,878	940,277	1,616	RLU	0	1,681.87	65.74
J-1007	530,218	945,892	1,658	RLU	0	1,661.25	3.24
N3B2	530,847	940,934	1,601	RLU	1.6	1,660.51	59.39
J-1016	528,807	941,256	1,645	RLU	0	1,683.04	37.96
N64A1	529,552	944,625	1,623	RLU	0.41	1,674.33	51.23
J-1624	529,274	941,572	1,624	RLU	0	1,682.74	58.63
N3I	531,561	941,133	1,603	RLU	1.27	1,635.52	32.46
N43A3	527,418	943,233	1,634	RLU	0.56	1,674.30	40.22
N106	531,049	946,663	1,672	Rk02	0	1,715.41	43.33
N15D	528,904	941,089	1,651	RLU	0.22	1,683.22	32.15
ILEBO23	531,350	941,093	1,596	RLU	1.91	1,644.07	47.98
N5A	530,158	941,946	1,601	RLU	0.22	1,675.87	74.72
N15F6	528,618	940,553	1,673	RLU	1.06	1,685.32	12.30
N21B	531,221	943,535	1,606	RLU	0.49	1,669.18	63.05
N43A6	527,314	943,076	1,636	RLU	0.58	1,675.18	39.10
NG-13	526,064	943,139	1,702	RGAG	1.39	1,749.62	47.52
N22A3	530,255	944,111	1,624	RLU	0.41	1,675.63	51.52
NG-51	525,798	943,203	1,718	RGAG	1.11	1,751.89	33.83
NG-33	525,694	942,376	1,712	RGAG	0.32	1,749.86	37.78
N45'	527,089	943,742	1,642	RLU	0.7	1,651.81	9.79
N81A	528,124	940,852	1,631	RLU	0.32	1,683.58	52.48
N3H2	531,571	941,307	1,597	RLU	0.28	1,635.74	38.66
J-1558	525,422	939,537	1,576	R.awash	0	1,706.86	130.60
N18C	530,515	942,747	1,599	RLU	1	1,672.94	73.80
N7A	530,502	942,077	1,601	RLU	0.58	1,674.55	73.40
N59	531,354	944,531	1,622	RLU	1.03	1,675.17	53.06
N63B'2	529,687	945,649	1,642	RLU	0.26	1,664.32	22.28
N61	530,450	945,135	1,636	RLU	2.23	1,670.47	34.40
BA-09	531,118	938,272	1,691	T.Bok	0	1,717.32	26.27
N29B	529,690	944,315	1,623	RLU	0.5	1,674.47	51.37
NG-27	525,728	942,654	1,708	RGAG	0	1,750.70	42.62
N25A2	531,898	943,938	1,606	RLU	0	1,675.32	69.18
N6A	530,891	941,862	1,598	RLU	0.41	1,670.59	72.44
N45'A	526,900	943,704	1,642	RLU	0.7	1,652.96	10.94
N11A1	529,317	942,886	1,621	RLU	0.58	1,678.89	57.77
N100R1	531,840	946,981	1,714	Rk02	0	1,722.26	8.24
J-1553	526,225	939,941	1,583	R.awash	0	1,702.98	119.74

J-1549	528,924	940,525	1,682	R.awash	0	1,688.37	6.36
BO-01	531,239	939,461	1,632	RLU	0	1,681.87	49.76
N15A	528,740	941,703	1,628	RLU	0.71	1,681.89	53.78
N103'	530,301	946,243	1,664	Rk02	0.38	1,738.53	74.39
N71B	531,966	945,083	1,639	RAU	0.72	1,710.62	71.48
N14B1	529,556	942,955	1,620	RLU	0.4	1,678.33	58.22
N12A2	529,091	941,878	1,623	RLU	0.64	1,681.00	57.88
N47A	528,550	944,102	1,617	RLU	0.8	1,676.93	59.81
NG-31	525,623	942,413	1,706	RGAG	0.28	1,749.87	43.79
ILEBO01	529,653	940,823	1,617	RLU	1.14	1,682.47	65.34
N30A6	529,422	943,768	1,622	RLU	0.46	1,677.38	55.26
N28A'	529,938	944,218	1,626	RLU	0.46	1,675.57	49.47
N71C	531,973	945,263	1,645	RAU	0.31	1,711.83	66.70
N68	529,697	945,558	1,639	RLU	1.19	1,665.12	26.07
J-1563	525,781	939,696	1,580	R.awash	0	1,705.17	124.92
N15F4	528,590	940,681	1,670	RLU	1.24	1,684.74	14.71
ILu-01	529,419	942,275	1,619	RLU	1.08	1,680.13	61.00
NNL-03	530,464	940,890	1,604	RLU	0.44	1,681.92	77.76
N30A8	529,130	943,717	1,624	RLU	0.55	1,677.39	53.28
N54C	530,099	944,965	1,628	RLU	0.07	1,673.52	45.42
N39A4	527,731	942,106	1,614	RLU	0.65	1,680.97	66.83
N38A3	527,797	942,584	1,619	RLU	0.44	1,679.92	60.80
BO-05	531,095	939,270	1,638	T. Bok	0	1,717.32	79.16
N48	528,266	944,578	1,626	RLU	0.56	1,654.56	28.50
BA-03	531,427	940,095	1,620	R.BOK	0.35	1,715.85	95.65
N81C3	527,933	940,424	1,633	RLU	0.58	1,681.78	48.68
ND-43	531,844	947,072	1,711	RDHA	1.68	1,746.46	35.39
N37	527,887	942,274	1,616	RLU	0.47	1,680.37	64.24
N10A3	529,899	942,529	1,625	RLU	0.92	1,676.77	51.66
N17B	530,272	943,583	1,621	RLU	1.48	1,674.09	52.98
N82A	527,790	941,308	1,613	RLU	1.54	1,683.69	70.54
N9B	530,795	942,634	1,599	RLU	0	1,673.95	74.80
N52C	528,999	944,421	1,622	RLU	0.5	1,674.82	52.72
J-1629	529,063	941,613	1,627	RLU	0	1,682.81	55.69
N64D	529,391	944,850	1,627	RLU	0.59	1,673.24	46.15
N52D	528,931	944,612	1,622	RLU	0.64	1,674.98	52.87
BO-08	530,742	940,575	1,609	RLU	0	1,681.87	72.73
NG-42	525,806	943,236	1,725	RGAG	0.54	1,752.08	27.03
ND-47	531,887	947,778	1,713	RDHA	0.1	1,747.97	34.90
N54B1'	529,930	945,127	1,634	RLU	0.33	1,671.69	37.62
N39B2	527,585	942,300	1,624	RLU	1.72	1,679.85	55.74
N20B	531,159	943,717	1,607	RLU	0.92	1,670.41	63.28
N55A	530,059	944,518	1,625	RLU	0.36	1,675.51	50.41
NG-02	525,801	942,624	1,716	RGAG	0.42	1,750.35	34.28
N106A	530,904	946,292	1,663	RAU	0.95	1,715.28	52.18
N103	530,357	946,222	1,665	Rk02	0.77	1,738.54	73.39

N8A	529,977	942,355	1,612	RLU	0.44	1,676.12	63.99
N10	529,789	942,715	1,627	RLU	0.17	1,677.57	50.47
ND-35	531,954	947,341	1,715	RDHA	1.07	1,747.98	32.91
N111C	530,775	945,088	1,642	RAU	0.37	1,714.79	72.64
N109	532,088	945,538	1,657	RAU	0.24	1,714.31	57.20
N14B2	529,558	942,875	1,620	RLU	0.4	1,678.27	58.15
N36A1	528,619	942,586	1,616	RLU	2.01	1,679.23	63.11
N22D1	530,632	943,866	1,614	RLU	0.98	1,675.45	61.32
BA-07	531,682	938,531	1,679	R.BOK	0.63	1,716.79	37.71
BO-04	531,057	939,881	1,625	RLU	0	1,681.87	56.76
N15F	528,662	940,832	1,666	RLU	0.5	1,684.23	18.19
N14A	529,162	943,111	1,623	RLU	0.94	1,678.88	55.77
N44B4	527,710	944,044	1,625	RLU	1.93	1,670.91	45.81
NG-49	525,822	942,571	1,717	RGAG	0.59	1,750.14	33.07
N39	527,341	941,279	1,617	RLU	1.83	1,682.73	65.60
N24E	531,608	944,242	1,614	RLU	0	1,675.33	61.21
N15A1	528,792	941,071	1,657	RLU	0.49	1,683.45	26.39
J-1570	522,826	938,353	1,575	R.awash	0	1,719.18	143.89
N22A1	530,634	944,076	1,616	RLU	0	1,675.49	59.37
N49	528,211	944,430	1,622	RLU	0.96	1,677.23	55.12
N20	531,051	943,286	1,606	RLU	1.81	1,671.83	65.70
N30A1	529,539	943,895	1,620	RLU	0.66	1,676.60	56.48
ND-40	532,035	948,454	1,707	RDHA	1.26	1,747.55	40.46
NN-02	529,771	940,565	1,620	RLU	0.54	1,682.29	62.17
N3	530,571	941,027	1,601	RLU	1.62	1,665.87	64.73
N81B1	527,897	940,944	1,621	RLU	0.3	1,682.48	61.35
N52B'	529,054	944,563	1,622	RLU	0.48	1,674.74	52.64
NG-20	525,811	943,200	1,713	RGAG	0.18	1,751.83	38.75
N54D	529,995	944,712	1,629	RLU	0.44	1,673.53	44.44
N54E1	529,945	944,554	1,625	RLU	0.29	1,673.84	48.74
ND-34	532,192	947,244	1,707	RDHA	2.43	1,748.05	40.97
N6B2	531,117	942,289	1,599	RLU	0.62	1,671.15	72.01
NG-79	525,878	943,358	1,725	Tank AG	0	1,764.46	39.38
N68C1	529,649	945,451	1,639	RLU	0.67	1,671.16	32.10
N72	530,241	945,925	1,658	Rk02	0	1,741.47	83.30
N58A1	530,875	944,760	1,633	RLU	2.01	1,670.57	37.49
J-1610	529,471	941,542	1,618	RLU	0	1,682.69	64.56
N39A2	527,619	941,763	1,617	RLU	1.06	1,681.49	64.36
N81B	528,061	940,774	1,634	RLU	0.55	1,683.10	49.00
N65	528,993	945,237	1,636	RLU	0.35	1,674.54	38.46
N81D1	527,460	940,507	1,614	RLU	0.4	1,681.69	67.56
NG-29	525,630	942,528	1,702	RGAG	0.62	1,750.00	47.91
N27B1	530,289	944,304	1,629	RLU	0.66	1,675.47	46.38
N32A	528,828	943,989	1,619	RLU	0.79	1,676.90	57.79
N29A	529,537	944,045	1,621	RLU	0.17	1,675.55	54.44
N15F2	528,855	940,791	1,675	RLU	0.33	1,683.91	8.89

N6B4	531,084	942,513	1,598	RLU	0.34	1,672.28	74.13
N81E	527,849	940,531	1,630	RLU	0.59	1,682.03	51.92
N81D	527,676	940,314	1,623	RLU	0.78	1,681.29	58.17
N105A3	530,446	947,275	1,675	Rk02	1.1	1,730.46	55.35
N24	531,237	944,049	1,611	RLU	1.39	1,675.36	64.23
N7	530,560	942,187	1,600	RLU	0.41	1,674.98	74.82
NG-68	526,184	943,330	1,697	Tank AG	0	1,771.80	74.65
N28B1'	529,615	944,008	1,622	RLU	0.25	1,675.82	53.71
N34	528,567	943,260	1,615	RLU	1.66	1,679.22	64.09
N54A	529,841	944,899	1,630	RLU	0.43	1,672.47	42.39
N24A1	531,761	943,988	1,606	RLU	0.42	1,675.32	69.18
N39A	527,350	941,590	1,621	RLU	1.29	1,682.22	61.09
N19	530,958	942,913	1,599	RLU	1.24	1,673.72	74.57
N46A2	528,515	943,723	1,620	RLU	0.39	1,679.50	59.38
NG-18	526,231	942,761	1,700	RGAG	2.38	1,745.41	45.32
N6A3	530,455	941,841	1,602	RLU	0.16	1,673.68	71.54
N6B1	531,047	942,121	1,599	RLU	0.1	1,670.91	71.76
N28C	529,812	944,268	1,624	RLU	0.58	1,674.42	50.32
N54B	529,798	944,789	1,627	RLU	0	1,672.83	45.74
N15C	528,988	941,105	1,650	RLU	0.21	1,683.01	32.94
J-1626	529,542	941,198	1,615	RLU	0	1,682.58	67.45
N30A4	529,206	943,808	1,623	RLU	0.4	1,677.37	54.26
J-1554	528,196	940,902	1,633	R.awash	0	1,691.70	58.58
N64B1	529,472	945,049	1,631	RLU	0.64	1,672.68	41.60
N39B1	527,401	942,156	1,624	RLU	2.01	1,680.72	56.60
N47A1	528,860	944,899	1,630	RLU	0.14	1,675.21	45.12
N31	529,021	943,837	1,616	RLU	0.58	1,677.43	61.31
NG-71	526,091	943,310	1,702	Tank AG	0	1,769.77	67.63
J-1725	530,199	945,886	1,658	Rk02	0	1,742.13	83.96
N17	530,098	943,251	1,621	RLU	2.06	1,674.63	53.52
J-1568	527,512	940,970	1,613	R.awash	0	1,695.84	82.68
N6C	531,141	941,382	1,598	RLU	0.21	1,644.09	45.99
NG-48	526,295	943,104	1,701	RGAG	0.65	1,747.91	46.82
N43A4	527,360	943,249	1,635	RLU	0.58	1,674.00	38.92
J-1544	526,032	939,808	1,580	R.awash	0	1,703.99	123.74
N56A	530,342	944,867	1,631	RLU	0.71	1,675.19	44.10
N43B4	528,181	943,252	1,617	RLU	0.58	1,679.59	62.46
NG-11	525,951	943,177	1,708	RGAG	0.42	1,750.51	42.42
BO-03	531,128	938,271	1,691	R.BOK	0.32	1,717.04	25.99
N3B1	530,754	941,097	1,599	RLU	1.45	1,661.04	61.91
N38A	527,546	942,515	1,621	RLU	1.37	1,679.75	58.63
N44A	527,383	943,496	1,634	RLU	1.5	1,669.13	35.06
N82B	527,749	941,262	1,615	RLU	1.45	1,683.58	68.44
NG-50	525,884	942,421	1,716	RGAG	0.62	1,750.09	34.02
NG-16	526,286	943,073	1,694	RGAG	1.6	1,748.51	54.39
N22A4	530,147	944,091	1,625	RLU	0.4	1,675.68	50.58

N6	530,367	941,892	1,602	RLU	0.2	1,674.54	72.40
N53A1	528,918	944,221	1,620	RLU	0.53	1,676.45	56.34
N77	531,598	944,725	1,625	RAU	0.35	1,710.58	85.41
N12A1	529,144	941,623	1,626	RLU	0.4	1,681.51	55.39
N9	530,031	942,497	1,614	RLU	0.84	1,676.34	62.22
N31D	529,590	943,531	1,622	RLU	1.76	1,677.00	54.89
NG-19	526,249	942,742	1,700	RGAG	0	1,745.40	45.31
N52'	529,335	944,711	1,626	RLU	0.62	1,674.53	48.43
NG-34	525,774	942,333	1,705	RGAG	0.47	1,749.86	44.77
N63A	529,531	945,198	1,630	RLU	0.9	1,672.67	42.59
N11A2	529,430	942,842	1,618	RLU	0.32	1,678.92	60.79
N105C	530,998	947,726	1,693	Rk02	0.98	1,729.80	36.73
N30	529,500	943,889	1,621	RLU	0.44	1,676.76	55.65
N30A7	529,541	943,724	1,620	RLU	0.83	1,676.90	56.79
NG-25	525,726	942,800	1,705	RGAG	0.24	1,750.93	45.84
N54D'	530,131	945,049	1,631	RLU	0.5	1,671.34	40.26
NG-41	524,969	942,909	1,728	RGAG	0.24	1,750.64	22.59
BO-06	531,119	937,829	1,713	T.Bok	0	1,717.32	4.31
J 2	519,815	937,320	1,559	R.awash	0	1,732.95	173.60
N24B	531,627	944,402	1,617	RLU	0.71	1,675.27	58.15
N67E1	529,878	946,027	1,647	RLU	1.06	1,665.02	17.99
N7B2	530,135	942,327	1,605	RLU	0.59	1,675.79	70.65
N22B	530,849	944,095	1,615	RLU	0.65	1,675.44	60.32
NG-30	525,626	942,470	1,702	RGAG	0.18	1,749.93	47.83
N15E	529,008	940,771	1,677	RLU	0.32	1,683.70	6.68
N12	529,233	942,335	1,621	RLU	0.16	1,680.13	59.01
NG-26	525,730	942,684	1,702	RGAG	0.13	1,750.75	48.65
NG-69	526,157	943,321	1,698	Tank AG	0	1,771.20	73.05
NG-21	525,771	943,143	1,712	RGAG	0.25	1,751.61	39.53
NG-40	526,396	943,262	1,706	RGAG	0.26	1,747.15	41.07
N14B3	529,468	942,911	1,620	RLU	0.4	1,678.25	58.13
N68A1	529,814	945,493	1,640	RLU	1.06	1,665.32	25.27
J-1561	528,656	940,543	1,673	R.awash	0	1,689.53	16.49
N27C	530,668	944,185	1,618	RLU	0.55	1,675.42	57.31
N25A	531,979	943,848	1,606	RLU	0.29	1,675.32	69.18
J-1551	528,152	940,945	1,631	R.awash	0	1,691.96	60.84
NG-90	525,835	942,184	1,698	RGAG	0.4	1,749.81	51.71
N43A1	527,864	943,337	1,624	RLU	1.39	1,677.83	53.72
N12A4	529,105	942,008	1,623	RLU	0.21	1,680.76	57.64
N63A1	529,580	945,264	1,634	RLU	0.58	1,671.64	37.56
N71'	531,709	945,680	1,657	RLU	0.9	1,714.50	57.38
N101	531,173	946,619	1,674	Rk02	0	1,728.72	54.61
N51B	528,692	944,962	1,631	RLU	0.4	1,670.14	39.07
J-1552	528,966	940,528	1,683	R.awash	0	1,688.19	5.68
N105D	530,778	947,815	1,685	Rk02	0.84	1,729.80	44.71
N31A	529,248	943,334	1,626	RLU	1.03	1,678.47	52.37

N107	530,013	946,276	1,656	Rk02	0.46	1,738.52	82.36
N15F3	528,612	940,750	1,668	RLU	0.45	1,684.52	16.48
N71BC	531,906	945,107	1,641	RAU	0.51	1,710.61	69.47
N82E	527,565	941,199	1,612	RLU	0.45	1,683.14	70.99
N38A1	527,696	942,460	1,620	RLU	0.44	1,679.80	59.68
N27B2	530,333	944,416	1,630	RLU	0.88	1,675.48	45.39
NG-09	525,865	943,197	1,711	RGAG	0	1,751.31	40.23
N67	529,739	945,670	1,639	RLU	0.74	1,665.19	26.14
N111A'	530,942	945,486	1,649	RAU	0.88	1,714.86	65.73
J-1550	528,128	940,969	1,628	R.awash	0	1,692.11	63.98
N14	529,069	942,868	1,628	RLU	0	1,679.33	51.23
N55A'	530,525	944,518	1,627	RLU	0.86	1,675.40	48.31
N6A2	530,681	941,796	1,599	RLU	0.19	1,672.09	72.95
N33	528,778	943,784	1,619	RLU	1.17	1,679.16	60.04
N54E2	529,949	944,564	1,625	RLU	0.4	1,673.90	48.80
N39B3	527,644	942,288	1,623	RLU	0.21	1,679.85	56.74
N43B	528,124	943,052	1,619	RLU	1	1,679.70	60.58
N43A5	527,039	943,337	1,644	RLU	0.71	1,667.41	23.37
N68C	530,108	945,583	1,646	RLU	1.11	1,667.51	21.46
BA-05	531,371	939,217	1,637	R.BOK	1.46	1,716.52	79.36
NG-12	525,993	943,161	1,705	RGAG	1.74	1,750.12	45.03
N68D	530,175	945,752	1,650	RLU	1.56	1,665.99	15.96
J-1608	528,825	941,260	1,644	RLU	0	1,683.03	38.95
NG-15	526,210	943,094	1,697	RGAG	1.15	1,748.82	51.72
N67A	529,721	945,624	1,638	RLU	0.74	1,665.11	27.05
N47A3	528,941	944,867	1,628	RLU	0.28	1,674.93	46.83
N15	528,611	941,712	1,625	RLU	0.92	1,681.89	56.77
J-1620	528,840	941,458	1,638	RLU	0	1,682.97	44.88
N28A"	529,886	944,073	1,622	RLU	0.3	1,675.61	53.50
N68D1	530,222	945,881	1,659	Rk02	0	1,741.91	82.74
N44B	528,050	943,989	1,620	RLU	1.93	1,677.24	57.12
N39B5	527,671	942,345	1,619	RLU	0.21	1,679.92	60.79
N48B	528,237	944,498	1,624	RLU	0.56	1,654.54	30.48
N100R4	531,374	946,810	1,686	Rk02	0	1,726.15	40.07
N67A1	529,784	945,665	1,640	RLU	0.66	1,665.24	25.19
NG-32	525,645	942,403	1,711	RGAG	0.43	1,749.86	38.78
NG-28	525,634	942,596	1,702	RGAG	0.36	1,750.21	48.12
NG-43	525,870	943,359	1,734	RGAG	0.12	1,752.88	18.84
J-1631	528,745	941,678	1,627	RLU	0	1,682.90	55.79
N106A'	531,028	946,247	1,665	RAU	0.32	1,715.28	50.18
N18A	530,626	943,037	1,603	RLU	1.77	1,673.93	70.79
N28B1	529,620	943,968	1,622	RLU	0	1,675.98	53.87
N63B	529,616	945,358	1,636	RLU	0.32	1,671.35	35.28
N47	528,641	944,336	1,623	RLU	0.18	1,676.78	53.67
N55	530,069	944,514	1,625	RLU	0.36	1,675.51	50.41
N31C	529,364	943,622	1,624	RLU	0.95	1,677.96	53.85

N59A	531,293	944,290	1,616	RLU	1.21	1,675.34	59.22
NG-38	526,554	942,989	1,692	RGAG	0.53	1,743.63	51.53
N71E	531,882	944,872	1,633	RAU	0.31	1,710.59	77.43
N25A1	531,858	943,960	1,607	RLU	0.82	1,675.32	68.18
N16A1	529,635	943,185	1,620	RLU	0.84	1,677.14	57.02
N38A2	527,752	942,439	1,618	RLU	1.53	1,679.82	61.70
N4B	529,642	941,343	1,615	RLU	0.12	1,673.06	57.94
NG-83	525,880	943,543	1,736	Tank AG	0	1,760.51	24.47
N70'	531,124	945,415	1,651	RAU	0.84	1,714.69	63.56
ND-32	532,258	947,564	1,714	RDHA	1.36	1,748.34	34.27
ND-37	530,388	948,110	1,692	RDHA	0.41	1,747.83	55.71
N39B4	527,607	942,378	1,621	RLU	0.5	1,679.86	58.74
N56B1	530,246	944,627	1,628	RLU	0.66	1,675.34	47.24
NG-24	525,728	942,848	1,711	Tank AG	0.12	1,751.02	40.14
J-1613	528,827	941,318	1,643	RLU	0.49	1,683.01	39.93
N67A2	529,875	945,724	1,644	RLU	0.7	1,665.39	21.34
NG-45	526,218	942,792	1,706	RGAG	0.91	1,745.50	39.42
N81C	527,759	940,421	1,622	RLU	0.36	1,681.66	59.54
N6A1	530,777	941,760	1,598	RLU	0.32	1,671.44	73.29
N57A	530,934	944,355	1,619	RLU	0.51	1,675.37	56.25
N46A1	528,422	943,703	1,620	RLU	0.68	1,679.50	59.38
NG-14	526,131	943,117	1,700	RGAG	0.84	1,749.22	49.13
N27B3	530,434	944,275	1,626	RLU	0.88	1,675.45	49.35
N100U2	531,436	946,785	1,687	Rk02	0	1,725.69	38.62
N17A	530,290	943,178	1,613	RLU	1.28	1,674.78	61.65
N51A	529,144	944,788	1,625	RLU	0.47	1,674.67	49.57
NG-22	525,760	943,063	1,710	RGAG	0.53	1,751.42	41.34
N15B1	528,824	941,461	1,639	RLU	0.29	1,682.61	43.52
ND-38	531,648	947,915	1,711	RDHA	0.21	1,747.96	36.89
N27B	530,425	944,252	1,626	RLU	0.53	1,675.47	49.37
N67E	529,854	946,160	1,651	RLU	1.36	1,665.00	13.97
N15F8	528,974	940,536	1,682	RLU	0	1,687.60	5.68
N105C'	531,414	947,558	1,702	Rk02	0	1,727.47	25.42
N28AA	530,037	944,106	1,626	RLU	0.33	1,675.58	49.48
N45A'	527,062	943,421	1,642	RLU	0.35	1,665.78	23.73
J-609	531,242	946,771	1,679	RAU	0	1,715.92	36.84
J-610	531,352	946,740	1,681	RAU	1.58	1,716.63	35.76
J-611	531,437	946,776	1,682	RAU	0	1,717.34	35.27
J-612	531,741	946,796	1,701	RAU	1.64	1,719.66	18.62
J-614	531,230	946,708	1,674	RAU	1.65	1,715.52	41.44
J-615	531,187	946,614	1,673	RAU	1.28	1,715.50	42.71
J-616	531,165	946,597	1,673	RAU	2.49	1,715.46	42.18
J-617	531,179	946,593	1,674	RAU	1.15	1,715.48	41.69
J-618	531,043	946,669	1,671	Rk02	0	1,729.67	58.25
J-619	531,057	946,664	1,673	Rk02	0	1,729.56	56.25
NG-67	525,934	943,275	1,714	RGAG	0.15	1,751.31	37.24

Appendix E: EPS; Nodes results at maximum consumption hour

Nodes Label	Easting X (m)	Northing Y (m)	Elevation (m)	Supply Zone	Demand (Calculated) (l/s)	Calculated Hydraulic Grade (m)	Pressure (mH2O)
N65C	528,996	945,005	1,630	RLU	2.06	1,674.3	44.224
N22	530,636	944,110	1,618	RLU	0.2	1,675.1	56.966
N29B'	529,568	944,363	1,622	RLU	0.67	1,674.2	52.068
N63B'	529,627	945,853	1,644	RLU	0.51	1,660.9	16.829
N53A	528,912	944,206	1,620	RLU	0.49	1,676.5	56.372
N3C	530,854	940,398	1,612	RLU	2.22	1,660.2	48.098
N3H1	531,558	941,391	1,594	RLU	1.27	1,635.9	41.86
N43	527,747	942,943	1,622	RLU	0.74	1,678.3	56.221
N82D	527,589	941,192	1,612	RLU	0.14	1,683.0	70.849
N15B2	528,839	941,464	1,638	RLU	0.22	1,681.8	43.721
N29	529,321	944,063	1,623	RLU	0.34	1,675.4	52.305
N30A5	529,427	943,779	1,622	RLU	0.48	1,677.0	54.867
N31D1	529,565	943,537	1,621	RLU	1.76	1,676.7	55.602
N44A1	527,941	943,591	1,620	RLU	0.88	1,677.2	57.12
J-1618	530,578	940,943	1,602	RLU	2.8	1,681.7	79.504
N53'	529,106	944,129	1,620	RLU	0.46	1,675.5	55.383
N8	529,985	942,376	1,612	RLU	0.59	1,675.9	63.724
ND-36	531,691	947,455	1,701	RDHA	0	1,748.0	46.875
NG-23	525,750	942,998	1,711	RGAG	0.62	1,751.3	40.233
N11	529,391	942,742	1,618	RLU	0.58	1,678.7	60.584
N81C2	527,918	940,445	1,633	RLU	0.3	1,681.6	48.482
N56	530,128	944,659	1,628	RLU	0.2	1,675.0	46.915
N58	530,863	944,665	1,629	RLU	1.03	1,674.8	45.685
ND-07	532,152	947,294	1,711	Rk02	0	2,005.9	294.33
N46B1	528,206	944,001	1,622	RLU	0.77	1,676.7	54.589
N22A	530,687	944,071	1,616	RLU	0.3	1,675.1	58.952
BA-02	531,240	940,457	1,614	R.BOK	0.62	1,716.0	101.777
N46	528,412	943,743	1,619	RLU	0.58	1,676.9	57.811
ND-46	532,898	947,359	1,715	RDHA	2.03	1,741.7	26.608
N43A2	527,472	943,437	1,633	RLU	0.56	1,675.2	42.114
N39B6	527,674	942,398	1,619	RLU	0.17	1,679.6	60.507
J-1562	528,041	941,055	1,623	R.awash	0	1,692.7	69.507
N82C	527,645	941,144	1,613	RLU	1.45	1,683.1	69.978
N81C1	527,838	940,360	1,630	RLU	0.3	1,681.5	51.409
N45	526,944	943,394	1,645	RLU	0	1,659.4	14.404
N57A'	531,038	944,317	1,616	RLU	0.51	1,675.0	58.833
N22A2	530,325	944,113	1,623	RLU	0.5	1,675.2	52.091
N20A	531,123	943,573	1,605	RLU	0.92	1,669.5	64.34
N7C	530,219	942,097	1,604	RLU	1.25	1,674.7	70.586
N28A	530,064	944,168	1,626	RLU	0.33	1,675.1	49.033
ILWA-01	528,129	945,101	1,635	RLU	2.15	1,655.6	20.543
BO-07	531,119	938,090	1,700	RBOK	0	1,717.6	17.542

N39A5	527,926	942,059	1,614	RLU	0.67	1,680.5	66.353
N22E	530,905	943,787	1,608	RLU	0.81	1,670.8	62.666
NG-37	526,313	942,671	1,707	RGAG	0.45	1,745.4	38.349
N42	527,713	942,828	1,624	RLU	1.87	1,678.6	54.519
N7B	530,266	942,223	1,603	RLU	0.6	1,675.1	71.952
ND-41	533,282	947,952	1,715	RDHA	1.14	1,731.3	16.224
N39A7	527,756	942,300	1,616	RLU	0.36	1,680.1	63.952
ND-45	532,826	947,227	1,716	RDHA	2.22	1,744.8	28.689
N15D2	528,999	941,003	1,659	RLU	0.14	1,683.2	24.162
N47C	528,471	944,401	1,623	RLU	0.46	1,676.4	53.243
N35	528,256	943,354	1,617	RLU	0.58	1,679.3	62.131
N54E	529,934	944,558	1,625	RLU	0.48	1,673.3	48.239
N63B'1	529,595	945,837	1,644	RLU	0.51	1,661.0	16.95
N3H3	531,579	941,220	1,603	RLU	0.28	1,635.3	32.198
N7B1	530,117	942,280	1,606	RLU	0.59	1,675.4	69.262
N29A3	529,514	944,220	1,624	RLU	0.29	1,674.2	50.124
NG-89	525,897	943,754	1,748	Tank AG	0	1,756.0	8.002
N109B	531,552	945,244	1,644	RAU	0.65	1,721.5	77.355
N6B	530,932	941,901	1,597	RLU	0.11	1,670.3	73.193
N29A2	529,510	944,211	1,623	RLU	0.29	1,674.2	51.124
J-1565	526,717	940,248	1,590	R.awash	0	1,700.7	110.494
N65A	529,049	945,380	1,638	RLU	0.76	1,674.1	36.044
N29A"	529,608	944,117	1,623	RLU	0.16	1,674.7	51.599
N102A	531,127	945,926	1,657	RAU	0.34	1,722.1	64.922
N27A	530,386	944,148	1,623	RLU	0.17	1,675.1	52.012
N3F	531,318	941,449	1,597	RLU	1.27	1,643.1	45.983
N24C	531,580	944,069	1,607	RLU	0.55	1,674.9	67.789
N22A5	529,853	944,026	1,624	RLU	0.55	1,675.4	51.331
J-1567	527,813	941,276	1,614	R.awash	0	1,694.1	79.888
NN-01	529,583	941,019	1,615	RLU	0.33	1,682.3	67.186
N54B1	529,898	945,046	1,635	RLU	0.52	1,671.4	36.351
N39A6	527,978	942,247	1,613	RLU	0.47	1,680.3	67.111
N81A1	528,252	940,754	1,641	RLU	0.25	1,682.8	41.76
ND-31	532,283	947,681	1,720	RDHA	2.46	1,748.4	28.361
N111A	530,975	945,569	1,651	RAU	0.21	1,721.9	70.755
N3G	531,677	940,693	1,616	RLU	1.33	1,634.7	18.69
N32C	529,114	944,147	1,620	RLU	0.74	1,675.4	55.309
NG-77	525,913	943,319	1,717	Tank AG	0	1,765.5	48.434
NG-46	526,570	943,034	1,691	RGAG	0.71	1,743.4	52.26
N82F	527,459	941,253	1,612	RLU	0.24	1,682.8	70.603
N44B1	527,350	943,631	1,636	RLU	2	1,668.5	32.383
N63B1	529,853	945,267	1,634	RLU	0.32	1,670.4	36.341
N10A	529,581	942,668	1,617	RLU	0.91	1,678.0	60.879
N69A2	530,495	945,397	1,642	RLU	2.8	1,660.9	18.851
N4	530,200	941,852	1,602	RLU	0.57	1,675.2	73.02
N22D	530,812	943,817	1,610	RLU	0.82	1,675.0	64.901

NG-44	525,882	943,726	1,749	RGAG	0	1,755.0	6.02
N15B	528,752	941,623	1,628	RLU	0	1,682.0	53.901
NG-47	526,347	943,236	1,703	RGAG	0.37	1,747.2	44.145
N44B3	527,384	944,038	1,631	RLU	1.93	1,668.6	37.512
N47A4	529,018	944,837	1,626	RLU	0.28	1,674.6	48.517
N62	530,003	945,312	1,637	RLU	0.36	1,669.4	32.362
N3H	531,538	941,439	1,594	RLU	1.27	1,638.0	43.947
J-1609	529,453	941,547	1,618	RGAG	0	1,682.5	64.353
N12A	528,985	941,654	1,627	RLU	1.01	1,681.6	54.482
N35A	528,332	943,331	1,615	RLU	0.48	1,679.3	64.126
ND-39	531,013	947,732	1,693	RDHA	1.11	1,747.9	54.772
N30A	529,526	943,947	1,622	RLU	0.1	1,676.0	53.881
J-1564	526,455	940,084	1,588	R.awash	0	1,702.1	113.852
J-1560	528,747	940,536	1,677	R.awash	0	1,689.1	12.031
N15D1	528,920	940,992	1,660	RLU	0.41	1,683.1	23.068
N16A	529,675	943,188	1,622	RLU	2.24	1,676.7	54.536
J-1541	519,821	937,323	1,560	R.awash	0	1,734.0	173.673
N67A4	530,105	945,765	1,654	RLU	0.53	1,665.0	10.992
NG-17	526,211	942,821	1,698	RGAG	2.24	1,745.7	47.569
N18B	530,760	943,395	1,606	RLU	1.94	1,671.6	65.45
N21D	531,566	943,468	1,603	RLU	0.9	1,668.1	65.012
N14B	529,373	943,028	1,621	RLU	0.63	1,678.4	57.239
N30A2	529,470	943,888	1,622	RLU	0.96	1,676.5	54.397
J-1566	527,015	940,435	1,601	R.awash	0	1,699.2	97.968
N67C	529,684	946,136	1,650	RLU	0.63	1,664.2	14.161
N36A	528,208	942,698	1,613	RLU	1.39	1,679.0	65.815
N82	528,566	940,561	1,671	RLU	1.07	1,684.9	13.903
N106A"	531,138	945,956	1,656	RAU	0.87	1,722.1	65.927
N43B5	528,196	943,303	1,616	RLU	0.58	1,679.3	63.168
N61A	530,202	945,232	1,637	RLU	0.51	1,669.8	32.708
N111	530,663	945,687	1,648	RAU	0.56	1,721.9	73.772
N64A2	529,602	944,702	1,626	RLU	0.54	1,673.5	47.353
N12A3	529,089	941,931	1,624	RLU	1	1,680.7	56.534
J-1557	528,824	940,531	1,682	R.awash	0	1,688.7	6.701
N15F7	528,897	940,535	1,682	RLU	1.11	1,687.0	4.965
N57	530,765	944,422	1,621	RLU	0.86	1,675.0	53.876
N29A1	529,426	944,021	1,623	RLU	0.34	1,674.2	51.133
J-1555	528,484	940,620	1,675	R.awash	0	1,689.9	14.879
N10A1	529,822	942,607	1,629	RLU	0.19	1,676.9	47.823
N52B	529,247	944,488	1,622	RLU	0.78	1,674.2	52.117
N7AB1	530,446	942,215	1,600	RLU	0.48	1,674.8	74.668
N11A	529,277	942,786	1,622	RLU	0.11	1,678.8	56.692
N43A7	527,479	943,022	1,630	RLU	0.63	1,676.2	46.08
NG-60	526,530	943,349	1,689	Tank AG	0	1,779.3	90.148
N78	530,967	945,012	1,640	RAU	0.41	1,721.6	81.423
NG-01	525,784	943,199	1,720	RGAG	0.32	1,751.8	31.725

N81	528,189	940,928	1,632	RLU	0	1,684.5	52.403
N7D	530,460	941,998	1,602	RLU	0.59	1,674.3	72.124
ILWA-02	527,950	944,605	1,627	RLU	1.64	1,654.2	27.174
N7AB	530,285	942,278	1,604	RLU	0.59	1,675.0	70.878
ND-44	531,634	947,273	1,701	RDHA	0.42	1,746.2	45.06
BA-08	531,062	939,143	1,643	T. Bok	0	1,717.6	74.427
N7A1	530,606	942,043	1,602	RLU	0.12	1,673.3	71.143
N50	528,398	945,080	1,636	RLU	2.22	1,655.7	19.607
ND-33	532,250	947,522	1,714	RDHA	1.58	1,748.3	34.203
J-1559	525,487	939,563	1,573	R.awash	0	1,707.0	133.681
N58A2	530,952	944,935	1,638	RLU	1.24	1,670.0	31.891
N27A2	530,201	944,136	1,625	RLU	0.17	1,675.2	50.045
N3B	531,199	941,269	1,595	RLU	1.72	1,644.1	48.999
N53B	528,795	944,273	1,620	RLU	0.66	1,676.0	55.87
N31B	529,463	943,252	1,618	RLU	0.75	1,678.1	59.968
N21	530,423	943,523	1,612	RLU	1.11	1,673.8	61.662
N46B	528,472	943,899	1,618	RLU	0.79	1,676.8	58.682
IAU-01	531,049	945,223	1,646	RLU	0.9	1,721.6	75.438
NG-39	526,080	942,315	1,703	RGAG	0.16	1,750.1	47.013
N68A3	530,006	945,622	1,646	RLU	0.32	1,666.1	20.008
ND-42	531,885	947,171	1,713	RDHA	0.41	1,746.8	33.722
N10A2	529,860	942,519	1,626	RLU	0.14	1,676.6	50.51
N43A	527,806	943,142	1,622	RLU	0.74	1,678.0	55.843
N64E	529,197	944,927	1,628	RLU	0.88	1,674.3	46.164
N43B2	528,442	942,958	1,615	RLU	0.84	1,678.9	63.813
N24E2	531,820	944,352	1,617	RLU	0.21	1,674.8	57.717
N6B3	531,211	942,456	1,597	RLU	0.17	1,671.5	74.323
N43B1	528,289	943,001	1,614	RLU	0.84	1,678.9	64.811
N39A1	527,608	941,571	1,615	RLU	1.62	1,681.6	66.447
N22C	530,938	944,082	1,613	RLU	0.65	1,675.0	61.9
N69A1	530,428	945,580	1,645	RLU	0.17	1,662.5	17.412
N52A	529,193	944,346	1,621	RLU	0.78	1,674.2	53.121
NG-64	526,356	943,351	1,689	Tank AG	0	1,775.4	86.206
N29A'	529,569	944,133	1,623	RLU	0.16	1,674.8	51.733
N2	528,962	941,481	1,633	RLU	1.19	1,681.9	48.787
N15F1	528,713	940,803	1,670	RLU	0.5	1,683.9	13.914
N69A	530,300	945,704	1,651	RLU	0.17	1,664.0	12.94
N71	531,322	945,834	1,657	RAU	0.62	1,721.7	64.609
N22D2	530,682	944,011	1,615	RLU	0.92	1,675.1	59.939
N64A	529,273	945,128	1,633	RLU	0.56	1,674.2	41.086
J-1556	528,524	940,563	1,670	R.awash	0	1,689.6	19.563
N21C	531,384	943,523	1,604	RLU	0.9	1,668.3	64.198
N67A3	529,993	945,764	1,648	RLU	0.65	1,664.8	16.756
N47B	528,375	944,440	1,627	RLU	0.46	1,676.6	49.51
N24A	531,572	944,013	1,607	RLU	0.55	1,674.9	67.789
N44B2	527,339	943,716	1,635	RLU	0.24	1,668.5	33.392

N100U3	531,218	946,177	1,664	RAU	0.12	1,722.1	58.021
N36	528,035	942,744	1,615	RLU	1.07	1,679.6	64.508
N38B	527,965	942,522	1,616	RLU	0.71	1,679.8	63.707
J-1569	520,259	937,352	1,559	R.awash	0	1,732.1	172.735
N47A2	528,915	945,039	1,632	RLU	0.35	1,674.4	42.298
N18	530,285	943,165	1,613	RLU	2.06	1,674.5	61.375
N13	528,911	942,465	1,633	RLU	0.28	1,679.9	46.812
N24E1	531,794	944,238	1,614	RLU	0.17	1,674.8	60.709
N39A3	527,691	941,894	1,616	RLU	0.65	1,681.1	64.925
N39B	527,452	942,327	1,624	RLU	0.8	1,680.0	55.93
N3D	530,727	940,683	1,606	RLU	1.45	1,661.2	55.112
J-1616	529,852	940,604	1,615	RLU	0	1,682.0	66.905
N32A1	528,841	943,984	1,618	RLU	0.66	1,676.7	58.54
N56B	530,133	944,673	1,628	RLU	0.2	1,675.0	46.913
N36A2	528,800	942,973	1,620	RLU	1.62	1,679.0	58.867
N9B1	530,818	942,615	1,601	RLU	0.39	1,673.5	72.31
N54	529,811	944,609	1,626	RLU	4.4	1,673.1	46.964
N54F	529,877	944,759	1,628	RLU	0.43	1,672.6	44.493
NG-10	525,889	943,188	1,710	RGAG	0.32	1,751.1	41.023
N30A3	529,310	943,832	1,621	RLU	0.53	1,677.0	55.886
N102	530,810	946,057	1,659	RAU	0.36	1,722.3	63.213
NG-75	525,942	943,284	1,706	Tank AG	0	1,766.5	60.37
N43B3	528,280	943,219	1,617	RLU	0.48	1,679.3	62.171
ILWBO01	527,339	942,948	1,632	RLU	1.29	1,678.4	46.283
N3E	531,489	941,084	1,600	RLU	2.77	1,637.9	37.796
N64B	529,707	944,952	1,630	RLU	0.6	1,672.2	42.08
NG-36	525,849	942,238	1,700	RGAG	0.22	1,749.9	49.781
N3J1	531,828	941,426	1,636	RLU	1.03	1,637.1	1.08
N54A1	529,656	944,585	1,625	RLU	5.32	1,674.0	48.917
N6A4	530,391	941,852	1,603	RLU	0.31	1,673.9	70.73
N43B6	528,238	943,316	1,616	RLU	0.59	1,679.3	63.145
N56A1	530,379	944,953	1,633	RLU	0.83	1,670.6	37.477
N44	527,955	943,638	1,621	RLU	1.52	1,677.2	56.057
NG-52	525,829	942,178	1,709	RGAG	0.35	1,749.8	40.759
N55B	530,616	944,762	1,631	RLU	0.71	1,674.8	43.692
N4A	530,289	941,647	1,602	RLU	0	1,672.8	70.634
N24D	531,771	944,049	1,607	RLU	0.42	1,674.8	67.696
N32	528,780	943,828	1,619	RLU	0.55	1,676.8	57.689
N27A1	530,318	944,150	1,624	RLU	0.17	1,675.1	51.025
N32B	529,278	943,940	1,621	RLU	0.49	1,676.8	55.666
N81F	527,654	940,701	1,618	RLU	1.24	1,681.7	63.57
NG-35	525,861	942,290	1,701	RGAG	0.34	1,749.9	48.842
N65B	529,076	945,205	1,635	RLU	0.4	1,674.2	39.141
NG-61	526,446	943,367	1,692	Tank AG	1.41	1,777.3	85.143
BO-09	530,878	940,277	1,616	RLU	0	1,681.7	65.532
J-1007	530,218	945,892	1,658	RLU	0	1,660.2	2.204

N3B2	530,847	940,934	1,601	RLU	1.6	1,660.2	59.107
J-1016	528,807	941,256	1,645	RLU	0	1,682.8	37.756
N64A1	529,552	944,625	1,623	RLU	0.41	1,674.0	50.9
J-1624	529,274	941,572	1,624	RLU	0	1,682.5	58.418
N3I	531,561	941,133	1,603	RLU	1.27	1,635.2	32.175
N43A3	527,418	943,233	1,634	RLU	0.56	1,674.1	39.975
N106	531,049	946,663	1,672	Rk02	0	1,723.8	51.655
N15D	528,904	941,089	1,651	RLU	0.22	1,683.0	31.949
ILEBO23	531,350	941,093	1,596	RLU	1.91	1,643.8	47.694
N5A	530,158	941,946	1,601	RLU	0.22	1,675.6	74.439
N15F6	528,618	940,553	1,673	RLU	1.06	1,685.2	12.139
N21B	531,221	943,535	1,606	RLU	0.49	1,668.9	62.77
N43A6	527,314	943,076	1,636	RLU	0.58	1,674.9	38.857
NG-13	526,064	943,139	1,702	RGAG	1.39	1,749.7	47.552
N22A3	530,255	944,111	1,624	RLU	0.41	1,675.2	51.122
NG-51	525,798	943,203	1,718	RGAG	1.11	1,751.9	33.857
NG-33	525,694	942,376	1,712	RGAG	0.32	1,749.9	37.815
N45'	527,089	943,742	1,642	RLU	0.7	1,651.5	9.522
N81A	528,124	940,852	1,631	RLU	0.32	1,683.4	52.311
N3H2	531,571	941,307	1,597	RLU	0.28	1,635.5	38.378
J-1558	525,422	939,537	1,576	R.awash	0	1,707.3	130.996
N18C	530,515	942,747	1,599	RLU	1	1,672.7	73.511
N7A	530,502	942,077	1,601	RLU	0.58	1,674.3	73.116
N59	531,354	944,531	1,622	RLU	1.03	1,674.8	52.652
N63B'2	529,687	945,649	1,642	RLU	0.26	1,663.5	21.484
N61	530,450	945,135	1,636	RLU	2.23	1,669.9	33.802
BA-09	531,118	938,272	1,691	T.Bok	0	1,717.6	26.523
NG-59	526,587	943,348	1,687	Tank AG	1.07	1,780.7	93.477
N29B	529,690	944,315	1,623	RLU	0.5	1,674.0	50.913
NG-27	525,728	942,654	1,708	RGAG	0	1,750.7	42.649
N25A2	531,898	943,938	1,606	RLU	0	1,674.9	68.772
N6A	530,891	941,862	1,598	RLU	0.41	1,670.3	72.159
N45'A	526,900	943,704	1,642	RLU	0.7	1,652.7	10.669
N11A1	529,317	942,886	1,621	RLU	0.58	1,678.6	57.481
N100R1	531,840	946,981	1,714	Rk02	0	1,884.2	169.814
J-1553	526,225	939,941	1,583	R.awash	0	1,703.3	120.035
J-1549	528,924	940,525	1,682	R.awash	0	1,688.3	6.261
BO-01	531,239	939,461	1,632	RLU	0	1,681.7	49.564
N15A	528,740	941,703	1,628	RLU	0.71	1,681.7	53.549
N71B	531,966	945,083	1,639	RAU	0.72	1,717.6	78.453
N14B1	529,556	942,955	1,620	RLU	0.4	1,678.0	57.913
N12A2	529,091	941,878	1,623	RLU	0.64	1,680.8	57.634
N47A	528,550	944,102	1,617	RLU	0.8	1,676.7	59.552
NG-31	525,623	942,413	1,706	RGAG	0.28	1,749.9	43.816
ILEBO01	529,653	940,823	1,617	RLU	1.14	1,682.3	65.136
N30A6	529,422	943,768	1,622	RLU	0.46	1,677.0	54.912

N28A'	529,938	944,218	1,626	RLU	0.46	1,675.2	49.067
N71C	531,973	945,263	1,645	RAU	0.31	1,718.8	73.675
N68	529,697	945,558	1,639	RLU	1.19	1,664.3	25.279
J-1563	525,781	939,696	1,580	R.awash	0	1,705.5	125.273
N15F4	528,590	940,681	1,670	RLU	1.24	1,684.6	14.536
ILu-01	529,419	942,275	1,619	RLU	1.08	1,679.9	60.733
NNL-03	530,464	940,890	1,604	RLU	0.44	1,681.7	77.554
N30A8	529,130	943,717	1,624	RLU	0.55	1,677.0	52.934
N54C	530,099	944,965	1,628	RLU	0.07	1,673.0	44.939
N39A4	527,731	942,106	1,614	RLU	0.65	1,680.7	66.61
N38A3	527,797	942,584	1,619	RLU	0.44	1,679.7	60.569
BO-05	531,095	939,270	1,638	T.Bok	0	1,717.6	79.417
N48	528,266	944,578	1,626	RLU	0.56	1,654.3	28.234
BA-03	531,427	940,095	1,620	R.BOK	0.35	1,716.1	95.911
N68A2	529,939	945,444	1,641	RLU	1.11	1,665.0	23.915
N81C3	527,933	940,424	1,633	RLU	0.58	1,681.6	48.512
ND-43	531,844	947,072	1,711	RDHA	1.68	1,746.5	35.389
N37	527,887	942,274	1,616	RLU	0.47	1,680.1	64.003
N10A3	529,899	942,529	1,625	RLU	0.92	1,676.5	51.379
N17B	530,272	943,583	1,621	RLU	1.48	1,673.8	52.699
N82A	527,790	941,308	1,613	RLU	1.54	1,683.5	70.364
N9B	530,795	942,634	1,599	RLU	0	1,673.7	74.512
N52C	528,999	944,421	1,622	RLU	0.5	1,674.5	52.405
J-1629	529,063	941,613	1,627	RLU	0	1,682.6	55.487
N64D	529,391	944,850	1,627	RLU	0.59	1,672.8	45.712
N52D	528,931	944,612	1,622	RLU	0.64	1,674.7	52.567
BO-08	530,742	940,575	1,609	RLU	0	1,681.7	72.518
ND-21	530,848	947,393	1,690	Rk02	0	2,005.9	315.288
NG-42	525,806	943,236	1,725	RGAG	0.54	1,752.1	27.057
ND-47	531,887	947,778	1,713	RDHA	0.1	1,748.0	34.899
N54B1'	529,930	945,127	1,634	RLU	0.33	1,671.1	37.056
N39B2	527,585	942,300	1,624	RLU	1.72	1,679.6	55.518
N20B	531,159	943,717	1,607	RLU	0.92	1,670.1	62.994
N55A	530,059	944,518	1,625	RLU	0.36	1,675.1	50.002
NG-02	525,801	942,624	1,716	RGAG	0.42	1,750.4	34.31
N106A	530,904	946,292	1,663	RAU	0.95	1,722.4	59.299
N103	530,357	946,222	1,665	Rk02	0.77	1,884.7	219.22
N8A	529,977	942,355	1,612	RLU	0.44	1,675.8	63.711
N74	531,820	944,668	1,624	RAU	0.15	1,717.6	93.387
N10	529,789	942,715	1,627	RLU	0.17	1,677.3	50.184
ND-35	531,954	947,341	1,715	RDHA	1.07	1,748.0	32.912
N111C	530,775	945,088	1,642	RAU	0.37	1,721.8	79.625
N109	532,088	945,538	1,657	RAU	0.24	1,721.3	64.173
N14B2	529,558	942,875	1,620	RLU	0.4	1,678.0	57.851
N36A1	528,619	942,586	1,616	RLU	2.01	1,679.0	62.824
N22D1	530,632	943,866	1,614	RLU	0.98	1,675.0	60.92

BA-07	531,682	938,531	1,679	R.BOK	0.63	1,717.1	37.969
BO-04	531,057	939,881	1,625	RLU	0	1,681.7	56.55
N15F	528,662	940,832	1,666	RLU	0.5	1,684.1	18.011
N14A	529,162	943,111	1,623	RLU	0.94	1,678.6	55.463
N44B4	527,710	944,044	1,625	RLU	1.93	1,670.7	45.563
NG-49	525,822	942,571	1,717	RGAG	0.59	1,750.2	33.107
N39	527,341	941,279	1,617	RLU	1.83	1,682.5	65.407
N24E	531,608	944,242	1,614	RLU	0	1,674.9	60.804
N15A1	528,792	941,071	1,657	RLU	0.49	1,683.3	26.194
J-1570	522,826	938,353	1,575	R.awash	0	1,719.9	144.613
N22A1	530,634	944,076	1,616	RLU	0	1,675.1	58.963
N49	528,211	944,430	1,622	RLU	0.96	1,677.0	54.874
N20	531,051	943,286	1,606	RLU	1.81	1,671.5	65.412
N30A1	529,539	943,895	1,620	RLU	0.66	1,676.2	56.105
ND-40	532,035	948,454	1,707	RDHA	1.26	1,747.6	40.465
NN-02	529,771	940,565	1,620	RLU	0.54	1,682.1	61.958
N3	530,571	941,027	1,601	RLU	1.62	1,665.6	64.451
N81B1	527,897	940,944	1,621	RLU	0.3	1,682.3	61.184
N52B'	529,054	944,563	1,622	RLU	0.48	1,674.4	52.323
NG-20	525,811	943,200	1,713	RGAG	0.18	1,751.9	38.779
N54D	529,995	944,712	1,629	RLU	0.44	1,673.1	43.958
N54E1	529,945	944,554	1,625	RLU	0.29	1,673.4	48.266
ND-34	532,192	947,244	1,707	RDHA	2.43	1,748.1	40.969
N6B2	531,117	942,289	1,599	RLU	0.62	1,670.9	71.725
NG-79	525,878	943,358	1,725	Tank AG	0	1,764.4	39.343
N68C1	529,649	945,451	1,639	RLU	0.67	1,670.6	31.522
BA-04	531,075	939,887	1,624	R.BOK	0.47	1,716.1	91.913
N58A1	530,875	944,760	1,633	RLU	2.01	1,670.0	36.899
J-1610	529,471	941,542	1,618	RLU	0	1,682.5	64.348
N39A2	527,619	941,763	1,617	RLU	1.06	1,681.3	64.15
N81B	528,061	940,774	1,634	RLU	0.55	1,682.9	48.834
N65	528,993	945,237	1,636	RLU	0.35	1,674.2	38.141
N81D1	527,460	940,507	1,614	RLU	0.4	1,681.5	67.387
NG-29	525,630	942,528	1,702	RGAG	0.62	1,750.0	47.938
N27B1	530,289	944,304	1,629	RLU	0.66	1,675.1	45.973
N32A	528,828	943,989	1,619	RLU	0.79	1,676.7	57.531
N29A	529,537	944,045	1,621	RLU	0.17	1,675.1	54.029
N15F2	528,855	940,791	1,675	RLU	0.33	1,683.7	8.703
N6B4	531,084	942,513	1,598	RLU	0.34	1,672.0	73.847
N81E	527,849	940,531	1,630	RLU	0.59	1,681.9	51.756
N81D	527,676	940,314	1,623	RLU	0.78	1,681.1	58.004
N24	531,237	944,049	1,611	RLU	1.39	1,675.0	63.829
N7	530,560	942,187	1,600	RLU	0.41	1,674.7	74.541
NG-68	526,184	943,330	1,697	Tank AG	0	1,771.7	74.559
N28B1'	529,615	944,008	1,622	RLU	0.25	1,675.4	53.309
N34	528,567	943,260	1,615	RLU	1.66	1,678.9	63.813

N54A	529,841	944,899	1,630	RLU	0.43	1,672.0	41.861
N24A1	531,761	943,988	1,606	RLU	0.42	1,674.9	68.779
N39A	527,350	941,590	1,621	RLU	1.29	1,682.0	60.896
N19	530,958	942,913	1,599	RLU	1.24	1,673.4	74.289
N46A2	528,515	943,723	1,620	RLU	0.39	1,679.2	59.115
NG-18	526,231	942,761	1,700	RGAG	2.38	1,745.4	45.346
N6A3	530,455	941,841	1,602	RLU	0.16	1,673.4	71.253
N6B1	531,047	942,121	1,599	RLU	0.1	1,670.6	71.478
N28C	529,812	944,268	1,624	RLU	0.58	1,674.0	49.861
N54B	529,798	944,789	1,627	RLU	0	1,672.3	45.226
N15C	528,988	941,105	1,650	RLU	0.21	1,682.8	32.737
J-1626	529,542	941,198	1,615	RLU	0	1,682.4	67.239
N30A4	529,206	943,808	1,623	RLU	0.4	1,677.0	53.91
J-1554	528,196	940,902	1,633	R.awash	0	1,691.7	58.569
N64B1	529,472	945,049	1,631	RLU	0.64	1,672.2	41.104
N39B1	527,401	942,156	1,624	RLU	2.01	1,680.5	56.389
N47A1	528,860	944,899	1,630	RLU	0.14	1,674.9	44.819
N31	529,021	943,837	1,616	RLU	0.58	1,677.1	60.962
NG-71	526,091	943,310	1,702	Tank AG	0	1,769.7	67.555
J-1725	530,199	945,886	1,658	Rk02	0	1,885.1	226.59
N17	530,098	943,251	1,621	RLU	2.06	1,674.3	53.234
J-1568	527,512	940,970	1,613	R.awash	0	1,695.9	82.776
N6C	531,141	941,382	1,598	RLU	0.21	1,643.8	45.709
NG-48	526,295	943,104	1,701	RGAG	0.65	1,747.9	46.848
N43A4	527,360	943,249	1,635	RLU	0.58	1,673.8	38.68
J-1544	526,032	939,808	1,580	R.awash	0	1,704.3	124.062
N56A	530,342	944,867	1,631	RLU	0.71	1,674.8	43.693
N43B4	528,181	943,252	1,617	RLU	0.58	1,679.3	62.207
NG-11	525,951	943,177	1,708	RGAG	0.42	1,750.5	42.453
BO-03	531,128	938,271	1,691	R.BOK	0.32	1,717.3	26.251
N3B1	530,754	941,097	1,599	RLU	1.45	1,660.8	61.629
N38A	527,546	942,515	1,621	RLU	1.37	1,679.5	58.406
N44A	527,383	943,496	1,634	RLU	1.5	1,668.9	34.81
N82B	527,749	941,262	1,615	RLU	1.45	1,683.4	68.258
NG-50	525,884	942,421	1,716	RGAG	0.62	1,750.1	34.048
NG-16	526,286	943,073	1,694	RGAG	1.6	1,748.5	54.428
N22A4	530,147	944,091	1,625	RLU	0.4	1,675.3	50.176
N6	530,367	941,892	1,602	RLU	0.2	1,674.3	72.111
N53A1	528,918	944,221	1,620	RLU	0.53	1,676.2	56.072
N77	531,598	944,725	1,625	RAU	0.35	1,717.6	92.388
N12A1	529,144	941,623	1,626	RLU	0.4	1,681.3	55.154
N9	530,031	942,497	1,614	RLU	0.84	1,676.1	61.936
N31D	529,590	943,531	1,622	RLU	1.76	1,676.6	54.529
NG-19	526,249	942,742	1,700	RGAG	0	1,745.4	45.344
N52'	529,335	944,711	1,626	RLU	0.62	1,674.2	48.111
NG-34	525,774	942,333	1,705	RGAG	0.47	1,749.9	44.803

N63A	529,531	945,198	1,630	RLU	0.9	1,672.2	42.092
N11A2	529,430	942,842	1,618	RLU	0.32	1,678.6	60.507
ND-12	531,109	947,720	1,701	Rk02	0	2,005.9	304.31
N30	529,500	943,889	1,621	RLU	0.44	1,676.4	55.276
N30A7	529,541	943,724	1,620	RLU	0.83	1,676.5	56.424
NG-25	525,726	942,800	1,705	RGAG	0.24	1,751.0	45.873
N70	531,150	945,405	1,652	RAU	0.25	1,721.7	69.541
N54D'	530,131	945,049	1,631	RLU	0.5	1,670.8	39.687
NG-41	524,969	942,909	1,728	RGAG	0.24	1,750.7	22.622
BO-06	531,119	937,829	1,713	T.Bok	0	1,717.6	4.568
J 2	519,815	937,320	1,559	R.awash	0	1,734.1	174.697
N24B	531,627	944,402	1,617	RLU	0.71	1,674.9	57.743
N67E1	529,878	946,027	1,647	RLU	1.06	1,664.2	17.185
N7B2	530,135	942,327	1,605	RLU	0.59	1,675.5	70.363
N22B	530,849	944,095	1,615	RLU	0.65	1,675.0	59.917
NG-30	525,626	942,470	1,702	RGAG	0.18	1,750.0	47.861
N15E	529,008	940,771	1,677	RLU	0.32	1,683.5	6.491
N12	529,233	942,335	1,621	RLU	0.16	1,679.9	58.74
NG-26	525,730	942,684	1,702	RGAG	0.13	1,750.8	48.683
NG-65	526,313	943,344	1,690	Tank AG	0	1,774.5	84.287
NG-69	526,157	943,321	1,698	Tank AG	0	1,771.1	72.963
NG-21	525,771	943,143	1,712	RGAG	0.25	1,751.6	39.564
BA-06	531,790	939,373	1,645	R.BOK	0.47	1,716.4	71.279
NG-40	526,396	943,262	1,706	RGAG	0.26	1,747.2	41.096
N14B3	529,468	942,911	1,620	RLU	0.4	1,678.0	57.83
J-1546	522,072	937,983	1,563	R.awash	0	1,723.6	160.289
N68A1	529,814	945,493	1,640	RLU	1.06	1,664.5	24.48
J-1561	528,656	940,543	1,673	R.awash	0	1,689.5	16.424
N27C	530,668	944,185	1,618	RLU	0.55	1,675.0	56.903
N25A	531,979	943,848	1,606	RLU	0.29	1,674.9	68.772
J-1551	528,152	940,945	1,631	R.awash	0	1,692.0	60.836
NG-90	525,835	942,184	1,698	RGAG	0.4	1,749.8	51.738
N43A1	527,864	943,337	1,624	RLU	1.39	1,677.6	53.478
N12A4	529,105	942,008	1,623	RLU	0.21	1,680.5	57.386
J-1542	519,830	937,326	1,561	R.awash	0	1,734.0	173.13
N63A1	529,580	945,264	1,634	RLU	0.58	1,671.1	37.002
N71D	531,855	944,899	1,632	RAU	0.52	1,717.6	85.408
N30A9	528,997	943,781	1,618	RLU	0.66	1,677.1	58.953
N71'	531,709	945,680	1,657	RLU	0.9	1,721.5	64.355
N51B	528,692	944,962	1,631	RLU	0.4	1,669.9	38.798
J-1552	528,966	940,528	1,683	R.awash	0	1,688.1	5.577
N31A	529,248	943,334	1,626	RLU	1.03	1,678.2	52.049
N15F3	528,612	940,750	1,668	RLU	0.45	1,684.3	16.309
N71BC	531,906	945,107	1,641	RAU	0.51	1,717.6	76.446
N82E	527,565	941,199	1,612	RLU	0.45	1,683.0	70.806
N38A1	527,696	942,460	1,620	RLU	0.44	1,679.6	59.457

N27B2	530,333	944,416	1,630	RLU	0.88	1,675.1	44.981
NG-09	525,865	943,197	1,711	RGAG	0	1,751.3	40.263
N67	529,739	945,670	1,639	RLU	0.74	1,664.4	25.335
N111A'	530,942	945,486	1,649	RAU	0.88	1,721.9	72.712
J-1550	528,128	940,969	1,628	R.awash	0	1,692.1	63.979
N14	529,069	942,868	1,628	RLU	0	1,679.0	50.938
N55A'	530,525	944,518	1,627	RLU	0.86	1,675.0	47.902
N6A2	530,681	941,796	1,599	RLU	0.19	1,671.8	72.662
N33	528,778	943,784	1,619	RLU	1.17	1,678.9	59.758
N54E2	529,949	944,564	1,625	RLU	0.4	1,673.4	48.332
N39B3	527,644	942,288	1,623	RLU	0.21	1,679.6	56.512
N43B	528,124	943,052	1,619	RLU	1	1,679.4	60.322
N43A5	527,039	943,337	1,644	RLU	0.71	1,667.2	23.111
N68C	530,108	945,583	1,646	RLU	1.11	1,666.8	20.719
BA-05	531,371	939,217	1,637	R.BOK	1.46	1,716.8	79.622
NG-12	525,993	943,161	1,705	RGAG	1.74	1,750.2	45.064
N68D	530,175	945,752	1,650	RLU	1.56	1,665.2	15.147
J-1608	528,825	941,260	1,644	RLU	0	1,682.8	38.747
NG-15	526,210	943,094	1,697	RGAG	1.15	1,748.9	51.749
N67A	529,721	945,624	1,638	RLU	0.74	1,664.3	26.256
N47A3	528,941	944,867	1,628	RLU	0.28	1,674.6	46.527
N15	528,611	941,712	1,625	RLU	0.92	1,681.7	56.539
J-1620	528,840	941,458	1,638	RLU	0	1,682.8	44.674
N28A"	529,886	944,073	1,622	RLU	0.3	1,675.2	53.096
N44B	528,050	943,989	1,620	RLU	1.93	1,677.0	56.876
ND-25	531,716	947,472	1,704	Rk02	0	2,005.9	301.316
N39B5	527,671	942,345	1,619	RLU	0.21	1,679.7	60.567
N48B	528,237	944,498	1,624	RLU	0.56	1,654.3	30.21
N100R4	531,374	946,810	1,686	Rk02	0	1,884.2	197.758
N67A1	529,784	945,665	1,640	RLU	0.66	1,664.4	24.386
NG-32	525,645	942,403	1,711	RGAG	0.43	1,749.9	38.815
NG-28	525,634	942,596	1,702	RGAG	0.36	1,750.3	48.148
NG-43	525,870	943,359	1,734	RGAG	0.12	1,752.9	18.869
J-1631	528,745	941,678	1,627	RLU	0	1,682.7	55.582
ND-05	530,187	945,880	1,658	Rk02	0	2,005.9	347.226
N106A'	531,028	946,247	1,665	RAU	0.32	1,722.2	57.087
N18A	530,626	943,037	1,603	RLU	1.77	1,673.6	70.502
N28B1	529,620	943,968	1,622	RLU	0	1,675.6	53.47
N63B	529,616	945,358	1,636	RLU	0.32	1,670.8	34.705
N47	528,641	944,336	1,623	RLU	0.18	1,676.5	53.417
N55	530,069	944,514	1,625	RLU	0.36	1,675.1	50
N31C	529,364	943,622	1,624	RLU	0.95	1,677.6	53.514
N59A	531,293	944,290	1,616	RLU	1.21	1,674.9	58.814
NG-38	526,554	942,989	1,692	RGAG	0.53	1,743.7	51.559
N71E	531,882	944,872	1,633	RAU	0.31	1,717.6	84.409
N25A1	531,858	943,960	1,607	RLU	0.82	1,674.9	67.775

N15F5	528,585	940,558	1,672	RLU	0.29	1,685.0	12.921
J-1548	528,892	940,527	1,681	R.awash	0	1,688.4	7.4
N16A1	529,635	943,185	1,620	RLU	0.84	1,676.8	56.671
N38A2	527,752	942,439	1,618	RLU	1.53	1,679.6	61.468
N4B	529,642	941,343	1,615	RLU	0.12	1,672.8	57.659
NG-83	525,880	943,543	1,736	Tank AG	0	1,760.5	24.458
N70'	531,124	945,415	1,651	RAU	0.84	1,721.7	70.537
ND-32	532,258	947,564	1,714	RDHA	1.36	1,748.3	34.268
ND-37	530,388	948,110	1,692	RDHA	0.41	1,747.8	55.714
N39B4	527,607	942,378	1,621	RLU	0.5	1,679.6	58.521
N56B1	530,246	944,627	1,628	RLU	0.66	1,674.9	46.834
NG-24	525,728	942,848	1,711	Tank AG	0.12	1,751.1	40.166
J-1613	528,827	941,318	1,643	RLU	0.49	1,682.8	39.725
N67A2	529,875	945,724	1,644	RLU	0.7	1,664.6	20.54
NG-45	526,218	942,792	1,706	RGAG	0.91	1,745.5	39.449
N81C	527,759	940,421	1,622	RLU	0.36	1,681.5	59.373
N6A1	530,777	941,760	1,598	RLU	0.32	1,671.2	73.008
N57A	530,934	944,355	1,619	RLU	0.51	1,675.0	55.849
N46A1	528,422	943,703	1,620	RLU	0.68	1,679.2	59.114
NG-14	526,131	943,117	1,700	RGAG	0.84	1,749.3	49.156
N27B3	530,434	944,275	1,626	RLU	0.88	1,675.1	48.947
N100U2	531,436	946,785	1,687	Rk02	0	1,884.2	196.76
N17A	530,290	943,178	1,613	RLU	1.28	1,674.5	61.37
N51A	529,144	944,788	1,625	RLU	0.47	1,674.4	49.252
BA-10	531,246	939,462	1,632	R.BOK	1.74	1,716.2	84.03
NG-22	525,760	943,063	1,710	RGAG	0.53	1,751.5	41.368
N15B1	528,824	941,461	1,639	RLU	0.29	1,682.4	43.303
ND-38	531,648	947,915	1,711	RDHA	0.21	1,748.0	36.889
N27B	530,425	944,252	1,626	RLU	0.53	1,675.1	48.963
N67E	529,854	946,160	1,651	RLU	1.36	1,664.2	13.167
N15F8	528,974	940,536	1,684	RLU	0	1,687.5	3.47
N28AA	530,037	944,106	1,626	RLU	0.33	1,675.2	49.074
N45A'	527,062	943,421	1,642	RLU	0.35	1,665.5	23.475
J 1	519,809	937,317	1,559	R.awash	-110	1,734.1	174.728
J-1011	530,208	945,921	1,657	Rk02	0	1,659.2	2.201
J-609	531,242	946,771	1,679	RAU	0	1,722.0	42.867
J-610	531,352	946,740	1,681	RAU	1.58	1,721.9	41.061
J-611	531,437	946,776	1,682	RAU	0	1,721.9	39.864
J-612	531,741	946,796	1,701	RAU	1.64	1,722.0	20.904
J-613	531,848	946,966	1,713	RAU	1.6	1,722.0	8.962
J-614	531,230	946,708	1,674	RAU	1.65	1,722.0	47.862
J-615	531,187	946,614	1,673	RAU	1.28	1,722.0	49.161
J-616	531,165	946,597	1,673	RAU	2.49	1,722.0	48.671
J-617	531,179	946,593	1,674	RAU	1.15	1,722.0	48.167
NG-67	525,934	943,275	1,714	RGAG	0.15	1,751.3	37.269